9 200-BP

This chapter presents information for the 200-BP groundwater interest area, which includes groundwater and associated contaminant plumes beneath the northern half of the 200 East Area and adjacent portions of the surrounding 600 Area (Figures 9-1 and 9-2). This chapter includes an overview; a discussion of CERCLA-, RCRA-, and AEA-related groundwater activities conducted in 2016; and a summary of 2016 groundwater monitoring results.

9.1 Overview

The 200-BP interest area, which includes the 200-BP-5 Groundwater OU and six RCRA sites, extends from the northern portion of the 200 East Area to the northwest to the Columbia River shoreline. The main process separation facilities overlying the OU were B Plant and the Hot Semiworks Facility. Table 4-4 of the 200-BP-5 RI/FS (DOE/RL-2009-127, Remedial Investigation Report for the 200-BP-5 Groundwater Operable Unit) summarized the following sources of groundwater contamination, grouped within regions of 200-BP (Figures 9-1 and 9-2).

- **B Complex (northwestern 200 East Area):**
  - Unplanned release from tank 241-BX-102 (highly contaminated waste stream that included uranium, technetium-99, tritium, iodine-129, and nitrate)
  - BY Cribs (moderately contaminated waste stream with technetium-99, iodine-129, cobalt-60, cyanide, and nitrate)
  - Unplanned release near tank 241-B-105 (moderately contaminated waste stream with the same contaminants found at the BY Cribs)
  - 216-B-50 Crib (moderately contaminated waste streams with tritium)
  - 216-B-7 A&B Cribs (moderately contaminated waste stream with technetium-99, chromium, and nitrate)
  - 216-B-8 Crib (moderately contaminated waste stream with technetium-99, iodine-129, chromium, and nitrate)

- **B Plant:**
  - 216-B-12 Crib (moderately contaminated waste stream with uranium, tritium, and nitrate)
  - 216-B-5 injection well (moderately contaminated waste stream with uranium, strontium-90, cesium-137, plutonium-239, and nitrate; injected into the unconfined aquifer)

- **WMA C:**
  - Various unplanned releases (highly contaminated waste streams with technetium-99 and nitrate)

- **216-B-2-1 and 216-B-2-2 Ditches** (nitrate)

- **Gable Mountain Pond** (nitrate and strontium-90)

- **B Pond** (tritium and iodine-129)

Current continuing sources to groundwater have been identified at the B Complex and WMA C (DOE/RL-2009-127).
Figure 9-1. 200-BP Groundwater Interest Area and Geometry of Groundwater Contaminant Plumes
Figure 9-2. 200-BP Sampling Locations, 2016
Nitrate, iodine-129, technetium-99, and uranium are the most extensive groundwater plumes in 200-BP. These contaminants originate mainly from local sources, except for iodine-129, which predominantly migrated into 200-BP from 200-PO in the late 1980s and early 1990s. Other contaminants exceeding the DWS have smaller areal extent within 200-BP, including arsenic, cesium-137, cyanide, fluoride, plutonium-239/240, strontium-90, and tritium. In 2016, cesium-137 and fluoride exceeded the DWS only at a single monitoring well in 200-BP, adjacent to the decommissioned 216-B-5 injection well where waste was discharged directly into the aquifer in the past. Plutonium-239/240 exceeded the DWS in two wells adjacent to the 216-B-5 injection well. Arsenic also exceeded the DWS sporadically at seven wells in 200-BP. These contaminants are not discussed further in this chapter; see DOE/RL-2009-127 for additional information. The contaminant plumes in 200-BP originated from multiple sources, and groundwater contaminant ratios (e.g., technetium-99-to-nitrate) have been used to distinguish between different sources, as discussed in DOE/RL-2009-127. DOE conducts groundwater monitoring in 200-BP under CERCLA, RCRA, and AEA requirements, discussed in Sections 9.9, 9.10, and 9.11, respectively. Table 9-1 lists plume areas and other pertinent information about 200-BP. The listed water quality standards for radionuclides assume that only one radionuclide is present. In many locations in 200-BP, multiple radionuclides are present in groundwater, and the dose is cumulative. As discussed in Section 9.11, the estimated TED exceeded the 100 mrem/yr standard at 7 groundwater wells in 200-BP and the cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at 104 locations.

### Table 9-1. 200-BP at a Glance

<table>
<thead>
<tr>
<th>B Plant operations:</th>
<th>1945 to 1952 (plutonium separation)</th>
<th>1967 to 1985 (strontium and cesium recovery)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2016 Groundwater Monitoring</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Contaminant</strong></td>
<td><strong>Water Quality Standard</strong></td>
<td><strong>Maximum Concentration</strong></td>
</tr>
<tr>
<td>Nitrate</td>
<td>45 mg/L</td>
<td>1,510 mg/L (299-E33-15)</td>
</tr>
<tr>
<td>Iodine-129</td>
<td>1 pCi/L</td>
<td>5.27 pCi/L (299-E27-155)</td>
</tr>
<tr>
<td>Technetium-99</td>
<td>900 pCi/L</td>
<td>32,700 pCi/L (299-E33-3)</td>
</tr>
<tr>
<td>Uranium</td>
<td>30 µg/L</td>
<td>3,790 µg/L (299-E33-345)</td>
</tr>
<tr>
<td>Strontium-90</td>
<td>8 pCi/L</td>
<td>4,470 pCi/L (299-E28-25)</td>
</tr>
<tr>
<td>Cyanide</td>
<td>200 µg/L</td>
<td>1,350 µg/L (299-E33-3)</td>
</tr>
<tr>
<td>Tritium</td>
<td>20,000 µg/L</td>
<td>61,400 pCi/L (299-E28-31)</td>
</tr>
</tbody>
</table>

**Remediation**

Perched water extraction (200-DV-1 Operable Unit) and groundwater extraction as a removal action (200-BP-5) in B Complex.

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*a. Maximum concentration within the regional unconfined aquifer (i.e., excludes the perched water beneath the B Complex) detected in 2016.*

*b. Estimated area above the listed water quality standard.*

*c. Single isotope equivalent DWS. If two or more radionuclides are present, the sum of their annual dose equivalents shall not exceed 4 mrem/yr.*
Figure 9-3 shows changes in plume areas over time within 200-BP. Abrupt changes in plume area estimates, such as uranium in 2011 and strontium-90 in 2012, are caused by changes in interpretation (e.g., due to data from new wells or changes in plume mapping methods). Section 1.5 provides details about plume mapping, including descriptions of the terms used in figure legends (e.g., Type 1 control point).

Groundwater conditions in 200-BP include a perched zone and unconfined, semiconfined, and confined aquifers. The perched water horizon lies 3 m (10 ft) above the water table, extending along the north side of the B Tank Farm (see Figure 2-10 of DOE/RL-2011-102, Remedial Investigation/Feasibility Study and RCRA Facility Investigation/Corrective Measures Study Work Plan for the 200-DV-1 Operable Unit) and is contaminated from a 1951 overfill event associated with tank 241-BX-102. The release consisted of 347,000 L (91,600 gal) of contaminated liquid. The derived release inventory is estimated to have released 2.27 Ci of technetium-99, 10,100 kg of uranium, 3,800 kg of nitrate, and 3.85 Ci of tritium (RPP-26744, Hanford Soil Inventory Model, Rev. 1). The 2011 reassessment of the 1951 release, as presented in RPP-RPT-47562, Hanford BX-Farm Leak Assessment Report, estimated that 20,000 kg of uranium was released. DOE is extracting water from the perched zone (Section 9.9), which is a part of the 200-DV-1 OU.

The unconfined aquifer within the 200 East Area boundary is the primary aquifer impacted by past waste disposal operations and is associated with the suprabasalt sediment of the Ringold Formation, CCU, and Hanford formation (Figure 1-7). Depths from land surface to the water table in 200-BP range from less than 1 m (3 ft) near the Columbia River to 105 m (340 ft) in the southern portion of the interest area. The unconfined aquifer thickness varies from less than 1 m (3 ft) north of the 200 East Area to more than 40 m (130 ft) in Gable Gap. Within and south of Gable Gap, the aquifer is mainly composed of unconsolidated to semiconsolidated gravels of the Hanford formation and CCU. Additional details are provided in PNNL-19702, Hydrologic Model for the Gable Gap Area, Hanford Site. Within the northern portion of the 200 East Area and south of the Gable Gap area, lower cohesive units of the Ringold Formation underlie, or have been incised by, the Hanford and Cold Creek sediments. The base of the aquifer south of Gable Gap is the Elephant Mountain Member Basalt.
The highest levels of nitrate, technetium-99, and uranium in the unconfined aquifer in 200-BP are detected within the northwest portion of the 200 East Area, in an area referred to as the B Complex (e.g., WMA B-BX-BY and adjacent liquid waste sites; see Figure 2 of DOE/RL-2016-41, Action Memorandum for 200-BP-5 Operable Unit Groundwater Extraction). These plumes extend to the northwest and southeast within an ancestral Columbia River paleochannel that incised Ringold deposits. Due to the high concentrations of nitrate, technetium-99, and uranium detected at the B Complex, groundwater is being extracted by a single well as a treatability test (DOE/RL-2010-74, Treatability Test Plan for the 200-BP-5 Groundwater Operable Unit).

Semiconfined aquifers are present in the Ringold Formation beneath and east of the higher permeability paleochannel. More specifically, the semiconfined aquifers are associated with hydrostratigraphic units 9B and 9C (Figure 1-7). Contaminants in the semiconfined area east of the 200 East Area are associated with the former B Pond and are limited to iodine-129 and tritium. Contaminants in the semiconfined area in the western half of the 200 East Area are limited to nitrate and tritium, which are thought to be associated with the 216-B-12 Crib. Some portion of this contamination is also likely associated with past northwestward groundwater migration of PUREX Cribs contaminants from 200-PO.

Within the uppermost basalt-confined aquifer (Rattlesnake Ridge interbed), contamination exceeding the DWS is limited to technetium-99 at well 299-E33-12 beneath the B Complex area.

Water level monitoring between 2014 and 2016 indicate a divide in the water table north of the 200 East Area and south of Gable Mountain and Gable Gap. Figure 9-4 illustrates water table contours based on April 2016 data as an example. The divide appears to be caused by water flowing in from the west and coincides with a buried basalt anticlinal ridge. North of this ridge, groundwater flows toward the north through the gap between Gable Mountain and Gable Butte. Groundwater to the south of this ridge flows south-southeast into the northwestern quarter of the 200 East Area. The water table in the highly transmissive sediments of the paleochannel responds to seasonal changes in Columbia River stage that propagate from the north. However, water level monitoring conducted between 2014 and 2016 indicated the flow divide persisted even during periods of high river stage effects. Before 2011, the divide was farther south, and groundwater flow in the northwestern quarter of the 200 East Area was toward the north. The flow direction changed 180 degrees in July 2011 because of ongoing water table declines in the 200 East Area and temporal Columbia River stages.

Groundwater flow directions within the 200 East Area are shown in Figure 9-5. The inferred directions are based on contaminant migration and low-gradient water table maps. Figure 9-6 provides a more detailed depiction of the water table in a portion of the 200 East Area. The process used to complete this detailed water table map is discussed in ECF-200E-16-0093, Preparation of 200 East Area Water Table Maps for Calendar Year 2015. The use of water level data to determine groundwater flow directions in the 200 East Area has been problematic because of a very low hydraulic gradient magnitude combined with a relatively large depth to water. This results in a low signal-to-noise ratio in the water level elevation measurements, making it difficult to determine the hydraulic gradient. This problem has been reduced by improving the accuracy of the water level measurements (by resurveys of well casing elevations, performing borehole path surveys, and analyzing barometric pressure effects) and analyzing the data by trend surface analysis. Using the average of monthly measurements helps minimize the remaining error.
Figure 9-4. Water Table Map for the Paleochannel North of the 200 East Area, April 2016

Figure 9-5. Interpreted Groundwater Flow Directions in the 200 East Area, 2016

Figure 9-6. Monthly Average 200 East Area Low Hydraulic Gradient Water Table Map, 2016
9.2 Nitrate

Groundwater contamination exceeding the 45 mg/L DWS equivalent covers a large portion of the southern half of 200-BP, and concentrations greater than 450 mg/L are focused at the B Complex and B Plant (Figure 9-7). These two areas are associated with uranium recovery waste where specific liquid waste sites received over a million kg of nitrate waste (Appendix C of RPP-26744). The amount of nitrate disposed in these two areas is over an order of magnitude greater than other areas where nitrate exceeds the DWS. Sections 9.2.1 through 9.2.5 discuss nitrate contamination in various regions of 200-BP.

9.2.1 B Complex

This section describes nitrate sources of groundwater contamination associated with B Complex, including the BY Cribs, the unplanned release from the B Tank Farm, and the BX Tank Farm.

