

# **100-HR**

## 100-HR Overview

Groundwater in 100-HR was contaminated by waste releases associated with past operation of the deactivated D, DR, and H Reactors and from associated support facilities. At the end of 2012, approximately 70 percent of the waste sites were classified as closed, interim closed, no action, not accepted, or rejected. 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. Additional details about 100-HR-3 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](#), *Remedial Investigation/Feasibility Study for 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*).

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 nearly 0 to 12 meters across the area. 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 RUM (*Hydrogeological Summary Report for 600 Area Between 100-D and 100-H for the 100-HR-3 Groundwater Operable Unit* [[DOE/RL-2008-42](#)]). The uneven surface of the silt- and clay rich Ringold Formation upper mud unit (RUM) forms the base of the unconfined aquifer.

The unconfined aquifer is primarily present in the Ringold Formation unit E sand and gravels in 100-D and in the Hanford formation gravels in 100-H (Figure HR.1). 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. Areas where Ringold unit E is absent form channels across the Horn, resulting in preferential groundwater flow pathways.

Groundwater in 100-HR-3 flows generally to the east-northeast direction, from 100-D across the Horn to 100-H (Maps HR.1 and HR.2). Flow in 100-H is easterly, 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 flatter during high river stage when compared to low river conditions. Operation of pump-and-treat (P&T) systems at 100-HR-3 has created localized changes in groundwater flow direction and velocity throughout 100-HR-3. These changes are expressed as local depressions and mounds in the water table, affecting the local flow direction and gradient (Maps HR.1 and HR.2).

Daily and seasonal fluctuations in the river stage (Figure HR.2) also affect groundwater flow in 100-HR-3. 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 effect of river water migrating into the aquifer can cause lower contaminant concentrations in aquifer tubes and in some near-river wells. Seasonal changes in hexavalent chromium concentrations caused by mixing with river water are most evident at locations within a few meters of the shoreline. 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 relative to daily fluctuations.

Contaminants of concern in the 100-HR-3 unconfined aquifer were identified in the RI/FS and include hexavalent chromium, nitrate, strontium-90, and uranium. In the first water bearing unit within the RUM in the 100-H and Horn areas, the contaminant of concern is hexavalent chromium. Monitoring, extraction and injection wells, and aquifer tubes monitored in 100-HR-3 are shown on Maps HR.1 and HR.2.

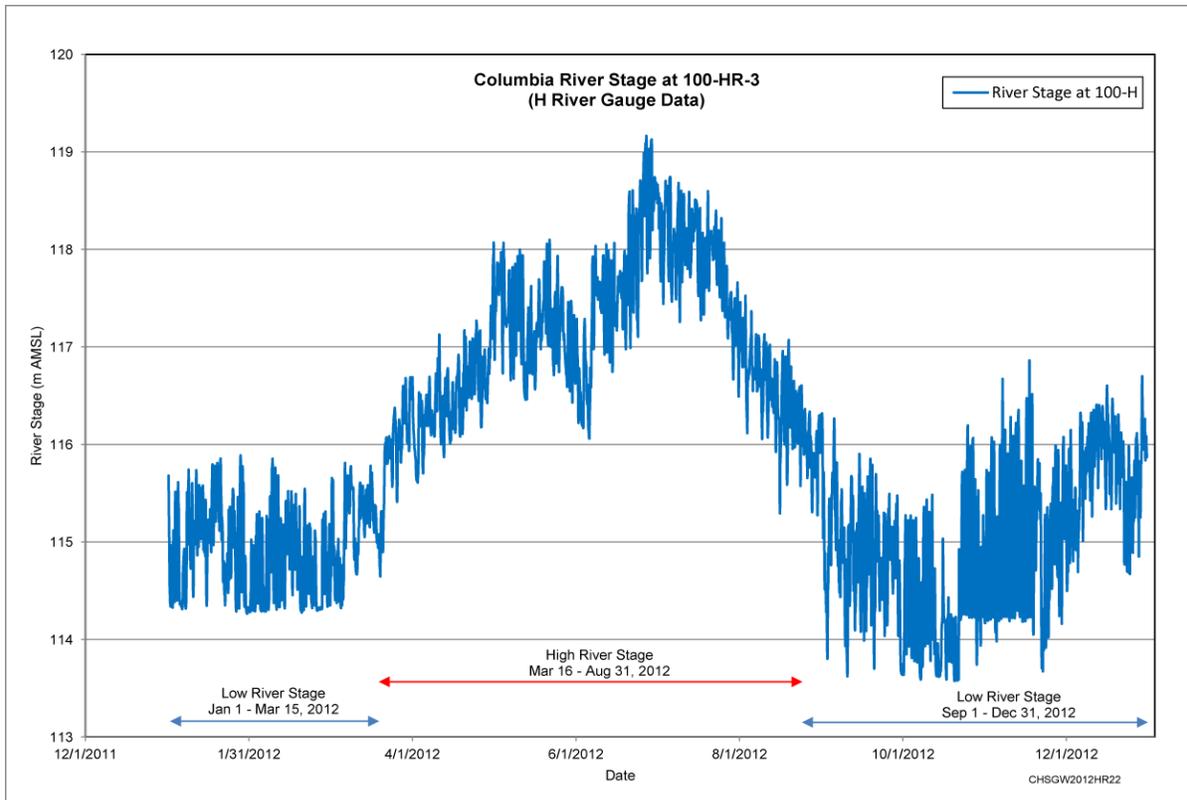
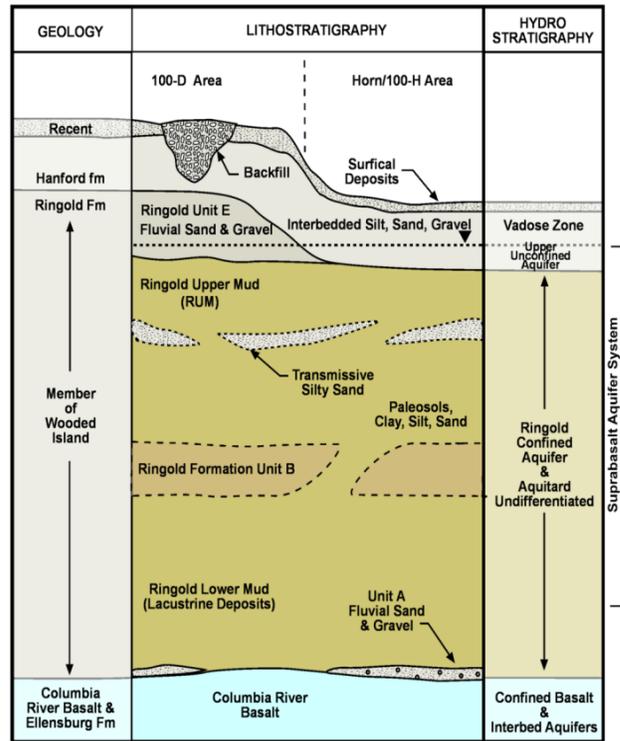
Other contaminants of interest within 100-HR-3 include technetium-99, sulfate, and tritium. Technetium-99 and uranium have historically been detected in 100-HR-3 groundwater downgradient from their source (the 116-H-6 [183-H] Basins). Sulfate previously exceeded the 250 mg/L secondary drinking water standard in wells within and downgradient of the In Situ Redox Manipulation (ISRM) barrier in 100-D because of injections of sodium dithionite solution.

**Table HR.1 100-HR-3 at a Glance**

Reactor Operations: D 1944-1967; DR 1950-1964; H 1949-1965				
2012 Groundwater Monitoring				
Contaminant	Water Quality Standard	Maximum Concentration	Plume Area <sup>a</sup> (km <sup>2</sup> )	Shoreline Impact (m)
Hexavalent Chromium	20 µg/L <sup>b/</sup>	22,400 (199-D5-122)	4.1 <sup>c</sup>	55 <sup>c</sup>
Nitrate	45 mg/L	135 (199-H4-84)	0.34	0
Strontium-90	8 pCi/L	40 (199-D5-132)	0.03	30
Remediation				
Waste Sites (interim action): >70 percent complete <sup>d</sup> Groundwater (interim action for hexavalent chromium):				
<ul style="list-style-type: none"> <li>• HR-3 pump-and-treat: 1997-2011, removed 406 kg</li> <li>• DR-5 pump-and-treat: 2004-2011, removed 338 kg</li> <li>• DX pump-and-treat: 2010-2012, removed 931 kg</li> <li>• HX pump-and-treat: 2011-2012, removed 43 kg</li> <li>• In Situ Redox Manipulation barrier: 1997-2012</li> </ul>				
Final ROD anticipated in 2014.				

- 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. 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.
- d. Sites with status closed, interim closed, no action, not accepted, or rejected.

**Figure HR.1 100-HR Geology**



**Figure HR.2 Columbia River Stage at 100-HR-3**





## 100-HR CERCLA Activities

CERCLA groundwater activities in 100-HR-3 included groundwater monitoring, operation of interim remediation systems for hexavalent chromium, and submittal of RI documents. CERCLA groundwater sampling includes monitoring for interim remedial action effectiveness, and monitoring wells throughout 100-HR-3 to track plumes, plume areas (Figure HR.3), and concentration trends. Wells sampled during 2012 are shown on Maps HR.3 and HR.4.

### Remedial Investigation/Feasibility Study

In 2010 and 2011, DOE conducted extensive field studies as described in an RI/FS work plan addendum ([DOE/RL-2008-46-ADD1](#), *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 1: 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*) and sampling and analysis plan ([DOE/RL-2009-40](#), *Sampling and Analysis Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study*). Changes to the sampling and analysis plan were documented in Tri-Party Agreement Change Notices ([TPA-CN-460](#), *Tri-Party Agreement Change Notice Form: DOE/RL-2009-40 Sampling and Analysis Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study, Rev. 0*; [TPA-CN-368](#), *Tri-Party Agreement Change Notice Form: DOE/RL-2009-40, Sampling and Analysis Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study, Rev. 0*).

The RI/FS results were evaluated, and DOE submitted Draft A of the RI/FS and Proposed Plan for 100-D/H in 2012 ([DOE/RL-2010-95](#); [DOE/RL-2011-111](#), *Proposed Plan for Remediation of the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*). The RI/FS is reviewed by the Washington State Department of Ecology (Ecology), and the Proposed Plan is reviewed by 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.

The Executive Summary of [DOE/RL-2010-95](#) states that “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.”

After comments are incorporated, a record of decision (ROD) will be issued that identifies the final remedial alternatives. 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 drinking water standards and achieving ambient water quality criteria in the Columbia River that protect aquatic life.

### Interim Action Groundwater Remediation

DOE has been operating a groundwater P&T system at 100-HR-3 since April 1996 under an interim remedial action ROD ([EPA/ROD/R10-96/134](#), *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions, Hanford Site, Benton County, Washington*), which was amended in 2000 ([EPA/AMD/R10-00/122](#), *Interim Remedial Action Record of Decision Amendment for the 100-HR-3 Operable Unit, Hanford Site, Benton County, Washington*). Under the interim action, two P&T systems operate at 100-HR-3: DX and HX (Figure HR.4). In 2012, the combined systems removed 501 kilograms of hexavalent chromium from groundwater. Since 1997, the 100-HR-3 P&T systems have removed 1,717 kilograms of chromium from the aquifer. Over half of this mass was removed by the DX system, which has operated for only two years. 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 at 100-D in 2012. Operation of remediation systems and groundwater monitoring results are described in *Calendar Year 2012 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation* (DOE/RL-2013-13).

