

100-HR

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100-HR Overview

The 100-HR-3 groundwater operable unit (OU), in the northern Hanford Site, includes the 100-HR-D and 100-HR-H groundwater interest areas. Groundwater in this area was contaminated by waste releases associated with past operation of the D, DR, and H Reactors and associated support facilities. Removing contaminants from the vadose zone eliminates secondary sources of contamination that could migrate to groundwater and reduces the risk of direct exposure at the surface. At the end of 2013, approximately 77 percent of the waste sites were classified as closed, interim closed, no action, not accepted, or rejected. Table HR.1 lists key facts about 100-HR. Additional details about 100-HR history, waste sites, and hydrogeology are provided in Chapters 1 and 3 of the 100-D/H remedial investigation/feasibility study (RI/FS) ([DOE/RL-2010-95 Draft A](#)). Monitoring, extraction and injection wells, aquifer tubes, and water table contours are shown on Figures HR.1 and HR.2. Data from monitoring seeps and springs is included on each of the plume figures presented, but was not used for plume development due to their transient nature.

Vadose zone thickness, which also represents the depth to groundwater, ranges from 0 to 27 meters, with an average thickness of 20 meters in 100-D and an average thickness of 11.3 meters in 100-H. Thickness of the unconfined aquifer ranges from less than a meter in areas at 100-H to 12 meters at 100-D, with the aquifer generally thinning from west to east. Average aquifer thickness varies from about 6 to 9 meters beneath 100-D, and from 2 to 5 meters beneath 100-H. The thickness of the unconfined aquifer mimics the topography of the Ringold Formation upper mud unit (RUM) ([DOE/RL-2008-42](#)). The uneven surface of the silt- and clay-rich RUM forms the base of the unconfined aquifer. Water-bearing units are also found within the RUM, forming confined or semi-confined aquifers across 100-HR. It is unclear if the water-bearing units within the RUM are connected across the site, or are small isolated areas.

Table HR.1 100-HR at a Glance

Reactor Operations: D 1944-1967; DR 1950-1964; H 1949-1965				
2013 Groundwater Monitoring				
Contaminant	Water Quality Standard	Maximum Concentration	Plume Area^a (km²)	Shoreline Impact (m)
Hexavalent Chromium	20 µg/L ^{b/}	5,392 (199-D5-104) ^c	4.0 ^d	525 ^d
Nitrate	45 mg/L ^e	70.4 mg/L (199-D4-20)	0.06	0
Strontium-90	8 pCi/L	31 pCi/L (199-D5-132)	0.03	30
Tritium ^f	20,000 pCi/L	20,000 pCi/L (199-D4-20)	--	--
Remediation				
Waste Sites (interim action): >77 percent complete ^g Groundwater (interim action for hexavalent chromium): <ul style="list-style-type: none"> • HR-3 pump-and-treat: 1997-2011, removed 406 kg • DR-5 pump-and-treat: 2004-2011, removed 338 kg • DX pump-and-treat: 2010-2013, removed 1225 kg • HX pump-and-treat: 2011-2013, removed 70 kg • In Situ Redox Manipulation barrier: 1997-2012 Final ROD anticipated in 2015.				

- a. Estimated area at a concentration greater than the listed drinking water standard.
 b. 20 µg/L groundwater cleanup target identified in ROD for interim remedial action.
 c. Table lists maximum in a P&T sample. The maximum from a routine sample was 4,690 in well 199-D5-104.
 d. Based on a concentration greater than the 20 µg/L remedial action objective. This area is for the plume within the 100-HR interest area.
 e. 45 mg/L as NO₃ is equivalent to the drinking water standard of 10 mg/L as N
 f. Tritium was detected in a single well at the standard. No plume area was calculated.
 g. Sites with status closed, interim closed, no action, not accepted, or rejected.

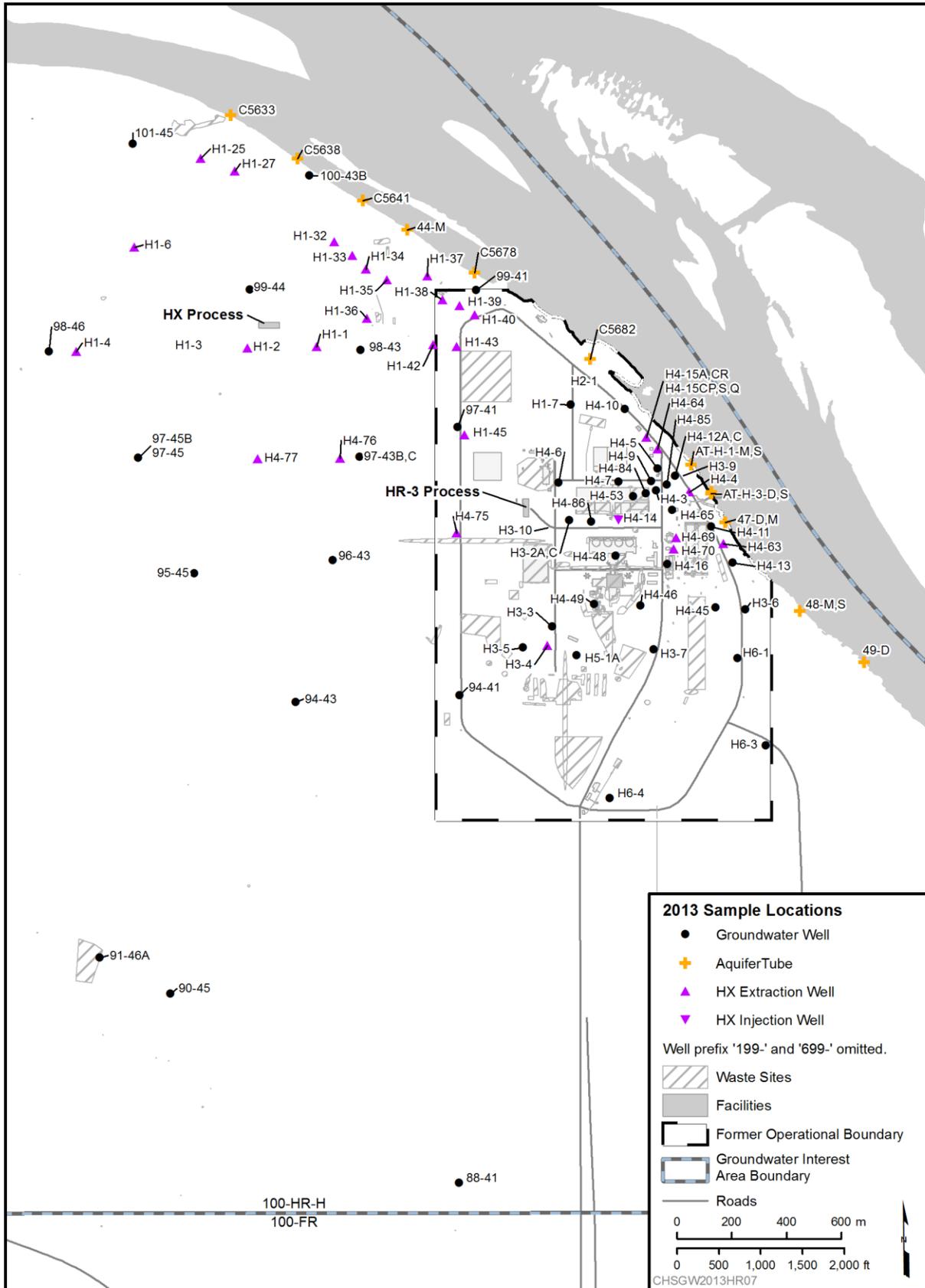


Figure HR.2 100-HR-H Wells and Aquifer Tubes

The unconfined aquifer is primarily present in the Ringold Formation unit E sands and gravels in 100-D, and in the Hanford formation gravels in 100-H (Figure HR.3). Across the Horn, the geology is transitional, changing from predominantly Ringold unit E (closer to 100-D) to Hanford formation farther east. Pockets of Ringold unit E are found as remnants in various locations. In the areas across the Horn where Ringold unit E is absent, channels are formed which result in preferential groundwater flow pathways. This complicated geology is discussed in detail in Chapter 3 of (DOE/RL-2010-95).

Groundwater in 100-HR flows generally to the east-northeast direction, from 100-D across the Horn to 100-H. Flow in 100-H is eastward, generally towards the river. In the southern and central portions of 100-D, groundwater flows to the northwest, towards the Columbia River. The hydraulic gradients are generally flatter during high river stage (ranging from approximately 0.0014 to 0.0023 meters per meter) when compared to low river conditions (ranging from approximately 0.0017 to 0.0031 meters per meter). Operation of pump and treat (P&T) systems has created changes in groundwater flow direction and velocity throughout 100-HR. These changes are expressed as local depressions and mounds in the water table, affecting the local flow direction and gradient. The March 2013 water table (Figures HR.4 and HR.5) shows the overall flow for the area. However, the flow directions and gradients experienced during low and high river stage have a greater affect in the River Corridor.

