4 100-HR

The 100-HR-3 Groundwater OU, in the northern Hanford Site, encompasses the 100-HR-D and 100-HR-H groundwater interest areas, which together make up 100-HR (Figure 1-1). This chapter includes an overview; a discussion of CERCLA-, RCRA-, and AEA-related groundwater activities conducted in 2017; and a summary of 2017 groundwater monitoring results.

4.1 Overview

Groundwater in 100-HR was contaminated by waste releases associated with past operation of the D, DR, and H Reactors and associated support facilities. At the end of 2017, 98% of the waste sites were classified as closed, interim closed, final closed, no action, not accepted, or rejected. The final 2% of the waste sites will be remediated under a ROD for final remedial action.

Table 4-1 lists key facts about 100-HR, including plume areas. A plume area is not included for uranium because it is present in only a few locations. Additional details about 100-HR history, waste sites, and hydrogeology are provided in Chapters 1 and 3 of the 100-D/H RI/FS (DOE/RL-2010-95, Remedial Investigation/Feasibility Study for the 100-DR-I, 100-DR-2, 100-HR-I, 100-HR-2, and 100-HR-3 Operable Units). Figures 4-1 and 4-2 show the locations of monitoring, extraction, and injection wells and aquifer tubes. Data from monitoring seeps and springs are shown on each of the plume figures presented but were not used for plume development due to their transient nature. Plume mapping details, including descriptions of terms (e.g., Type 1 control point) used in the figure legends, are provided in Section 1.5.

Vadose zone thickness, which also represents the depth to groundwater, ranges from 0 to 27 m (0 to 89 ft), with an average thickness of 20 m (66 ft) in 100-HR-D and 11.3 m (37.1 ft) in 100-HR-H. The thickness of the unconfined aquifer ranges from 12 m (39 ft) in 100-HR-D to less than 1 m (3.3 ft) in portions of 100-HR-H, with the aquifer generally thinning from west to east. The thickness of the unconfined aquifer mimics the topography of the RUM (DOE/RL-2008-42, Hydrogeological Summary Report for 600 Area Between 100-D and 100-H for the 100-HR-3 Groundwater Operable Unit). The uneven surface of the silt- and clay-rich RUM forms the base of the unconfined aquifer.

Water-bearing units are found within and below the RUM and form confined or semiconfined aquifers. The uppermost water-bearing unit of the RUM is typically referred to as the RUM aquifer. The extent and hydraulic interconnection of the RUM water-bearing unit (laterally and vertically) and the degree of leakage or confinement of the overlying fine-grained RUM layer remain uncertain due to a lack of wells within the lower water-bearing units. As noted in Section 4.4, recent and future evaluations are helping to determine the hydraulic connectivity between RUM wells, connections between the RUM aquifer and the overlying unconfined aquifer, and connections between the RUM and the Columbia River. Tests conducted in 2016 also provided some estimates of aquifer parameters (Section 4.4).

The unconfined aquifer is primarily present in Ringold unit E in 100-HR-D and in the Hanford formation gravel in 100-HR-H (Figure 4-3). Across the Horn, the geology is transitional, changing from predominantly Ringold unit E in the west 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 formed and resulted in preferential groundwater flow pathways.
Table 4-1. 100-HR at a Glance

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Groundwater Monitoring</td>
<td></td>
</tr>
<tr>
<td>Contaminant, Water Quality Standard, Units</td>
<td>Year</td>
</tr>
<tr>
<td>Hexavalent chromium, 48/10&lt;sup&gt;e&lt;/sup&gt; µg/L</td>
<td>2017</td>
</tr>
<tr>
<td></td>
<td>2016</td>
</tr>
<tr>
<td>Nitrate, 45 mg/L</td>
<td>2017</td>
</tr>
<tr>
<td></td>
<td>2016</td>
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<tr>
<td>Strontium-90, 8 pCi/L</td>
<td>2017</td>
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<tr>
<td></td>
<td>2016</td>
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<tr>
<td>Tritium, 20,000 pCi/L</td>
<td>2017</td>
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<td></td>
<td>2016</td>
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<tr>
<td>Uranium, 30 µg/L</td>
<td>2017</td>
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<tr>
<td></td>
<td>2016</td>
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Remediation

| Waste sites: 98% complete. f |

Groundwater interim action for hexavalent chromium 1997 through present.

- a. Estimated area at a concentration greater than the listed water quality standard.
- b. Length of shoreline intersected by plume above listed water quality standard.
- d. Depth-discrete characterization sample collected during drilling.
- e. Limited to isolated occurrences; no defined plume.
- f. Sites with closed, interim closed, final closed, no action, not accepted, or rejected status as of December 31, 2017.

Groundwater in 100-HR flows generally to the east-northeast, from the 100-D Area across the Horn and toward 100-H Area. Flow in the 100-H Area is to the east and northeast, generally toward the Columbia River. The operation of P&T systems as interim actions for Cr(VI) influences groundwater flow direction and velocity throughout 100-HR, creating depressions and mounds in the water table. Figures 4-4 and 4-5 show the water table contours for March 2017, a transitional river stage period. Changes in river stage formerly affected groundwater flow directions. The P&T system has become more robust over time with the addition of wells in key locations; however, the effect of the river stage on plume configuration has lessened. Plume changes are now primarily controlled by modifications to the P&T system during the year.
Figure 4-1. 100-HR-D Sampling Locations, 2017
Figure 4-2. 100-HR-H Sampling Locations, 2017
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, Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units, Interim Remedial Actions Benton County, Washington) and include Cr(VI), total chromium, nitrate, strontium-90, and tritium. Figure 4-6 illustrates how the areas of the contaminant plumes have changed over time. Figure 4-7 shows the Cr(VI) plume in 1999, 2 years after the first P&T system began operating, and in 2017, after 20 years of active P&T. The P&T systems have shrunk the plume and eliminated nearly all of the concentrations greater than 100 µg/L.

Within the unconfined aquifer, vertical stratification of Cr(VI) was identified in areas below waste sites where highly concentrated sodium dichromate was handled, such as beneath the 100-D-100 waste site excavation area (SGW-58416, Persistent Source Investigation at 100-D Area). However, the stratification is not well defined or consistent in all parts of 100-HR.

Figure 4-4. 100-HR-D Water Table, March 2017

Figure 4-5. 100-HR-H Water Table, March 2017
4.2 **100-HR-D Hexavalent Chromium**

In 100-HR, Cr(VI) is the most widely distributed COPC. Cr(VI) in groundwater resulted from historical releases of two different types of wastewater. The first type of release included spills, leaks, and unintentional discharge of concentrated sodium dichromate solutions used as feed chemicals for conditioning reactor cooling water. A high-concentration release of sodium dichromate stock solution is the primary cause of the southern Cr(VI) plume. The second type of release included spent reactor cooling water from retention basin leaks and intentional discharges to the 116-DR-1&2 Trenches during an infiltration test in 1967, which had high volumes of water with lower concentrations of sodium dichromate. The releases to the 116-DR-1&2 Trenches are the primary cause of the northern Cr(VI) plume and the plume across the Horn (Section 4.3.1).

