9.0 200-BP-5 Operable Unit

G.S. Thomas

The groundwater flow and contaminant distributions in the 200-BP-5 Operable Unit (OU) are discussed in this chapter, which includes portions of the 200 East Area and adjacent 600 Area (Figure 9-1). The reporting period covers the timeframe from January 1, 2010, through December 31, 2010, referred to as calendar year (CY) 2010.

Figures 9-2 and 9-3 identify the waste sites, waste management units, and wells in the 200 East Area and 600 Area, respectively, within the 200-BP-5 OU. These figures identify the well names in subsequent figures discussed in this chapter.

The groundwater in the 200-BP-5 OU is monitored to track local and regional contaminant plumes associated with past-practice sites in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Atomic Energy Act of 1954 (AEA). The main CERCLA sites monitored in the 200-BP-5 OU include the following:

- 216-A-25 Pond (Gable Mountain Pond)
- BY Cribs and other proximal waste sites (B Complex)
- 216-B-5 injection well
- B Plant waste sites (including the 216-B-9, 216-B-12, and 216-B-62 Cribs).

In addition, the 200-BP-5 OU monitoring network is supplemented by several wells associated with sites that are monitored in accordance with the Resource Conservation and Recovery Act of 1976 (RCRA). The RCRA sites in the 200-BP-5 OU include the following:

- Single-shell tank farms at Waste Management Area (WMA) B-BX-BY and WMA C
- Low-Level Waste Management Areas (LLWMAs) 1 and 2
- Liquid Effluent Retention Facility (LERF)
- 216-B-63 Trench
- 216-B-3 Pond (B Pond).

Note that the B Pond is partially in the 200-BP-5 OU and partially in the 200-PO-1 OU. Discussion on the B Pond site is provided with the 200-PO-1 OU in Chapter 10.0. Wells monitoring the B Pond within the 200-BP-5 OU are discussed for applicable contaminants of concern (COCs) in Section 9.1.

Ten COCs were initially defined in the Groundwater Sampling and Analysis Plan for the 200-BP-5 Operable Unit (DOE/RL-2001-49) and are the main constituents discussed in Section 9.1. One of the constituents, cobalt-60, has decreased below the drinking water standard (DWS) due to radiological decay and natural attenuation. Several RCRA wells that supplement the 200-BP-5 OU monitoring network near treatment, storage, and disposal (TSD) units are also used to interpret local changes in contaminant distribution. Section 9.3 discusses the WMA monitoring results associated with RCRA sites. The conclusions and recommendations associated
The groundwater contaminant plume contours in the 200-BP-5 OU did not show a significant difference when compared to last year.

Most of the groundwater contamination in the 200-BP-5 OU from past Hanford Site operations is present in the unconfined aquifer. The only exceptions are at well 299-E33-12 in the upper basalt-confined aquifer, the Rattlesnake Ridge interbed, near the BY Cribs; and in well 699-43-41G in a semiconfined aquifer beneath B Pond. The main source of contamination in well 299-E33-12 was associated with the lack of a proper annular seal that allowed contaminants from the BY Cribs to travel down the wellbore and into the confined aquifer. Placement of an annular seal in this well in 1979 has apparently remedied the intercommunication between the unconfined and the underlying confined aquifer at well 299-E33-12. Further discussion of contaminant extent at well 299-E33-12 is provided in Section 9.1.3.1. The semiconfined aquifer beneath B Pond is mainly discussed in Chapter 10.0; where appropriate, contaminants within the 200-BP-5 wells are discussed in Section 9.1.

Active groundwater remediation is currently not underway in the 200-BP-5 OU. However, the evaluation of a pump-and-treat technology for possible future remediation of the uranium and technetium-99 contaminant plumes at the B Complex was drafted in a treatability test plan in 2010 in accordance with Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) (Ecology et al., 1989)
Milestone M-015-082. The purpose of the test is to evaluate whether a pumping rate of 189 liters per minute can be sustained in the thin unconfined aquifer where uranium and technetium-99 plumes reside. The treatability test is planned at two locations during CY 2012 (providing the availability of sufficient funding): (1) a site along the west side of the BY Tank Farm, and (2) in well 299-E33-343 adjacent the northwest corner of the B Tank Farm. Other CERCLA activities completed in CY 2010 included installing the last three remedial investigation (RI) wells and depth-discrete sampling at fourteen existing 200-BP-5 OU wells. The RI wells were installed near the 216-B-12 Crib, 216-B-6 injection well, and the 216-C-1 Crib. The investigation was integrated with the corresponding waste site OUs to investigate both the vadose zone and groundwater. The depth-discrete sampling at the existing wells was completed mainly to investigate the vertical extent of existing contaminant plumes. Both investigations were performed in accordance with the Remedial Investigation/Feasibility Study Work Plan for the 200-BP-5 Groundwater Operable Unit (DOE/RL-2007-18). Upon completion of the work, an RI report was initiated. The CERCLA activities completed during this reporting period are discussed further in Section 9.2.

The geology of the 200-BP-5 OU consists of sediments of the Hanford formation and Ringold Formation overlying the Saddle Mountains Basalt. The uppermost basalt member of the Saddle Mountains Basalt in the 200-BP-5 OU is generally the Elephant Mountain Member. This member defines the base of the unconfined aquifer in the OU, with the exception of the Gable Mountain/Gable Butte Gap area (Gable Gap) and further north. In the Gable Gap area, portions of the Elephant Mountain, Pomona, Esquatzel, and Asotin members of the Saddle Mountains Basalt were removed by erosion, exposing and interconnecting the lower permeability Ringold, Rattlesnake Ridge interbed, and Selah interbed groundwater to the unconfined aquifer. An excellent cross section of this area is provided in Figures A-2 and A-4 of the Hydrogeologic Model for the Gable Gap Area, Hanford Site (PNNL-19702). Groundwater elevations in the interbeds south of the Gable Gap area (e.g., upgradient) are higher than the overlying unconfined aquifer water table, indicating an upward hydraulic gradient and flow regime. Therefore, groundwater contamination migrating from the 200 East Area as far as the Gable Gap area is constrained to the unconfined aquifer within the highly permeable Hanford formation. North of Gable Gap, a high-angle reverse fault shifted basalt upward across the Ringold Formation unit 8 (e.g., Ringold lower mud), which defines the base of the unconfined aquifer north of the fault.

The unconfined aquifer is mainly contained within moderate to low-permeability Ringold Formation sediments along the southwestern boundary of the OU. The Ringold sediments extend from the southerly portion of the LLWMA-1, east of B Plant near well 299-E28-6, and into the 200-PO-1 OU as defined in the Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington (PNNL-12261, plate maps 3, 4, and 5). Two 200-BP-5 OU RI wells were drilled through the Ringold Formation to basalt near B Plant in CY 2010. Based on these wells, the aquifer thickness in this area is ~18.3 meters and it lies entirely within the Ringold Formation.

North and east of this area, cataclysmic flooding eroded some to all of the Ringold Formation sediments and deposited sediments of the Hanford formation. Due to past folding of the underlying basalts, the aquifer thins to the north-northeast. Along the northern boundary of the 200 East Area, the aquifer becomes very thin or is absent. East of the 200 East Area, the Ringold sediments are again present throughout the
Most of the sediments east of the 200 East Area are comprised of the Ringold lower mud unit (PNNL-12261, unit 8). This unit creates a semiconfined aquifer where it overlies the silty, sandy, gravelly Ringold sediments (unit 9) and the Elephant Mountain Basalt. The Ringold lower mud unit is mainly the only saturated unit that extends north to Gable Mountain and groundwater contaminants are generally west of this unit. An exception is beneath both the Gable Mountain Pond and B Pond were a few contaminants still reside.

The saturated glaciofluvial Hanford formation and/or Cold Creek units are deposited in an eroded channel between the Ringold Formation sediments discussed above (i.e., to the east and west). Some remnant Ringold Formation sediments are present within paleochannels north of the 200 East Area, as discussed in PNNL-19702. The saturated Hanford sediments are thickest within the southerly portion of the 200-BP-5 OU and thin as the sediments extend to the northwest toward Gable Gap. Previous folding of the underlying basalts causes the aquifer to thin to apparently a couple meters or less between the 200 East Area and Gable Gap. The saturated Hanford sediments extending northwest of the 200 East Area is thought to be the primary groundwater flow path from the northwest portion of the 200 East Area to Gable Gap. It is worth noting that the more permeable Hanford sediments are juxtaposed with the remnant Ringold Formation paleochannel sediments. It appears that groundwater contaminants migrate primarily within the more permeable Hanford sediments as opposed to the Ringold sediments. The thinnest part of the saturated Hanford sediments is thought to be northwest of well 699-49-57A (Figure 9-3). A cross section of this area is provided in Figure A.5 of PNNL-19702; the primary flow path is shown between wells 699-50-59 and 699-50-56 in Figure A.5. Geophysical methods have been used in this area, but the aquifer thickness remains uncertain.

In general, groundwater moves into the 200-BP-5 OU from the southwest (Figure 9-4). As it approaches the more permeable Hanford sediments, some of the flow is diverted to the north-northwest toward Gable Gap. The flow to the north is limited by multiple contributing factors including permeability, the width and thickness of the Hanford sediments, heterogeneity of the saturated sediments, groundwater gradient, high Columbia River spring runoff elevations, and discharges to the TEDF.

Discharges at TEDF have been shown to cause groundwater elevations to increase in the 200 East Area (Figure 9-5). Discharges at TEDF have been shown to cause groundwater elevations to increase within the 200 East Area (Figure 9-5). The groundwater elevation increases appear to coincide with the statistically significant gradient measurements at LLWMA-1 to the north over the past 2 years. The statistically significant northward groundwater gradient measurements at LLWMA-1 occurred in July 2009 and June 2010. As seen in Figure 9-5 the flow reversal to the south at LLWMA-1 due to the high Columbia River spring runoff in 2008 occurred when TEDF discharges were absent. The data suggest a delicate balance between TEDF discharges and the Columbia River surface elevation. In fact, the flow return to the north at LLWMA-1 was not statistically determined until after the large-volume discharges at TEDF in spring 2009. Figure 9-5 shows how the groundwater elevation in the 200 East Area rose in response to these discharges. By July 2009, the groundwater measurements at LLWMA-1 showed a statistically north groundwater flow direction (Figure 9-6). During CY 2010, the TEDF discharges were significant in both the spring and fall, apparently causing increased northward groundwater flow at LLWMA-1 and WMA B-BX-BY. The assumed flow divide during most of CY 2010 was thought to be south of B Plant but may have fluctuated based on the schedule and volume of water discharged at the TEDF.
The remaining groundwater flow into the 200-BP-5 OU from the southwest moves generally northeast-east before diverting to the southeast, possibly west of WMA C. This appears to be consistent with the flow direction noted south of the Plutonium-Uranium Extraction Facility, near the Integrated Disposal Facility.

The groundwater gradient within the north central and northeast portion of the 200 East Area is too flat to be measured at this time. This is the location where the aquifer is cut off to the north by basalt rising above the water table. Consequently, the average groundwater flow appears to be very slow (less than 0.1 meter/day) in this area, as discussed in later sections (e.g., Sections 9.1.1.6, 9.3.2, and 9.3.5).

9.1 Groundwater Contaminants

This section summarizes the distribution of groundwater contamination in the 200-BP-5 OU, as required by the sampling and analysis plan (DOE/RL-2001-49). The COCs defined in DOE/RL-2001-49 include nitrate, iodine-129, technetium-99, uranium, strontium-90, cyanide, cobalt-60, cesium-137, plutonium-239/240, and tritium (the following subsections discuss the contaminants in this order). Each subsection includes discussion of the following: (1) areal extent of contamination exceeding the DWSs, (2) probable source, (3) groundwater flow direction at that site, (4) relevant geologic information, and (5) any RI activities conducted during fiscal year (FY) 2010 to address the contaminant at that location. Cobalt-60 and mercury have been included in previous reports, but their concentrations did not exceed the DWSs this year; therefore, these constituents are not discussed. Note, however, that cobalt-60 and mercury are still monitored in accordance with the previously mentioned sampling plan. Sulfate, although not identified in DOE/RL-2001-49 as a COC, is discussed because it exceeded the secondary DWS in several wells.

Contaminant distribution maps presented in this section show annual averages. Some wells provide four quarters of data, some wells provide two quarters of data, other wells provide one value per year, and some wells provide one value every 3 years. The 200-BP-5 OU well network is divided into the 200 East Area wells (Figure 9-2) and the 600 Area wells (Figure 9-3). Additional wells sampled in CY 2010 included the sixteen 200-BP-5 OU RI wells associated with the RI/feasibility study (FS) (DOE/RL-2007-18), wells associated with RCRA TSD sites, and wells associated with the 100-F/IU-2/IU-6 RI.

Elevated concentrations of constituents of interest in the 200-BP-5 OU occur in the following regions and are discussed in the following subsections:

- B Complex (e.g., WMA B-BX-BY and surrounding waste sites)
- 216-B-62 Crib and north along the west side of LLWMA-1
- Grouped wells 699-53-55A, B, and C (located near Gable Mountain Gap and Gable Mountain Pond)
- Gable Gap, Gable Mountain Pond, and B Pond
- B Plant
- 216-B-5 injection well
- WMA C
- LLWMA-2.

<table>
<thead>
<tr>
<th>Plume areas (square kilometers) in the 200-BP-5 Operable Unit:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyanide, 200 µg/L — 0.345</td>
</tr>
<tr>
<td>Iodine-129*, 1 pCi/L — 6.2</td>
</tr>
<tr>
<td>Nitrate*, 45 mg/L — 6.14</td>
</tr>
<tr>
<td>Strontium-90, 8 pCi/L — 0.37</td>
</tr>
<tr>
<td>Technetium-99*, 900 pCi/L — 2.4</td>
</tr>
<tr>
<td>Tritium, 20,000 pCi/L — 0.495</td>
</tr>
<tr>
<td>Uranium, 30 µg/L — 0.347</td>
</tr>
<tr>
<td>* Includes plume area that overlaps into the ZP-1 and PO-1 Operable Units.</td>
</tr>
</tbody>
</table>
Discussions on flow rates are limited to areas where multiple observations (e.g., gradient, trend plots, and ion chemistry) correlate to each other. This approach with multiple lines of evidence is necessary to ensure consistency due to low groundwater gradient (~1.5 x 10^{-5} based on regional water-level measurements).

### 9.1.1 Nitrate

Nitrate analyses were performed on groundwater samples at least once from 141 wells across the 200-BP-5 OU. Sampling at three wells (299-E28-5, 299-E28-6, and 299-E28-18) was missed due to a work stoppage in the fourth quarter of CY 2010.

Figure 9-7 shows the average annual distribution of nitrate above the DWS (45 mg/L). Eight areas had nitrate concentrations above the DWS in CY 2010, as discussed below.

#### 9.1.1.1 Wells at the B Complex and Extending Northwest Beyond Well 699-49-57A

The highest nitrate concentrations in the 200-BP-5 OU continued to be reported from wells associated with the BY Cribs. Three wells monitoring the groundwater beneath the BY Cribs had a maximum concentration of 1,540 mg/L (299-E33-3, 299-E33-7, and 299-E33-341), reported in May, February, and August, respectively. The concentrations are lower than last year and may be associated with an increased groundwater flow rate due to the increased TEDF discharges during CY 2010 versus CY 2009. This assumes that the contaminant infiltration rate from the vadose zone into the unconfined aquifer is constant, which is unknown; however, an increased flow rate is consistent with contaminant trend comparisons between wells near the BY Cribs and wells within the plume to the northwest. Figure 9-7 shows the majority of the nitrate plume from this area extending to the northwest. Based on the Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B Complex (PNNL-19277), the plume to the northwest appears to be associated with the following waste sites/facilities in this area: BY Cribs, 241-BX-102 unplanned release, 216-B-57 Crib, 216-B-8 Crib, 216-B-7A&B Crib, and possibly the 216-B-11A&B french drain.

The average groundwater flow rate extending from the BY Cribs to the northeast corner of LLWMA-1 was determined at ~0.78 meter/day based on the average of ten groundwater-level measurements between wells 299-E33-38 and 299-E33-34 during CY 2010 and early 2011. The two wells used to determine the flow rate are consistent with various three-point calculations in the area, plume migration, ion chemistry comparisons, and trend plot comparisons. The groundwater elevation data and calculation for these two wells are provided in Table 9-1. The average horizontal groundwater gradient between these wells was 2.08 x 10^{-5}. The ion chemistry and contaminant trend plot comparisons are discussed further in Section 9.1.3.1.

Nitrate concentrations decreased significantly in wells just south of the BY Cribs (299-E33-9, 299-E33-13, and 299-E33-31) during CY 2010. For example, concentrations at well 299-E33-31 decreased from ~900 mg/L in February to 584 mg/L by the end of December. The decrease in well 299-E33-13 was not as significant as the decrease in well 299-E33-31, but by early January 2011, nitrate concentrations had decreased by more than 150 mg/L.