Nitrate contamination in the B Complex appears to be primarily from past discharge sites and unplanned releases of liquid scavenged waste. The scavenging process used a ferrocyanide complexant to reduce the cesium-137 and strontium-90 levels of uranium recovery and first-cycle decontamination waste before disposal to the soil column. There appear to be three such release sites in the B Complex area: BY Cribs, unplanned pipeline releases in the B Tank Farm, and possible tank overfill and transfer line leaks in the BX tank farm. More information on the BY Crib can be found in PNNL-19277, Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B-Complex. More discussion of the unplanned releases can be found in Table 5-1 of RPP-RPT-49089, Hanford B-Farm Leak Inventory Assessments Report, and Section 4.3.3 of RPP-RPT-47562.

Contributing sources of nitrate contamination from the B Complex include cribs mentioned in PNNL-19277 and contributions from a 1951 unplanned liquid release of metal waste from tank 241-BX-102 (Section 9.2.1.3). The B Complex sources from the other cribs blend with the scavenged waste sources and are not distinguishable and are not discussed further. The 241-BX-102 source has significantly contaminated a perched horizon located 3 m (10 ft) above the unconfined aquifer. The contaminated perched horizon acts as a continuous source of groundwater contamination beneath the north side of the B Tank Farm and is distinguishable by a higher technetium-99-to-nitrate ratio. The 200-DV-1 OU is addressing the contamination in the perched horizon as discussed in Section 9.9.

A removal action work plan is currently being prepared that will evaluate how to best remediate the unconfined aquifer beneath the perched horizon.

9.2.1.1 BY Cribs

The sources of the largest and most concentrated nitrate plumes in 200-BP are associated with liquid waste from the BY Cribs, which received an average inventory of 6.7 million kg of nitrate (Appendix C of RPP-26744). Large discharge volumes (2.1 to 6.7 million L per crib) and groundwater flow dynamics over the past 60 years have resulted in plumes extending to the north, northwest, and south-southeast. The extent and concentrations did not change significantly between 2015 and 2016, except near extraction well 299-E33-268, which has removed over 70,000 kg of nitrate from the aquifer since September 2015.
Figure 9-7. 200-BP Nitrate Plume, 2016
The extent to the north includes a north and northwest plume. The north plume was discovered in the late 1960s at well 699-50-53A, which became sample dry and was decommissioned in 2005. Concentrations at well 699-50-53A exceeded 1,000 mg/L in the 1960s and approached that level in 1991 (Figure 9-8). A migration model for this plume was completed as part of DOE/RL-95-59, 200-BP-5 Operable Unit Treatability Test Report, and concluded a north-northwest migration pathway near existing wells 699-53-55C, 699-55-57, 699-57-59, and 699-60-60 (Figure 5-30 of DOE/RL-95-59 depicts technetium-99 modeled future flow pathway). The 2016 northern extent of this plume, at concentrations exceeding the DWS, is interpreted to be southeast of well 699-60-60. Concentrations within this plume did not change significantly between 2015 and 2016 (Figure 9-8).

The northwest plume was established between the late 1980s and 2010 when groundwater flow was predominantly northwest. The plume extends primarily through wells 699-49-57A and 699-50-56 (Figure 9-7). Concentrations between 2015 and 2016 did not change significantly (Figure 9-9).

Prior to the 2011 groundwater flow reversal, nitrate concentrations beneath the BY Cribs exceeded 1,000 mg/L (Figure 9-10). These high concentrations were the result of slower groundwater flow between 2006 and 2011, continued groundwater elevation decline, and continued nitrate infiltration into the aquifer. Since 2011, the nitrate plume has migrated and expanded to the east-southeast. In 2016, nitrate concentrations remained near the historical maximum at well 299-E33-3 (1,150 mg/L). However, continued groundwater extraction at well 299-E33-268, initiated in September 2015 as a treatability test (Section 9.9), reduced the concentration and extent of nitrate by removing over 70,000 kg of nitrate from the aquifer.
Figure 9-9. 200-BP Nitrate Data at Wells in the Northwest BY Cribs Plume

Figure 9-10. 200-BP Nitrate Data at Wells beneath the BY Cribs
The concentration declines to the south of the BY Cribs also appear to reflect ongoing extraction. For example, concentrations at well 299-E33-42, 75 m south of the extraction well, appear to decline more rapidly after pumping began at well 299-E33-268 (Figure 9-11). Water levels at well 299-E33-42 also declined as a result of pumping at well 299-E33-268 (DOE/RL-2015-75, Aquifer Treatability Test Report for the 200-BP-5 Groundwater Operable Unit). The declining concentrations to the north and south support the capture zone numerical model discussed in DOE/RL-2015-75. The spike in concentration at well 299-E33-31 reflects groundwater 1 month after the extraction well went offline for expansion of the extraction system (Figure 9-11).

![Figure 9-11. 200-BP Nitrate Data at Wells South of Extraction Well 299-E33-268](image)

### 9.2.1.2 B Tank Farm

In 2010, nitrate began to increase along the east side of the B Tank Farm and exceeded the 45 mg/L DWS. This plume was linked to an unplanned release from within the B Tank Farm, near tanks 241-B-105 and 241-B-106. Nitrate peaked in 2013 at 1,680 mg/L at 299-E33-47 (Figure 9-12). The plume extends to the south-southeast beyond well 299-E33-361 (Figure 9-17). The extent of the plume did not change significantly between 2015 and 2016.
9.2.1.3 BX Tank Farm

In 2010, nitrate concentrations began to increase along the east side of the BX Tank Farm at well 299-E33-339 (Figure 9-12). Shortly thereafter nitrate concentrations began to increase at well 299-E33-337. This contamination appears to be a mixture of possibly three plumes: a scavenged waste source within the BX Tank Farm, the 241-BX-102 unplanned release, and possible contributions from the scavenged waste release in the B Tank Farm. Nitrate concentrations at well 299-E33-337 peaked in November 2015 at 575 mg/L and by November 2016 nitrate was 350 mg/L.

To the east of the 241-BX tank farm the perched water zone and the unconfined aquifer located along the north boundary of the B Tank Farm show impacts from a 1951 unplanned release from tank 241-BX-102 (RPP-RPT-47562). As with other contaminants, nitrate concentrations in groundwater in this region increased in recent years, coincident with decreasing groundwater elevations and flow rate. In 2005, the nature of the nitrate groundwater contamination at well 299-E33-18 (located beneath the north side of the B Tank Farm) began to change. The technetium-99-to-nitrate ratio increased from a ratio less than 20 pCi/mg, indicating local discharges from nearby cribs, to a higher technetium-99-to-nitrate ratio representing contributions from the 1951 unplanned release from tank 241-BX-102. The undiluted technetium-99-to-nitrate ratio from tank 241-BX-102 is approximately 600 pCi/mg based on perched horizon well 299-E33-344.

Nitrate concentrations in the perched water horizon monitored by well 299-E33-344 have ranged from 316 to 810 mg/L, with no overall increase or decrease. DOE initiated a perched water treatability test in August 2011 at well 299-E33-344, which has removed an estimated 778 kg of nitrate through December 2016.
The nitrate groundwater plume associated with the 241-BX-102 tank release extends northwest and east-southeast of the north boundary of the B Tank Farm (Figure 9-7). Groundwater extraction at well 299-E33-268, initiated in September 2015 as a treatability test, reduced the nitrate concentrations of the northwest portion of the plume by removing over 70,000 kg of nitrate. Figure 9-11 provides examples of the nitrate trends in wells 299-E33-31, 299-E33-41, and 299-E33-42, located to the south and southeast of the extraction well. The extent of the nitrate plume to the southeast did not change significantly from the 2015 plume extent, but concentrations within the plume boundary continued to decrease (Figure 9-13). A removal action work plan is currently being prepared that will evaluate how best to remediate the technetium-99 and uranium plumes exceeding 10 times the DWS in this area, which should also remove much of this nitrate plume. Well 299-E33-360, located beneath the source of contaminant loading from the vadose zone, was connected to the B Complex extraction system in late 2016. Information from the non-time-critical removal action will be used to determine the appropriate remedial action for nitrate.

**Figure 9-13. 200-BP Nitrate Data at Groundwater Wells beneath the Perched Horizon, North of the B Tank Farm**

### 9.2.1.4 Well 299-E28-24

The nitrate concentration at well 299-E28-24 was 708 mg/L in 2016, about the same as 2015. This well is screened 7.6 to 9.1 m (25 to 30 ft) below the water table and also has elevated concentrations of cyanide and technetium-99. The elevated level of nitrate and other co-contaminants are not reflected in the nearby wells 299-E28-3, 299-E28-7, 299-E28-23, and 299-E28-25. For example, nitrate concentration at well 299-E28-23 was 70.8 mg/L in 2016. One possible reason these other wells have lower concentrations is the well screens are longer, extending from nearly the same depth as well 299-E28-24, but to the water table surface. The significantly greater cyanide concentration at depth in well 299-E28-24 indicates a plume migrating through the deeper part of the aquifer. The plume appears to be associated with sources from the B Complex, but the pathway is uncertain. As a result of this uncertainty, contamination at this site was not extended to a source, but contoured around well 299-E28-24 (Figure 9-7).
9.2.2 216-B-12 Crib

A region of nitrate with concentrations above 450 mg/L is defined near the 216-B-12 Crib. The majority of this plume appears to be in the deeper Ringold sediments. The extent of the plume is uncertain as it is currently only defined by wells 299-E28-31 and 299-E28-32 (Figure 9-7). It is possible that this plume is considerably larger and connects with the elevated nitrate near the PUREX Cribs.

The 216-B-12 Crib received 2.86 million kg of nitrate during discharges between 1952 and 1957. In the late 1950s, grams per liter of nitrate were identified in the groundwater near the 216-B-12 Crib at well 299-E28-9. In the 1980s, the nitrate plume began migrating to the northwest as a result of a change in the water table caused by terminated discharges to Gable Mountain Pond. Concentrations exceeding 100 mg/L were detected in wells north of the 216-B-12 Crib.

Groundwater investigations in 2010 detected nitrate deep in the aquifer exceeding 800 mg/L near the 216-B-12 Crib and just south of B Plant. Near the 216-B-12 Crib the maximum concentration was at 8 m (24 ft) below the water table. At B Plant the maximum concentration was 1,310 mg/L at the bottom of the aquifer, 20 m (66 ft) below the water table.

In 2015, two deep aquifer investigation wells, 299-E28-31 and 299-E28-32 (located to the north and south of B Plant), were drilled to further define the vertical profile of nitrate (SGW-58328, Sampling Instruction for the FY2015 M-24 200 East Groundwater Monitoring Well Drilling and Installations). In both wells, the majority of the nitrate is contained in lower permeability Ringold sediments, and both wells were screened across the maximum nitrate concentration horizon. Well 299-E28-31 was screened 12 to 15 m (39 to 49 ft) below the water table. Well 299-E28-32, south of B Plant, was screened 17 to 20 m (56 to 66 ft) below the water table.

In 2016, a routine groundwater sample from well 299-E28-31 confirmed the elevated nitrate concentration in the screened zone with a concentration of 930 mg/L. Well 299-E28-32 has not been sampled following construction, awaiting installation of a sampling pump.

9.2.3 216-B-2 Ditches

Nitrate concentrations in groundwater north of the 216-B-2 Ditches began to increase in the 1980s and 1990s. The 1980s increases were coincident with blockage of the back end of the 216-B-2-3 Ditch, which eventually led to infiltration of cooling water into an open disposal trench within the 218-E-12B Burial Ground (SD-WM-TI-260, Water Inflow Investigation at the 218-E-12A and 218-E-12B Burial Grounds). Investigation indicated that prior to cooling water infiltrating the open disposal ditch, approximately 9.4 million L/day (2.5 million gal/day) of cooling water may have percolated into the coarse sands and gravels lining the 216-B-2-3 Ditch. Previous nitrate-laden pore water from unplanned releases associated with the 216-B-2-1 and 216-B-2-2 Ditches was apparently available in the vadose zone for remobilization.

A nitrate plume near the 216-B-2 Ditches has concentrations above the DWS equivalent (Figure 9-7). The highest 2016 nitrate concentration in this plume was 70.8 mg/L at well 299-E26-14. Concentrations appeared to have peaked in the wells within the northeast portion of this plume, and concentrations started decreasing in 2016 (299-E26-14, 299-E26-77, and 299-E26-79). Concentrations held steady in the west part of the plume at wells 299-E27-9 and 299-E27-10. Concentrations in the south part of the plume, at well 299-E27-25, ranged between 48 and 53.1 mg/L. The December concentration at well 299-E27-25 is under review, as it was affected by sulfamic acid used to clean this well.
9.2.4 Gable Mountain Pond (216-A-25)

A nitrate plume with concentrations above 45 mg/L closely outlines the former Gable Mountain Pond boundaries (Figure 9-7). Concentrations exceeding 45 mg/L were first observed in the mid-1980s and have been continuously present since the early 1990s. Nitrate concentrations in this region have decreased steadily since the mid-1990s, and the highest concentration in 2016 was 93 mg/L in well 699-53-48A. This well is located in the southeastern portion of the former Gable Mountain Pond, where the pipeline outfall was located. The nitrate concentrations have decreased from 320 mg/L at this well since 1996.