Based on the 2014 investigation of the 100-D-100 waste site (the result of a high-concentration sodium dichromate release), there are two CSMs for Cr(VI) in groundwater along the River Corridor. The first and more prevalent CSM may still apply to lower concentration releases (e.g., contaminated cooling water), but the presence of a secondary source is not confirmed. In these areas of low-concentration source material, it is assumed that Cr(VI) is essentially entirely mobile and moves easily with the groundwater. A second CSM for Cr(VI) applies at high-concentration sites (e.g., those spills and releases containing high-concentration sodium dichromate solution), where it has been shown that a chromium-substitute calcite may be present in the soil at the groundwater/vadose interface. The presence of chromium-substitute calcite provides a slow-leaching source of Cr(VI) to the aquifer, resulting in a long-term secondary source (Section 7.3 of **SGW-58416**).
Figure 4-7. 100-HR Cr(VI) Plume in 1999 (Early in Interim Action Period) and 2017 (During Interim Action)
4.2.1 Southern Plume at 100-D

The overall Cr(VI) plume size in the southern portion of the 100-D Area (Figures 4-8 and 4-9) is smaller than in previous years, with a general reduction in concentrations across the area. Concentrations in most locations in the southern plume were below the MTCA (WAC 173-340) standard of 48 µg/L. Several wells near the former 100-D-100 and 100-D-30/104 excavation areas and the former 100-D-56 pipeline continue to exhibit concentrations above 48 µg/L. Wells 199-D5-104 and 199-D5-34 (Figure 4-10) continue to show a decreasing trend, but concentrations in both wells began to asymptote during 2016 with the rate of concentration decline slowing. This trend continued throughout 2017.

In contrast to the overall declining trends, well 199-D5-103, located near the former 100-D-56 sodium dichromate supply pipeline and between the 100-D-100 and 100-D-30/104 excavations, is exhibiting quickly increasing concentrations (Figure 4-10). It is known that visual Cr(VI) staining remained along the eastern sidewall of the 100-D-100 excavation during the 2014 excavation activities, near current wells 199-D5-103 and 199-D5-160. The concentrations and amount of remaining material are unknown. It is hypothesized that the high water levels experienced during 2017 resulted in the remobilization of Cr(VI) remaining within the deep vadose zone. Well 199-D5-103 had Cr(VI) concentrations of 730 µg/L by December 2017 and now exhibits the highest Cr(VI) levels within 100-HR.

The in situ redox manipulation (ISRM) barrier is located on the southern end of the 100-D Area. Cr(VI) concentrations in 2017 were slowly declining at the northern end of the ISRM barrier. The Cr(VI) along the barrier is below 48 µg/L, with the exception of well 199-D4-60, which had a filtered Cr(VI) result of 68 µg/L in November 2017. It is unknown if a continuing source is present near the ISRM barrier because Cr(VI) concentrations are still generally decreasing, and this area may have lower hydraulic conductivity or less groundwater flow than surrounding areas.

Consistent with previous years, the fall 2017 samples from aquifer tubes and the near-shore monitoring wells indicate that Cr(VI) continues to reach the shoreline of the Columbia River downgradient and south (i.e., upriver) of the ISRM barrier (Figures 4-8 and 4-9). The plume may be migrating to the south around the ISRM barrier along a preferential pathway, or it could be coming from a southern source. During 2016, aquifer tube Redox-3-3.3, located along the shoreline downgradient of the ISRM barrier, had an elevated average Cr(VI) value of 21.5 µg/L. This was related to the temporary shutdown of nearby extraction well 199-D4-38. With the extraction well back in operation, concentrations at aquifer tube Redox-3-3.3 have since declined, and the average Cr(VI) value in 2017 was 4.5 µg/L. The only other area with elevated aquifer tube concentrations was south of the ISRM at aquifer tube clusters DD-50 and DD-49. The highest Cr(VI) concentration in these aquifer tubes in 2017 was 22 µg/L in DD-50-4.

4.2.2 Northern Plume at 100-D

The overall footprint of the northern 100-D Area Cr(VI) plume (Figures 4-8 and 4-9) was slightly smaller in 2017 than in previous years. The area of the plume with concentrations greater than 48 µg/L continued to decline in response to continued P&T extraction and system optimization. The small area of concentrations greater than 48 µg/L are primarily located near the 120-D-1 (100-D Pond) waste site, the 126-D-1 coal ash waste site, and southwest of the 116-DR-1&2 Trenches. Consistent with previous years, extraction well 199-D8-95 had the highest concentrations in the northern 100-D plume, with a maximum of 150 µg/L in January 2017. Well 199-D8-95 and nearby extraction well 199-D8-96 had concentrations over 48 µg/L during 2017, but both wells exhibited declining trends over the year, with concentrations at the end of 2017 at 98 and 54 µg/L, respectively (Figure 4-11). No other wells in the northern plume had concentrations above 48 µg/L during 2017.

Figure 4-8. 100-HR-D Cr(VI) Plume, Spring/Summer 2017 (High River Stage)

Figure 4-9. 100-HR-D Cr(VI) Plume, Fall 2017 (Low River Stage)
Figure 4-10. 100-HR Cr(VI) Data for Wells 199-D5-103, 199-D5-104, 199-D5-160, and 199-D5-34

Figure 4-11. 100-HR Cr(VI) Data for Extraction Wells 199-D8-95 and 199-D8-96
Despite years of remediation, low to moderate levels of contamination remain in wells located between the 116-DR-1&2 Trenches and the Columbia River (Figures 4-8 and 4-9). Upgradient injection and near-river extraction have resulted in stable concentrations in the area at about 10 to 15 µg/L. It is suspected that a continuing source remains near the 116-DR-1&2 Trenches, but no source area has been clearly identified.

Downgradient of the 116-DR-1&2 Trenches, aquifer tubes DD-17-2 and DD-16-4 continued to exhibit Cr(VI) concentrations at or near 10 µg/L. While capture of the plume in this area has improved due to P&T system modifications, Cr(VI) continued to reach the river in 2017 at concentrations near 10 µg/L.

### 4.3 100-HR-H Hexavalent Chromium

Discharge to the 116-DR-1&2 Trenches during 1967 resulted in the unconfined aquifer Cr(VI) plume that extends across the Horn from the 100-D Area to the 100-H Area (Figures 4-12 and 4-13) (DOE/RL-2010-95). This plume encompasses the largest area of 100-HR, but the plume area is continuing to shrink and concentrations are declining. In 2017, Cr(VI) concentrations were at or below the MTCA (WAC 173-340) standard of 48 µg/L across the Horn. Remediation activities continue to reduce contaminant levels slowly, but removal effectiveness is complicated by the hydrogeology of the area.

