

100-KR

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100-KR Overview

The 100-KR groundwater interest area includes the 100-KR-4 operable unit (OU). Groundwater in 100-KR was contaminated by waste releases associated with past operations of the KE and KW Reactors and from associated support facilities. At the end of 2013, approximately 59 percent of the waste sites were classified as closed, interim closed, no action, or not accepted or rejected, with approximately 37 percent having undergone active remediation. Removing contaminants from the vadose zone eliminates secondary sources of contamination that could migrate to groundwater and reduce the risk of direct exposure at the surface. Table KR.1 lists key facts about 100-KR and additional details about 100-KR history, waste sites, and hydrogeology are provided in Chapters 1 and 3 of the Draft A remedial investigation (RI)/feasibility study (FS) for the K Reactor Area source and groundwater OUs ([DOE/RL-2010-97 Draft A](#)). Former waste sites known or suspected to have contributed to observed groundwater contamination at 100-KR include 183-KE and 183-KW Head House tank farms, 116-KE-1 and 116-KW-1 Gas Condensate Cribs, 116-KE-3 and 116-KW-2 Fuel Storage Basin Cribs/Reverse Wells, 116-K-1 Crib, 116-K-2 Trench, and 118-K-1 Burial Ground. Figure KR.1 shows the locations of key features in 100-KR and the inferred groundwater elevation contours generated from the measurements collected in March 2013 .

The unconfined aquifer in 100-KR ranges from 5.2 to more than 32 meters thick. This aquifer is primarily present in the Ringold Formation unit E sand and gravel (Figure KR.2). This unit is overlain by the gravels and interbedded sand and silt of the Hanford formation, which comprise the bulk of the vadose zone. The vadose zone ranges from less than 1 meter thick near the Columbia River to 32 meters thick inland. The uneven surface of the silt- and clay-rich Ringold Formation upper mud unit (RUM) forms the bottom of the unconfined aquifer. Contaminant concentrations are generally highest within the uppermost portion of the aquifer near the water table, however, mobile contaminants (e.g., hexavalent chromium) have been detected over the entire aquifer thickness, particularly near source areas.

Groundwater in 100-KR flows generally to the northwest toward the Columbia River, which forms a discharge boundary for the unconfined aquifer. Operation of pump and treat (P&T) systems at 100-KR creates changes in groundwater flow direction and velocity. These changes are expressed as depressions and mounds in the water table, affecting the flow direction (Figure KR.1). Larger mounds, such as that produced by the combined discharges from KR4 and KX systems near the middle of the 116-K-2 Trench, create conditions of radial flow away from the mound. This creates local diversion of groundwater flow direction away from the natural patterns. Groundwater further inland of 100-K Area generally flows to the north and northeast toward 100-N and 100-D Areas. The actual flow direction and apparent velocity in this inland area is somewhat uncertain due to sparse groundwater elevation measurements in the area.

Daily and seasonal fluctuations in the river stage also affect groundwater flow in 100-KR. As would be expected, longer term changes in the river stage produce more extensive and longer lived changes in the water levels, hydraulic gradient, and flow directions in the unconfined aquifer. Intrusion of river water into the aquifer during high river stage can lower contaminant concentrations in aquifer tubes and in some near-river wells. Peak high river stage in 2013 was observed at three periods in April, May, and June. Low river stage periods for calendar year 2013 were observed from January 2013 through March and from early August through December 2013. The peak river stage elevation observed in 2013 was about 2 meters lower than the peaks observed in the two years preceding (i.e., 2012 and 2011).

Contaminants of concern (COCs) in the 100-KR unconfined aquifer were identified in the RI/FS and include chromium (total and hexavalent), tritium, nitrate, strontium-90, carbon-14, and trichloroethene (TCE). Figure KR.3 shows how the plume areas have changed since 2003. All elevated anthropogenic chromium at 100-KR is understood to be present as hexavalent chromium and so total chromium and hexavalent chromium are discussed as hexavalent chromium for purposes of this report.

Table KR.1 100-KR at a Glance

Reactor Operations: KE 1955–1971; KW 1955–1970				
2013 Groundwater Monitoring				
Contaminant	Water Quality Standard	Maximum Concentration	Plume Area^a (km²)	Shoreline Impact (m)
Hexavalent Chromium	20 µg/L ^b	3,280 µg/L (199-K-205) ^c	1.05 ^d	800 ^e
Tritium	20,000 pCi/L	76,000 pCi/L (199-K-202)	0.02	0
Nitrate	45 mg/L	63.7 mg/L (199-K-34)	0.03	0
Strontium-90	8 pCi/L	13,200 pCi/L ^f	0.05	200
Carbon-14	2,000 pCi/L	39,500 pCi/L ^f	0.03	0
Trichloroethene	5 µg/L	8.3 µg/L (199-K-185)	0.01	0
Remediation				
Waste Sites (interim action): ~ 59 percent complete ^g				
Groundwater Remediation (interim ROD for hexavalent chromium): <ul style="list-style-type: none"> • KR4 pump-and-treat: 1997–2013, removed 368 kg • KW pump-and-treat: 2007–2013, removed 205 kg • KX pump-and-treat: 2009–2013, removed 174 kg Final record of decision anticipated after 2015.				

- a. Estimated area at a concentration greater than the listed water quality standard.
- b. 20 µg/L groundwater cleanup target identified in ROD for interim remedial action.
- c. January 2014 sample collected during drilling of new well.
- d. Based on a concentration greater than the 20 µg/L remedial action objective. This area is for the plume within the 100-K interest area. Approximately 0.2 km² of additional chromium plume area greater than 20 µg/L that is apparently attributable to 100-K historic operations is located within 100-NR interest area.
- e. Length of shoreline at 100-K that is not considered to be “protected” against potential for continuing release of hexavalent chromium to the river.
- f. Maximum based on estimated migration of historical plumes
- g. Sites with status of closed, interim closed, no action, not accepted, or rejected.

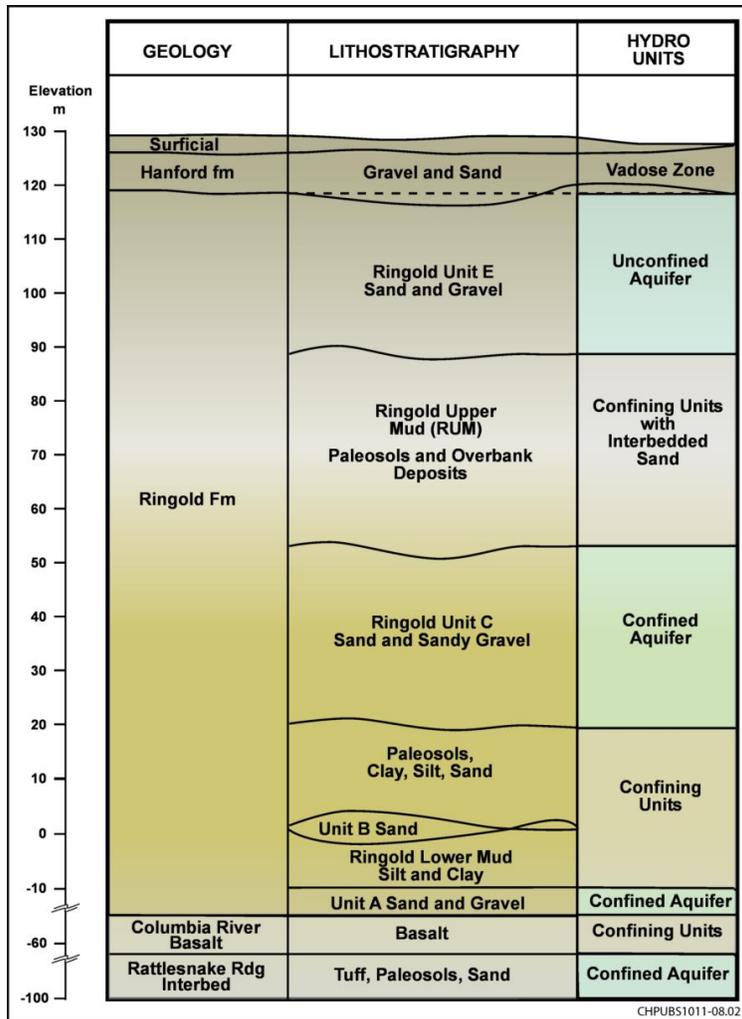


Figure KR.2 100-KR Geology

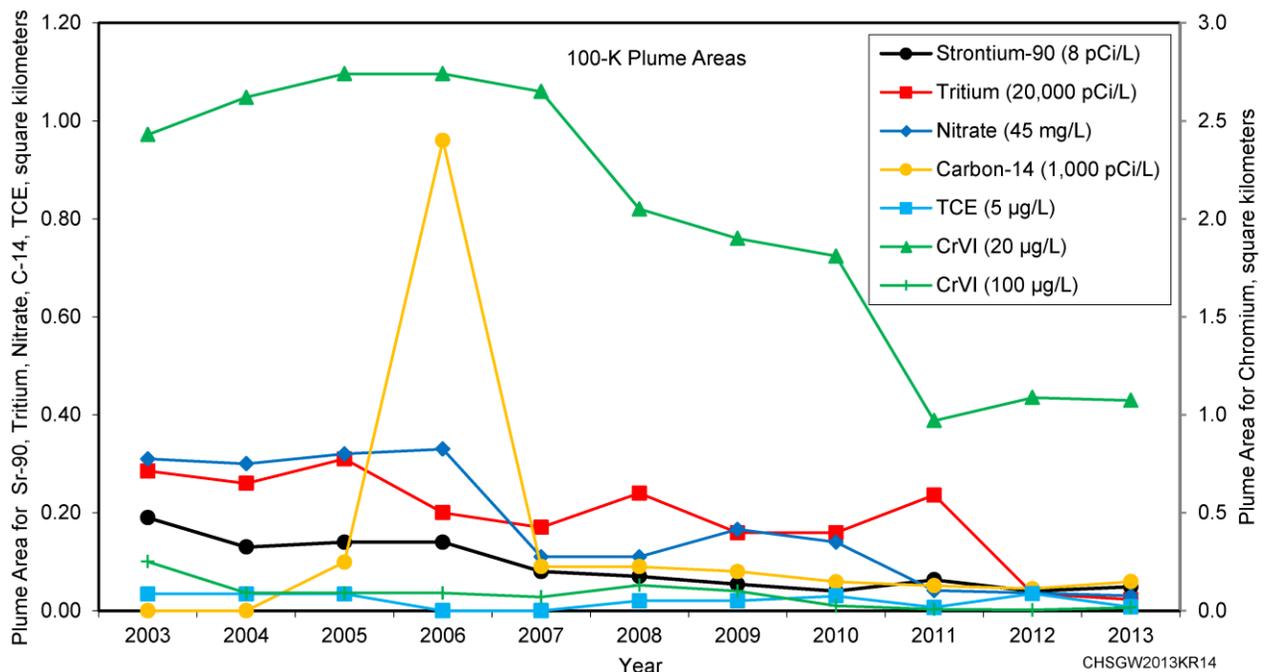


Figure KR.3 Changes in Selected Plume Areas Since 2003 at 100-KR-4 OU

100-KR CERCLA Activities

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) groundwater activities in 100-KR included groundwater sampling and analysis at monitoring well locations and operation of three interim groundwater remediation systems focusing on removal of hexavalent chromium (Figure KR.4; Table A.4 of Appendix A). CERCLA groundwater sampling includes monitoring interim remedial actions for effectiveness and monitoring wells throughout 100-KR to track contamination. Additional groundwater samples are collected and analyzed for identified co-contaminants of carbon-14, nitrate, strontium-90, TCE, and tritium, which are discussed separately. These constituents, which have been identified as groundwater COCs through the RI/FS process, may be captured and extracted incidentally by the interim remedial action system. They are not, however, treated by the interim action and are, therefore, considered to be “co-contaminants” of the hexavalent chromium, which is the primary target of the interim action. Another contaminant related to historical reactor operations at 100-KR is technetium-99. Technetium-99 is detected in groundwater within 100-KR at concentrations consistently less than 100 pCi/L, which is much less than the drinking water standard (DWS) of 900 pCi/L.

Total petroleum hydrocarbons have been encountered in the vadose zone during drilling of well 199-K-167 (decommissioned), well 199-K-173, and RI well 199-K-186. Total petroleum hydrocarbons were not detected in groundwater during 2013 at any location. The overall results are consistent with previous sampling events.

100-KR aquifer tubes are generally scheduled for annual sampling in the fall; this provides information about conditions near the river during the period of most rapid movement of groundwater toward the river. Aquifer tubes (essentially small diameter wells placed within the unconsolidated formation near the river shore) provide samples of water from the near-river environment and hyporheic zone. Analysis of near-river samples provides information on conditions in potential exposure points for aquatic organisms. Appendix C lists aquifer tubes sampled in 2013.

With respect to groundwater remediation, as of December 2013, 35 extraction wells and 17 injection wells were in use. Combined, the three systems are capable of treating more than 6.5 million liters of groundwater per day. The combined P&T systems in 100-KR removed 49 kilograms of hexavalent chromium from groundwater in 2013. Since 1997, the P&T systems have removed 747 kilograms of hexavalent chromium from the aquifer. *Calendar Year 2013 Annual Summary Report for the 100-HR-2 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation* (DOE/RL-2014-25) provides additional detail.

Remedial Investigation/Feasibility Study (RI/FS). The U.S. Department of Energy (DOE) submitted Draft A of an RI/FS ([DOE/RL-2010-97 Draft A](#)) and Proposed Plan ([DOE/RL-2011-82 Draft A](#)) to the U. S. Environmental Protection Agency (EPA) in 2011. EPA reviewed the documents in 2012, and DOE will incorporate the results of supplemental source characterization activities upon completion of investigation activities. The RI/FS report presents results of RI studies and evaluates alternatives for cleanup of the vadose zone and groundwater. Based on the observed efficacy of P&T systems at 100-KR-4 OU, it seems likely that the proposed plan for this OU will include P&T as a major element of a preferred alternative.

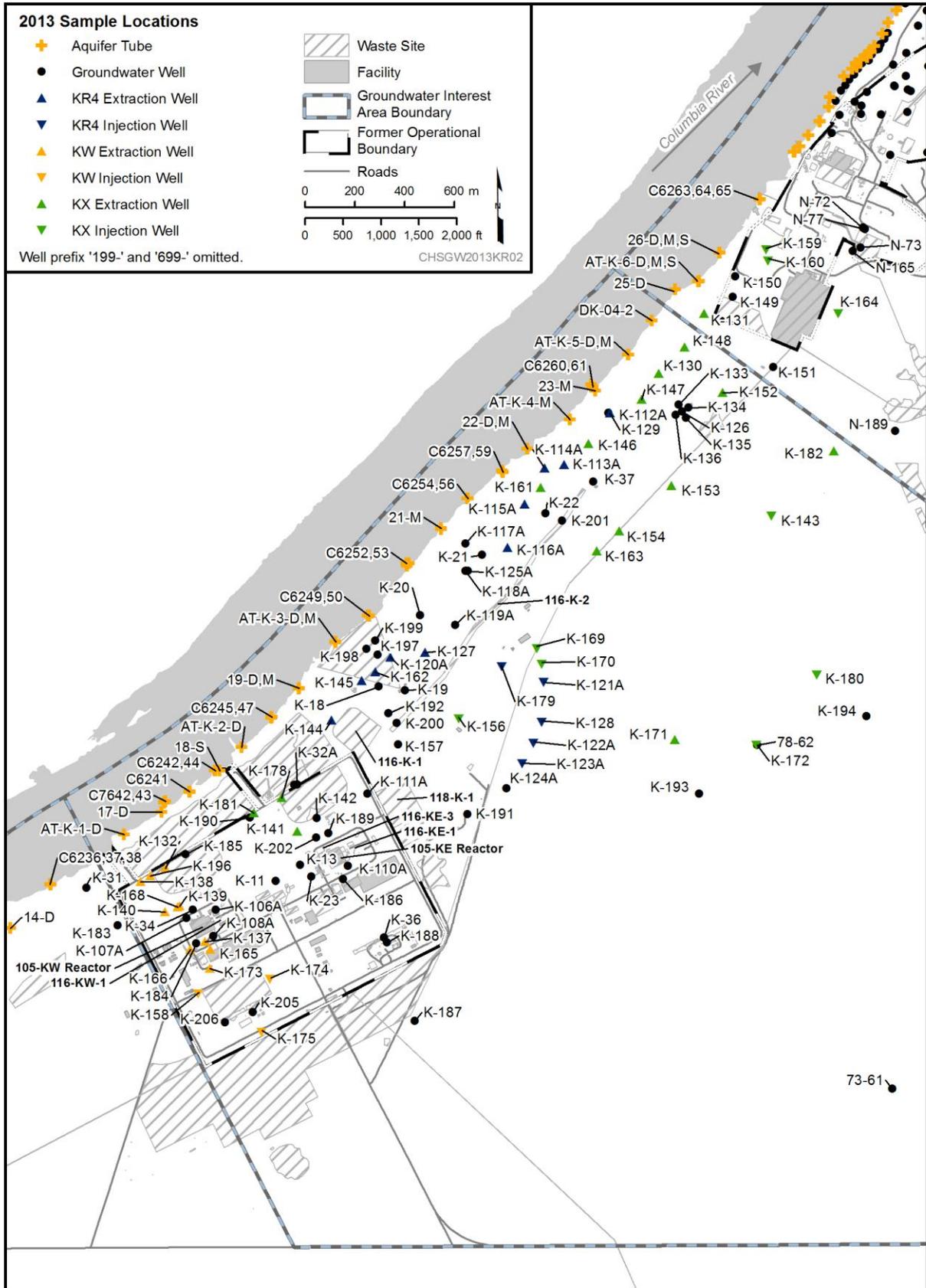


Figure KR.4 100-KR 2013 Sampling Locations

100-KR Hexavalent Chromium – Low River Stage

Hexavalent chromium is a mobile contaminant at 100-KR, and its presence resulted from historical releases of two different types of wastewater contaminated with chromium. The first type of release included spills, leaks, and limited intentional discharge of concentrated sodium dichromate dihydrate solutions used as feed chemicals for conditioning reactor cooling water. The second type of release included spent reactor cooling water from retention basin leaks and intentional discharges to the 116-K-1 Crib and 116-K-2 Trench. The plumes from these sources are associated with three general areas: (1) a plume originating at, or near, the 183-KW Head House chemical storage tank farm and extending riverward, (2) a plume originating at, or near, the 183-KE Head House chemical storage tank farm and extending riverward, and (3) a plume originating at the 116-K-1 Crib and 116-K-2 Trench and extending radially away from those sites. These plumes have been reshaped and/or dissected by operation of the groundwater P&T systems at 100-K (Figures KR.5 and KR.6), which substantially reduced the observed groundwater hexavalent chromium concentrations since 1996. Based on aquifer tube sampling and near-river wells, the extent of hexavalent chromium at the river shore continues to decline.