Farther south, along the north side of the B Tank Farm, nitrate concentrations did not change much. It is assumed that the flow in this area is slower because the aquifer is thicker. PNNL-19277 indicates that nitrate from the 241-BX-102 unplanned release and the 216-B-7A&B Crib releases have impacted, and most likely continue
to impact, groundwater in this area. Consequently, the infiltration rate from a perched contaminated water horizon ~3.05 meters above the aquifer must nearly match the flow rate for concentrations to remain nearly constant. This conceptualization is based on the consistent nitrate concentrations in wells 299-E33-343 and 299-E33-345 and the much lower nitrate groundwater concentrations to the south.

Along the southern side of WMA B-BX-BY, nitrate concentrations increased in most wells until August, and then showed large decreases in December. The reason is unclear for the significant increase in nitrate concentrations in 2010 in certain wells such as well 299-E33-339 (along the south boundary of the BX Tank Farm) when the flow is presumed to be north. Nitrate concentrations further south in well 299-E28-8 were much lower (34 to 39.9 mg/L) than concentrations in well 299-E33-339 (145 to 201 mg/L) and decreased during the year. In addition, concentrations to the east and west were also much lower than concentrations at well 299-E33-339. In last year’s annual report (DOE/RL-2010-11, Hanford Site Groundwater Monitoring and Performance Report for 2009: Volumes 1 & 2), the elevated nitrate in this well was attributed to a south groundwater flow direction and the specific gravity of infiltrating residual liquid waste from the vadose zone to the north. The south groundwater flow explanation from last year was carried over from a groundwater flow reversal that was initiated in 2008. The groundwater flow reverted back to north in mid-2009 based on statistical groundwater level measurements at LLWMA-1. Continued northerly groundwater flow from mid-2009 through the end of 2010 is consistent with statistical evaluations of the flow regime in this area (Figure 9-6). Therefore, the north groundwater flow regime in 2010 does not correlate with the increasing nitrate through August 2010 near well 299-E33-339. It is possible an unknown source of infiltrating nitrate may be the cause of the increase. Another possible explanation (also discussed in DOE/RL-2010-11) is associated with residual vadose zone contamination with a high specific gravity entering the groundwater. The groundwater results from an investigation completed in CY 2010 associated with this theory are provided in the following discussion.

A density driven conceptual model was previously considered for contaminants associated with the BY Cribs that may preferentially sink and move along the bottom of the aquifer. This conceptual model is further explained in Potential for Groundwater Contamination from High Density Wastes Disposed at the BY Cribs, 200-BP-1 CERCLA Operable Unit (WHC-SD-EN-TA-003). One reason for evaluating this theory was not only the specific gravity of the waste associated with the BY Cribs, but also the specific gravity (1.25 grams per cubic centimeter [g/cc]) of the metal waste released by the 241-BX-102 tank overfill event in 1951 (HW-23043, Flow Sheets and Flow Diagrams of Precipitation Separations Process). Based on discussion in WHC-SD-EN-TA-003, the density of the waste released to the BY Cribs was possibly 1.21 g/cc, indicating similar density as that associated with the metal waste. Another reason for investigating this theory was the nitrate, cyanide, technetium-99, and other contaminants characteristic of the BY Cribs found in the confined aquifer at well 299-E33-12 in the 1950s. These contaminants migrated into the confined aquifer due to poor well construction. Note that a higher hydraulic head has continually been present in the confined aquifer versus the unconfined aquifer, indicating an upward flow regime between the confined and unconfined aquifers (see Section 9.1.3.1). The contaminants that entered the confined aquifer have persisted to the present day, approximately six decades later. During the late 1950s after well 299-E33-12 was drilled, the nitrate concentrations exceeded 4,000 parts per million (ppm). The highest nitrate concentrations currently observed
In well 299-E33-49, down the basalt dip from the 241-BX-102 unplanned release and BY Cribs, a nitrate concentration an order of magnitude higher was reported from a sample collected at the bottom of the aquifer versus a sample collected ~2 meters above the bottom of the aquifer (e.g., 371 mg/L versus 54 mg/L, respectively).

The 2010 nitrate concentration reported at well 699-49-57A, located north of 200 East Area, was 269 mg/L, which is 46 mg/L higher than in April 2009 (223 mg/L). This was the first significant nitrate increase since 2006 in this well.

in the confined aquifer remain at well 299-E33-12 and are just under the DWS, at ~42 ppm. The highest nitrate concentrations currently in the unconfined aquifer are beneath the BY Cribs at just above 1,000 ppm. However, well 299-E33-4 (also beneath the BY Cribs) had nitrate concentrations as high as 17,800 ppm in 2008; this well has not been sampled since because the aquifer is too thin for sampling at this location. According to “Numerical Simulation of the Effects of Variable Density in a Contaminant Plume” (Koch and Zhang, 2005), concentrations of ~4,000 ppm were shown to have a density effect on plume migration in a porous media. Based on these factors, the nitrate in well 299-E33-339 may be associated with residual liquid waste from the BY Cribs or the 241-BX-102 unplanned release, or both. Depth-discrete groundwater samples were collected in January and February at wells 299-E33-339 and 299-E33-49 to further investigate this conceptual model.

Depth-discrete groundwater samples collected in January and February found no significant variation in nitrate concentration with depth in well 299-E33-339. However, further to the west in well 299-E33-49, also down the basalt dip from the 241-BX-102 unplanned release and BY Cribs, a nitrate concentration an order of magnitude higher was reported from a sample collected at the bottom of the aquifer versus a sample collected ~2 meters above the bottom of the aquifer (e.g., 371 mg/L versus 54 mg/L, respectively). Even lower nitrate concentrations were reported at shallower depths in the aquifer at this well. Although the concentration of nitrate at the bottom of the aquifer collected from this well does not appear sufficient for a density plume, the stratification of the contamination is interesting. It could be speculated that the depth-discrete results at well 299-E33-49 may represent the disperse fringe of such a plume rather than the center of a possible density plume.

The ratio for technetium-99 to nitrate was also compared to groundwater results at wells near both the BY Cribs and the infiltration point of the 241-BX-102 unplanned release. The ratio of technetium-99 to nitrate at well 299-E33-49 was 33.2, which is between the ratios of the two sources (e.g., BY Cribs at ~18 and 299-E33-343 at ~55 in CY 2010). Thus, the elevated contamination at wells 299-E33-339 and 299-E33-49 may have been associated with various sources. Figure 9-8 provides one conceptual model of a possible density plume extending from the BY Cribs. The location of the cross section provided in Figure 9-8 is shown on Figure 9-2. In conclusion, the elevated nitrate concentrations at wells 299-E33-339 and 299-E33-49 may be associated with some unknown release near these wells (as stated above) or possibly associated with a density plume, or a combination of sources. Although the depth-discrete data do not provide sufficient information to conclude a source for the elevated nitrate concentrations observed at wells 299-E33-339 and 299-E33-49, no known sources of technetium-99 activities to the south of these wells exist to source the activities found in these wells. Thus, it is possible that a portion of some density plume from the north migrated south of these wells in the past and is now moving back to the north in accordance with the northerly flow regime.

As discussed in previous annual reports, the nitrate plume from WMA B-BX-BY and surrounding waste sites extends to the northwest beyond the 200 East Area. The primary stratigraphic unit north of the B and BX Tank Farms and to the northwest toward well 699-49-57A is interpreted as the Cold Creek unit/Hanford formation. A recent interpretation of sediments from the two new RI wells 699-48-50B and 699-50-56, north of the 200 East Area, were used to define a low-permeability paleochannel of Ringold sediments in this area (Figure 6.3 in PNNL-19702). This paleochannel apparently runs in a northwest direction just north of the Cold Creek/Hanford formation, north of the 200 East Area. The lower permeability of
the Ringold sediments versus the Cold Creek/Hanford sediments creates an apparent preferential flow path toward well 699-49-57A and to the northwest. The nitrate concentration reported at well 699-49-57A was 269 mg/L, which is 46 mg/L higher than in April 2009 (223 mg/L). This was the first significant nitrate increase since 2006 in well 699-49-57A. The estimated northerly extent of the 45 mg/L (DWS) contour is between wells 699-49-57A and 699-55-60A (Figure 9-7).

The future flow path between wells 699-49-57A and 699-55-60A is in question due to the continuing water table decline and the apparent limit of aquifer thickness. Historical groundwater elevation plots between wells north and south of this basalt high indicate that groundwater flow through this paleochannel may be “cut off” at a certain elevation as the water table declines (Figures 9-9 and 9-10). Figure 9-9 shows the conceptual model of the aquifer thickness extending between wells 699-49-57A and 699-55-60A. The location of the cross section in Figure 9-9 is shown in Figure 9-3. Figure 9-10 shows the water-level trends at wells 299-E33-18 and 699-60-60. Well 299-E33-18 is located just north of the B Tank Farm, and the water level began to increase significantly in the latter part of 1955, when the water level at well 699-60-60 reached ~121.6 meters. Well 699-60-60 is located north of well 699-55-60A and the basalt high (Figure 9-9). As of September 2010, the groundwater elevation in well 699-60-60 was 121.76 meters. Based on data discussed in this subsection, the groundwater near WMA B-BX-BY appears to continue moving to the northwest.

9.1.1.2 216-B-62 Crib and North to Low-Level Waste Management Area 1

For the past 10 plus years, nitrate has been detected at levels exceeding the 45 mg/L DWS in well 299-E28-18, which monitors the 216-B-62 Crib (Figure 9-7). Nitrate concentrations were over 200 mg/L in the mid-1970s to early 1980s and have recently been approaching these levels again. Samples for this well were not collected during 2010 due to the work stoppage; however, increases were expected based on increases in wells 299-E28-26 to the north and the increasing nitrate trend in well 299-E28-18 (Figure 9-11).

The source of nitrate for wells 299-E28-18 and 299-E28-21 was initially thought to be the 216-B-62 Crib; however, the only waste site with significant nitrate inventory in this area is the 216-B-12 Crib (Appendix C of RPP-26744, Hanford Site Soil Inventory Model, Rev. 1). Supporting evidence for identifying the 216-B-12 Crib as the source is the elevated nitrate detected in CY 2010 in the aquifer to the southeast of this crib. Depth-discrete analytical results for nitrate at 7.6 meters below the water table during drilling of new 200-BP-5 RI well 299-E28-30 were 828 mg/L (Figure 9-12).

Figure 9-12 provides a conceptualization of the nitrate plume at depth extending toward well 299-E28-26. The location of the cross section in Figure 9-12 is shown in Figure 9-2. The rational for this model is based on the following: (1) the apparent widespread nature of elevated nitrate beneath the 216-B-12 Crib based on results from wells 299-E28-18, 299-E28-30, and 299-E29-54; (2) the dominant north-northwest flow over the past couple decades since termination of discharges to Gable Mountain Pond; (3) the northerly gradient determination in this area (discussed in Chapter 3.0, Section 3.2); and (4) the nitrate trend concentration increases at well 299-E28-26 to the northwest along the south side of LLWMA-1 (Figure 9-11). Another supporting factor is the increased tritium activity in well 299-E28-26, which is a co-contaminant associated with nitrate from the 216-B-12 Crib. The model is discussed in more detail below.
The conceptual model is based on several factors, beginning with the sharp increase in nitrate in the early 1970s shortly after discharges resumed to the 216-B-12 Crib. The nitrate trend plots for wells 299-E28-9 and 299-E28-16, both located near the 216-B-12 Crib, show the change in concentrations between 1960 and present (Figure 9-13). The nitrate trend plots for these wells and the information provided previously in this subsection indicate nitrate infiltration into the groundwater from the 216-B-12 Crib occurred as early as the 1970s. Continued infiltration from the vadose zone through the late 1970s, and possibly into the 1980s, is thought to have driven contamination into the deeper aquifer sediments based on the depth-discrete groundwater samples collected at new 200-BP-5 RI wells 299-E28-30 and 299-E29-54. Although the extent of infiltration into the aquifer during the 1970s and 1980s is unknown, similar depth-discrete profiles at wells 299-E28-30 and 299-E29-54 indicate that contamination migrated to the east in the past. The vertical concentration profile for new well 299-E28-30 is provided in Figure 9-12. Wells to the south (299-E28-6, 299-E28-13, and 299-E28-17) do not provide nitrate results near the concentrations seen in well 299-E28-18 or in the depth-discrete sample results from wells 299-E28-30 and 299-E29-54. Wells 299-E28-30 and 299-E29-54 share the same contaminants (nitrate, tritium, and uranium) with elevated concentrations of these contaminants at the same depths.

The model continues with the termination of discharges to the Gable Mountain Pond, which caused residual contaminants to migrate to the northwest. Vertical heterogeneity in the aquifer sediments allowed preferential migration from the more permeable sediment horizons. This is likely best displayed in the variability associated with the depth-discrete results at wells 299-E28-30 and 299-E29-54. Only well 299-E28-30 is shown in Figure 9-12, but the vertical distribution in 299-E29-54 is similar. Continuing with the model description, the continued flow to the north over the past couple decades has created contaminant spreading to the north. It is assumed that elevated contaminant concentrations in the tighter sediment horizons have leached into the Hanford sediments to the north (Figure 9-12).

The primary stratigraphic units represented in Figure 9-12 are discussed in this paragraph. The Ringold Formation unit 9A appears just above the aquifer near well 299-E28-30 and extends throughout most of the saturated thickness overlying a thin layer of Ringold unit 9B (mud) and an approximate 6.1 meters of Ringold unit 9C (PNNL-12261, plate maps 3, 4, and 5). North of well 299-E28-30, the Ringold unit 9A is truncated by glaciofluvial Hanford sediments that overlie the Ringold unit 9C. The change in hydraulic conductivity of these two formations ranges from an order of magnitude to several orders of magnitude (PNNL-12261). It is believed that nitrate is migrating from the Ringold unit toward the Hanford sediments and is the reason for continued elevated concentrations to the north beneath the 216-B-62 Crib and along the southeast side of LLWMA-1.

A 450 mg/L contour map is provided around well 299-E28-30 in Figure 9-14 because the annual average plume map (Figure 9-7) does not show this plume configuration. The reason the plume is not shown in Figure 9-7 is because the annual average plume maps are designed to show elevated plumes within the upper portion of the aquifer. The 450 mg/L contour map is based on vertical sampling data collected at ~7.6 meters into the aquifer in CY 2010 at wells 299-E28-30 and 299-E29-54. The vertical sampling data for these two wells are also not posted on the annual average maps because vertical sampling data during drilling are not always comparable to routine samples from completed and developed wells. However, comparative duplicate sample results for wells 299-E28-30 and 299-E29-54 at
~7.6 meters in the aquifer indicate that the elevated nitrate results reported above are good. Therefore, a 450 mg/L contour map was added so this area would be noted as having elevated nitrate contamination (greater than ten times the DWS). Data from two adjacent wells (e.g., 299-E28-13 and 299-E28-18) were also used to construct the contour because these wells are screened 6+ meters into the aquifer.

Over the past couple of decades, the prevailing groundwater flow direction near LLWMA-1 has been to the northwest (see Chapter 3.0, Section 3.2). Nitrate concentrations in wells along the western boundary of LLWMA-1 ranged from 46.9 to 82.3 mg/L during 2010, with the highest concentrations in well 299-E32-7. High concentrations were also found in well 299-E28-27 (the southeast corner of LLWMA-1) where concentrations ranged between 95.2 and 100 mg/L in CY 2010.

9.1.1.3 Grouped Wells 699-53-55A, B, and C Near Gable Mountain/Gable Butte Gap

The cluster of wells 699-53-55A, B, and C are located in an area where a basalt window exists, west of Gable Mountain Pond (Figure 9-7). The term “basalt window” was applied because of the irregular erosion of the Elephant Mountain Member of the Saddle Mountains Basalt exposing and interconnecting the underlying Rattlesnake Ridge interbed. The three wells are screened across the bottom, middle, and top of the unconfined aquifer in this area, respectively (Figure 9-15). The location of the cross section in Figure 9-15 is shown in Figure 9-3. The aquifer is ~42.7 meters thick, comprised of ~21.3 meters of Hanford sediments, overlying ~21.4 meters of Rattlesnake Ridge interbed. Well 699-53-55A is screened below the base of the aquifer, which is more than 42.7 meters beneath the water table within the Pomona basalt but appears to be hydraulically connected to the bottom of the Rattlesnake Ridge interbed through a sand and gravel pack around the screen that appears to extend above the top of the Pomona basalt. Well 699-53-55B is screened ~15.3 to 21.3 meters below the water table, and well 699-53-55C is screened across the upper portion of the aquifer.

The difference in hydraulic conductivity between these two units is significant, with the Hanford formation ranging between ~500 to 2,700 meters per day versus the Rattlesnake Ridge interbed ranging from 0.01 to 10 meters per day. The range of the hydraulic conductivities for the Hanford formation in this area is based on a 4-day aquifer constant discharge test at well 699-55-50 and an 8-day aquifer constant discharge test at well 699-62-43 documented in Hydraulic Characteristics of Hanford Aquifers (HW-48916). The range of the hydraulic conductivity for the Rattlesnake Ridge interbed was derived from various test described in An Assessment of Aquifer Intercommunication in the B Pond-Gable Mountain Pond Area of the Hanford Site (RHO-RE-ST-12P).