The aquifer thickness beneath the site ranges from 2 to 13 m (6 to 45 ft), with the thinnest part near the former outfall pipe and the deepest part to the northwest. All of the wells in this area are screened in the upper 4 m (13 ft) of the aquifer. The 2016 concentration at well 699-54-49, near the central portion of the former Gable Mountain Pond, was 48.7 mg/L. This well is screened across half of the 6 m (20 ft) thick aquifer. Nitrate concentrations are interpreted to be similar throughout the vertical extent of the aquifer beneath the former Gable Mountain Pond, based on data from the upper and lower parts of the aquifer near the southeast portion of the pond.

Currently and historically, nitrate concentrations decrease to the northwest of Gable Mountain Pond as the aquifer thickness increases. Well 699-55-50C monitors this area and nitrate concentrations have never exceeded 45 mg/L (7.08 mg/L in 2016).

9.2.5 Waste Management Area C

Nitrate contamination present in the unconfined aquifer at WMA C appears to have multiple sources (version 4 of RPP-ENV-33418, Hanford C-Farm Leak Inventory Assessments Report). The primary source beneath the west side of the WMA appears to be PUREX-derived liquid waste. Because of the nitrate recycling program employed at PUREX during operations, the concentrations of nitrate in this area have not exceeded 50 mg/L. A higher concentrated nitrate source contributor also appears to be impacting groundwater beneath the east side of the farm. The presence of persistent cyanide and a lower technetium-99-to-nitrate ratio suggests this plume is derived from a liquid scavenged waste release.

A nitrate plume from the north appears to merge with the nitrate plume extending from the southeast portion of the C Tank Farm (Figure 9-7). The highest 2016 nitrate concentration in this plume ranged from 79.7 to 93 mg/L at well 299-E27-14 in 2016, less than in 2015. The plume extends throughout the 15 m (49 ft) aquifer thickness based on nitrate concentrations at well 299-E27-24, screened at the bottom of the aquifer.

Nitrate concentrations in deep well 299-E27-155, located to the southwest of WMA C and screened at the bottom of the aquifer, increased from 66 mg/L to 93 mg/L in 2016. The chemistry of this plume also changed, as alkalinity concentrations decreased. Previously the nitrate and alkalinity at well 299-E27-155 mirrored concentrations located to the west at well 299-E24-25; however, the 2016 nitrate concentrations at well 299-E27-155 began to conform to levels similar to well 299-E27-14 to the east. The chemical changes included increased nitrate and lower alkalinity, which may suggest a temporary change in groundwater flow direction.

9.3 Iodine-129

An iodine-129 plume with concentrations above the 1 pCi/L DWS (Figure 9-14) covers an area from Gable Gap southeast into the 200-PO-1 OU, but concentrations and plume area continued to decline in 2016. The iodine-129 plume migrated into 200-BP primarily from sources located in the 200-PO groundwater interest area: 216-A-10 Crib vicinity, 216-A-29 Ditch, and B Pond (discussed in Chapter 10). B Pond straddles the boundary between 200-PO and 200-BP and is discussed in Chapter 10.
Figure 9-14. 200-BP Iodine-129 Plume, 2016
Overall iodine-129 concentration at most wells in 200-BP decreased in 2016, especially along the plume boundaries. In the Gable Gap area, only well 699-57-59 had detectable levels. Between Gable Gap and the 200 East Area iodine-129 is only detected in wells 699-49-57A and 699-50-59.

Comparing the 2016 plume (Figure 9-14) to the 2015 plume (Figure 9-10 of DOE/RL-2016-09) shows that much of the plume in the southern part of the B Complex, beneath B and BX Tank Farms, dropped below 1 pCi/L in 2016. This change may have been a response to extraction at well 299-E33-268.

Iodine-129 concentrations decreased near the 216-B-5 Injection Well in 2016 with detectable levels only at wells 299-E28-4 and 299-E28-5. Iodine-129 activity north of WMA C and in B Pond wells 699-42-40A and 699-43-41F also decreased. The highest iodine-129 concentration near B Pond continues to be at well 699-43-45 (7.21 pCi/L), located in 200-PO (discussed in Chapter 10).

9.4 Technetium-99

Technetium-99 in 200-BP groundwater (Figure 9-15) is primarily associated with past discharge sites and unplanned releases of liquid scavenged waste. The scavenging process was used to reduce the cesium-137 and strontium-90 levels of uranium recovery and first-cycle decontamination waste before disposal to the soil column. In 200-BP, sources of elevated technetium-99 groundwater are limited to the B Complex and WMA C.

9.4.1 B Complex

This section describes technetium-99 sources of groundwater contamination associated with B Complex, including the BY Cribs, the unplanned release from the B Tank Farm, and the BX Tank Farm.

Groundwater contamination in the B Complex appears to be primarily from three release sites of scavenged waste: BY Cribs, unplanned pipeline releases in the B Tank Farm, and possible tank overfill and/or transfer line leaks in the BX Tank Farm. More information on the BY Cribs can be found in PNNL-19277. More discussion of the unplanned releases can be found in RPP-RPT-49089 and RPP-RPT-47562. The plume extent and 2016 concentration changes extending from these sites are discussed in Sections 9.4.1.1 through 9.4.1.4.

A smaller contributing source of groundwater contamination in the B Complex is the 1951 unplanned liquid release of metal waste from tank 241-BX-102. The 241-BX-102 source has significantly contaminated a perched horizon located 3.1 m (10 ft) above the unconfined aquifer. The contaminated perched horizon acts as a continuous source of groundwater contamination in this area (SGW-59086, Annual Performance Report for the 200-DV-1 Operable Unit Perched Water Extraction, fiscal Year 2015, PNNL-22499, Perched-water Evaluation for Deep Vadose Zone Beneath the B, BX and BY Tank Farms Area of the Hanford Site). The 200-DV-1 OU is addressing this source as discussed in Section 9.9. More discussion on this source is provided in PNNL-19277. The extent of contamination from this source is discussed in Section 9.4.1.3.
Figure 9-15. 200-BP Technetium-99 Plume, 2016
9.4.1.1 **BY Cribs**

The largest technetium-99 plumes in 200-BP (Figure 9-15) are associated with liquid waste from the BY Cribs, which received an estimated total inventory of 128.6 Ci of technetium-99 (Appendix C of RPP-26744). Large discharge volumes, 2.1 to 6.7 million L per crib, and groundwater flow dynamics over the past 60 years have resulted in plumes extending to the north, northwest, south-southeast, and into the underlying confined aquifer. The extent and concentrations did not change significantly between 2015 and 2016, except near extraction well 299-E33-268, which has removed 1.29 Ci of technetium-99 from the aquifer.

The extent to the north includes a north and northwest plume. The north plume was discovered in the late 1980s at well 699-50-53A, which became sample dry and was decommissioned in 2005. Concentrations at well 699-50-53A were 32,700 pCi/L in 1988. Plume migration modeling, as part of DOE/RL-95-59, concluded a north-northwest migration pathway near existing wells 699-53-55C, 699-55-57, 699-57-59, and 699-60-60 (Figure 5-30 of DOE/RL-95-59; depiction of technetium-99 modeled future flow pathway). Concentrations within this plume did not change significantly between 2015 and 2016 (Figure 9-16).

The northwest plume was established between the late 1980s and 2010 when groundwater flow was predominantly northwest. The plume extends to well 699-49-57A with a remnant plume located at well 699-50-56 (Figure 9-15). Concentrations between 2015 and 2016 did not change significantly (Figure 9-17).

![Figure 9-16. 200-BP Technetium-99 Data at Wells in the North BY Cribs Plume](image-url)
Prior to the 2011 groundwater flow reversal, technetium-99 beneath the BY Cribs exceeded 30,000 pCi/L as a result of slower groundwater flow, water table decline, and continued contaminant loading into the aquifer (Figure 9-18). Since 2011, the plume has migrated and expanded to the east-southeast. In early 2016, technetium-99 concentrations were near the historical maximum at well 299-E33-3 (32,700 pCi/L). However, continued groundwater extraction at well 299-E33-268, initiated in September 2015 as a treatability test, appears to be a contributing factor to the reduced activity of technetium-99. The concentration declines to the south of the BY Cribs also appear to reflect ongoing extraction. For example, concentrations at well 299-E33-42, 75 m south of the extraction well, appear to decline more rapidly after pumping began at well 299-E33-268 (Figure 9-19). Water levels at well 299-E33-42 also declined as a result of pumping at well 299-E33-268 (DOE/RL-2015-75). The declining concentrations to the north and south support the capture zone numerical model discussed in DOE/RL-2015-75. The spike in concentration at well 299-E33-31 reflects groundwater 1 month after the extraction well went offline for expansion of the extraction system (Figure 9-19).

Technetium-99 concentrations continue to exceed the DWS in well 299-E33-12, which monitors the uppermost basalt-confined aquifer within the Rattlesnake Ridge interbed (Appendix D). However, concentrations in wells 299-E33-50 (south) and 299-E33-340 (north) continue to be near detection limits (Figure 9-20).
Figure 9-18. 200-BP Technetium-99 Data at Wells in the BY Crib Plume near Extraction Well 299-E33-268

Figure 9-19. 200-BP Technetium-99 Data at Wells South of Extraction Well 299-E33-268
In 2010, technetium-99 began to increase along the east side of the B Tank Farm at well 299-E33-47 (Figure 9-21). This plume was linked to an unplanned release from within the B Tank Farm, near tanks 241-B-105 and 241-B-106. Technetium-99 peaked in 2013 at 31,000 pCi/L at well 299-E33-47, after which levels declined. This plume has extended to the south-southeast beyond well 299-E33-361 (Figure 9-15). The extent of the plume did not change significantly between 2015 and 2016. A removal action work plan is currently being prepared that will evaluate how to best remediate this plume.

### 9.4.1.3 BX Tank Farm

In 2011, technetium-99 concentrations began increasing along the south side of the B Tank Farm at well 299-E33-337 (Figure 9-21). This contamination appears to be a mixture of possibly three plumes: a scavenged waste source within the BX Tank Farm, the 241-BX-102 unplanned release, and possible contributions from the scavenged waste release in the B Tank Farm.

To the east of the BX Tank Farm the perched water zone and the unconfined aquifer beneath the north part of the B Tank Farm show impacts from the 1951 unplanned release from tank 241-BX-102. As with other contaminants, technetium-99 concentrations in groundwater in this region increased in recent years, coincident with decreasing groundwater elevations and flow rate. In 2005, the nature of the technetium-99 groundwater contamination at well 299-E33-18 (located beneath the north side of the B Tank Farm) began to change, as discussed in Section 9.2.1.
Figure 9-21. 200-BP Technetium-99 Data at Wells East and South of the B and BX Tank Farms

Technetium-99 concentrations in the perched water horizon monitored by well 299-E33-344 have ranged from 4,130 to 53,300 pCi/L. DOE initiated a perched water treatability test in August 2011 at well 299-E33-344, which has removed an estimated 0.042 Ci (2.5 g) of technetium-99 through December 2016. Concentrations at wells 299-E33-350 and 299-E33-351, which also monitor the perched zone, ranged from 16,900 to 50,100 pCi/L in 2016.

The technetium-99 groundwater plume associated with the tank 241-BX-102 release extends northwest and east-southeast of the north boundary of the B Tank Farm (Figure 9-15). Groundwater extraction at well 299-E33-268 appears to have contributed to the decline of technetium-99 below the DWS at wells to the west-northwest of this plume source (Figure 9-19). The extent of the technetium-99 plume to the east-southeast did not change significantly from 2015, but concentrations within the plume boundary decreased (e.g., 299-E33-20, 299-E33-345, and 299-E33-360; Figure 9-22). A removal action work plan is currently being prepared that will evaluate how to best remediate this plume. Well 299-E33-360, located beneath the source of contaminant loading from the vadose zone, was recently connected to the B Complex extraction system.
9.4.1.4 **Well 299-E28-24**

Technetium-99 is elevated in the lower part of the unconfined aquifer at well 299-E28-24 (Figure 9-15). The technetium-99 concentration at well 299-E28-24 was 13,300 pCi/L in 2016, about the same as 2015, but much higher than the 56 pCi/L initially detected in the well in 2012. The elevated levels of technetium-99 and other co-contaminants are not reflected in the nearby wells 299-E28-3, 299-E28-7, 299-E28-23, and 299-E28-25. One plausible reason these other wells have lower concentrations is the well screens are longer, extending from nearly the same depth as well 299-E28-24, but to the water table surface. Well 299-E28-24 is screened from 7.6 to 9.1 m (25 to 30 ft) below the water table. The geologic unit at or near the bottom of well 299-E28-24 changes from more permeable Cold Creek/Hanford sediments above to lower permeable Ringold sediments (unit 9) below. The well also has elevated concentrations of cyanide and nitrate. The plume appears to be associated with sources from the B Complex, but the pathway is uncertain. As a result of this uncertainty, contamination at this site was not extended to a source, but contoured around well 299-E28-24 (Figure 9-15). Additional characterization in this area will be completed as part of the non-time-critical removal action discussed further in Section 9.9.1. The characterization will be outlined in the removal action work plan.