In addition to measurements collected from the near-river environment at aquifer tubes, river shore seeps at 100-K Area were also sampled in 2013. The seeps are discrete areas of groundwater discharge to the ground surface near the river shore that appear during the low river stage and are most apparent during the falling limb of the river stage cycle. Seeps represent groundwater leaving the aquifer in areas where the groundwater elevation remains higher than the river elevation for some period of time. At 100-K Area, four seeps were sampled during 2013, all during September and October. The seep measurements provide useful information regarding near-shore surface water conditions, however, they do not technically represent groundwater. For information purposes, the results of hexavalent chromium measurement of the 2013 seep samples are posted on the hexavalent chromium plume maps for both low and high river stages in this report.

The Columbia River is a discharge boundary for groundwater beneath the 100-K Area. When river stage is low (generally during the period from September through March [Figure KR.7]), groundwater flows readily toward the river and discharges into the river through areas of interaction in the hyporheic zone where the aquifer meets the surface water. The low river stage period has been selected for collection of water samples from the aquifer tubes placed into the near-river environment at 100-KR. At this time, the chromium plume is understood to be continuous between the inland aquifer and aquifer tube locations where hexavalent chromium is detected. The inferred distribution of hexavalent chromium at 100-KR during the low river stage period is shown in Figure KR.5 and KR.6.

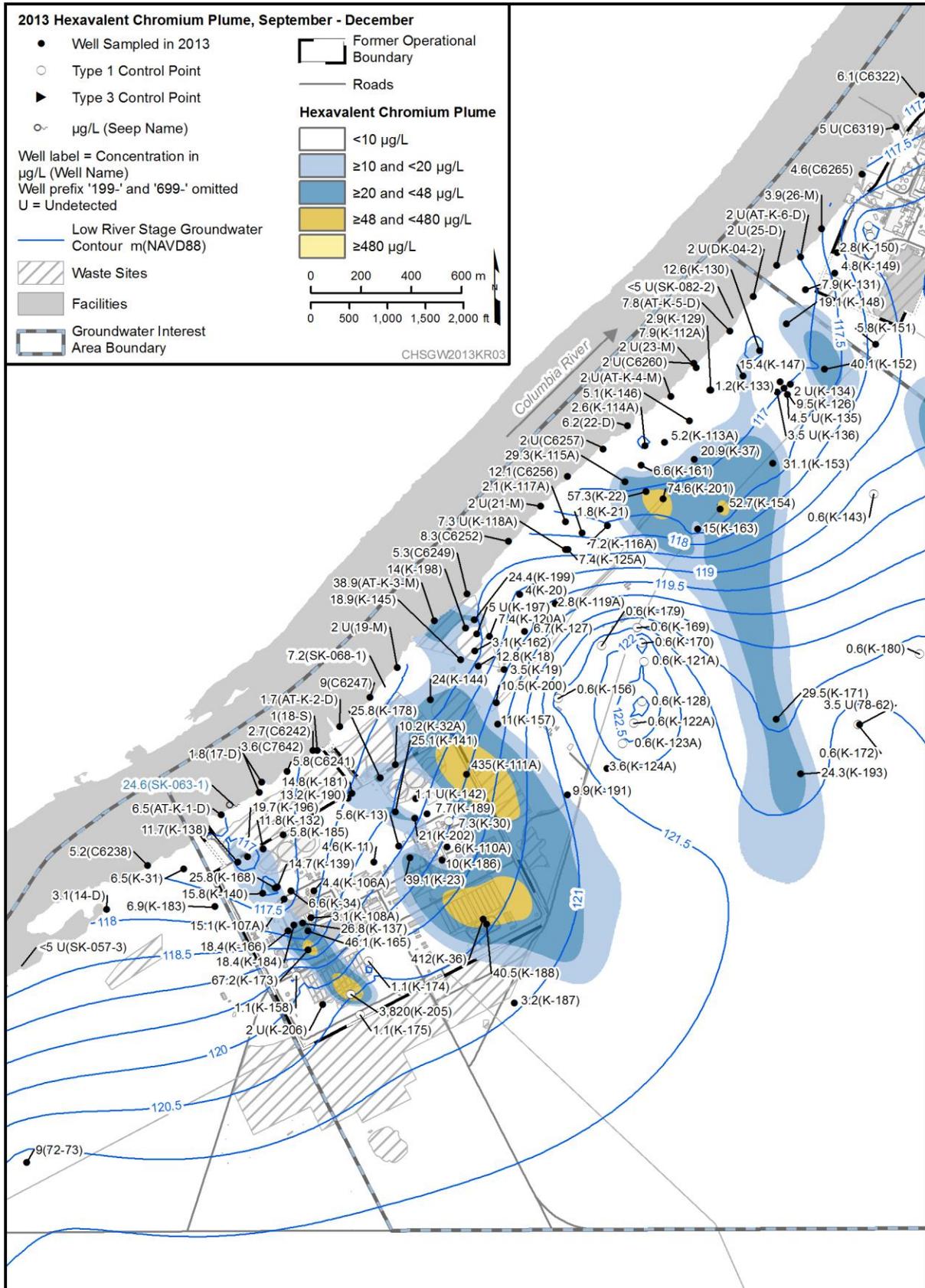


Figure KR.5 100-KR 2013 Hexavalent Chromium Plume (Low River Stage)

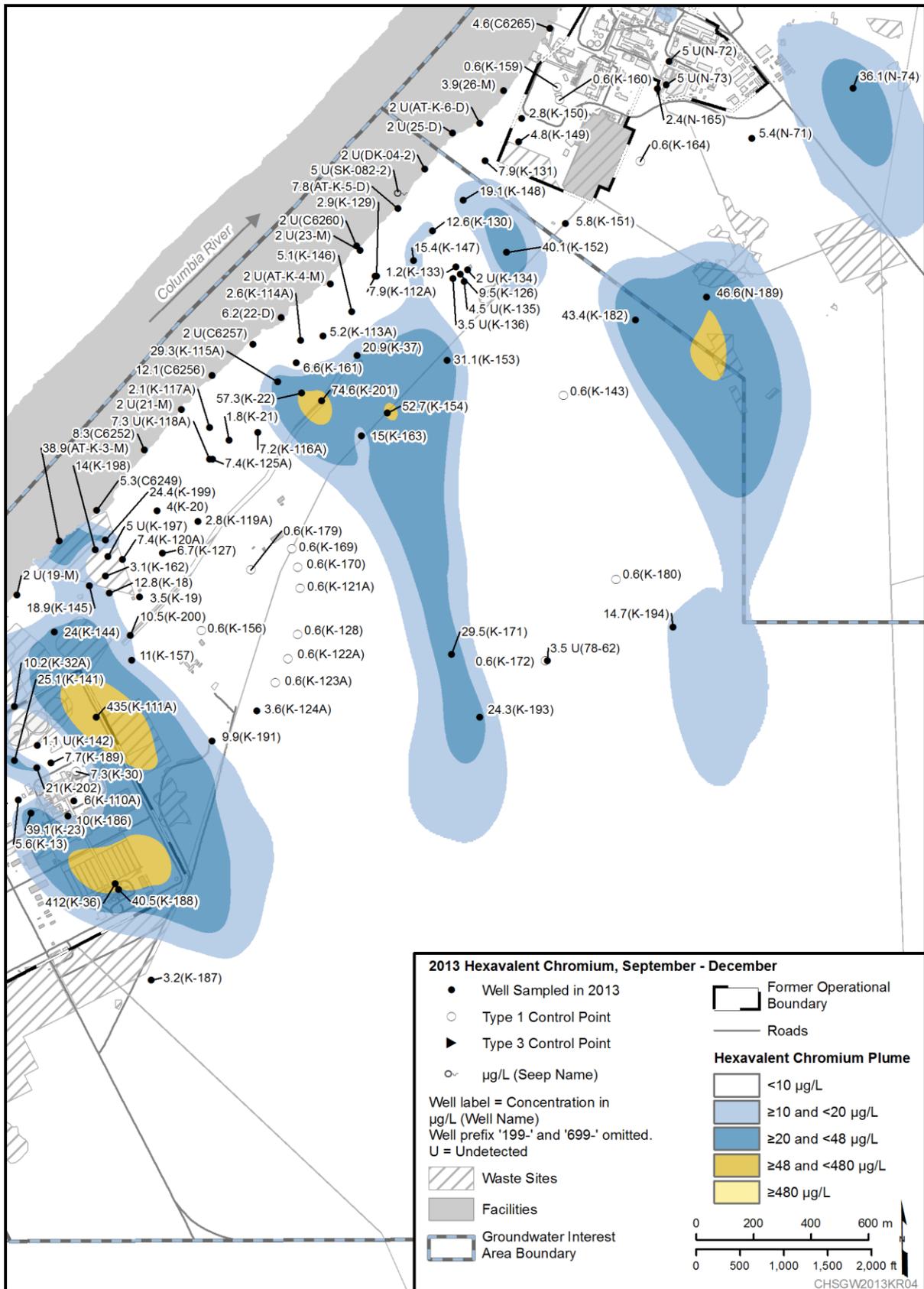


Figure KR.6 100-KR 2013 Hexavalent Chromium Plume (Low River Stage) - Magnified

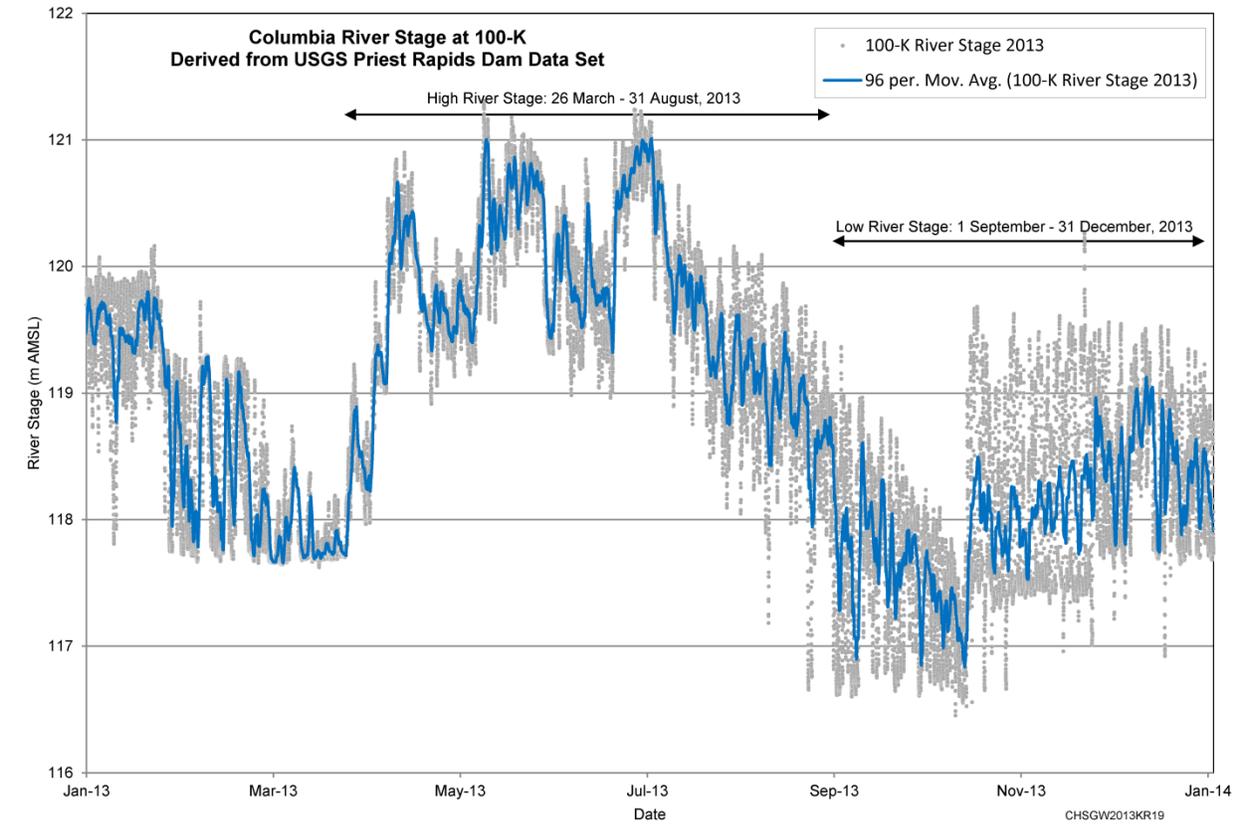


Figure KR.7 Columbia River Stage at 100-K During 2013

116-K-2 Trench Associated Plume. The current hexavalent chromium groundwater plume associated with the 116-K-2 trench occurs in multiple, isolated plume segments at the 10 µg/L contour. This plume, which was initially inferred as being continuous over the length of the 116-K-2 Trench, has been dissected by operation of the P&T systems. The northeastern portion of the 116-K-2 Trench plume extends northeast into the 100-NR-2 OU. Well 199-N-189, constructed in 2011, exhibited hexavalent chromium at 44 µg/L, similar to the 37 to 60 µg/L observed in well 199-K-182. Well 199-N-74, which is located approximately 2 kilometers from the end of the trench and farther north than 199-N-189, exhibited a hexavalent chromium concentration of 34.6 µg/L in 2013. Hexavalent chromium concentrations near the river have been generally decreasing (Figures KR.8 and KR.9).

A central plume segment, exhibiting concentrations greater than 10 µg/L, extends from the vicinity of the 116-K-2 Trench inland to the vicinity of well 199-K-193. Operation of injection wells of the KR4 and KX P&T systems has further dissected the hexavalent chromium plume in the central portion of the trench.

The hexavalent chromium plume associated with the head end (southwest end) of the 116-K-2 Trench was previously inferred to be continuous with chromium originating at the 183-KE Head House area. The apparent source(s) of hexavalent chromium in groundwater in the vicinity of the 116-K-1 Crib include comingling of chromium from the crib and trench and chromium originating at the 183-KE Head House area. Concentrations of hexavalent chromium near the river have been generally decreasing in active extraction wells (Figure KR.8 and KR.9). The observation of a slight increase in hexavalent chromium concentration in well 199-K-148 is consistent with active capture of chromium from upgradient (in the vicinity of well 199-K-152).