Extraction pumps require a minimum of 0.6 m (2 ft) of water above the pump intake to operate. Across the Horn and in the northern portion of the 100-H Area, the aquifer is less than 1 m (3 ft) thick in some locations during low river stage, with the thinnest locations along the northern portion of the Horn. During low river-stage periods, the amount of water available in the aquifer is minimal, and even when pumps are set low into well sumps, there may be insufficient water for the pumps to operate. The reduced operational period during low river stage can adversely affect hydraulic containment. Injection of water into the Horn appears to have helped move the contaminants toward the extraction wells, but a rise in water level in response to the injection has not been confirmed.

Cr(VI) in the 100-H operational area is primarily from H Reactor operations. The areas of elevated concentrations are located near the 183-H Solar Evaporation Basins and in an area north of H Reactor at wells 199-H4-86 and 199-H4-87. Seasonal water table variations in these areas result in corresponding fluctuations in Cr(VI) concentrations, indicating a potential continuing source. Figure 4-14 presents the water table fluctuations in well 199-H4-88, located within the 183-H Solar Evaporation Basins, and the corresponding response in Cr(VI).

#### 4.3.1 Plume in the Horn

The overall Cr(VI) concentrations in the Horn area unconfined aquifer are slowly declining and were below 48 µg/L for the first time during 2017. Ongoing P&T system operations are attributed with the reduction in Cr(VI); however, the complex hydrogeology and thin aquifer across the Horn has resulted in a slow response to remediation. Injection of P&T system effluent in the middle and south of the Horn was increased in 2015 and 2016 and appears to be moving the remaining Cr(VI) mass toward the extraction locations and resulting in a shrinking plume. Injection well 699-95-45B, which currently accepts approximately 530 L/min (140 gal/min), was added to the system in late 2015; injection well 699-90-45B was added to the system in late 2016 and currently accepts about 490 L/min (130 gal/min).

Figure 4-12. 100-HR-H Cr(VI) Plume, Spring/Summer 2017 (High River Stage)

Figure 4-13. 100-HR-H Cr(VI) Plume, Fall 2017 (Low River Stage)
Areas of elevated concentrations but less than 48 µg/L remain in the Horn near extraction wells 199-H4-93, 199-H4-75, 199-H1-4, and 199-H1-2, and near monitoring well 699-97-45. Wells 199-H4-93 and 199-H4-75 are located in the southwest area of the Horn. The aquifer is less than 3 m (10 ft) thick in this area, limiting groundwater extraction from these two wells, especially during the early spring. The extraction rate of well 199-H3-93 was averaging 68 L/min (18 gal/min) when operational during 2017, but the well was offline until the end of February 2017. Similarly, well 199-H4-75 averaged 57 L/min (15 gal/min) during 2017. As a result of the low flow rates, which are typical in this area, Cr(VI) concentrations are declining slowly. Concentrations in wells 199-H4-93 and 199-H4-75 were at 20 and 29 µg/L, respectively, by December 2017, compared to 47 µg/L in both wells at the end of 2016. Concentrations in wells 199-H1-4 and 199-H1-2 (located in the middle of the Horn) changed little during 2017, averaging 34 and 36 µg/L, respectively. The stable Cr(VI) concentrations in these two extraction wells was typical across the Horn during 2017.

Closer to the river and north of the 100-H Area, concentrations fluctuated seasonally. The lower concentrations generally occurred during high river stage, when groundwater gradients are directed inland in near-river areas. For example, well 199-H1-46 had seasonal average Cr(VI) concentrations of 9.9 and 39.5 µg/L during the high and low river stages, respectively. Flow rates in well 199-H1-46 were between 75 and 95 L/min (20 and 25 gal/min) during high river stage (when concentrations are low) and between 19 and 38 L/min (5 and 10 gal/min) during low river stage in 2017.

Consistent with previous years, Cr(VI) was detected along the Columbia River shoreline above 10 µg/L in aquifer tube C5641 during low river stage (Figure 4-13). Slightly upriver, aquifer tubes C5638 and 43-M also exhibited elevated Cr(VI) concentrations with levels just below 10 µg/L, at average concentrations of 9.7 and 9.6 µg/L, respectively. These aquifer tubes are located in an area where plume capture is difficult due to the thin aquifer.
4.3.2 Plume at 100-H Area and South

The Cr(VI) concentrations in the 100-H Area unconfined aquifer are typically less than 10 µg/L. In recent years, however, the amount of injection water within the 100-H operational area has been reduced. The reduction was conducted, in part, to determine if any continuing sources remained. As a result, a maximum Cr(VI) concentration of 130 µg/L was detected in well 199-H4-84 in April 2017, and concentrations over 30 µg/L were detected in several other monitoring wells within the 100-H Area during 2017. The areas of elevated Cr(VI) are near the 183-H Solar Evaporation Basins (wells 199-H4-84 and 199-H4-88) and near upgradient waste sites 126-H-2 and 100-H-46 (wells 199-H4-86 and 199-H4-87, respectively). At each of the waste site locations, the associated wells exhibit elevated Cr(VI) concentrations during periods of high water levels and are areas of suspected or known continuing sources in the lower vadose zone.

Aquifer tube C7650, located downgradient of the 107H Retention Basin, continues to have elevated Cr(VI) concentrations, averaging 29.5 µg/L during 2017. Cr(VI) concentrations also continued to be above 10 µg/L in aquifer tube 51-D, located to the south of the 100-H Area. This appears to be an isolated area of slightly elevated Cr(VI), and concentrations are slowly declining.

4.4 Hexavalent Chromium in the Ringold Upper Mud Unit

The surface of the RUM forms the base of the unconfined aquifer in 100-HR. In 100-HR-D, the RUM material is primarily silt and clay and is relatively thick, providing a barrier between the unconfined aquifer and the first water-bearing unit within the RUM. Across the Horn and in 100-HR-H, data from borehole logs indicate that the uppermost RUM material is thinner and contains more sand and gravel than elsewhere at 100-HR. In addition, reworked RUM material is present in small pockets, mostly within the Horn and the 100-H Area. This material contains gravel in a silt and clay matrix that represents a transition zone above the more massive silt or clay. This may result in a less competent barrier between the unconfined aquifer and the RUM aquifer below, possibly contributing to a hydraulic connection between the two units.

Within the RUM, thin sand-to-gravel layers with variable hydraulic conductivities act as confined or semiconfined leaky aquifers (DOE/RL-2010-95). Multiple water-bearing units are known to be present in the 100-H Area. Within the 100-D Area and in the Horn, deeper water-bearing units are suspected but are not confirmed or monitored.