9.4.2 **Waste Management Area C**

A technetium-99 plume extends beneath the east, south, and west sides of WMA C (Figure 9-15). The primary source beneath the west side of the facility appears to be a PUREX derived liquid waste. The source is not yet determined, but may include multiple source sites as discussed in version 4 of RPP-ENV-33418. A lower activity source contributor also appears to be impacting groundwater beneath the east side of the farm. Based on the presences of cyanide and the lower technetium-99-to-nitrate ratio, this plume appears to be derived from a liquid scavenged waste release.
Technetium-99 concentrations are highest in wells 299-E27-21 and 299-E27-23 (Figure 9-23) and extend to the south-southeast toward WMA A-AX (Chapter 10). The groundwater flow direction changed in 2012 causing concentrations at well 299-E27-23 to decrease and concentrations to increase at well 299-E27-21. Levels at well 299-E27-21 peaked in the middle of 2016 at 29,100 pCi/L. By December 2016, the level had diminished to 23,900 pCi/L. Coincidently, since March 2016, technetium-99 levels have increased at well 299-E27-23. The recent increase at well 299-E27-23 and decrease at well 299-E27-21 appear to be the result of a flow direction change.

Figure 9-23. 200-BP Technetium-99 Data at Wells South-Southeast of WMA C

9.5 Uranium

Uranium contamination in 200-BP is associated with two sources: 1951 unplanned liquid release of metal waste from tank 241-BX-102 in the B Complex and 1952 to 1957 liquid waste discharge of uranium recovery process condensate at the 216-B-12 Crib just west of B Plant. The uranium inventory associated with each of these releases exceeded 10,000 kg (RPP-26744). The 241-BX-102 source had much higher uranium concentrations and contaminated a perched horizon located 3.1 m (10 ft) above the unconfined aquifer. The contaminated perched horizon acts as a continuous source of groundwater contamination in this area. The 200-DV-1 OU is addressing this source as discussed in Section 9.9. The 216-B-12 Crib (Figure 9-2) is monitored by downgradient well 299-E28-30 and shows no apparent contributions to groundwater contamination at this time. The two uranium plumes are discussed in Sections 9.5.1 and 9.5.2.

The 216-B-5 injection well was a former source of uranium. Uranium concentrations at well 299-E28-23, located 1.5 m (4.5 ft) from the decommissioned injection well, have not exceeded the DWS of 30 µg/L since 2007. Well 299-E28-24, 4.5 m (15 ft) southeast of well 299-E28-23, has maintained concentrations between 54 and 62 µg/L from 2014 through 2016. Concentrations in well 299-E28-7, 12 m (40 ft) southeast of well 299-E28-24, have been less than half the DWS.
9.5.1 B Complex

The uranium plume associated with the tank 241-BX-102 release extends northwest and southeast of the north boundary of the B Tank Farm (Figure 9-24). Groundwater extraction at well 299-E33-268, initiated in September 2015 as a treatability test, has removed 14 kg of uranium through 2016. Uranium concentration decreases near well 299-E33-268 appear to be attributed to groundwater extraction at well 299-E33-268. For example, wells 299-E33-31, 299-E33-38, and 299-E33-42, located to the north and south of the 299-E33-268 extraction well, declined more significantly upon start of pumping at well 299-E33-268 (Figure 9-25). In addition, these wells were within the cone of depression during the pump test (DOE/RL-2015-75). The increase at well 299-E33-31 at the end of 2016 was a month after pumping was terminated at well 299-E33-268 for further expansion of the extraction system. The extent of the uranium plume to the southeast did not change significantly from 2015, but concentrations near the source increased. Examples of the boundary conditions and concentration changes near the source are provided below. A removal action work plan is currently being prepared that will evaluate how to best remediate this plume. Well 299-E33-360, located beneath the source of contaminant loading from the vadose zone, was recently connected to the B Complex extraction system.

The plume extent to the southeast of the B Tank Farm did not change from 2015 to 2016. The 2016 extent is defined by stable uranium concentrations from wells 299-E28-5, 299-E28-8, and 299-E33-37 (Figure 9-26). However, uranium concentrations within the plume, along the east and south sides of the B Tank Farm, increased at wells 299-E33-47, 299-E33-48, and 299-E33-338 (Figure 9-27).

9.5.2 B Plant

The 2016 uranium extent was smaller than in 2015, based on a lower concentration in well 299-E28-31. Concentrations at other wells were stable between 30 and 50 µg/L (Figure 9-28).

Past 200-BP RI characterization results suggested a zone of higher uranium concentrations at depth. Samples collected during drilling of well 299-E28-31 in 2015 indicated uranium concentrations as high as 286 µg/L. However, 2016 routine groundwater samples from the same depth were only 5.38 µg/L.

9.6 Strontium-90

Strontium-90 exceeds the 8 pCi/L DWS near the former Gable Mountain Pond (inactive and dry since the mid- to late 1980s) and near the 216-B-5 injection well. Strontium-90 tends to bind to vadose zone sediments, so in 200-BP it only reached groundwater at locations where the vadose zone is relatively thin (e.g., less than 12 m [39 ft] at Gable Mountain Pond) or where waste was injected into the aquifer (216-B-5 injection well).

The extent of strontium-90 exceeding the DWS closely outlines the area of the former Gable Mountain Pond, with concentrations diminishing to the west where the aquifer is thicker (Figure 9-29). Well 699-53-47B, which is perforated across the 2 m (6.6 ft) thick aquifer, had the highest concentrations in 2016 (281 pCi/L). Strontium-90 decreased from a peak of 1,080 pCi/L in 1997 to 220 pCi/L in 2013 and subsequently rose to 281 pCi/L in 2016. Four other wells (699-53-48A, 699-54-48, 699-54-49, and 699-55-50C) were sampled in 2016 at Gable Mountain Pond (Figure 9-29). The 2016 activity levels decreased in three of these well and remained less than detection in well 699-55-50C.
Figure 9-24. 200-BP Uranium Plume, 2016
Figure 9-25. 200-BP Uranium Data at Wells North and South of Extraction Well 299-E33-268

Figure 9-26. 200-BP Uranium Data at Wells along the South Extent of the B Complex Plume
Figure 9-27. 200-BP Uranium Data at Wells along the B Tank Farm East and South Boundaries

Figure 9-28. 200-BP Uranium Data at Wells Defining the B Plant Plume
Figure 9-29. 200-BP Strontium-90 Plume, 2016
Strontium-90 is detected in wells near the 216-B-5 injection well. The highest concentrations historically were in wells 299-E28-23 and 299-E28-25, which are screened near the water table (Figure 9-29). At well 299-E28-25, strontium-90 levels increased from 1,100 to 4,470 pCi/L. Concentrations in well 299-E28-24, screened 7.6 to 9.1 m (25 to 30 ft) below the water table, are typically lower (756 pCi/L in 2016). The areal extent of the plume is delimited by wells with concentrations below the DWS (Figure 9-29).

9.7 Total Cyanide

Cyanide contamination in 200-BP is associated with past discharge sites and unplanned releases of liquid scavenged waste. The scavenging process was used to reduce the cesium-137 and strontium-90 levels of uranium recovery and first-cycle decontamination waste before disposal to the soil column. The primary scavenging process used was sodium ferrocyanide and nickel sulfate; however, reduction of strontium-90 to cribbing criteria levels required calcium nitrate for some tanks. Groundwater cyanide contamination is considered to be in the form of an iron-ferrocyanide complex. In 2016 and historically, it was measured as total cyanide, which has a DWS of 200 µg/L. In 2017 free cyanide will be analyzed in some locations. Free cyanide has a MTCA (WAC 173-340) cleanup level of 4.8 µg/L.

The three main sources contributing to cyanide in groundwater are tank waste supernatant discharged to the BY Cribs, unplanned pipeline releases of tank waste in the B Tank Farm, and possible tank waste overfill and transfer line leaks in tank 241-BX. More information on the BY Crib can be found in PNNL-19277. More discussion of the unplanned releases can be found in Table 5-1 of RPP-RPT-49089 and Section 4.3.3 of RPP-RPT-47562. Monitoring wells at WMA C detect low levels of cyanide, as discussed in Section 9.10.2. One additional plume is located at well 299-E28-24; however, the source of this plume is not known at this time.

9.7.1 BY Cribs

The plume extends northwest and east-southeast of the BY Cribs (Figure 9-30). In 2016, continued groundwater extraction at well 299-E33-268, initiated in September 2015 as a treatability test, removed 45.5 kg of cyanide from groundwater. This action appeared to reduce the extent of the plume in 2016.

Beneath the BY Cribs the total cyanide concentrations at well 299-E33-3 declined from 1,480 µg/L in October 2015 to 890 µg/L in October 2016. The concentration at well 299-E33-38 declined from 1,010 µg/L in August 2015 to 702 µg/L in November 2016. The declining concentrations at these wells support the capture zone numerical model discussed in DOE/RL-2015-75.

The 2016 extent of cyanide diminished based on lower cyanide concentrations in wells 299-E34-9 (east), 299-E33-20 (southeast), 299-E33-34 (northwest), and 299-E33-31 (south) (Figure 9-31). However, in November 2016 the concentrations rebounded to 396 µg/L at well 299-E33-31 in response to the extraction well going offline for further expansion of the system.

9.7.2 B and BX Tank Farms

The cyanide plume extends along the east side of the B Tank Farm to the southeast (Figure 9-30). The highest 2016 concentration in this plume is found at well 299-E33-47 (Figure 9-32), which is assumed to be near the source within the B Tank Farm. The plume extends southeast through well 299-E33-361 where total cyanide concentrations were below the DWS of 200 µg/L.
Figure 9-30. 200-BP Cyanide Plume, 2016
Figure 9-31. 200-BP Cyanide Data at Wells along the Boundaries of the B Complex Plume

Figure 9-32. 200-BP Cyanide Data at Wells Extending Southeast of B and BX Tank Farm Sources
In 2012, total cyanide concentrations began to increase along the east side of the BX Tank Farm at well 299-E33-339 (Figure 9-32). Shortly thereafter cyanide concentrations began to increase at well 299-E33-337. Cyanide concentrations at well 299-E33-337 peaked in November 2015 at 350 µg/L, and by November 2016 cyanide was 234 µg/L. Based on the cyanide concentrations at these wells the majority of the elevated cyanide extends to the northwest of well 299-E33-337.

9.7.3 Well 299-E28-24

The total cyanide concentration at monitoring well 299-E28-24, screened 7.6 to 9.1 m (25 to 30 ft) below the water table, was 552 µg/L in 2016, about the same as 2015 and more than twice the 200 µg/L DWS. This well also has elevated concentrations of nitrate and technetium-99. The elevated levels of cyanide and other co-contaminants are not reflected in nearby monitoring wells 299-E28-3, 299-E28-7, 299-E28-23, and 299-E28-25, which are screened over longer intervals. For example, well 299-E28-25, screened from the water table to 12 m (39 ft) below the water table, had a cyanide concentration of 6 µg/L in 2016. The significantly greater cyanide concentration at depth in well 299-E28-24 indicates a plume migrating through the deeper part of the aquifer. The plume does not appear to be associated with waste discharged to the 216-B-5 injection well, which was screened in the vadose zone and upper part of the aquifer. The plume appears to be associated with sources from the B Complex, but the pathway is uncertain. As a result of this uncertainty, contamination at this site was not extended to a source, but contoured around the 299-E28-24 well (Figure 9-30).

9.8 Tritium

Tritium concentrations exceed the 20,000 pCi/L DWS near the 216-B-50 and 216-B-12 Cribs (Figure 9-33), and near the 216-B-3 Pond.

9.8.1 216-B-50 Crib

The remaining tritium plume exceeding the DWS and originating at the B Complex is associated with past discharges to the 216-B-50 Crib in the 1960s and 1970s. The 216-B-50 Crib received approximately 126.3 Ci of tritium. This inventory was over 100 Ci greater than most of the other site inventories in this area (RPP-26744).

Well 299-E33-3 had the only tritium level exceeding the DWS in 2016 at 25,500 pCi/L in July, declining to 17,900 pCi/L in October. The diminished plume is attributed to an increased groundwater flow rate associated with continued extraction at well 299-E33-268.