Generalized Hydrogeology of 100-HR-3

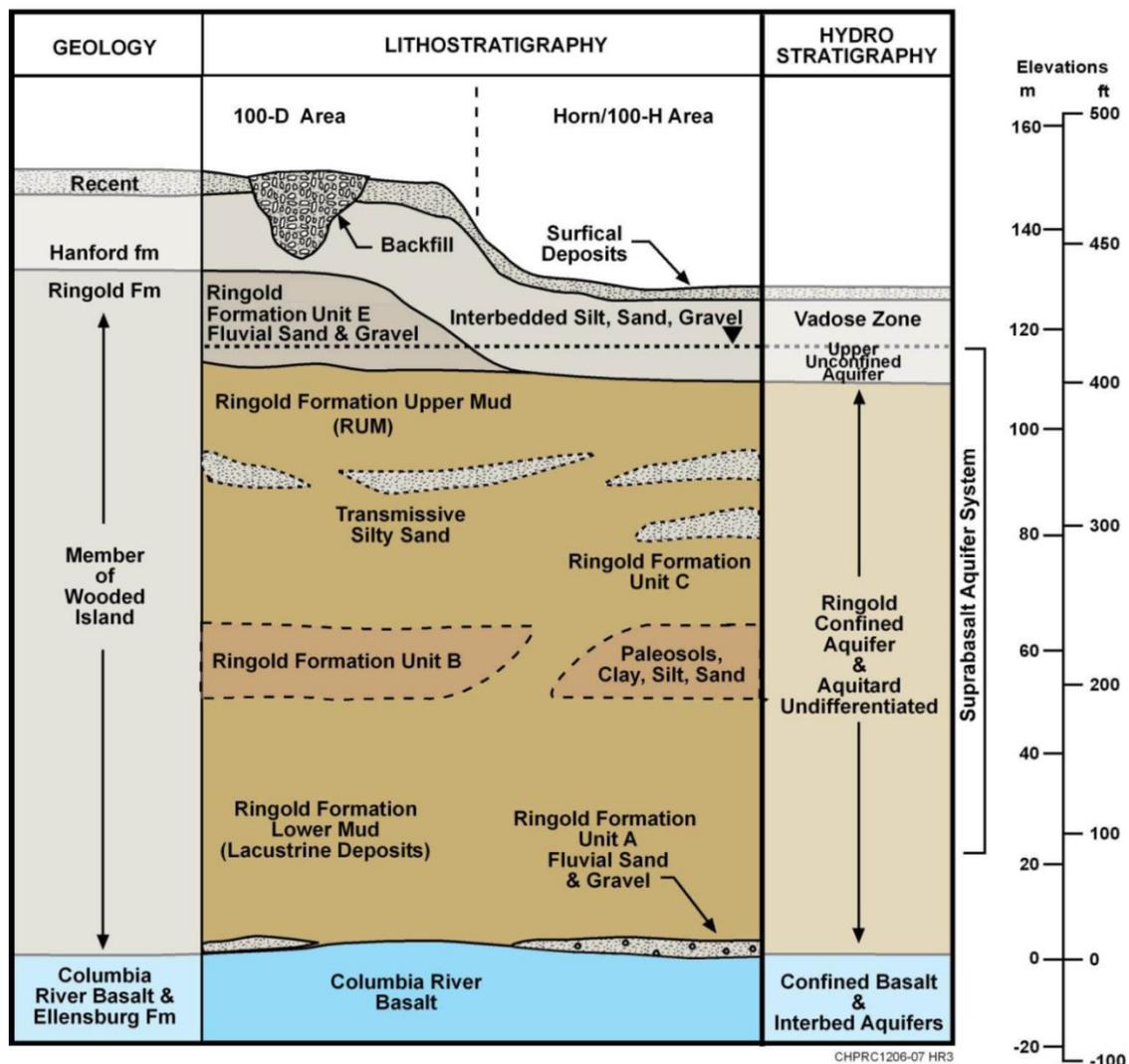


Figure HR.3 100-HR Geology

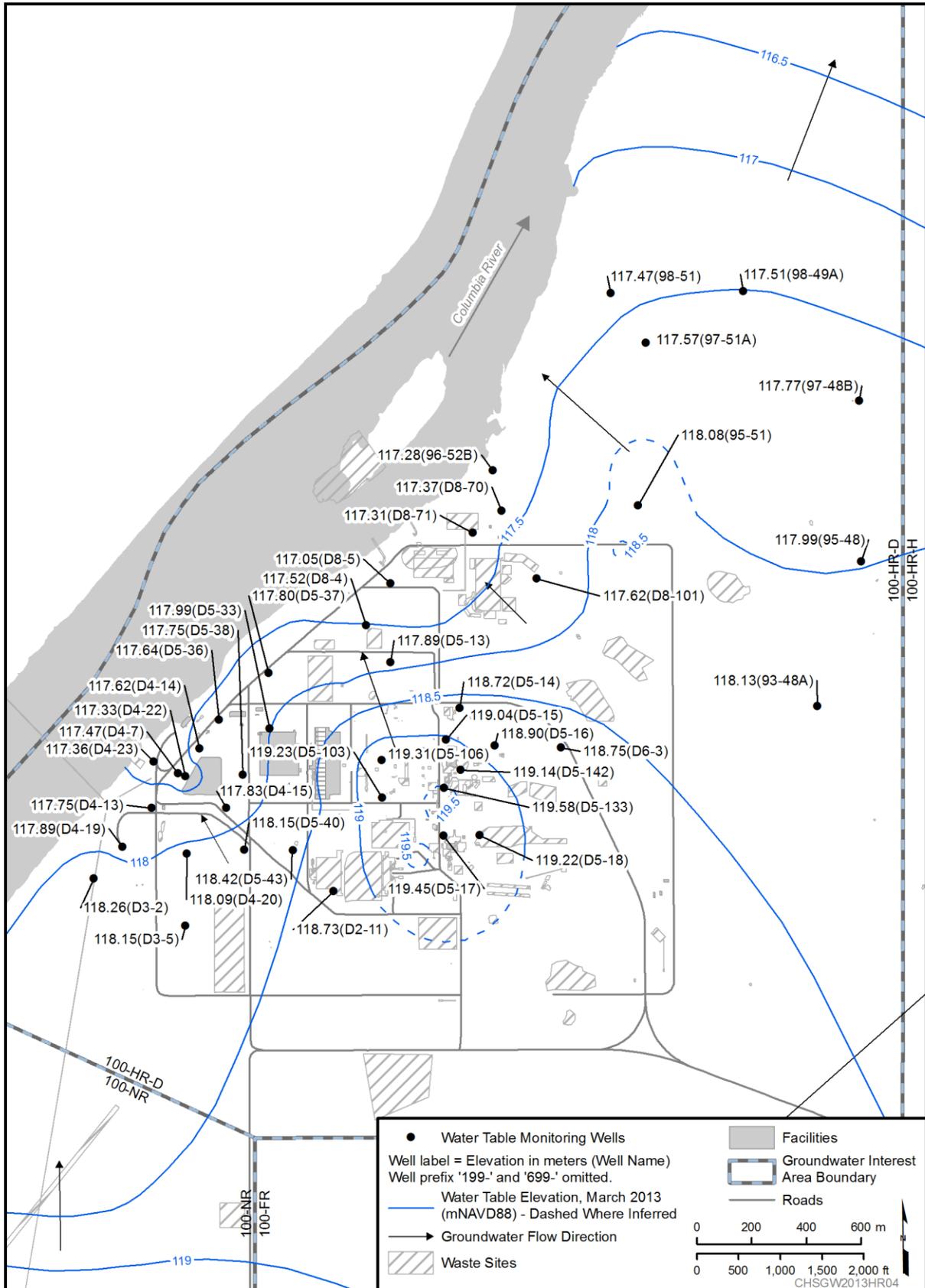


Figure HR.4 100-HR-D Overview and March 2013 Water Table

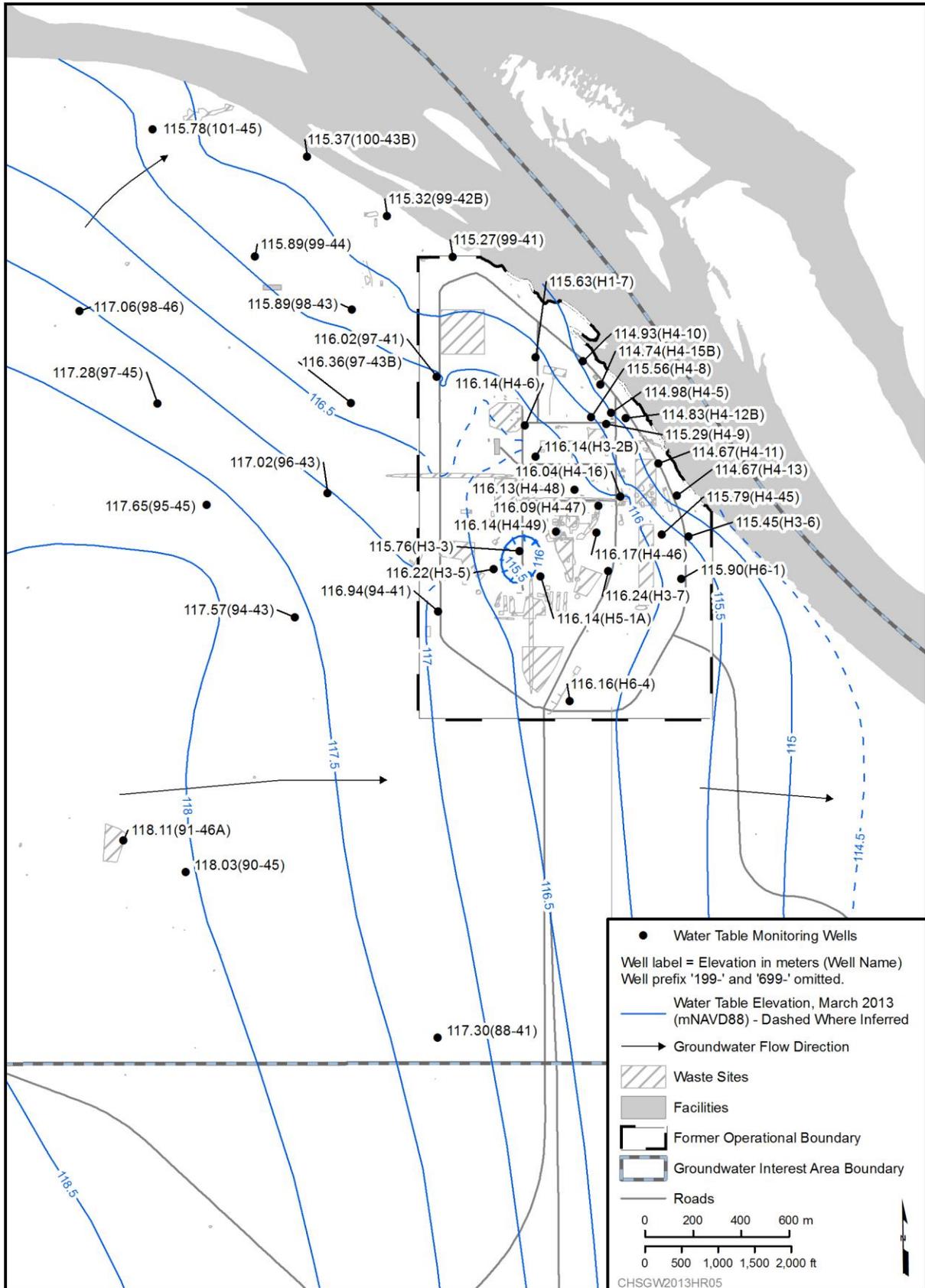


Figure HR.5 100-HR-H Overview and 2013 Water Table

Daily and seasonal fluctuations in the river stage (Figure HR.6) affect groundwater flow in 100-HR. 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. The high and low river stages, which typically last a period of a few months, affect the groundwater flow near the river. During 2013, the higher river stage during the summer months was less pronounced than in the previous two years, resulting in little to no groundwater flow reversal effect during the higher river conditions (see discussion in Hexavalent Chromium sections below). This was not the case in the past few years, when high river stage resulted in river water pushing the contaminant plume inland due to the pressure wave.

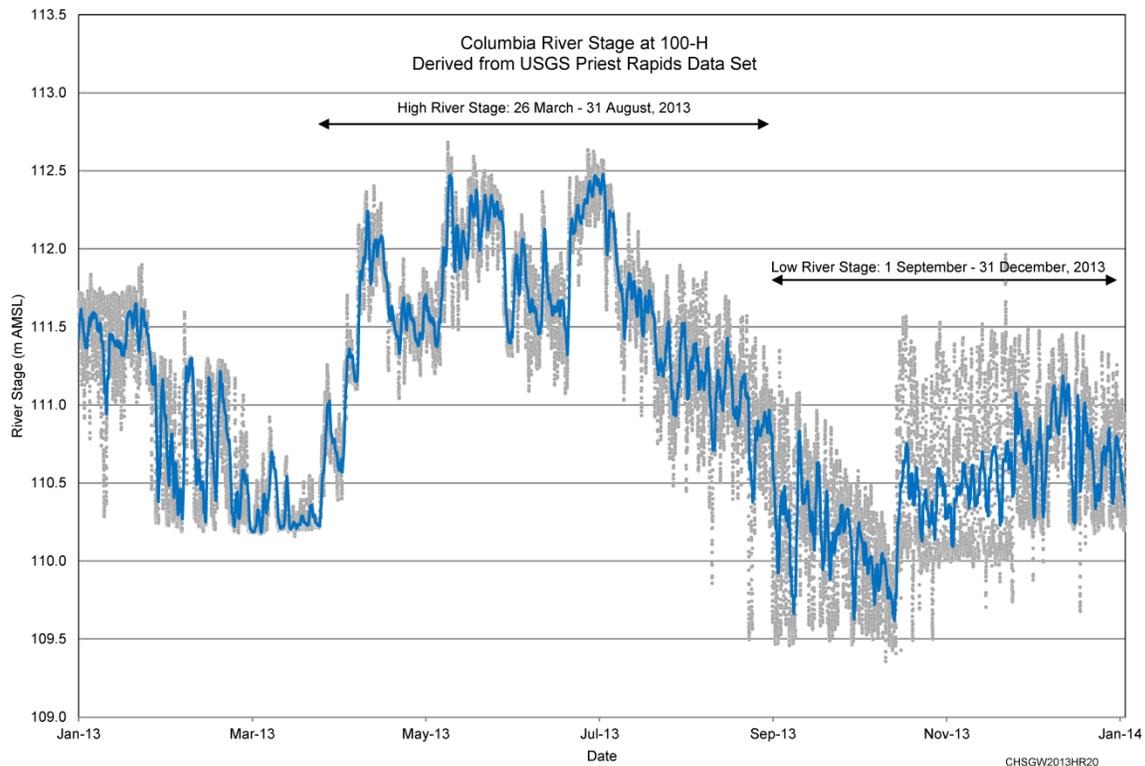


Figure HR.6 Columbia River Stage at 100-H Area in 2013

Water level changes in monitoring wells are tracked using the Automated Water Level Network (AWLN), along with transducers in the pump-and-treat system extraction and injection wells. Since several of the AWLN systems needed repairs and upgrades in 2013, the water table contour maps have more uncertainty than usual and rely more heavily on the pump-and-treat system measurements. The AWLN is undergoing upgrades and additional wells are being added to the network during 2014. The high and low river water table contour maps are shown with the hexavalent chromium plumes in the sections below.

Under high river stage, the effect of river water migrating into the aquifer along the shoreline can cause lower contaminant concentrations in aquifer tubes and in some near-river wells. However, since the groundwater flow reversal effect was muted during 2013 and the water-table contours at high river stage indicated a gradient towards the river during this period, seasonal changes in contaminant concentrations due to near-shore mixing were also muted. The result was higher concentrations near the river for more of the year.

Contaminants of potential concern (COPCs) in the 100-HR unconfined aquifer were identified in the interim ROD (Tables 1 and 2 of [EPA/ROD/R10-96/134](#)) and include hexavalent chromium, total

chromium, nitrate, technetium-99, strontium-90, and others. Based on recent data, the COPC in the first water bearing unit within the RUM in the 100-H and Horn areas is hexavalent chromium. Other contaminants of interest within 100-HR include uranium, technetium-99, fluoride, sulfate, and tritium. Chromium, nitrate, uranium, technetium-99, and fluoride are monitored under the *183-H Solar Evaporation Basins Postclosure Plan* ([DOE/RL-97-48](#)).

Uranium and technetium-99 are listed in the *Resource Conservation and Recovery Act of 1976* (RCRA) permit as waste indicators for the 183-H Basins. Uranium concentrations in the vicinity of the waste site have been declining over time, with no exceedances of the drinking water standard (DWS) of 30 µg/L in 2013. The high concentration of uranium in 2013 was 21.2 µg/L (well 199-H4-84), with all other results for uranium in 2013 being below 10 µg/L in that well. The last exceedance of the uranium DWS was in 2012 (well 199-H4-3), with previous exceedances being on an infrequent basis. Uranium concentrations fluctuate with water table elevations but are declining overall. Technetium-99 was historically detected above the DWS of 900 pCi/L near the 116-H-6 waste site (183-H Solar Evaporation Basins), up until 1999 and then sporadically until 2005. Concentrations have been declining overall, with the maximum concentration of technetium-99 in 2013 being 45 pCi/L in well 199-H4-12A (October).

Fluoride is also monitored under the RCRA permit at the 183-H Solar Evaporation Basins, and evaluated relative to the established trends. The DWS for fluoride (4,000 µg/L) has not been exceeded in groundwater in 100-HR. The RCRA permit, however, lists the DWS at the time the permit was written, a concentration limit of 1,400 µg/L. The permit level of 1,400 µg/L for fluoride has historically been exceeded in well 199-H4-3, but results have been consistently below 300 µg/L in well 199-H4-3 since mid-2006 and have not exceeded 1,400 µg/L since 2000. Concentrations of fluoride have been below 300 µg/L at 100-HR-3 in nearly all locations since 2011. Only 3 sample results were higher than 300 µg/L during that time frame, and occurred in 3 different wells with a maximum of 339 µg/L in well 199-H1-33 in 2011 and 199-H6-4 in 2013.

Sulfate previously exceeded the 250 mg/L secondary DWS in wells within and downgradient of the In Situ Redox Manipulation (ISRM) barrier in 100-D as a result of sodium dithionite solution injections. Sulfate concentrations remain highest along the ISRM barrier. Eight wells have had sulfate levels above 200 mg/L since 2011, with seven of those located along the ISRM barrier. Well 199-D5-133, located adjacent to injection well 199-D5-129, is the only other location with sulfate concentrations above 200 mg/L. This well had a maximum concentration of 221 mg/L in November 2013. Tritium has historically been detected at concentrations near or over 20,000 pCi/L in the southern area of 100-D. In 2013, a single well had a tritium concentration of 20,000 pCi/L (199-D4-20), located in the area of historic detections.

100-HR CERCLA Activities

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) groundwater activities in 100-HR included groundwater monitoring, operation of interim remediation systems for hexavalent chromium, and comment resolution for the RI/FS document. CERCLA groundwater sampling includes monitoring for interim remedial action effectiveness and monitoring wells throughout 100-HR to track plumes, plume areas (Figure HR.7, Table HR.1), and concentration trends. Wells sampled during 2013 are shown on Figures HR.1 and HR.2 and listed in Appendix A, Table A.8.

Remedial Investigation/Feasibility Study (RI/FS). In 2010 and 2011, the U.S. Department of Energy (DOE) conducted extensive field studies as described in an RI/FS work plan addendum ([DOE/RL-2008-46-ADD1](#)) and sampling and analysis plan (SAP) ([DOE/RL-2009-40](#)). Changes to the SAP were documented in Tri-Party Agreement Change Notices ([TPA-CN-460](#)).

The RI/FS results were evaluated, and DOE submitted Draft A of the RI/FS and Proposed Plan for 100-D/H in late 2012 ([DOE/RL-2010-95](#); [DOE/RL-2011-111](#)). The RI/FS is reviewed by the Washington State Department of Ecology (Ecology), and the Proposed Plan is reviewed by the Environmental Protection Agency (EPA), Ecology, Tribal Nations, and the public. The RI/FS results will support selection of final remedies under CERCLA, using an approach that integrates source and groundwater remedial actions.

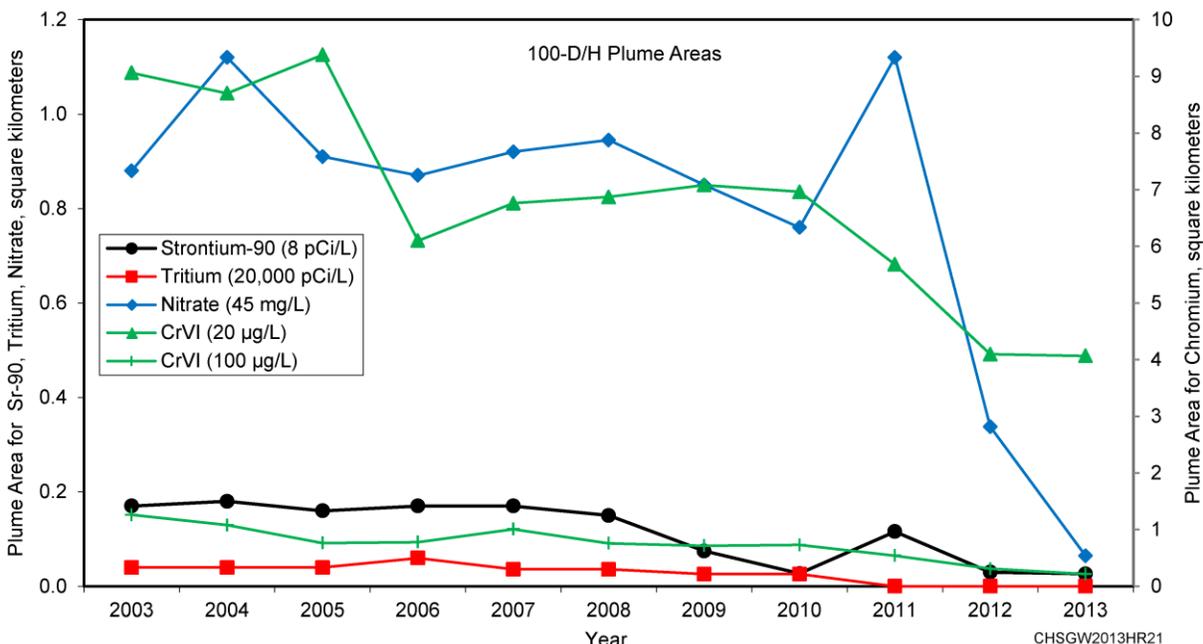


Figure HR.7 100-HR Plume Areas

The Executive Summary of [DOE/RL-2010-95](#) states, “Site investigation and risk assessment work conducted for [100-D and 100-H] determined that contaminants in the vadose zone and groundwater pose a threat to the environment and that a CERCLA remedial action is warranted. Based on the 100-D/H RI/FS, the Proposed Plan... identifies a preferred alternative, as well as other alternatives considered for cleanup of the 100-D/H Operable Units.”

Starting in 2013 and continuing through 2014, DOE and Ecology have been working through the comment resolution process. After comments are incorporated, public comments will be received and then a record of decision (ROD) will be issued that identifies the final remedial alternatives. The Proposed Plan is expected to be available for public comment in late 2014 or early 2015. Remedial action decisions will address the integrated cleanup of source waste sites and groundwater. The objective for all of these decisions is to protect human health and the environment; including restoring groundwater to meet DWS and achieving ambient water quality criteria in the Columbia River that protects aquatic life.

Interim Action Groundwater Remediation. DOE has been operating a groundwater P&T system in the 100-HR-3 OU since 1997 under an interim remedial action ROD ([EPA/ROD/R10-96/134](#)), which was amended in 2000 ([EPA/AMD/R10-00/122](#)). Under the interim action, two P&T systems operate at 100-HR-3; DX and HX (Figure HR.8). In 2013, the combined systems removed 386 kilograms of hexavalent chromium from groundwater. From 1997 through 2013, the 100-HR-3 P&T systems removed 2,038 kilograms of chromium from the aquifer. Over half of this mass was removed by the DX system, which has operated since late 2010. Most of the hexavalent chromium mass removed from the DX and HX systems originated in the interior of the plumes; the areal extent of the plumes, as defined by the 10 µg/L contour, did not change significantly in 2013. Operation of remediation systems and groundwater monitoring results are described in *Calendar Year 2013 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation* (DOE/RL-2014-25).