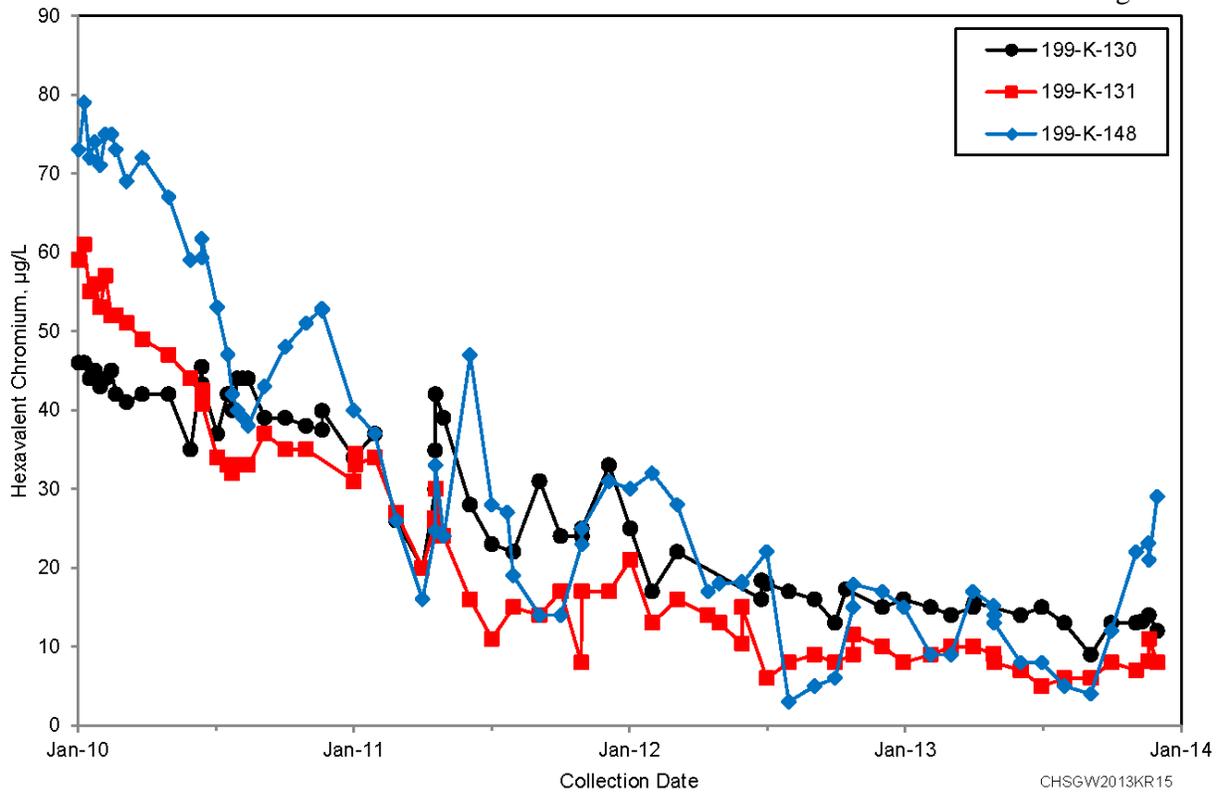


Figure KR.8 100-KR Hexavalent Chromium Data for Wells 199-K-130, 199-K-131, and 199-K-148 (Near-River Extraction Wells in Northern Portion 100-KR)

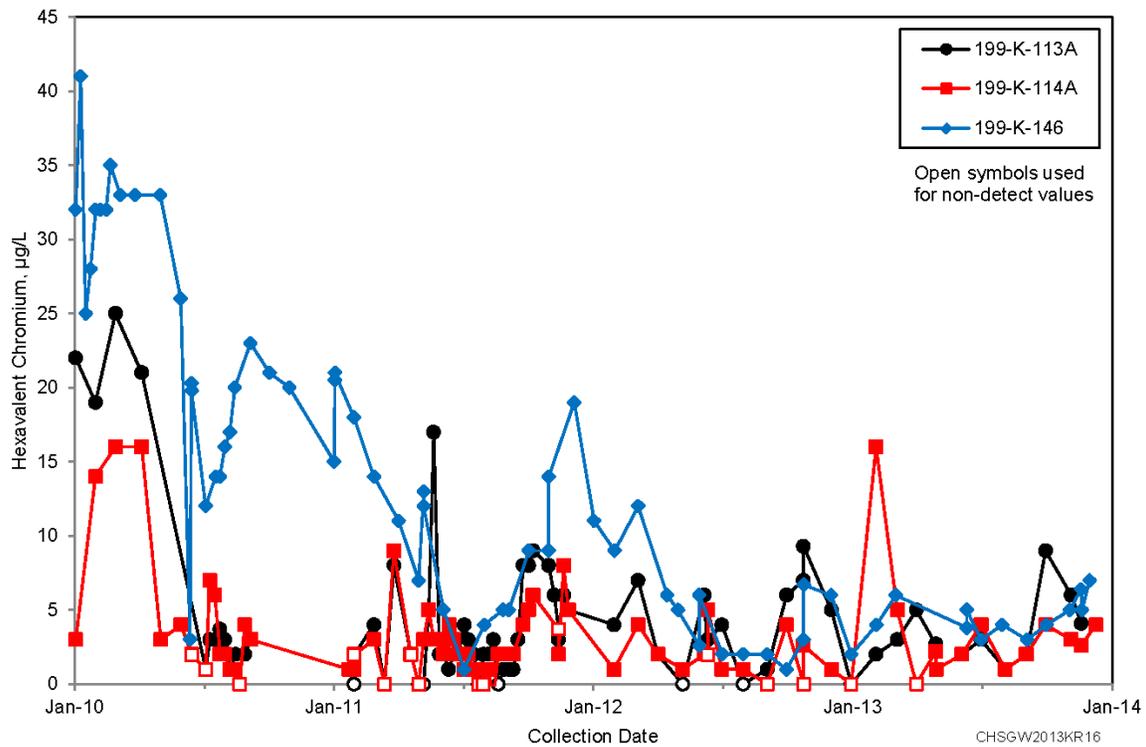


Figure KR.9 100-KR Hexavalent Chromium Data for Wells 199-K-113A, 199-K-114A, and 199-K-146 (Near-River Extraction Wells in Northern Portion 100-KR)

The distribution of hexavalent chromium in groundwater in this area is interpreted somewhat differently for 2013 than in previous years. Previous interpretation (e.g., in 2012 and years prior) inferred a likely connection of areas of elevated concentration at the 183-KE Head House (as illustrated by conditions in well 199-K-36) and the vicinity of well 199-K-111A, located closer to the river. For 2013, the consistent groundwater flow vectors caused by the combination of forces related to recharge mounding from injection wells, and capture by extraction wells, were critically evaluated during plume development. This resulted in modification of the inferred chromium distribution in this area. As illustrated in Figure KR.5, the hexavalent chromium plume at the 48 µg/L contour is now interpreted as being discontinuous between the 183-KE Head House and Well 199-K-111A. The dynamic conditions imparted on the aquifer by operation of the P&T systems are apparent as an east-to-west groundwater gradient in this area that segregates the hexavalent chromium plume into two distinct segments.

K West Associated Plume. The K West hexavalent chromium plume is observed in a narrow band with relatively high concentrations starting near the head house and extending toward the river (Figure KR.5). The dimensions of this plume did not change substantially between 2011 and 2013. The highest hexavalent chromium concentrations in 100-KR in 2013 were in wells upgradient from the KW Reactor building and extending to the 183-KW Head House vicinity.

With the decommissioning of well 199-K-195, which previously exhibited the highest hexavalent chromium concentration of 3,340 µg/L (April 2011), no monitoring or extraction wells remain within the KW Head House vicinity. Well 199-K-205 was constructed during late 2013 with completion in early 2014 as an additional extraction well for the 100-KW system. Preliminary observations and measurement of samples collected during drilling of this well in early 2014 indicated elevated hexavalent chromium at concentrations of about 3,000 µg/L, consistent with the high concentrations observed in well 199-K-195 in 2011. Well 199-K-205 will be placed in service as an extraction well. The persistent presence of this elevated concentration in an area immediately downgradient of a system injection well suggests the likelihood of a continuing contribution from a vadose source, or sources, in the vicinity of the former 183-KW Head House.

The next downgradient extraction well (199-K-173) continued to exhibit elevated, although decreasing, concentrations of hexavalent chromium. Hexavalent chromium, observed in that well at a high of 500 µg/L in late 2011, declined to less than 70 µg/L at the end of 2013. The presence of injection wells 199-K-175, 199-K-174, and 199-K-158 controls the upgradient edge of the plume. The plume does not extend inland past well 199-K-175, which had concentrations below 10 µg/L when the well was sampled before conversion to an injection well.

At 2013 low river stage, aquifer tube AT-K-1-D exhibited 6.1 µg/L of hexavalent chromium; this is a substantial decrease from the 32.7 µg/L observed at that location in 2012. Extraction wells 199-K-132 and 199-K-138 (Figure KR.10) appear to be capturing contaminated groundwater inland of the river shore. In addition, well 199-K-196 was realigned for operation as an extraction well in 2013 to enhance plume capture in this downgradient, near-river portion of the KW plume area. Well 199-K-196 exhibited an increase in hexavalent chromium concentration shortly after being placed in service as an extraction well. Representative concentration trends for wells near the river and upgradient of the 105-KW reactor are shown in Figures KR.10 and KR.11. Of particular interest with respect to hexavalent chromium, seep number SK-063-1, located in the vicinity of the 100-KW chromium plume, exhibited a hexavalent chromium concentration of 24.6 µg/L in a sample collected on September 23, 2013. This is higher than the sample collected from nearby aquifer tube AT-K-1-D (6.1 µg/L hexavalent chromium) on September 12, 2013. Operation of extraction well 199-K-196 is anticipated to intercept the leading edge of the Cr(VI) plume; monitoring activities at aquifer tube AT-K-1-D and Seep SK-063-1 will continue to evaluate performance of the KW extraction system.

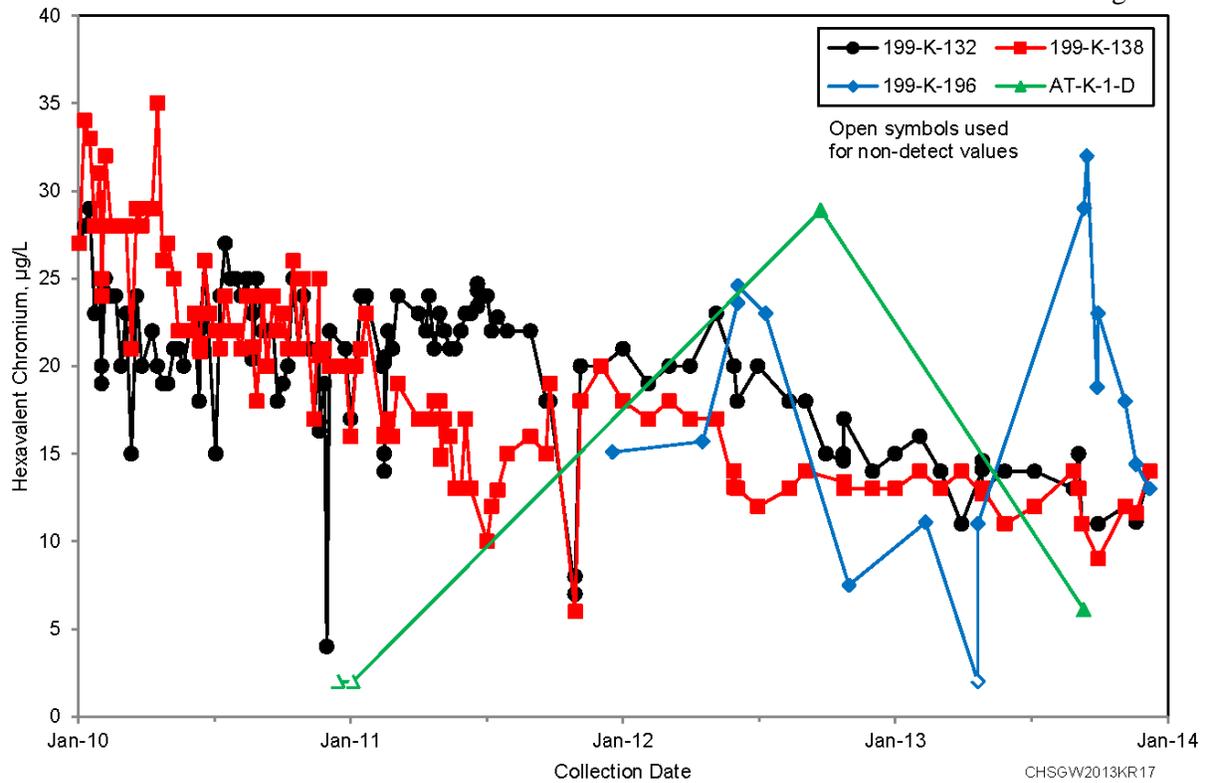


Figure KR.10 100-KR Hexavalent Chromium Data for Wells 199-K-132, 199-K-138, 199-K-196, and Aquifer Tube AT-K-1-D, Located Down Gradient of 105-KW Reactor

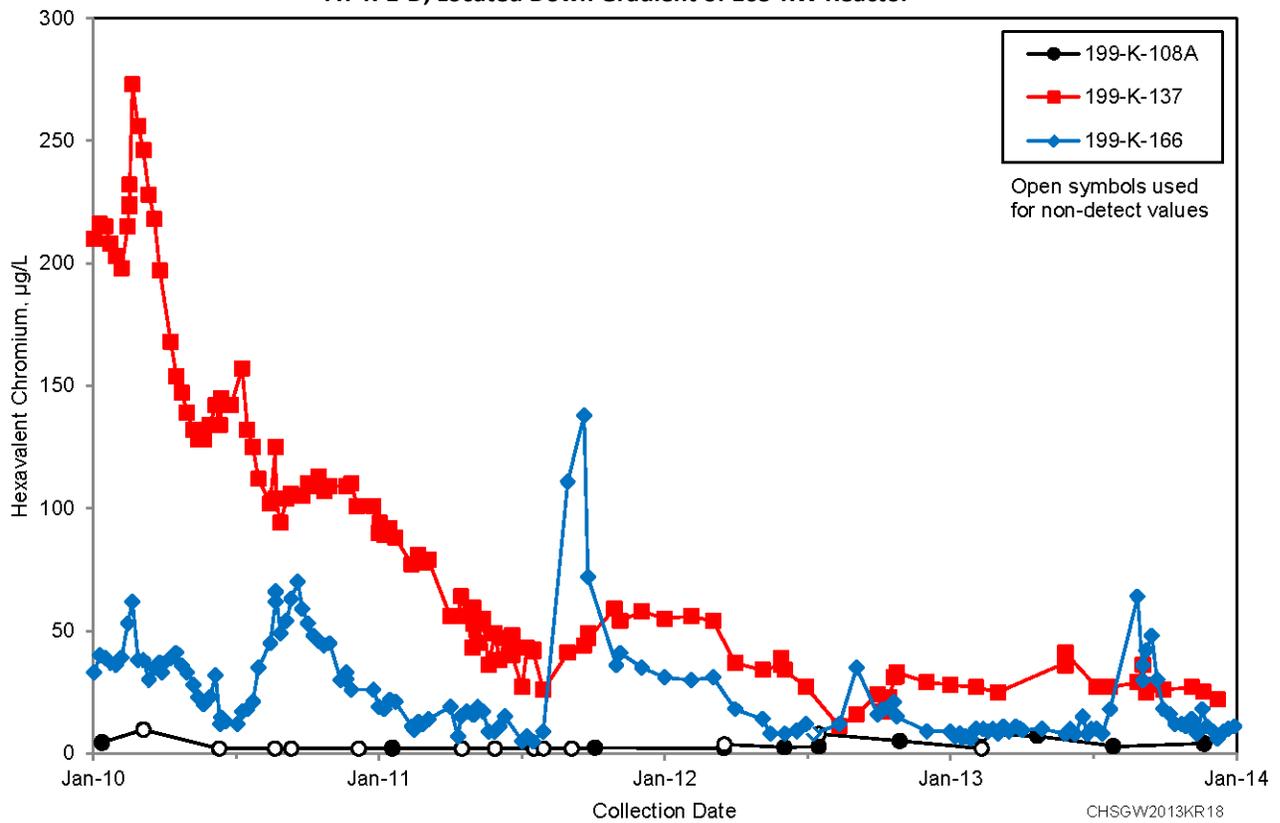


Figure KR.11 100-KR Hexavalent Chromium Data for Wells 199-K-108A, 199-K-137, and 199-K-166, Located Just Upgradient of 105-KW Reactor

K East Associated Plume. The K East plume is a relatively high concentration plume that extends from the vicinity of the 183-KE Head House in a northwesterly direction to the Columbia River (Figure KR.5). The apparent source is in the vicinity of the 183-KE Head House chemical storage tank farm, similar to the condition observed at KW. The existing monitoring well network does not clearly define the dimensions of the K East hexavalent chromium plume, but the plume definition has improved from previous years.

Upgradient (inland) of the 183.1-KE Head House, well 199-K-187 exhibited hexavalent chromium ranging from 4 to 6 µg/L in 2013. This location has consistently exhibited low hexavalent chromium concentration and appears to define the inland extent of elevated concentrations for this plume segment. The plume extends from the 183.1-KE Head House (near wells 199-K-36 and 199-K-188) toward the river. As described above for the plume related to the 116-K-2 Trench, evaluation of the dynamic groundwater gradients influenced by extraction and injection well operations produced an inferred hexavalent chromium plume distribution that differs from previous years. Wells 199-K-36 (located at the former KE Head House) and 199-K-111A (located east of the 105-KE Reactor and just west of the 118-K-1 Burial Ground) continued to exhibit similar hexavalent chromium concentrations and similar rates of increase during the period from 2010 through 2013. Examination of the concentration time series for other co-contaminants, however, suggests that the chromium at these two wells likely originated from separate source areas. In well 199-K-36 (at the Head House), chromium and sulfate have increased in a parallel manner, while tritium has remained very low. At well 199-K-111A (east of KE reactor), chromium and tritium have increased in a parallel manner, while sulfate has remained relatively low. These relationships suggest that the chromium observed increasing at 199-K-111A is likely related to a plume segment historically related to the 116-K-2 Trench moving westward coincidentally with tritium potentially originating from the burial ground contribution. The westward flow at this location is apparently induced by the persistent recharge mound associated with the KR4 and KX injection wells located to the east. Elevated tritium was present in deep vadose zone soil beneath the 118-K-1 Burial Ground. The increasing chromium observed at 199-K-36 is most likely related to continuing contribution of hexavalent chromium from secondary sources in the vadose zone in the vicinity of the former head house chemical storage tank farm, migrating to groundwater coincidentally with sulfate residuals from historical release of other water treatment chemicals (e.g., alum or sulfuric acid) managed in the same tank farm area. These separate source conditions are consistent with the current inferred plume distribution based on apparent groundwater flow gradients.