4.4.1 Ringold Upper Mud Unit Plume at 100-HR-D

Three wells in the 100-D Area monitor the first water-bearing unit of the RUM. Cr(VI) has not been detected in well 199-D4-141, which is located south of the 182D reservoir. The other RUM wells are 199-D8-54B (located near the 116-DR-1&2 Trench) and 199-D5-134 (located north of D Reactor). The Cr(VI) concentrations in these wells have fluctuated historically, with concentrations below 10 µg/L. Concentrations in well 199-D8-54B have been trending slowly upward, with a maximum concentration in 2017 of 8.8 µg/L. These wells will continue to be monitored to track concentrations.
4.4.2 Ringold Upper Mud Unit Plume in the Horn

Elevated concentrations of Cr(VI) are known to be present within the Horn. Figure 4-15 presents the annual average concentrations during 2017 for the RUM wells. The maximum concentration is presented only for wells drilled in 2017. A plume is not depicted due to the varied spatial distribution of Cr(VI) concentrations, a limited number of wells for such a large area, and uncertainty regarding the lateral continuity of the RUM aquifer. Based on current knowledge, elevated Cr(VI) concentrations are present in a small area centered near well 699-97-48C, which had a maximum concentration of 140 µg/L in 2017 and is exhibiting an increasing trend.

Concentrations are declining in well 699-97-61, located west of 699-97-48C, which may indicate the tailing edge of the plume. Well 699-97-61 had a maximum concentration of 196 µg/L in 2016 and 123 µg/L in 2017. None of the other wells in the same area are completed in the RUM, and it is uncertain if the plume extends farther to the north or south. To the east, RUM well 699-97-45B has Cr(VI) levels just above the detection limit. It is presumed that this well represents the eastern boundary of the Cr(VI) plume, but as in the west, there are limited wells in the area and no wells to define the plume to the north or south. It should also be noted that wells 699-97-61 and 699-97-45B are 675 m (2,200 ft) apart, and in the Horn, all of the RUM wells are nearly in a straight line running west to east. Additional wells are planned to be installed in the Horn as funding becomes available.

4.4.3 Ringold Upper Mud Unit Plume at 100-HR-H

There are several water-bearing units within the RUM in the 100-H Area. The source of contamination in the RUM aquifer in this area is hypothesized to be Cr(VI)-contaminated groundwater in the overlying unconfined aquifer that was driven downward through the upper RUM material and into the RUM aquifer by high hydraulic heads during reactor operations (Section 4.1.5.3 of DOE/RL-2010-95). This hypothesis is supported by the fact that the RUM in the 100-H Area includes a relatively thin zone of silt and clay material separating the two aquifers. Under current conditions, the RUM aquifer in the 100-H Area exhibits slightly higher head than the unconfined aquifer, indicating a small upward vertical gradient. This gradient has been decreasing over time (Section 3.7.2.2 of DOE/RL-2010-95), likely due to groundwater extraction at several RUM wells.

The top of the zones with higher hydraulic conductivity is typically 3 to 5 m (9 to 16 ft) below the RUM surface. This material also exhibits a substantial sand and gravel fraction, making the competency of the RUM material as a confining layer questionable. To date, Cr(VI) contamination has been identified in only the uppermost of these units, with the lower water-bearing zones having levels at or near the detection limits.

The first water-bearing unit in the RUM is better defined in the 100-H Area than elsewhere across 100-HR. Three new wells were installed in 2017, with well 199-H3-29 having the highest Cr(VI) concentration (140 µg/L) in the 100-H Area (including in the unconfined aquifer). Assuming a hydraulic connection, well 199-H3-29 is located just upgradient of RUM extraction wells 199-H4-12C and 199-H3-9. Together, these two extraction wells average 158 L/min (42 gal/min). Wells 199-H4-12C and 199-H3-9 have slowly declining Cr(VI) concentrations (Figure 4-16). Well 199-H2-1, to the north, has exhibited an increasing trend, with concentrations at 20 µg/L in November 2017. It is unknown if this well is hydraulically connected to the high-concentration wells (199-H4-12C, 199-H3-9, and 199-H3-29) located near the 183-H Solar Evaporation Basins.
Figure 4-15. 100-HR Cr(VI) Concentrations in the RUM Monitoring Wells, 2017
New RUM well 199-H3-30 also exhibits high Cr(VI) levels, with concentrations at 88 µg/L in December 2017 (post-development). This well is located within the footprint of the former 107H Retention Basin (waste site 116-H-7). The presence of Cr(VI) in this location is consistent with the current CSM for the area. South of the retention basin, concentrations at well 199-H4-91 have been stable at about 30 to 40 µg/L. Slightly inland at well 199-H4-90, Cr(VI) levels are lower and typically range from 8 to 15 µg/L (Figure 4-17).

In 2016, a series of hydraulic characterization and aquifer tests were performed in five RUM wells in the 100-H Area (199-H3-10, 199-H3-2C, 199-H4-90, 199-H3-9, and 199-H4-12C). The results of these tests and analyses were evaluated to help determine the hydraulic connectivity between RUM wells and the connections between the RUM aquifer and the overlying unconfined aquifer and Columbia River. The results were published in 2017 in SGW-60571, Aquifer Testing of the First Water-Bearing Unit in the RUM at 100-H.

Results of the aquifer characterization tests identified and quantified the RUM confining layer leakage, which provides initial leakage parameter estimates that can be used for modeling contaminant transport from the overlying unconfined aquifer to the underlying RUM aquifer. All of the drawdown derivative patterns were characteristic of leaky confined aquifers (PNL-8539, Selected Hydraulic Test Analysis Techniques for Constant-Rate Discharge Tests). This is typical for confining layers that are relatively thin with overlying productive aquifers (i.e., those with high transmissivity and storativity), which is consistent with the hydrogeologic model for the 100-H Area (DOE/RL-2010-95). Thus, these tests provided specific evidence of leaky aquifer conditions and estimates of the leaky, confining layer properties.
As demonstrated from the Phase 2 characterization tests, leakage from the overlying unconfined aquifer through the RUM confining layer is sufficient to limit the lateral propagation of test drawdown response that would occur if non-leaky, confined aquifer conditions were present. Phase 2 characterization test results suggest that hydrologic continuity of the RUM aquifer is likely to extend 300 m (1,000 ft) and perhaps considerably more.

SGW-60571 also evaluated whether the unconfined aquifer and the RUM aquifer are hydraulically connected to the Columbia River. Selected 100-H Area wells completed in the unconfined aquifer above the RUM appear to exhibit a hydraulic communicative response, whereas wells completed within the uppermost RUM aquifer exhibit either a hydraulic communicative or loading response. The wide areal response to river-stage fluctuations suggests that both the unconfined and uppermost RUM aquifers are hydraulically connected to the Columbia River. However, the nature and extent of the hydraulic communication interface between the RUM aquifer and the river is unclear. Hydraulic communication may be limited to a few local or preferential contact interfaces where the RUM aquifer is in direct contact with the river channel, or the connection may be more broadly extensive along the river shoreline.

Additionally, the study provided quantitative aquifer hydraulic properties (e.g., transmissivity and storativity) for the first water-bearing unit of the RUM. The test results will support future decisions for remediating affected groundwater in the 100-H Area.