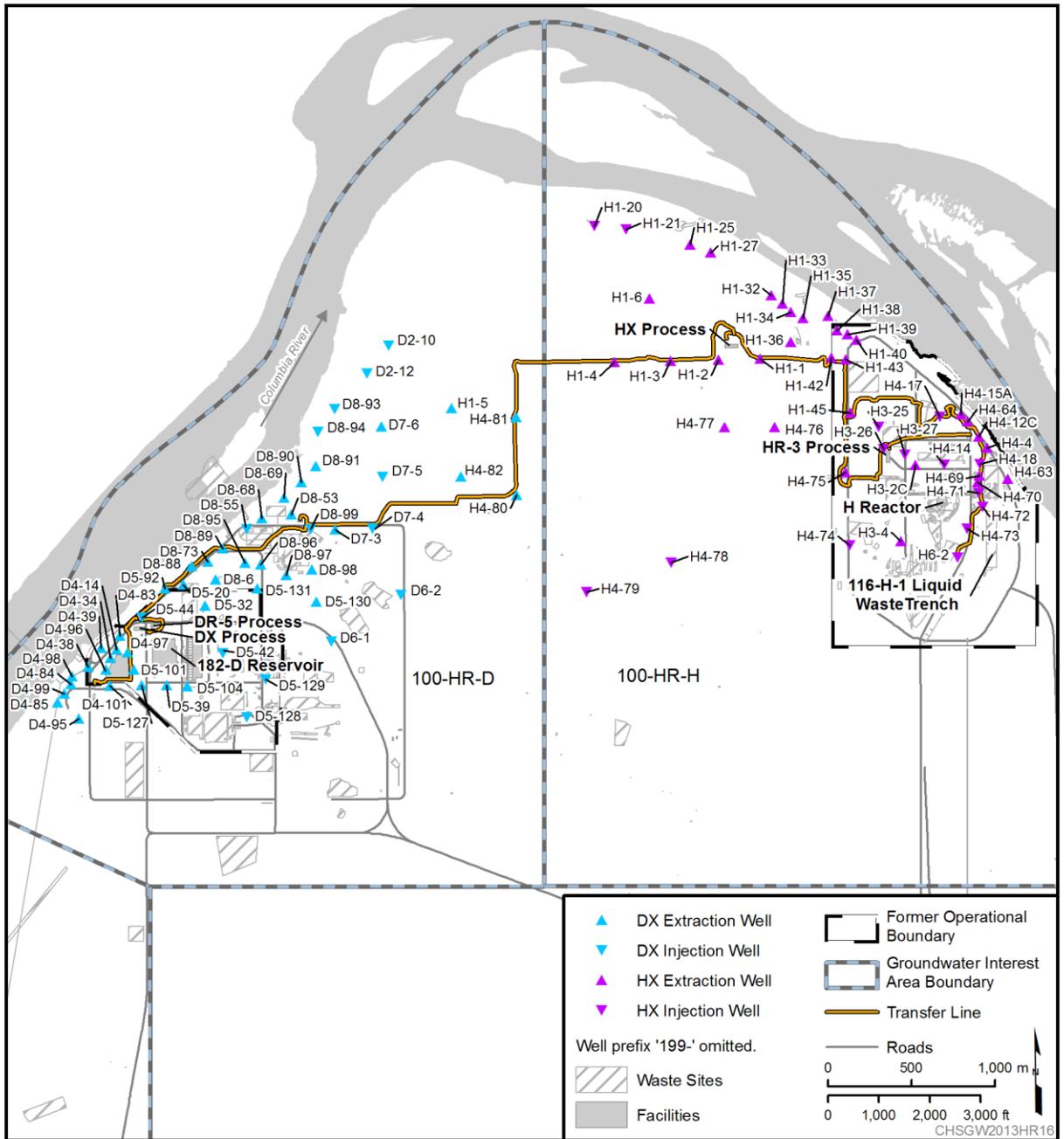


Figure HR.8 100-HR-3 Pump-and-Treat Systems

100-HR-D Hexavalent Chromium

The mobile contaminant hexavalent chromium is the primary contaminant of concern at 100-HR. 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 quantity intentional discharge of concentrated sodium dichromate 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-DR-1&2 Trench during an infiltration test in 1967, which had high volumes of water with lower concentrations of sodium dichromate.

Hexavalent chromium is widespread across 100-HR, although the size of the plume is decreasing due to groundwater remediation (Figure HR.7). The plume is generally present in four areas: 100-D south, 100-D north, the Horn, and 100-H. The southern 100-D plume (Figures HR.9 and HR.10) continues to have the highest hexavalent chromium concentrations on the Hanford Site, with hexavalent chromium concentrations as high as 5,392 µg/L in extraction well 199-D5-104 in April 2013. Overall, concentrations continued to decline during 2013 in response to continued groundwater and source area remediation.

Historical handling of 70 percent sodium dichromate solution at the 100-D Area railcar unloading area resulted in discharges to the ground and a large area of hexavalent chromium in the vadose zone. This waste site, 100-D-100, appears to be the source of the southern plume ([DOE/RL-2009-92, Report on Investigation of Hexavalent Chromium Source in the Southwest 100-D Area](#)). The highest hexavalent chromium concentrations in the northern plume are found north of the 105-D Reactor.

The southern source area (100-D-100) and several north plume source areas (waste sites 100-D-104 and 100-D-30) were undergoing active remediation during 2013 which involved the removal of a large volume of highly contaminated soil. As a result of source area remediation and continued operation of the DX P&T system, hexavalent chromium concentrations in both the southern and northern plumes have been declining overall.

Southern Plume at 100-D. Hexavalent chromium concentrations over the majority of the southern part of 100-D Area have declined. Remaining pockets of higher concentrations are located near the 100-D-100 waste site, the 100-D-104/30 waste site, the northern end of the ISRM barrier and pond, and just upgradient of the middle of the ISRM barrier. Currently, the highest concentrations are found in extraction well 199-D5-104, located downgradient from the 100-D-100 waste site.

Near the 100-D-100 waste site, hexavalent chromium concentrations have dropped dramatically over the last few years as a result of the expanded P&T system and source area remediation. For example, concentrations in well 199-D5-122 dropped by two orders of magnitude in the two years following the start of the DX P&T system; just prior to the well being decommissioned for source area remediation in 2012 (Figure HR.11). Hexavalent chromium concentrations in well 199-D5-104 have been declining overall, but the trend slowed as the nearby remediation activity at 100-D-100 approached groundwater (Figure HR.12). In addition, seasonal variation has some effect on the contaminant trends, which makes a direct correlation between concentration changes and excavation activities more difficult.

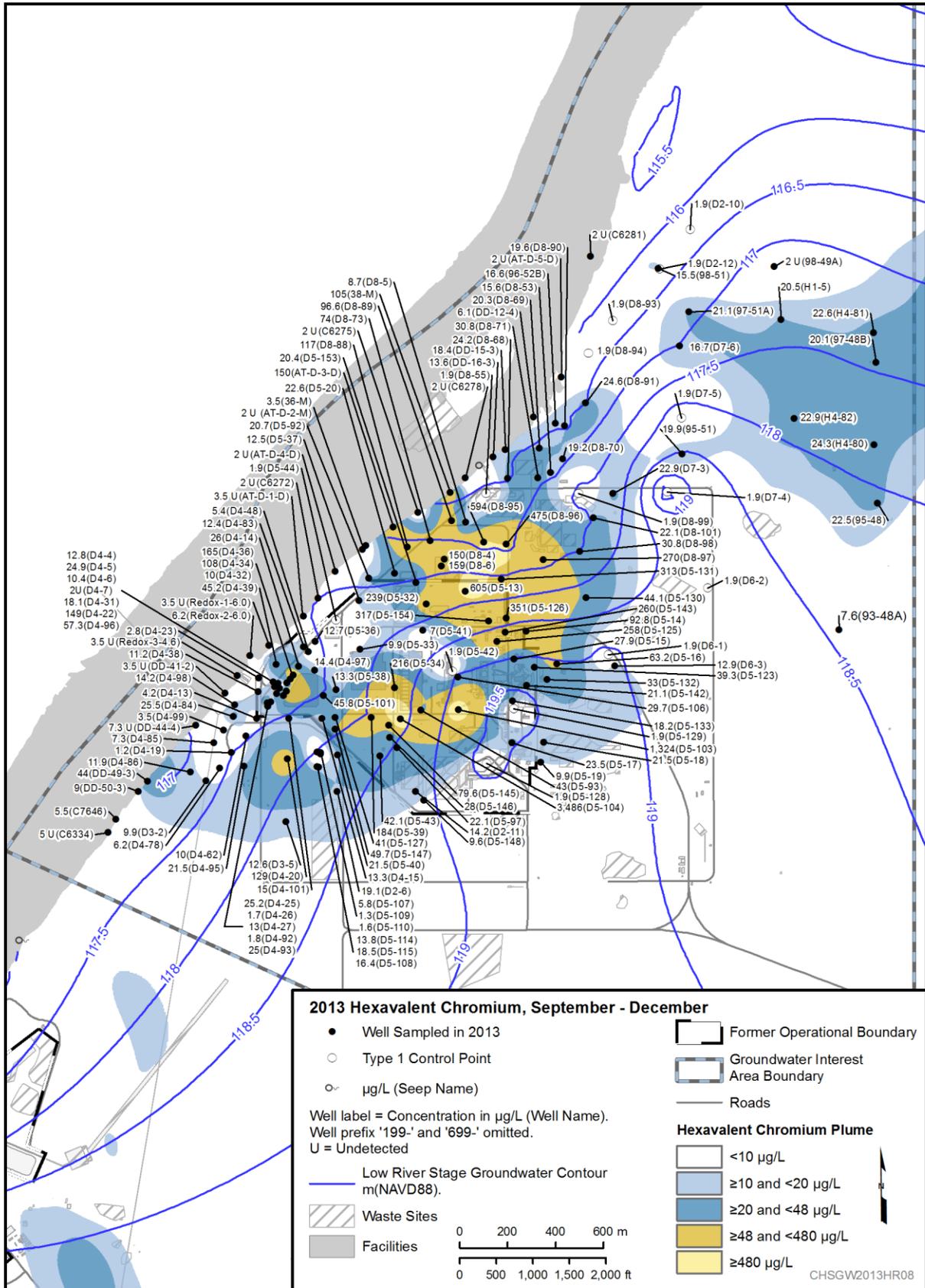


Figure HR.9 100-HR-D Hexavalent Chromium Plume, Fall 2013 (Low River Stage)

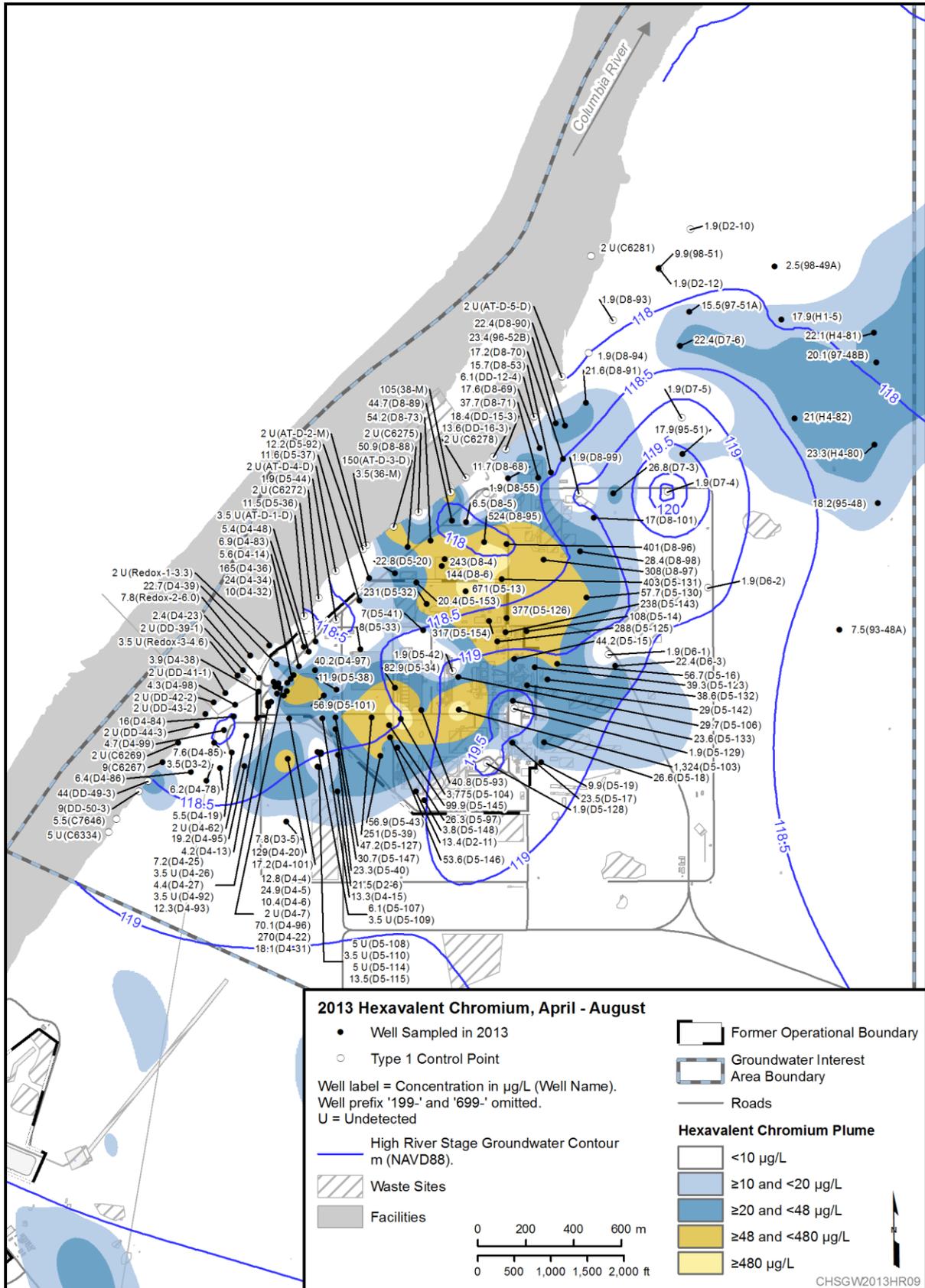


Figure HR.10 100-HR-D Hexavalent Chromium Plume, Spring/Summer 2013 (High River Stage)

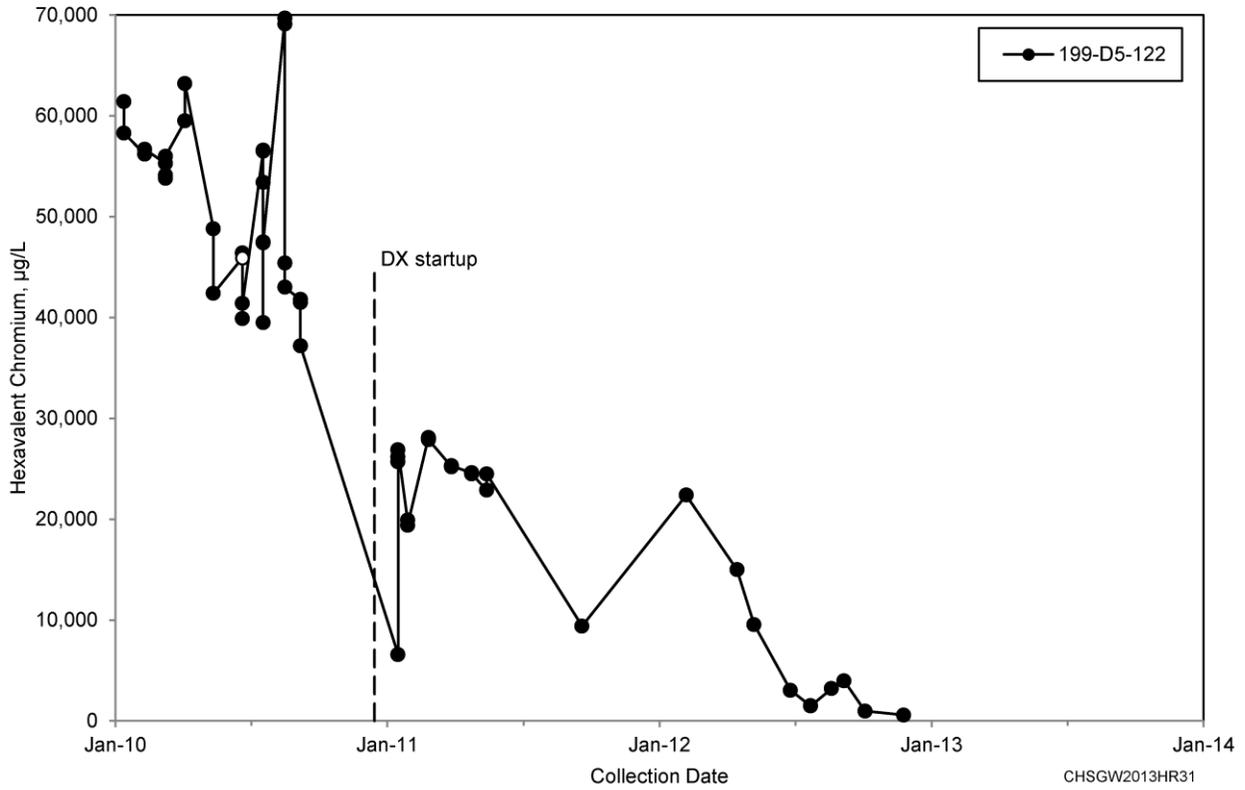
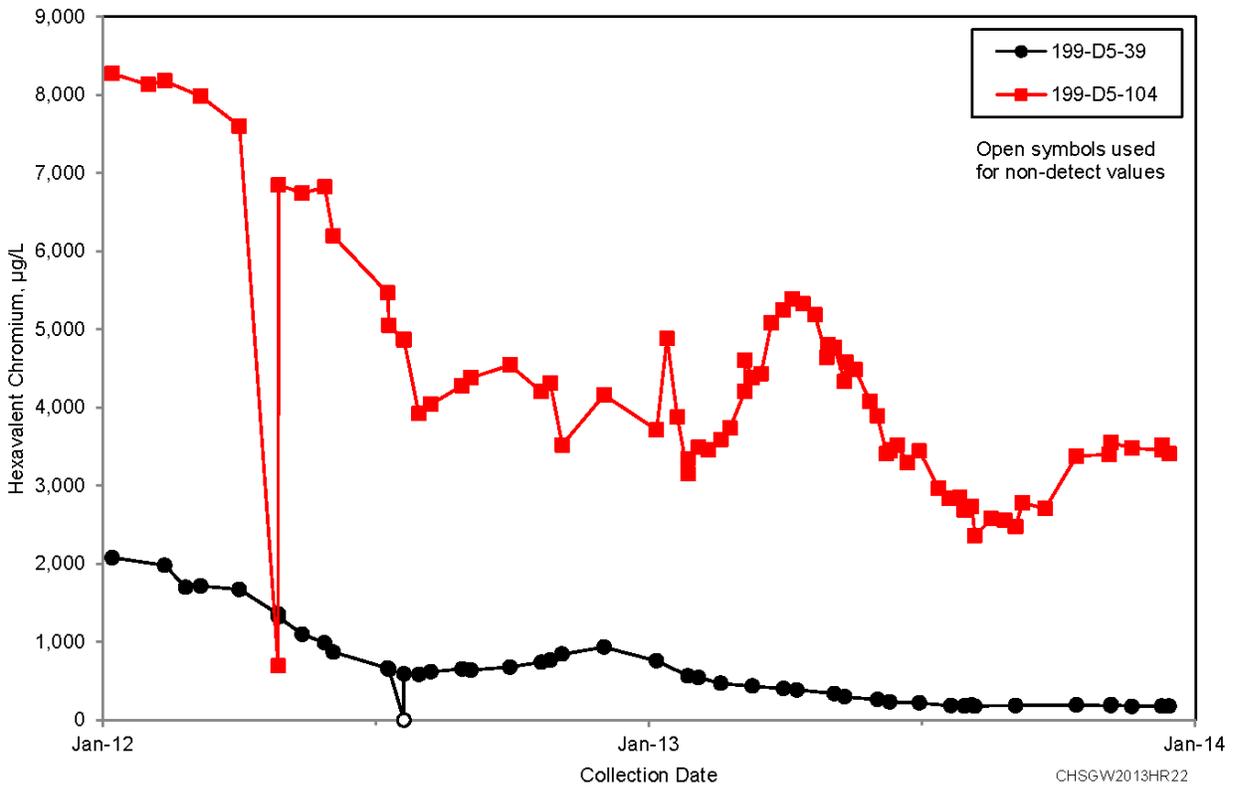


Figure HR.11 100-HR Hexavalent Chromium Data for Well 199-D5-122



An apparent response to excavation activities was also noted in well 199-D5-103, which is located near the 100-D-104 and 100-D-30 waste sites. This well had a significant increase in hexavalent chromium during active excavation activities, with concentrations increasing from 105 µg/L in May 2011 to a peak of 1,520 µg/L in September 2013. This was followed by a sharp decline to 1,140 µg/L by the end of 2013, which continued into 2014. The decline in concentrations at well 199-D5-103 generally coincides with the period that the excavation activity neared groundwater and stopped for a short period.