100-KR Hexavalent Chromium – High River Stage

The observed stage in the Hanford Reach of the Columbia River varies daily with controlled release of water from the upstream Priest Rapids Dam and seasonally in response to annual snow melt in the mountains of the drainage upstream. High river stage in the Hanford Reach of the Columbia River typically occurs in mid-summer at the peak of the annual freshet. A hydrograph of river stage at 100-K Area is shown in Figure KR.7. The high water stage was observed to begin in late-March and three distinct peak responses were observed in 2013: one peak was observed in late-April at about elevation 120.8 meters above mean sea level, and two higher peaks in early late-May and late-June at about elevation 121.2 meters above mean sea level. The peak river stage elevations at 100-K Area in 2013 were about 2 meters (6 ft) lower than the corresponding peak stage elevations observed in the preceding two years. The high river stage period continued through the decline of the peak stage through August 2013. The low river stage period was identified to have started in early September 2013.

Based on concentrations of hexavalent chromium in groundwater samples collected during the high river stage period, the distribution of plumes within 100-KR at high river stage (Figure KR.12) are not dramatically different from those observed during the low river period. During the high river stage, river water may intrude into the aquifer, causing displacement and/or dilution of the aquifer water in the near-shore environment. During 2013, this bank storage condition was not apparent based on evaluation of groundwater elevation maps. Groundwater elevation estimates indicate that a reversed gradient did not occur for any substantial length of time in the near-river aquifer. During 2012, when peak river stage was as much as 2 meters higher than observed in 2013, an estimated hexavalent chromium concentration value of 0 µg/L was assigned to the aquifer tubes, to reflect the bank storage of river water. The peak river stage period at 100-K Area during 2013 is not inferred to have resulted in substantial bank storage. The measured hexavalent chromium concentrations in aquifer tubes collected during the low water period were, therefore, applied to those locations to prepare the high river stage plume maps. This was determined to be the most representative interpretation of the conditions observed during 2013. With the exception of a localized capture area in the vicinity of wells 199-K-132, 199-K-138, and 199-K-196 in the K West Reactor vicinity, and a broad capture area in the vicinity of the distal portion of 116-K-2 Trench, inferred groundwater gradient was toward the Columbia River consistently over the course of 2013.

Some inland wells (e.g., wells more than 200 meters away from the river shore) exhibit transient hexavalent chromium concentration effects during periods of seasonal high groundwater elevation. An example of this effect is shown at well 199-K-189, located in the vicinity of 105-KE Reactor (Figure KR.13). This well has consistently exhibited seasonal concentration transients that appear to be directly proportional to changes in groundwater elevation (i.e., as groundwater elevation rises, hexavalent chromium concentration rises).

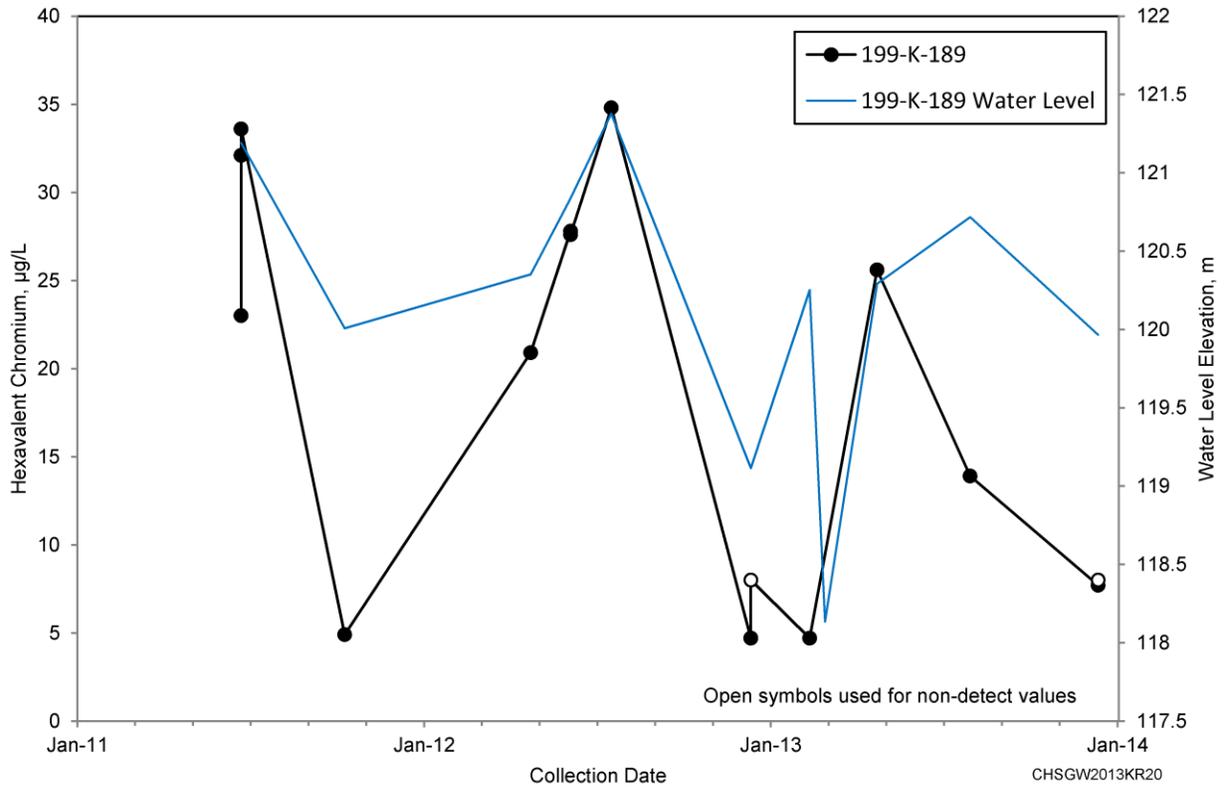


Figure KR.13 100-KR Hexavalent Chromium Data for Well 199-K-189, Located Downgradient of 105-KE Reactor

100-KR Tritium

Tritium is a highly mobile contaminant in 100-KR groundwater at levels above the 20,000 pCi/L DWS. The major historical sources of tritium contamination included the following:

- Releases of reactor gas dryer condensate to the 116-KE-1 and 116-KW-1 Cribs (tritium activity concentrations up to 1×10^{10} pCi/L in the condensate, per [HW-76258](#), *Reactor Gas Drier Condensate Waste – Decontamination Studies*)
- Release of fuel storage basin water to the 116-KE-3 and 116-KW-2 Cribs (tritium activity concentrations up to 6,000 pCi/L in the basin water, per WHC-EP-0877, *K Basin Corrosion Program Report*)
- Contaminated solid waste disposed at the 118-K-1 Burial Ground (tritium activity concentrations up to 13,400 pCi/g in deep vadose zone soil remaining after surface remediation, per [CVP-2013-002](#), Rev. 0).

Another source of tritium was the release of contaminated reactor cooling water to the retention basins, the 116-K-1 Crib, and the 116-K-2 Trench. The tritium distribution in groundwater in 2013 is shown in Figure KR.14.

As part of the active remediation of hexavalent chromium, extraction wells are also capturing tritium in this area. Because tritium is present primarily as tritiated water, it passes through the treatment system unaffected. The current treatment for tritium is recirculation of the contaminated water within the aquifer until tritium has decayed. Because of recirculation, tritium is now in groundwater at the active injection wells at 100-KR. Based on the design of the P&T system, much of this water will be recaptured by the downgradient extraction wells and the tritium will continue to decay. The plume is not reaching the river at levels above the DWS, based on data from aquifer tubes. Tritium was detected in effluent water from the KX and KR-4 P&T systems. The average effluent concentration of the KR-4 system for 2013 was 9,250 pCi/L, which is below the DWS. Tritium concentration in the effluent from both KX and KW systems was less than 2,000 pCi/L during 2013, consistent with conditions observed in 2012.

The highest measured tritium value in groundwater during 2013 (76,000 pCi/L) was in a characterization sample from new well 199-K-202, located in the vicinity downgradient of 105-KE Reactor. Tritium at this location is likely related to historical releases in the vicinity of the 116-KE-1 Gas Condensate Crib. Only four monitoring wells at 100-KR exhibited tritium concentrations exceeding 20,000 pCi/L in 2013 (199-K-18, 199-K-111A, 199-K-145, and new well 199-K-202).

A portion of the tritium plume at K East appears to have originated at the 116-KE-1 Crib, with potential contribution from waste at the 118-K-1 Burial Ground (Figure KR.14). Concentrations in 2013 were relatively stable at about 30,000 pCi/L in well 199-K-18 (which exhibited the highest concentration in 2012). Well 199-K-111A exhibited a continuing upward trend in tritium concentration during 2013 (Figure KR.15). This is inferred to result from westward migration of tritium-contaminated groundwater from the vicinity of the 118-K-1 Burial Ground. Tritium in well 199-K-157 remained stable at concentration below 10,000 pCi/L during 2013 (Figure KR.16). This pattern is consistent with migration of contaminated groundwater from historical release points along inferred flow paths to locations where it is intercepted by extraction wells.

Tritium concentrations in K West in 2013 were consistently below the DWS. However, concentrations as high as 430,000 pCi/L were measured in well 199-K-106A as recently as 2009 (with a historical maximum observed concentration of 2,240,000 pCi/L in 2005). Well 199-K-106A exhibited tritium at a maximum concentration of 2,600 pCi/L during 2013. It is unlikely that the plume has disappeared because the half-life of tritium is 12.32 years, but the plume has likely migrated downgradient to a location without monitoring wells. Planned well 199-K-204 will be located in this area of uncertainty to monitor carbon-14 and tritium.

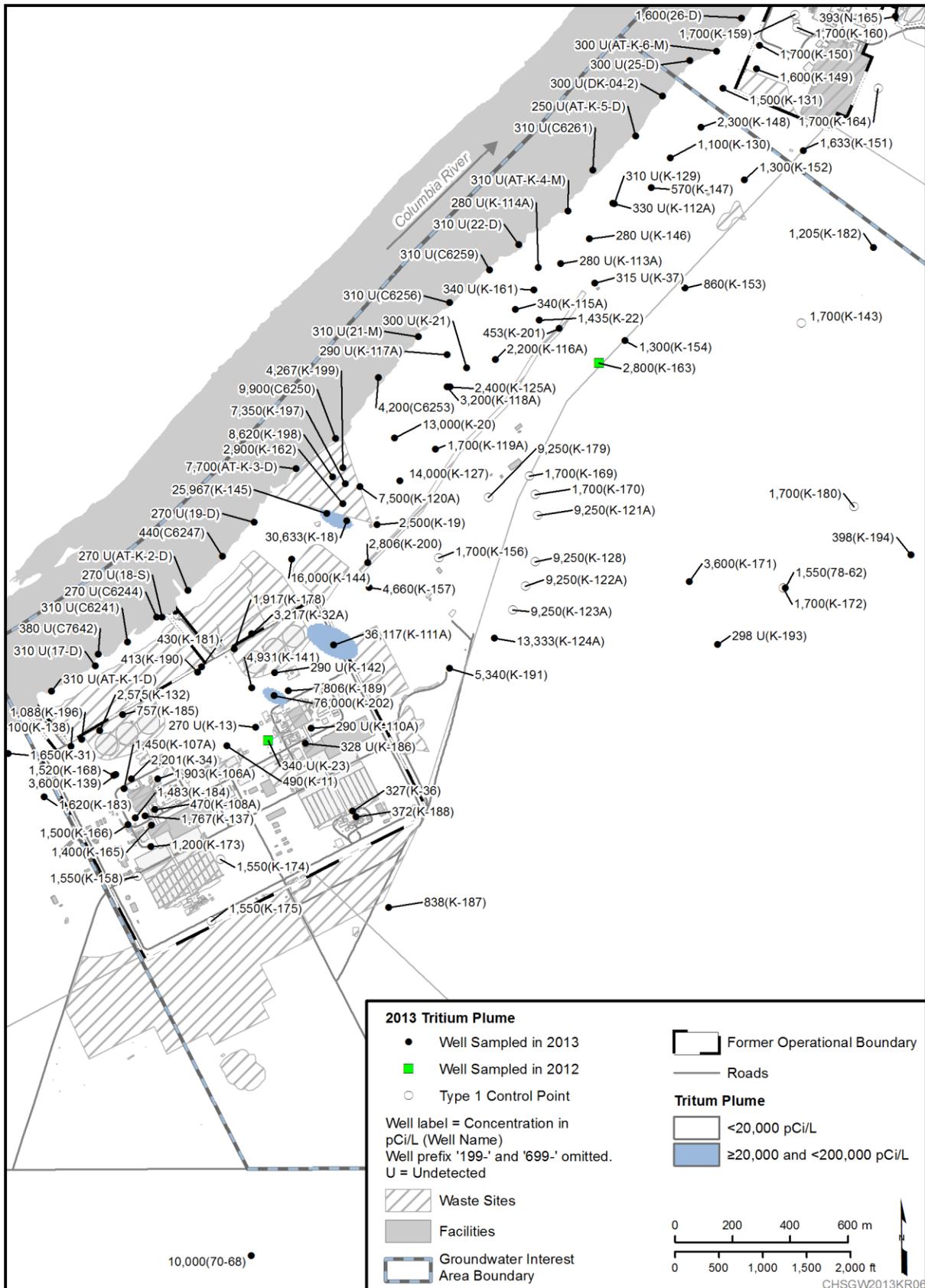


Figure KR.14 100-KR 2013 Tritium Plume

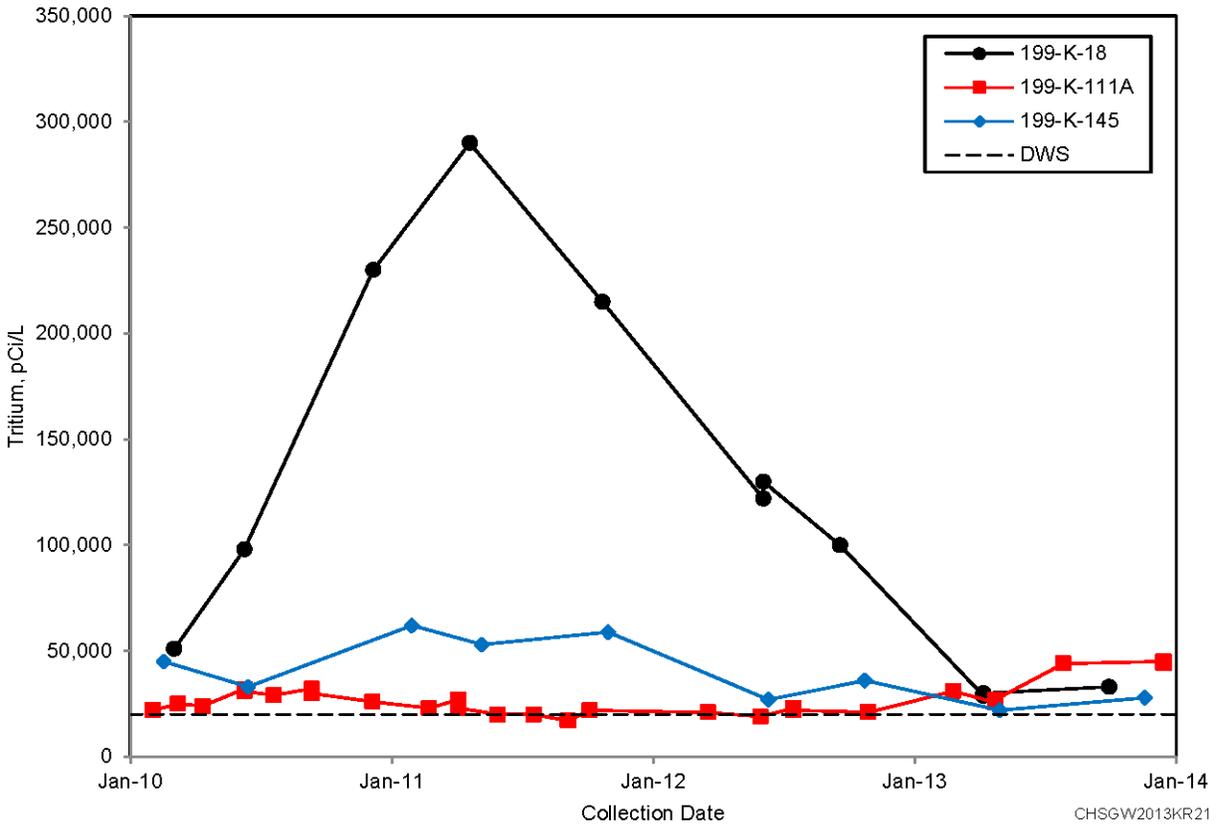


Figure KR.15 100-KR Tritium Data for Wells 199-K-18, 199-K-111A, and 199-K-145, Located Northeast of 105-KE Reactor