9.8.2 216-B-12 Crib

In the late 1950s, elevated tritium was identified in the groundwater near the 216-B-12 Crib at well 299-E28-9. The 216-B-12 Crib received 2,340 Ci of tritium from 1952 to 1957. In the 1980s, the tritium plume began migrating to the northwest, and levels exceeding 200,000 pCi/L were detected in wells north of the 216-B-12 Crib. Concentrations subsequently declined to levels below the 20,000 pCi/L DWS in the upper part of the unconfined aquifer.
Figure 9-33. 200-BP Tritium Plume, 2016
A deep zone of elevated tritium was discovered in 2010 during well drilling within the low-permeability hydrostratigraphic units 9A, 9B, and 9C at 8 m (26 ft) below the water table. The tritium concentration was 94,000 pCi/L at well 299-E28-30, located next to the 216-B-12 Crib. In addition, a tritium concentration of 150,000 pCi/L was observed near the bottom of the aquifer at well 299-E29-54, located south of B Plant. Two wells, 299-E28-31 and 299-E28-32, were drilled in this area in 2015. Based on 2015 depth-discrete sampling data at well 299-E28-31 (north of B Plant), the well screen was placed from 11.6 to 14.7 m (38 to 48 ft) below the water table. The 2016 routine groundwater sample result was 61,400 pCi/L. Well 299-E28-32 (south of B Plant) was screened from 17.3 to 20.4 m (56.8 to 66.8 ft) below the water table, near the bottom of the aquifer. The elevated tritium at this depth observed during drilling (91,600 pCi/L) has not been verified because a groundwater pump has yet to be installed in this well.

9.8.3 216-B-3 Pond

The tritium plume at B Pond is associated with previous PUREX discharges. Because of the decline in the water table beneath B Pond due to the termination of discharges in the mid-1990s, the unconfined aquifer is no longer present beneath B Pond. Concentrations exceeding the DWS are currently found in only one 200-BP well (699-42-40A). The concentration at this well has been relatively stable since sampling was restarted in 2007, and the 2016 result was 39,100 pCi/L. Chapter 10 includes additional discussion of the B Pond tritium plume.

9.9 CERCLA Remediation and Monitoring

This section summarizes activities in the 200-BP-5 groundwater OU and the 200-DV-1 deep vadose zone OU.

9.9.1 200-BP-5 Operable Unit

DOE submitted the Draft A RI report (DOE/RL-2009-127) to Ecology in August 2015. The RI report describes the nature and extent of contamination and identifies the COPCs for the OU.

Groundwater monitoring in 2016 continued under CERCLA, as described in the SAP for the 200-BP-5 OU (DOE/RL-2001-49, Groundwater Sampling and Analysis Plan for the 200-BP-5 Operable Unit). Figure 9-2 shows the locations of monitoring wells, and Table A-10 in Appendix A lists the wells, constituents, and 2016 sampling status. Because of the changes in groundwater flow directions and corresponding plume extents, DOE submitted a revised SAP to Ecology in 2015 (DOE/RL-2014-33, Groundwater Sampling and Analysis Plan for the 200-BP-5 Groundwater Operable Unit). When approved, the new SAP will replace DOE/RL-2001-49.

Results of a 2015 aquifer test were issued in a treatability test report (DOE/RL-2015-75) in September 2016. The test results indicated the aquifer could sustain extraction rates greater than 568 L/min (150 gal/min), capture was sufficiently wide to consider P&T as a plausible alternative in the 200-BP-5 OU FS, and treatment to reduce technetium-99 and uranium from the groundwater was achieved by the 200 West P&T Facility. The test also provided hydraulic parameters that were used to update the local-scale hydrologic numerical plume capture simulation. The report recommended continued pumping at the extraction well until a non-time-critical removal action could be completed. As of December 31, 2016 the total estimated removal of technetium-99 and uranium from the aquifer since the test began in September 2015 was 1.29 Ci and 14 kg, respectively. In 2016, 0.98 Ci of technetium-99 and 9.6 kg of uranium were removed (Table 9-2). Continued groundwater extraction under the treatability test will be performed until the RAWP is completed.
<table>
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<th>Removed 2016</th>
<th>Removed Since Startup</th>
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<tr>
<td>Perched Water Extraction Treatability Test (Single Well: 2011-2015; Three Wells 2016)</td>
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<tr>
<td>Nitrate (kg)</td>
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<tr>
<td>Technetium-99 (g; Ci)</td>
<td>0.36, 6.1 \times 10^{-3}</td>
<td>2.5; 4.3 \times 10^{-2}</td>
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<tr>
<td>Uranium (kg)</td>
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<td>79.7</td>
</tr>
</tbody>
</table>

| Groundwater Extraction Treatability Test (Single Well, 2015-2016) |                |                       |
| Cyanide (kg)          | 45.5           | 57.9                  |
| Nitrate (kg)          | 53,100         | 70,190                |
| Technetium-99 (g; Ci) | 57.3; 0.98     | 75.4; 1.29            |
| Uranium (kg)          | 9.6            | 14                    |

DOE completed an engineering evaluation/cost analysis (EE/CA) for groundwater extraction at the B Complex ([DOE/RL-2015-26](#), Engineering Evaluation/Cost Analysis for 200-BP-5 Operable Unit Groundwater Extraction) in 2016. The EE/CA evaluated the implementation of a non-time-critical removal action for the extraction and treatment of groundwater contaminated with technetium-99 and uranium. [DOE/RL-2015-26](#) recommended groundwater extraction at well 299-E33-268 (used in the aquifer treatability test) and possibly additional wells. The EE/CA also recommended the extracted groundwater continue to be conveyed and treated at the 200 West P&T. In alignment with the EE/CA, in 2016 the extraction system was expanded by adding a conveyance pipeline to well 299-E33-360 that is connected to a shared transfer tank located in the B Complex. The shared transfer tank combines extracted water from well 299-E33-268 with perched water from the 200-DV-1 OU (Section 9.9.2).

An action memorandum ([DOE/RL-2016-41](#)) was released in December 2016. The action memorandum documents the decision to implement a non-time-critical removal action for the B Complex technetium-99 and uranium plumes exceeding 10 times the DWS, at rates up to 567 L/min (150 gal/min). Under this action memorandum groundwater extracted from well 299-E33-268 and up to three additional extraction wells will continue to be conveyed and treated at the 200 West P&T before reinjection into the 200 West Area. A RAWP will be prepared in 2017 that describes how the removal action will be implemented.

Also in 2016, [ECF-200E-16-0093](#) was released. This document discussed how the use of water-level data to determine groundwater flow directions in the 200 East Area has been problematic because of a very low hydraulic gradient magnitude combined with a relatively large depth to water. This results in a low signal-to-noise ratio in the water-level elevation measurements, making it difficult to determine the hydraulic gradient. This problem was overcome at certain RCRA facilities in the 200 East Area through improving the accuracy of the water-level measurements (by resurveys of well casing elevations, performing borehole path surveys, and analyzing barometric pressure effects) and analyzing the data by trend surface analysis (i.e., least squares fit of a plane to the measurements) ([SGW-54165](#), Evaluation of the Unconfined Aquifer Hydraulic Gradient Beneath the 200 East Area, Hanford Site). However, other facilities were still problematic because of either their small areal extent or a spatial distribution of wells not suitable for trend surface analyses (i.e., the wells occur mostly along a line). To address sites throughout the 200 East Area, a regional 52-well, low-gradient monitoring network was created from existing groundwater wells. The data were analyzed by generating digital grids of the water table.
The gridding method was inverse distance to a power set to emphasize spatial averaging. Data for each well were averaged over a yearly period producing contour lines representing the underlying trend in the data (SGW-58828, Water Table Maps for the Hanford Site 200 East Area, 2013 and 2014). Using this technique has provided a repeatable process in which the results are in reasonable agreement with plume movement and direction.

### 9.9.2 200-DV-1 Operable Unit

The 200-DV-1 OU was created in 2010 to support remedy selection for waste sites with deep vadose zone contamination on the Central Plateau. In general, deep vadose zone contamination is considered to be contamination that poses a potential threat to groundwater and cannot be remediated using standard surface-based remedies. The goal for the 200-DV-1 OU is to ensure long-term protection of the groundwater on the Central Plateau. Forty-three waste sites are assigned to the 200-DV-1 OU and are shown in Figure 9-34. In the 200 East Area, the 200-DV-1 OU waste sites are in the vicinity of WMA B-BX-BY. In the 200 West Area, the 200-DV-1 OU waste sites are in the vicinities of WMAs T, TX-TY, and S-SX. However, the OU does not include the tank farms.

In August 2011, DOE began a treatability test at perched well 299-E33-344 (DOE/RL-2014-34, Action Memorandum for 200-DV-1 Operable Unit Perched Water Pumping/Pore Water Extraction). The treatability test investigated the feasibility of contaminant removal from the perched water horizon. Two additional perched water extraction wells (299-E33-350 and 299-E33-351) were added to the system in 2016, and the treatability test transitioned to a CERCLA removal action (DOE/RL-2014-34). Conveyance of contaminated perched water was aligned with the 200-BP-5 EE/CA for conveyance to the 200 West P&T, and the system began operating in December 2016. Through the end of December 2016, a combined total of 1,360,000 L (360,000 gal) of water has been removed, containing 777.9 kg of nitrate, 2.5 g of technetium-99, and 79.7 kg of uranium (Table 9-2).

Characterization activities in the 200-DV-1 OU are being performed under DOE/RL-2011-104, Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit. The characterization of 26 boreholes began in October 2015 while the work plan was being finalized. The work plan (DOE/RL-2011-102), which was approved and issued in July 2016, presents the combined CERCLA RI/FS and RCRA RFI/CMS characterization to support the final remedy selection. In 2016, 22 boreholes were drilled to total depth, sampled, analyzed, and decommissioned. The four remaining boreholes will be drilled in calendar year (CY) 2017. The boreholes overlie three groundwater OUs: 200-BP-5 (Table 9-3), 200-ZP-1, and 200-UP-1. Information from these boreholes will be used to refine the CSMs and will guide future remedy selection for 200-DV-1 OU waste sites. Characterization results will be described in an upcoming 200-ZP-1 report.

### 9.10 RCRA Monitoring

DOE/RL-2016-66 presents the results of RCRA groundwater monitoring on the Hanford Site in 2016. This section repeats that information for RCRA WMAs in 200-BP. These WMAs are monitored under RCRA requirements for dangerous waste/dangerous waste constituents and under AEA for source, special nuclear, and byproduct materials. Data from unit-specific monitoring are also integrated into CERCLA groundwater investigations. Dangerous constituents and radionuclides are occasionally discussed jointly in this section to provide comprehensive interpretations of groundwater contamination. Pursuant to RCRA, the source, special nuclear, and byproduct material components of radioactive mixed waste are not regulated under RCRA but are instead regulated by DOE, acting pursuant to its AEA authority. Therefore, the inclusion of information on radionuclides in such a context is for informational purposes only and may not be used to create conditions or other restrictions set forth in any RCRA Permit.
Figure 9-34. Location of 200-DV-1 OU Waste Sites on the Central Plateau
<table>
<thead>
<tr>
<th>Well Name</th>
<th>Well ID</th>
<th>Well 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 or Decommission Date</th>
<th>Comment</th>
</tr>
</thead>
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<tr>
<td>299-E27-26</td>
<td>C9449</td>
<td>WMA C Monitoring&lt;sup&gt;a&lt;/sup&gt;</td>
<td>85.3</td>
<td>280</td>
<td>85.6</td>
<td>280.9</td>
<td>4/12/2016</td>
<td>Replacement for 299-E27-7.</td>
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<tr>
<td>C8706</td>
<td>C8706</td>
<td>200-DV-1 characterization&lt;sup&gt;b&lt;/sup&gt;</td>
<td>61.7</td>
<td>202.3</td>
<td>61.7</td>
<td>202.3</td>
<td>9/28/2016</td>
<td>Instrument boring.</td>
</tr>
<tr>
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<td>C8707</td>
<td>200-DV-1 characterization&lt;sup&gt;b&lt;/sup&gt;</td>
<td>--</td>
<td>--</td>
<td>9.1</td>
<td>29.7</td>
<td>9/28/2016</td>
<td>Unsuccessful.&lt;sup&gt;c&lt;/sup&gt; Replaced by C9549. Decommissioned.</td>
</tr>
<tr>
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<td>C8709</td>
<td>200-DV-1 characterization&lt;sup&gt;b&lt;/sup&gt;</td>
<td>--</td>
<td>--</td>
<td>5.0</td>
<td>16.3</td>
<td>9/28/2016</td>
<td>Unsuccessful.&lt;sup&gt;c&lt;/sup&gt; Replaced by C9552. Decommissioned.</td>
</tr>
<tr>
<td>C8711</td>
<td>C8711</td>
<td>200-DV-1 characterization&lt;sup&gt;b&lt;/sup&gt;</td>
<td>--</td>
<td>--</td>
<td>8.4</td>
<td>27.6</td>
<td>9/28/2016</td>
<td>Unsuccessful.&lt;sup&gt;c&lt;/sup&gt; Replaced by C9550. Decommissioned.</td>
</tr>
<tr>
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<td>C9487</td>
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<td>--</td>
<td>71.6</td>
<td>235.0</td>
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</tr>
<tr>
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<td>C9488</td>
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<td>225.0</td>
<td>9/28/2016</td>
<td>Decommissioned.</td>
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<tr>
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<td>C9489</td>
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<td>--</td>
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<td>253.1</td>
<td>9/28/2016</td>
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</tr>
<tr>
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<td>C9490</td>
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<td>77.0</td>
<td>252.6</td>
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<td>90.6</td>
<td>9/28/2016</td>
<td>Replacement for C8707, but unsuccessful.&lt;sup&gt;c&lt;/sup&gt; Replaced by C9549. Decommissioned.</td>
</tr>
<tr>
<td>Well Name</td>
<td>Well ID</td>
<td>Well Purpose</td>
<td>Construction Depth (m bgs)</td>
<td>Construction Depth (ft bgs)</td>
<td>Drilled Depth (m bgs)</td>
<td>Drilled Depth (ft bgs)</td>
<td>Acceptance or Decommission Date</td>
<td>Comment</td>
</tr>
<tr>
<td>-----------</td>
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<td>-----------------------------</td>
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<td>-------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>C9549</td>
<td>C9549</td>
<td>200-DV-1 characterization&lt;sup&gt;b&lt;/sup&gt;</td>
<td>--</td>
<td>--</td>
<td>61.1</td>
<td>200.5</td>
<td>9/28/2016</td>
<td>Instrument boring. Replacement for C8707.</td>
</tr>
<tr>
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<td>C9550</td>
<td>200-DV-1 characterization&lt;sup&gt;b&lt;/sup&gt;</td>
<td>61.1</td>
<td>200.5</td>
<td>61.1</td>
<td>200.5</td>
<td>9/28/2016</td>
<td>Replacement for C8711. Instrument boring.</td>
</tr>
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<td>C9551</td>
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<td>--</td>
<td>--</td>
<td>3.9</td>
<td>12.9</td>
<td>9/28/2016</td>
<td>Replacement for C8709 but unsuccessful.&lt;sup&gt;c&lt;/sup&gt; Replaced by C9552. Decommissioned</td>
</tr>
</tbody>
</table>

b. Vadose characterization borings (not to groundwater) per [DOE/RL-2011-104](#), *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*.  
c. Borehole could not be advanced to desired depth and was replaced.  
   -- = no construction depth; boreholes decommissioned