Nitrate concentrations were slightly higher in wells 699-53-55B&C than last year (141 and 143 mg/L versus 142 and 151 mg/L for 2009 and 2010, respectively). The 2010 nitrate concentration in well 699-53-55C is the highest concentration historically reported in this well. The nitrate concentrations exceeding the DWS are limited to the Hanford formation sediments, as displayed in the cross section in Figure 9-15.

The source of the nitrate plume at wells 699-53-55B&C is considered to have originated at the BY Cribs. During the early 1990s, the BY Cribs nitrate plume was shown centered around well 699-50-53A, ~1,000 meters south of well 699-53-55 (DOE/RL-95-59, 200-BP-5 Operable Unit Treatability Test Report). Groundwater sample results at well 699-53-50A in the early 1990s reported nitrate concentrations exceeding
A recent geologic study of the area revised the basalt surface interpretation east of well 699-50-53A (PNNL-19702). The new interpretation used previous conceptual interpretations of folding and erosion and later deposition associated with formation of a paleochannel during the early to late Pleistocene to extend a channel between wells 699-50-53A and 699-53-55C (Figure 6.3 in PNNL-19702). As a result, the depositional sediments associated with the paleochannel provide a reasonable pathway for migration of the nitrate plume from well 699-50-53A to wells 699-53-55B&C. A distinctive characteristic linking the contamination in wells 699-50-53A and 699-53-55C (other than technetium-99, nitrate, and cyanide) is the lack of iodine-129. The contaminant plume near well 699-49-57A contains iodine-129; the lack of iodine-129 at wells 699-50-53A and 699-53-55C provides the rationale for separating the two plumes. Data from the 1950s indicate that the nitrate plume from the BY Cribs migrated to well 699-50-53A during this time. Continued migration northward was apparently hydraulically blocked by Gable Mountain Pond discharges until 1987, when discharges to the pond were terminated. After Gable Mountain Pond discharges terminated, the preferential pathway from the 200 East Area to Gable Gap was to the northwest through well 699-49-57A. Thus, when iodine-129 began migrating to the north shortly after discharges to Gable Mountain Pond were terminated from sites in the northern portion of the 200-PO-1 OU, it appears the iodine-129 stayed in the pathway toward well 699-49-57A; mixing between this plume and the plume at 699-50-53A has not been seen. Further discussion on the iodine-129 plumes is provided in Section 9.1.2.

The water-level elevations are currently consistently higher in well 699-53-55A than well 699-53-55B (indicating upward groundwater movement), while nitrate concentrations continue to increase in well 699-53-55A. Nitrate concentrations in upgradient wells within the Rattlesnake Ridge interbed have been and are significantly lower than the concentration in this well for CY 2010. Well 699-53-55A has an outer casing wall that is perforated from 49.7 to 94.5 meters below ground surface (bgs) where it terminates near the Pomona basalt. A 3.05-meter-thick cement cap is located at 81.4 meters bgs. The cement cap is located between the outer 8-inch casing and an inner 2-inch casing. A sand pack is located beneath the cement cap, extending 2.4 meters into the top of the Pomona basalt. A gravel pack is below the sand pack, which extends to the screen associated with the 2-inch casing, assumed to be 100.6 to 102.1 meters bgs. It is uncertain why nitrate is increasing in this well when upgradient wells have had (and continue to have) much lower concentrations, and the most prominent source of elevated nitrate would have to migrate downward through the low-permeability Rattlesnake Ridge interbed sediments against an upwelling flow regime. An alternative migration pathway to the pump may be through perforations in the outer 8-inch casing of well 699-53-55A, which extend from the upper portion of the aquifer. After entering through these perforations, elevated nitrate concentrations may slowly migrate toward the pump during purging, either through a fractured cement plug or compromised 2-inch inner casing joints; regardless, it appears that the elevated concentrations in well 699-53-55A are from faulty well control rather than from the bottom of the aquifer within the Rattlesnake Ridge interbed sediments. Decommissioning of this well is recommended.

The plume configuration within the Hanford sediments is currently defined to extend toward the northwest based on nitrate concentrations in wells 699-55-57, 699-57-59, and 699-59-58 (Figure 9-7). Use of well elevations to triangulate a groundwater gradient in this area appears to be affected by possible errors associated with well elevation surveys, measurement error, and in some cases possibly well
deviation from vertical as wells have not been gyroscopically surveyed. Triangulation results generally derive a west flow direction from well 699-53-55C rather than a northwest flow direction as defined by the nitrate concentrations in the wells discussed above. Determining a flow rate with suspect well elevations is not recommended and, therefore, is not provided in this area.

9.1.1.4 Gable Mountain Pond Area

The highest average nitrate concentration reported near Gable Mountain Pond was from well 699-53-48A at 141 mg/L. This well is located beneath the southeastern portion of the inactive pond that has been dry since the late 1980s (Figure 9-7). The nitrate concentration in this well decreased ~32 mg/L since last year. During the past 2 years, concentrations did not change much in this well; however, the concentration decreased significantly during the prior 10 years. The stabilization of the nitrate concentrations over the past couple of years may have been associated with the high spring Columbia River elevations over the past couple years starting in 2008 and extending to 2009. Sampling of this well has been completed in June since 2005. In addition, this well screen only extends ~ 0.3 to 0.6 meters into the aquifer characterized as broken basalt.

Further to the northwest in well 699-54-49, nitrate concentrations are lower and have remained about the same over the previous 5 years. For this reporting period, the nitrate concentration in well 699-54-49 was 46.9 mg/L, which is the same concentration observed last year. Still further to the northwest in well 699-55-50C (located near the northwest end of Gable Mountain Pond), the nitrate concentration was 6.82 mg/L for the reporting period. This concentration is consistent, but slightly lower, compared to the concentrations reported over the previous 6 years. Based on these results, no change was observed in the plume configuration in this area. It should be noted that well 699-54-45A (located east of Gable Mountain Pond and screened in the Ringold Formation mud unit) continues to be reported at near detectable concentrations for nitrate (0.81 mg/L) and constrains the eastern boundary of the plume.

As depicted in Figure 9-7, the basalt rises above the water table along the south side of Gable Mountain Pond, confining the plume in this direction. The aquifer to the east is contained within the Ringold Formation mud unit and portrays a groundwater flow direction to the west. Beneath the east side of Gable Mountain Pond, the Ringold Formation mud unit is truncated by the highly permeable Hanford formation. Groundwater elevation measurements in July 2010 between wells 699-55-50C and 699-57-59 provided a gradient of 1.1 x 10^{-5} to the west. Based on the range of hydraulic conductivity (Section 9.1.1.3), the flow rate in this area may range between 10 to 53 meters per year. These wells have not been surveyed with the accuracy as described in Chapter 3.0, Section 3.2; therefore, the flow rate is an approximation.

9.1.1.5 B Plant Area

As discussed in Section 9.1.1.2, elevated nitrate was detected in three wells near B Plant: 299-E28-6, 299-E28-17, and 299-E29-54. The contaminants in these wells are considered to have originated at the 216-B-12 Crib because of the lack of nitrate inventory from other waste sites. Eight other waste sites in the area have a combined total of 2,229 kilograms of nitrate (Appendix C in RPP-26744). The only other waste site in the area with significant inventory is the 216-B-6 injection well with an inventory of 58,373 kilograms of nitrate, which is small compared to the 2,860,615 kilograms of nitrate received at the 216-B-12 Crib.
9.1.1.6 216-B-5 Injection Well and 216-B-9 Crib

Only well 299-E28-25 was sampled near the 216-B-5 injection well for nitrate during the reporting period. The other three results are associated with sampled collected during CY 2008 and CY 2009. The 59.8 mg/L concentration in well 299-E28-25 is consistent with results from the previous 3 years and much less than the FY 2006 result of 166 mg/L, which was flagged as suspect. Nitrate concentrations at well 299-E28-25 have shown an increasing trend since 1995, when groundwater flow in the area appeared to be faster. Further north, well 299-E28-2 reported results similar to those of previous years, with an increasing trend similar to well 299-E28-25. Because of the lack of results to the northwest and southeast of well 299-E28-25, it is difficult to determine the exact extent of nitrate near the 216-B-5 injection well and whether the elevated concentration in well 299-E28-25 is associated with migration from a distal source, proximal source, or a combination of both. Due to the consistent concentrations in this well, the nitrate plume configuration was not changed in this area from last year. Additional wells have been added to the sampling schedule for 2011 to better define the extent of the plume around this waste site.

The highest quarterly nitrate concentration at WMA C for CY 2010 was reported from well 299-E27-14 at 101 mg/L.

9.1.1.7 Waste Management Area C Area

Groundwater analyses from four wells at WMA C had nitrate concentrations exceeding the DWS in CY 2010. Two of the wells, 299-E27-14 and 299-E27-24, are located on the southeast side of the WMA. The highest quarterly nitrate concentration for CY 2010 was from well 299-E27-14 at 101 mg/L (Figure 9-16). This well is screened across the upper 2.6 meters of the aquifer. The next highest nitrate concentration, 73 mg/L, was collected at new well 299-E27-24, located ~61 meters south of well 299-E27-14. The sample was collected just above the basalt during depth-discrete sampling while drilling. Well 299-E27-24 is now screened across the lower 6.1 meters of the aquifer, with the top of the screen ~9 meters below the water table. The position of the well screen was based on elevated cyanide concentrations found in the deeper portion of the aquifer during drilling. Finding cyanide at the base of the aquifer supports the concept of downward contaminant migration. The base of the well screen is just above the basalt, ~15.5 meters below the water table. December 2010 sample results from this well returned a nitrate concentration of 68.2 mg/L.

Nitrate concentrations began to increase in well 299-E27-14 in fall 1998. Concentrations have continued to trend upward since that time (Figure 9-16). It is postulated that the increased nitrate concentrations are associated with infiltration from the vadose zone beneath the C Tank Farm. A determination was made during an ongoing groundwater assessment at WMA C that groundwater has been impacted by the C Tank Farm based on the presence of the dangerous waste constituent cyanide (Section 9.3.4). The assessment was initiated because of the statistically significant increase of specific conductivity at well 299-E27-14. The sharp fluctuations in the nitrate trend at well 299-E27-14 appear to indicate a nearby point of infiltration (Figure 9-16). Additional evidence of a local source of infiltration is the lower nitrate concentrations in upgradient wells to the north of well 299-E27-14. A third line of evidence is the lower nitrate concentration reported in the downgradient well 299-E27-24, ~61 meters south of well 299-E27-14.

As previously discussed, the highest nitrate concentration in well 299-E27-24 was found at the bottom of the aquifer. This determination was based on depth-discrete groundwater samples collected at 3.9, 10, and 15.5 meters in the aquifer during
drilling. The increased nitrate with depth is not uncommon in the other WMA C wells. Depth-discrete samples collected during drilling or using the SPYDER sampler in existing wells have shown increased nitrate with depth in all seven of the deep wells at WMA C; the SPYDER sampler is discussed in additional detail in Section 9.1.3.3. The other two wells with elevated nitrate concentrations exceeding the DWS in CY 2010 were also associated with groundwater samples collected at 9.1 meters or more below the water table.

9.1.2 Iodine-129

Iodine-129 analyses were performed on groundwater samples at least once from 96 wells across the 200-BP-5 OU. Sampling at five wells (299-E28-5, 299-E28-6, 299-E28-18, 299-E33-16, and 299-E33-26) was missed due to the work stoppage. Sampling at well 299-E33-7 was missed due to insufficient water, and sampling at well 299-E33-43 was missed due to scheduling oversight. The missed well results did not affect the plume configuration, as most of these wells are adjacent to other wells with data available for CY 2010. Sampling at well 299-E28-6 was missed, with no proximal well; however, the well has been below the DWS and was assumed to be below the DWS this year. Figure 9-17 shows the distribution of iodine-129 above the 1 pCi/L DWS. The plume did not change significantly from 2009.

A historical evaluation of iodine-129 in the 200 East Area was completed during preparation of the draft 200-BP-5 RI in 2010, which provided an understanding of the most likely sources and current distribution. Three sources (216-A-10 Crib and vicinity, 216-A-29 Ditch, and the southeast end of the 216-B-3 Pond) in the northern portion of the 200-PO-1 OU are likely responsible for the widespread distribution of iodine-129 within the 200-BP-5 OU. Historical review of the plume indicates groundwater migration from the southern portion of the 200 East Area to the northwest and into Gable Gap during the late 1980s and early 1990s. A potential source of iodine-129 in the 200-BP-5 OU is the 241-BX-102 unplanned release site. Observations over the past several years indicate little change in plume configuration. Since the primary sources are associated with the 200-PO-1 OU, the order of discussion below follows a sequence of the nearest sites (e.g., southerly) to the furthest sites (e.g., northerly) to portray the decreased activities with distance. Five primary areas are discussed regarding iodine-129 activities above the DWS during this monitoring period:

- Wells monitoring WMA C
- Wells monitoring B Pond
- Wells monitoring LLWMA-2 and west of LERF
- Wells at the B Complex and extending northwest beyond well 699-49-57A
- Wells monitoring the 216-B-5 injection well and 216-B-9 Crib.

9.1.2.1 Waste Management Area C Area

All of the wells at WMA C sampled for iodine-129 had reported activities exceeding the DWS. The highest activity this year was in well 299-E27-13 (6.14 pCi/L), located on the west side of the tank farm. The activities in the four wells sampled this year ranged from 4.23 to 6.14 pCi/L. Historically, activities have fluctuated, but not much decrease has been noted over the past two decades.

9.1.2.2 B Pond Area

Eleven wells are located near the B Pond in the 200-BP-5 OU. Four of these wells had detectable iodine-129 concentrations during CY 2010. The highest activity was...
in well 699-45-42 (1.96 pCi/L), which was a significant decrease from 3.16 pCi/L reported last year. This well, and all of the 200-BP-5 OU wells monitoring B Pond, is located on the east side; the higher concentrations are located on the west side of the pond in the 200-PO-1 OU. The other three results were below the 1 pCi/L DWS.

9.1.2.3 Low-Level Waste Management Area 2

Elevated iodine-129 activities have been detected in the wells along the south side of LLWMA-2 since monitoring began in the early 1990s. The highest activity was in well 299-E27-10 when sampling began. Since 2003, the highest activity has been in well 299-E27-9 until this year, when higher activity was reported in well 299-E27-8, west of well 299-E27-9. The highest activity result in this well was 2.48 pCi/L from the December sampling event, which is an increase of 0.5 pCi/L since October 2009. Historically, activities have not shown much fluctuation or decrease within wells 299-E27-8, 299-E27-9, and 299-E27-11.

Last year, the most probable source for the iodine-129 was considered to be the inactive 216-B-2-1 and 216-B-2-2 Ditches. However, review of iodine-129 inventory versus liquid volume (RPP-26744) indicates that any iodine-129 from these ditches should not be detectable in the groundwater.

9.1.2.4 216-B-5 Injection Well and 216-B-9 Crib Area

The highest iodine-129 activity (1.71 pCi/L) at this location during this reporting period was ~1 meter from the 216-B-5 injection well at well 299-E28-25. The activity in this well has shown a constant decreasing trend since monitoring began for iodine-129 in this well in 1994. Well 299-E28-25 is a key well for defining the western edge of the 1 pCi/L isopleth because wells to the west have lower activity than the DWS, including the depth-discrete results at well 299-E29-54 at B Plant. One elevated concentration was noted in the depth-discrete samples collected during drilling at well 299-E28-30 (adjacent the 216-B-12 Crib), but the result was the only detected value and is suspect at this time. Higher activity is found to the north near WMA B-BX-BY.

9.1.2.5 Wells at the B Complex and Extending Northwest Beyond Well 699-49-57A

The highest iodine-129 activity in WMA B-BX-BY was from new investigation/monitoring well 299-E33-343 (4.38 pCi/L in May 2010), located adjacent the northwest corner of B Tank Farm and northeast of the 241-BX-102 tank release. Last year it was difficult to discern what source(s) contributed to this plume; however, based on evaluation during the RI, the majority of iodine-129 is considered to be from past sources south of the 200-BP-5 OU. The 241-BX-102 unplanned release may also contribute due to the iodine-129 activity in the perched water zone and the inventory associated with the unplanned release versus other nearby sources. Historically, the activity in this area (as portrayed in wells 299-E33-16 and 299-E33-18) has fluctuated but has not shown much decrease.