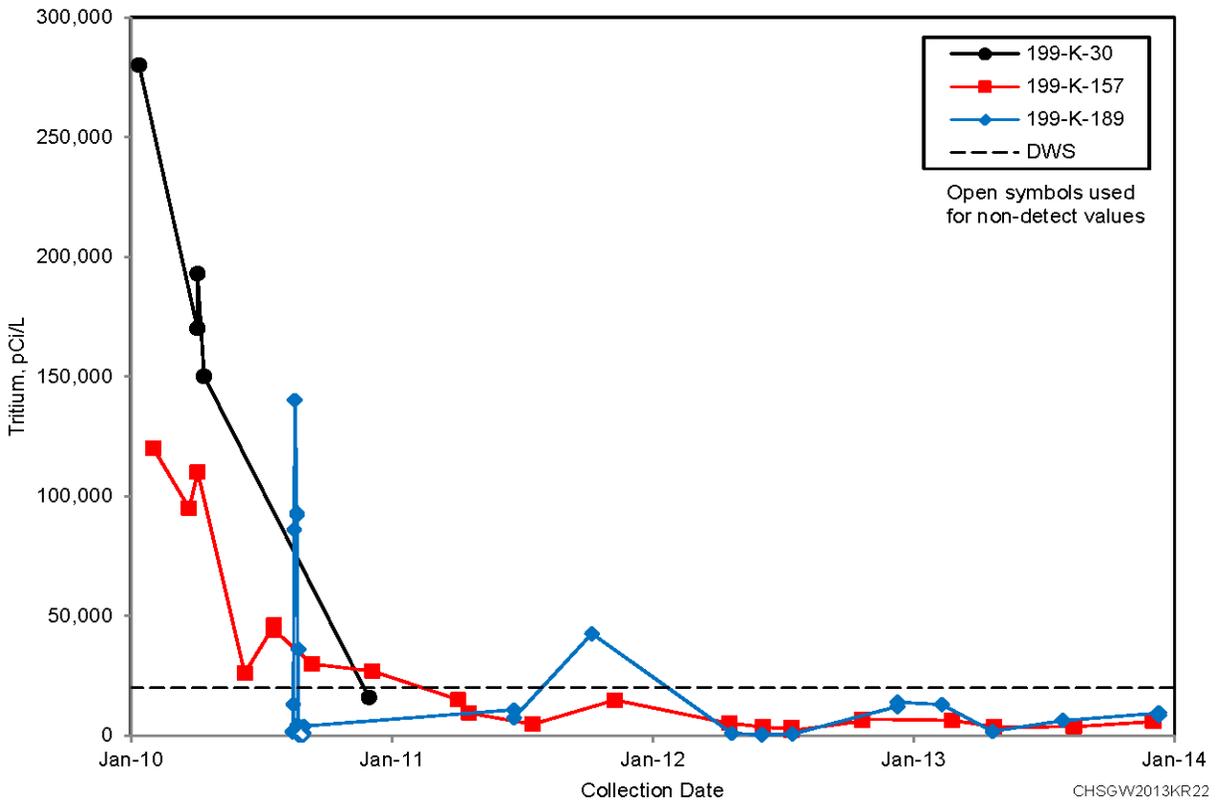


Figure KR.16 100-KR Tritium Data for Wells 199-K-30, 199-K-157, and 199-K-189, Located Downgradient of the 116-KE-1 Crib and 118-K-1 Burial Ground

100-KR Nitrate

Nitrate concentrations continued to exceed 45 mg/L in several 100-KR wells in 2013. The nitrate observed in groundwater at 100-KR originated primarily from high concentrations of ammonia in reactor gas dryer condensate (i.e., up to 36,000 mg/L) that was discharged to the 116-KE-1 and 116-KW-1 Cribs. Additional nitrate contributions to groundwater may have come from sanitary waste drain fields at various locations within the 100-K Area. Nitrate distribution in groundwater in 2013 is shown in Figure KR.17. The size of the plume area exceeding the DWS decreased between 2011 and 2012, but remained fairly stable in 2013 (Figure KR.3).

In the K East region, two wells (199-K-23 and 199-K-11) exhibited a nitrate concentration above 45 mg/L in 2013 (maximum observed concentrations of 62 and 54.9 mg/L, respectively). Concentrations in both wells were variable during 2013 (Figure KR.18).

Two K West wells had nitrate levels above 45 mg/L in 2013; wells 199-K-34 and 199-K-106A (Figure KR.19). These are the two nearest wells to the 116-KW-1 Gas Condensate Crib, a known source of nitrate contamination. Two aquifer tubes downgradient from K West have historically exhibited nitrate concentrations above 45 mg/L, but did not in 2013. Aquifer tube C6241, which historically exhibited concentrations of 48 to 54 mg/L, exhibited 32.1 mg/L in 2013. The nitrate concentration in aquifer tube 17-D with a maximum of 66.4 mg/L in 2009, has exhibited less than 10 mg/L nitrate since 2011. The concentration measured in 2013 was 9.4 mg/L. Of particular interest with respect to nitrate, seep number SK-063-1, located in the vicinity of the 100-KW nitrate plume, exhibited a nitrate concentration of 13.7 mg/L in a sample collected on September 23, 2013. This is slightly higher than the nitrate concentrations measured in nearby aquifer tubes AT-K-1-D and 17-D (2 mg/L and 9.4 mg/L, respectively). It is notable that the concentration of nitrate in the treated effluent from 100-KW P&T system was 23 mg/L. Nitrate concentration in the effluent of 100-KR and 100-KX P&T systems was 10 and 12 mg/L, respectively.

100-KR Strontium-90

Strontium-90 is a fission product generated within the reactor fuel during nuclear fission. Strontium-90 was historically released during fuel failure events and resulted in contamination of reactor cooling water. Contaminated cooling water, along with fragments of irradiated fuel, could be released to the 116-K-2 Trench under off-normal conditions as well as being released to the reactor fuel storage basins during discharge of irradiated fuel from the reactors. Cooling water contaminated by fuel rod failures was held in the 107-KE or 107-KW retention basins and subsequently discharged to the 116-K-2 Trench. Fission products, including strontium-90, contaminated the discharged water. The highest strontium-90 concentrations in groundwater are associated with historical releases from the fuel storage basins and their associated drainage systems. The fuel storage basins also had cooling water contaminated with strontium-90. Releases from the fuel storage basins and discharges to the 116-K-2 Trench are the apparent sources of the strontium-90 contamination in 100-KR groundwater. Discharges to the 116-K-2 Trench resulted in strontium-90 distributed in groundwater at several locations along the length of the trench. Strontium-90 has also been released to groundwater via discharges to the 116-KW-2 and 116-KE-3 fuel storage basin cribs and reverse wells, or by direct leakage from the basins themselves. DOE installed a new monitoring well in 2013 (well 199-K-202) downgradient of the 105-KE Reactor to help delineate the strontium-90 plume in that area.

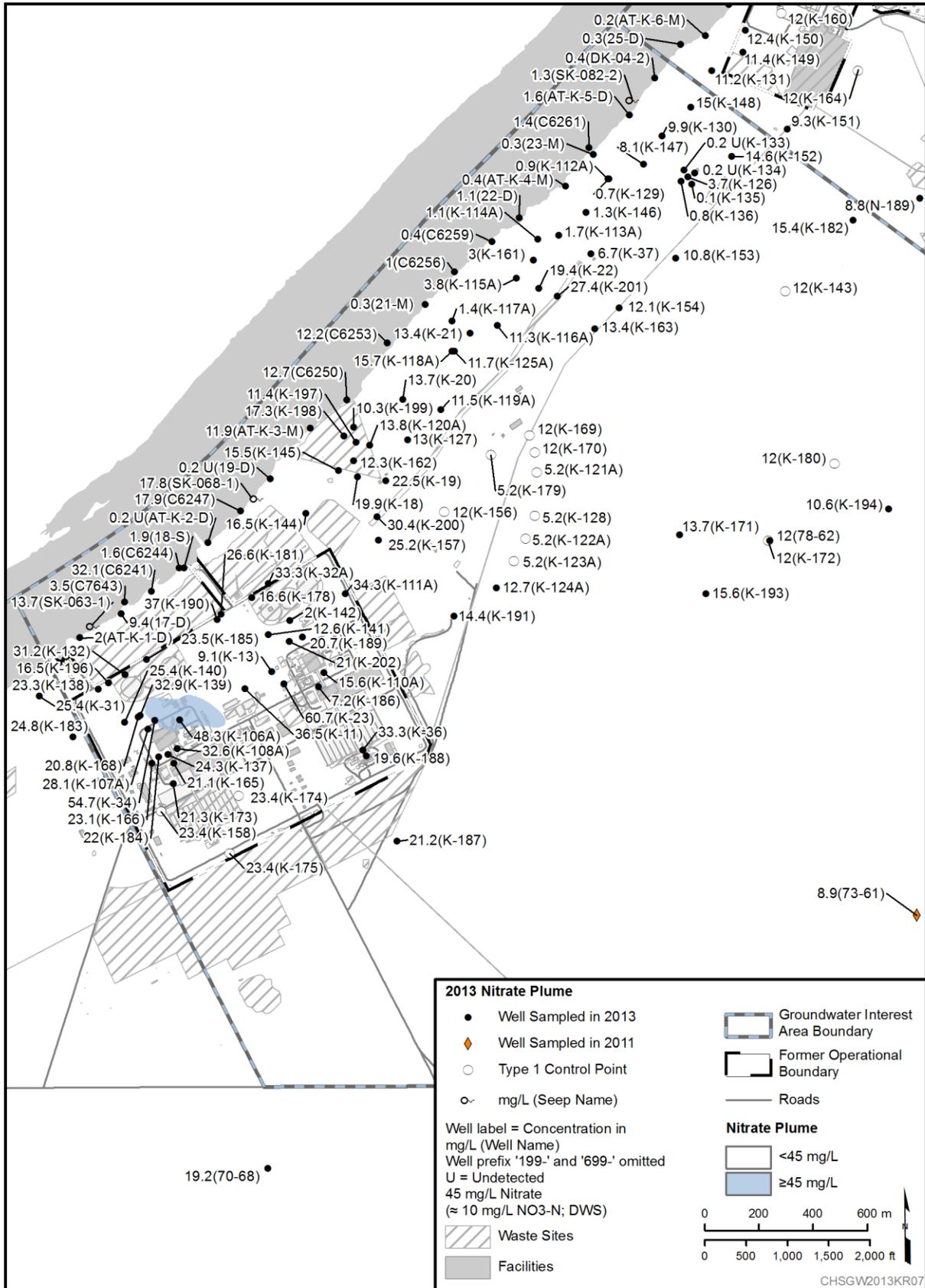


Figure KR.17 100-KR 2013 Nitrate Plume

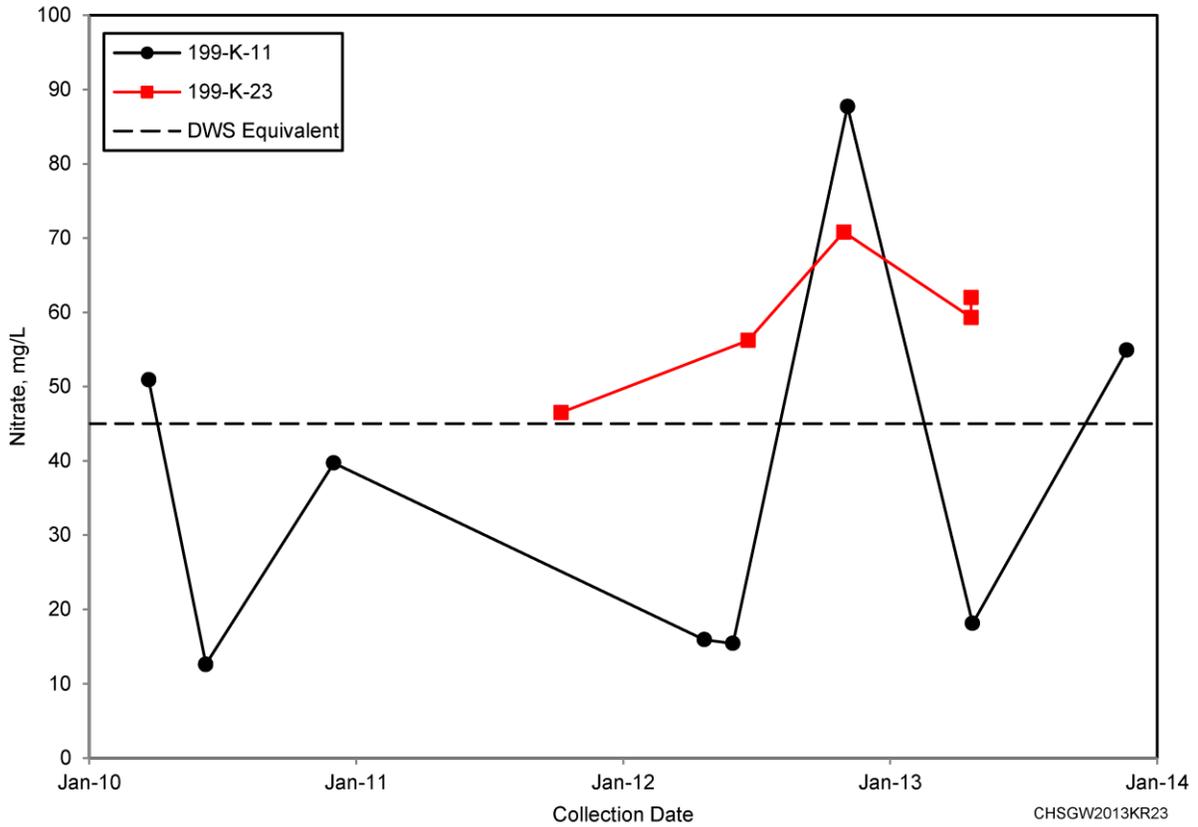


Figure KR.18 100-KR Nitrate Data for Wells 199-K-11 and 199-K-23, Located West of 105-KE Reactor

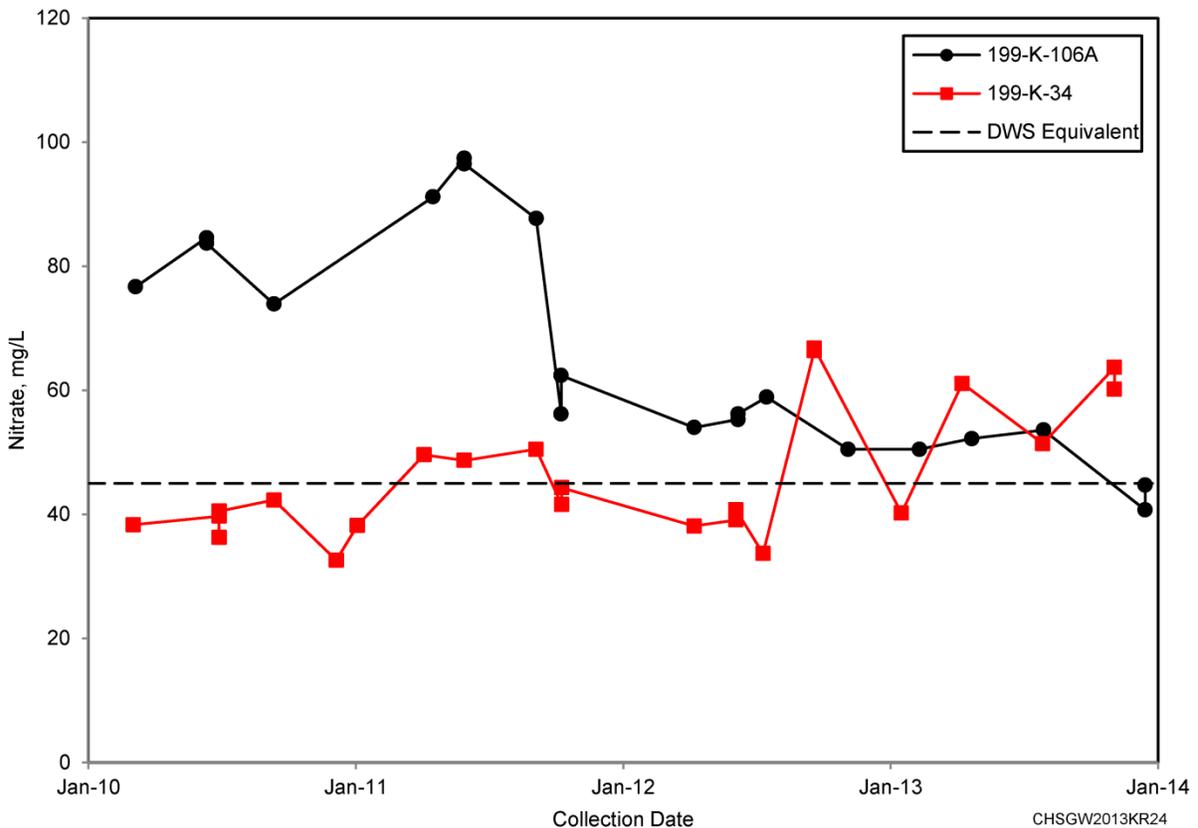


Figure KR.19 100-KR Nitrate Data for Wells 199-K-106A and 199-K-34, Located Near 105-KW Reactor

Strontium-90 contamination in 100-KR groundwater is found in four localized plumes at concentrations exceeding the 8 pCi/L DWS (Figure KR.20). These plume areas are relatively small and approach, but do not reach, the Columbia River, except at the distal end (northwest end) of the 116-K-2 Trench, where aquifer tube 22-M exhibited a strontium-90 concentration of 8.8 pCi/L in 2013. This condition appears to represent downgradient migration of strontium-90 from the vicinity of the trench, where inland wells 199-K-114A and 199-K-161 have both exhibited decreasing strontium-90 concentrations since 2000. The maximum 2013 strontium-90 concentrations in those wells were 6.5 and 9.4 pCi/L, respectively.