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The 200-BP groundwater interest area contains six RCRA WMAs with groundwater monitoring requirements: WMA B-BX-BY, WMA C, 216-B-63 Trench, LERF, LLWMA-1, and LLWMA-2 (Figure 9-2). The following discussion summarizes the results of statistical comparisons, assessment studies, and other developments for this reporting period. Groundwater data are available in the HEIS database and in the data files accompanying this report. Appendix B provides additional information, including well and constituent lists, and statistical tables.

9.10.1 Waste Management Area B-BX-BY

WMA B-BX-BY is located in northwestern 200 East Area (Figure 9-35). It was constructed in stages: B Tank Farm between 1943 and 1944, BX Tank Farm between 1946 and 1947, and BY Tank Farm between 1948 and 1949. All three tank farms provided interim storage of radioactive mixed waste, primarily from the bismuth phosphate, PUREX, and uranium extraction processes. However, no self-boiling wastes from PUREX or REDOX were sent to the B-BX-BY Tank Farms prior to removal of high heat-generating fission products. All of the 24 SSTs in the B and BX Tank Farms were built to store up to 2.0 million L (530,000 gal) of radioactive mixed waste or high-level radioactive liquid wastes.

Each of the 12 SSTs in the BY Tank Farm had a 2.9 million L (770,000 gal) capacity. In the B Tank Farm, four additional tanks each had a capacity of 208,000 L (55,000 gal). Ancillary equipment at WMA B-BX-BY includes 13 diversion boxes, the 244-BXR waste transfer vault, 5 catch tanks, and several connecting underground lines. Of the 40 tanks, 20 were defined as confirmed or assumed to have leaked. To minimize the probability and severity of future leaks, most of the drainable liquid in each tank has been removed and transferred to DSTs. Additional sources of unplanned releases within WMA B-BX-BY include tank overfills, waste loss from spare inlet nozzles or cascade lines, pipeline leaks, and surface releases.

DOE monitors groundwater beneath WMA B-BX-BY under an interim status assessment program in accordance with 40 CFR 265.93(d)(4), as defined in DOE/RL-2012-53, Groundwater Quality Assessment Plan for Single-Shell Tank Waste Management Area B-BX-BY. This site initially went into assessment in 1996 as the result of elevated specific conductance at well 299-E33-32 (WHC-SD-ENV-AP-002, Assessment Groundwater Monitoring Plan for Single Shell Tank Waste Management Area B-BX-BY). Multiple assessment plans have been released over the years; however, no dangerous waste/dangerous waste constituents had been identified. The most recent groundwater monitoring plan (DOE/RL-2012-53) realigned the upgradient and downgradient monitoring network to the new southeast groundwater flow condition. While developing DOE/RL-2012-53, an assessment of historical process chemistry, leak assessment reports, and past and current groundwater constituent distribution was performed. This led to the determination that cyanide, a dangerous waste or dangerous waste constituent, had affected groundwater quality beneath the B Tank Farm, as seen in well 299-E33-47 results. The probable cyanide source and a conceptual model for transport were provided as part of the determination. Although other releases from WMA B-BX-BY have affected groundwater, there is currently no evidence of additional dangerous waste or dangerous waste constituents. Dissolved chromium appears to have originated solely at the 216-B-8 Crib.

Table B-73 lists the WMA B-BX-BY wells, their construction, and water-level information. The well network consists of six upgradient and nine downgradient wells that are WAC compliant (except well 299-E33-20). The depth of the water column in the network wells ranges from 0.9 to 6.0 m (2.9 to 19.8 ft). Most of the well screens extend across the entire unconfined aquifer to the underlying basalt surface. The water table elevation at WMA B-BX-BY declined an average of 1.9 mm/month between May 2011 and September 2016 (Figure 9-36). The WMA B-BX-BY groundwater wells have adequate water columns in the screened interval for sampling during the next decade.

Figure 9-35. WMA B-BX-BY
The WMA B-BX-BY water table elevations have periodically increased in response to Columbia River stages and significant discharges at TEDF (Figure 9-36). Groundwater gradient magnitudes and flow directions were determined using the 200 East Area low-gradient monitoring network (discussed in SGW-58828) for the northwest corner of the 200 East Area. A 12-month rolling average calculation from October 2015 through September 2016 was used to derive the regional water table gradient. In addition, the local groundwater flow pathways were influenced by local groundwater extraction between October 2015 and September 2016 (Figure 9-37). The pathway was inferred using modeling results from the treatability test report and review of groundwater chemistry. The gradient ranges from $1.08 \times 10^{-6}$ to $3.9 \times 10^{-6}$ m/m with flow directions ranging from northwest to southeast (Table B-74). The estimated groundwater flow rate ranges from 0.09 to 0.37 m/day (0.3 to 1.2 ft/day) or 33.4 to 135 m/yr (110 to 443 ft/yr).

All of the network wells were sampled quarterly during the reporting period, except for decommissioned well 299-E33-18 (Table B-75). An extra sampling event was performed in September at wells 299-E33-48 and 299-E33-338 after their pumps were moved to the bottom of the aquifer. Constituent levels increased after lowering the pumps (e.g., nitrate in Figure 9-38), showing higher concentrations lower in the aquifer.

Figure 9-37. Inferred Groundwater Flow Pathways Based on Water Table (Left Panel) and Modeling (Right Panel)
The dangerous waste constituent cyanide had sources in the BY Cribs and in WMA B-BX-BY. A portion of the plume extends from the B and BX Tank Farms with concentrations well above the 200 µg/L total cyanide DWS (Figure 9-39). Elevated cyanide has persisted in these wells. One of the highest total cyanide concentrations in this region (1,060 µg/L) was detected at well 299-E33-47 in February and May. The contamination in this well appears to be associated with cyanide loading from a release of tributyl phosphate waste near tanks 241-B-105 and 241-B-106. The estimated average groundwater cyanide migration rate from this source in 2016 is 0.09 m/day (0.3 ft/day) or 33.4 m/yr (110 ft/yr).

Another possible source of cyanide loading beneath the BX Tank Farm appears to be a combination of possible line leaks, unplanned spills, and overfills near and associated with tanks 241-BX-108 and 241-BX-111. The suite of contaminants is characteristic of scavenged uranium recovery waste reported to have been released in this area. Upgradient wells to the west-northwest also show lower cyanide levels. The estimated average groundwater cyanide migration rate extending from this source in 2016 is 0.09 m/day (0.3 ft/day) or 33.4 m/yr (110 ft/yr).

Cyanide is present in other WMA B-BX-BY monitoring wells, but determining if a source exists within the BY Tank Farm is difficult because of the proximity of known source sites in the BY Cribs. Data from well 299-E33-9 (BY Tank Farm) may help determine if persistent cyanide at well 299-E33-44 is from a BY Tank Farm source or BY Crib sources.

Other constituents sampled per the WMA B-BX-BY assessment program include pH, specific conductance, TOC, alkalinity, anions, and metals. The 2016 pH results are stable, ranging from 7.47 to 8.47. Wells where contaminants are detected at higher concentrations have consistently lower pH values.
Specific conductance in 2016 ranged from 458 and 2,952 µS/cm. The lowest value was at the southwest corner of the BX Tank Farm (well 299-E33-334). The highest specific conductance levels were at downgradient wells 299-E33-44 and 299-E33-47. Elevated specific conductance is primarily associated with elevated groundwater nitrate concentrations.

Nitrate exceeds the DWS in all WMA B-BX-BY wells, with the highest concentrations at downgradient wells 299-E33-44 and 299-E33-47. These wells were also associated with the only sulfate concentrations at or above the secondary DWS.

Iron exceeded the secondary DWS in filtered and unfiltered samples from several wells (Table B-75). Elevated filtered iron results are diagnostic of scavenged uranium recovery waste. The concentrations exceeding the secondary DWS are under or downgradient from the previously discussed cyanide sources.

Elevated manganese is associated with galvanized piping at well 299-E33-20. This well is not WAC compliant and is scheduled for decommissioning and replacement.

### 9.10.2 Waste Management Area C

WMA C is located in the east-central part of the 200 East Area (Figure 9-40). Constructed in 1943 and 1944, it provided interim storage of radioactive mixed waste, primarily from the bismuth phosphate, PUREX, and uranium extraction processes. High-level liquid wastes from these processes were stored in 12 SSTs, each with a capacity of 2.01 million L (530,000 gal). Four additional SSTs, each with a capacity of 208,000 L (55,000 gal), were also used to store high-level liquid waste. Ancillary equipment at WMA C includes seven diversion boxes, the 244-CR vault with four permitted tanks, the 241-C-301 catch tank, one french drain, two dry wells (liquid waste disposal units associated with the 241-C-801 cesium load-out facility), and several connecting underground lines. Of the 16 underground tanks in WMA C, 7 were confirmed or assumed to have leaked and retrieval processes since 1998 have removed their liquid wastes. Additional sources include waste loss from spare inlet nozzles or cascade lines, pipeline leaks, and surface releases.

Figure 9-40. WMA C
DOE monitors groundwater beneath WMA C under an interim status assessment program in accordance with 40 CFR 265.93(d)(4), as defined in DOE/RL-2009-77, Groundwater Quality Assessment Plan for the Single-Shell Waste Management Area C. The assessment plan was initiated in July 2009 when a critical mean exceedance for specific conductance was verified in downgradient well 299-E27-14. While developing DOE/RL-2009-77, an assessment of historical process chemistry, leak assessment reports, and past and current groundwater constituent distribution were performed. This led to the determination that cyanide, a dangerous waste constituent, had affected groundwater beneath the C Tank Farm, as shown by detections in various downgradient wells, but not in upgradient well 299-E27-22. Although well 299-E27-7 was previously considered an upgradient well, groundwater contamination detected at this well raised concern of the representativeness as an upgradient well for WMA C. As a result well 299-E27-25 was installed because it may be more representative of groundwater unaffected by the WMA (DOE/RL-2009-77). Other releases from WMA C have affected groundwater, there is currently no significant evidence of additional dangerous waste or dangerous waste constituents (EPA 530/R-09-007, Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance). Samples from some wells contain nickel, most likely related to casing and screen corrosion.

The WMA C monitoring well network consists of three upgradient wells, seven downgradient wells, and two cross-gradient wells (Table B-76). These wells are WAC compliant except for well 299-E27-7. Replacement well 299-E27-26 was installed in 2016 (Table 9-3), and samples were collected from wells 299-E27-7 and 299-E27-26 in September and December for comparison. Cyanide concentrations are somewhat higher in the new well (16 µg/L in September) than in the old well (2.6 µg/L). Specific conductance and nitrate are the same in the new and old wells. A revised assessment plan will remove well 299-E27-7 and add well 299-E27-26 to the network in 2017.

The depth of the water in the monitoring wells is from 1.3 to 16.2 m (4.2 to 53 ft). The water table elevation at WMA C has declined an average of 2.7 mm/month between November 2012 and August 2016. The WMA C groundwater wells have adequate water in the screened intervals for sampling during the next two decades.