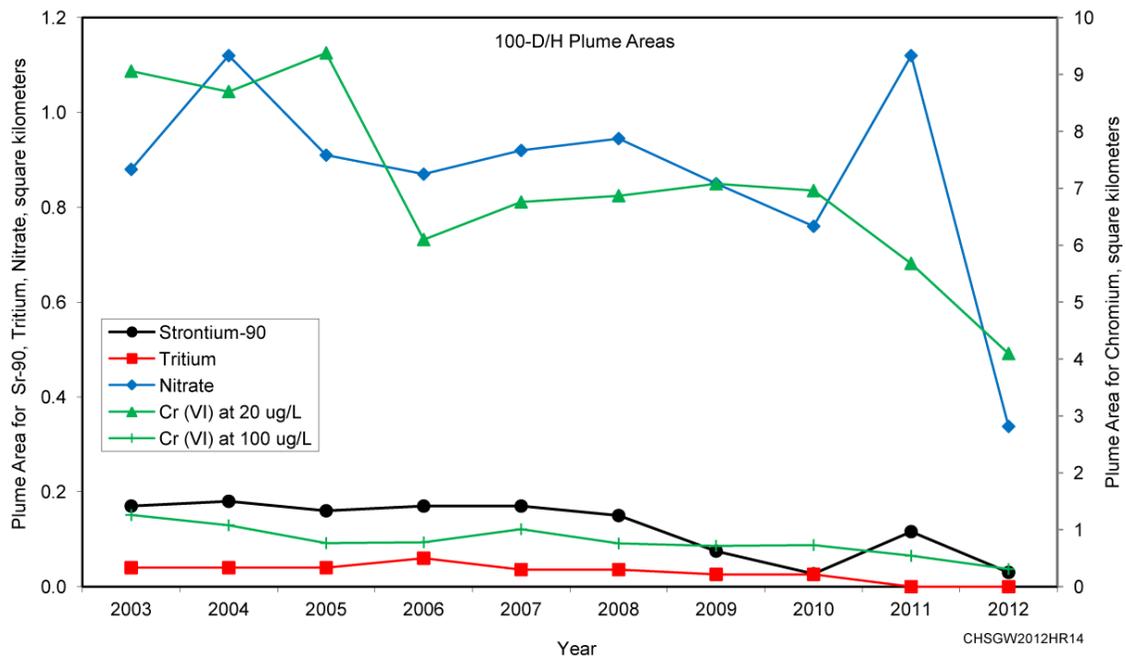


Figure HR.3 100-D/H Plume Areas

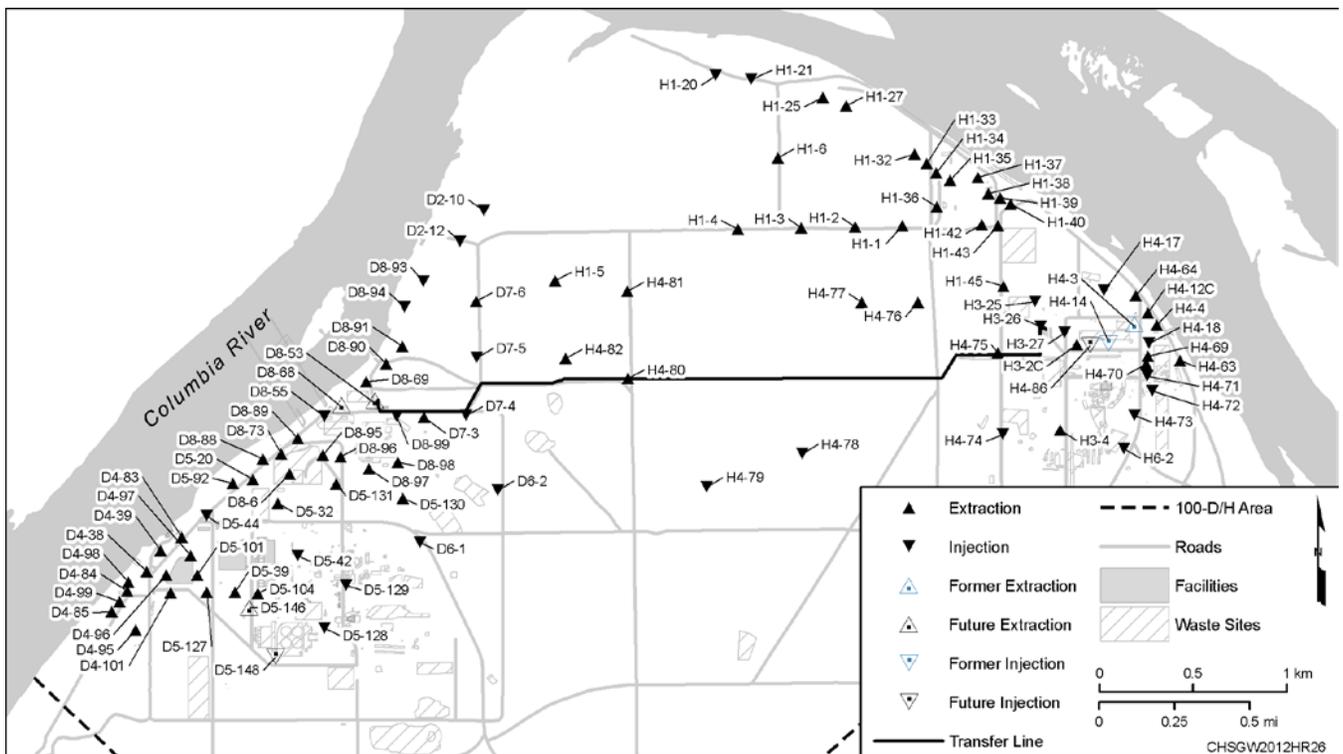
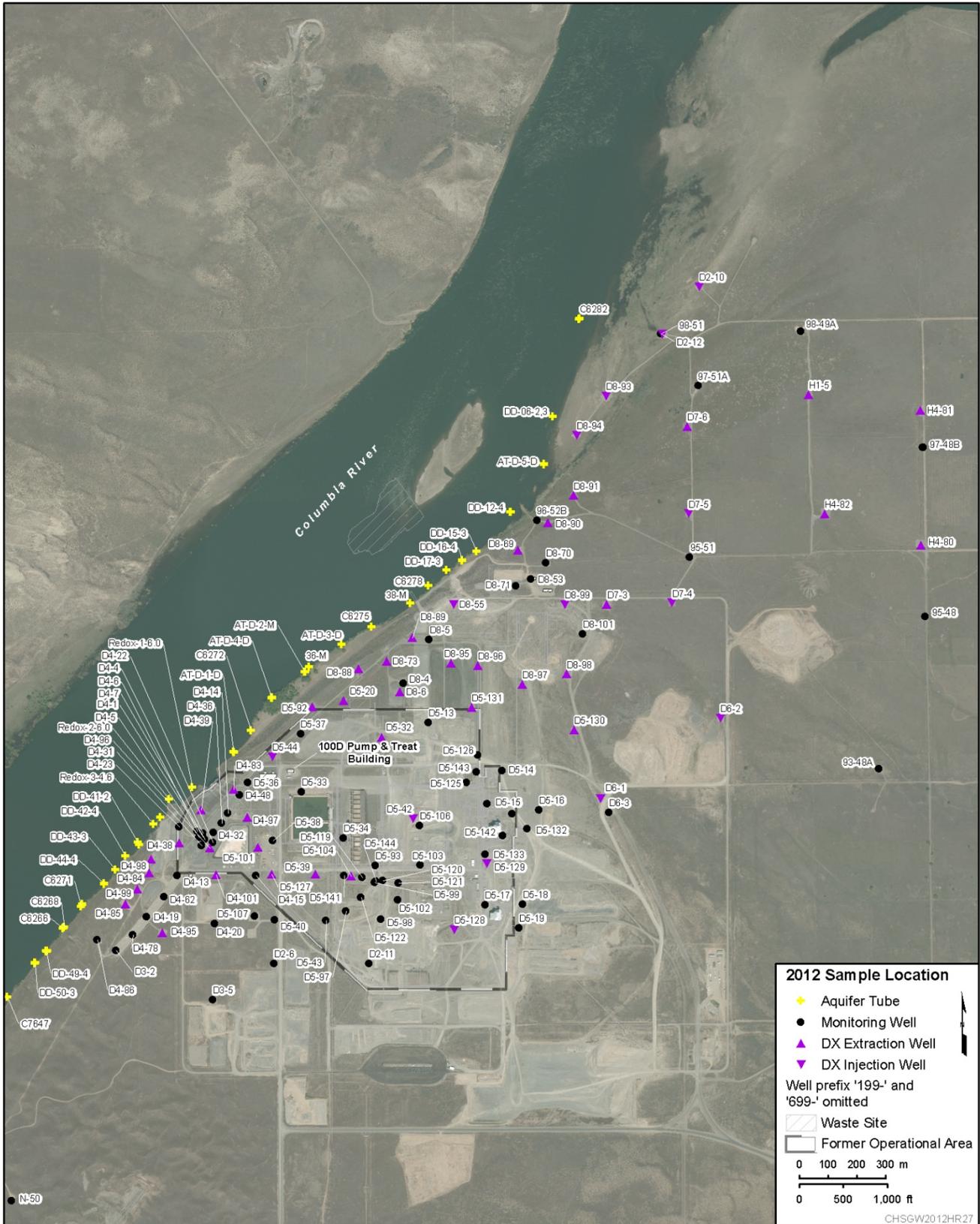
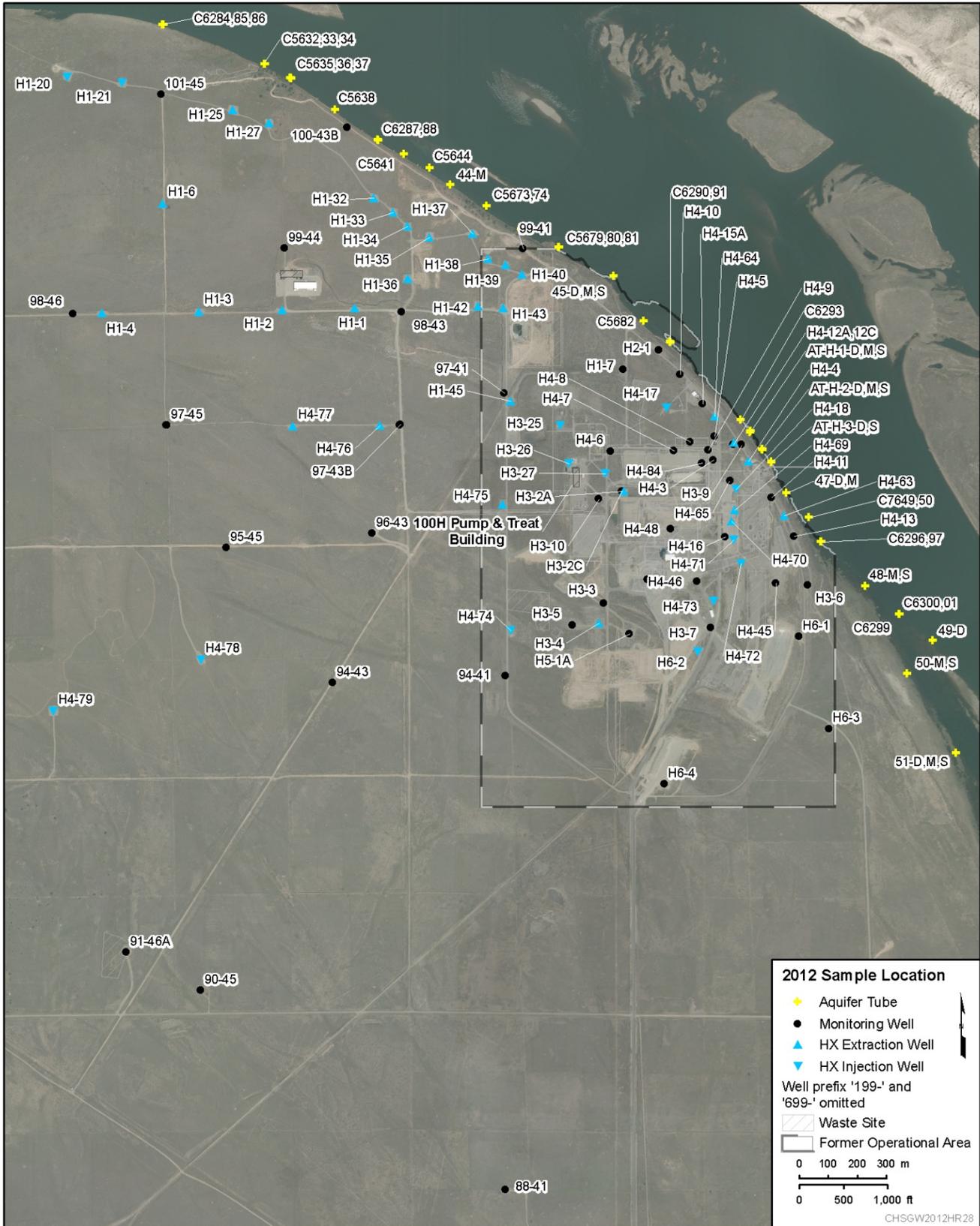


Figure HR.4 100-HR-3 Pump and Treat Systems DX and HX



Map HR.3 100-HR-D 2012 Sampling Locations



Map HR.4 100-HR-H 2012 Sampling Locations

## 100-HR-D Hexavalent Chromium

The mobile contaminant hexavalent chromium is the primary contaminant of concern at 100-HR-3, 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 quantity 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-DR-1&2 Trench during an infiltration test in 1967.

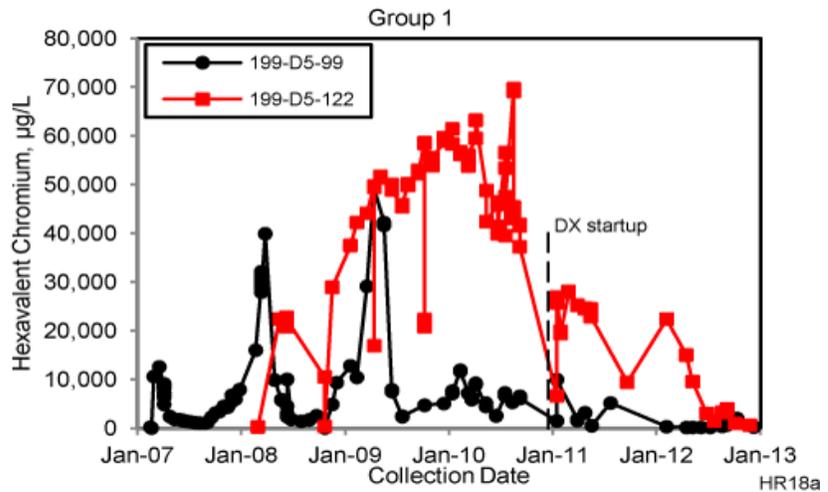


Figure HR.5 100-HR-D Hexavalent Chromium Data for wells 199-D5-99 and 199-D5-122

As shown in low and high river stage plume maps (Maps HR.5 and HR.6), hexavalent chromium is widespread across 100-HR-3. The plume is generally present in four areas: 100-D south, 100-D north, the Horn, and 100-H. The southern 100-D plume has had the highest hexavalent chromium concentrations on the Hanford Site, with hexavalent chromium concentrations declining by 60 percent in 2012, compared to 2011, throughout the south plume in response to groundwater remediation and remediation of contaminated soil in source areas.

### Hexavalent Chromium at 100-D

Historical handling of 70 percent sodium dichromate solution at the 100-D Area railcar unloading area at waste site 100-D-100 is the likely 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. 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. The most dramatic reduction has been near the 100-D-100 waste site (i.e., the primary source of the southern 100-D plume). In that area, hexavalent chromium concentrations have declined from a peak of 69,700 µg/L in 2010 in well 199-D5-122 to 589 µg/L in the same well in November 2012 (Figure HR.5). Concentrations in the northern plume declined in nearly all of the wells in 2012.