4.5 Nitrate

Primary sources of nitrate in 100-HR groundwater included gas condensate from the reactors, septic systems and sewer lines, former agricultural practices, and waste sites that received nitric acid. The nitrate plume was largely collocated and is extracted during P&T operations. The area of the plume with nitrate concentrations above the 45 mg/L DWS equivalent has declined and now is exhibited in only a few wells.
Nitrate concentrations in the 100-D Area remained below the DWS and continued to decline in 2017. The highest concentration in the 100-D Area in 2017 was 40.7 mg/L in well 199-D8-97 (Figure 4-18). Wells 199-D5-130 and 199-D8-98 showed the next highest nitrate concentrations in 100-D, at 39.4 and 37.6 mg/L, respectively.

The highest nitrate concentrations in 100-HR during 2017 were found near the former 183-H Solar Evaporation Basins. Nitrate concentrations above 45 mg/L were detected in wells 199-H4-84 and 199-H4-88, with a maximum concentration of 124 mg/L at well 199-H4-84. Nitrate concentrations in well 199-H4-84 increased in spring 2017, reaching a peak in July, and then declining through the summer and fall when water levels dropped, which is consistent with concentration responses to water-level trends in a source area (Figure 4-19). The unusual decrease in nitrate and specific conductance during May and June appears to be related to the dilution from an influx of river water. However, adjacent wells 199-H4-88 and 199-H4-89 showed increases in nitrate concentrations during high river stages, with maximum concentrations of 76.6 and 48.7 mg/L, respectively.

Nitrate concentrations in the first water-bearing unit of the RUM remained much lower than in the unconfined aquifer in the 100-D Area and the Horn. Concentrations in the 100-D Area are typically below 2 mg/L, and concentrations in the Horn were below 4 mg/L. In the 100-H Area, nitrate concentrations remained low in the RUM in most locations. Concentrations in the RUM have increased in recent years in wells 199-H4-90, 199-H4-91, and 199-H4-12C, with a maximum of 21.7 mg/L in well 199-H4-12C. In new RUM wells 199-H3-28 and 199-H3-30, nitrate concentrations were at 23.5 mg/L and below 8 mg/L, respectively. However, new RUM well 199-H3-29 exhibits elevated concentrations of nitrate with an increasing trend. Nitrate levels in the well were at 155 mg/L during post-development sampling in November and increased to 416 mg/L by January 2018, exceeding the DWS of 45 mg/L. This is the first location in the RUM aquifer with an exceedance of nitrate. It should be noted that well 199-H3-29 is located near the 183-H Solar Evaporation Basins, where the RUM is known to be a leaky, confining unit.
Figure 4-19. 100-HR Nitrate, Specific Conductance, and Water-Level Data for Well 199-H4-84
4.6 Strontium-90

Strontium-90 was present in waste disposed at both the 100-D and 100-H Areas. Elevated concentrations are present in groundwater in isolated locations near D Reactor and the 107H Retention Basin (Figures 4-20 and 4-21). The concentrations and distribution of strontium-90 are declining gradually in both areas, consistent with natural radiological decay.

Groundwater near the former fuel storage basin (FSB) at D Reactor is monitored for strontium-90. Wells 199-D5-132 and 199-D5-142 are located near the FSB and continue to have strontium-90 concentrations above the DWS of 8 pCi/L. The highest strontium-90 concentration was identified in well 199-D5-132 at 27.8 pCi/L (February 2017). The average concentration dropped from 28.1 pCi/L in 2016 to 21.4 pCi/L in 2017. Strontium-90 concentrations in downgradient wells exhibit some fluctuation but remained below the 8 pCi/L DWS.

Historically, strontium-90 concentrations above DWS have been found in groundwater near the former 116-D-7 and 116-DR-9 Retention Basins in the northern 100-D Area. In 2017, the highest strontium-90 concentration in that area was 3.93 pCi/L in well 199-D8-68, a decline from previous years. Strontium-90 was detected at low concentrations in aquifer tubes downgradient from the retention basins, which is consistent with previous years. The highest detection was 3.74 pCi/L in aquifer tube C6278.

Strontium-90 levels in 100-H Area groundwater continue to exceed the DWS near the former 116-H-7 Retention Basin and 116-H-1 Trench, located near the Columbia River and east of H Reactor (Figure 4-21). This is the only area in 100-H with strontium-90 above the DWS. Strontium-90 concentrations in this area showed notable increases in 2017, likely due to the unusually high water levels in areas with known or suspected continuing sources in the lower vadose zone.

The highest strontium-90 concentration in the 100-H Area was 25.8 pCi/L in well 199-H4-83 in November 2017, which was an increase from 2016 (Figure 4-22). Concentrations were also elevated in nearby well 199-H4-13 and in well 199-H3-11 (located near H Reactor), with maximum concentrations of 23.1 and 14.4 pCi/L, respectively. Slightly elevated concentrations were also detected south of the 116-H-7 Retention Basin at wells 199-H4-45 and 199-H3-6. Strontium-90 was not detected in samples collected from aquifer tubes located downgradient of this area.

Previously, RUM wells were not located within the footprint of the 100-H or 100-D Area strontium-90 plumes. During late 2017, new RUM well 199-H3-30 was installed in the footprint of the 107H Retention Basin. New RUM wells 199-H3-28 and 199-H3-29 were installed upgradient and slightly downgradient of the 183-H Solar Evaporation Basins. Early analytical results from these wells indicate that strontium-90 is not present in the RUM aquifer.

In 2015, strontium-90 was detected for the first time at RUM extraction well 199-H4-12C at 6.05 pCi/L. Since the 2015 detection, well 199-H4-12C has been on a quarterly sampling schedule, with no detectable strontium-90 in 2016 or 2017. This well will continue to be monitored for strontium-90.

4.7 Tritium

Tritium concentrations in 100-HR are decreasing overall, with concentrations below 10,000 pCi/L during 2017. Historically, tritium occasionally exceeded the 20,000 pCi/L DWS in wells near the ISRM barrier in the southern portion of the 100-D Area and near DR Reactor. The last tritium concentration that exceeded the DWS in 100-HR was in 2014 at well 199-D4-20. Concentrations in well 199-D4-20 were at 2,970 pCi/L in 2017. The highest tritium concentration in 100-HR groundwater during 2017 was 9,440 pCi/L at well 199-D4-13, which is part of an increasing trend.
Figure 4-20. 100-HR-D Strontium-90 Plume, 2017
Figure 4-21. 100-HR-H Strontium-90 Plume, 2017
4.8 Uranium

Uranium is present in groundwater near the former 183-H Solar Evaporation Basins in the 100-H Area (Section 4.11) and exceeded the DWS of 30 µg/L in two wells during 2017. Concentrations in well 199-H4-84 ranged from 127 µg/L in July to 11 µg/L in October (Figure 4-23). The duplicate sample in July had a slightly lower result of 119 µg/L. Elevated uranium concentrations were also observed in well 199-H4-88, located within the western portion of the basins. The uranium concentration in well 199-H4-88 ranged from 4.5 µg/L in February to 55.2 µg/L in June.