Groundwater gradient magnitude and flow direction were determined using a low-gradient monitoring network across the 200 East Area, as discussed in SGW-58828. Quarterly calculations were completed during 2016 using a 12-month rolling average to verify consistency. WMA C water table elevations periodically increase in response to significant discharges at TEDF (Figure 9-41). Extended periods of high discharge (e.g., 2014-2015) can flatten the groundwater gradient, causing slower flow rates. After the higher discharges cease, higher flow rates are again likely. The 2016 groundwater gradient declined from $2.6 \times 10^{-5}$ m/m in the first quarter to $4.13 \times 10^{-6}$ m/m in the third quarter. The estimated flow rate declined from 2.2 to 0.35 m/day (7.2 and 1.1 ft/day) from January through September 2016 (Table B-77). The flow direction remained constant in 2016, ranging between 160 and 170° from north (south-southeast). Large future TEDF discharges are expected from the underground tank retrieval program.
Eleven of the twelve wells were sampled quarterly during the reporting period (Table B-78). In March, well 299-E27-4 was sampled but was observed to have advanced casing corrosion during a downwell video survey (Figures 9-42 and 9-43). It was removed from service in May and will be decommissioned and replaced. Further sampling details are discussed in **SGW-59914, WMA C January through March 2016 Quarterly Groundwater Monitoring Report**. All the other monitoring network wells were also video surveyed, and only slight-to-moderate amorphous encrustation was observed on their screens. Six wells were cleaned and disinfected with sulfamic acid in August and September. Residual sulfamic acid in these wells caused lower pH levels and affected the results for alkalinity, chloride, sodium, and select metals. Affected data from the September and December sampling events were flagged in the HEIS database. Additional scrubbing and purging should ensure the March 2017 sampling results are not affected.

The dangerous waste constituent cyanide was detected at 8 of the 12 WMA C wells in 2016. The average 2016 total cyanide concentrations exceeded the MTCA (WAC 173-340) cleanup level for free cyanide (4.8 µg/L) in four wells (Table B-78). Persistent elevated cyanide in these wells and the inferred plumes are shown in Figure 9-44. The highest concentration (35.1 µg/L) was detected at well 299-E27-14 in March, an increase from previous years. The high concentration appears to be associated with cyanide loading from the vadose zone during slower than normal groundwater flow conditions, possibly from middle to late 2015. Concentrations subsequently increased downgradient of well 299-E27-14, reaching a high of 20.7 µg/L in well 299-E27-24 in September. Well 299-E27-24 is screened across the bottom of the unconfined aquifer. The estimated cyanide migration rate from January through September 2016 is 1 m/day (3.3 ft/day).
Figure 9-42. Casing Corrosion in Well 299-E27-4 at 10 m (33 ft) bgs

Figure 9-43. Casing Corrosion in Well 299-E27-4 at 10.7 m (35 ft) bgs
Figure 9-44. Detections of Cyanide in the Upper 4 m and Lower 4 m of the Aquifer at WMA C and Cyanide Trends in Selected Wells
Other constituent sampling completed as part of the WMA C assessment program includes pH, specific conductance, alkalinity, anions, and metals per Table 3-1 of DOE/RL-2009-77. The following quarterly reports contain details of 2016 results for these other constituents:

- **SGW-59914,** *WMA C January through March 2016 Quarterly Groundwater Monitoring Report*
- **SGW-60442,** *WMA C April through June 2016 Quarterly Groundwater Monitoring Report*
- **SGW-60494,** *WMA C July through September 2016 Quarterly Groundwater Monitoring Report*
- **SGW-60546,** *WMA C October through December 2016 Quarterly Groundwater Monitoring Report*

### 9.10.3 216-B-63 Trench

The 216-B-63 Trench TSD unit is located in the north-central portion of the 200 East Area (Figure 9-45). Beginning in 1970, it was used as an emergency percolation trench for chemical sewer wastes from B Plant (*RHO-CD-798, Current Status of the 200 Area Ponds*). Major contributors to this waste were the 2902-B High Tank (contains potable sanitary water), cooling water from B Plant and the 225-B Waste Encapsulation and Separation Facility, some 221-B steam condensate, and demineralizer effluent. Minor contributions may have included the chemical makeup overflow system (sodium hydroxide and sodium nitrite), air conditioning units, and space heaters (radiators). The effluent compositions were kept below regulated values (*WHC-EP-0342, Addendum 6, B Plant Chemical Sewer Stream-Specific Report*).

Before November 1985, acidic effluent from anion exchanger regeneration and the basic effluent from cation exchanger regeneration were discharged without neutralization (*WHC-EP-0287, Waste Stream Characterization Report*, p. A.9-2). In March and April 1987, incidental corrosive liquid waste releases were discharged to the 216-B-63 Trench. The corrosive amount released in March 1987 was 1,136 kg (2,504 lb) of an unknown acid (*WHC-EP-0342, Hanford Site Stream-Specific Reports*). The April 1987 release was 2,863 kg (6,312 lb) of nitric acid. These releases were only part of the 378,000 to 1,408,000 L/day (100,000 to 370,000 gal/day) chemical sewer and cooling water discharges (*DOE/RL-93-74, 200-BP-11 Operable Unit RFI/CMS and 216-B-3 Main Pond, 216-B-63 Trench, and 216-A-29 Ditch Work/Closure Plan Volume 1: Field Investigation and Sampling Strategy*). Discharges to this trench ceased in 1992. The corrosive waste discharges were regulated under *RCW 70.105*, “Hazardous Waste Management,” and its implementing requirements in *WAC 173-303*.

DOE monitors the groundwater under an interim status indicator evaluation program in accordance with *40 CFR 265*, Subpart F, as defined in *DOE/RL-2008-60, Interim Status Groundwater Monitoring Plan for the 216-B-63 Trench*. An update of this plan was completed in 2012 to realign the upgradient and downgradient monitoring network to the new southeast groundwater flow condition. Prior to this change, the groundwater flow was predominantly north-northwest. Previously, there was no evidence of contaminant effects on groundwater quality from the 216-B-63 Trench.

Table B-29 presents construction information and water levels for the 216-B-63 wells. The monitoring network consists of three upgradient and three downgradient wells screened in the upper part of the aquifer at the water table. The water column depth in the monitoring wells ranges from 1.2 to 3.1 m (4.0 to 10.3 ft). Most of the well screens extend to within 1.5 m (5 ft) of the underlying basalt surface. The water table elevation at the 216-B-63 Trench has declined an average of 2 mm/month between May 2011 and October 2016 (Figure 9-46). Based on this information, the 216-B-63 Trench monitoring wells have adequate water in the screened interval for sampling over the next two decades or longer.

Figure 9-45. 216-B-63 Trench
With the water table surface being essentially flat, the Columbia River and large-volume effluent discharges at the TEDF influence the gradient in the 200 East Area (DOE/RL-2015-07, Hanford Site Groundwater Monitoring Report for 2014). Although river stage changes affect water levels, this does not mean that river water is flowing into the 200 East Area. Instead, the water table response to river stage change is a pressure effect that propagates inland through the aquifer. Because this river stage stressor originates from the north, seasonal water table fluctuations tend to drive 200 East Area groundwater flow toward the southeast, especially when the river stage is higher than normal (SGW-58828).

Discharges to TEDF, east of the 200 East Area, have the opposite effect of river stage changes on the 200 East Area hydraulic gradient. In addition, the Ringold Formation lower mud unit occurs above the water table beneath TEDF and dips to the south. Water discharged to TEDF migrates southward along the top of the mud in the vadose zone until it reaches the aquifer, where the mud dips below the water table about 500 m (1,600 ft) south of TEDF (PNNL-12261, Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington). Discharges to TEDF enter the aquifer east-southeast of the 200 East Area and tend to act as a hydraulic dam that slows flow toward the southeast.

The 216-B-63 Trench water table elevations have periodically increased in response to high Columbia River stages and significant discharges at TEDF (Figure 9-46). High river stages between September 2012 and March 2013 increased the hydraulic gradient and caused higher flow rates. Extended periods of higher discharge to TEDF, as experienced in 2014 and 2015, can decrease the groundwater gradient, causing slower flow rates. After high TEDF discharges cease, higher groundwater flow rates are likely. Periodic large future discharges at TEDF are expected due to the underground tank retrieval program.
Groundwater gradient magnitude and flow direction were inferred using a low-gradient monitoring network across the 200 East Area, as discussed in SGW-58828. A 12-month rolling average calculation from October 2015 through September 2016 was used to derive the regional water table gradient (Figure 9-6). The resulting groundwater gradient was $1.06 \times 10^{-6}$ m/m, dipping to the southeast, and the estimated groundwater flow rate was 0.09 m/day (0.3 ft/day) (Table B-30).

As required by 40 CFR 265.93(b), downgradient average indicator parameters were compared to upgradient critical mean values semiannually. No indicator parameters exceeded the critical mean in 2016 (Table B-31), although specific conductance has increased in upgradient and downgradient wells. A 2016 TOX critical mean was not calculated due to the number of upgradient well nondetects. In lieu of a critical mean, sampling results were compared to the laboratory LOQ (Table 1-1 of DOE/RL-2016-66).

While the revised well network allows for statistical comparisons to determine if the 216-B-63 Trench has impacted groundwater quality under stationary conditions over time, contaminant plumes migrating toward the site from the northwest may affect both upgradient and downgradient wells in the near future. Increasing specific conductance in upgradient wells may require the critical mean values to be recalculated as recommended in the EPA unified guidance (EPA 530/R-09-007) for representativeness as required by 40 CFR 265.91(a)(1), “Ground-Water Monitoring System.” The upward trend in background concentrations violates the assumption of stationary concentrations over time, which is a key assumption for the statistical interim Student t-test approach used to derive background levels in accordance with 40 CFR 265.93(b). Furthermore, 40 CFR 265.91(a)(1) requires upgradient wells that are representative of background groundwater quality, so critical mean values will be recalculated, as necessary, to ensure representative comparisons with the changing groundwater background quality.

Table B-31 provides the 2016 range of groundwater quality parameters (40 CFR 265.92(d)(1)). Table B-32 summarizes additional constituents required by the monitoring plan (DOE/RL-2008-60). Nitrate was the only parameter above a water quality standard. Nitrate reflects contaminant migration from sources northwest of 216-B-63 (e.g., BY Cribs). Chloride and sulfate above Hanford Site background levels also reflect contaminant migration from sources to the northwest. While low metal concentrations indicate that the well casing, screen, and pump column tubing are still in good condition, borehole video surveys in 2017 will investigate some recent spikes in metal concentrations (299-E27-18 and 299-E27-19).

9.10.4 Liquid Effluent Retention Facility

Located on the eastern boundary of the 200 East Area, LERF is a TSD unit with three lined-surface impoundment basins (Basins 42, 43, and 44) (Figure 9-47). Construction of LERF was completed in 1991 using a dual-confinement barrier concept (i.e., dual basin liners and pipe-in-a-pipe transfer piping system) to minimize human exposure and the potential for accidental releases to the environment. A leachate detection, collection, and removal system and basin covers also reduce possible environmental or personnel exposure. The basins are side by side, with 18 m (60 ft) of separation between them. Each basin (cell) is 100 by 82 m (330 by 270 ft), with a maximum fluid depth of 6.7 m (22 ft).

LERF provides aqueous waste storage and treatment prior to final treatment in the 200 Area ETF. Treatment at LERF consists of flow and pH equalization. Flow equalization allows for several smaller waste streams that are intermittently received at the LERF basins, to accumulate for continuous higher volume campaign processing at ETF.
Figure 9-47. LERF
LERF continues to receive liquid waste from a number of onsite facilities, with the largest volume from the 242-A Evaporator. Several of the wastes contain metals and organics, which are regulated under RCW 70.105 and are subject to groundwater monitoring. Groundwater monitoring is under a final status detection program in accordance with WAC 173-303-645(9). Previously, no evidence of contaminant effects from the LERF site were detected in groundwater.

In 2013, DOE prepared a Class 2 modification of the Hanford RCRA Permit, including a new monitoring plan (DOE/RL-2013-46, Groundwater Monitoring Plan for the Liquid Effluent Retention Facility, Rev. 0). The Class 2 modification was part of a sequence of investigations and modifications completed at LERF because of the changing groundwater flow, declining groundwater table, and additional hydrogeology information needs to establish a defensible conceptual model. The new monitoring network design was based on statistical evaluations of the water table gradient magnitude and flow direction discussed in SGW-54165. As a result, upgradient well 299-E26-14 and downgradient well 299-E26-79 were identified for detection monitoring as required by DOE/RL-2013-46. The modified plan also required a new downgradient well (299-E26-15), which was completed in 2015 (fall) and sampled semiannually in 2016.

The depth of the water column in the LERF network wells ranges from 1.0 to 7.3 m (3.4 to 23.9 ft) (Table B-45). Four of the five well screens extend to the underlying basalt or within the basalt fracture zone. Well 299-E26-14 extends to within 0.9 m (3 ft) of the underlying basalt surface. The water table elevation at LERF declined an average of 1.9 mm/month between May 2011 and October 2016 (Figure 9-48). Based on this information, the LERF groundwater wells have adequate water columns in the screened interval for sampling during the next two decades.