On the northern end of the ISRM barrier, hexavalent chromium concentrations remained elevated in 2013. The need for improved capture by the P&T system in this area was identified in 2012, and in response to this, two additional extraction wells were connected during 2013: 199-D4-14 and 199-D4-34 (Figure HR.8). Since being connected to the P&T system, concentrations in both wells have increased (Figure HR.13), indicating improved capture and mass removal in that area. This is also evidenced by the decrease in concentrations in extraction well 199-D4-39 (Figure HR.13), which is located downgradient of the two newer extraction wells.

South of the ISRM barrier, the plume continues to reach the shoreline of the Columbia River. Concentrations in aquifer tubes DD-49-3 and DD-50-3 were at 44 and 9 µg/L, respectively, in December 2013 and January 2014. This was an increase from previous years. The data point from DD-49-3 was flagged as suspect because the results were not corrected for sample turbidity, which can bias hexavalent chromium analyses high. Additional wells are being evaluated for extraction in that vicinity.

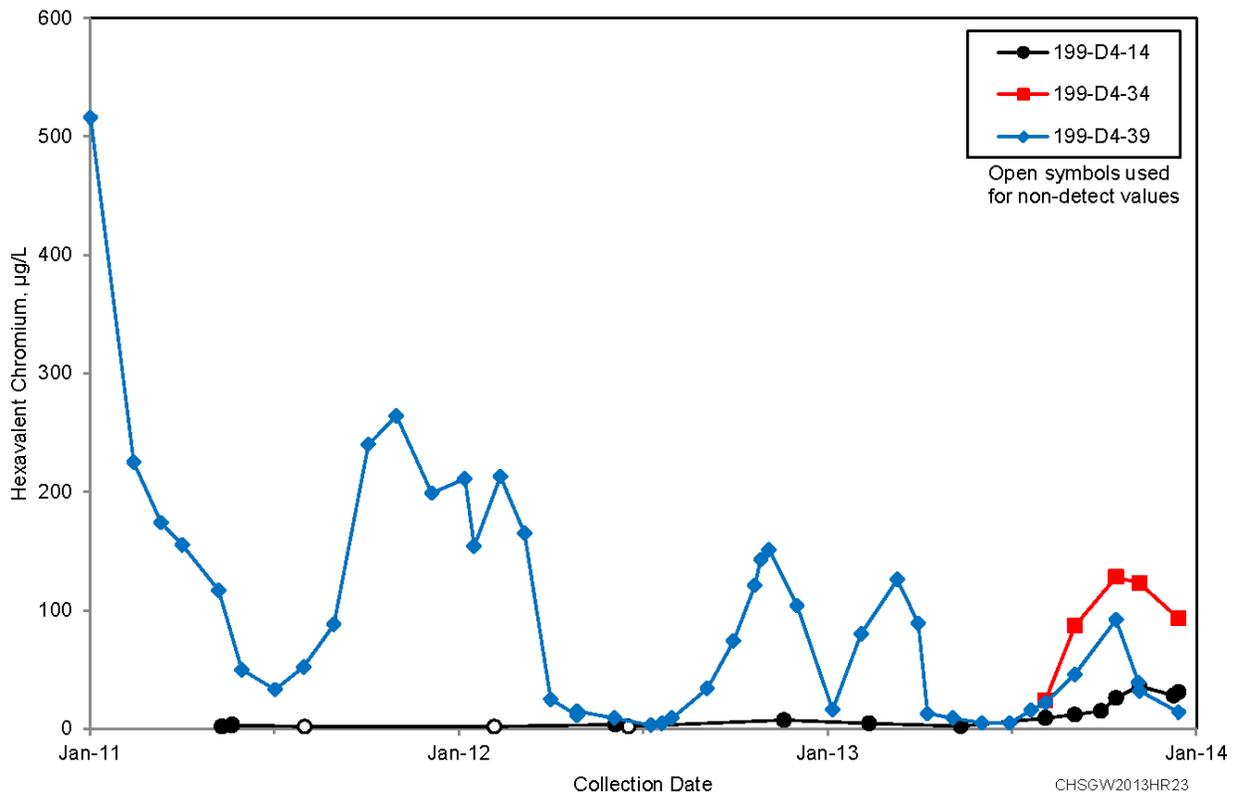


Figure HR.13 100-HR Hexavalent Chromium Data for Wells 199-D4-14, 199-D4-34, and 199-D4-39

Northern Plume at 100-D. The overall footprint of the 2013 hexavalent chromium plume on the north end of 100-D (Figures HR.9 and HR.10) remained similar in shape to the 2012 plume. Areas of higher concentrations decreased in size, mostly in response to active groundwater remediation and source area removal. Currently, the majority of wells within the northern plume are active extraction or injection wells which cause a very dynamic water level. As a result, concentrations in individual wells fluctuated during 2013 as the contaminants were moved through the aquifer and hexavalent chromium concentrations in extraction wells generally increased, as compared to 2012. For example, extraction wells 199-D8-73, 199-D8-95, and 199-D8-88 (Figure HR.14) are located downgradient of the heart of the northern plume. Concentrations have generally increased in these wells as they draw the higher concentrations toward them. Seasonal variability also is evident in these wells.

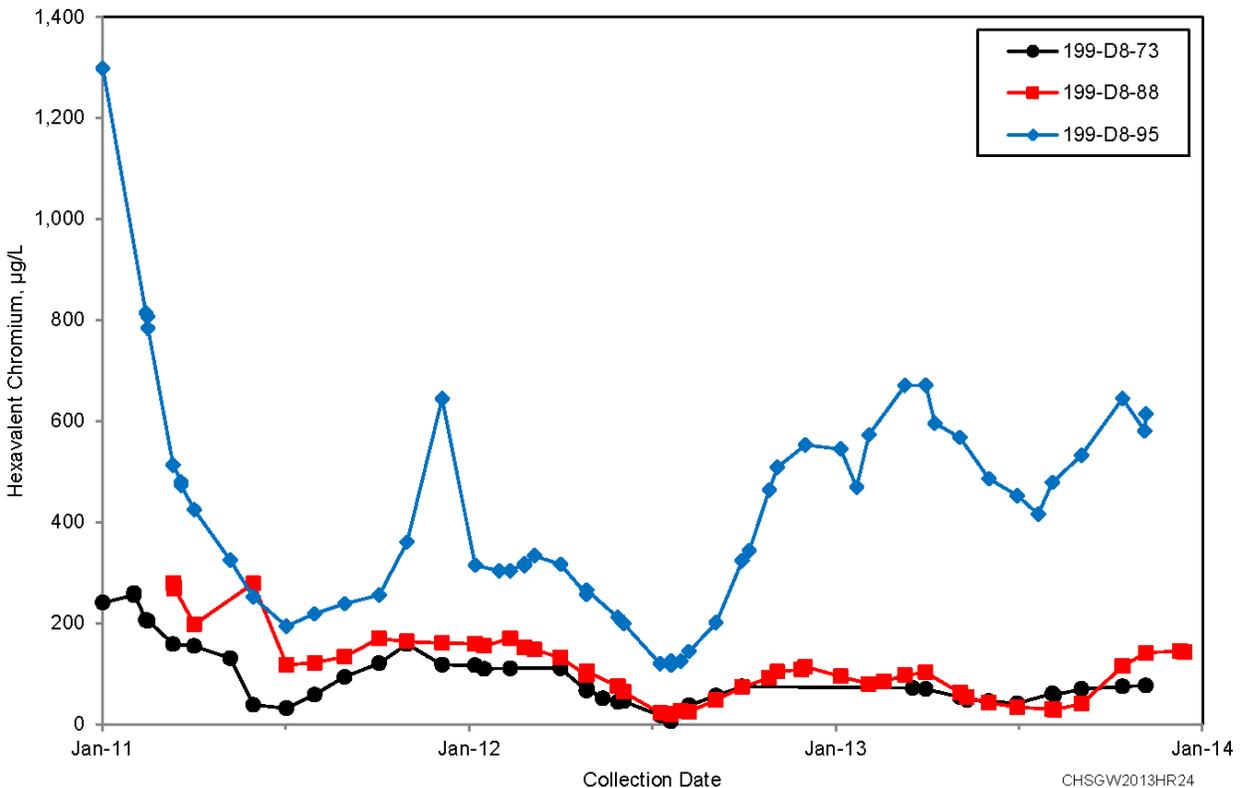


Figure HR.14 100-HR Hexavalent Chromium Data for Wells 199-D8-73, 199-D8-88, and 199-D8-95

Hexavalent chromium concentrations in aquifer tubes downgradient of the northern plume had an increase in concentrations in 2013. Unlike the previous two years, where high river stage was very pronounced, river stage during 2013 was muted (Figure HR.6). This resulted in little to no groundwater flow reversal effect during the summer months, as determined by an evaluation of the water table elevations during high river stage, and therefore higher concentrations persisted at the shoreline for a longer period. The highest concentration of hexavalent chromium in aquifer tubes was identified in AT-D-3-D at 150 µg/L. Slightly farther north, aquifer tube 38-M had a concentration of 105 µg/L in 2013. Both of these results are flagged as suspect because the results were not corrected for sample turbidity, which can bias hexavalent chromium analyses high. Spring 110-1 is located just north of 38-M and had a concentration of 20.8 µg/L which is consistent with the plume configuration. This is an area along the shoreline that was identified as being at risk for impacts during the 2012 evaluation ([DOE/RL-2013-13](#)). To mitigate the risk in that area (identified in 2012), wells 199-D5-153 and 199-D5-154 were drilled during 2013 and are planned for connection to the P&T system during 2014, and well 199-D8-55 is being

converted from injection to extraction. Hexavalent chromium samples from these two wells from early 2014 were nearly the same or lower than the samples collected during drilling.

On the far north end of the 100-D plume a need for improved capture was identified in 2012. Two additional wells were connected to the extraction system in 2013 (199-D8-53 and 199-D8-68) to improve capture and increase mass removal (Figure HR.9). Evaluation of that area of the plume indicates that the overall mass has decreased, with no wells having concentrations above 48 µg/L, although the aerial footprint above 10 µg/L has changed little over the last year.

100-HR-H Hexavalent Chromium

Plume in the Horn and 100-H. Discharge to the 116-DR-1&2 Trenches during 1967 resulted in the hexavalent chromium plume that extends across the Horn from 100-D to 100-H (Figures HR.15 and HR.16; and Section 3.7.1 of DOE/RL-2010-95 Draft A). This plume encompasses the largest area of 100-HR, but concentrations in the unconfined aquifer remain consistently less than 100 µg/L. Ongoing remediation activities continue to reduce the contaminant levels and have separated the Horn plume from the 100-D area plume. Injection wells 199-D7-5 and 199-D7-4, located on the northern end of the 100-D plume areas, have contributed to this separation. Currently, the highest concentrations in the unconfined aquifer in the Horn are found in extraction wells 199-H4-75, 199-H4-76, and 199-H4-77, located just west of the 100-H area. Concentrations in these extraction wells ranged from 46 to 68 µg/L in 2013, gradually declining from concentrations between 75 and 106 in 2012. Along the western edge of the reactor area, the plume from the Horn is being drawn to the east due to the current configuration of the extraction and injection wells, and relative flow rates.

In the unconfined aquifer at 100-H Area, concentrations are typically less than 10 µg/L. Areas in 100-H with higher hexavalent chromium concentrations are found just north of the 105-H Reactor. One of these locations is at well 199-H4-86, which is located just north of waste site 100-H-46. Well 199-H4-86, which was installed in 2013, had a high concentration of 90.8 µg/L in November, during low river stage. This was the highest concentration identified within the 100-H Area. The presence of this small area of higher hexavalent chromium concentrations, along with other wells in that area having concentrations above 10 µg/L, resulted in the plume being drawn to connect the Horn plume with the area near the 183-H Basins (Figure HR.15). Concentrations in aquifer tube 47-D and Spring 152-2 of 9 and 3.1 µg/L, respectively, are consistent with inland concentrations in that area.

The other areas with continuing hexavalent chromium are located downgradient of the 183-H Solar Evaporation Basin, downgradient of the 116-H-7 Retention Basin, and at 100-H-46 waste site (Figure HR.15). Hexavalent chromium concentrations in several wells in that vicinity fluctuated at about 10 µg/L, with concentrations above 20 µg/L detected at least once during 2013 in wells 199-H4-3, 199-H4-7, 199-H4-9, 199-H4-12A, 199-H4-15A, 199-H4-84, and 199-H4-85 (Figure HR.15). Higher concentrations were typically detected during low river stage, however concentrations in wells 199-H4-3 and 199-H4-7 were above 20 µg/L during the monitored time period. It should be noted that 199-H4-3 and 199-H4-7 were decommissioned during high river stage, 2013, and had a shortened monitoring record as a result.

Along the southern end of the 100-H area the plume continues to move to the south. This plume migration is following a path which coincides roughly with an interpolated paleochannel in that area, which is discussed in detail in [DOE/RL-2010-95 Draft A](#). This apparent channel has a higher percentage of gravel material, and a slightly thicker aquifer, with groundwater flow rates that are much higher than in other areas of 100-H. Reconfiguration of the extraction and injection wells in this area is planned to take advantage of the presence of the groundwater flow regime in that area. Modifications to the pump-and-treat systems are discussed in the *Calendar Year 2013 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation* (DOE/RL-2014-25).

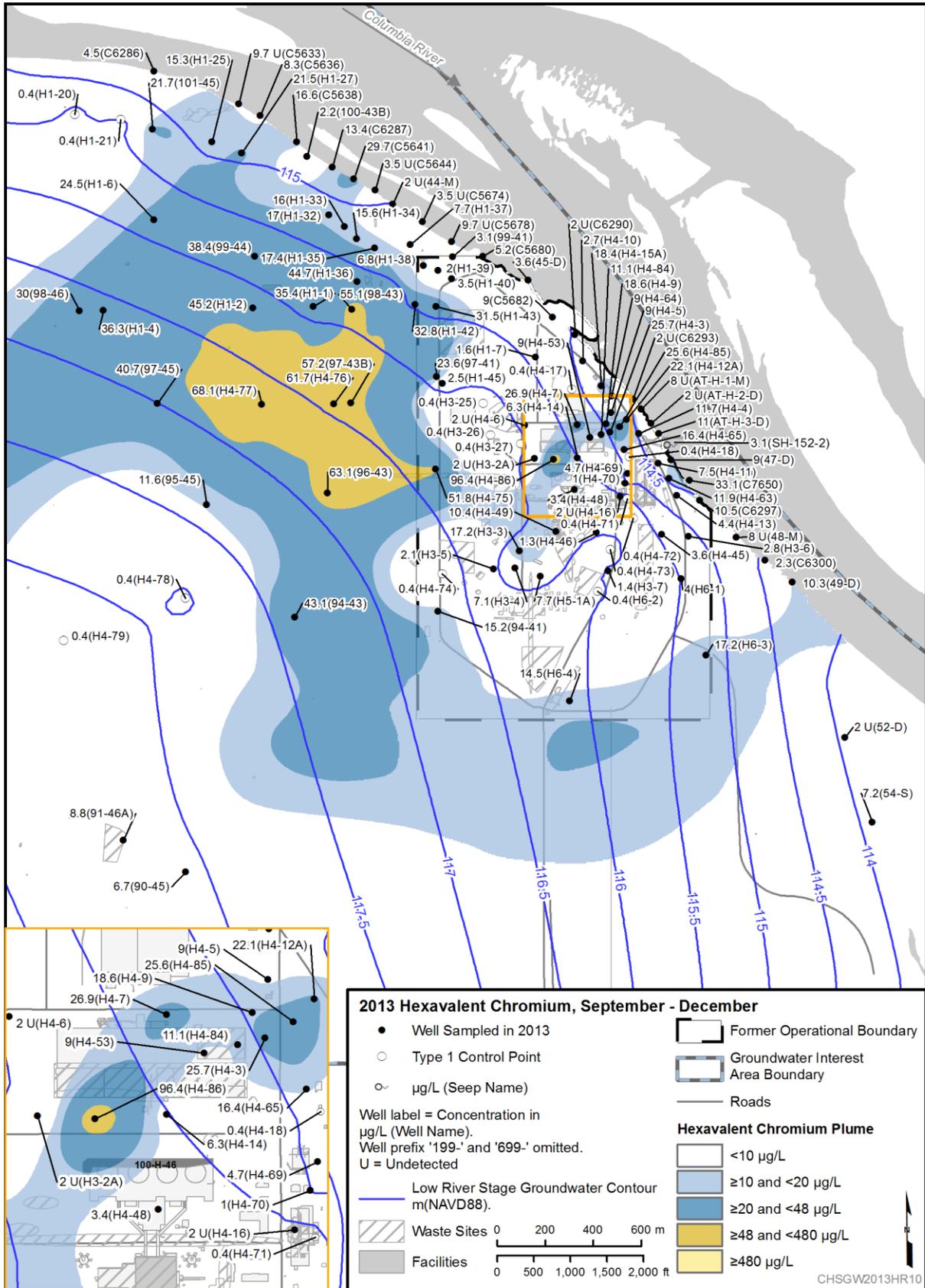


Figure HR.15 100-HR-H Hexavalent Chromium Plume, Fall 2013 (Low River Stage)