The historical area of the strontium-90 plume above the DWS is subject to substantial uncertainty because the plumes have not historically been delimited on the downgradient or cross-gradient directions from either of the fuel storage basin cribs. The plumes were also interpreted to be smaller as concentrations at wells located near the release points declined. The strontium-90 plume areas for 2013 are similar to 2012.

Many of the wells monitoring the 116-K-2 Trench have detectable strontium-90, but most concentrations are below or near the DWS of 8 pCi/L. The highest concentrations near the trench in 2013 were at well 199-K-200 (Figure KR.21), which was drilled through the former trench near the head end (southwest). Concentrations in this well remained fairly stable in 2013 at about 200 pCi/L. Concentrations in other wells in the 116-K-2 Trench region were consistently less than 30 pCi/L. Strontium-90 has migrated away from the 116-K-2 Trench downgradient toward the Columbia River in at least two locations; downgradient wells 199-K-19, 199-K-21, 199-K-22, and 199-K-161 all exhibited at least one measurement of strontium-90 exceeding the DWS during 2013. In late 2013, downgradient aquifer tube 22-M, located along the Columbia River shore, exhibited its first exceedance of the DWS for strontium-90 at a concentration of 8.8 pCi/L.

A high concentration strontium-90 plume is present in the K East region. The highest concentration portion of the plume formerly was represented by well 199-K-109A, which had a strontium-90 concentration of 1,120 pCi/L the last time the well was sampled, in 2008, and historical maximum concentration of 18,600 pCi/L. This well historically exhibited strontium-90 concentrations greater than 5,000 pCi/L from 1996 to 2000. This well was decommissioned to facilitate demolition activities. About 120 meters directly downgradient from 199-K-109A, the measured strontium-90 concentration continued to rise in extraction well 199-K-141 to 42 pCi/L in late 2012 (Figure KR.22), with the increase beginning soon after starting groundwater extraction at that well. The increased concentration in extraction well 199-K-141 indicates part of the leading edge of the K East strontium-90 plume continued migration downgradient in 2013. The leading edge of the plume in this vicinity remains poorly defined. New well 199-K-202, located downgradient of the apparent source area and about half the distance to well 199-K-141, did not exhibit detectable strontium-90. The plume is bounded by the non-detect concentration at 199-K-202. This indicates that the plume is relatively narrow and extending from the approximate vicinity of former well 199-K-109A toward well 199-K-141, where the strontium-90 concentration continues to increase. This direction of plume movement is consistent with the current interpretation of groundwater gradient in this area. Two wells in the K West region continued to consistently exhibit strontium-90 concentrations above the DWS of 8 pCi/L (199-K-107A and 199-K-34) in 2013. The maximum concentration of 54 pCi/L reported in late 2013 (well 199-K-34) was an increase from 2012. The concentration continued to gradually declining in well 199-K-107A (16 pCi/L in late 2013). The plume is inferred to be similar in size, however, concentration in wells downgradient from the apparent source area (i.e., 116-KW-2 Crib and Reverse Well) continues to rise (e.g., wells 199-K-34 and extraction well 199-K-139). This indicates that strontium-90 is migrating away from the source area. Concentrations are near detection limits in wells farther downgradient. Strontium-90 was not detected in samples collected from seeps at 100-KR during 2013.

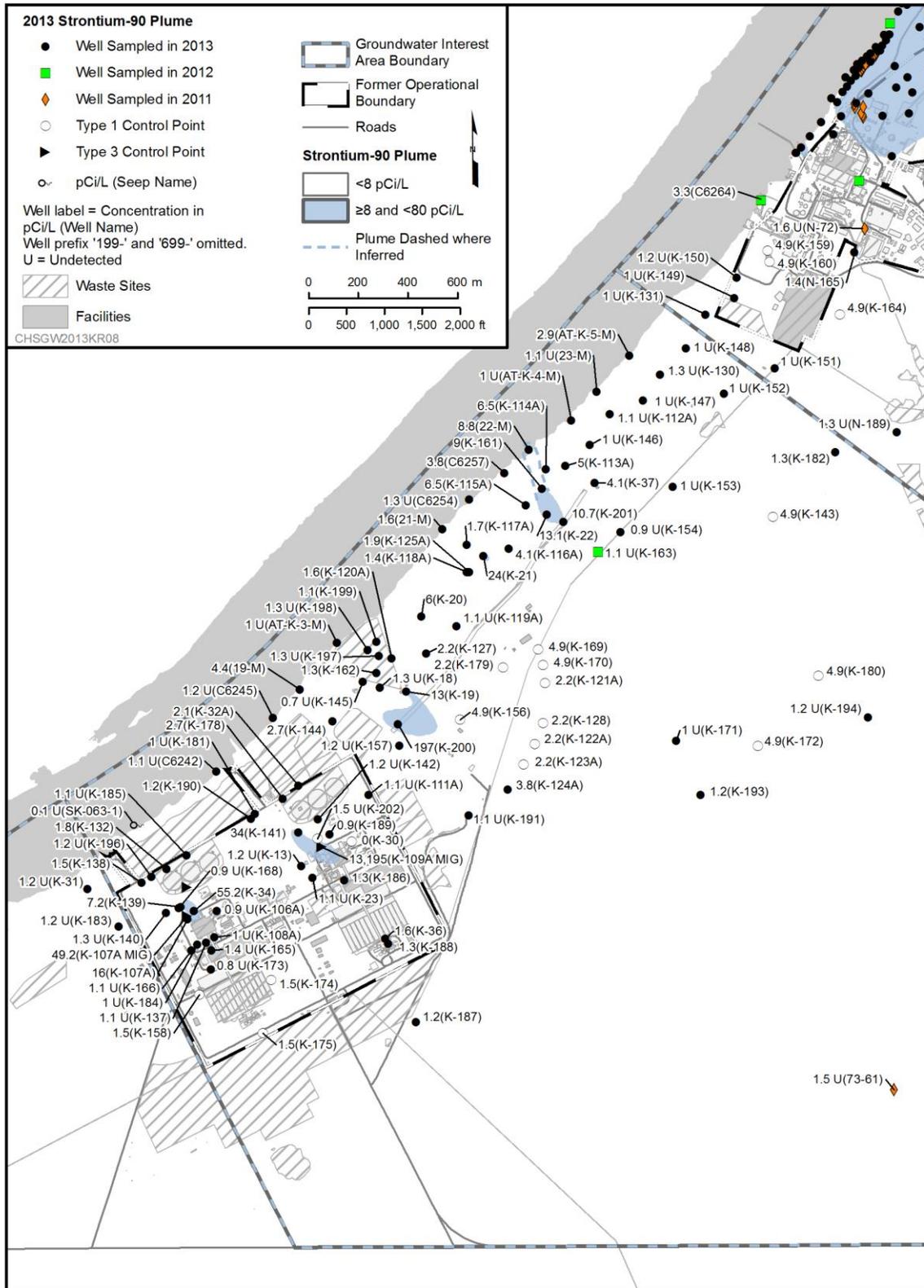


Figure KR.20 100-KR 2013 Strontium-90 Plume

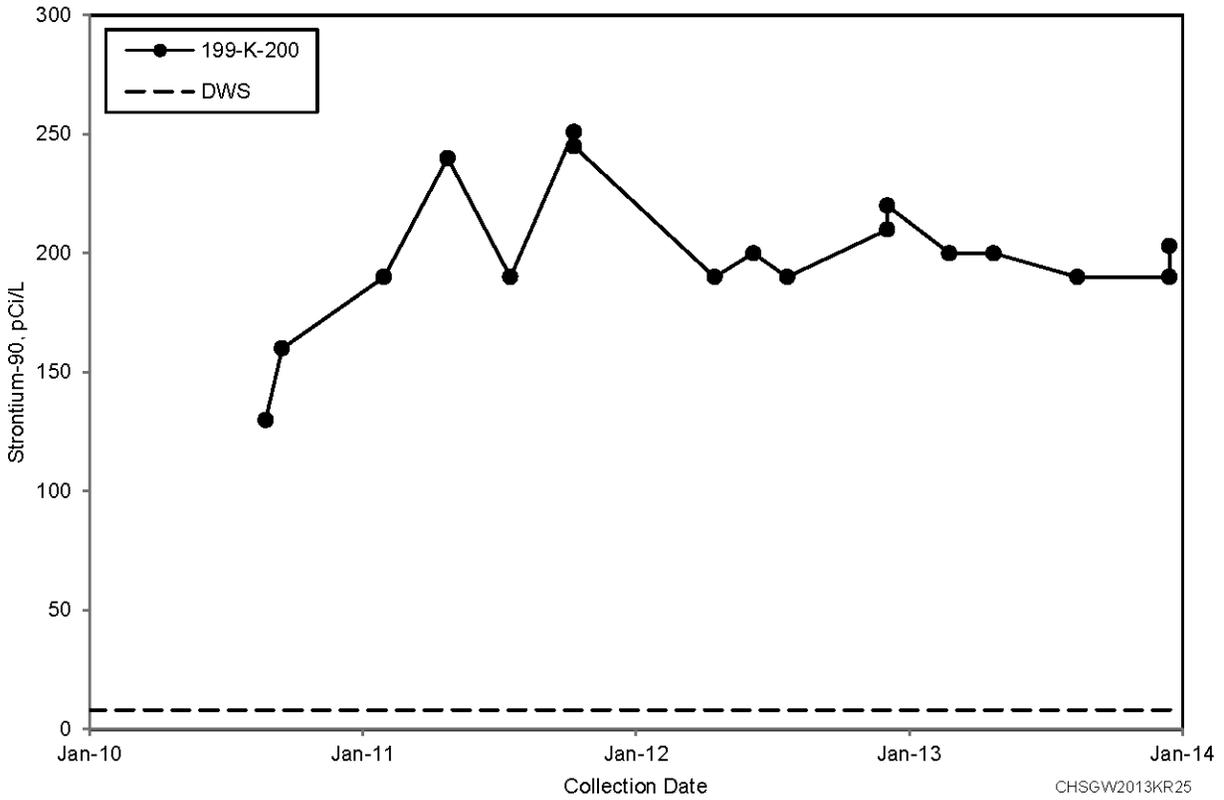


Figure KR.21 100-KR Strontium-90 Data for Well 199-K-200, Located in Former 116-K-2 Trench

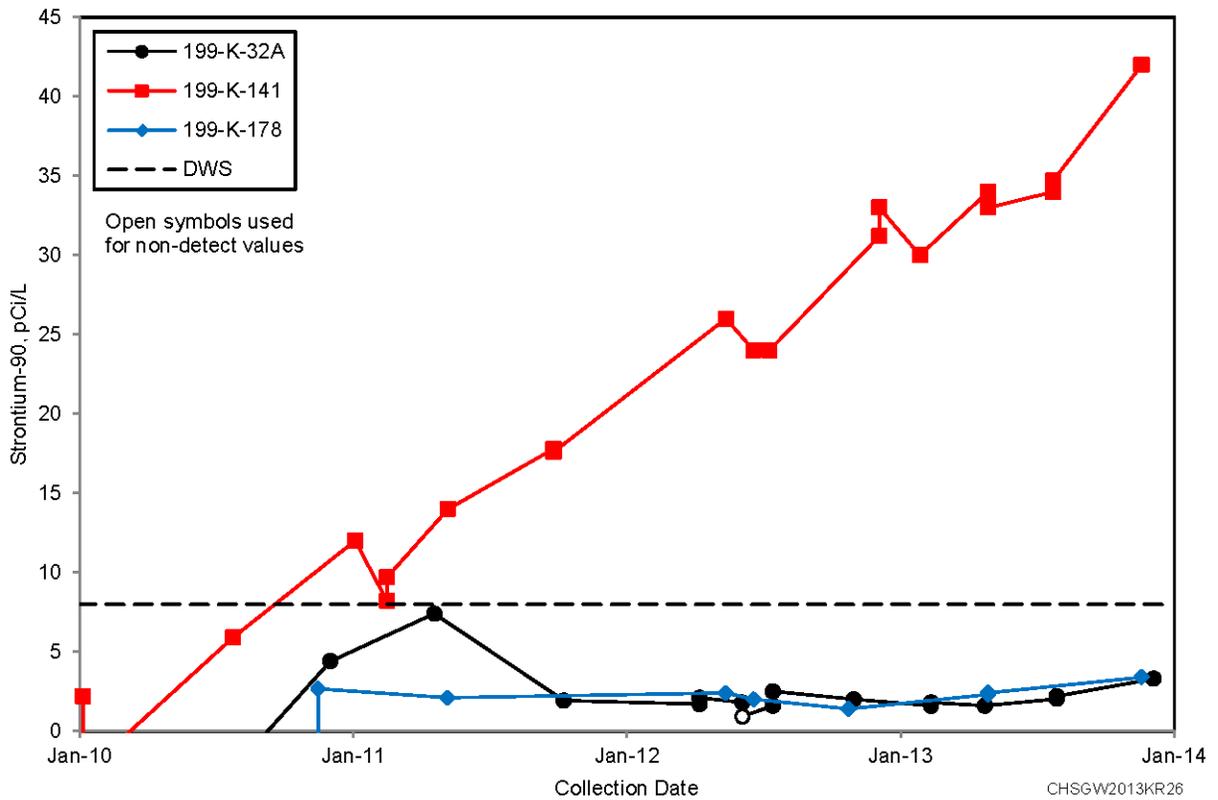


Figure KR.22 100-KR Strontium-90 Data for Wells 199-K-32A, 199-K-141, and 199-K-178, Located Downgradient of 105-KE Reactor

100-KR Carbon-14

Most of the carbon-14 in groundwater in 100-KR originated from historical discharges of reactor gas dryer regeneration condensate to the 116-KE-1 and 116-KW-1 gas condensate cribs. Measurements of carbon-14 in gas dryer condensate collected at KE and KW reactors during operation ranged from 2.9×10^8 pCi/L at 105-KW Reactor to 1.04×10^9 pCi/L at KE Reactor. The gas condensate stream also contained tritium ranging from 3×10^9 pCi/L to 1×10^{10} pCi/L and ammonia ranging from 9,000 to 36,000 mg/L ([HW-76258](#)).

To estimate the extent of carbon-14 groundwater contamination more accurately, extrapolations of historical carbon-14 concentrations from 199-K-30 and 199-K-106A were evaluated. Plume migration was estimated in an area with no downgradient well. Values presented in the plume map (Figure KR.23) represent the extrapolated data. The highest residual carbon-14 concentrations in groundwater are associated with the KW Reactor, where the estimated maximum concentration derived from the extrapolation is approximately 39,500 pCi/L. The extrapolated concentrations associated with the KE Reactor are slightly lower, with the estimated maximum concentration of approximately 22,900 pCi/L. At both reactor areas, the resultant plume distribution exhibits an aerial extent of concentrations exceeding the 2,000 pCi/L DWS that is similar to that inferred in 2012 (Figure KR.23). Three monitoring wells in the K West region continued to exhibit concentrations above the DWS (199-K-132, 199-K-34 and 199-K-106A). These wells are located downgradient of the historical release site at the 116-KW-1 Crib and have exhibited a generally increasing trend in carbon-14 concentration since 2009. The carbon-14 concentration trends in these wells likely reflect migration of carbon-14 away from the inferred area of maximum concentration (greater than 30,000 pCi/L) immediately downgradient of the crib. A new well, 199-K-204, will be installed in this area of uncertainty to monitor carbon-14, tritium and other contaminants of concern.

Monitoring results in 2013 from extraction well 199-K-132 indicate that this well consistently exhibited carbon-14 concentration exceeding 2,000 pCi/L. Carbon-14 contamination in groundwater continued to be observed widely-distributed over the 105-KW Reactor vicinity at concentrations below 1,000 pCi/L.

A lower-concentration carbon-14 plume exists in the K East region. The plume was formerly defined by wells 199-K-29 and 199-K-30, which have been decommissioned. In 2010, wells 199-K-29 and 199-K-30 had maximum concentrations of 3,120 and 6,900 pCi/L, respectively, which are above the DWS. These wells monitored conditions downgradient of the 116-KE-1 Crib waste site. As with conditions near the 105-KW Reactor, the carbon-14 plume at the KE Reactor area appears to be migrating downgradient away from the source area. The extrapolated downgradient concentrations indicate that carbon-14 concentrations in groundwater, greater than 20,000 pCi/L, likely exist in the downgradient area where no effective monitoring currently exists. The carbon-14 plume at K East may not lie completely within the expected capture zone of the operating extraction wells of the KX P&T system. A characterization sample from new well 199-K-202 had a carbon-14 concentration of 1,110 pCi/L, indicating that the plume in the vicinity of 105-KE Reactor is migrating in a west-northwest direction, consistent with the inferred groundwater flow direction and migration of hexavalent chromium. A new well, 199-K-203, will be installed in this area of uncertainty to monitor carbon-14, tritium and other contaminants of concern.

Additional monitoring wells are planned (as described in the preceding paragraphs) to monitor downgradient from the 116-KE-1 Crib area (Figure KR.4) to define the carbon-14 plume and track tritium and nitrate during remediation activities. Well 199-K-189, located downgradient of 105-KE Reactor, continued to exhibit an increasing trend in carbon-14 concentration, with a maximum measured value of 2,210 pCi/L during 2013. New well 199-K-202 exhibited a carbon-14 concentration of 1,110 pCi/L. Similar to the conditions observed at 105-KW Reactor area, carbon-14 continued to be detected at relatively low concentrations in aquifer tubes near 105-KE vicinity (below 500 pCi/L).