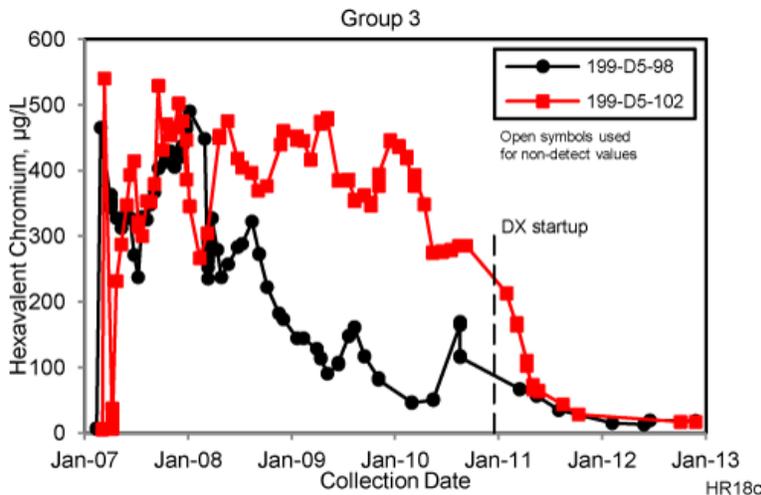


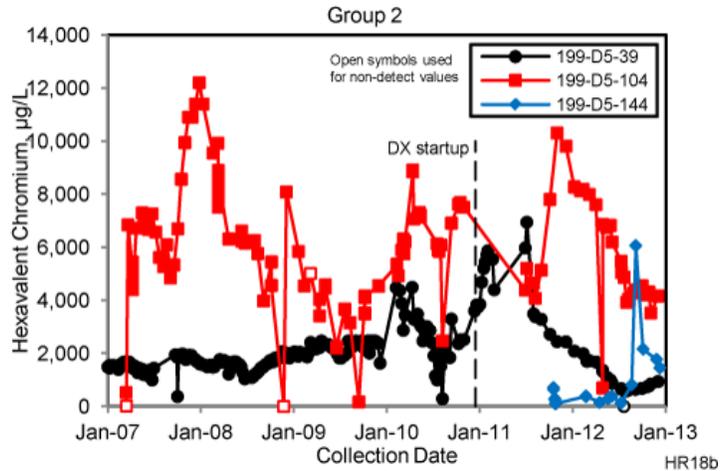
Figure HR.6 100-HR-D Hexavalent Chromium Data for wells 199-D5-98 and 199-D5-102

**Southern Plume at 100-D**

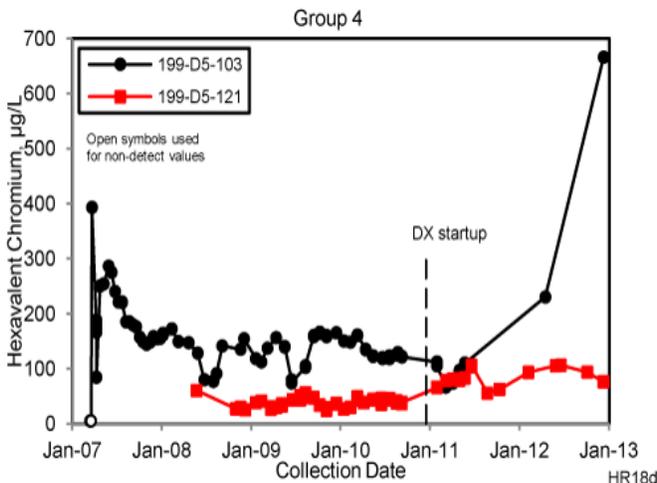
Hexavalent chromium trends in wells upgradient of the highest concentration portion of the southern plume varied in 2012. Concentrations declined to less than 20 µg/L in wells 199-D5-102 and 199-D5-98 (Figure HR.6). Nearby wells 199-D5-121 (decommissioned), 199-D5-103, and 199-D5-144 (decommissioned) were the only wells in the southern plume that showed overall increases in concentration between 2011 and 2012 (Figures HR.7 and HR.8). Well 199-D5-103, which is located between several ongoing excavations (100-D-100, 100-D-50:7, and 100-D-104), had a significant increase in hexavalent chromium, with concentrations increasing from 105 µg/L in May 2011 to 722 µg/L in December 2012. The increase appears to be the result of nearby excavation activities.

Upgradient of the ISRM barrier, wells 199-D4-15 and 199-D4-101 (an extraction well) showed declines in 2012. Well 199-D4-15 is located slightly upgradient of 199-D4-101 and downgradient of another extraction well (199-D5-127). Well 199-D4-22, located between the 147-D holding pond and the barrier, showed variable concentrations but an overall decline (Figure HR.9).

Downgradient of the ISRM barrier near the Columbia River, extraction wells 199-D4-38 and 199-D4-39 had variable concentrations (Figure HR.10). Concentrations were low during summer 2012 and rose in the fall because of river stage changes. Concentrations in aquifer tubes in this region were consistently low in 2012, which is in direct response to extraction being conducted between the ISRM barrier and the aquifer tubes, along with the overall expansion of the P&T system.



**Figure HR.7 100-HR-D Hexavalent Chromium Data for wells 199-D5-39, 199-D5-104, and 199-D5-144**



**Figure HR.8 100-HR-D Hexavalent Chromium Data for wells 199-D5-103 and 199-D5-121**

**Northern Plume at 100-D**

Concentrations declined in nearly all of the wells in this area in 2012. In well 199-D5-13, located downgradient of the main northern plume, concentrations increased in late 2011 and early 2012, and then started to decline again by October 2012. Inland from the heart of the plume, chromium levels have declined in 199-D5-16 and in extraction wells 199-D5-130 and 199-D7-3. Extraction wells 199-D5-32, 199-D8-95, and 199-D8-96 (Figure HR.11) 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 (Figure HR.10). Seasonal variability also is evident in these wells.

Hexavalent chromium concentrations in aquifer tubes downgradient of the northern plume have declined since 1997, when the original 100-HR-3 P&T system began. Concentrations were below the 20 µg/L remedial action goal in 2012 (Figure HR.12).





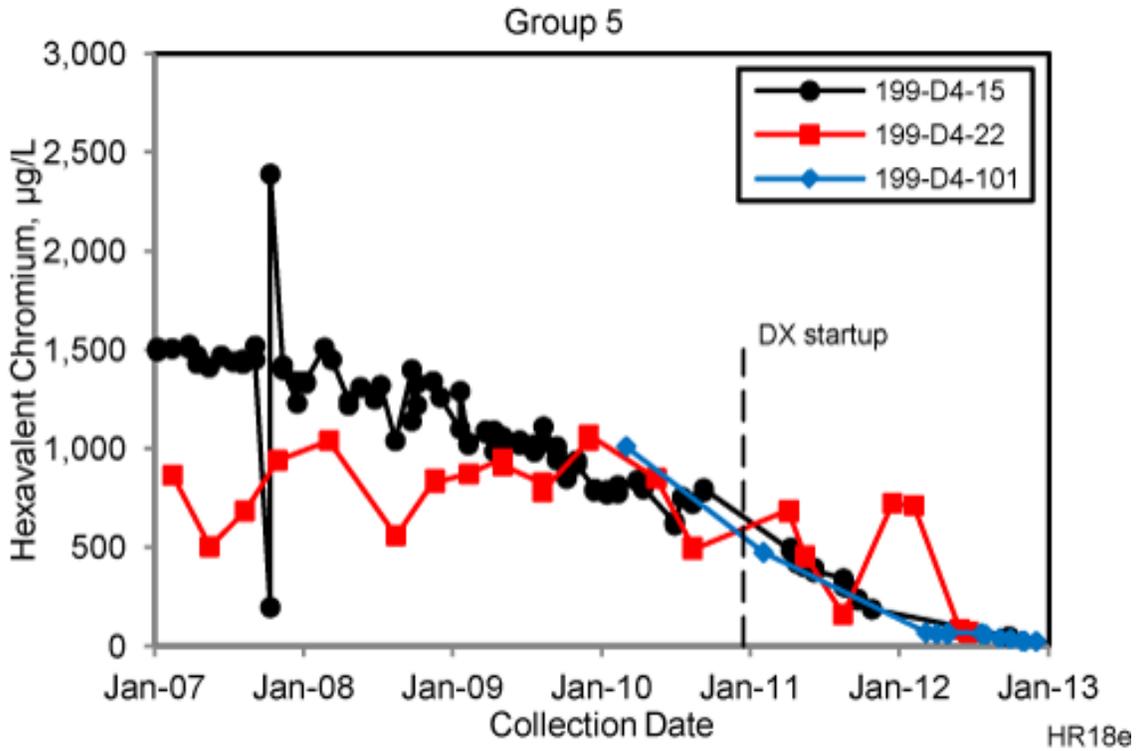


Figure HR.9 100-HR-D Hexavalent Chromium Data for wells 199-D4-14, 199-D4-22, and 199-D4-101

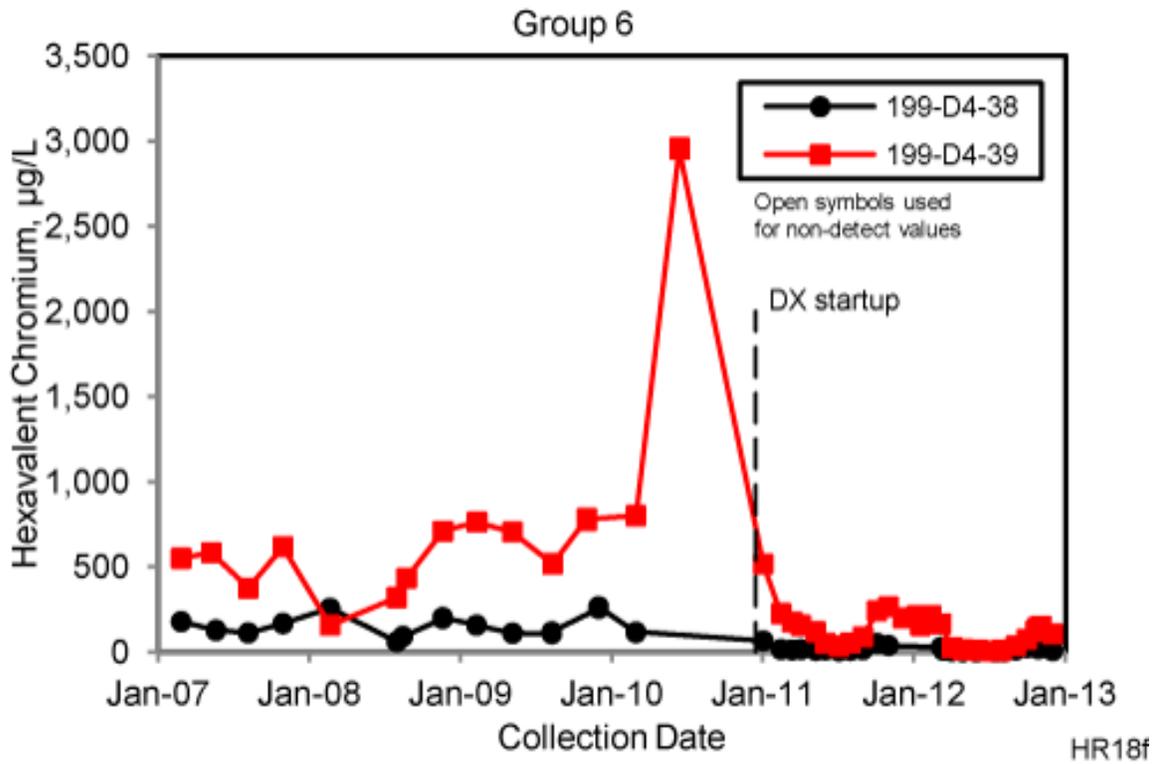


Figure HR.10 100-HR-D Hexavalent Chromium Data for wells 199-D4-38 and 199-D4-39

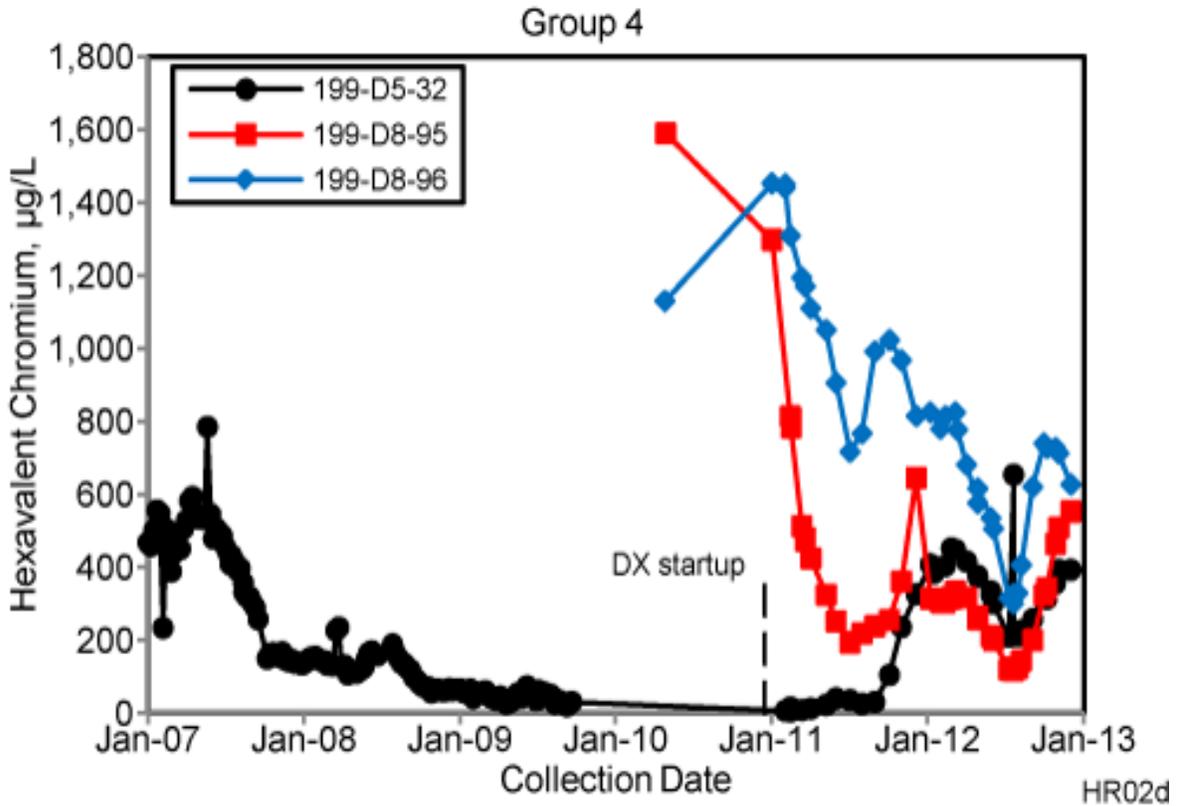


Figure HR.11 100-HR-D Hexavalent Chromium Data for wells 199-D5-32, 199-D8-95, and 199-D8-96