![Figure 9-48. TEDF Discharges Compared with Water Table Measurements at LERF](CHS/GW20170226)
The LERF water table elevation has increased in response to high river stages and TEDF discharges (Figure 9-48; Section 9.10.3). The 2016 groundwater gradient magnitude and flow direction beneath LERF were based on the same methodology discussed in SGW-54165: using average monthly flow directions between May and October 2016 to calculate a rolling average water table gradient using the five-well network. The derived 2016 groundwater gradient was $2.79 \times 10^{-4}$ m/m toward the south (Table B-46). The estimated groundwater flow rate was 0.11 m/day (0.36 ft/day) or 40.2 m/yr (132 ft/yr).

In 2016, the LERF monitoring wells were sampled semiannually for indicator parameters as scheduled (Table B-47). Carbon tetrachloride, pH, TOC, and TOX did not exceed their respective critical mean values during the 2016 semiannual sampling events. Specific conductance exceeded the critical mean for the July sampling event at well 299-E26-15. DOE notified Ecology of the exceedance on August 22, 2016 (16-AMRP-0252, “Notification of Groundwater Sampling Results Exceeding Specific Conductance for the Liquid Effluent Retention Facility 2013 Monitoring Well Network Plan Per 40 CFR 365.93(2)(d)(1)”), and verification samples were collected at the well in September 2016. The average results for the field and two laboratory split samples were all below the critical mean. A demonstration report (DOE/RL-2016-71, Demonstration of Other Source or Natural Variation Causing Elevated Specific Conductance in Groundwater at the Liquid Effluent Retention Facility (LERF) Point of Compliance) was prepared and cleared in November 2016 for delivery to Ecology. This report concluded that LERF did not cause the critical mean exceedance at well 299-E26-15; it was likely caused by analytical error. The report recommended revising the monitoring plan for LERF (DOE/RL-2013-46).

Table B-47 summarizes groundwater indicator and geochemical parameters for LERF. Nitrate and TOC in upgradient well 299-E26-14 were elevated in 2016, as discussed in DOE/RL-2016-71. Elevated nitrate is also present in downgradient well 299-E26-79 and cross-gradient well 299-E26-77, although at lower levels. Elevated sulfate was detected in cross-gradient well 299-E26-77. Chloroform and elevated pH were detected in downgradient well 299-E26-15. Split verification sampling in February for chloroform indicated the January 2016 result was a false-positive. Field sampling results in May 2016 produced elevated pH at well 299-E26-15, but July samples did not confirm the increase.

### 9.10.5 Low-Level Waste Management Area-1

Low-level waste management area (LLWMA)-1 is located in the northwest corner of the 200 East Area (Figure 9-49). The 218-E-10 Burial Ground (14 unlined and covered trenches) received low-level radiological waste from 1955 to 2000. Low-level mixed waste was received in the north portion of Trench 9 from 1987 to 1993 (Figure 9-50). Dangerous chemicals in the low-level mixed waste portion of the 218-E-10 Burial Ground are regulated under RCRA and its implementing requirements in 40 CFR 265, Subpart F, as referenced by WAC 173-303-400. The LLWMA-1 monitoring network is designed to detect dangerous waste or dangerous waste constituents affecting groundwater from the 218-E-10 Burial Ground. The monitoring network encompasses the LLWMA-1 boundary to provide coverage for potential groundwater flow direction changes. DOE monitors groundwater under an interim status indicator evaluation program in accordance with 40 CFR 265.93(b), as defined in DOE/RL-2009-75, Interim Status Groundwater Monitoring Plan for the LLBG WMA-1 (Rev. 0), which was revised (Rev. 1) in 2015 and will be used for monitoring the site in 2017 (Figure 9-50).

The LLWMA-1 monitoring network consists of 18 wells screened in the upper part of the aquifer at the water table (Table B-48). The depth of the water column extending into the aquifer for the LLWMA-1 monitoring wells ranged from 1.5 to 5.2 m (4.8 to 17.1 ft). The water table elevation at LLWMA-1 declined an average 1.6 mm/month between May 2011 and October 2016 (Figure 9-51). Based on this information, the LLWMA-1 wells have adequate water columns in the screened interval for sampling during the next four decades. A new well is planned near the southeast corner of LLWMA-1.

Figure 9-49. LLWMA-1
Figure 9-50. Revised LLWMA-1 Monitoring Network for 2017
The LLWMA-1 water table elevations have periodically increased in response to high river stages and significant discharges at TEDF (Figure 9-51). Groundwater gradient magnitudes and flow directions were determined using the 200 East Area low-gradient monitoring network (discussed in SGW-58828) for the northwest corner of 200 East Area. A twelve-month rolling average calculation from October 2015 through September 2016 was used to derive the regional water table gradient. In addition, the local groundwater flow pathway was influenced by local groundwater pumping from October 2015 to September 2016 (Figure 9-51). The pathway was inferred using modeling results from the treatability test report and review of groundwater chemistry. The hydraulic gradient in the northeast corner was $4.7 \times 10^{-6}$ m/m, sloping to the southeast. The gradient in the south part of LLWMA-1 was $1.8 \times 10^{-6}$ m/m, sloping to the east (Table B-49). The average groundwater flow rate ranged from 0.15 to 0.40 m/day (0.50 to 1.3 ft/day or 56 to 145 m/yr (180 to 480 ft/yr).

In 2016, LLWMA-1 monitoring wells were sampled semiannually for indicator parameters as scheduled (Table B-50). Specific conductance, pH, TOC, and TOX did not exceed critical mean values and LLWMA-1 remains in indicator evaluation monitoring.

Table B-50 summarizes the groundwater quality parameters for LLWMA-1. Unfiltered iron exceeded the secondary DWS in wells 299-E32-4 and 299-E33-35. Unfiltered chromium was elevated in wells 299-E32-2, 299-E32-4, 299-E32-6, 299-E33-29, and 299-E33-35 (Table B-51). Unfiltered nickel was also elevated, likely from well screen, casing, or pump column tubing corrosion. A video survey will be completed at these wells in 2017, and maintenance will be provided as needed.

Table B-51 lists additional constituents required under the monitoring plan (DOE/RL-2009-75). Nitrate was greater than 45 mg/L in about half the wells due to a regional nitrate plume. Nitrate concentrations are declining and are expected eventually to decline below the DWS across the site.
9.10.6 Low-Level Waste Management Area-2

LLWMA-2 is located in the northeast corner of the 200 East Area (Figure 9-52) and consists of the 218-E-12B and 200-E-304 Burial Grounds, which contain 39 inactive and covered north-south-oriented trenches (in 216-E-12B) and one active uncovered trench (Trench 94 in 200-E-304). The 218-E-12B Burial Ground received solid, low-level, radiological, and transuranic waste from 1967 to 2004 and is not subject to the requirements of WAC 173-303. Trench 94 was initially included in the Hanford RCRA Part A Permit for the low-level burial ground due to the integrated lead shielding associated with the reactor compartment. In 2015, during an update of the RCRA monitoring plan it was recognized that the integrated lead shielding does not meet the definition of a solid waste because it is fulfilling its intended purpose. As a result, DOE wrote a letter to Ecology requesting removal of Trench 94 from the Hanford RCRA Permit Part A Form (16-AMRP-0032, “Request for Removal of 218-E-12B Trench 94 from the Hanford Facility Resource Conservation and Recovery Act/Dangerous Waste Permit Application Part A Form for the Low-Level Burial Grounds Operating Unit Group”). Until this action is completed, LLWMA-2 continues to follow the implementing requirements in WAC 173-303-400, as defined in DOE/RL-2009-76, Interim Status Groundwater Monitoring Plan for the LLBG WMA-2.

Table B-52 lists construction information and water levels for LLWMA-2 wells. The depth of the water column in monitoring wells ranges from 1.0 to 2.6 m (3.3 to 8.4 ft). The water table elevation at LLWMA-2 declined an average of 1.6 mm/month between May 2011 and October 2016 (Figure 9-53). These wells have adequate water in the screened interval for sampling during the next two decades.

The LLWMA-2 water table elevations have periodically increased in response to high Columbia River stages and significant discharges at TEDF (Figure 9-53). Groundwater gradient magnitudes and flow directions were determined using the 200 East Area low-gradient monitoring network (discussed in SGW-58828) for the north-central portion of the 200 East Area. A 12-month rolling average calculation from October 2015 through September 2016 was used to derive the water table gradients and flow directions at LLWMA-2. The 121.735 m water table isopleth extends to the northeast between low-gradient wells 299-E27-17 and 299-E34-12 before extending due east to well 299-E26-77 (Figure 9-52). Based on the 121.735 m water table isopleth orientation, the flow direction north of this isopleth is inferred to be southward, while in the southwest corner of LLWMA-2 the flow direction is southeast. Also inferring an equal spacing between the 121.734 and 121.735 m isopleths the gradient is 5.6 × 10^{-6} m/m (Table B-53). Estimates of groundwater flow rates range from 0.04 to 0.19 m/day (0.14 to 0.62 ft/day) or 15 to 69 m/yr (51 to 230 ft/yr).

All of the wells were sampled semiannually, as required, during the reporting period (Table B-54). There were no confirmed critical mean exceedances in 2016. Elevated TOC (9,860 µg/L) was reported at well 299-E27-10 in April and elevated pH (8.35) was reported in well 299-E27-11 in October but verification sampling results did not confirm the exceedances. The averaged laboratory TOC verification results at well 299-E27-10 were less than 720 µg/L from Test America and 780 µg/L from GEL. The averaged laboratory pH verification results at well 299-E27-11 were 8.0 from Test America and 8.22 from GEL. Therefore, it was determined that the two elevated results were associated with either a laboratory error or an issue during sampling. The site remains in interim status detection monitoring.

Figure 9-52. LLWMA-2
Table B-54 summarizes groundwater quality parameters required by 40 CFR 265.92(b)(2). Wells 299-E27-10 and 299-E27-17 had elevated unfiltered iron results exceeding the secondary DWS. Sulfate was elevated in wells 299-E27-9 and 299-E27-10. The elevated sulfate appears to be ongoing loading from the vadose zone associated with unplanned releases to the 216-B-2 Ditches in the early 1960s and 1970s. The conceptual model for migration from the 216-B-2 Ditches includes northeast migration through the vadose zone to groundwater and southward migration within the aquifer to wells 299-E27-9 and 299-E27-10. Sulfate could also be associated with gypsum mobilized by dust-suppression water used during excavation of sediments associated with Trench 94.

Table B-55 summarizes additional constituents required under the monitoring plan (DOE/RL-2009-76). One unfiltered chromium result exceeded the MTCA (WAC 173-340) Method B cleanup standard for Cr(VI) in well 299-E27-17. Nitrate was elevated in wells 299-E27-9, 299-E27-10, 299-E34-9, 299-E34-10, and 299-E34-12. The elevated nitrate in wells 299-E27-9 and 299-E27-10 appears to be ongoing loading from the vadose zone associated with unplanned releases to the 216-B-2 Ditches in the early 1960s and 1970s. The elevated nitrate in wells 299-E34-9, 299-E34-10, and 299-E34-12 appears to be associated with southeast migration from sources to the northwest, primarily the BY Cribs.

Overall, the geochemistry of the groundwater portrays a calcium-sulfate facies in the east and west with a calcium-sulfate-carbonate facies in between. Elevated nitrate and sulfate in wells along the west side of LLWMA-2 are associated with southeast contaminant plume migration from the BY Cribs. The elevated nitrate and sulfate in wells along the east side of LLWMA-2 appear to be associated with releases from the 216-B-2 Ditches. Iron concentrations above the secondary DWS were unfiltered results. Previous video surveys of these wells show moderate encrustation of apparent amorphous ferric hydroxide (orange in color). Other metals associated with stainless steel corrosion (chromium and nickel) are also found in this well at elevated levels. It appears likely that this well has some corrosion affecting the samples, and maintenance will be requested for it in 2017.
9.11 Atomic Energy Act Monitoring

AEA groundwater monitoring was conducted at 115 groundwater wells in the 200-BP groundwater interest area in accordance with the SAP issued in December 2015 (DOE/RL-2015-56). The primary AEA constituents for 200-BP are iodine-129, nitrate, technetium-99, uranium, and tritium. Eight wells were not sampled in accordance with SAP requirements in 2016 (Table C-8 in Appendix C). Minor exceptions to planned monitoring occurred because of maintenance issues and scheduling constraints. Appendix C lists the sampling frequencies, types of laboratory analyses, and sample status for 2016 AEA monitoring of the 200-BP groundwater wells.

Concentrations of radionuclides in groundwater samples from 150 wells 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 exceeded the 100 mrem/yr standard at seven groundwater wells in 200-BP (Table 9-4). The cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at 104 locations in this interest area. The DWSs for cumulative alpha emitters were not exceeded, but one location exceeded the EPA net alpha activity standard. The uranium mass DWS of 30 µg/L was exceeded at 22 locations. None 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 institutional controls that restrict access to groundwater and through remedial action measures to control the migration of contaminated groundwater to exposure points.

Table 9-4. Cumulative Total Effective Doses and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 200-BP in 2016

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