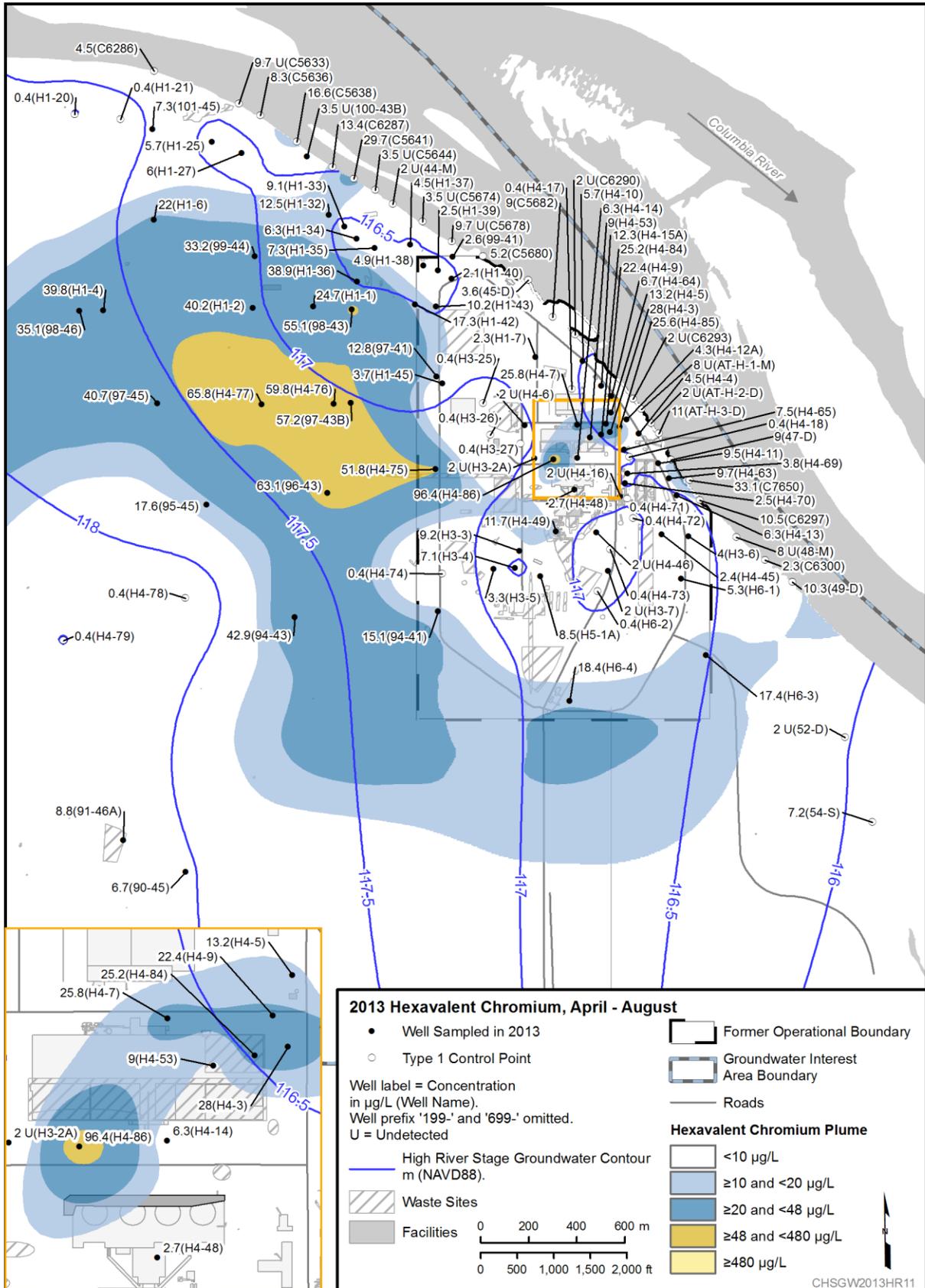


Figure HR.16 100-HR-H Hexavalent Chromium Plume, Spring/Summer 2013 (High River Stage)

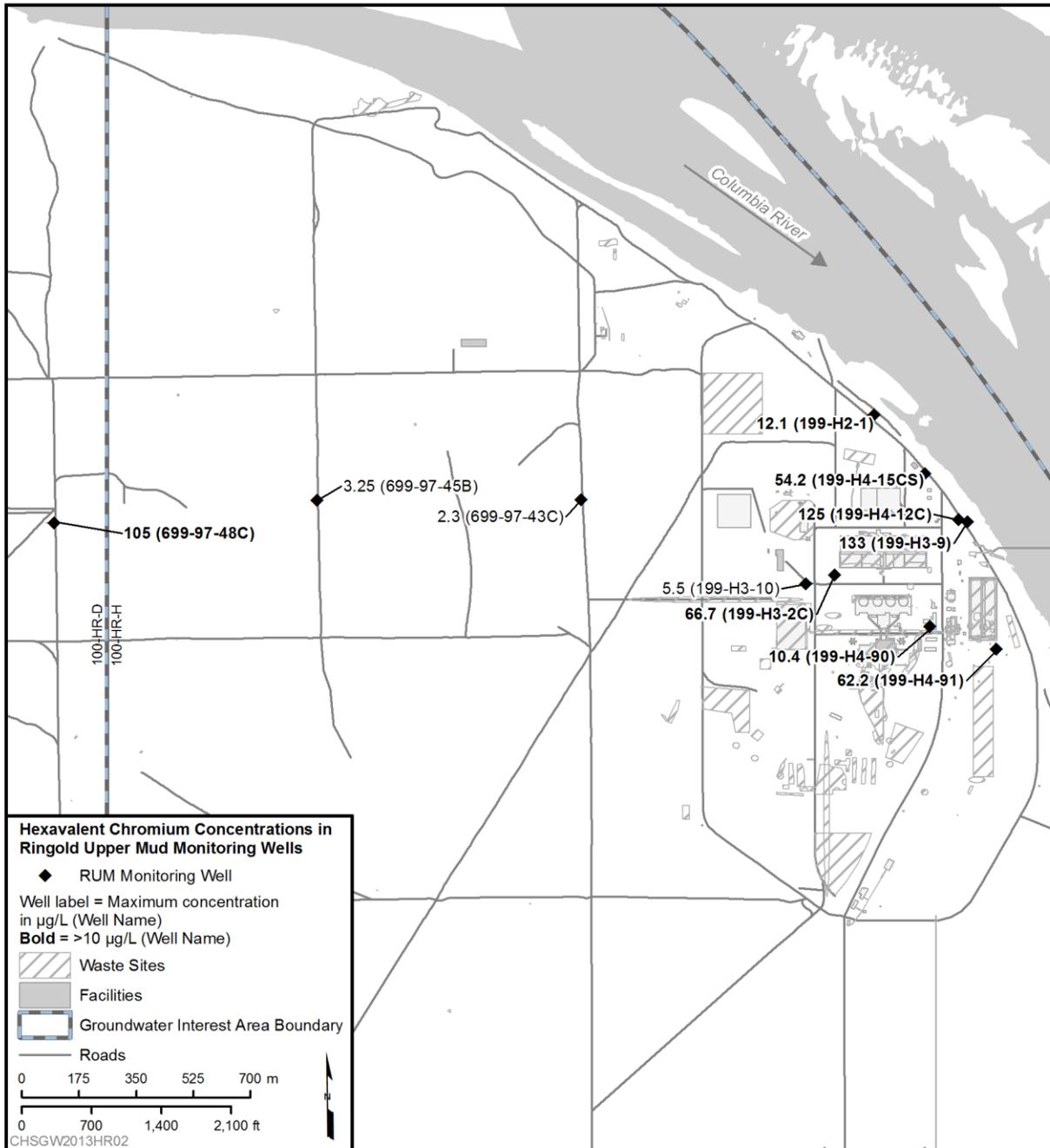


Figure HR.17 100-HR Hexavalent Chromium Concentrations in the RUM during 2013

Hexavalent Chromium in the Ringold Upper Mud (RUM). Hexavalent chromium has been detected in the first water bearing unit of the RUM in 100-H and the Horn. Concentrations near the river at 100-H range from below detection limits to $133 \mu\text{g/L}$ (well 199-H3-9). In the Horn, hexavalent chromium concentrations in the RUM have been increasing since 2008. The current distribution of hexavalent chromium in the RUM at 100-HR is shown in Figure HR.17. The groundwater conditions are summarized as follows (additional information is provided in Section 3.7.6 and 4.5.1 of DOE/RL-2010-95 Draft A):

- Hexavalent chromium concentrations declined slightly in 199-H4-12C and 199-H3-2C during 2013 (Figure HR.18). These two extraction wells are sampled for hexavalent chromium concentrations on a monthly (or more frequent) basis. Concentrations in well 199-H4-15CS have been declining since fall of 2011.

- Three additional RUM wells were installed in 2011 as part of the RI: 199-H2-1, 199-H3-9, and 199-H3-10. Hexavalent chromium concentrations in wells 199-H3-10 and 199-H2-1 remained below 15 µg/L, with concentrations in well 199-H3-9 ranging between 114 and 133 µg/L during 2013. Concentrations in well 199-H3-9 are consistent with those in nearby extraction well 199-H4-12C.
- Well 199-H4-90 and 199-H4-91 were installed in 2013 and completed in the first water bearing unit of RUM. Hexavalent chromium was analyzed during drilling, but a routine sampling event did not take place in 2013 due to well access limitations. Considering the relatively low concentrations of hexavalent chromium detected in characterization samples, initial results indicate that these wells represent the approximate southern extent of the RUM contamination. The wells will be sampled in 2014.
- Contamination within the first water bearing unit of the RUM is present near the Columbia River. This water bearing unit is connected to the HX system through well 199-H4-12C, an extraction well. Concentrations in this well remain fairly constant at about 120 µg/L, with a slow decline over time.
- A pump test plan is being developed to determine if the water-bearing units within the RUM are connected across the site, or are small isolated areas. This will also be used to determine if the Columbia River is being impacted by the confined aquifer.
- Three wells in the Horn Area monitor the first water-bearing unit in the RUM. Hexavalent chromium continues to be below the detection limit in Well 699-97-45B. In well 699-97-43C, hexavalent chromium is typically below detection limits; however there was a low level detection in 2013 of 2.30 µg/L.
- Concentrations in well 699-97-48C, located on the west side of the Horn, increased from 63 µg/L in 2012 to 105 µg/L in 2013, which exceeds the DWS of 100 µg/L . This well has a continuing increasing trend in concentrations. Well 699-97-48C is being evaluated for connection to the P&T system in 2014. The source of the contamination detected is likely attributed to the discharge to 116-DR-1&2 trench during the 1967 infiltration test.

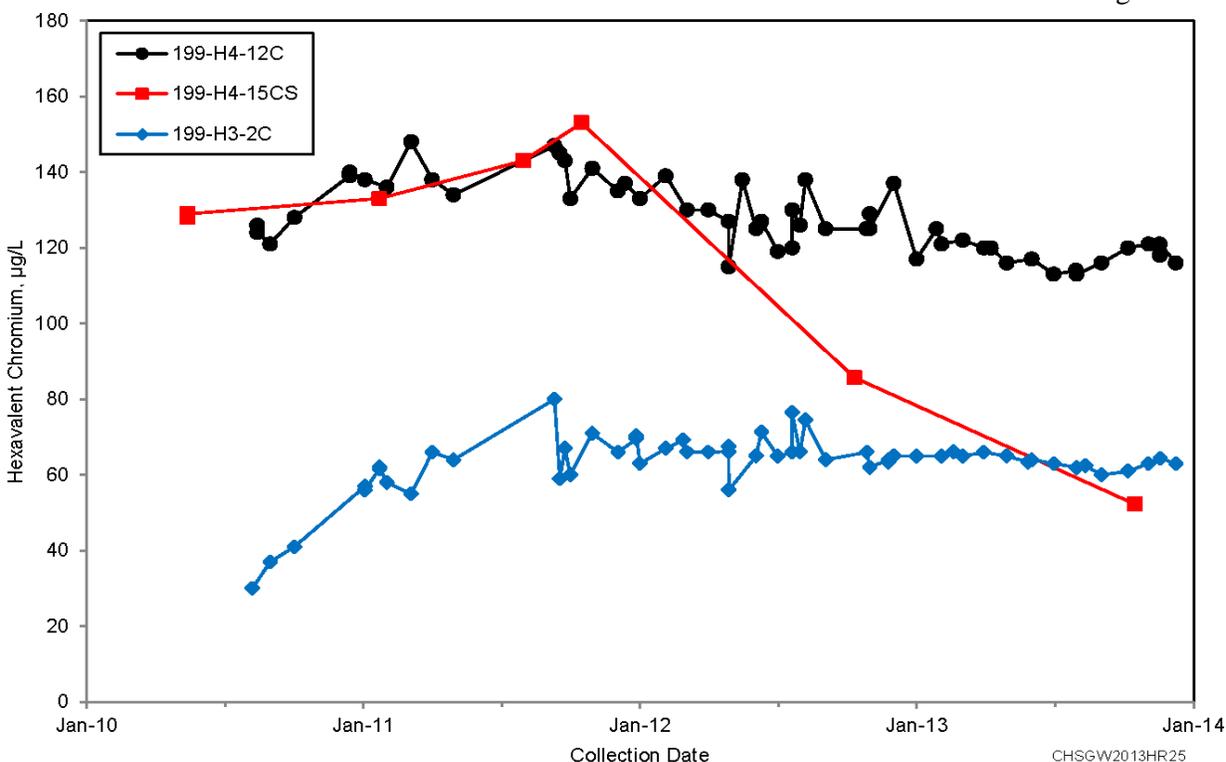


Figure HR.18 100-HR Hexavalent Chromium Data for Wells 199-H3-2C, 199-H4-12C, and 199-H4-15CS

100-HR Nitrate

Primary sources of nitrate in 100-HR included gas condensate from the reactors, septic systems and sewer lines, former agricultural practices, and waste sites that received nitric acid. Nitrate concentrations continued to exceed 45 mg/L DWS equivalent in 100-D groundwater. Historically, nitrate has been found above 45 mg/L in 100-H, however concentrations were below that level throughout 100-H in 2013. Nitrate is not found above the DWS equivalent in the Horn. Overall, the combined area of the nitrate plumes continued to decrease (Figure HR.7).

Nitrate contamination in 100-D was previously distributed in southern and northern plumes, similar to hexavalent chromium. As the expanded P&T system continued to operate in 2013, nitrate concentrations have slowly declined and the plume area above the DWS has contracted (Figure HR.19). Only small pockets continue to have concentrations above 45 mg/L. All are below 80 mg/L with most wells having concentrations below 55 mg/L. In 100-D, the highest nitrate concentrations are near well 199-D4-20 (just upgradient of the ISRM barrier in southern 100-D) and well 199-D8-97 (located in the north plume).

Figure HR.20 shows nitrate distribution in 100-H and the Horn. Nitrate concentrations did not exceed 45 mg/L in 100-H or the Horn during 2013. Areas in 100-H which have had elevated nitrate concentrations historically are near the 183-H solar evaporation basins. Well 199-H4-3 had a history of elevated nitrate concentrations, with maximum concentrations at more than 8,000 mg/L in 1978. Concentrations were below 45 mg/L from 2008 through 2010, but increased during low river stage following higher than normal groundwater elevations during the summers of 2011 and 2012 (Figure HR.21).

The concentrations in well 199-H4-3 are inversely correlated to groundwater elevations, with higher concentrations occurring during low river stage, which is consistent with a monitoring well location downgradient of a source area. Nitrate concentrations in 199-H4-3 ranged from 31.8 to 30.4 mg/L from January through April 2013, when the well was decommissioned for source area remediation. As a replacement to well 199-H4-3, new wells 199-H4-84 and 199-H4-85 were installed to monitor the contaminant concentrations in the vicinity of the 183-H Solar Evaporation Basins. Well 199-H4-85 had the highest measured nitrate concentration in 100-H, at a concentration of 37.5 mg/L in October 2013, with a seasonal pattern similar to that which was present at well 199-H4-3.

Nitrate concentrations in the RUM remain much lower than in the unconfined aquifer throughout 100-HR. Concentrations in 100-D remain near 2 mg/L, with concentrations in the Horn ranging from about 2 to 5 mg/L. In 100-H, nitrate concentrations have increased during 2013 in most of the RUM wells (Figure HR.22). The highest nitrate concentrations in the RUM at 100-H were found in well 199-H3-9 at 16.8 mg/L in October 2013, an increase from 8.2 mg/L in October 2012. Increases in other RUM wells were much smaller, with the typical increase being from 8 to 11 mg/L. While the concentrations remain well below 45 mg/L, the increasing trend will be monitored. Contamination in the RUM is associated with reactor operations.