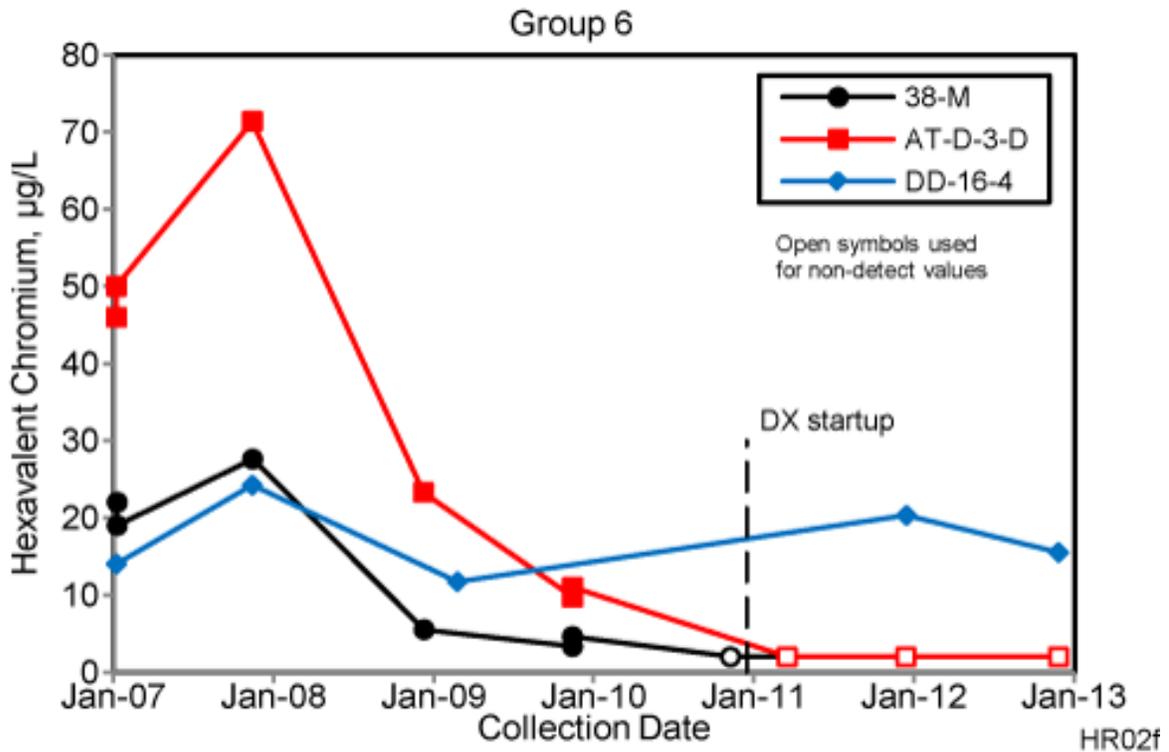


Figure HR.12 100-HR-D Hexavalent Chromium Data for wells 38-M, AT-D-3-D, and DD-16-4

## 100-HR-H Hexavalent Chromium

**Hexavalent Chromium Horn and 100-H:** The portion of the hexavalent chromium plume that originated at the 116-DR-1&2 Trenches extends across the Horn to 100-H (Maps HR.7 and HR.8). This portion encompasses the largest area of the hexavalent chromium plume at 100-HR-3, but concentrations are consistently less than 100 µg/L. The average concentration in the Horn plume declined over 2012, and much of 100-H has concentrations < 10 µg/L. Only a few wells in the unconfined aquifer at 100-H exceeded 20 µg/L. In addition, remediation activities have resulted in the Horn plume separating 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. Another substantial change in the plume shape is related to the placement of extraction and injection wells around the 100-H area. Injection of treated water along the southern part of 100-H appears to be moving the plume to the south, which coincides roughly with a paleochannel in that area.

Hexavalent chromium trends in extraction wells in the northeastern part of the Horn plume (for example, 199-H1-6, 199-H1-25, and 199-H1-36) are shown in Figure HR.13. These wells have been operating only since late 2011, and concentrations are expected to decline with time as the P&T system continues to operate, which is shown in Figure HR.13, and the area is remediated.

In two extraction wells in 100-H (199-H4-12A and 199-H4-15A), located near the 183-H solar evaporation basins, hexavalent chromium concentrations remained below the 20 µg/L remedial action goal for much of 2012. However, concentrations in these wells and in nearby well 199-H4-3 increased in the late summer, shortly following high river stage (Figure HR.14). The peak value of 65.6 µg/L in 199-H4-3 in September was the highest in 100-H in 2012 but declined to around 25 µg/L by October.

Along the southern end of the 100-H area, the plume has shifted further south. Wells 199-H3-3, 199-H3-4, and 199-H3-5, located in this area, operated as injection wells from 1997 to 2004. Well 199-H3-4 has subsequently been converted to an extraction well as part of the HX P&T system. Wells 199-H3-3 and 199-H3-5 are currently monitoring wells. After injection and extraction associated with the HR-3 P&T system ceased, the hexavalent chromium plume began to migrate into southern 100-H. This movement southward appears to have been accelerated by the addition of injection wells in southern 100-H, such as wells 199-H4-73 and 199-H6-2. In late 2011, groundwater extraction from 199-H3-4 was restarted and concentrations subsequently declined overall in that area (Figure HR.15), with well 199-H3-4 drawing the southern edge of the plume slightly north.

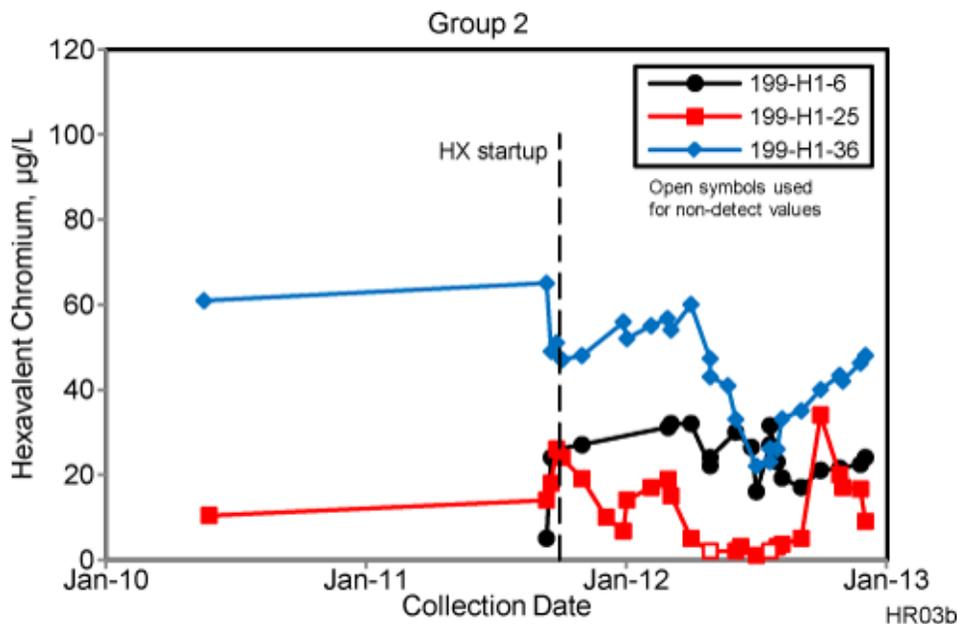


Figure HR.13 100-HR-H Hexavalent Chromium Data for wells 199-H1-6, 199-H1-25, and 199-H1-36

**Hexavalent Chromium in the Ringold Upper Mud:** Hexavalent chromium has been detected in the first RUM water bearing unit. Concentrations near the river at 100-H range from below detection to nearly 200 µg/L. In addition, hexavalent chromium has been detected in the Horn, with increasing concentrations since 2008. The groundwater conditions are summarized as follows:

- Hexavalent chromium concentrations declined slightly in 199-H4-12C during 2012 (Figure HR.16) but remained steady in 199-H3-2C. Concentrations in well 199-H4-15CS have not been consistent.
- Three additional deep wells were installed in 2011 as part of the RI: 199-H2-1, 199-H3-9, and 199-H3-10. Hexavalent chromium was detected in each of the new wells during 2012, with levels below the 10 µg/L in all but well 199-H3-9. Concentrations in well 199-H3-9 ranged from 179 (July) to 146 µg/L (October) during 2012.
- 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; however, concentrations in this well remain fairly constant at about 130 µg/L.
- Three wells in the Horn Area monitor water-bearing zones in the RUM. Wells 699-97-43C and 699-97-45B, located on the 100-H portion of the Horn, continued to have no detection of hexavalent chromium in groundwater samples in 2012. Concentrations in well 699-97-48C, located on the west side of the Horn, increased to 63 µg/L in 2012 (Figure HR.16) and have an increasing trend. New wells are recommended to determine the extent of this area of contamination.

In 2009, wells 199-H4-12C, 199-H3-2C, and 199-H4-15CS were used for a series of aquifer tests to gather data on the presence of deep chromium in the RUM ([SGW-47776](#), *Aquifer Testing and Rebound Study in Support of the 100-H Deep Chromium Investigation*). Hexavalent chromium concentrations in the RUM rose slightly due to pumping during the test. The aquifer tests indicated that the RUM at well 199-H3-2C is connected to the upper aquifer. The estimated extent of hexavalent chromium in the RUM in the 100-H Area is shown in Figure HR.17.

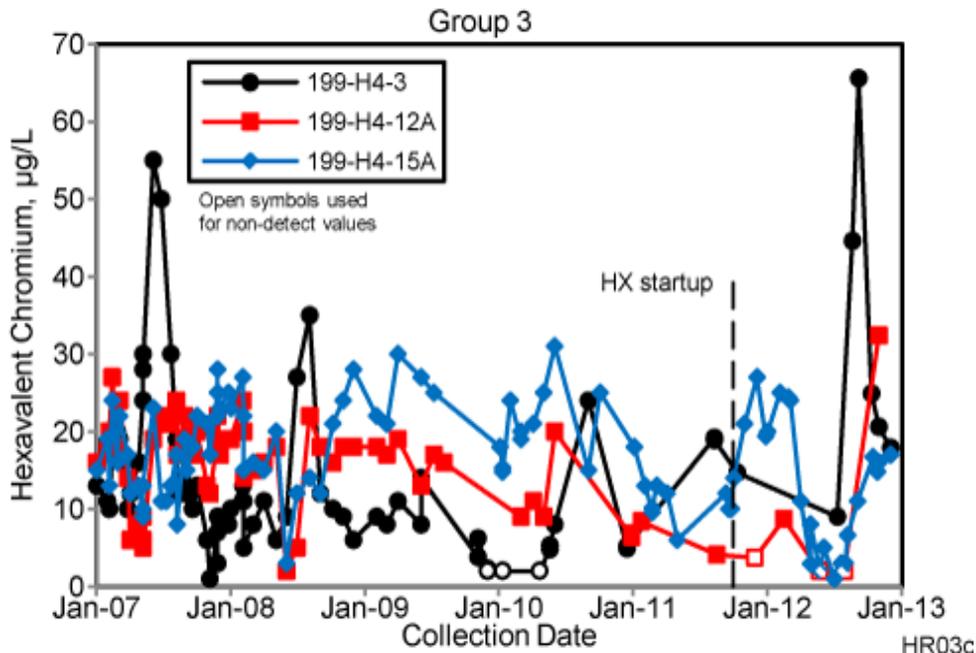


Figure HR.14 100-HR-H Hexavalent Chromium Data for wells 199-H4-3, 199-H4-12A, and 199-H4-15A

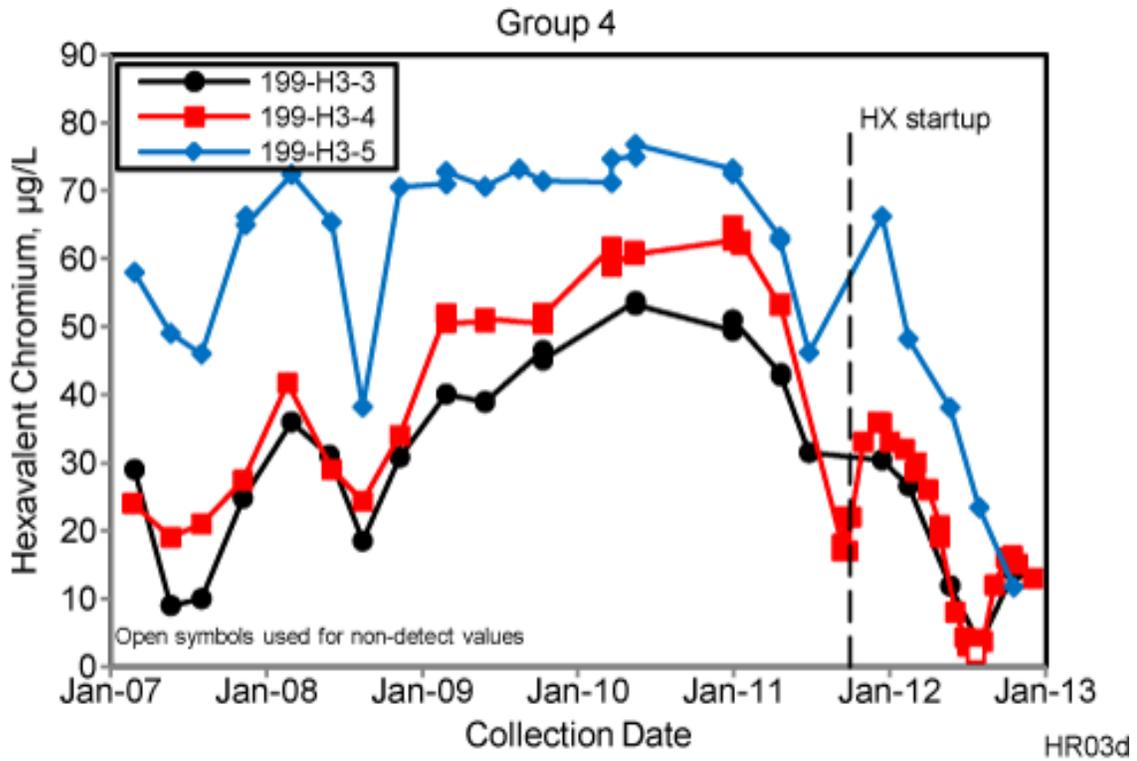


Figure HR.16 100-HR-H Hexavalent Chromium Data for wells 199-H3-3, 199-H3-4, and 199-H3-5