The iodine-129 groundwater plume continues from WMA B-BX-BY and extends toward the northwest to Gable Gap (see Section 9.1.1.1 for details on flow regime). The 1 pCi/L (DWS) leading contour is shown between wells 699-57-59, 699-59-58, and 699-61-62 (Figure 9-17). The 1 pCi/L iodine-129 contour (Figure 9-17) extends further west than supported by the average activities from well 699-55-60A (see Figure 9-3 for location of well 699-55-60A). The rationale for extending the contour west and northwest of this well is based on the screen position of well 699-55-60A, the erosion of the basalt at depth near well 699-55-60A, and the iodine-129 activity.
in wells to the north. Well 699-55-60A is screened deeper in the aquifer (5.18 to 17.37 meters) than wells to the north. It is interpreted that the activity in this well is associated with the dispersed portion of the plume at depth. The thickness of the aquifer contributes to this interpretation, as the aquifer may be only a couple of meters or less within the paleochannel northwest of well 699-49-57A and thickens to more than 33.5 meters near well 699-55-60A. Therefore, the 1 pCi/L contour is continued through this area based on higher interpreted activity near the water table.

9.1.3 Technetium-99

Technetium-99 analyses were performed on groundwater samples at least once from 130 wells across the 200-BP-5 OU. All of the 200-BP-5 OU required wells were sampled at least once in accordance with DOE/RL-2001-49.

The distribution of technetium-99 above the 900 pCi/L DWS was limited to three isolated regions in the 200-BP-5 OU during CY 2010 (Figure 9-18):

- Wells at the B Complex and extending northwest beyond well 699-49-57A
- Grouped wells 699-53-55A, B, and C near Gable Gap
- Wells at WMA C.

9.1.3.1 Wells at the B Complex and Extending Northwest Beyond

Well 699-49-57A

The highest technetium-99 activity in the 200-BP-5 OU continued to be reported in wells monitoring the BY Cribs. Five wells were sampled beneath or adjacent to the BY Cribs in CY 2010: 299-E33-3, 299-E33-7, 299-E33-38, 299-E33-341, and 299-E33-342. Three of the wells were sampled quarterly: 299-E33-38, 299-E33-341, and 299-E33-342. The highest activity (38,000 pCi/L) was at well 299-E33-7 in February 2010; this value was 1,000 pCi/L higher than the previous year and was the highest activity ever reported at this well. Activities for wells at the BY Cribs (sampled quarterly) were lower at the end of the year versus the beginning of the year. The decreases ranged from 2,000 to ~9,000 pCi/L and appear to be associated with increased groundwater flow compared to the last couple of years when the flow was apparently slower due to changing flow direction in 2008 and 2009.

The density of the liquid waste received by the BY Cribs appears to have been a reason for past contaminant migration into the upper basalt-confined aquifer, the Rattlesnake Ridge interbed, at well 299-E33-12. Past reports attribute the source of contamination in well 299-E33-12 with the BY Cribs and poor well construction during early Hanford Site operations. A higher hydraulic head has continually been present in the confined aquifer versus the unconfined aquifer, indicating an upward flow regime between the confined and unconfined aquifers (Figure 9-19). Cobalt-60, iron, nitrate, and technetium-99 previously exceeded their respective DWSs in well 299-E33-12. The well seal was remediated in 1979 and appears to have sealed the intercommunication between aquifers. Technetium-99 is currently the only contaminant that still exceeds the DWS (1,200 pCi/L). Two new 200-BP-5 RI wells, 299-E33-50 and 299-E33-340, were installed to assess the groundwater in the Rattlesnake Ridge interbed in the upgradient and downgradient directions, respectively, from well 299-E33-12. Neither of the new wells exhibited technetium-99 activities exceeding the DWS in CY 2010. Technetium-99 activities in downgradient well 299-E33-340 ranged between nondetect and 26.6 pCi/L. The technetium-99 activity in this well decreased during the year. The previous high level of technetium-99 in this well appeared to be associated with leakage from the unconfined aquifer during drilling rather than from migration associated with well 299-E33-12.
Technetium-99 in well 299-E33-50 during CY 2010 was reported at an activity of 250 pCi/L in one sample and 46.1 pCi/L in a duplicate sample. Based on 3 years of previous results at well 299-E33-50 with no result above 43 pCi/L (in nine samples), the 250 pCi/L result was flagged as suspect. Suspect results are re-evaluated for possible changes when future results become available. Based on the current history of results in these three wells, the original contaminants near well 299-E33-12 appear localized and are dispersing under natural hydraulic conditions.

Near the B and BX Tank Farms, technetium-99 trends for wells 299-E33-41, 299-E33-339, and 299-E33-343 are similar over the last 3 years since well 299-E33-343 was installed. In May 2009, the elevated activity in well 299-E33-339 was attributed to infiltration of residual waste from the 241-BX-102 unplanned release and south flow due to a flow reversal. Activity in each of these wells was highest in the early part of the year and continued to decrease throughout the year (Figure 9-20). The technetium-99 trend appears to be consistent with the perceived flow direction to the north during CY 2010. The technetium-99 trend shows a significantly smaller increase in well 299-E33-339 in early CY 2010 than the nitrate trend. More specifically, the technetium-99 increase in early 2010 was about six times less than the peak in mid-2009. By comparison, the nitrate peak in early 2010 was nearly the same concentration as seen in the peak of 2009. The nitrate trend for well 299-E33-339 is discussed in Section 9.1.1.1. Because sources of high nitrate to the north of well 299-E33-339 are also associated with technetium-99, depth-discrete samples were collected from wells 299-E33-339 and 299-E33-49 along the south side of the BX Tank Farm to investigate a possible density conceptual model. The conceptual model and the results of the investigation are briefly discussed below.

In CY 2010, depth-discrete sampling was completed in wells 299-E33-339 and 299-E33-49 to evaluate a density theory based on the high specific gravity waste from the BY Cribs and 241-BX-102 unplanned release. The specific gravity of the neutralized metal waste was documented as 1.25 g/cc (HW-23043), which was slightly higher than the density of the waste released to BY Crib (at 1.21 g/cc) (WHC-SD-EN-TA-003). The conceptual model being investigated was associated with the specific gravity of the residual metal waste and/or BY Crib waste possibly causing the contaminants to sink when reaching the aquifer.

Depth-discrete groundwater samples did not find significant variation in technetium-99 activities with depth in well 299-E33-339. However, further to the west in well 299-E33-49, an activity an order of magnitude higher was reported for a sample collected at the bottom of the aquifer versus a sample collected ~2 meters above the bottom of the aquifer (e.g., 12,300 to 346 pCi/L, respectively); even lower activity was reported in the shallower samples at this well. Although the nitrate and technetium-99 analytical results from the bottom of the aquifer collected from well 299-E33-49 do not appear sufficient for a density plume, the stratification of the contamination is interesting (see discussion in Section 9.1.1.1 for nitrate stratification). It could be speculated that the depth-discrete results at well 299-E33-49 may represent the disperse fringe of such a plume rather than the center of a possible density plume.

The ratio for technetium-99 to nitrate was also compared to groundwater results at wells near both the BY Cribs and the 241-BX-102 unplanned release. The technetium-99 to nitrate ratio at well 299-E33-49 was 33.2, which is between the ratios at the two sources (e.g., BY Cribs ~18, and 299-E33-343 ~55 in CY 2010). Thus, the elevated contamination at wells 299-E33-339 and 299-E33-49 may have been associated with various sources. Figure 9-8 provides one conceptual model of
a possible density-driven flow regime extending from the BY Cribs. The conceptual model shown in Figure 9-8 is associated with nitrate results, not the technetium-99 results. The technetium-99 trend associated with standard monitoring results at wells 299-E33-339 and 299-E33-49 did not increase, which differed from the nitrate concentrations discussed above. Therefore, the elevated nitrate concentrations at wells 299-E33-339 and 299-E33-49 may be associated with some unknown release near these wells (Section 9.1.1). However, the technetium-99 to nitrate ratio at depth in well 299-E33-49 could also indicate a density plume from a northerly source. Evidence for this conclusion is strengthened by the lack of technetium-99 activity from sources to the south. In conclusion, the depth-discrete data do not provide sufficient data to conclude a source for the elevated nitrate or technetium-99 observed at wells 299-E33-339 and 299-E33-49; however, it does not appear to be associated with sources to the south.

The technetium-99 plume from the B Complex extends to the northwest beyond the 200 East Area boundary. The northwest average flow gradient from the BY Cribs to the northwest was determined as 2.08 x 10^{-5}, which is slightly less than the derived regional gradient of 1.5 x 10^{-5} (Chapter 3.0, Section 3.2). The calculated average flow rate for CY 2010 was 0.78 meters per day (Section 9.1.1 provides details on these calculations). Technetium-99 trend results between wells 299-E33-38 and 299-E33-26 were used to confirm the groundwater gradient direction and flow rate (Figure 9-21). Three specific activity changes are correlated in the trend plots. The last correlated change is the peak in February 2009 in well 299-E33-38 and the peak in well 299-E33-26 in February 2010. The ratio of the correlated activities for the three specific activity changes between these wells ranged from ~54% to 63%. The distance between these wells is ~273 meters, and the average flow rate for the most recent correlation is ~0.75 meters per day. This result agrees with the calculated Darcy velocity of 0.78 meters per day.

The apparent increasing flow rate to the northwest in CY 2010 since the reversal back to the north in mid-2009 is reflected in technetium-99 activity increases in well 699-49-57A, located ~1.3 kilometers northwest of the BY Cribs. Activity levels in this well returned to levels consistent with those seen prior to the initial groundwater flow reversal to the south (4,800 pCi/L versus 4,900 pCi/L). The 900 pCi/L (DWS) leading contour is found between wells 699-49-57A and 699-55-60A (Figure 9-18). Further discussion of the flow pathway is provided in Section 9.1.1.1.

### 9.1.3.2 Grouped Wells 699-53-55A, B, and C Near Gable Gap

The wells cluster 699-53-55A, B, and C is located in an area where a basalt window exists, west of Gable Mountain Pond (now dry) (Figure 9-18). The term "basalt window" was applied because of the irregular erosion of the Elephant Mountain Member of the Saddle Mountains Basalt exposing and interconnecting the underlying Rattlesnake Ridge interbed. The three wells are screened across the bottom, middle, and top of the unconfined aquifer in this area, respectively. Figure 9-15 provides a cross section of the well screen locations but shows nitrate rather than the technetium-99 activities. The aquifer is ~42.7 meters thick, comprised of ~21.3 meters of Hanford sediments overlying ~21.4 meters of Rattlesnake Ridge interbed. Well 699-53-55A is screened below the base of the aquifer, which is more than 42.7 meters beneath the water table within the Pomona basalt, but appears to be hydraulically connected to the bottom of the Rattlesnake Ridge interbed through a sand and gravel pack around the screen that appears to extend above the top of the Pomona basalt. Well 699-53-55B is screened ~15.3 to 21.3 meters below the water table, and well 699-53-55C is screened across the upper portion of the aquifer.
During the reporting period, technetium-99 groundwater activities was reported as slightly lower at well 699-53-55B than at well 699-53-55C (2,700 and 2,800 pCi/L, respectively), which is a 200 pCi/L increase in well 699-53-55B and a 200 pCi/L decrease in well 699-53-55C from CY 2009. The increased activity reported in CY 2010 in well 699-53-55A (130 pCi/L) versus CY 2009 (110 pCi/L) is not considered representative of the deeper aquifer but may instead be associated with poor well construction (see Section 9.1.1.3). Decommissioning of this well is recommended.

The increasing technetium-99 activity at wells 699-53-55B&C has been linked to high technetium-99 activities (up to 30,000 pCi/L) reported in well 699-50-53A before the well went dry in the mid-1990s. The pathway between the two wells was based on similar contaminants at both locations and a revised interpretation of the geology in the area (PNNL-19702). Section 9.1.1.3 provides additional information regarding the transport conceptual model and geologic discussion for the area.

9.1.3.3 Waste Management Area C Area

Seven wells at WMA C were reported with technetium-99 activities exceeding the DWS. Four wells (299-E27-4, 299-E27-13, 299-E27-23, and 299-E27-155) are located along the west to southwest side of the C Tank Farm, and three wells (299-E27-14, 299-E27-21, and 299-E27-24) are located along the south-southeast side of the tank farm. Higher average technetium-99 activities were reported in the west-southwest WMA C wells compared to the south-southeast wells. The highest activity during the reporting period was in well 299-E27-23 (20,800 pCi/L).

The peak technetium-99 concentration at well 299-E27-23 was determined during depth-discrete sampling at ~9 meters in the aquifer.

Figure 9-18 shows the estimated distribution of technetium-99 near the groundwater table in this area. The sample results from the two deep wells (299-E27-24 and 299-E27-155) and depth-discrete sample analyses within two long-screened wells (299-E27-4 and 299-E27-21) within the aquifer are not shown in Figure 9-18 because of the mapping criteria established for this annual report. Based on the elevated results with depth, the technetium-99 plume appears more widespread with depth.

The peak technetium-99 activity at well 299-E27-23 was determined during depth-discrete sampling at ~3-meter intervals in the aquifer. Although the highest activity was ~9 meters beneath the water table in well 299-E27-23, the activity was nearly constant at each depth (19,900 pCi/L at 3 meters and 20,500 pCi/L at 6 meters). Depth-discrete samples were also collected at wells 299-E27-4, 299-E27-7, and 299-E27-21. The results from these wells showed increases in technetium-99 with depth. For example, well 299-E27-4 had activities of 727 and 761 pCi/L in the first two intervals but 7,260 pCi/L in the lowest sample interval. Sample collection was completed via low-flow groundwater sample extraction with tubing that extended from the pump to the well screen (e.g., SPYDER sampler; discussed in PNNL-19129, Discrete Sampling Test Plan for the 200-BP-5 Operable Unit). The sampling flow rate was calculated between 1.6 to 3.4 milliliters per minute. The tubing was designed to slide against the well screen to maximize water collection from the sand pack. Longer purging durations were completed to draw water from the formation.

The depth-discrete groundwater data, as well as data from routine sampling at wells 299-E27-13 and 299-E27-155, were used to create more detailed technetium-99 isopleth contours for 3 and 9 meters in the aquifer (Figure 9-22). One reason that plume configuration was completed in this manner was based on ion chemistry. The ion chemistry between wells 299-E27-4, 299-E27-21, and 299-E27-23 is similar. In contrast, the ion chemistry in wells 299-E27-155 and 299-E27-14 is significantly different, with higher calcium, chloride, magnesium, and sulfate concentrations.
(Figure 9-23). This plume configuration suggests a generally south to southeast flow direction. If the flow is to the southeast, it also follows that technetium-99 may have infiltrated from the vadose zone near wells 299-E27-4 and 299-E27-23. However, vadose zone investigations have not found evidence for significant vadose zone contamination in this area to support this conceptual model. Therefore, an alternative conceptual model is provided below.

The alternative (and not necessarily exclusive) conceptual model is based on the ratio of technetium-99 to nitrate concentration in the wells along the west and southwest side of C Tank Farm. The technetium-99 result was divided by the corresponding nitrate result to create a ratio at each well location for evaluation. Figure 9-24 provides a contour of the ratio results. The contours provide the basis for another model, which conforms to the previous southwest flow direction interpretations at WMA C. Using this basis, the technetium-99 activities associated with the depth-discrete sample results at ~9 meters below the water table were contoured (Figure 9-24). A bias is given to this conceptual model because of similar technetium-99 to nitrate ratios for wells along the east side of the C Tank Farm. The varying technetium-99 to nitrate ratios to the east may also indicate more than one source of groundwater contamination from WMA C. Additional discussion on previous ratio evaluations at WMA C is provided in *Hanford Site Groundwater Monitoring for Fiscal Year 2007* (DOE/RL-2008-01).

### 9.1.4 Uranium

Uranium analyses were performed at least once from 114 wells across the 200-BP-5 OU. Three wells (299-E28-5, 299-E28-6, and 299-E28-18) were not sampled due to a work stoppage.

Uranium contamination in the 200-BP-5 OU was limited to three isolated regions during 2010 (Figure 9-25):

- Wells at the B Complex and northwest beyond the 200 East Area
- Wells near B Plant, the 216-B-62 Crib, and north to LLWMA-1
- Wells near the 216-B-5 injection well.

#### 9.1.4.1 B Complex and Northwest Beyond the 200 East Area

Well 299-E33-343 (adjacent the northwest corner of B Tank Farm) continues to record the highest groundwater uranium concentration in the 200-BP-5 OU. Groundwater concentrations peaked in February at 3,670 µg/L. During the year, uranium concentrations diminished, and the December 2010 result was 3,220 µg/L.

Uranium isotopic signatures from samples within the vadose zone at boreholes 299-E33-45 and 299-E33-343 and within the groundwater demonstrate the 241-BX-102 tank release as the primary source of uranium in groundwater at WMA B-BX-BY (PNNL-19277). After uranium enters the groundwater near well 299-E33-343, it migrates predominantly to the northwest. The pathway extends mainly beneath the BY Tank Farm, toward well 299-E33-34 (located beneath the northeast corner of LLWMA-1). The northern extent of the 30 µg/L uranium contour (the DWS) is between wells 299-E33-34 and 699-49-57A (Figure 9-25).

Sharp uranium groundwater concentration peaks have been observed in wells 299-E33-41 and 299-E33-339 over the past couple years. A breakthrough location south of well 299-E33-343 was discussed in last year’s annual report (DOE/RL-2010-11) as a possible explanation for the increased concentration at well 299-E33-339. Another explanation for the increase in uranium in this well, also provided last year, was migration due to the groundwater flow reversal and/or
density flow along the basalt at the bottom of the aquifer. Additional discussion of density flow is provided in Sections 9.1.1.1 and 9.1.3.1.