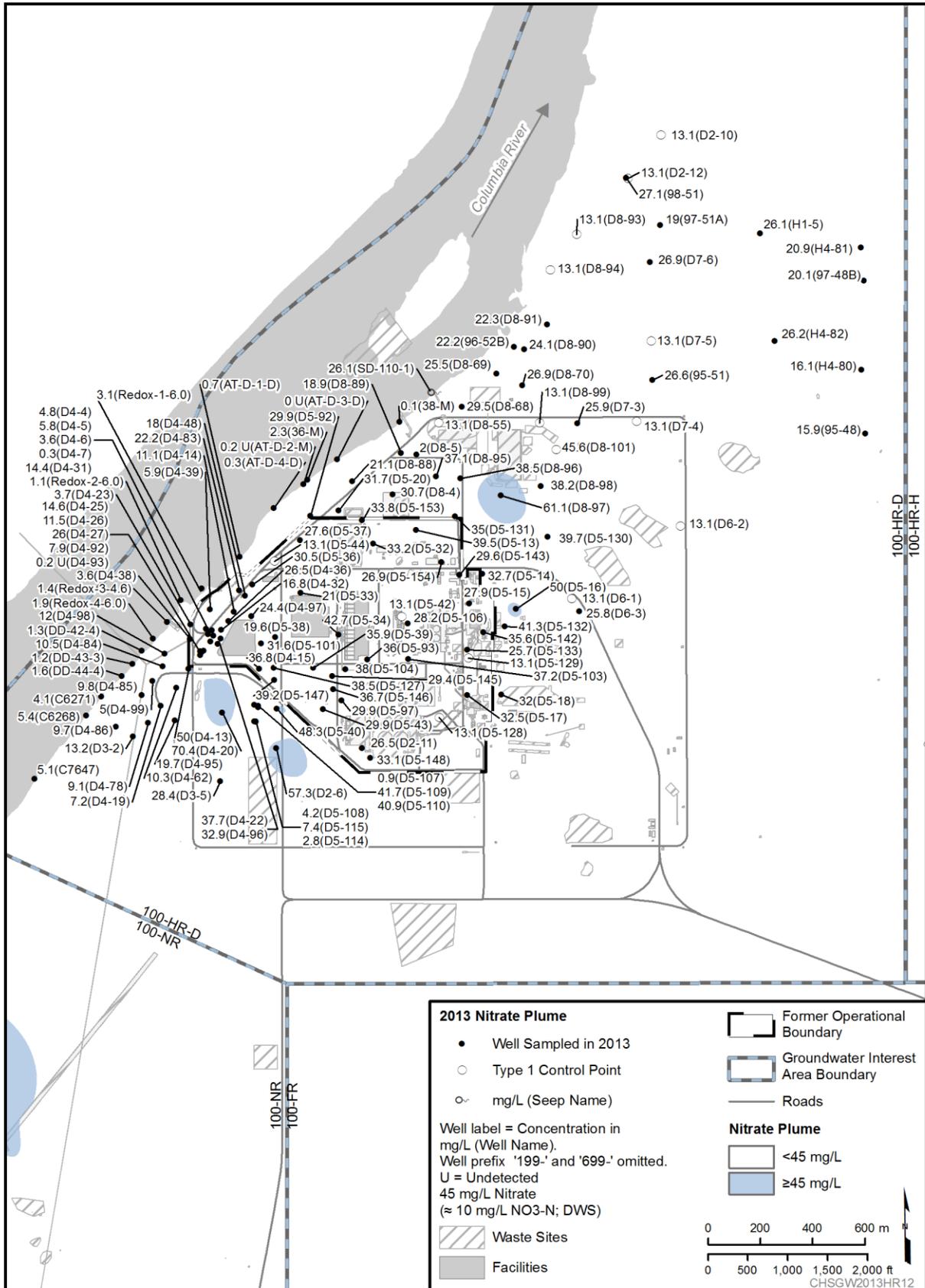


Figure HR.19 100-HR-D 2013 Nitrate Plume

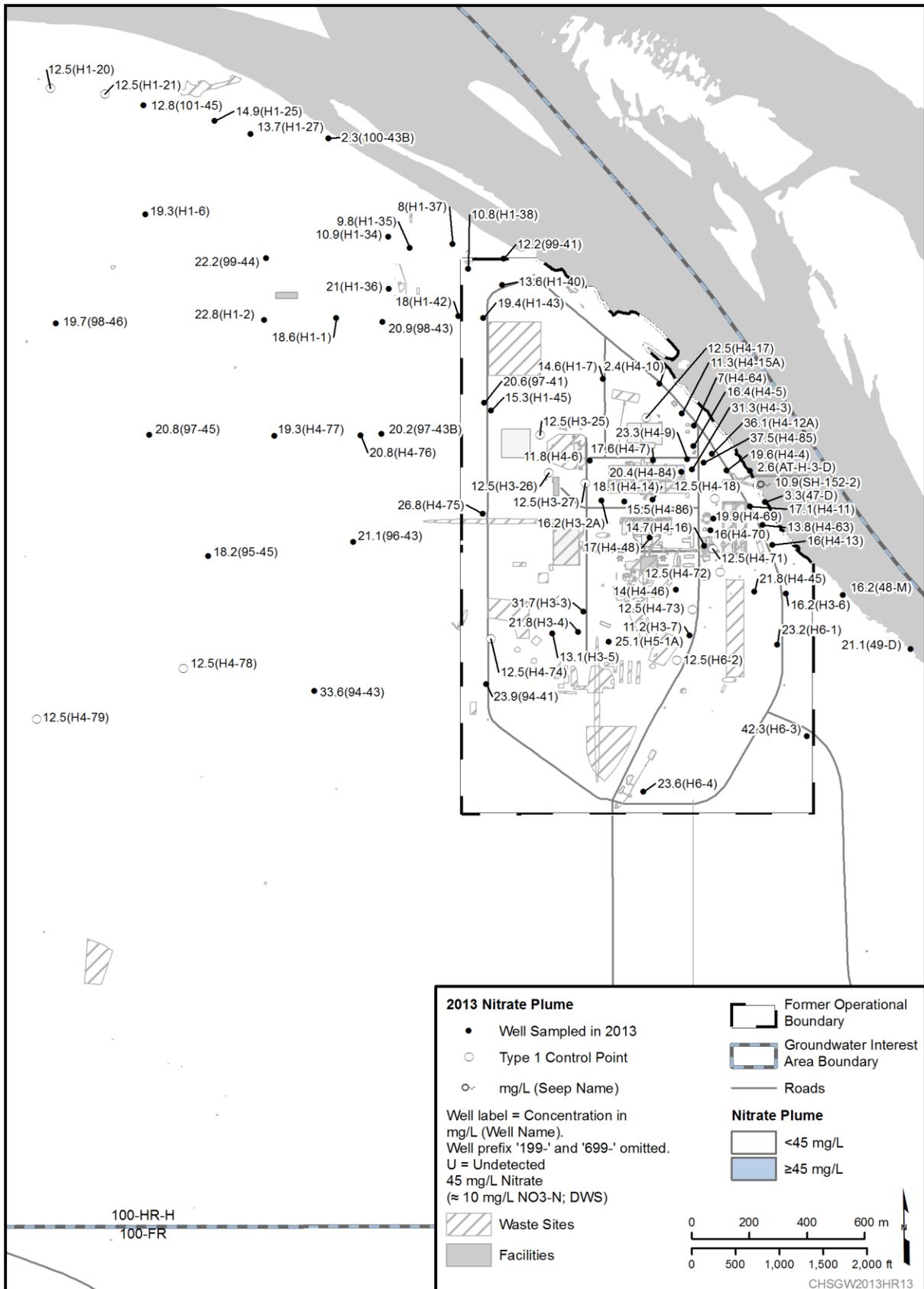


Figure HR.20 100-HR-H 2013 Nitrate Plume

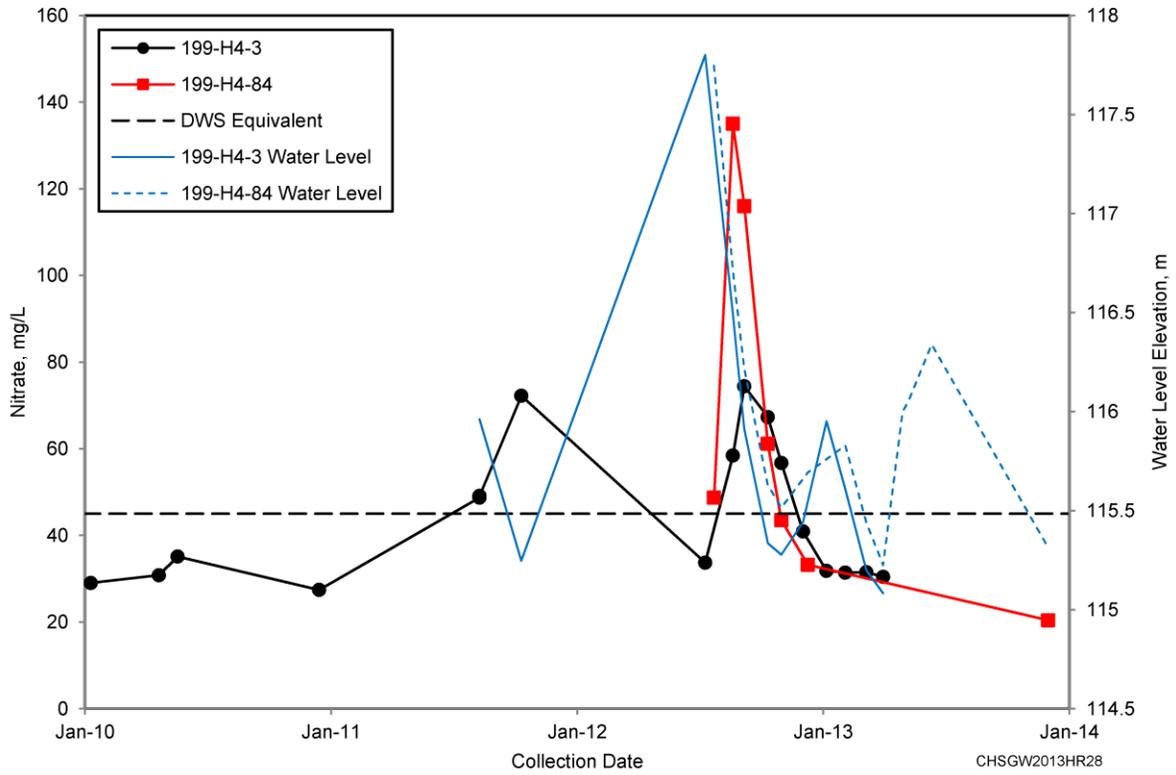


Figure HR.21 100-HR Nitrate Data for Wells 199-H4-3 and 199-H4-84

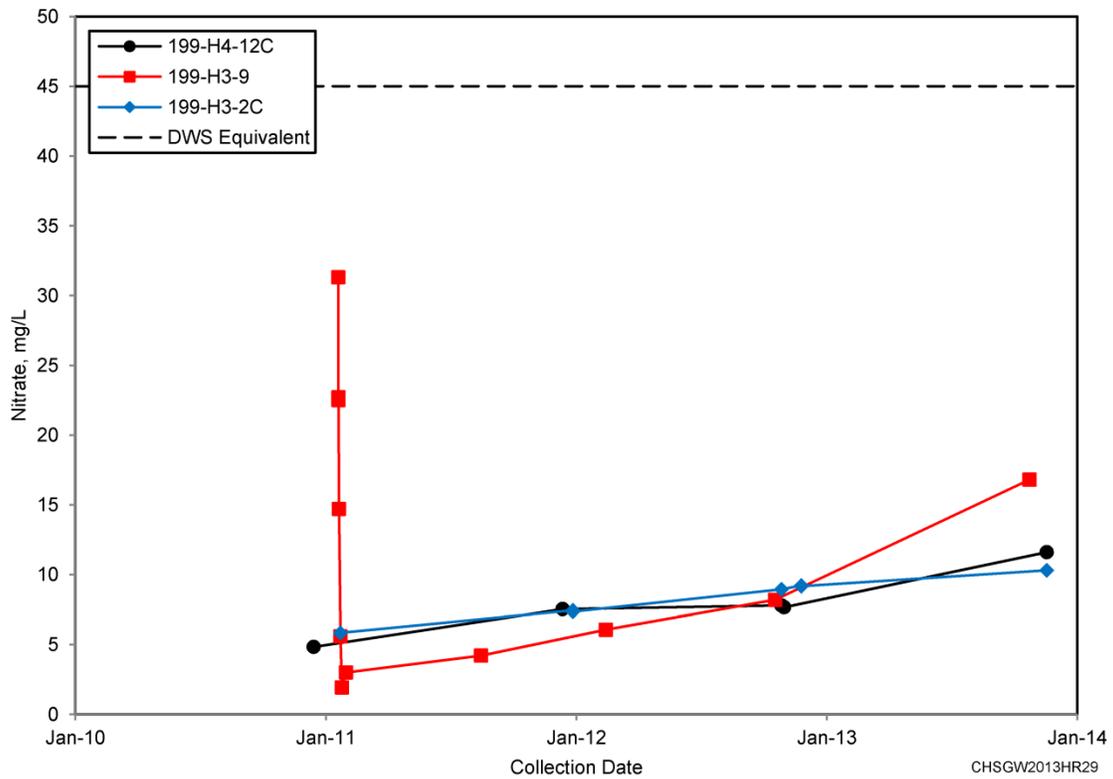


Figure HR.22 100-HR Nitrate Data for RUM Wells

100-HR Strontium-90

Strontium-90 was present in waste disposed of at both 100-D and 100-H. In 2013, concentrations in groundwater exceeded the 8 pCi/L DWS in two 100-D wells and in seven 100-H monitoring locations (Figures HR.23 and HR.24). Elevated strontium-90 is associated with isolated source areas in both 100-H and 100-D. Strontium-90 is not present in the Horn.

Strontium-90 is present in groundwater near the former fuel storage basin at the 105-D Reactor. Concentrations in the two wells with exceedances of 8 pCi/L, wells 199-D5-132 and 199-D5-142, were relatively stable throughout 2013, with concentrations at 26 to 30 pCi/L in well 199-D5-132 and 19 pCi/L in well 199-D5-142. Concentrations in both wells are consistent with the concentrations associated with well 199-D5-12 in 1999 (Figure HR.25) before the well went dry and was subsequently decommissioned.

To confirm that strontium-90 had not migrated from the source area, wells 199-D5-15, 199-D5-16, 199-D6-3, 199-D5-123, 199-D5-133, and 199-D5-140 were sampled in the spring of 2013. Analytical results show that the contamination remains localized, as expected with a lower mobility contaminant such as strontium-90. Strontium-90 was not detected in wells located a short distance from the source area (199-D5-16, 199-D5-133, 199-D5-140, and 199-D6-3). In well 199-D5-15, strontium-90 was detected at 1.10 pCi/L. Located closer to the source, well 199-D5-123 had a concentration of 4.70 pCi/L (minimum detectable activity of 1.1 pCi/L), but the concentration is still below the DWS of 8 pCi/L.

The area near the former retention basins in the northern 100-D Area also historically had strontium-90 detections in groundwater. Well 199-D8-68, near the former retention basins, had the highest concentrations in that area in 2013 at 7.6 pCi/L, which is slightly below the DWS of 8 pCi/L. Aquifer tube samples from the northern portion of 100-D were also analyzed for strontium-90 in fall 2013. A maximum activity level of 6 pCi/L was identified in aquifer tube DD-16-4, downgradient of the retention basins.

Strontium-90 concentrations in 100-H groundwater continue to exceed the DWS near the former 116-H-7 Retention Basin and 116-H-1 Trench (Figure HR.26), located near the Columbia River. All seven monitoring locations with exceedances (wells 199-H4-11, 199-H4-63, 199-H4-13, 199-H4-45, 199-H3-6, 47-D, and 47-M) are located in these two areas. Concentrations in monitoring wells near the retention basin and trench continue to exceed the DWS, but remain fairly stable, with a slight decrease overall trend over time. Concentrations in downgradient aquifer tubes 47-D and 47-M (essentially co-located, only 47-D is shown on the figure) also exceeded the DWS with concentrations of 14.0 and 9.9 pCi/L, respectively (Figure HR.24). The strontium-90 concentrations in Seep 152-2, located slightly downriver from aquifer tubes 47-D and 47-M, are consistent with a value of 5.43 pCi/L. As compared to 2012, there was relatively little change in plume shape or concentrations at 100-H. The highest strontium-90 concentration detected in 2013 was 30 pCi/L in well 199-H4-13.

None of the RUM wells are located within the footprint of the 100-H or 100-D strontium-90 plume where concentrations are greater than 8 pCi/L (DWS). However, strontium-90 was detected at levels just above the minimum detectable activity of 0.9 to 2.5 pCi/L in several RUM wells: 199-H2-1, 199-H3-2C, 199-H3-9, 199-H3-10, and 199-H4-90, and is further discussed in Section 4.5 of DOE/RL-2010-95 Draft A. These results are consistent with historical data, with only low level detections present. There were no other detections of strontium-90 in the RUM.