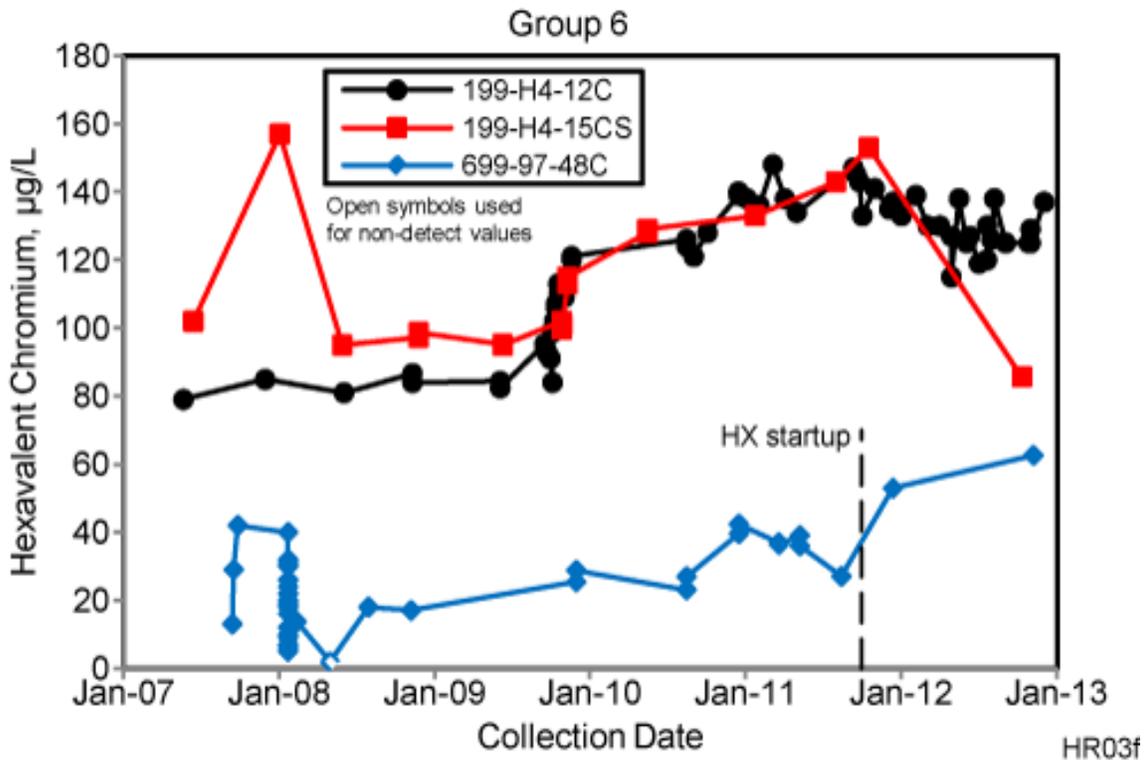


Figure HR.15 100-HR-H Hexavalent Chromium Data for wells 199-H4-12C, 199-H4-15CS and 699-97-48C

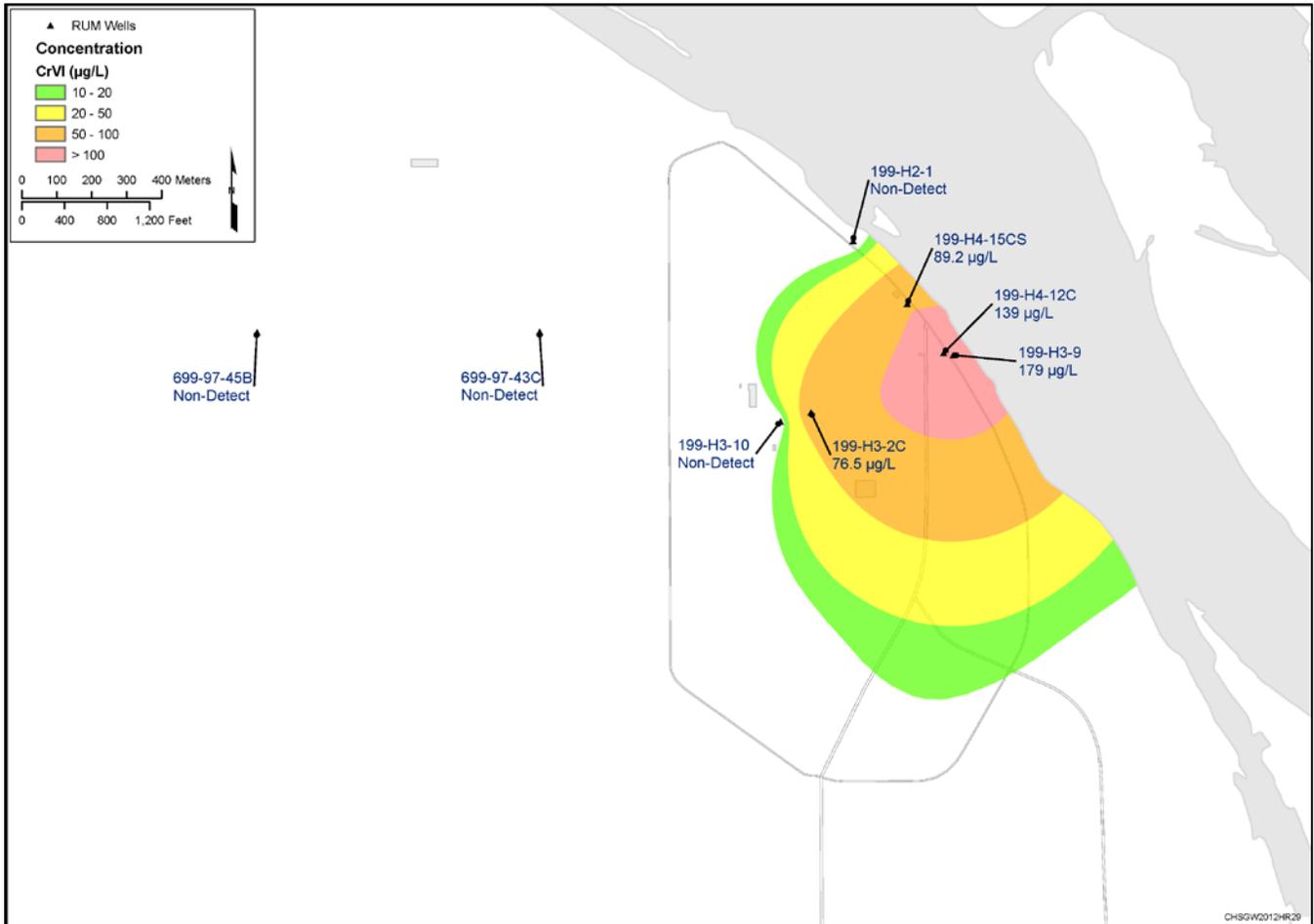
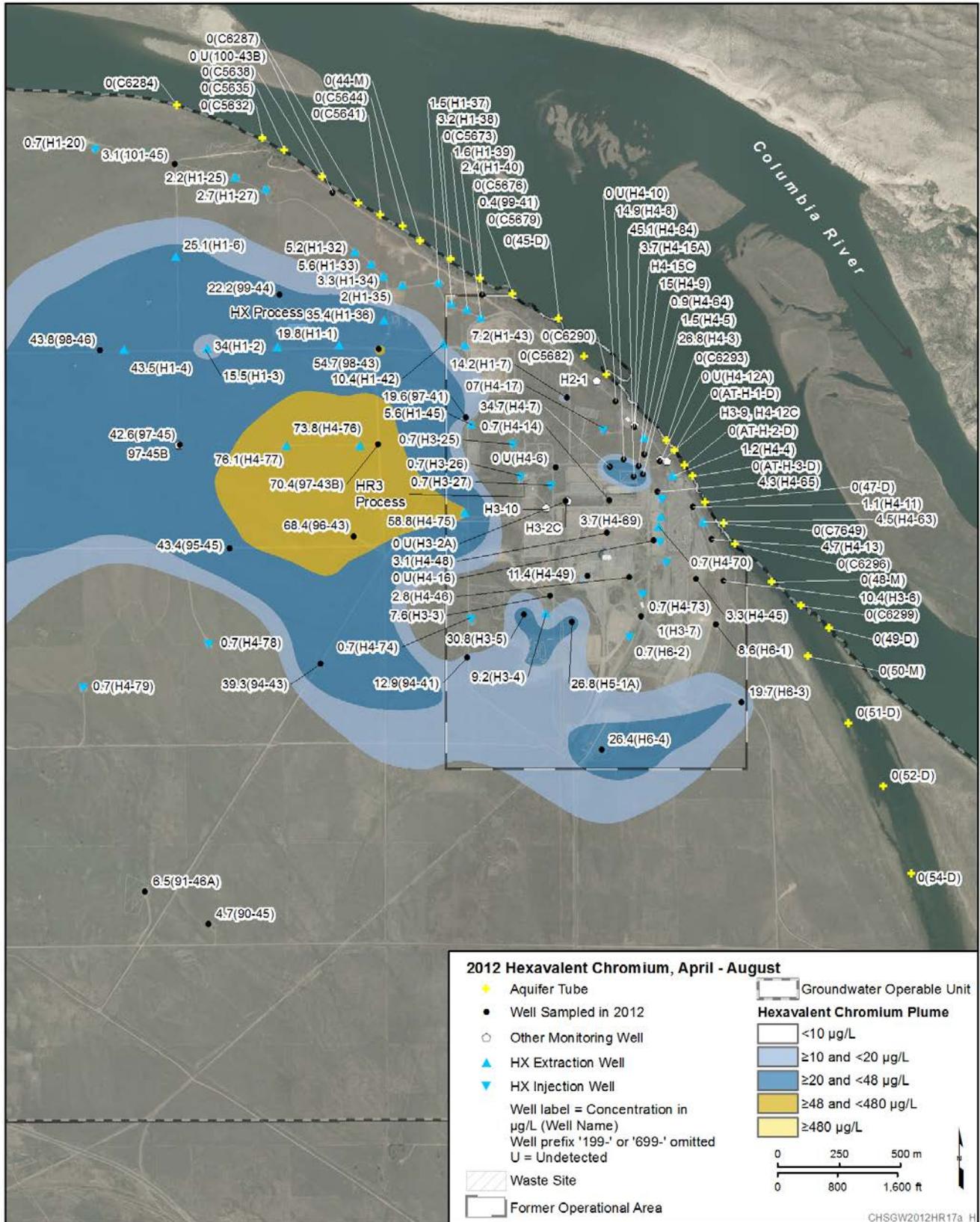


Figure HR.17 100-HR Hexavalent Chromium Concentrations



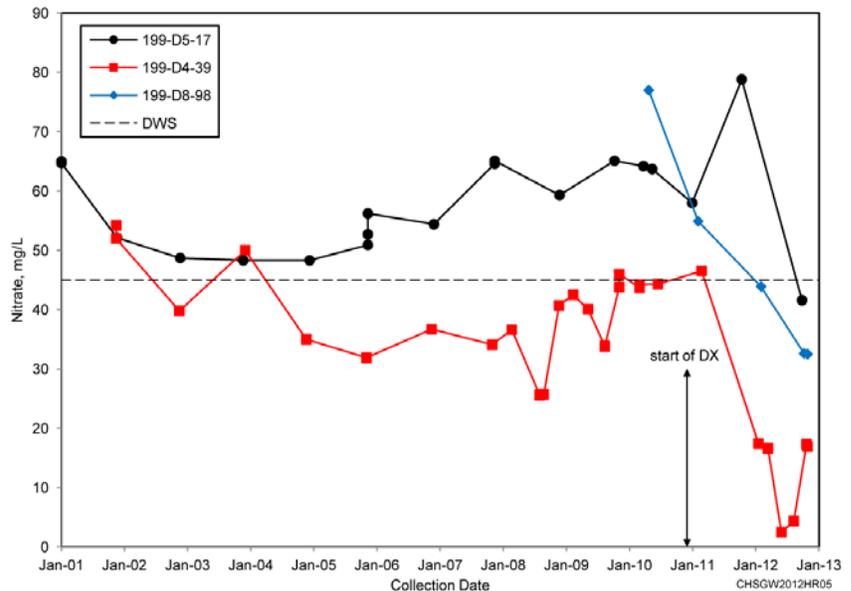


Map HR.8 100-HR-H 2012 Hexavalent Chromium Plume, April-August (High River Stage)

## 100-HR Nitrate

Primary sources of nitrate in 100-HR-3 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 the 45 mg/L drinking water standard in 100-D groundwater and in a few wells in 100-H. Nitrate is not found above the drinking water standard in the Horn. The combined area of the nitrate plumes decreased between 2011 and 2012 as a result of declining concentrations in 100-D (Figure HR.3).

Nitrate contamination in 100-D previously was distributed in southern and northern plumes, similar to hexavalent chromium. As the expanded P&T system continued to operate in 2012, nitrate concentrations slowly declined and the plumes contracted (Map HR.9 and Figure HR.18). Concentrations of nitrate are slightly below the drinking water standard in most of 100-D. In areas where the drinking water standard is exceeded, concentrations are below 80 mg/L. Concentrations in well 199-D4-20 increased from 18.9 mg/L in 2010 to 72.6 mg/L in late 2012. This is likely due to nearby extraction wells drawing in the plume since the change in trend coincides with the startup of the DX system.