A depth-discrete groundwater sampling investigation completed in CY 2010 did not include uranium at well 299-E33-339 or 299-E33-49. Other constituents did not showed elevated levels at depth within the aquifer in well 299-E33-339; however, depth-discrete samples at well 299-E33-49 (located to the west of well 299-E33-339) did show significant increases in nitrate and technetium-99 concentrations at depth. The ratio of nitrate to technetium-99 at depth in well 299-E33-49 is between the results associated with the BY Cribs and the 241-BX-102 unplanned release. Therefore, it is not clear if uranium associated with the 241-BX-102 unplanned release is associated with the density theory discussed in Sections 9.1.1.1 and 9.1.3.1.

Uranium concentrations in well 299-E33-339 have decreased since May 2009, when the groundwater reversal to the south appeared to be waning and a northerly groundwater flow was being re-established (further discussed in Chapter 3.0, Section 3.2.1). Uranium concentrations have not increased since the return of a northwest groundwater flow, which would suggest that the uranium may not be associated with the density plume speculated for the nitrate and technetium-99 concentrations found at depth in well 299-E33-49. This would mean that the peak concentration in well 299-E33-339 in CY 2009 was likely associated with the flow reversal to the south between 2008 and 2009.

9.1.4.2 216-B-62 Crib and North to Low-Level Waste Management Area 1

Over the past 10 years, uranium has been detected at levels near the 30 µg/L DWS in well 299-E28-18, which monitors the 216-B-62 Crib located northwest of B Plant (Figure 9-25). Uranium concentrations were over 200 µg/L in the mid-1980s but decreased by the late 1980s to levels similar to those reported during CY 2010 (43.7 µg/L).

Well 299-E28-21 also monitors the 216-B-62 Crib but is located northwest of well 299-E28-18. Uranium concentrations have been decreasing at this well since initial high values were observed in the mid-1980s. The CY 2010 uranium concentration in well 299-E28-21 was 10.7 µg/L.

The source of uranium for these wells (299-E28-18 and 299-E28-21) was initially linked to the 216-B-62 Crib; however, the only waste site with significant uranium inventory is the 216-B-12 Crib located southeast of the 216-B-62 Crib (Appendix C in RPP-26744). Supporting evidence for the 216-B-12 Crib as the source of elevated uranium in the aquifer is provided by the elevated analytical results from depth-discrete samples collected during drilling near this crib. Approximately 35 µg/L of uranium was reported for a sample collected 7.6 meters below the water table. Elevated uranium is interpreted to extend to the northwest, north, and northeast from the 216-B-12 Crib at depth within the aquifer, similar to the discussion provided for nitrate in this area in Section 9.1.1.2. The depth-discrete uranium concentrations at the new RI well 299-E28-30 near the 216-B-12 Crib are not shown in Figure 9-25 (for the same reasons provided in Section 9.1.1.2 for nitrate).

The prevailing groundwater flow direction near LLWMA-1 has been to the north-northwest over the past couple of decades. Previous uranium groundwater concentrations were observed to migrate from near wells 299-E28-18 and 299-E28-21 to the north-northwest. The elevated uranium concentrations along the western side of LLWMA-1 show the northwest extent of the migration. In CY 2010, uranium concentrations in wells along the western boundary of LLWMA-1 ranged from less than 3 µg/L to 19.5 µg/L, and the highest concentration was in well 299-E32-7. Higher
concentrations are also found in well 299-E28-27 (southeast corner of LLWMA-1), where the December 2010 value was 27 µg/L.

9.1.4.3 216-B-5 Injection Well Area

The 216-B-5 injection well is located northeast of B Plant (Figure 9-25). A small uranium plume has been reported since groundwater monitoring began at the injection well approximately three decades ago. The highest uranium concentration (22.9 µg/L) for CY 2010 was at well 299-E28-25, located ~7 meters to the northwest of the injection well. Uranium concentrations have been decreasing at the monitoring well (near injection well 299-E28-23) and to the south (well 299-E28-24) over the past 3 years; however, concentrations in well 299-E28-25 to the northwest have increased during this timeframe. All results are currently below the DWS. The increasing concentrations in well 299-E28-25 is consistent with the conceived northwest flow direction.

9.1.4.4 B Plant Area

Elevated uranium concentrations are reported for two wells near B Plant: 299-E28-6 (average 39 µg/L in CY 2009) and 299-E28-17 (33.9 µg/L in CY 2010). The well distribution near these wells is sparse. New RI well 299-E29-54, installed just south of B Plant, reported a ~9 µg/L uranium concentration during drilling. It is uncertain how uranium is distributed in this area, with a lower concentration between the 216-B-12 Cribs and wells 299-E28-6 and 299-E28-17; therefore, the plume was separated into two parts (Figure 9-25).

9.1.5 Strontium-90

Strontium-90 analyses were performed at least once from 58 wells across the 200-BP-5 OU. Two 200-BP-5 OU wells (299-E28-5 and 299-E28-6) were not sampled due to a work stoppage.

Eight wells were reported with strontium-90 levels above detection limits. Seven of the eight wells were reported with strontium-90 activities above the 8 pCi/L DWS, with the results of two of these strontium-90 detections unexpected. Four of the wells are located near the 216-B-5 injection well, and two wells are located near the inactive/dry Gable Mountain Pond (Figure 9-26).

The two wells with unexpected strontium-90 detections, 299-E33-341 and 699-50-56, are located beneath the BY Cribs and to the northwest of the 200 East Area, respectively. The activity reported in well 299-E33-341 in February 2010 was 2.6 pCi/L (±3 pCi/L); therefore, the result is within the analytical error and is considered a false positive. This evaluation is consistent with the nondetect values previously and subsequently reported in this well and for wells proximal to this well. The analytical result reported in well 699-50-56 was inconsistent with the duplicate and had a quality control issue; therefore, the result is considered to be a laboratory error.

The highest strontium-90 activity (4,200 pCi/L) for this reporting period was in well 299-E28-23, ~1 meter from the 216-B-5 injection well. This was the only well above the U.S. Department of Energy (DOE)-derived activity guide of 1,000 pCi/L. Distal strontium-90 activities from the 216-B-5 injection well indicate a predominant history of northwest groundwater flow from the 216-B-5 injection well. This is demonstrated by the 1,700 pCi/L activity at well 299-E28-25 (~7 meters to the northwest) versus the lower activity of 350 pCi/L in well 299-E28-24 (~5 meters to the southeast). The predominant northwest transport of strontium-90 is further seen by the 180 pCi/L activity in well 299-E28-2 (~170 meters to the northwest).
**Strontium-90 activity has been steadily decreasing at Gable Mountain Pond, and the highest concentration reported was 310 pCi/L in wells monitoring this area.**

The next closest well to the northwest is well 299-E28-27, which has continued to report nondetect values.

The highest strontium-90 activity reported near Gable Mountain Pond was in well 699-53-47A (beneath the southeastern portion of the once active pond) at 310 pCi/L. The activity at this well has steadily decreased over the last 13 years from 1,320 pCi/L. Further northwest beneath the central portion of Gable Mountain Pond, well 699-54-49 reported activities of 160 pCi/L; the activities in this well have also decreased but more slowly when compared to the decrease observed in well 699-53-47A. One reason for the more significant decrease in strontium-90 activities in well 699-53-47A may be related to the well screen placement. The screen at this well only extends only ~0.5 meter into the aquifer, while well 699-54-49 is screened across the upper 3 meters of the aquifer. Combined with low infiltration and migration, this may explain the significant decreases at well 699-53-47A versus well 699-54-49. In addition, well 699-53-47B, which is adjacent to well 699-53-47A and extends throughout the aquifer, has not shown as significant decreases. This well is screened across the 1.75 meters of aquifer thickness in this location.

Strontium-90 activities at well 699-53-48A, located between wells 699-53-47A and 699-54-49, have also decreased significantly since 2005, with nondetect values reported in CY 2010. The strontium-90 activity reported for the well in 2005 was 741 pCi/L. This well monitors the bottom of the aquifer and extends ~2.9 meters beneath the groundwater surface within broken basalt and clay. Well 699-53-48A does not have perforations or screen, and the bottom of the casing underlies 1.8 meters of silt and clay. The well produces water at a rate of more than 7.6 liters per minute. Recent results appear to be good because the duplicate result was also nondetect. Based on the results for this well, the strontium-90 contours at Gable Mountain Pond have been modified.

Well 699-55-50C, located near the northwest end of the inactive Gable Mountain Pond, was again reported with a nondetect strontium-90 activity. The continued nondetect values in this well indicate limited movement of the strontium-90 plume to the northwest.

### 9.1.6 Cyanide

Cyanide analyses were performed at least once from 81 wells across the 200-BP-5 OU. The distribution of cyanide above the 200 µg/L DWS originates beneath the BY Cribs and extends predominantly to the northwest beyond the 200 East Area boundary (Figure 9-27). Elevated cyanide concentrations, also originating from the BY Cribs, were found in well 299-E33-4, which has not been sampled since 2008 due insufficient groundwater in the well.

The maximum cyanide concentration in the 200-BP-5 OU in CY 2010 was located beneath the BY Cribs in well 299-E33-7 (1,590 µg/L).

**The maximum cyanide concentration in the 200-BP-5 OU in CY 2010 was located beneath the BY Cribs in well 299-E33-7 (1,590 µg/L).**

Cyanide is also present to the south and east of the BY Cribs. Cyanide groundwater concentrations to the south and east of the BY Cribs began to decrease as groundwater flow returned to the northwest. Furthermore, cyanide along the south side of the BY Cribs has been elevated over the past 3 years in wells 299-E33-9, 299-E33-13, 299-E33-31, and 299-E33-44, while the flow regime had changed from...
a dominate north flow to a south flow and back to a north flow regime. In CY 2010, the concentrations diminished significantly as apparent flow rates increased to the northwest. Density-driven contamination was considered as an alternative explanation for the increased concentration last year in these wells. During CY 2010, depth-discrete samples were collected in wells 299-E33-31 and 299-E33-342 south of the BY Cribs, and the cyanide concentrations in both these wells showed an increase with depth. For example, well 299-E33-342 had a concentration of 303 µg/L at ~0.76 meters in the aquifer versus 831 µg/L at the bottom of the aquifer. The concentrations in well 299-E33-31, although not as high, also increased at the bottom of the aquifer. Thus, the residual cyanide-bearing waste infiltrating into the aquifer appears to have sank through the aquifer initially and later dispersed with the flow in the direction of the groundwater gradient similar to the density theory discussed for nitrate and technetium-99 (Sections 9.1.1.1 and 9.1.3.1).

Elevated cyanide concentrations are also associated with well 699-53-55C, which has continued to decrease since the peak value in April 2009. Lower concentrations in January and July 2010 indicate a decreasing trend.

The current cyanide plume at well 699-53-55C has apparently migrated from near well 699-50-53A over the two past decades. In the early 1990s the cyanide concentrations at well 699-50-53A exceeded 1,000 µg/L. Concentrations at well 699-53-55C appear to now be decreasing after having increased for the past 7 years. Concentrations peaked in April 2009 at 195 µg/L and as of July 2010 had decreased to 158 µg/L. It appears that concentrations may not exceed the DWS due to the increased aquifer thickness near this well and the decreasing cyanide concentration trend. The aquifer residing in the Hanford sediments at well 699-53-55C is approximately 21.3 meters thick compared with the less than 1-meter-thick aquifer near well 699-50-53A in the early 1990s. This may be part of the reason that concentrations at well 699-53-55C have remained below the DWS while concentrations at well 699-50-53A exceeded the DWS. Well 699-53-55B, which is screened deeper in the aquifer, has slightly lower concentrations, indicating a possible dispersed portion of the plume. Concentrations at well 699-53-55B had decreased to 146 µg/L by May 2010.

9.1.7 Cesium-137

Cesium-137 analyses were performed at least once from 91 wells across the 200-BP-5 OU. Wells 299-E28-5 and 299-E28-6 were not sampled due to a work stoppage.

Only three wells (near the 216-B-5 injection well) had detectable activities of cesium-137 within the 200-BP-5 OU, ranging from 35.4 to 2,180 pCi/L. Well 299-E28-23, located ~1 meter from the 216-B-5 injection well, had the highest activity at 2,180 pCi/L (see Figure 9-2 for well location). The reported activity is above the 200 pCi/L DWS and is less than the DOE-derived activity guide of 3,000 pCi/L. The current activity is ~60% of the average observed in the 1980s.

Cesium-137 has relatively low mobility in the subsurface and does not migrate significant distances, as can be observed by the much lower activity (79.2 pCi/L) from well 299-E28-24, which is located ~5 meters to the southeast of the 216-B-5 injection well. An even lower activity (35.4 pCi/L) is found ~7 meters to the northwest in well 299-E28-25. Based on historical comparisons, this plume appears to be decaying without much movement, as modeled and concluded in DOE/RL-95-59.
9.1.8 Plutonium-239/240

Plutonium-239/240 analyses were performed at least once from 31 wells across the 200-BP-5 OU. Wells 299-E28-5 and 299-E28-6 were missed due to a work stoppage; these two wells have historically been reported with nondetect values.

Six wells had detectable activities of plutonium-239/240. Three of the wells (299-E82-23, 299-E28-24, and 299-E28-25) are near the 216-B-5 injection well. Detectable activities in these wells have been continuous since sampling began in 1986 and 1987. The activities reported for CY 2010 ranged between 0.21 and 42.6 pCi/L. Well 299-E28-23, located ~1 meter from the 216-B-5 injection well, had the highest activity at 42.6 pCi/L. Plutonium-239/240 is nearly immobile in the subsurface, as reflected by the stable, low results in wells 299-E28-24 and 299-E28-25, which are located ~5 to 7 meters from the 216-B-5 injection well.

The other three wells with detected activities (299-E33-38, 699-48-50, and 699-50-56) were unexpected because these wells have not had previous plutonium-239/240 detections. Two of these wells had measurement errors greater than the reported detection and, therefore, are within measurement error and are considered false positives. Well 699-48-50 had a result slightly above to the total analytical error of 0.029 pCi/L. Previous results in this well have been nondetects, and wells between the 216-B-5 injection well and this well have been consistently nondetect; therefore, this result is suspect. The well will be sampled again in CY 2011.

9.1.9 Tritium

Tritium analyses were performed at least once from 140 wells across the 200-BP-5 OU. Three wells (299-E28-5, 299-E28-6, and 299-E28-18) were missed due to a work stoppage. Tritium activities above the 20,000 pCi/L DWS are limited to three wells in the thin aquifer northwest and east of the 216-B-57 and 216-B-50 Cribs, respectively (Figure 9-28). Tritium was also reported above the DWS in samples collected at depth from two new 200-BP-5 RI wells drilled in CY 2010. Because these samples were collected at depths greater than 4 meters beneath the water table and also during drilling, the values are not shown in Figure 9-28.

The two wells with the highest tritium activities in CY 2010 were the two new RI wells, 299-E28-30 and 299-E29-54, located near the 216-B-12 Crib and B Plant, respectively. The highest activity, 150,000 pCi/L, was reported during sample collection while drilling at well 299-E29-54 and encountered ~18.3 meters below the water table. There was no duplicate; however, the sample was run twice with different dilution factors and provided consistent results. The next highest activity, 93,500 pCi/L, was reported during sample collection while drilling at well 299-E28-30, encountered at ~7.62 meters below the water table. The result is an average of two samples, one at 93,000 pCi/L and a duplicate sample at 94,000 pCi/L. The results are consistent with the significant tritium inventory associated with the 216-B-12 Crib (2,340 curies) versus the less than one curie for the other combined waste sites in this area (Appendix C of RPP-26744).

The high tritium activities in well 299-E28-30 coincide with the Ringold Formation unit 9A (PNNL-12261). The top of the Ringold unit 9A is interpreted to extend from just above the water table through most of the saturated thickness, overlying a thin layer of unit 9B and ~6.1 meters of unit 9C. North of this well, Ringold unit 9A is truncated by the glaciofluvial Hanford sediments which overlie the Ringold unit 9C. The change in hydraulic conductivity between these two formations ranges from an order of magnitude to several orders of magnitude (PNNL-12261). It is believed that tritium migrates north from Ringold units, causing elevated activities to the
north beneath the 216-B-62 Crib (similar to the nitrate discussion in Section 9.1.1.1). The elevated tritium is also interpreted as the source of elevated tritium along the southeast and west side of LLWMA-1.

A tritium contour is not provided around well 299-E28-30 because the results are based on vertical profiling data during drilling; therefore, the tritium contour is not shown in Figure 9-28. As stated in Section 9.1.1.2, vertical sampling data are not posted on annual average maps because vertical sampling data are not always comparable to routine samples from completed and developed wells.