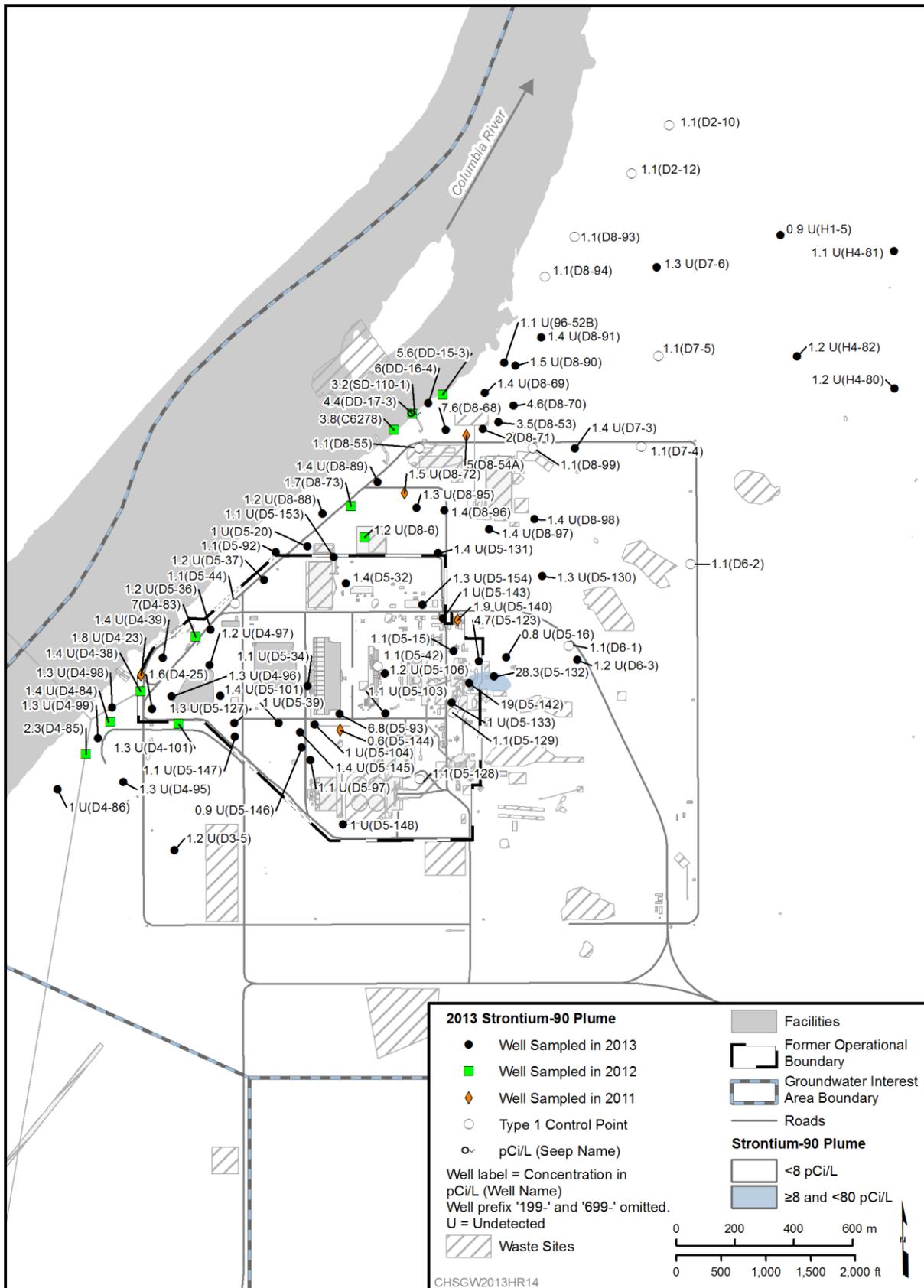


Figure HR.23 100-HR-D 2013 Strontium-90 Plume

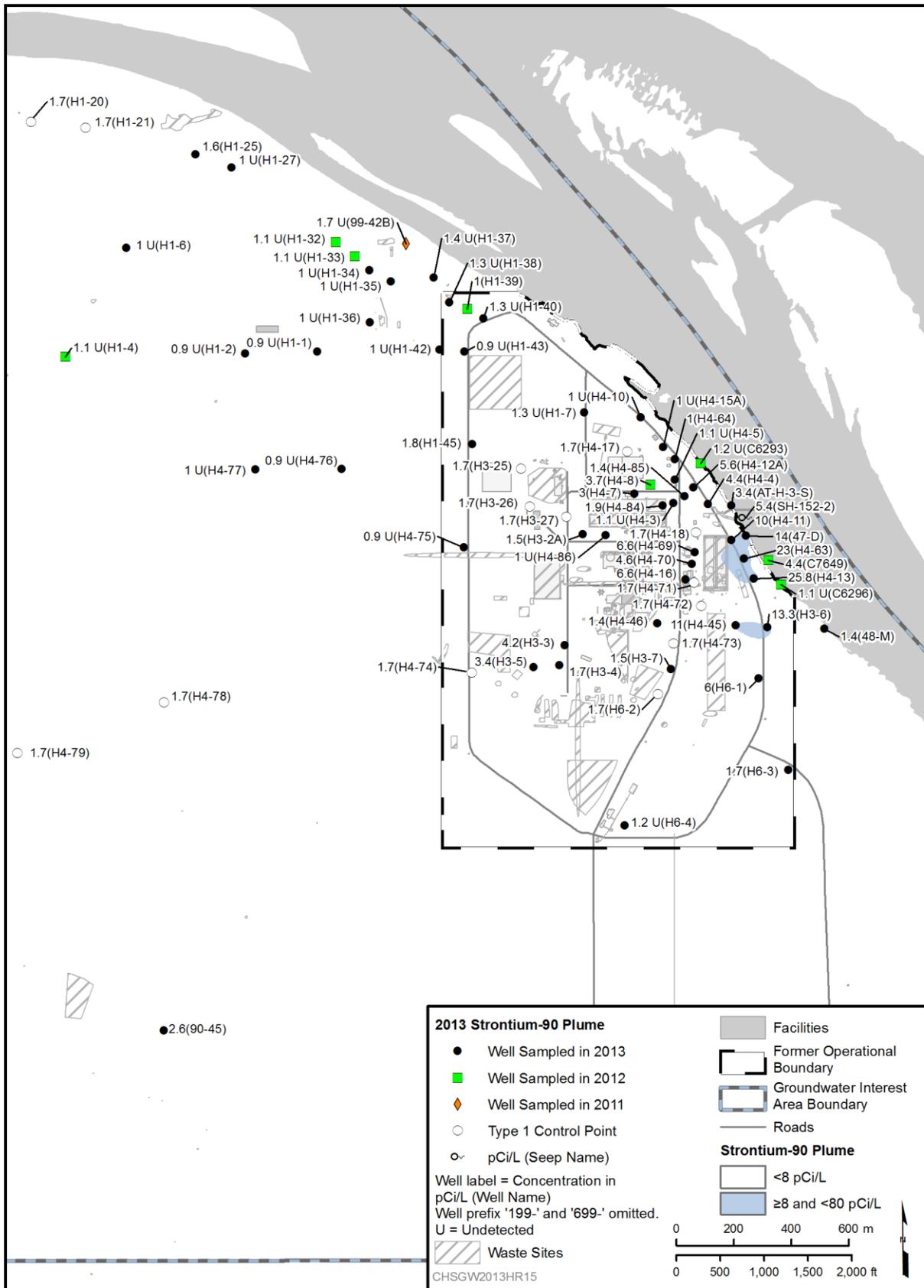


Figure HR.24 100-HR-H 2013 Strontium-90 Plume

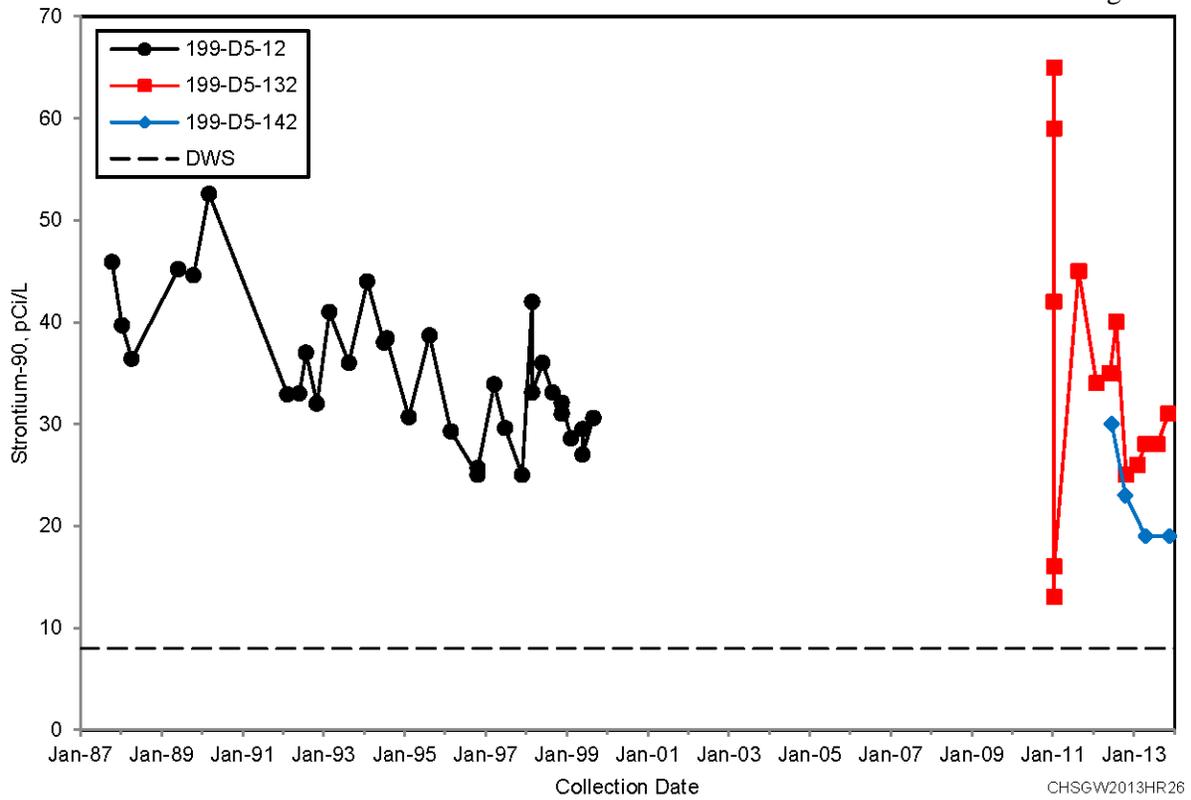


Figure HR.25 100-HR Strontium-90 Data in Wells 199-D5-12, 199-D5-132, and 199-D5-142

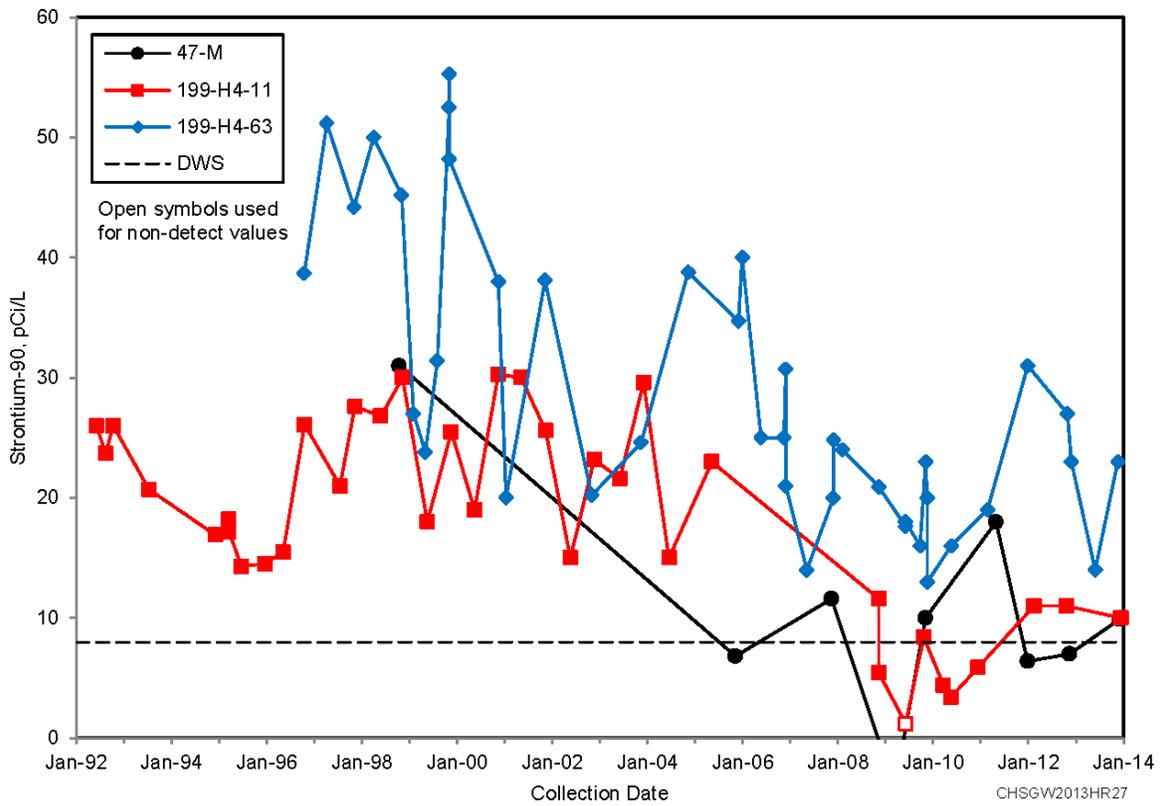


Figure HR.26 100-HR Strontium-90 Data in Wells near 116-H-1 and 116-H-7

100-HR Remedy Summary

Both active (groundwater P&T; Figure HR.27) and passive (ISRM; Figure HR.28) interim remedial actions continued to address hexavalent chromium contamination with the 100-HR-3 OU. DOE has been operating a groundwater P&T system in the 100-HR-3 OU since 1997, under an interim remedial action ROD ([EPA/ROD/R10-96/134](#)), which was amended in 2000 ([EPA/AMD/R10-00/122](#)). The initial pump-and-treat systems consisted of DR-5 and HR-3, which were replaced by DX and HX in 2010 and 2011.

A summary of 2013 operations is provided in Table HR.2. Two P&T systems currently operate at 100-HR-3: DX and HX. These facilities were constructed in response to an Explanation of Significant Difference (ESD) ([EPA et al., 2009, Explanation of Significant Differences for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision: Hanford Site Benton County, Washington](#)), which expanded the capacities of the P&T system and replaced the existing older DR-5 and HR-3 systems. These systems are described in previous P&T reports (e.g., [DOE/RL-2010-11](#)). Additional information on P&T system operations is provided in DOE/RL-2014-45.

Table HR.2 Summary of 2013 Pump-and-Treat		
Groundwater Operable Unit	100-HR-3	
Pump-and-Treat System	DX	HX
Design Capacity (liters per minute [gpm])	2,271 (600)	3,028 (800)
Extraction Wells	41	31
Injection Wells	14	15
Average Flowrate (liters per minute [gpm])	2,131	2,408
	(563)	(636)
Volume Treated (million liters [million gallons])	1,120	1,266
	(296)	(334)
Cr(VI) Mass Removed (kg)	293.9	27.5
Average Cr(VI) Influent Concentration (µg/L)	260	25.2
Average Cr(VI) Effluent Concentration (µg/L)	<2	<2