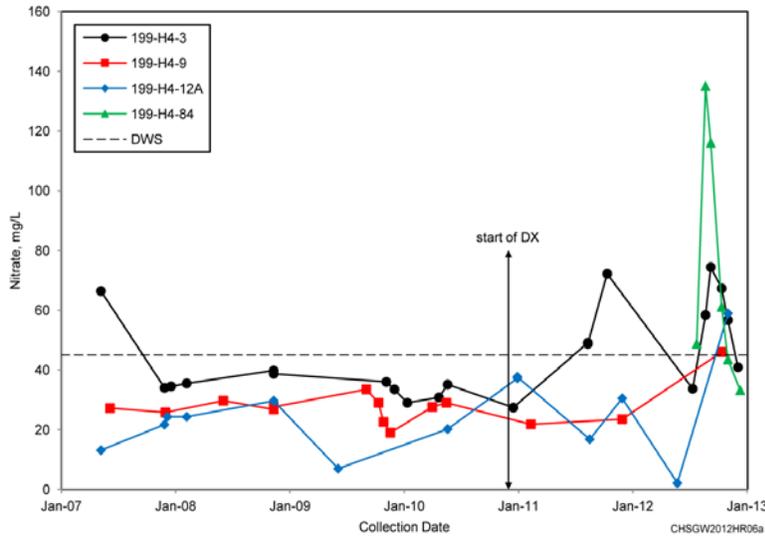
**Figure HR.18 100-HR-3 Nitrate Data for wells 199-D5-17, 199-D4-39, and 199-D8-98**

Characterization samples collected during drilling of RI wells in the 100-D Area showed that in the northern plume, nitrate concentrations declined with depth or remained relatively constant through the unconfined aquifer. In the southern plume, nitrate concentrations increased modestly with depth in wells 199-D3-5 and 199-D5-144 and decreased with depth through the unconfined aquifer while drilling of well 199-D5-141 (completed in a lower aquifer). Nitrate concentrations in the RUM are much lower than in the unconfined aquifer, with values of less than 2 mg/L in 100-D and below 10 mg/L in 100-H except in well 199-H3-2C, which appears to be connected to the unconfined aquifer.

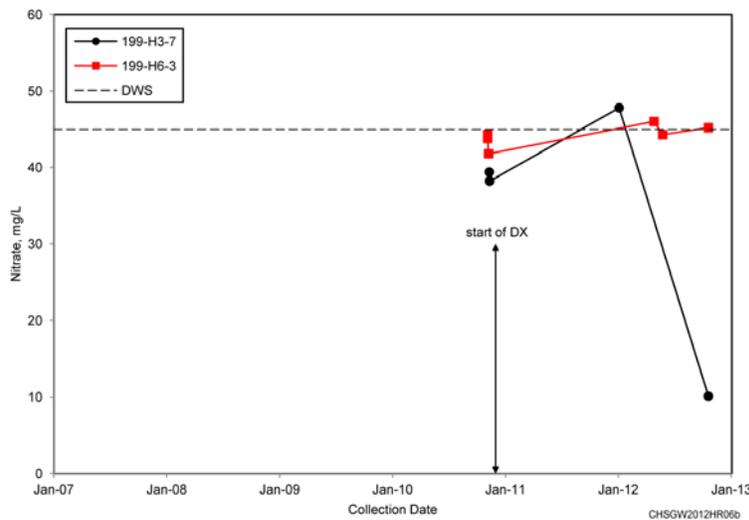
Map HR.10 shows nitrate distribution in the Horn and 100-H. Nitrate concentrations in six 100-H wells exceeded the drinking water standard at least once in 2012:

- Well 199-H4-3 has a history of elevated nitrate concentrations, with maximum concentrations at more than 8,000 mg/L in 1978. Concentrations were below the drinking water standard from 2008 through 2010, but increased in 2011 (Figure HR.19). The concentrations in 2012 ranged from 33.7 mg/L in July to 74 mg/L in September. The nitrate source in that area was the 116-H-6 (183-H) Basins.
- Nitrate concentrations in wells 199-H4-9, 199-H4-12A, and 199-H4-84, located near 199-H4-3, also exceeded the drinking water standard in 2012. Well 199-H4-84 had a peak nitrate concentration of 135 mg/L in August 2012. This well was drilled in 2011 to characterize the vadose zone beneath the former 116-H-6 Basins and was completed as a monitoring well. Concentrations in well 199-H4-12A were sampled twice in 2012, with results of 2.09 mg/L and 58.9 mg/L.
- The periods of low concentrations appear to coincide with higher water levels, indicating an inverse relationship with river stage. However, data are not sufficient to provide a conclusive correlation of the concentration changes to water level changes.

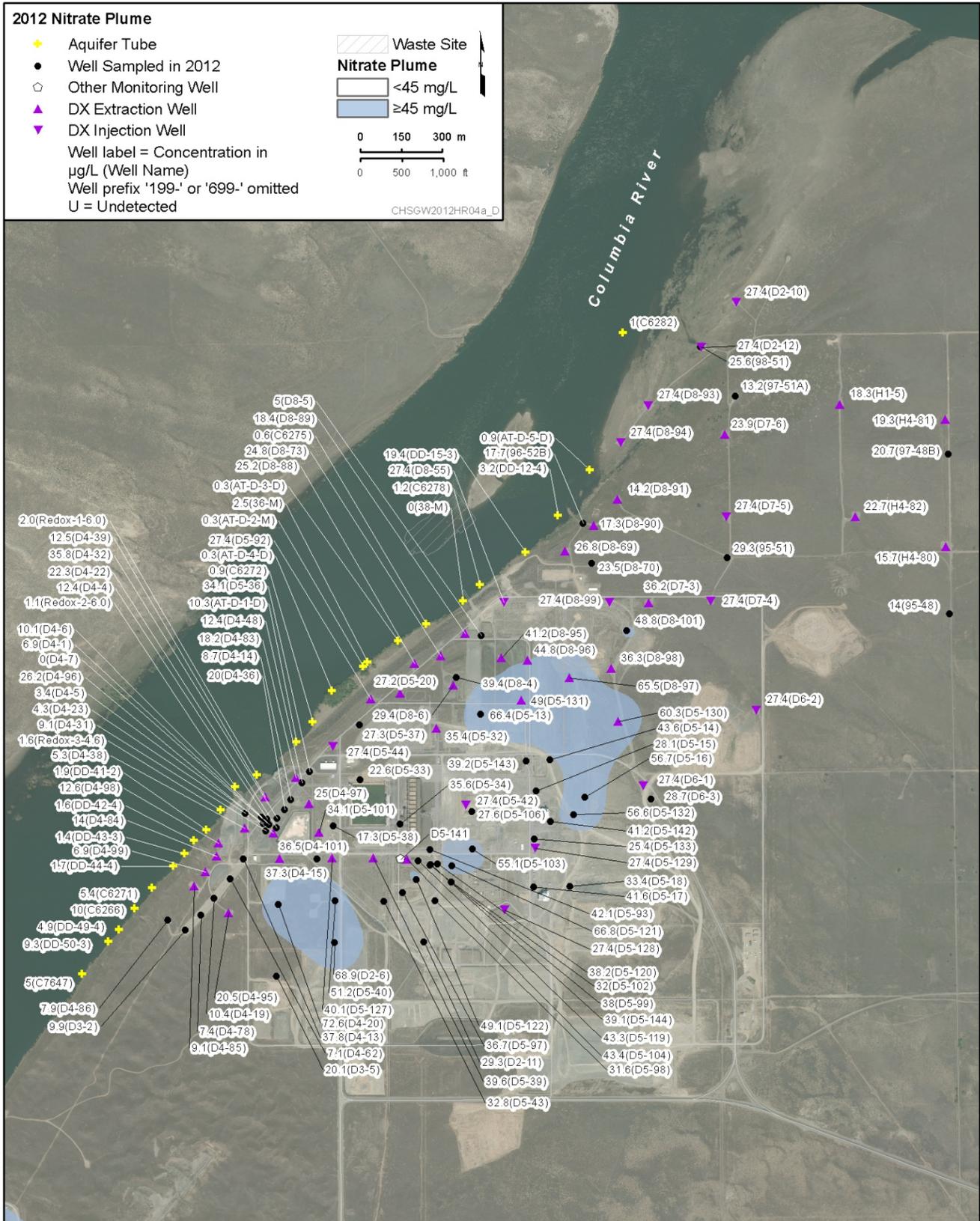
In southern 100-H, nitrate concentrations exceeded the standard in wells 199-H3-7 (which exceeded in January only) and 199-H6-3, with a maximum of 46 mg/L and little variation in concentrations during the year (Figure HR.20). In the 2011 annual report ([DOE/RL-2011-118](#), *Hanford Site Groundwater Monitoring for 2011*), nitrate exceedances were reported in wells 199-H1-27 (north of 100-H) of 69.5 mg/L and 199-H4-75 (west of 100-H) of 167 mg/L; locations not previously known to have nitrate contamination. The reported concentrations resulted in two isolated plumes being identified. However, after the report was published, data reviews identified errors, and the data were corrected; concentrations did not exceed the drinking water standard. The 2011 plume map (Figure 2.5-15 in [DOE/RL-2011-118](#)) included the erroneous data and was not representative of the 100-H nitrate plume near these wells.



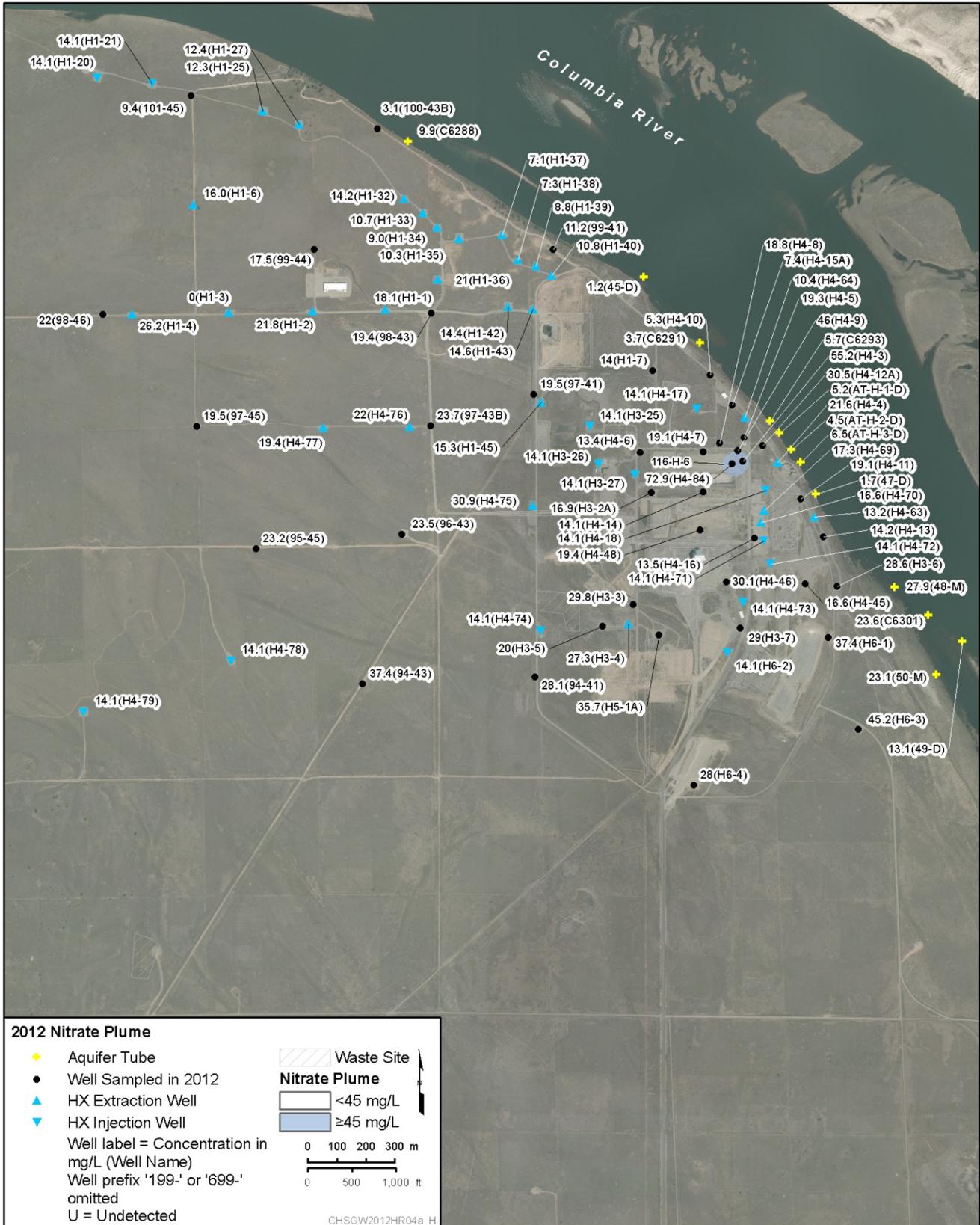
**Figure HR.19 100-HR-3 Nitrate Data for wells 199-H4-3, 199-H4-9, 199-H4-12A, and 199-H4-84**



**Figure HR.20 100-HR-3 Nitrate Data for wells 199-H3-7 and 199-H6-3**



Map HR.9 100-HR-D 2012 Nitrate Plume



Map HR.10 100-HR-H 2012 Nitrate Plume

## 100-HR Strontium-90

Strontium-90 was present in waste disposed of in 100-D and 100-H. In 2012, concentrations in groundwater exceeded the 8 pCi/L drinking water standard in six 100-H wells and in two 100-D wells (Maps HR.11 and HR.12).

Strontium-90 is present in groundwater near the former fuel storage basin at the 105-D Reactor. Concentrations in well 199-D5-132 were as high as 40 pCi/L in 2012, and in well 199-D5-142 concentrations were as high as 30 pCi/L, but remained fairly stable in both locations. Concentrations in wells 199-D5-142 and 199-D5-132 are consistent with the concentrations associated with well 199-D5-12 in 1999 (Figure HR.21), before the well went dry and was subsequently decommissioned. In addition, the contamination is apparently localized; nearby wells 199-D5-16, 199-D5-133, and 199-D6-3 have had no detectable strontium-90. Downgradient well 199-D5-15 had concentrations to below detection when last sampled in 2009 and 2010. Well 199-D5-15 and other wells in the vicinity are planned for sampling in 2013.