The other two wells with tritium levels exceeding the DWS in CY 2010 were wells 299-E33-7 and 299-E33-26. These wells are adjacent to waste site 216-B-50 (part of the BY Cribs) and the 216-B-57 Crib, which were reported with high tritium inventories of 126.3 and 194.6 curies, respectively (Appendix C of RPP-26744). The maximum tritium activity was formerly reported in well 299-E33-4, which has not been sampled since 2008 due insufficient groundwater in the well. The activities in wells 299-E33-7 and 299-E33-26 have recently decreased and appear to be associated with an increase in the groundwater flow rate in this area. This also appears to be the reason for the smaller 20,000 pCi/L plume configuration.

During the past 10 years, elevated tritium levels within Gable Gap continue to decrease slightly faster than the decay rate; this was observed in wells 699-60-60 and 699-61-62. North of Gable Gap, the tritium activity decrease appears to match the decay rate over the past 8 to 10 years in wells 699-64-62 and 699-66-64. In well 699-66-58 to the northeast of well 699-64-62, the tritium activities have not decreased as much as the decay rate. To the east of well 699-64-62 in well 699-63-55, the activities appear to be decreasing slightly faster than the decay rate. Based on the data, it appears that tritium migrating north of Gable Gap may preferentially migrate along the north side of Gable Mountain and to the northeast.

9.1.10 Sulfate

Sulfate analyses, like nitrate, were performed at least once from 141 wells across the 200-BP-5 OU. The distribution of sulfate above the secondary DWS (250 mg/L) is limited to a three locations within the 200-BP-5 OU (Figure 9-29):

- BY Cribs and adjacent wells
- East side of WMA C
- Well 299-E27-10 at LLWMA-2.

9.1.10.1 BY Cribs and Adjacent Wells

High sulfate concentrations beneath the BY Cribs are not unexpected based on the large inventories of sulfate that were added in the initial phase of the bismuth phosphate process. The waste generated (referred to as metal waste) was eventually sent to the BY Cribs after further separation of various fission and metal products. Thus, considering previous vadose zone and groundwater sample results, the current groundwater results are consistent with the other COCs associated with the BY Cribs (e.g., cyanide, nitrate, and technetium-99).

9.1.10.2 East Side of Waste Management Area C

The sulfate concentration reported in well 299-E27-14 (southeast side of WMA C) is associated with WMA C. In 2010, the sulfate concentrations in well 299-E27-14 averaged 296 mg/L. Although sulfate exceeded the 250 mg/L (secondary DWS) in other WMA C wells, the plume configuration (Figure 9-29) only reflects the result at this well because it is associated with the upper aquifer.
Sulfate concentrations also exceeded the secondary DWS in well 299-E27-24, located ~61 meters to the south. In this well, the sample concentrations collected during drilling at depth-discrete intervals in the aquifer were higher in the lower portion of the aquifer. For example, the concentration at ~3.93 meters into the aquifer was 185 mg/L, at 10 meters was 248 mg/L, and at 15.6 meters was 345 mg/L. The bottom of the 6.1-meter well screen was placed at just above the basalt. The first sample from the completed well in December 2010 reported 301 mg/L. This concentration is slightly higher than the concentration reported in the depth-discrete sample (286 mg/L) collected in well 299-E27-7 during February. Further to the northeast, the concentrations at depth in well 299-E27-25 were just above the secondary DWS. The December quarterly sample result at well 299-E27-25 was 250 mg/L.

9.1.10.3 Well 299-E27-10 at Low-Level Waste Management Area 2

The sulfate concentration in well 299-E27-10 has continued to increase since the late 1990s (Figure 9-30). The highest concentration during CY 2010 was 361 mg/L, reported in February as part of a depth-discrete sample located in the bottom portion of the screened interval for this well. The sulfate concentration in this well appears to be associated with releases from the 216-B-2-1 and 216-B-2-2 Ditches. High sulfate concentrations were reported beneath the 216-B-2-2 Ditch during the 200-CW-3 OU RI (DOE/RL-2000-35, 200-CW-1 Operable Unit Remedial Investigation Report). The Borehole Summary Report for the 216-B-2-2 Ditch (BHI-01177) reported four zones of elevated moisture at depth. In addition, the subsurface lithology has been described as having silt-rich interbeds capable of generating perched water conditions (WHC-SD-EN-TI-290, Geologic Setting of the Low-Level Burial Grounds); these interbeds appear to dip to the northeast. A possible contributor for the driving force to groundwater associated with the 216-B-2-1 and 216-B-2-2 releases may have been a subsequent release associated with the 216-B-2-3 Ditch, which was determined after water began entering an empty burial trench at LLWMA-2 in 1986. By May 1997, significant sulfate increases were reported in well 299-E34-7 (Figure 9-30). An increasing trend began in 1999 in well 299-E27-10, located to the southwest of well 299-E34-7. It is unknown whether the sulfate migrated through the aquifer toward well 299-E27-10 or infiltrated into the aquifer from the vadose zone near this location. However, both wells are north of the 216-B-2-1 and 216-B-2-2 Ditches, which is the prevailing dip direction of the vadose zone sediments.

Although the gradient at LLWMA-2 has suggested flow to the west along the southern boundary for nearly two decades, increased sulfate concentration observed in well 299-E27-10 has not been noted in well 299-E34-12, which is ~1,100 meters to the west. However, sulfate was found in the new WMAC well 299-E27-25. It appears that the sulfate in well 299-E27-10 is associated with the sulfate in wells 299-E27-25 and 299-E26-77. Therefore, the sulfate plume has been configured to include each of these wells (Figure 9-29).

9.2 CERCLA Groundwater Activities

The CERCLA groundwater activities for CY 2010 included routine groundwater monitoring, RI studies, and preparation of a treatability test plan to address technetium-99 and uranium contamination, as discussed below.

9.2.1 Routine Groundwater Monitoring

Routine CERCLA groundwater monitoring requirements are described in the Groundwater Sampling and Analysis Plan for the 200-BP-5 Operable Unit
The monitoring network, constituent lists, and sampling frequency are provide in Appendix A of this report. The CERCLA monitoring data are used to define the extent of groundwater contamination. Each year, contours are revised for each COC identified in DOE/RL-2001-49. The certainty of the plume interpretation is also assessed to determine the effectiveness of the CERCLA and AEA monitoring program. The assessment determines if the selected analytical methods, sampling frequencies, and well locations are appropriate. In addition, the new contours are compared each year with previous contours to interpret groundwater flow and track concentration trends near contaminant sources. DOE/RL-2001-49 also provides the direction for the integrated use of RCRA analytical data.

A revision of DOE/RL-2001-49 was initiated after RI well installations were completed in spring 2010. Data from the new RI wells and the existing monitoring network help to provide a better understanding of several potential contaminant sources and the groundwater flow direction across the central portion of the 200 East Area. The groundwater flow across the central portion of the 200 East Area has been uncertain for several years due to small groundwater elevation differences and an apparent groundwater divide, limiting the use of conventional three-point analyses. As a result, groundwater chemistry is compared with contaminant plume configurations and groundwater gradient information to ensure defensible interpretations.

The overall CY 2010 contaminant concentrations/activities were slightly lower than last year beneath areas in the northwest portion of the 200 East Area where infiltration of contaminants (discussed in Section 9.1) has been occurring: BY Cribs, 241-BX-102 unplanned release, 216-B-7A&B Cribs, 216-B-8 Crib, and 216-B-57 Crib. This appears to be a result of increased flow to the northwest. Further east, wells near apparent infiltration sites had peak concentrations in CY 2010, which were primarily associated with wells 299-E27-14 and 299-E27-23 near WMAC and well 299-E27-10 near the 216-B-2 Ditches. These increases appear to be associated with limited groundwater migration and continued residual liquid waste infiltration into the aquifer.

In CY 2010, all but three wells were successfully sampled (Appendix A). Sampling at wells 299-E28-5, 299-E28-6, and 299-E28-18 was missed due to a work stoppage in late 2010. Iodine-129 samples were also missed in a few additional wells due to insufficient water in the wells or scheduling oversight (Section 9.1.2).

### 9.2.2 Remedial Investigation Activities

The scope of the 200-BP-5 RI/FS work plan (DOE/RL-2007-18) was derived through the data quality objective process (WMP-28945, Data Quality Objectives Summary Report in Support of the 200-BP-5 Groundwater Operable Unit Remedial Investigation/Feasibility Study Process). The work plan identified the need for fifteen additional wells to resolve the future impact to groundwater, improve the understanding of contaminant nature and extent within the aquifer, and refine the groundwater flow direction. Field work began in 2006 and continued through 2010.

The last three RI wells (“K,” “L,” and “M”), identified in DOE/RL-2007-18 and WMP-28945, were drilled and installed early in CY 2010. The wells were located near the following: well 299-E28-30 (“K”) near the 216-B-12 Crib west of B Plant, well 299-E29-54 (“L”) near the 216-B-6 injection well south of B Plant, and well 299-E24-25 (“M”) near the 216-C-1 Crib near the Semi-Works Facility. All analytical data from the RI-derived samples collected both in the vadose zone and groundwater were verified, a portion was validated, and the data have been included in the Hanford Environmental Information System database.
Three contaminants were reported above the DWS at new RI well 299-E28-30: nitrate, tritium, and uranium. Nitrate and tritium were also reported at levels exceeding the DWS at new RI well 299-E29-54. The highest results in well 299-E28-30 were at the second depth-discrete interval, ~7.6 meters below the water table. Elevated results were also reported at this depth in well 299-E29-54; however, the highest results for nitrate and tritium in this well were in the lowest sample ~18.3 meters beneath the water table. No constituents were found to exceed the DWS in well 299-E24-25. The results associated with wells 299-E28-30 and 299-E29-54 are discussed in more detail in Sections 9.1.1.2, 9.1.4.2, and 9.1.9.

Another RI activity completed in CY 2010 involved the collection of depth-discrete samples at fourteen existing wells within the 200-BP-5 OU. The samples were collected to evaluate the vertical extent of contamination beneath, adjacent, and downgradient of waste sites where continuing contaminant infiltration is thought to be occurring. The wells included the following:

- Well 299-E27-10 along the north side of the 216-B-2-2 Ditches
- Wells 299-E33-49 and 299-E33-339 along the south side of the B and BX Tank Farms
- Wells 299-E33-343 and 299-E33-345 near apparent points of contaminant infiltration associated with the 241-BX-102 unplanned release and 216-B-7A&B Cribs discharges, respectively
- Wells 299-E33-31, 299-E33-39, and 299-E33-342 near the BY Cribs
- Well 699-50-56 located ~1.3 kilometers northwest of the BY Cribs
- Well 699-53-55C located ~1.6 kilometers north of the BY Cribs.

The nitrate and technetium-99 sample results are discussed in Sections 9.1.1 and 9.1.3. In general, depth-discrete results indicated that contaminant concentrations increase with depth, except in areas where infiltration appears to be occurring. For example, at well 299-E33-343, concentrations for the ions tested were nearly the same throughout the aquifer. This well is considered to be near the point of infiltration of contamination from the 241-BX-102 unplanned release because of the high concentrations of uranium compared to adjacent wells. Similar results were also found at well 299-E27-23 (near WMA C) where technetium-99 was significantly more concentrated than in the surrounding wells. Conversely, all but two of the remaining wells showed increased concentrations with depth. These wells were considered adjacent contaminant infiltration. Wells 699-50-56 and 699-53-55C were considered downgradient, and not much change in concentration was observed with depth. It appears that specific gravity of the residual vadose zone waste entering the aquifer plays a part in the initial downward movement of the contaminants. Another factor for high contaminant concentrations proximal to an infiltration source is slow groundwater movement, which relates to slow dispersion of the infiltrating contaminants.

Four major reports were prepared in CY 2010 for the 200-BP-5 RI/FS. Two of the reports were associated with a treatability test near WMA B-BX-BY: 200-BP-5 OU Data Quality Objectives Summary Report (SGW-44329) and Treatability Test Plan for the 200-BP-5 Groundwater Operable Unit (DOE/RL-2010-74). These two reports defined the boundary, location, data, infrastructure, and approach required to complete the treatability test. The submittal of the draft treatability test plan to the U.S. Environmental Protection Agency (EPA) completed Tri-Party Agreement
Milestone M-015-082. Another report initiated in CY 2010 was the Remedia
Investigation Report 200-BP-5 Groundwater Operable Unit (DOE/RL-2009-127),
which is still in draft status and planned for final publication in 2011. The final
report prepared this year was the Data Quality Assessment Report for the 200-BP-5
Groundwater Operable Unit: November 2004 Through November 2009 Groundwater
Data, which evaluated 10,926 groundwater samples over the past 5 years to determine
whether the data were of sufficient quality to support the baseline risk assessment
and selection of remedial alternatives. The report concluded that the data were of
the right type, quality, and quantity for use in the RI/FS process.

9.2.3 Treatability Test Plan

Two test sites were identified to evaluate the practicality of performing a
groundwater pump-and-treat system for the extraction of uranium and technetium-99
contaminant plumes near WMA B-BX-BY. The sites were selected based on
the proximity of the existing plumes, aquifer thickness, preliminary hydraulic
conductivity, and ability for manpower to reach the site easily. One test site is
located along the west side of the BY Tank Farm. This location is near the major
source of technetium-99 (the BY Cribs), where the aquifer thickens due to the dip of
the Elephant Mountain Member of the Saddle Mountains Basalt, and it is outside of
waste site boundaries. This location was thought to be the closest site available to
the BY Cribs that met the criteria for test locations. The location is also considered
to be downgradient of the uranium plume source, the 241-BX-102 unplanned release.

The other site selected was existing well 299-E33-343, located adjacent the
northwest corner of the B Tank Farm. This site was selected mainly due to high
uranium concentrations at this well. The well is considered to be near the infiltration
point of the uranium plume associated with the 241-BX-102 unplanned release.
Because the well is an existing 4-inch monitoring well, test equipment will be
evaluated for the ability to maintain a sustainable yield in accordance with test
performance objectives. This well is also used to access spatial variability of hydraulic
parameters and contaminant removal rates.

The treatability test is planned for early to mid-FY 2012 (based on available
funding). Prior to the start of testing, the following activities are required: complete
the design plan, level and prepare for site construction, drill and construct extraction
and associated monitoring well along the west side of BY Tank Farm, construct
a pipeline from both extraction wells to the cross-site line to the Effluent Treatment
Facility, construct a utility distribution rack, and provide an electrical connection.

9.3 RCRA Treatment, Storage, and Disposal Unit
Monitoring

This section describes the results of monitoring at individual units such as
TSD units or tank farms. These units are monitored under RCRA requirements
for 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 discussed jointly in this section to provide comprehensive interpretations of
groundwater contamination for each unit. As previously discussed and 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, while this report may be used to satisfy
RCRA reporting requirements, the inclusion of information on radionuclides in such a context is for information only and may not be used to create conditions or other restrictions set forth in any RCRA permit.

The 200-BP-5 OU contains six RCRA sites with groundwater monitoring requirements: LLWMA-1 and LLWMA-2, WMA B-BX-BY, WMA C, LERF, and 216-B-63 Trench. The following discussion summarizes the results of statistical comparisons, assessment studies, and other developments for this reporting period. Groundwater data are available in the Hanford Environmental Information System database and in the data files accompanying this report. Additional information (including well and constituent lists, maps, flow rates, and statistical tables) is included in Appendix B.

9.3.1 Low-Level Waste Management Area 1

G.S. Thomas

Groundwater monitoring at LLWMA-1, located in the northwestern corner of the 200 East Area, continued under RCRA and AEA requirements. In accordance with WAC 173-303-400, “Dangerous Waste Regulations,” “Interim Status Facility Standards” (as referenced by 40 CFR 265.93(b), “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” “Preparation, Evaluation, and Response”), the well network was sampled semiannually for RCRA indicator and site-specific parameters (DOE/RL-2009-75, Interim Status Groundwater Monitoring Plan for LLBG WMA-1). The AEA monitoring requirements were derived from the Performance Assessment Monitoring Plan for the Hanford Site Low-Level Burial Grounds (DOE/RL-2000-72). All of the existing LLWMA-1 wells were successfully sampled in January/February and June/July during the reporting period. Two new wells were also added to the network and were sampled in September. Appendix B, Table B-19 provides a list of the wells and constituents monitored during CY 2010. Appendix B, Table B-20 provides a list of the indicator parameter comparison values for use in CY 2011. The indicator parameter comparison values for CY 2010 are provided in Appendix C, Table C-20 in DOE/RL-2010-11 and are discussed specifically in Section 9.3.1.2. The following subsections discuss the annual evaluation requirements for the monitoring network, compliance status, and groundwater results.

9.3.1.1 Network Evaluation and Compliance Status

The interim status monitoring requirements of 40 CFR 265, Subpart F (“Ground-Water Monitoring”) and WAC 173-303-400 require upgradient and downgradient monitoring wells that ensure detection of statistically significant change in concentrations (e.g., above or below) of the derived critical means for the four indicator parameters at the limit of the WMA within the uppermost aquifer. This subsection discusses additions to the network, measures taken to determine groundwater flow, the results of statistical groundwater gradient measurements, correlation of the statistical measurements with observed contaminant migration, determination of flow direction and rate, and whether the network remains satisfactory for immediate detection of any statistical change in concentration within the LLWMA-1 monitoring network.