Like Cr(VI), uranium concentrations increase in this source area during or following high water table conditions. Since the river had higher peak stages during 2017 than in 2016, the number of exceedances of the DWS was not unexpected, and the groundwater level correlates with the elevated uranium concentrations.

Uranium was also detected in well 199-H4-65 at 25.9 µg/L in November 2017. This result was 10 times higher than previous results and is being reviewed as suspect data. The well is located south and downgradient from the 183-H Solar Evaporation Basins and has not been analyzed on a regular basis for uranium due to the presence of low levels (less than 5 µg/L) until 2017. The sample frequency for this well will be increased to better evaluate the elevated result from November 2017.
4.9 Sulfate

The area around the ISRM barrier in the 100-D Area has historically had elevated levels of sulfate related to sodium dithionite solution injections. There were no exceedances of the 250 mg/L secondary DWS at the ISRM barrier or elsewhere in 100-HR during 2017.

Sulfate concentrations tend to increase in wells located near P&T injection wells. Groundwater that has been treated by the DX P&T system is affected by the addition of sulfuric acid, which is used to lower the pH in the influent groundwater because the ResinTech® SIR-700 ion-exchange resin treatment technology is more efficient at a lower pH. Sodium hydroxide is added to the treated groundwater prior to injection into the aquifer to neutralize the acid and return the pH to near neutral. Sulfate concentrations in the effluent during 2017 averaged 161 mg/L.

During 2017, the highest concentrations of sulfate were found in monitoring well 199-D5-149 and extraction well 199-D5-101, with maximum concentrations at or near the DWS (Figure 4-24). The wells are located downgradient of injection wells 199-D5-128, 199-D5-129, and 199-D5-148 (Figure 4-1).

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1 ResinTech® is a registered trademark of ResinTech, Inc., West Berlin, New Jersey.
4.10 CERCLA Remediation and Monitoring

CERCLA groundwater activities in the 100-HR-3 OU included groundwater monitoring and operating and optimizing interim remediation systems for Cr(VI) (including adding new wells and realigning existing wells). The current DX and HX P&T systems are operated under the authority of the interim action ROD ([EPA/ROD/R10-96/134](EPA/ROD/R10-96/134) and the subsequent 2009 explanation of significant differences ([EPA et al., 2009](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). Groundwater is monitored to evaluate the effectiveness of interim remedial actions and to track plumes, plume areas (Figure 4-6 and Table 4-1), and trends. The current CERCLA SAP is [DOE/RL-2013-30](DOE/RL-2013-30), Sampling and Analysis Plan for 100-HR-3 Groundwater Operable Unit Monitoring, as modified by [TPA-CN-0743](TPA-CN-0743), Tri-Party Agreement Change Notice Form: Sampling and Analysis Plan for 100-HR-3 Groundwater Operable Unit Monitoring. Table A-1 in Appendix A lists the sampling exceptions for 2017.

A total of six new wells were installed in 2017 (Table 4-2) as part of remedial optimization. Wells 199-H1-47, 199-H1-48, and 199-H1-49 were installed for use as extraction wells. The wells were completed in the unconfined aquifer along the shoreline north of the 100-H Area, where plume containment has been difficult. Three wells were also installed in the RUM aquifer: 199-H3-28, 199-H3-29, and 199-H3-30. These wells are located in the 100-H Area, with well 199-H3-28 located inland near well 199-H3-2C; well 199-H3-29 located near the 183-H Solar Evaporation Basins; and well 199-H3-30 located within the 107H Retention Basin. The RUM wells 199-H3-28 and 199-H3-29 are currently planned for connection to the HX P&T system.
<table>
<thead>
<tr>
<th>Well Name</th>
<th>Well ID</th>
<th>Purpose*</th>
<th>Construction Depth (m bgs)</th>
<th>Construction Depth (ft bgs)</th>
<th>Drilled Depth (m bgs)</th>
<th>Drilled Depth (ft bgs)</th>
<th>Acceptance Date</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>199-H1-47</td>
<td>C9637</td>
<td>100-HR-3 unconfined aquifer extraction</td>
<td>13.2</td>
<td>43.4</td>
<td>13.9</td>
<td>45.6</td>
<td>12/13/2017</td>
<td></td>
</tr>
<tr>
<td>199-H1-48</td>
<td>C9638</td>
<td>100-HR-3 unconfined aquifer extraction</td>
<td>13.8</td>
<td>45.1</td>
<td>15.4</td>
<td>50.7</td>
<td>12/13/2017</td>
<td></td>
</tr>
<tr>
<td>199-H1-49</td>
<td>C9639</td>
<td>100-HR-3 unconfined aquifer extraction</td>
<td>18.6</td>
<td>61.2</td>
<td>36.7</td>
<td>120.5</td>
<td>12/13/2017</td>
<td></td>
</tr>
<tr>
<td>199-H3-28</td>
<td>C9715</td>
<td>100-HR-3 RUM extraction</td>
<td>35.5</td>
<td>116.4</td>
<td>36.7</td>
<td>120.4</td>
<td>12/13/2017</td>
<td></td>
</tr>
<tr>
<td>199-H3-29</td>
<td>C9716</td>
<td>100-HR-3 RUM extraction</td>
<td>29.3</td>
<td>96.3</td>
<td>70.0</td>
<td>230.5</td>
<td>12/13/2017</td>
<td></td>
</tr>
<tr>
<td>199-H3-30</td>
<td>C9717</td>
<td>100-HR-3 RUM extraction</td>
<td>26.9</td>
<td>88.2</td>
<td>35.1</td>
<td>115.0</td>
<td>12/13/2017</td>
<td></td>
</tr>
</tbody>
</table>

Some of the analytical results from samples collected during drilling are suspect due to low dissolved oxygen content in the sample, which may affect hexavalent chromium results.


bgs = below ground surface

ID = identification

RUM = Ringold upper mud unit
4.10.1 CERCLA Decision Documents and Plans
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-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units) and SAP (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 SAP were documented in Tri-Party Agreement change notices (TPA-CN-368 and 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).

The RI/FS results were evaluated, and DOE submitted Draft A of the RI/FS and the proposed plan for 100-D/H in late 2012 (DOE/RL-2010-95; DOE/RL-2011-111, Draft A, 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 was reviewed by Ecology, revised, and approved as Rev. 0 in October 2014. The RI/FS results support selection of final remedies under CERCLA using an approach that integrates source and groundwater remedial actions, which is documented in the proposed plan (DOE/RL-2011-111, Rev. 0). In 2016, the proposed plan was made available for public comment, public comments were received and incorporated, and work on the ROD for final remedial action commenced. The signed ROD will identify the final remedial alternative.