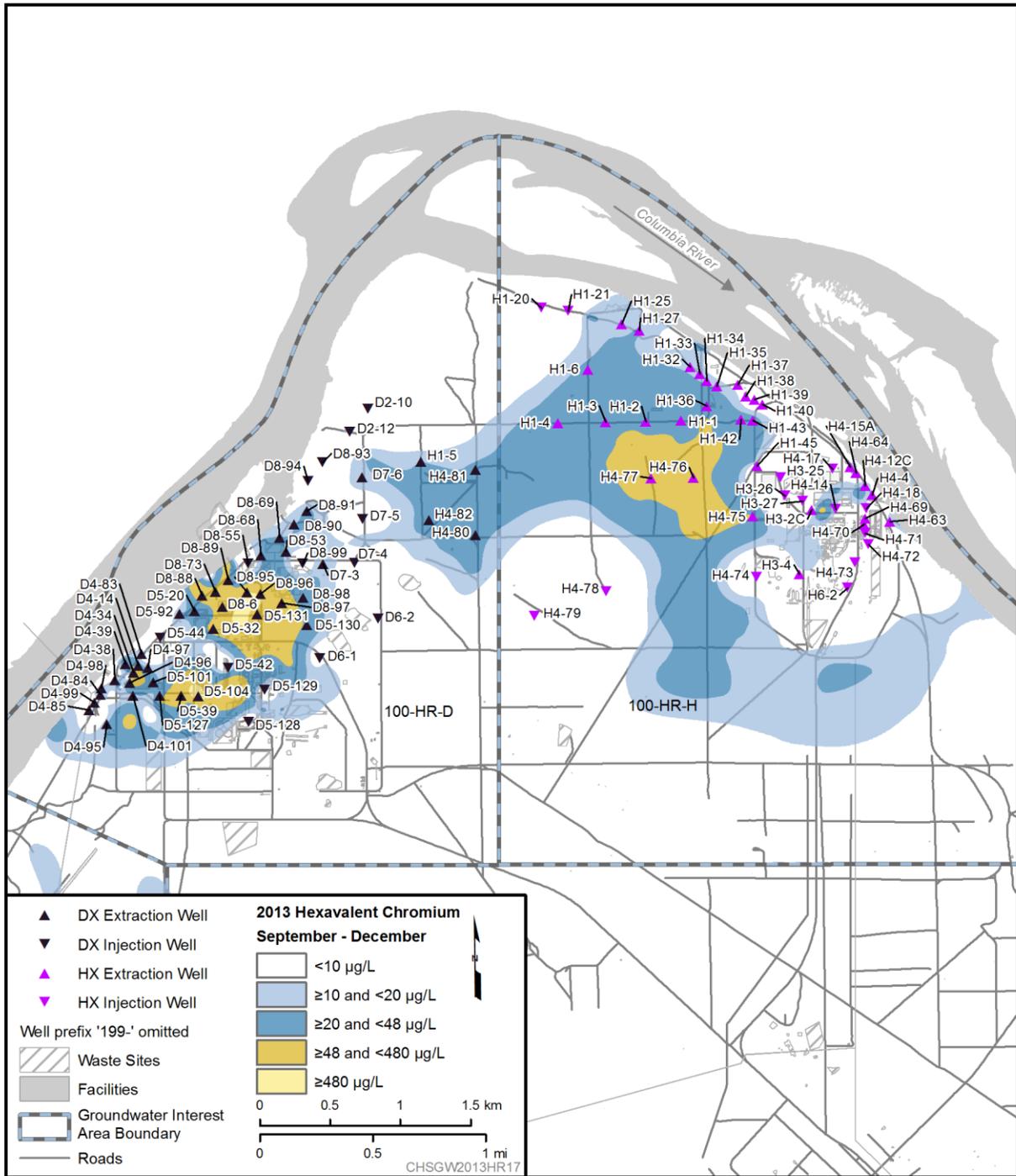


Figure HR.27 100-HR-3 Remedy Overview

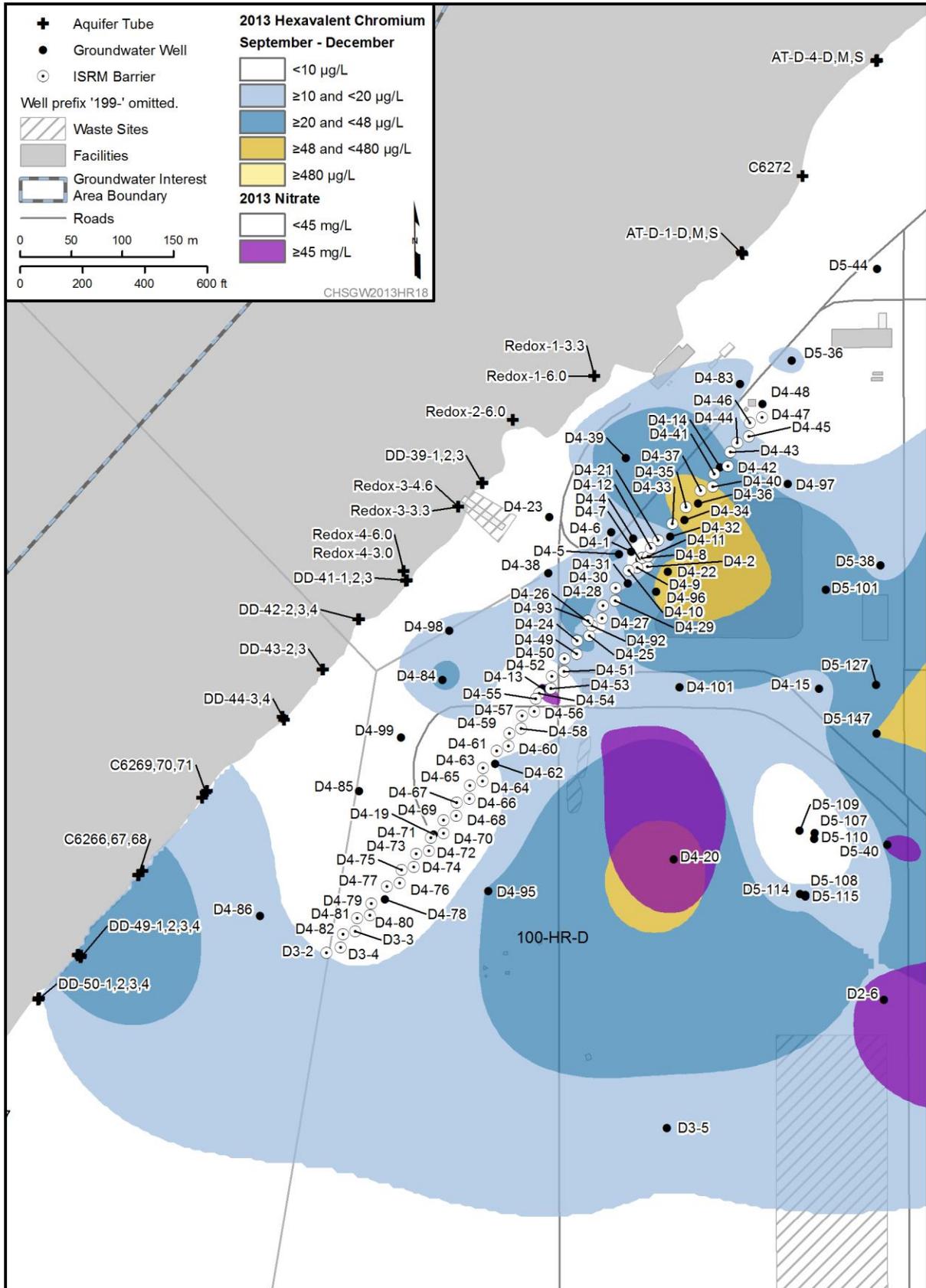


Figure HR.28 100-HR-3 ISRM Barrier

100-HR Pump-and-Treat

In 2013 there were a total of 72 extraction wells and 29 injection wells in use, with one injection well (199-H4-14) being decommissioned during the year to allow for waste site remediation. The combined systems removed 386 kilograms of hexavalent chromium from groundwater. Figure HR.29 presents the mass removed by system. From 1997 through 2013, the 100-HR-3 P&T systems removed 2,038 kilograms of chromium from the aquifer. Over half of this mass was removed by the DX system, which started operations in December 2010.

The DX facility (Figure HR.27), with a treatment capacity of 2,300 L/min (600 gallons per minute [gpm]), became operational in December 2010. As a result, the 189 L/min (50 gpm) capacity DR-5 P&T system went offline in March 2011. Extraction and injection wells formerly connected to the DR-5 P&T system were disconnected and transferred to the new DX P&T system, with the exception of former extraction wells 199-D8-72 and 199-D8-54A, which at the time of conversion were not needed for the DX P&T well configuration. Both of these wells were converted to monitoring wells.

The HX facility, with a treatment capacity of 3,000 L/min (800 gpm), became fully operational in October 2011. Two extraction wells, 199-D8-53 and 199-D8-68, were connected to the DX P&T system in 2013. Two other extraction wells that were previously part of the now decommissioned DX P&T system, 199-D8-54A and 199-D8-72, were converted to monitoring wells. Former injection well 199-H4-7 was not connected to the HX P&T system because it is not needed for the HX P&T well configuration, and was subsequently decommissioned to allow for remediation of the 128-H-1 waste site. Additional P&T system modifications were conducted in 2013 as part of the ongoing optimization of the system with the goal of accelerating cleanup.

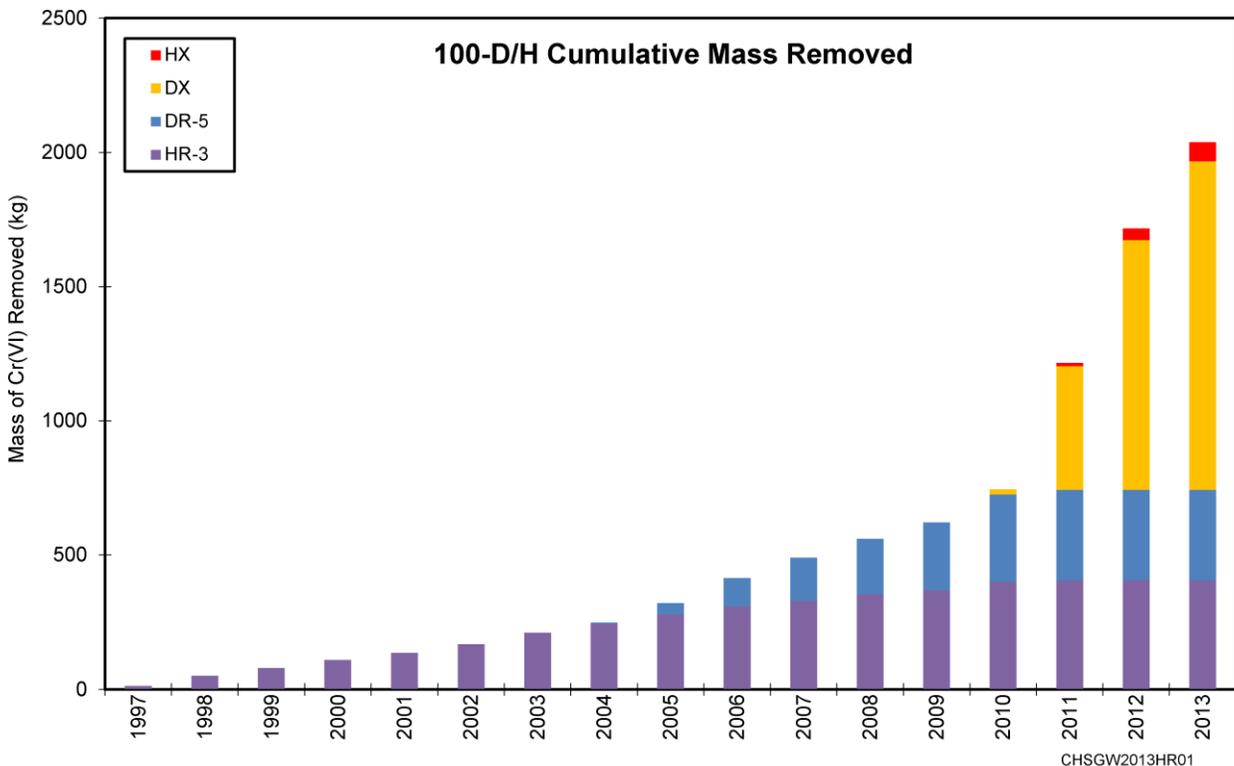


Figure HR.29 100-HR-3 Pump-and-Treat Mass Removal

The hexavalent chromium mass removed during 2013 was less than in 2012. This is a result of ongoing source area remediation (primarily related to contaminated soil removal for the 100-D-100 and 100-D-104 waste sites) and P&T operations. During the first year of operations, the concentrations in the heart of the 100-D south plume were reduced dramatically, reducing the amount of mass remaining in the aquifer. This trend is expected to continue before a reduction in the footprint of the plume is significantly reduced. Most of the mass removed from the DX and HX systems originated in the interior of the plumes; the areal extent of the plumes, as defined by the 10 µg/L contour, did not change significantly in 2013.

In 2012, several areas along the river were identified as having potential to be impacted by hexavalent chromium ([DOE/RL-2013-13](#)). As a result, refinement of the P&T systems in 2013 was targeted and initiated in those areas. In 100-D, wells 199-D5-153 and 199-D5-154 were drilled to increase capture and mass removal of the northern plume (Figure HR.1). Connection of these wells to the P&T system as extraction wells is planned for 2014. Wells 199-D5-146 and 199-D5-148 were installed in 100-D south to improve contaminant mass recovery near the 100-D-100 waste site. Realignment in 100-D included connection of wells 199-D4-14 and 199-D4-34 as extraction wells along the ISRM barrier, and connection of wells 199-D8-53 and 199-D8-68 as extraction wells on the northern end of 100-D area. The results of the system modifications were not yet apparent in 2013 along the 100-D north area. Operation of remediation systems and groundwater monitoring results are described in DOE/RL-2014-45.

100-HR ISRM Barrier

Additional cleanup action was taken using an in situ chemical treatment technology in 2000 (Figure HR.28). Use of this new technology was approved by the 1999 interim ROD amendment ([EPA/AMD/R10-00/122](#)). Rather than pumping contaminated groundwater to the surface for treatment, this technology treats the groundwater in the aquifer by reducing hexavalent chromium to trivalent chromium, which is a much less toxic and less mobile form. Due to breakthrough of contaminants at the ISRM barrier, a notice of non-significant change to the ROD was issued in 2010, which indicated that the barrier would no longer be actively maintained ([11-AMCP-0002](#)). The notice of non-significance shifted the groundwater remedy at the ISRM barrier to the P&T system. Groundwater at the ISRM site is still monitored, however, as part of CERCLA interim action monitoring, with hexavalent chromium as the target contaminant. In addition, where it is still effective, the barrier treatment process reduces oxygen content in the aquifer; consequently, dissolved oxygen is also monitored.

In 2013, the ISRM barrier continued to convert some hexavalent chromium to a nontoxic, immobile form (trivalent chromium) in the southern portion of the barrier. The dissolved oxygen profile near the ISRM treatment zone is generally characterized by relatively high dissolved oxygen concentrations upgradient of the treatment zone, decreasing significantly through the treatment zone, and recovering to higher dissolved oxygen concentrations as groundwater flow approaches the river. However, dissolved oxygen levels have been increasing across the length of the barrier and hexavalent chromium concentrations in the downgradient extraction wells are also increasing. This indicates that the barrier is becoming less effective.

Groundwater samples collected from some wells in the ISRM barrier in 100-D contain concentrations of gross beta above 50 pCi/L, which is the level where additional monitoring is required. This gross beta activity is primarily caused by naturally present potassium-40 in the pH buffer that was used during injection of sodium dithionite (Section 2.5 of [PNNL-13116](#)). The highest gross beta concentration associated with the ISRM barrier in 2013 was 74 pCi/L in well 199-D4-19. Concentrations in barrier wells have declined from the peak levels seen in 2001 or 2002, a concentration of 466 pCi/L gross beta in well 199-D4-19 in 2002 associated with high tritium levels. Additional monitoring details are provided in DOE/RL-2014-45.

100-HR-H RCRA

The 183-H Solar Evaporation Basin site is a RCRA Treatment Storage and Disposal (TSD) unit that consisted of four basins. The basins were originally part of the larger 183-H water treatment facility which had 12 additional basins. Following decommissioning of the water treatment facility, the four remaining basins were used to evaporate various liquid waste streams, including neutralized, spent acid etch solutions containing technetium-99 and uranium from the 300 Area fuel fabrication facilities. The basins were used for waste evaporation from July 1973 until November 1985, demolished in 1995 and contaminated soil was removed from the surface to a depth of 7.6 meters (25 feet) below ground surface beneath the site in 1996.

Groundwater protection was demonstrated through modeling and a modified RCRA closure (soil) was approved in 1997. Clean closure of the site was not achieved because fluoride and nitrate levels in soil below the 4.6 meters-deep excavation exceed the “Model Toxics Control Act–Cleanup” ([WAC 173-340](#)) Method B cleanup levels for groundwater protection. Therefore, the unit was closed under the modified-closure option, with specified measures for post-closure care.

The Hanford Facility RCRA Permit ([WA7890008967](#)) requires semi-annual groundwater monitoring of the facility. Sampling was scheduled at wells 199-H4-3, 199-H4-8, 199-H4-12A, and 199-H4-12C for total chromium, fluoride, nitrate, technetium-99, and uranium (Figure HR.30). In early 2013, DOE modified the permit, with approval from Ecology, to replace well 199-H4-3 with 199-H4-84 in the RCRA permit (13-NWP-051). Monitoring well 199-H4-3 was decommissioned in April 2013 and replaced in the permit by well 199-H4-84. Although not regulated under RCRA, technetium-99 and uranium were included in the monitoring plan as indicators and were incorporated by reference in the Hanford Facility RCRA Permit ([WA7890008967](#)).

In 2013, the RCRA wells were generally sampled as scheduled for the constituents of interest listed in the groundwater monitoring plan ([PNNL-11573](#); Tables B-12 and B-14, Appendix B). Samples from well 199-H4-8 were scheduled for collection on an annual basis. During 2013, water levels in well 199-H4-8 dropped to below the pump intake level and the well was unable to be sampled. Another attempt to sample the well following lowering of the pump was also unsuccessful. As a result, to ensure a sample was collected, samplers used a smaller pump and collected the sample with a low flow rate and had bailers available if that method was not successful. A sample was obtained in early 2014.

An electrical problem at the well head at monitoring well 199-H4-84 resulted in a “stop work”, with sampling suspended at that well and other wells with a similar pump configuration. This resulted in well 199-H4-84 being unavailable for sampling for several months. The problem was resolved; however the sample was not collected until December 2013 instead of its regularly scheduled November event.

The concentrations of nitrate, fluoride, and technetium-99 remained below applicable concentration limits in all of the RCRA wells in 2013, including 199-H4-3 and its replacement 199-H4-84.

Uranium exceeded the permit concentration limit (20 µg/L) in well 199-H4-84 in June 2013, with a concentration of 21.20 µg/L, but did not exceed the 30 µg/L DWS. The elevated uranium concentration in well 199-H4-84 coincided with the high water level in that well. Analytical results from the December monitoring event were at 2.94 and 2.87 µg/L for the unfiltered and filtered samples, respectively, indicating that the higher concentrations were a transient condition. The fluctuations of uranium above the concentration limit do not represent non-compliance with the RCRA Permit because the unit is already in corrective action in accordance with the permit and [WAC 173-303-645](#)(11). Uranium was not detected above 20 µg/L in any of the other RCRA wells.

Total chromium continued to exceed the 122 µg/L permit concentration limit in 199-H4-12C, which monitors the first water-bearing unit within the RUM. The exceedance of the CERCLA remedial action objectives (RAOs) (20 µg/L) and permit concentrations (122 µg/L) in 199-H4-12C were addressed by

connecting the well to the P&T system in 2009. Because none of the other 183-H Basin co-contaminants were elevated in 199-H4-12C, total chromium in this well is from historical releases at other sources, not releases from the 183-H Solar Evaporation Basin. Hexavalent chromium in 199-H4-12C fluctuated from just above to just below the permit limit of 122 µg/L in 2013. Filtered sample results of total chromium from November 2013 at well 199-H4-12C were out of trend (low) and did not agree with hexavalent chromium results or the unfiltered sample results. The data have been reviewed and were flagged as suspected errors.

DOE submitted two semiannual reports to Ecology, as required under RCRA corrective action monitoring ([SGW-56519](#); [SGW-56886](#), *Post-Closure Corrective Action Groundwater Monitoring Report for the 183-H Solar Evaporation Basins and the 300 Area Process Trenches*) for the 183-H Solar evaporation Basins. The unit will remain in corrective action until the groundwater contamination is remediated under RCRA.



Figure HR.30 100-HR RCRA Facility 183-H Monitoring Well Locations