At the beginning of the reporting period, the LLWMA-1 groundwater monitoring network consisted of seventeen wells. Two additional LLWMA-1 monitoring wells (299-E33-265 and 299-E33-266) were added during the reporting period in accordance with the Groundwater Monitoring Needs Assessment for Low-Level
**Burial Grounds Waste Management Areas (SGW-40037).** The two new wells were installed to detect groundwater contamination that could emanate from the buried RCRA-regulated wastes associated with Trench 9 in the 218-E-10 Burial Ground (Figure 9-31).

As discussed in Appendix A of SGW-40037, use of uncorrected water-level measurements to determine groundwater flow direction is problematic in the 200 East Area because the hydraulic gradient is very small (~1.5 x 10⁻⁵ based on regional water-level measurements). To increase the accuracy of water-level elevation determinations for LLWMA-1, six perimeter LLWMA-1 wells, three wells to the north, three wells to the south, and two wells to the east were resurveyed to a single bench mark, and gyroscopic surveys were conducted to determine well plumbness (deviation from vertical) (see Figure 3-4 in Chapter 3.0). Sixteen wells in the north central and northeastern portion of the 200 East Area were also resurveyed to the same marker and gyroscoped to more accurately determine the regional groundwater flow regime (Figure 3-6 in Chapter 3.0). Additional details of this work are provided in Chapter 3.0, Section 3.2.1.

Statistical monthly water-level measurement evaluations for the fourteen-well network were reduced to five monthly measurements in 2010 due to requirements associated with monitoring evaluations and the work stoppage. The statistical measurement evaluations were completed from the January, May, June, July, and September data. An additional set of measurements collected during in January 2011 was also included for this discussion. Each set of measurements was analyzed using trend-surface analyses (see discussion in Chapter 3.0, Section 3.2.1). Since the fall of 2008, statistically significant values for groundwater flow using this network have been limited to two summer results: one in July 2009 and one in June 2010 (Figure 9-6). Although the probability in almost all of the statistical measurements exceeded 5% (e.g., \( p \) values shown in Figure 9-6), since April 2009 the flow direction (“Dir.” in Figure 9-6) value indicates a predominant northerly flow direction. April 2009 signifies the return of a predominant north flow regime from the flow reversal statistically determined in July 2008.

During the reporting period, the probability that the fitted trend surface results did not represent a good approximation of the overall groundwater gradient (i.e., the \( p \) value) ranged between 34% and 68%, except for one statistically significant gradient determination (with a \( p \) value of less than or equal to 5%) in June 2010. The higher the \( p \) value, the higher the probability that the azimuth direction provided in Figure 9-6 could be different from the true gradient. Evaluation of the corrected groundwater elevations indicates that the uncertainty was due to low groundwater elevations in the southerly wells 299-E28-17 and 299-E28-1 during the first part of the year (e.g., January and May). During the year, well 299-E28-17 consistently had low groundwater elevations, except in June and early January 2011. The only well with lower groundwater elevations was well 699-50-56, north of the 200 East Area. Unlike well 299-E28-17, well 299-E28-1 had one of the highest groundwater elevations in the summer (June through September) and in January 2011. If the two high elevations and two low elevations are removed, the flow direction is then based on 6 millimeters or less of water-level elevation change, which is within the measurement error. The flow regime depicted from the remaining wells is variable from month to month or is indeterminate; therefore, the use of CY 2010 water levels only to derive the flow direction and rate across LLWMA-1 is not recommended. Because of the small groundwater elevation differences and uncertainty regarding the measurements, ion chemistry and contaminant trend plots were also evaluated before determining flow direction.

**Two new wells were installed to detect groundwater contamination that could emanate from buried RCRA-regulated wastes associated with Trench 9 in the 218-E-10 Burial Ground.**

The use of water levels only to derive the flow direction and rate across LLWMA-1 is not recommended for 2010. Therefore, ion chemistry and contaminant trend plots were also evaluated before determining flow direction.
to determine if correlation between these observation methods were in agreement before deciding the flow direction.

One area where the use of groundwater-level data maybe appropriate is between the south portion of the BY Cribs and the northeast corner of LLWMA-1. Between wells 299-E33-38 and 299-E33-34, the groundwater elevation was consistently higher in well 299-E33-38, except in August and September (see Section 9.1.1.1). More importantly, contaminant trend plots and ion chemistry in these wells and the well between these wells (e.g., 299-E33-26) all suggest a northwest groundwater flow direction. For example, comparable technetium-99 trend results between wells 299-E33-38 and 299-E33-26 indicate a northwest flow, as discussed further in Section 9.1.3.1 (Figure 9-21). Nitrate trend plots for these wells provide a similar comparison; furthermore, ion chemistry between the three wells is comparable. Since the ion chemistry and trend plots are consistent with the elevation differences between these wells, further evaluation between these wells regarding the flow is discussed below.

A range of groundwater gradient values for wells 299-E33-38 and 299-E33-34 was derived by subtracting the corrected groundwater elevations and dividing by the distance between these wells (Table 9-1). The calculations ranged between -3.73 x 10^-6 and 1.96 x 10^-7 for the 10-month evaluation, including early January 2011 (see Section 9.1.1.1). After removing the two high and low values, the range was from 1.00 x 10^-5 to 2.16 x 10^-6. Summing and dividing by six produced an average of 2.08 x 10^-5, which is slightly less than the regional gradient of 1.5 x 10^-5. Multiplying the average by the upper hydraulic conductivity range of 7,500 meters per day (PNNL-14753, Groundwater Data Package for Hanford Assessment) and dividing by an effective porosity of 0.2 derived an average flow rate of 0.78 meters per day to the northwest. This flow rate correlates with the nitrate and technetium-99 trend changes in these wells, which indicates a flow rate of ~0.75 meters per day (Section 9.1.3.1). Because of the correlation between groundwater elevation differences, trend plots, and ion chemistry, the average gradient between the BY Cribs and northeast corner of LLWMA-1 is considered to be ~2.08 x10^-5 to the northwest.

Groundwater elevation differences beneath the remaining portion of LLWMA-1 are within the measurement error, as previously explained. In addition, conclusive evidence does not exist to indicate a particular flow direction in this area. Based on the review of previous groundwater flow through this area and the evidence of northwest flow further north, it is postulated that flow in this area is also to the north or northwest.

In conclusion, the contaminant plume orientation along the north side of the WMA is consistent with the azimuth direction from statistical groundwater gradient measurements in this area. If the contaminant plumes orientation and statistical measurements are an indication of the general flow throughout the WMA, then the addition of the two new wells (299-E33-265 and 299-E33-266) provides even greater confidence for detection of potential groundwater contamination that could emanate from the buried RCRA-regulated wastes associated with Trench 9 in the 218-E-10 Burial Ground. Based on this information, DOE considers the network capable of the immediate detection of any statistical change in concentration at the point-of-compliance within the LLWMA-1 monitoring network.

### 9.3.1.2 Groundwater Contaminants

The groundwater in LLWMA-1 monitoring wells is sampled and analyzed for the parameters listed in Appendix B, Table B-19. In accordance with WAC 173-303-400...
and 40 CFR 265.92, the LLWMA-1 network wells are monitored semiannually for RCRA groundwater quality and indicator parameters. The comparison criteria (critical mean) for the indicator parameters and the basis for deriving the critical mean are provided in Appendix C, Table C-20 of DOE/RL-2010-11, and specific comparisons are provided below. Water-level measurements are taken before each sampling event. During CY 2010, all groundwater sample analyses were completed as required (DOE/RL-2009-77, Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area C).

During the reporting period, the indicator parameter measurements for pH, total organic carbon, and total organic halides did not exceed the statistically derived background comparison values (e.g., critical mean). The pH levels for all of the wells ranged from 7.73 to 8.17, which is within the lower and upper bound of the critical mean (7.48 to 8.43, respectively). Five wells had total organic carbon levels exceeding the critical mean (800 µg/L) in the June sampling event; however, verification sampling results were nondetect. The highest total organic halide concentration was reported just above the detection level in well 299-E33-29. The annual groundwater phenol results were all reported as nondetects for the January 2010 sampling event.

The indicator parameter specific conductance was reported below the critical mean of 912 µS/cm for all wells except 299-E32-10 and 299-E33-34. The exceedance of specific conductance in well 299-E33-34 was initially reported by DOE to the Washington State Department of Ecology in 1999. The most recent specific conductance levels are the highest respective levels reported for these two wells (1,165 and 2,325 µS/cm, respectively) and are influenced primarily by the nitrate plume migrating from the BY Cribs. The nitrate concentrations in these two wells ranged from 50% to 70% of the total anion milliequivalents per liter versus less than 35% in the other WMA wells. This indicates a difference in groundwater quality in this portion of the monitoring network compared to the remainder of the network. Thus, the elevated specific conductance in wells 299-E32-10 and 299-E33-34 is not cause for change of the interim status indicator evaluation groundwater monitoring conducted at LLWMA-1.

Nitrate and cyanide are the only groundwater quality parameters exceeding DWSs beneath LLWMA-1, with nitrate concentrations exceeding the DWS in nearly every well. As reported in previous annual reports, the sources of nitrate are east and south of LLWMA-1 (BY Cribs and WMA B-BX-BY, and the 216-B-12 Crib, respectively). The largest nitrate increase was in well 299-E33-34 where the reported concentration was 1,050 mg/L in July 2010. This value is the highest nitrate concentration ever reported in this well and for the monitoring network. Well 299-E33-34 also had the only cyanide concentration (340 µg/L) reported exceeding the DWS. Wells 299-E32-9 and 299-E32-10, located west of well 299-E33-34 along the northern boundary, also reported increased nitrate and cyanide concentrations. The increased concentrations are consistent with the contaminant trends noted in wells to the east of LLWMA-1. The next highest nitrate concentrations in the remaining LLWMA-1 monitoring wells (excluding wells 299-E32-9, 299-E32-10, and 299-E33-34) are found in monitoring well 299-E28-27 located in the southeast corner of LLWMA-1. The source of this contamination has been reported from the south and, because of results at new 200-BP-5 RI well 299-E28-30, is considered from the 216-B-12 Crib (Section 9.1.1.2).
9.3.1.3 Performance Assessment Monitoring

Performance assessment monitoring of radionuclides at LLWMA-1 (in accordance with AEA authority) is designed to complement RCRA detection monitoring and specifically at monitoring radionuclides not regulated under RCRA. The current monitoring plan (DOE/RL-2000-72) includes technetium-99, iodine-129, tritium, and uranium specifically for performance assessment.

Technetium-99 concentrations have changed significantly in wells monitoring LLWMA-1 in the eastern, central, and northern portion of the WMA. The increased technetium-99 groundwater concentrations in the northeast wells (299-E32-9, 299-E32-10, and 299-E33-34) is the result of the technetium-99 plume migrating from the BY Cribs. Technetium-99 detected in wells 299-E33-28 and 299-E33-30 may be associated with sources in the WMA B-BX-BY and/or the 216-B-7A&B Cribs.

Elevated iodine-129 activities are also found predominantly in the eastern, central, and northern LLWMA-1 monitoring wells. The source of the iodine-129 appears to be locally from the east and regionally from the southeast when groundwater was strongly influenced by the B Pond groundwater mound in the late 1980s and early 1990s (Section 9.2.2).

Uranium concentrations at LLWMA-1 continue to increase and exceed the 30 µg/L DWS in well 299-E33-34. The uranium concentrations also exceeded the DWS in well 299-E32-10 (west of well 299-E33-34) for the first time during this reporting period. To the west of these wells, uranium concentrations are also increasing in wells 299-E32-9 and 299-E32-8, indicating prevailing flow direction to the west along the northern boundary of LLWMA-1. The increasing uranium concentration previously reported in well 299-E28-27, near the southeastern corner of LLWMA-1, appears to have stabilized over the past few years. The source appears to be the 216-B-12 Crib, based on depth-discrete groundwater sample results from a new 200-BP-5 RI well installed near this location and the predominant north flow direction over the past two decades.

Tritium was not reported above the DWS in any LLWMA-1 monitoring well in CY 2010. The highest activity continued to be in well 299-E33-34, which is the result of migration from wells to the southeast (Section 9.2.9).

9.3.2 Low-Level Waste Management Area 2

G.S. Thomas

Groundwater at LLWMA-2 in the northeast corner of the 200 East Area continued to be monitored under RCRA and AEA requirements. In accordance with WAC 173-303-400 (as referenced by 40 CFR 265.93[b]), the well network was scheduled for semiannual sampling for RCRA indicator and site-specific parameters (DOE/RL-2009-76, Interim Status Groundwater Monitoring Plan for LLBG WMA-2). The AEA monitoring requirements were derived from DOE/RL-2000-72. All of the LLWMA-2 wells were successfully sampled during this reporting period; however, due to a work stoppage in September 2010, the October sampling event was delayed until December. Appendix B, Table B-21 includes a list of the wells and constituents monitored during CY 2010. Appendix B, Table B-22 provides a list of the indicator parameter comparison values for use in CY 2011. The indicator parameter comparison values for CY 2010 are provided in Appendix C, Table C-22 of DOE/RL-2010-11 and are discussed specifically in Section 9.3.2.1 below. The following subsections provide annual evaluation requirements for the monitoring network, groundwater results, and compliance status.
9.3.2.1 Network Evaluation and Compliance Status

The interim status monitoring requirements of 40 CFR 265, Subpart F and WAC 173-303-400 require upgradient and downgradient monitoring designed to detect any statistically significant change in concentrations (e.g., above the derived critical mean for the four indicator parameters) of dangerous waste or dangerous waste constituents at the limit of the WMA within the uppermost aquifer. The flow direction for this WMA is uncertain due to the nearly flat groundwater table. An assessment of the groundwater monitoring needs was completed in 2008 and published in January 2009 (SGW-40037). The following discussion presents the changes implemented in 2010 in association with the assessment (SGW-40037). Also discussed are the additional measures taken to more accurately determine the groundwater gradient, the results of statistical groundwater gradient measurements, an evaluation of contaminant migration, and whether the network remains adequate for immediate detection of any statistical change in concentration within the LLWMA-2 monitoring network.

At the beginning of the reporting period, the LLWMA-2 groundwater monitoring network consisted of nine wells. One additional LLWMA-2 monitoring well, 299-E34-13, was drilled during the reporting period in accordance with SGW-40037 (Figure 9-32). The new well was located ~80 meters north of well 299-E34-2 as a new downgradient well of RCRA waste disposal site. In accordance with DOE/RL-2009-76, an additional well was also planned north of well 299-E34-13. During drilling of well 299-E34-13, groundwater was not observed prior to reaching basalt. Drilling then extended ~2.1 meters into the basalt to check for groundwater associated with the flow top. Groundwater was not observed in the well after 105 minutes, and examination of the basalt chips indicated no fractured flow top at this location. The lack of a fractured flow top is consistent with previous observations of basalt chips from adjacent wells 299-E34-2 and 299-E34-4. Drilling later continued to ~3.1 meters into the basalt to check for groundwater associated with fractures in the basalt. Groundwater was encountered; however, the groundwater infiltration rate was 0.4 meters over 1.5 hours (13.2 liters per hour). A sample of the groundwater was collected and analyzed, showing a calcium-sulfate chemistry (Figure 9-33). The sulfate was reported as 244 mg/L, and elevated nitrate was present at 40.3 mg/L. Because the well did not produce sufficient groundwater and the groundwater produced did not appear to be associated with the upper unconfined aquifer, the well was decommissioned and well 299-E34-14 was not drilled.

As discussed in Appendix B of SGW-40037, use of uncorrected water-level measurements to determine groundwater flow direction is problematic in the 200 East Area because the hydraulic gradient is very small (~1.5 x 10^-5 based on regional water-level measurements). To increase the accuracy of water-level elevation determination for LLWMA-2, five wells along the perimeter of the WMA and three wells to the west-southwest were resurveyed to a single benchmark, and gyroscope surveys were performed (Figure 3-6 in Chapter 3.0). An additional fourteen-well network to the west was also resurveyed to the same marker and gyroscoped previously to more accurately determine the regional groundwater flow regime for the northwest 200 East Area (Figure 3-4 in Chapter 3.0). Additional information regarding this work is provided in Chapter 3.0, Section 3.2.2.