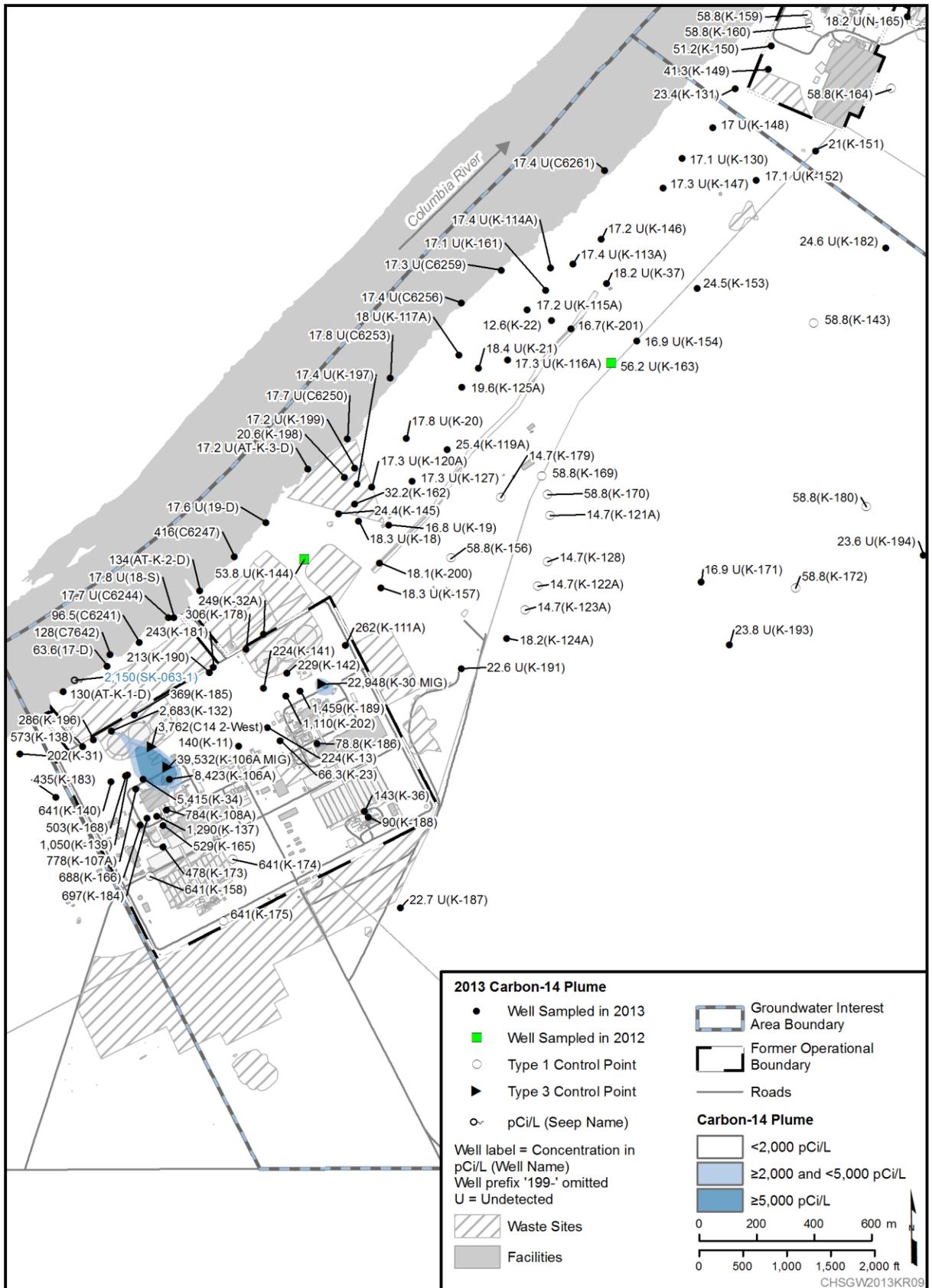


Figure KR.23 100-KR 2013 Carbon-14 Plume

100-KR Trichloroethene (TCE)

TCE continues to be detected in some 100-KR wells, primarily in the K West region (Figure KR.24). Two wells in 100-KR (199-K-132, and 199-K-185) exhibited TCE at concentrations above the 5 µg/L DWS in 2013. The highest concentrations in routine samples in 2013 were 8.3 and 6.4 µg/L in wells 199-K-185 (Figure KR.25) and 199-K-132 (Figure KR.26), respectively. The sources of TCE at 100-KR are not apparent but are likely related to the use of solvents during equipment maintenance activities; specific release points for TCE have not been identified at 100-KR. The TCE plume is poorly defined by the available measurements; there are relatively few wells in the general vicinity of the exceedance and this injects an element of uncertainty into interpolation of the plume contours. As with other contaminants at 100-KR, TCE is detected in effluent water at the KW P&T system. The annual average effluent concentration of 4.8 µg/L was assigned to the injection wells for the plume map interpretation. The relatively wide-spread occurrence of TCE in groundwater in the 105-KW Reactor vicinity results in a dispersed plume in the KW vicinity that is slightly below the 5 µg/L drinking water standard.

The primary source and release point(s) of TCE near the KW reactor have not been identified, and historic maximum concentrations measured in monitoring wells were substantially larger than currently observed (e.g., 35 µg/L at well 199-K-106A measured in 1995). The distribution of TCE in groundwater, as well as the actual maximum concentration, remains somewhat uncertain. Of particular interest with respect to TCE, seep number SK-063-1, located in the vicinity of the 100-KW area, exhibited a TCE concentration of 2.38 µg/L in a sample collected on September 23, 2013.

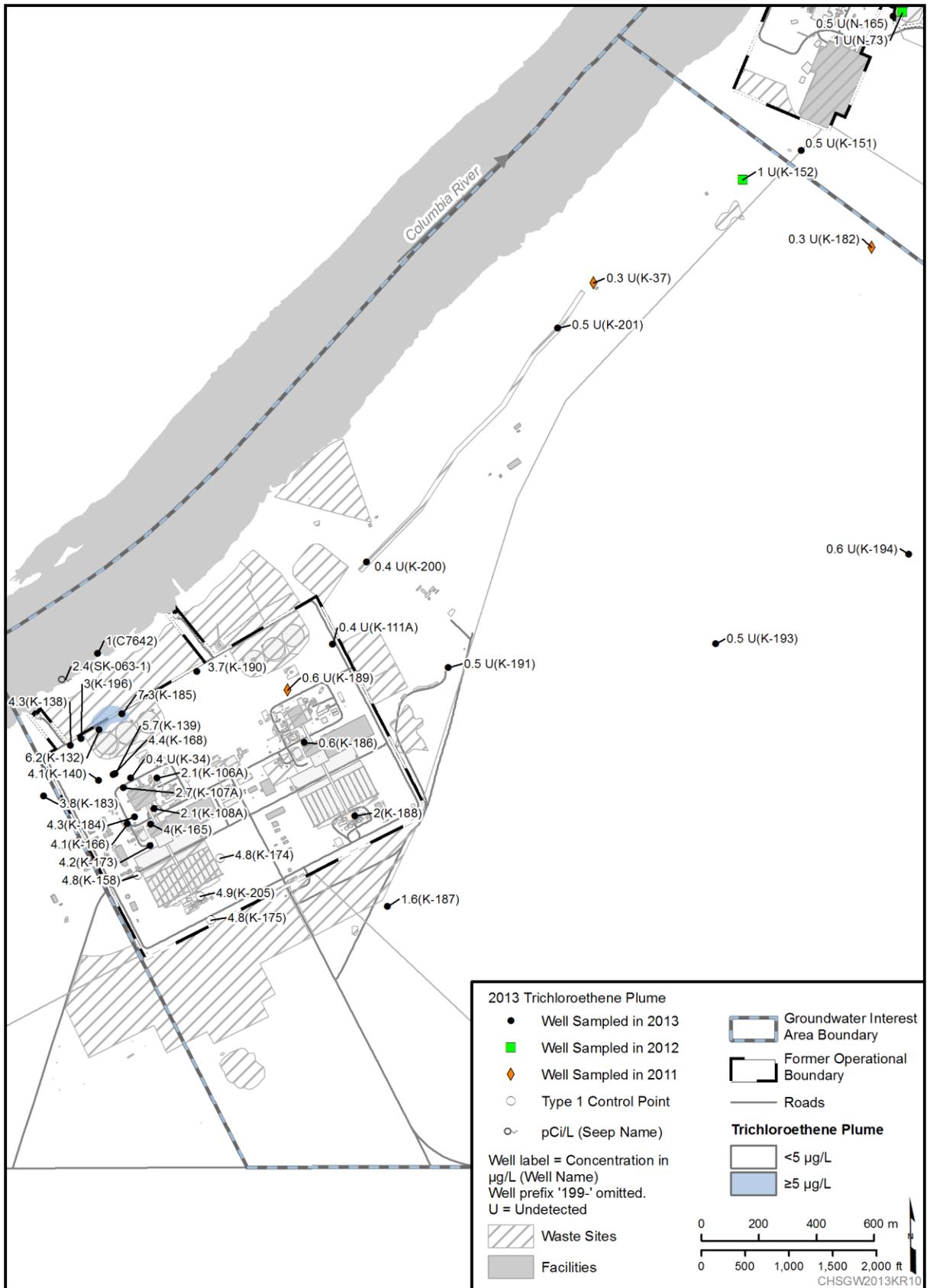


Figure KR.24 100-KR 2013 Trichloroethene Plume

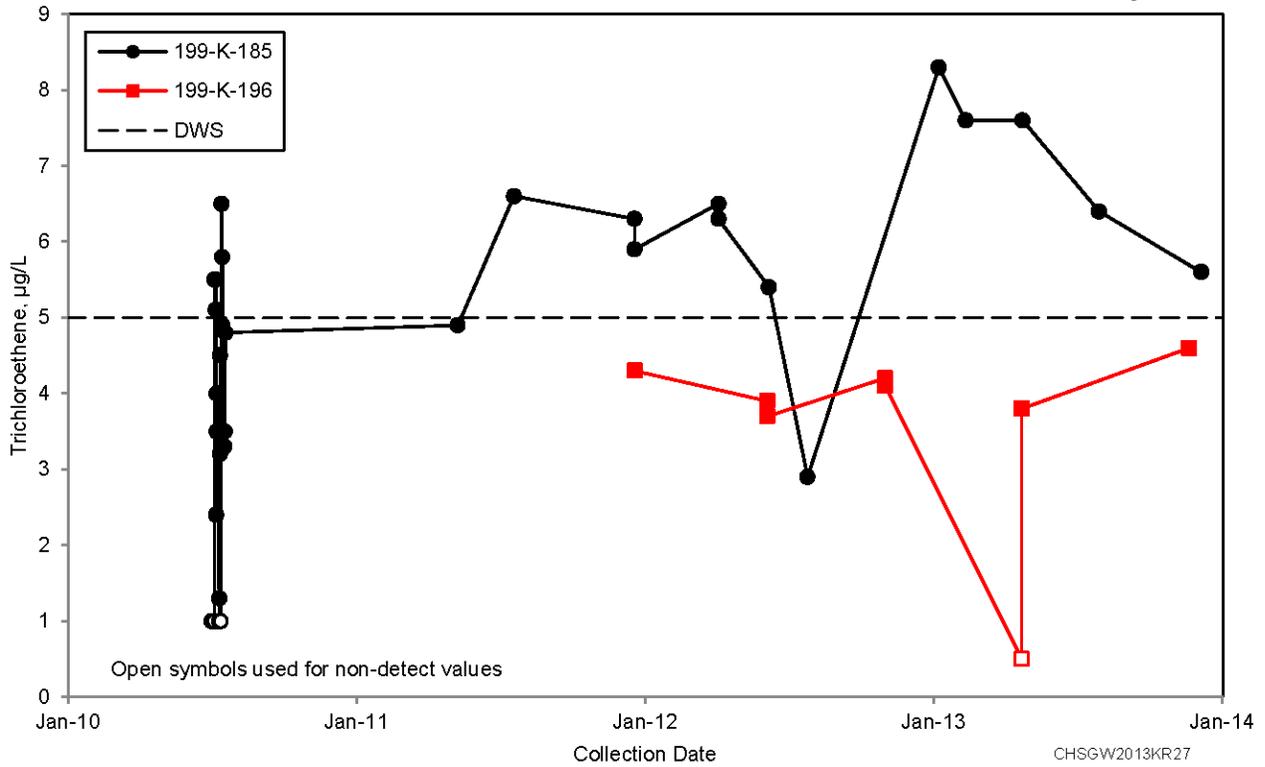


Figure KR.25 100-KR Trichloroethene Data for Wells 199-K-185 and 199-K-196, Located Downgradient of 105-KW Reactor

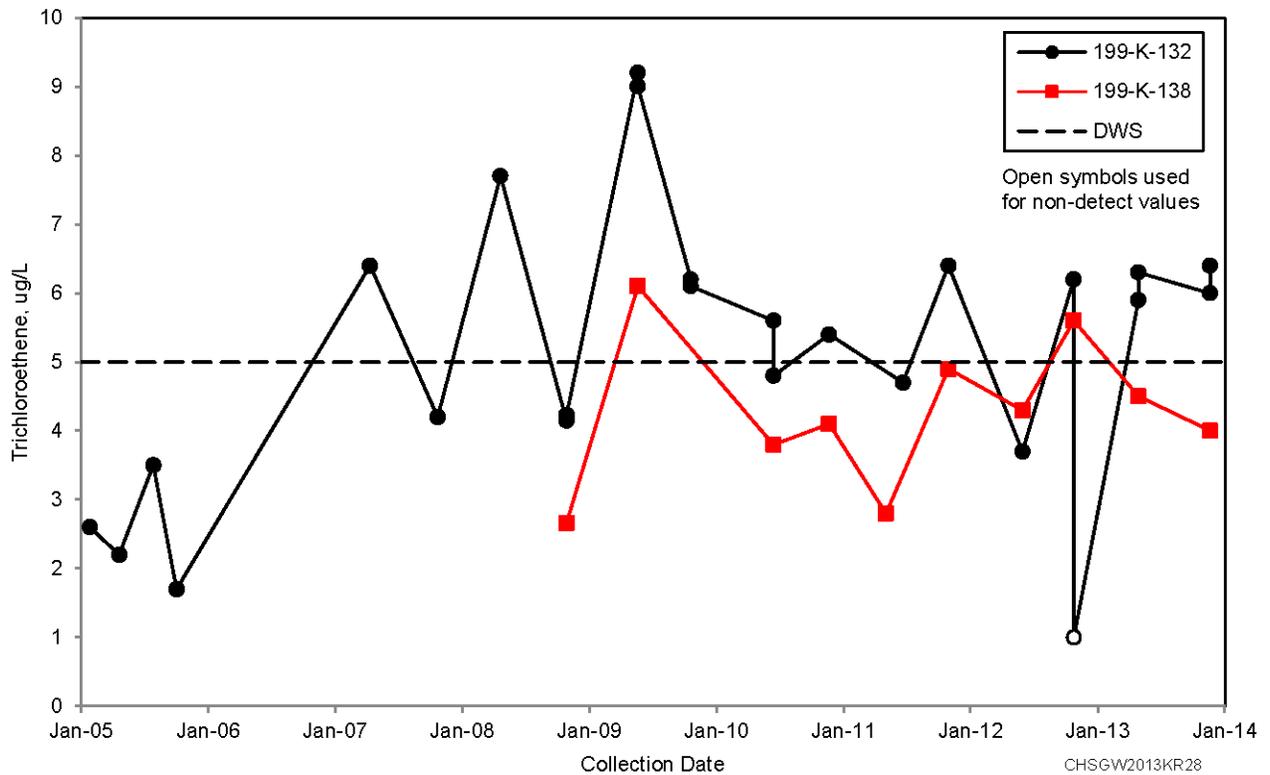


Figure KR.26 100-KR Trichloroethene Data for Wells 199-K-132 and 199-K-138, Located Downgradient of 105-KW Reactor

100-KR Remedy – Introduction

An interim action record of decision (ROD) for the 100-KR-4 OU was issued in April 1996 ([EPA/ROD/R10-96/134](#)). One of the remedial action objectives identified in the interim action ROD is to protect aquatic receptors in the Columbia River from contaminants in groundwater. The interim action ROD included a dilution factor of 1:1 for demonstrating compliance, under the assumption that dilution of groundwater with river water is expected before the groundwater would reach the aquatic receptor point of concern within the river substrate.

The interim action goal for compliance monitoring of hexavalent chromium was changed from 22 µg/L to 20 µg/L in August 2009 by an explanation of significant differences for the 100-HR-3 and 100-KR-4 OUs, which sets a 20 µg/L threshold at onshore, near-river monitoring locations to achieve the surface water standard of 10 µg/L at the point where groundwater discharges to the river ([EPA et al., 2009](#)).