Remedial action decisions will address the integrated cleanup of source waste sites and groundwater. The general objectives for all of these decisions are to protect human health and the environment, restore groundwater to beneficial use, and protect aquatic life in the Columbia River from exposure to 100-HR groundwater COPCs exceeding ambient water quality criteria.

4.10.2 Pump and Treat
DOE has operated a groundwater P&T system in the 100-HR-3 OU since 1997 under an interim action ROD (EPA/ROD/R10-96/134), which was amended in 1999 (EPA/AMD/R10-00/122, Interim Remedial Action Record of Decision Amendment for the 100-HR-3 Operable Unit, Hanford Site, Benton County, Washington). Two P&T systems (DX and HX) currently operate in 100-HR (Figure 4-25) in accordance with the 2009 explanation of significant differences (EPA et al., 2009). A passive interim remedial action system, the ISRM, is monitored but is no longer maintained.

Table 4-3 summarizes DX and HX P&T operations. These facilities were constructed in response to the 2009 explanation of significant differences (EPA et al., 2009), 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).

In 2017, the DX and HX systems removed a combined total of 56 kg of Cr(VI) from 2,921 million L (771 million gal) of groundwater (Table 4-3). Due to continuing and effective remediation, the mass of Cr(VI) remaining in the aquifer is declining, which results in lower mass recovery, as shown in Figure 4-26. Most of the Cr(VI) mass removed from the DX and HX systems during 2017 originated in what remains of the plume interior, where concentrations are higher. The overall areal extent of the plumes continues to decline (Figure 4-6), illustrating plume response to remediation. Operation of the remediation systems and groundwater monitoring results for 2017 are described in DOE/RL-2017-67.
During 2017, 85 active extraction wells and 28 active injection wells operated, including those that only operated a short time during the year. System realignments at the DX system included disconnecting four injection wells located north of the 100-D Area and converting them to monitoring wells. At the HX system, realignments included converting injection well 199-H1-3 to a monitoring well.
Table 4-3. 100-HR-3 Remedy Summary

<table>
<thead>
<tr>
<th>P&amp;T system</th>
<th>DX</th>
<th>HX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design capacity (L/min [gal/min])</td>
<td>2,935 (775)</td>
<td>3,788 (900)</td>
</tr>
<tr>
<td>Extraction wells</td>
<td>48</td>
<td>37</td>
</tr>
<tr>
<td>Injection wells</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>Average flow rate (L/min [gal/min])</td>
<td>2,829 (747)</td>
<td>2,806 (741)</td>
</tr>
<tr>
<td>Volume treated (million L [million gal])</td>
<td>1,470 (388)</td>
<td>1,451 (383)</td>
</tr>
<tr>
<td>Cr(VI) mass removed (kg)</td>
<td>30.4</td>
<td>25.9</td>
</tr>
<tr>
<td>Average Cr(VI) influent concentration (µg/L)</td>
<td>21.8</td>
<td>18.3</td>
</tr>
<tr>
<td>Average Cr(VI) effluent concentration (µg/L)</td>
<td>&lt;2</td>
<td>&lt;2</td>
</tr>
</tbody>
</table>

All 100-HR-3 P&T Systems, 1997-2017

| Volume treated (million L [million gal]) | 21,050 (5,561) |
| Cr(VI) mass removed (kg) | 2,460 |

In Situ Redox Manipulation Barrier, 1999-2017

Barrier no longer maintained but reduced conditions remain.

Cr(VI) = hexavalent chromium
P&T = pump and treat

Figure 4-26. 100-HR-3 P&T Cr(VI) Mass Removal
The spatial distribution of specific conductance (Figures 4-27 and 4-28) indicates areas where plume capture is more successful. Areas with lower values along the river indicate where the river water is pulled toward nearby extraction wells. These figures correlate well with areas where the plume is under hydraulic control, as discussed in DOE/RL-2017-67.

4.10.3 In Situ Redox Manipulation Barrier

In 2000, an ISRM barrier was added to the existing P&T remedy. Due to Cr(VI) breakthrough at this barrier, a notice of nonsignificant change to the ROD was issued in 2010, indicating that the barrier would no longer be actively maintained and shifting the groundwater remedy to the P&T system (11-AMCP-0002, “Non-Significant Change for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision, Hanford Site, Washington. July 2010. Memo to File Regarding: Supplemental Actions for the In-Situ Reduction/Oxidation Manipulation Barrier Performance for the 100-HR-3 Groundwater Operable Unit Interim Remedy”). Groundwater at the ISRM site is still monitored as part of CERCLA interim action monitoring, with Cr(VI) as the target contaminant. Where it is still effective, the ISRM barrier reduces oxygen content in the aquifer, so dissolved oxygen is also monitored.

In 2017, the ISRM barrier continued to convert some Cr(VI) to a nontoxic, immobile form (trivalent chromium) in the southern portion of the barrier, as suggested by the dissolved oxygen (Figure 4-29). The dissolved oxygen levels near and along the ISRM barrier are increasing overall. The dissolved oxygen concentrations are relatively high upgradient of the treatment zone, decreasing significantly through the treatment zone, and recovering as groundwater flow approaches the river. The P&T system capture is improving in that area in response to system modifications.

Groundwater samples collected from some wells in the ISRM barrier have gross beta levels above 50 pCi/L, the level where additional monitoring is usually required by EPA. However, the gross beta activity is primarily caused by naturally present potassium-40 in the pH buffer used during sodium dithionite injections for the ISRM barrier (Section 2.5 of PNNL-13116, Hanford Site Groundwater Monitoring for Fiscal Year 1999). The highest gross beta concentration associated with the ISRM barrier in 2017 was 83.4 pCi/L in well 199-D4-1.

4.11 RCRA Monitoring at the 183-H Solar Evaporation Basins

The 183-H Solar Evaporation Basins (116-H-6 waste site) (Figure 4-30) consisted of four basins in the 100-H Area. 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 from the 300 Area fuel fabrication facilities. The waste solutions contained various contaminants, including chromium, uranium, and nitrate. The basins were used for waste evaporation from July 1973 until November 1985 and were demolished in 1995. The contaminated soil was removed to a depth of 4.6 m (15 ft) below Basin 1 in 1996 (DOE/RL-97-48).

Groundwater protection was demonstrated through modeling, and Ecology approved a modified RCRA closure in May 1997 (Soper, 1997, “Re: Acceptance of “Closure Certification for the 183-H Solar Evaporation Basins (T-1-4),” 96-EAP-246). Clean closure of the site was not achieved because fluoride and nitrate levels in soil below the 4.6 m (15 ft) deep excavation exceeded the MTCA (WAC 173-340) Method B cleanup levels for groundwater protection. Therefore, the TSD unit was closed in place under the modified closure provisions of the Hanford RCRA Permit with specified measures for post-closure care.
Figure 4-27. 100-HR-D Specific Conductance Map, Fall 2017
Figure 4-29. Dissolved Oxygen at 100-HR-3 ISRM Barrier, 2017
Figure 4-30. 183-H Solar Evaporation Basins (116-H-6)

Groundwater monitoring to meet RCRA requirements is conducted in accordance with DOE/RL-2015-28, Final Status Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins, which was incorporated into Part VI of the Hanford RCRA Permit, Revision 8c, on May 24, 2017. This new plan supersedes PNNL-11573, Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins. The new plan monitors total chromium (collected as a filtered sample) and nitrate as dangerous waste constituents identified for corrective action monitoring. Other constituents identified for monitoring in the previous plan (PNNL-11573) (uranium, technetium-99, and fluoride) were removed in this revised plan.