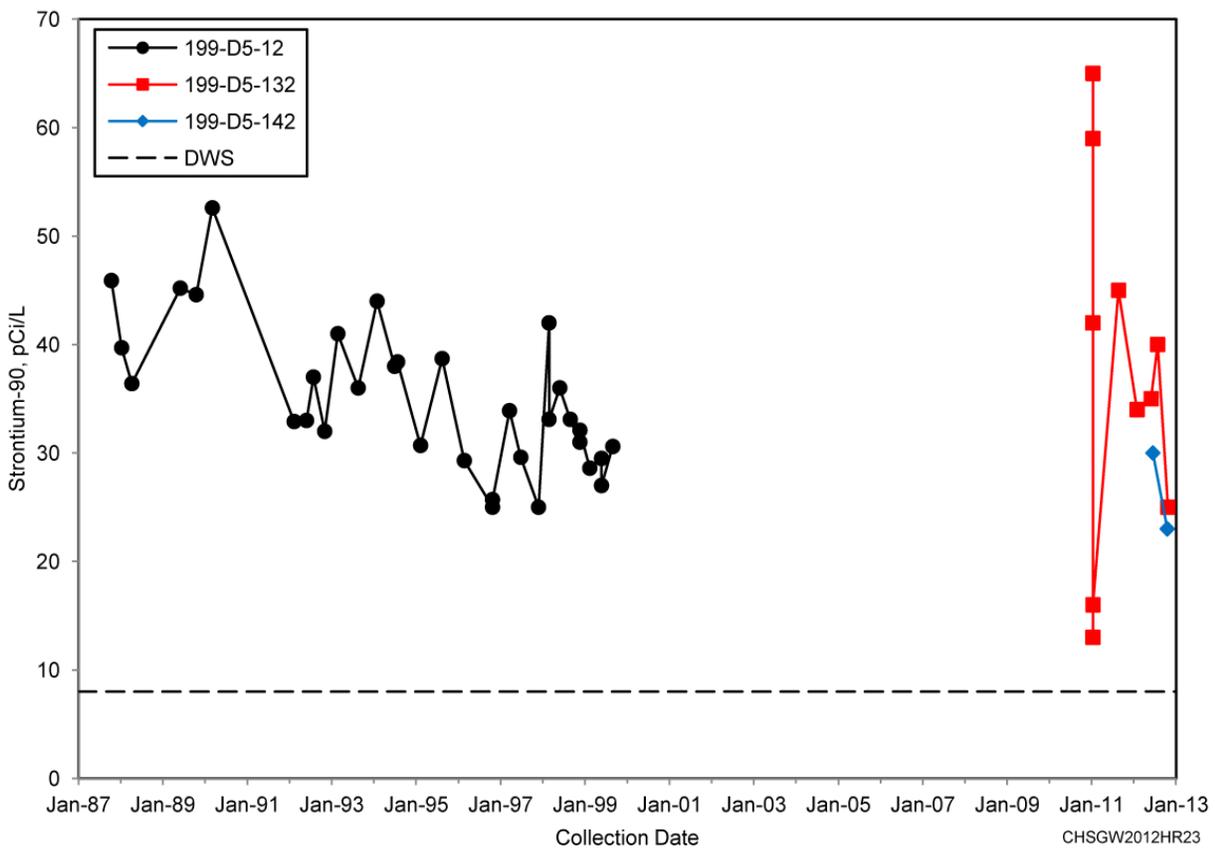


Figure HR.21 100-HR-3 Strontium-90 Data for wells 199-D5-12, 199-D5-132, and 199-D5-142

The area near the former retention basins in the northern 100-D Area historically had strontium-90 detections in groundwater. Only a few wells in this region were sampled for strontium-90 in 2012. Well 199-D8-68, near the former retention basins, previously had the highest concentrations, but levels have declined and were 3 pCi/L or less when last sampled in 2011. The well was not sampled in 2012 while it was being converted to an extraction well.

Aquifer tube samples from the northern portion of 100-D were analyzed for strontium-90 in fall 2012. Concentrations were near detection limits, with a maximum of 5.6 pCi/L in aquifer tube DD-15-3, near the retention basins.

Strontium-90 concentrations in 100-H groundwater exceed the drinking water standard near the former 116-H-7 Retention Basin and 116-H-1 Trench (Map HR.12), located near the Columbia River. Wells with strontium-90 levels above or near the drinking water standard include wells 199-H4-69 (extraction well), 199-H4-16, 199-H4-11, and 199-H4-45, along with those shown on Figure HR.22. Concentrations adjacent to the river in downgradient aquifer tube 47-D also exceeded the drinking water standard. Concentrations have declined slightly since the early 1990s (Figure HR.22), with a slight contraction of the plume area. Changes in plume shape result from slight variations in the concentration, causing the well either to drop below or rise above the drinking water standards and are, therefore, mapped differently. The highest strontium-90 concentration detected in 2012 was 30 pCi/L in well 199-H4-13, which was within the range previously seen in this well.

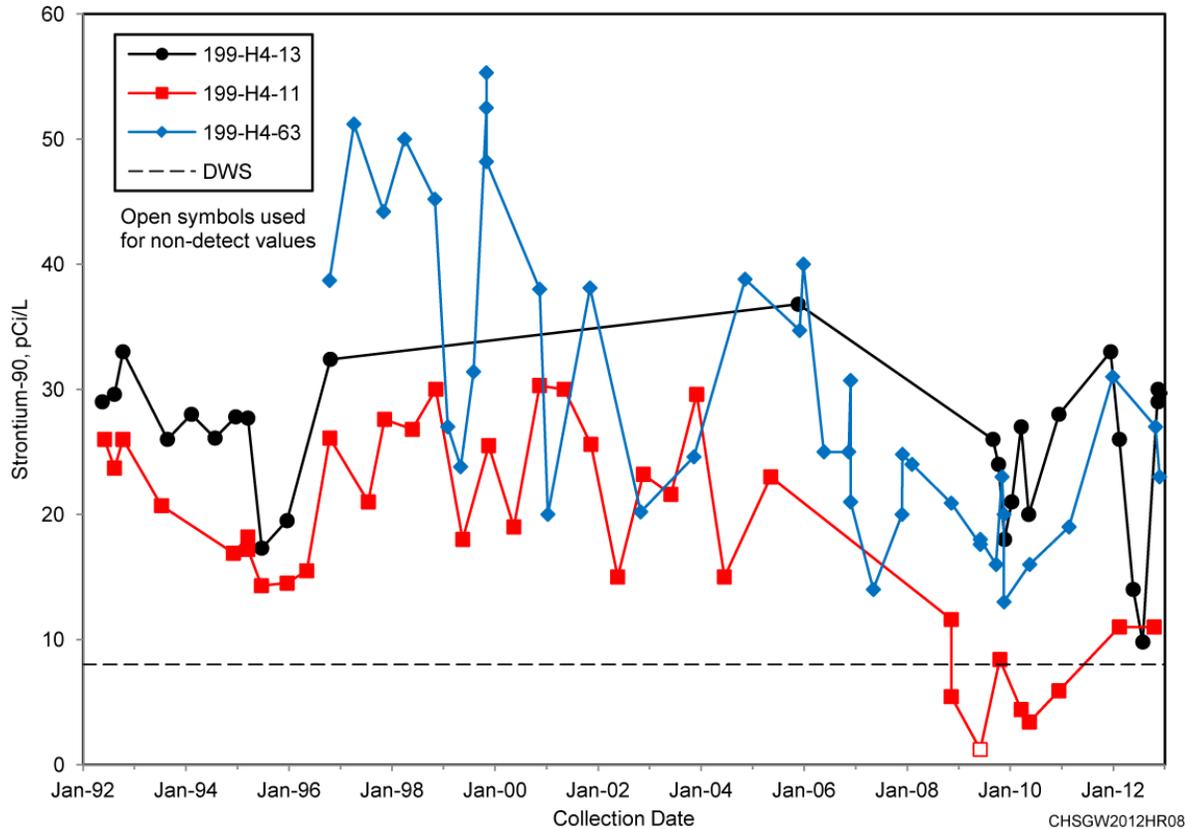
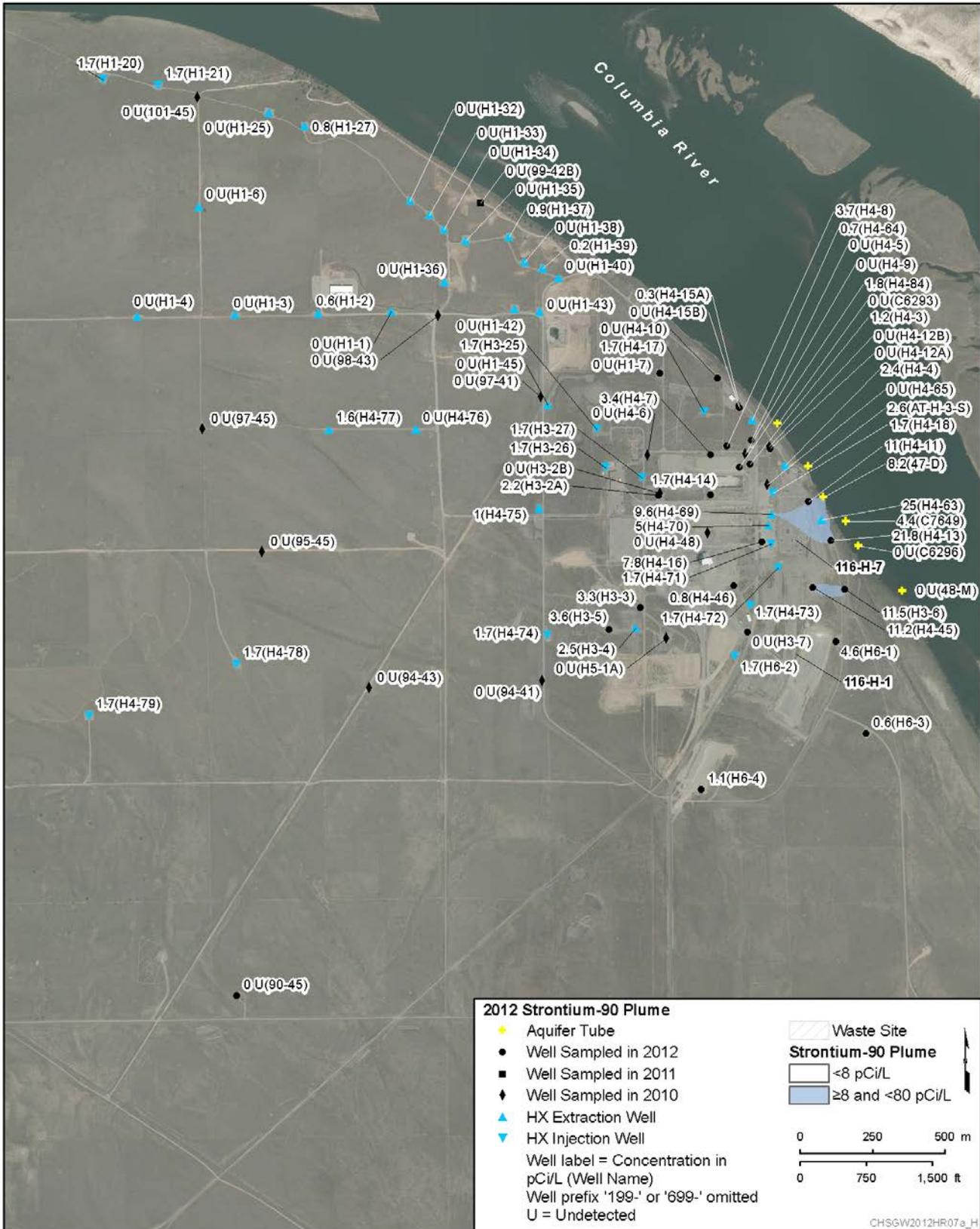


Figure HR.22 100-HR-3 Strontium-90 Data for wells 199-H4-13, 199-H4-11, and 199-H4-63

Four 100-H Area aquifer tubes, all near the former retention basins, had strontium-90 detections in 2012. Aquifer tube C7649 had a detection of 4.4 pCi/L, C7650 had a detection of 3.4 pCi/L, 47-M had a detection of 7.0 pCi/L, and 47-D had a detection of 8.2 pCi/L. Only 47-D had a strontium-90 concentration above the drinking water standard.

None of the RUM wells screened are located within the footprint of the 100-H or 100-D strontium-90 plume. Strontium-90 was detected in RUM well 199-H3-9 at  $2.2 \pm 1.8$  pCi/L in 2011, and at  $1.7 \pm 0.94$  pCi/L in 199-H3-10 in 2012, with no other detections in the RUM. Two planned wells, located within the strontium-90 footprint at 100-H, will also be sampled for strontium-90.





Map HR.12 100-HR-H 2012 Strontium-90 Plume

## 100-HR Remedy Summary

Both active (groundwater P&T) and passive (ISRM) interim remedial actions continued primarily to address hexavalent chromium contamination with 100-HR-3. The groundwater P&T system at 100-HR-3 includes two operating facilities: DX and HX. These facilities were constructed in response to an 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](#), *Hanford Site Groundwater Monitoring and Performance Report for 2009: Volumes 1 & 2*).

Additional information on P&T system operations is provided in DOE/RL-2013-13.

### Groundwater Pump-and-Treat

The DX facility (Map HR.13), 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 injection well 199-D5-41, which was not needed for injection in the DX P&T well configuration.

Construction of the HX P&T system, with a treatment capacity of 3,000 L/min (800 gpm), was completed in July 2011, and the system became fully operational on October 1, 2011. In May, the HR-3 P&T system went offline to support realignment of its wells to the new DX and HX well networks. The extraction and injection wells within the two areas were consolidated to reduce water transfer across the Horn area. The HR-3 P&T wells were disconnected in May 2011, and the HR-3 system was placed in cold-standby status. Extraction and injection wells formerly connected to the HR-3 P&T system were connected to the new DX and HX P&T systems. Of the four extraction wells (199-D8-53, 199-D8-54A, 199-D8-68, and 199-D8-72) that were part of the 100-D Area transfer line to the HR-3 P&T system, wells 199-D8-53 and 199-D8-68 will be connected to the DX P&T system. Wells 199-D8-54A and 199-D8-72 are being converted to monitoring wells. Injection well 199-H4-7 was not connected to the HX P&T system because it is not needed for injection in the HX P&T well configuration.