The second CERCLA five-year review ([DOE/RL-2006-20](#)), published in 2006, identified four actions pertaining to 100-KR groundwater. The actions involved installing new wells and expanding P&T systems. All of the actions have been completed. DOE revised the third five-year review report ([DOE/RL-2011-56](#)) and submitted it to EPA in February 2012. DOE implemented three P&T systems to remediate hexavalent chromium contamination in 100-KR groundwater and protect the Columbia River. All three systems, as listed below, operated in 2013 and are continuing to operate in 2014; 31 compliance wells are identified for these systems (the measurement results for those wells are summarized in the Table KR.2):

- The original P&T system (KR-4), which began operating in 1997, focuses on contamination originating beneath the 116-K-2 Trench.
- The KX P&T system has two focus areas: one at the northeastern end of the 116-K-2 Trench, where the hexavalent chromium plume historically migrated toward 100-NR-2, and the hexavalent chromium plume in the vicinity of 105-KE Reactor facilities. The KX system began operating in 2009.
- The KW P&T system, which began operating in 2007, focuses on the hexavalent chromium plume at 105-KW Reactor facilities.

In November 2012, DOE submitted a letter report to EPA and the Washington State Department of Ecology (Ecology) ([12-AMRP-0172](#)). The due date for this milestone was December 31, 2012. Continued operation of interim groundwater remediation systems constitutes the action that meets this milestone at 100-K.

Source removal remedial actions at 100-K Area are continuing.

Table KR.2 100-KR-4 Interim Action Pump-and-Treat Systems, 2013

	KR4		KX		KW		Total	
Performance	2013	1997–2013	2013	2009–2013	2013	2007–2013	2013	1997-2013
Groundwater processed (million liters/million gallons)	553/146	6,753/1786	1,024/270	4575/1,208	487/129	2,337/618	2,064/545	13,665/ 3,612
Mass of hexavalent chromium removed (kilograms/pounds)	6/14	368/811	27/60	174/384	16/34	205/452	49/108	747/1,647
Wells	2013	2012	2013	2012	2013	2012		
Number of extraction wells	11	10	14	13	11	7	36	N/A
Number of injection wells	5	5	9	9	3	3	17	N/A
Hexavalent Chromium Plume Area	2013				Change from 2012			
Greater than 10 µg/L	2.1 km ² /0.8 mi ²				+12%			
Greater than 20 µg/L	1 km ² /0.4 mi ²				0%			

100-KR Remedy – Pump and Treat (P&T)

As of December 2013, 37 extraction wells and 17 injection wells were in service (Figure KR.27). Four additional extraction wells (three at the KX system and one at the KW system) were under construction along with one additional injection well at the KW system. Combined, the three systems are capable of treating about 6.5 million liters of groundwater per day. The combined P&T systems in 100-KR-4 removed 49 kilograms of hexavalent chromium from groundwater in 2013. Since 1997, the 100-KR-4 P&T systems have removed 747 kilograms of hexavalent chromium from the aquifer. *Calendar Year 2013 Annual Summary Report for the 100-KR-3 and 100-KR-4 Pump-and-Treat Operation, and 100-NR-2 Groundwater Remediation* (DOE/RL-2014-25) provides additional detail.

Under the current configuration, the 100-KR-4 P&T systems are demonstrating progress toward the interim remedial action objectives (Table KR.2; Figure ES.5). Operation of the systems and containment of the plumes address the first and third objective: (1) protect aquatic receptors in the river bottom from contaminants in groundwater entering the Columbia River, and (3) provide information that will lead to a final remedy. A summary of hexavalent chromium concentrations detected in compliance wells during 2013 is provided in Table KR.3. 11 of 31 wells had concentrations above the remedial action target concentration of 20 µg/L in 2013. Containment of the plume in combination with institutional controls also meets the second remedial action objective: (2) protect human health by preventing exposure to contaminants in the groundwater. Operation and refinement of these remedial systems are also meeting the third objective, which is to provide information that will lead to the final remedy. This included conversion of several monitoring wells (i.e., 199-K-196, 199-K-141, 199-K-198, 199-K-199, and 199-K-181) to extraction wells in 2013 to increase capture in locations of elevated hexavalent chromium. In addition, groundwater monitoring provides additional information regarding the nature, extent, and dynamic nature of the groundwater plumes at 100-KR-4 OU.

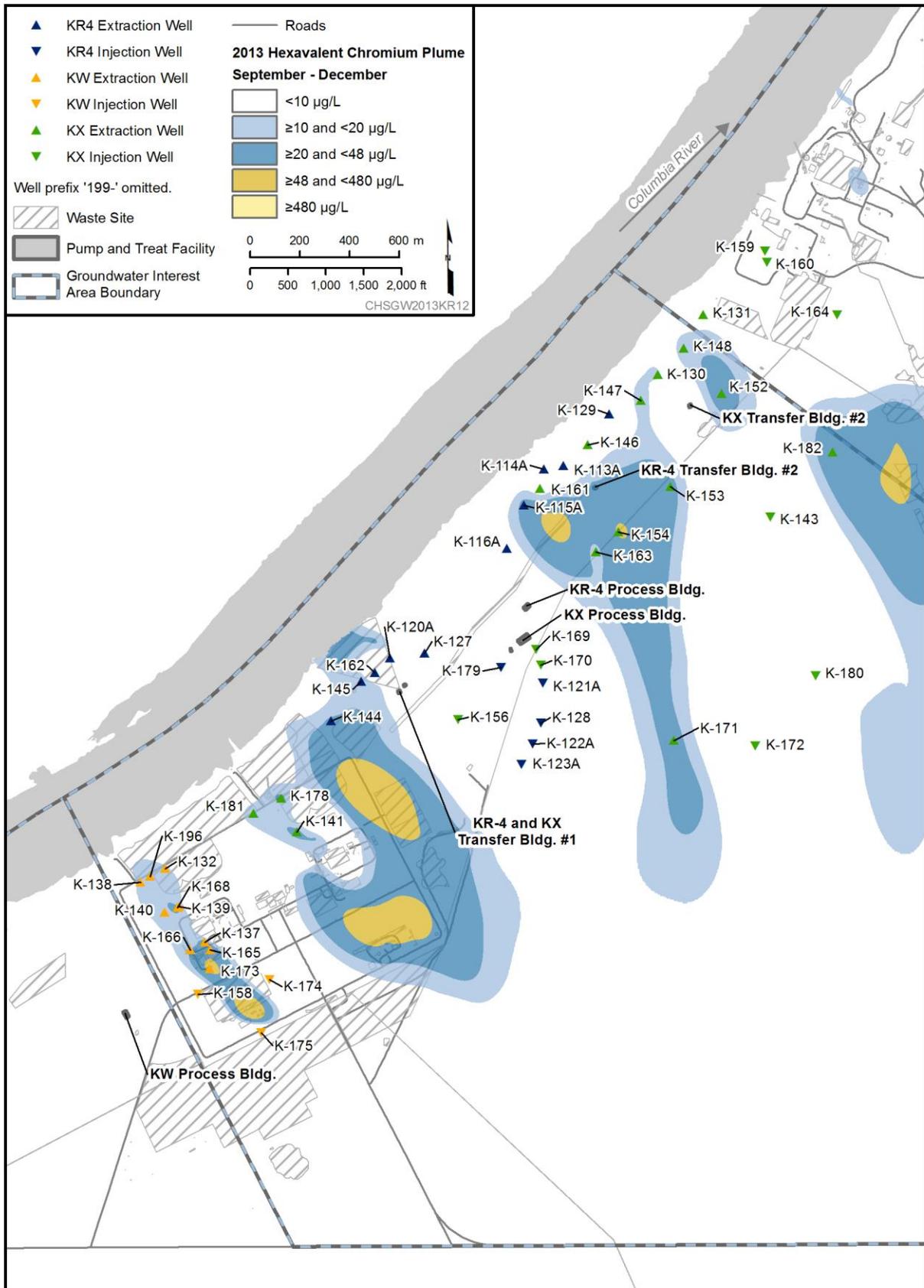


Figure KR.27 100-KR Pump-and-Treat Well Locations

Table KR.3 Summary of Hexavalent Chromium in 100-KR-4 OU Compliance Wells for 2013

Well	Treatment System	Maximum 2013 Hexavalent Chromium Concentration (µg/L)
199-K-132	100-KW	15
199-K-138	100-KW	14
199-K-113A	100-KR4/KX ¹	5
199-K-114A	100-KR4/KX	16
199-K-115A	100-KR4/KX	41
199-K-116A	100-KR4/KX	9
199-K-120A	100-KR4/KX	9
199-K-127	100-KR4/KX	21
199-K-129	100-KR4/KX	5
199-K-130	100-KR4/KX	15
199-K-131	100-KR4/KX	11
199-K-144	100-KR4/KX	30
199-K-145	100-KR4/KX	23
199-K-146	100-KR4/KX	7
199-K-147	100-KR4/KX	22
199-K-148	100-KR4/KX	29
199-K-152	100-KR4/KX	49
199-K-161	100-KR4/KX	11
199-K-162	100-KR4/KX	7
199-K-171	100-KR4/KX	33
199-K-178	100-KR4/KX	40
199-K-182	100-KR4/KX	61
199-K-198	100-KR4/KX	17.7
199-K-199	100-KR4/KX	24.4
199-K-18	100-KR4/KX	15
199-K-19	100-KR4/KX	6
199-K-20	100-KR4/KX	4.3
199-K-32A	100-KR4/KX	14
199-K-119A	100-KR4/KX	5.4
199-K-125A	100-KR4/KX	9.7
199-K-181	100-KR4/KX	14.4

Notes:

Because the extraction and injection wells of the KR4 and KX pump-and-treat systems are proximal to each other in many locations, it is not practical to evaluate compliance for the individual systems. The compliance evaluations for both systems are considered together.

100-KR AEA Monitoring

DOE requires monitoring of environmental conditions, including groundwater, to document and understand impacts to the environment and to ensure that site-related nuclear contaminants do not result in unacceptable exposures to human and ecological receptors. This monitoring, generically referred to as “AEA monitoring” (after the Atomic Energy Act, which invokes the requirements) is conducted at selected locations and typically at concurrent timing with other groundwater monitoring activities required by CERCLA within the 100-KR-4 Groundwater OU. AEA Monitoring at 100-K is conducted in the vicinity of the fuel storage basins.

The fuel storage basins in the KW and KE Reactor buildings were used from 1955 to 1971 to store irradiated fuel generated at the K Reactors, and 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 held approximately 4.9 million liters of shielding water that became highly contaminated with fuel residues and fission products (e.g., strontium-90, cesium-137, and tritium). In addition, each basin was connected to a drain system that included a combined crib and reverse well (waste sites 116-KE-3 and 116-KW-2) designed to receive basin overflow water. These waste sites, as well as leaks around the KE Basin, contaminated the adjacent vadose zone and groundwater. The KW Basin has no documented leaks.

Fuel rods and debris were removed from the K Basins by 2008. The KE Basin, substructure, and crib were demolished in 2009. The reverse well associated with the 116-KE-3 Crib remains in place. Contaminated soil around the basin and crib was removed, however, more contaminated vadose zone soil remains at these locations. Prior to demolition and remediation, downgradient groundwater monitoring wells around the KE Basin were decommissioned. It is noted here that previous annual groundwater monitoring reports (prior to 2012) incorrectly described the 105-KW Fuel Storage Basin as not containing shielding water. The KW Basin has been emptied of fuel rods but remains water-filled and continues to serve as a depository for contaminated sludge from the KE and KW Basins. The KW Basin and the 116-KW-2 Crib and reverse well are scheduled for removal.

Based on reported contamination in the basin shielding water, analytes that may affect groundwater include tritium, carbon-14, technetium-99, strontium-90, and cesium-137. Tritium and strontium-90 in groundwater are considered to be the primary indicators of water loss from the fuel storage basin and crib system.

[PNNL-14033](#) specifies groundwater monitoring requirements. Although the KE Basin no longer exists, the KW Basin remains in service, and a continuing sampling program is being maintained (Figure KR.28; Table B.88 of Appendix B). Previous leakage at the KE Basin and the use of dust-suppression water during basin and vadose zone remediation warrant continued monitoring at downgradient wells for the near future. The groundwater monitoring network has been modified to account for wells that have been decommissioned. There are currently no groundwater monitoring wells remaining in the immediate downgradient vicinity of the KE Basin and monitoring of the area for contamination by strontium-90 will continue using the existing wells. One new well (199-K-202) was installed downgradient of this area in 2013. DOE plans to place two characterization borings in this area (one each at the location of 116-KE-3 Crib and the historical release site from 105-KE Fuel Storage Basin [aka: UPR-100-K-1]). Current plans include completion of those borings as wells.

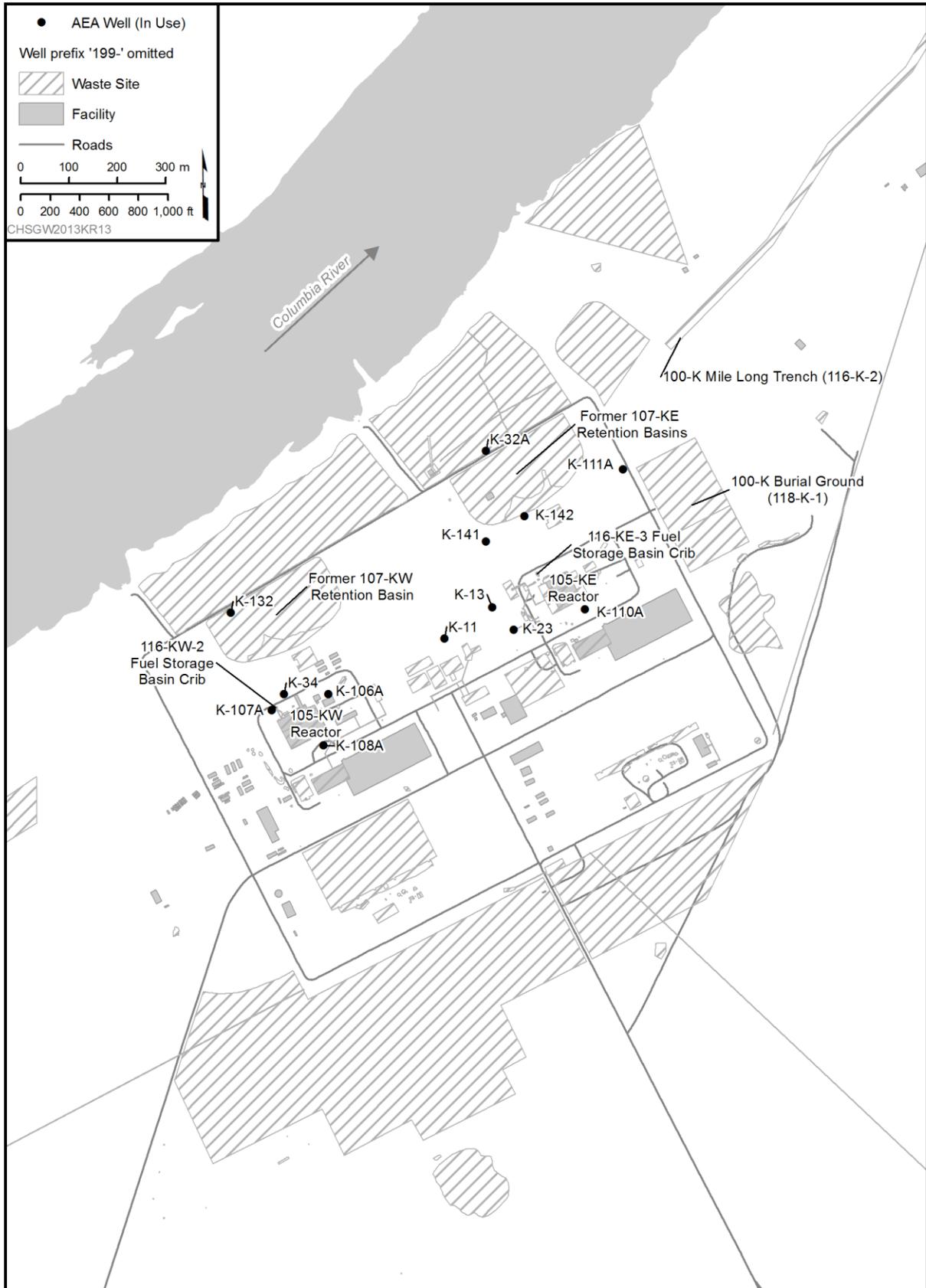


Figure KR.28 100-KR AEA Well Locations

Tritium concentrations in wells downgradient from the KE Basins maintained previous trends, suggesting no new releases. Tritium was detected in a characterization sample from new well 199-K-202 at 76,000 pCi/L. Well 199-K-111A exhibited an increasing trend since mid-2012, however, this tritium is believed to originate in the vicinity of 118-K-1 Burial Ground, not the fuel storage basin. Strontium-90 concentrations continued to increase in downgradient well 199-K-141 (an extraction well for the chromium P&T system) in 2013. This contamination likely originated in the KE Basins or the adjacent 116-KE-3 Crib. In the past, higher levels of strontium-90 were detected in 199-K-109A, adjacent to the crib. Decreases in concentration at 199-K-109A between 1990 and 2008, when it was decommissioned, as well as the observed increase in 199-K-141, likely indicate downgradient movement of the plume. Strontium-90 was not detected in characterization samples collected from new well 199-K-202. This indicates that the migrating strontium-90 plume is likely a narrow plume that lies between the location of the 116-K-3 Crib and well 199-K-141. These conditions are consistent with migration of an existing plume and do not, of themselves, indicate any new release of contaminants to groundwater.

Tritium and strontium-90 concentrations in wells downgradient from the KW Fuel Storage Basin in 2013 were consistent with previous measurements and the expected migration of plumes downgradient, away from the source areas.