The revised groundwater monitoring plan also modified the groundwater monitoring well network. The plan removed well 199-H4-12C, which is completed in the semiconfined RUM aquifer, from the monitoring network. Monitoring well 199-H4-12A was replaced with 199-H4-85, which is located closer to the 183-H Solar Evaporation Basins and is completed in the unconfined aquifer. New wells 199-H4-88 and 199-H4-89 were drilled in 2016 and were added to the monitoring network.

Table B-14 in Appendix B lists the wells monitored for RCRA under the current revised plan. Wells are sampled semiannually for dangerous waste constituents (total chromium [filtered] and nitrate) and field parameters. New wells 199-H4-88 and 199-H4-89 will be sampled quarterly for 2 years to collect sufficient samples to support statistical evaluation. The unconfined aquifer is very thin below the 183-H Solar Evaporation Basins, and most of the wells are screened across the entire aquifer. The saturated aquifer thickness varies from less than 1 m (3 ft) in the fall during low river stage to 3 m (10 ft) in the spring and early summer during high river stage.


The CERCLA P&T extraction and injection wells influence groundwater flow near the 183-H Solar Evaporation Basins. The March 2017 water table shows a local groundwater depression created by the P&T extraction wells (Figure 4-30). The estimated groundwater velocities during 2017 ranged from 0.1 to 5.1 m/d (0.7 to 16.7 ft/d), and flow directions ranged from southwest to east-northeast (Table B-15 in Appendix B).

Table B-16 in Appendix B summarizes the results from RCRA sample events performed under the newly revised monitoring plan. Total chromium (filtered sample) remained below the permit concentration limit of 48 µg/L in each of the five wells in the monitoring network. The maximum concentration observed in the network during the RCRA sample events was 19 µg/L in well 199-H4-88 (located within the footprint of Basin 1 of the 183-H Solar Evaporation Basins).

Nitrate exceeded the Hanford RCRA Permit concentration limit of 45 mg/L in wells 199-H4-88 and 199-H4-89 during both RCRA sample events (Table B-16 in Appendix B). The nondetect value for nitrate in well 199-H4-85 on November 10, 2017, appears to be a suspect result and is currently under additional review.

As shown in Table B-14 in Appendix B, low water table conditions during the November sampling event resulted in four of the wells being pumped dry prior to full sample volume collection. The pumps were shut off, the wells were allowed to recharge, and then sampling continued. The on/off cycling of the sampling pumps likely agitated the well water columns and stirred up sediment that normally rests on the bottom of the wells. This likely explains the unusually high turbidity in wells 199-H4-8, 199-H4-84, and 199-H4-89. In 2017, the wells were sampled with a portable (nondedicated) pump. Staff will evaluate
whether installing dedicated sampling pumps with the intake located near the bottom of the screened interval will help prevent high turbidity in future low-water sampling events.

Many of the analytical results from November 2017 samples from well 199-H4-85 were anomalous, so a data review was conducted. Reported values of specific conductance (32.8 μS/cm) and anions (near or below detection limits) were unreasonably low for groundwater. Dissolved oxygen, pH, and temperature were also much lower than the data previously reported. The evaluation concluded that the data should be rejected as not representative for unknown reasons. Data review qualifiers of “R” were assigned to all of the November 10, 2017, data from well 199-H4-85. The well will be resampled, and a video survey of the well is planned.

Under the new corrective action monitoring plan, filtered total chromium and nitrate data are evaluated as follows:

- If any of the last 8 to 10 sample results exceed the concentration limits established in the Hanford RCRA Permit, the upper confidence limits (UCLs) on the mean are calculated and compared to the applicable concentration limit.
- If all of the last 8 to 10 results are below the concentration limit, a UCL is not calculated and a visual evaluation is allowed.
- The data set may include non-RCRA sampling results until at least eight RCRA sample results are available.

The statistical evaluation is conducted semiannually (SGW-61639; SGW-61763). The 95% UCL for total chromium (filtered) exceeded the Permit concentration limit from well 199-H4-84 (Table B-17 in Appendix B). For nitrate, wells 199-H4-84 and 199-H4-88 had 95% UCLs that exceeded the concentration limit (Table B-17 in Appendix B).

4.12 Atomic Energy Act Monitoring

AEA groundwater monitoring was scheduled at 60 groundwater wells and aquifer tubes in the 100-HR groundwater interest area in accordance with the SAP issued in December 2015 (DOE/RL-2015-56). The primary AEA constituents for 100-HR are nitrate, strontium-90, and tritium. Historically, nitrate has been monitored through the AEA as an indicator of contaminant migration and continues to be monitored in the current SAP (DOE/RL-2015-56). One well in the 100-D Area was not sampled in accordance with SAP requirements (Table C-1 in Appendix C). Minor exceptions to planned monitoring occurred due to maintenance issues and scheduling constraints.

Radionuclide concentrations detected in groundwater samples from 165 wells2 and aquifer tubes were used to estimate the cumulative TED and to compare the cumulative beta/photon emitters, alpha emitters, and uranium mass to DWSs, as described in Section 1.2.4. The estimated TED did not exceed the 100 mrem/yr standard at any of the groundwater wells in 100-HR. The DWS for cumulative alpha emitters was not exceeded. The cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at nine locations in this interest area (Table 4-4). The DWS uranium mass was exceeded at four locations, one of which was part of characterization sampling at a new well. Some of these locations are adjacent to the Columbia River, which is the primary potential pathway for offsite exposure to Hanford Site contaminated groundwater. Members of the public are protected from exposure to groundwater through the implementation of ICs that restrict access to groundwater.

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2 The AEA calculations used data from wells sampled only for CERCLA, as well as those sampled specifically for the AEA.
CERCLA remedial action decisions (i.e., P&T for 100-HR-3) provide additional protection of the public and the environment.

Table 4-4. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 100-HR in 2017

<table>
<thead>
<tr>
<th>Monitoring Location/Well Name</th>
<th>Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr</th>
<th>Cumulative Uranium Mass ≥ 30 µg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>199-D5-132</td>
<td>9.75</td>
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Notes: None of the wells in 100-HR had total effective dose ≥100 mrem/yr or cumulative alpha activity ≥15 pCi/L. Blank cells indicate no exceedances.

*Characterization sampling.