### ISRM Barrier

Additional cleanup action was taken using an in situ chemical treatment technology in 2000 (i.e., ISRM). 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.

The ISRM barrier continued to convert hexavalent chromium to a nontoxic, immobile form (trivalent chromium) within a portion of the aquifer. During 2012, concentrations in some downgradient wells remained above the interim remedial action goal of 20 µg/L, where the northeast segment of the barrier is not working effectively. This area is treated with extraction wells installed for the DX P&T system downgradient of the barrier.



## 100-HR-3 Pump-and-Treat

DOE has been operating a groundwater P&T system at 100-HR-3 since April 1996, under an interim remedial action ROD ([EPA/ROD/R10-96/134](#)), which was amended in 2000 ([EPA/AMD/R10-00/122](#)).

In 2012, 66 extraction wells and 29 injection wells were in use. Under the interim action, two P&T systems operate at 100-HR-3: DX and HX. In 2012, the combined systems removed 501 kilograms of hexavalent chromium from groundwater (Map HR.14 and Figure HR.23). Since 1997, the 100-HR-3 P&T systems have removed 1,717 kilograms of chromium from the aquifer. Over half of this mass was removed by the DX system, which has operated for only two years. 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 at 100-D in 2012.

Under the current configuration, the 100-HR-3 P&T systems are demonstrating substantial progress toward the interim remedial action objectives. Operation of the systems and containment of the plumes addresses 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. 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 two monitoring wells (i.e., 199-D8-68 and 199-D8-53) to extraction wells starting in late 2012 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-HR-3 OU. Operation of remediation systems and groundwater monitoring results are described in DOE/RL-2013-13.

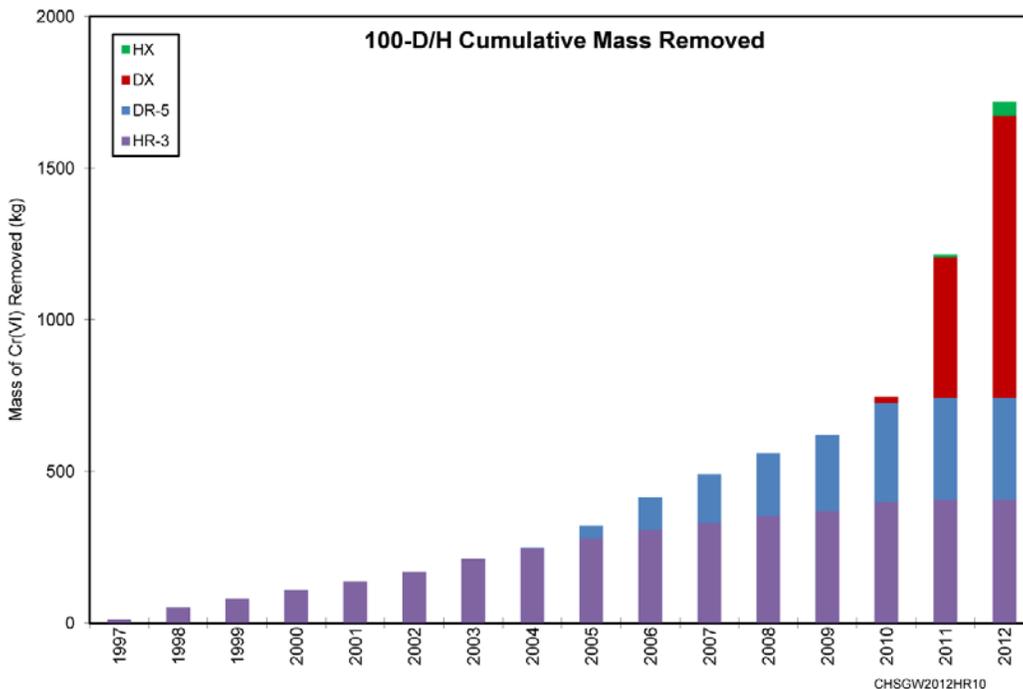


Figure HR.23 100-D/H Cumulative Mass Removed



## 100-HR-D In Situ Redox Manipulation

Groundwater at the ISRM site is sampled as part of CERCLA interim action monitoring, and hexavalent chromium is the target contaminant. The barrier treatment process reduces oxygen content in the aquifer; consequently, dissolved oxygen is also monitored. Additional monitoring details are provided in DOE/RL-2013-13.

### **Hexavalent Chromium**

The ISRM barrier (Map HR.15) intersects the southern hexavalent chromium plume and has largely cut off the highest concentration portion of the plume, preventing it from extending to the Columbia River. The remedial action goal of 20 µg/L is exceeded in three of the compliance wells (199-D4-38, 199-D4-39, and 199-D4-84).

Historically, the compliance monitoring wells in the northeastern portion of the ISRM barrier generally have hexavalent chromium concentrations above the remedial action goal. In 2012, the maximum hexavalent chromium concentration was detected in well 199-D4-39 at 213 µg/L. The maximum concentration in 2011 was 516 µg/L. Concentrations in wells 199-D4-38 and 199-D4-84 (downgradient from the central portion of the ISRM barrier) had maximum concentrations of 27 and 31 µg/L, respectively. The maximum concentrations in 2011 for wells 199-D4-38 and 199-D4-84 were 64 and 43 µg/L, respectively. These wells exhibit a seasonal variation, with concentrations dropping to below detection during part of the year.

The northeastern half of the barrier continues to have the greatest number of wells with concentrations greater than 20 µg/L. Overall, concentrations in the barrier decreased in 2012 most likely due to extraction of contaminated groundwater in the ISRM area for treatment through the DX P&T system.

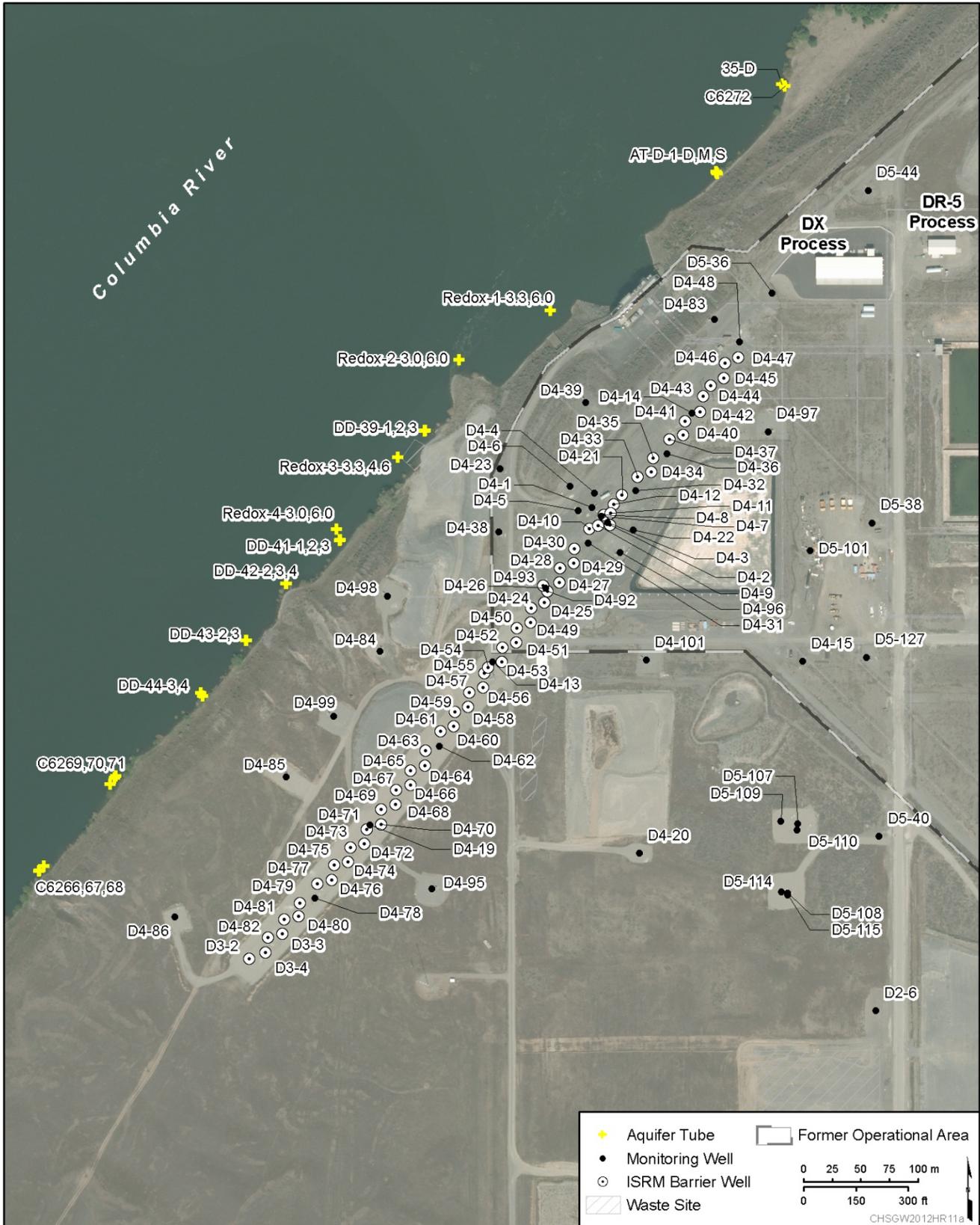
### **Dissolved Oxygen**

The dissolved oxygen concentrations are monitored as required by the ROD amendment ([EPA/AMD/R10-00/122](#)) and the remedial design report/remedial action work plan ([DOE/RL-99-51](#), *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit In Situ Redox Manipulation*). The sodium-dithionite injection process reduced dissolved oxygen in the groundwater at the barrier to low levels. Low levels of dissolved oxygen are monitored to assess changes in concentration as groundwater approaches the Columbia River. 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.

Based on dissolved oxygen results, the ISRM barrier continues to create favorable conditions for reducing hexavalent chromium. Additional discussion and figures showing dissolved oxygen levels (Figure 2-35) are presented in DOE/RL-2013-13.

### **Gross Beta**

Groundwater samples collected from some wells in the ISRM barrier in 100-D contain concentrations of gross beta above the drinking water standard. 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](#), *Hanford Site Groundwater Monitoring for Fiscal Year 1999*). The highest gross beta concentration in 2012 was 100 pCi/L in 199-D4-1. Concentrations in barrier wells have declined from the peak levels seen in 2001 or 2002.



Map HR.15 100-HR-D Aquifer Tube Locations

## 100-HR-H RCRA

The 183-H solar evaporation basins (waste site 116-H-6) included four sedimentation and flocculation basins that remained from operation of the 183-H water treatment facility. The four basins received combined radioactive and dangerous (mixed) waste for storage and treatment from the 300 Area fuel fabrication facilities from July 1973 until November 1985. By fall 1996, the waste remaining in the basins was removed, the basins were demolished, and the underlying contaminated soil was replaced with clean fill. Clean closure of the site was not achieved because fluoride and nitrate levels in soil below the 4.6 meter-deep excavation exceed the “Model Toxics Control Act–Cleanup” ([WAC 173-340](#)) Method B cleanup levels. Therefore, the unit was closed under the modified-closure option, with specified measures for post-closure care.

The Hanford Facility RCRA Permit ([WA7890008967](#), *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage, and Disposal of Dangerous Waste*) requires annual groundwater monitoring of the facility, which includes sampling wells 199-H4-3, 199-H4-8, 199-H4-12A, and 199-H4-12C for total chromium, fluoride, nitrate, technetium-99, and uranium (Map HR.16). 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 2012, the RCRA wells were sampled as scheduled for the constituents of interest listed in the groundwater monitoring plan ([PNNL-11573](#), *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*) (Table 3-6, [SGW-55438](#)). The concentrations of fluoride and technetium-99 remained below applicable concentration limits in all four 183-H Basins wells. Nitrate and uranium were measured at levels exceeding their concentration limits in well 199-H4-3 in 2012. A 37.1 µg/L uranium concentration in well 199-H4-3 exceeded both the 20 µg/L permit concentration limit and the 30 µg/L drinking water standard. In addition, the uranium concentration at 23.7 µg/L in well 199-H4-12A exceeded the permit concentration limit. Concentrations increased from previous measurements in both locations. The most likely cause for these increases in uranium concentrations was the unusually high river stage observed in 2011 and again in 2012. Water rising into the overlying zone of contamination may have increased the rate at which it discharges to the groundwater, causing a temporary peak in concentration.

These fluctuations above the concentration limits 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\(11\)](#), “Dangerous Waste Regulations,” “Releases from Regulated Units.” The unit will remain in corrective action until the groundwater contamination is remediated under CERCLA. Total chromium continued to exceed the 122 µg/L permit concentration limit in 199-H4-12C, which monitors a RUM water-bearing zone. Because none of the other 183-H Basin co-contaminants were elevated in 199-H4-12C, total chromium in this well likely has an alternative source (100-HR-H Hexavalent Chromium section).

DOE submitted two semiannual reports to Ecology, as required under RCRA corrective action monitoring ([SGW-53895](#), *First Semiannual Report for 2012 Post-Closure Corrective Action Groundwater Monitoring at the 183-H Solar Evaporation Basins and 300 Area Process Trenches: January – June 2012*; [SGW-54971](#), *Post-Closure Corrective Action Groundwater Monitoring Report for the 183-H Solar Evaporation Basins and the 300 Area Process Trenches: July – December 2012 - Second Semi-Annual Report*).

In early 2013, DOE requested temporary authorization to replace well 199-H4-3 with 199-H4-84 ([13-EMD-0019](#), “Proposed Class 2 Resource Conservation and Recovery Act (RCRA) Permit Modifications and Request for Temporary Authorization at the 183-H Solar Evaporation Unit (TSD: T-1-4)”) in the RCRA permit. This will ensure that no groundwater monitoring impact will occur due to ongoing waste site remediation activities in 100-H.



Map HR.16 100-HR-H RCRA Monitoring Well Locations

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