Monthly water-level measurements for the network were reduced to nine monthly measurements in 2010 due to a work stoppage. The monthly measurements were completed in January through September, as well as an additional set of measurements collected during early January 2011. Each set of measurements was analyzed using
trend-surface analysis (see Chapter 3.0, Section 3.2 for further discussion). Since March 2009, when the well network was resurveyed to a common bench mark, eleven statistically significant trend-surface results have been derived. However, to achieve statistically significant results at LLWMA-2, two to four of the eight wells used were removed from the analysis due to inconsistent groundwater elevations. The azimuth values derived for the statistically significant measurement generally portray a north-northeast flow direction. Groundwater movement to the north-northeast seems inconsistent based on the lack of groundwater in eight previous wells/borings spaced across the north portion of the WMA and the high groundwater elevations to the east. The northerly wells have little to no water due to groundwater elevation decreases. In addition, basalt chip observations indicate no apparent rubbly flow top in this area that could contain or transmit water. As described in Chapter 3.0, Section 3.2, the error in the water-level elevation determinations for LLWMA-1 was estimated to have a range of 0.012 meters; presumably, this error estimate would also apply to the LLWMA-2 measurements. The water-level elevations determined for LLWMA-2 exhibit an average range of 0.013 meters, which is nearly equal to the expected error. This likely accounts for the unsatisfactory trend-surface analysis results at this WMA. Thus, the hydraulic gradient at LLWMA-2 is currently deemed too low to measure.

Evaluation of contaminant history, along with knowledge of the geological setting and previous discharges from wastewater disposal sites, indicates that the groundwater is being influenced by infiltration of residual waste liquids from the unlined 216-B-2 Ditches (see Section 9.1.10.3 for further discussion of the 216-B-2 Ditches). Most of the WMA wells are located along the north side of the 216-B-2 Ditches, which transferred ~151 billion liters of water to B Pond during active operations (1945 through 1987). Wells 299-E27-9 and 299-E27-10 along the ditches have had significantly increased nitrate and sulfate concentrations. The concentration increases appear to indicate limited groundwater flow for the following reasons:

- Residual infiltration into the aquifer is considered to be small.
- Indeterminate regional groundwater gradient suggests little movement.
- Nitrate and sulfate concentration increases over the past decade and a half indicate limited dispersion.

These combined factors indicate slow groundwater flow in the area. The driving force of the elevated nitrate and sulfate concentrations appears to be residual moisture associated with blockage of the weir box at the east end of the 216-B-2-3 Ditch during the mid-1980s (Section 9.1.10.3). Figure 9-7 depicts a nitrate plume beneath this area, which appears to be centered beneath the weir box at the east end of the 216-B-2-3 Ditch where the blockage occurred. Comparison of groundwater chemistry and contaminant trends between wells 299-E27-10, 299-E27-9, and 299-E27-8 portrays a west-northwest flow direction over the past several years.

If flow is west-northwest, well 299-E34-2 is ideally located for monitoring downgradient of buried RCRA waste because the aquifer is bounded to the north by the basalt, as confirmed from drilling results for well 299-E34-13. In addition, wells 299-E27-11, 299-E27-17, 299-E34-12, 299-E34-10, and 299-E34-9 provide monitoring to the west-southwest. Therefore, based on current data trends and understanding of the surrounding wastewater disposal history, the LLWMA-2 monitoring network remains satisfactory for detection of statistical changes.
9.3.2.2 Groundwater Contaminants

The groundwater in LLWMA-2 monitoring wells is sampled and analyzed for the parameters listed in Appendix B, Table B-21. In accordance with WAC 173-303-400 and 40 CFR 265.92, the LLWMA-2 network wells are monitored semiannually for RCRA groundwater quality and indicator parameters. The critical mean for the indicator parameters and the basis for deriving the critical mean are provided in Appendix C, Table C-22 of DOE/RL-2010-11; however, specific comparisons are provided below. Water-level measurements are taken before each sampling event. During CY 2010, all groundwater sample analyses were completed as required (DOE/RL-2009-76).

During the reporting period, the indicator parameter measurements for pH, total organic carbon, total organic halides, and specific conductance were consistent with previous results and did not exceed the statistically derived background comparison values (e.g., critical mean). The pH levels for each of the wells ranged from 7.87 to 8.3, which is within the lower and upper bound of the critical mean (6.85 to 8.56, respectively). The highest average total organic carbon concentration reported was 936 µg/L in December 2010 at well 299-E27-10. The highest average total organic halide concentration reported was slightly above detection at 8.05 µg/L also in December 2010 at well 299-E27-10. The annual groundwater phenol results were all reported as nondetects for the annual fall sample collection event. Samples from wells 299-E27-8 and 299-E27-17 were also collected and analyzed for phenols in April 2010, with no detected results.

The indicator parameter of specific conductance was reported below the critical mean of 1,278 µS/cm for all LLWMA-2 monitoring wells. The highest specific conductance level was reported in December 2010 for well 299-E27-10 (1,111 µS/cm).

Sulfate and nitrate are the only groundwater quality parameters that exceeded DWSs during the reporting period at LLWMA-2. Elevated sulfate concentrations were limited to well 299-E27-10, with a high concentration of 335 mg/L from December 2010. Elevated nitrate concentrations were reported in well 299-E27-10 and for the first time well in 299-E27-9. The highest concentration was 58 mg/L in well 299-E27-10 for December 2010 sampling, while well 299-E27-9 had a value of 49.6 mg/L for December 2010 sampling.

9.3.2.3 Performance Assessment Monitoring

Performance assessment monitoring of radionuclides at LLWMA-2 (in accordance with AEA authority) is designed to complement RCRA detection monitoring and specifically at monitoring radionuclides that are not regulated under RCRA. The current monitoring plan (DOE/RL-2000-72) includes technetium-99, iodine-129, tritium, and uranium.

The technetium-99 concentrations increased slightly in well 299-E27-10 during the reporting period, with an activity of 84 pCi/L in December 2010. Other wells in the monitoring network have lower technetium-99 concentrations and only periodically report detected results. Iodine-129 concentration was most prominent in well 299-E27-8 at 2.48 pCi/L in December. Wells adjacent to well 299-E27-8 had elevated concentrations, but wells to the east were all below the DWS, with the exception of well 299-E34-12 at 1.06 pCi/L in April, which decreased to 0.72 pCi/L in December. The overall iodine-129 activity appears to be slowly decreasing in all LLWMA-2 wells. Tritium concentrations have also decreased over the past two decades, with maximum concentrations currently below 550 pCi/L (December 2010). Uranium concentrations in LLWMA-2 samples were less than 5 µg/L.
9.3.3 Waste Management Area B-BX-BY

C.J. Martin

Located in the north-central portion of the 200 East Area, this single-shell tank WMA consists of the B, BX, and BY Tank Farms; ancillary waste transfer lines; and diversion boxes. The three tank farms consist of a total of 36 underground tanks, ranging in capacity between 2 and 2.9 million liters, as well as four 208,000-liter tanks constructed between 1945 and 1949.

Groundwater monitoring is conducted at this WMA in accordance with WAC 173-303-400 (and by reference, 40 CFR 265, Subpart F) and the AEA. The WMA B-BX-BY is currently in a RCRA groundwater quality assessment program and is monitored quarterly, as detailed in the RCRA assessment plan (PNNL-13022, Groundwater Quality Assessment Plan for Single-Shell Tank Waste Management Area B-BX-BY at the Hanford Site). In addition to monitoring dangerous waste/dangerous waste constituents for RCRA assessment, the site is monitored for CERCLA and AEA purposes under the 200-BP-5 Groundwater OU program.

9.3.3.1 Network Evaluation and Compliance Status

The RCRA groundwater monitoring requirements include an annual evaluation of the network to determine if it remains adequate to monitor the WMA. The network must include upgradient and downgradient wells in the uppermost aquifer. The current network consists of 26 wells. The groundwater gradient beneath WMA B-BX-BY is virtually flat (i.e., the gradient is near zero), so the network includes wells on all sides of the WMA, which remains capable of monitoring the extent and concentration of contaminants throughout 2011.

Wells specified in the assessment plan (PNNL-13022) near the WMA and in nearby past-practice liquid disposal sites are sampled in an effort to differentiate tank-related contamination from that associated with the surrounding non-RCRA waste sites. Many of the wells are co-sampled for the 200-BP-5 OU under CERCLA guidance, although CERCLA sampling is generally performed at a lower frequency, and sampling is coordinated to avoid redundancy.

A site-wide sampling stop work was initiated on September 2010 and was not completely lifted until November 8, 2010. This impacted the collection of the fourth quarter samples at this WMA. The final quarter of sampling at wells 299-E33-7, 299-E33-9, and 299-E33-26 was not performed. Access to the BY Tank Farm had closed during the stop work, thus well 299-E33-9 could not be accessed for sampling. Well 299-E33-26 had pump problems that could not be resolved before the end of CY 2010. In well 299-E33-7, the groundwater elevation decreased in May to a nonpumpable level; the well is awaiting maintenance to lower the pump. Two other wells, 299-E33-15 and -E33-205, also missed complete sampling for the year. Due to scheduling conflicts, access to the BX Tank Farm had closed before well 299-E33-205 could be sampled in December, while well 299-E33-15 had electrical problems that were not resolved in time to collect the first quarter sample. By the end of CY 2010, all but four wells had been sampled for the fourth quarter as scheduled, and those four were sampled by the end of the first week of January 2011.

Determining the hydraulic gradient and flow direction using uncorrected water-level measurements to determine groundwater flow direction is problematic in the 200 East Area because the hydraulic gradient is very small (~1.5 x 10^-5 based on regional water-level measurements). To improve the accuracy of water-level measurements in the northwest 200 East Area, a network of fourteen wells was
established at the nearby LLWMA-1, which included two wells from WMA B-BX-BY (299-E33-38 and 299-E33-339). Casing elevations were resurveyed and borehole deviation surveys were performed to correct for nonverticality of the wells. Resulting trend-surface analyses indicated a long-term average flow direction to the north-northwest (340 degrees azimuth), with a gradient of $\sim 1.9 \times 10^{-5}$ ($\pm 0.2 \times 10^{-5}$). The average flow rate appears to increase to the north as the aquifer thins and where trend plots and groundwater elevation differences indicate $\sim 0.72$ to 0.75 meters per day, as discussed further in Sections 9.3.1.1 and 9.1.1.1.

9.3.3.2 Groundwater Contaminants

In FY 1996, the groundwater monitoring program for WMA B-BX-BY shifted from indicator parameter evaluation to groundwater assessment because specific conductance in a downgradient monitoring well exceeded the critical mean value. Results from the ensuing investigation indicated that waste products from the WMA had entered and affected groundwater quality (PNNL-11826, Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas B-BX-BY at the Hanford Site). Subsequent annual assessment reports have been included in the Hanford Site annual groundwater reports (e.g., DOE/RL-2010-11).

The groundwater in WMA B-BX-BY monitoring wells is sampled and analyzed for the parameters listed in Appendix B, Table B-30. In accordance with WAC 173-303-400 and 40 CFR 265.93, selected WMA B-BX-BY network wells are monitored quarterly for RCRA COCs and associated field/supporting parameters. Some of the wells listed in Appendix B, Table B-30 are sampled at other frequencies for selected constituents to provide additional information on contaminant movement and to differentiate tank-related contamination from contamination associated with the surrounding waste sites. Water-level measurements are taken before each sampling event. During CY 2010, most groundwater samples were collected as scheduled. Section 9.3.3.1 discusses the wells missed and the causes for missed sampling.

Additional parameters (i.e., alkalinity, dissolved oxygen, temperature, and turbidity) are measured as indicators of groundwater quality and general aquifer/well environmental conditions. Other anions sampled include chloride and sulfate to detect potential contamination from surrounding waste sites, as well as to provide input for charge-balance calculations.

The primary dangerous waste constituent found beneath WMA B-BX-BY is cyanide. However, based on leak inventories, the likely source of the cyanide beneath the WMA is the BY Cribs (RPP-26744). Certain non-RCRA-regulated constituents (e.g., nitrate, sulfate, and radionuclides) are also found within the boundaries of the WMA (DOE/RL-2010-11). In the past, elevated nitrite levels were also observed. These constituents are attributed to multiple sites, including WMA B-BX-BY and the surrounding cribs.

Several non-RCRA contaminant plumes coincide with WMA B-BX-BY, and the sources of some of these plumes are likely from within the WMA. Nitrate, technetium-99, and uranium are observed under, and both northwest and southeast of, the BY Tank Farm. The proximity of these contaminants to the BY Tank Farm suggests a possible tank-related source. Technetium-99, nitrate, uranium, sulfate, tritium, cobalt-60, and cyanide occur together near the BY Cribs and, with the exception of uranium, are at high concentrations. Elevated concentrations of iron and manganese are present in the groundwater above DWSs (300 and 50 μg/L, respectively) under the BY Tank Farm. Near the 216-B-8 Crib, nitrate, nitrite, technetium-99, and uranium contamination coincide. In general, many of these contaminants appear to be a significant source of AEA-regulated contamination in the 200-BP-5 OU.
contaminants occur together in tank and crib waste, and their coincidence in groundwater monitoring is expected.

The results from well 299-E33-47 stand out as requiring an individual discussion for CY 2010. Since installation of well 299-E33-47 in 2003, the well (along with well 299-E33-338) has had contaminant concentrations that can be considered “background” when compared to other wells in the WMA B-BX-BY network. This trend continued through the first two quarters of CY 2010 (Figure 9-34). In the latter half of the year, the concentrations of most metals and anions show a dramatic increase (up to 91% for nitrate). The non-RCRA constituent technetium-99 also increased. The exact cause and meaning of these increases remains unknown. Some early possibilities include impact from density flow of contamination along the basalt surface (which dips toward well 299-E33-47 from the potential sources of the BY Cribs and 241-BX-102 tank release), impact from some unrecorded source, or a combination of both. For additional information regarding density flow, see Section 9.1.1.1.

**Cyanide.** Cyanide concentrations from scavenged waste disposed to the BY Cribs continued to increase in groundwater under the BY Cribs, with concentrations ranging up to 1,590 µg/L in well 299-E33-7. The cyanide plume extends a couple of kilometers to the northwest. Much lower cyanide concentrations north of the 216-B-8 Crib (in wells 299-E33-15 and 299-E33-39) also show continued increases, with a maximum of 159 µg/L in well 299-E33-39 during the reporting period. It is important to note that the 216-B-8 Crib and Tile Field did not receive scavenged waste.

Cyanide concentrations beneath the BY Tank Farm decreased during CY 2010 in wells 299-E33-9, 299-E33-31, and 299-E33-44, with a maximum concentration of 61.4 µg/L in well 299-E33-44. The concentrations reported in wells 299-E33-9, 299-E33-31, and 299-E33-44 appear to be sourced from the BY Cribs. In general, the elevated concentrations in these wells were reported in the 2009 annual report (DOE/RL-2010-11) and occurred during a prolonged groundwater gradient reversal to the south, which was determined by a low-level groundwater elevation study. This flow reversal would have resulted in periods of stagnation when contaminant concentrations would increase. As the flow returned to its normal direction toward the northwest, the elevated concentrations would decline as the contamination once again moved with the groundwater.

A contributing explanation for the elevated cyanide concentrations in these wells may be associated with density flow of contamination along the basalt surface, which dips to the south in this area. A depth-discrete groundwater sampling investigation was performed in CY 2010 and is discussed in Section 9.1.1.1.

Other wells with measurable cyanide concentrations include 299-E33-17 (north of the B Tank Farm and east of the 216-B-8 Tile Field) and well 299-E33-26 (west of the BY Cribs). The two new wells (299-E33-341 and -E33-342), located within the footprint of the BY Cribs also have measurable cyanide. Along with well 299-E33-38 (also in the BY Cribs), wells 299-E33-26, 299-E33-341, and 299-E33-342 each have approximately the same cyanide concentrations.

Only sporadic detection of cyanide has occurred in wells monitoring the B and BX Tank Farms. The maximum concentration measured at the B Tank Farm was 4.7 µg/L in well 299-E33-343, while the maximum concentration measured at the BX Tank Farm was 4.2 µg/L in well 299-E33-205.

**Chromium.** Chromium concentrations in wells around the BY Tank Farm and north of the B Tank Farm continue to show a slow increase. Well 299-E33-16,
beneath the 216-B-8 Crib, has the highest overall chromium concentration average at 86.9 µg/L. The 216-B-8 Crib is the likely source based on the inventory added to this waste site and the higher groundwater concentrations primarily reported in well 299-E33-16 versus other wells. The chromium received at this site was associated with the sodium dichromate used in the first-cycle decontamination process of plutonium (HW-10475, Hanford Technical Manual). In addition, this site received hydrochloric and citric acid (HW-17088, Underground Disposal of Liquid Wastes at the Hanford Works). The acid may have augmented the total chromium concentration by reaction with and mobilization of the native chromium in sediments within the vadose zone.

The maximum concentration this reporting period was 71.0 µg/L in well 299-E33-18, located between the B Tank Farm and 216-B-8 Crib. The highest tank farm average is 19.36 µg/L at the BY Tank Farm. All concentrations are well below the chromium DWS of 100 µg/L.

**Nitrate.** Nitrate is prevalent in WMA B-BX-BY as part of process wastes discharged to both tanks and cribs. Generally, nitrate extends along a northwestern-southeastern trend from the northern portion of the 216-B-8 Crib through the BY Cribs and the northeastern corner of LLWMA-1, and it extends to the north-northwest away from the WMA. DOE/RL-2008-01 provides an extensive history of the nitrate plume. No significant changes were observed in CY 2010, although many wells exhibited a general decrease in concentrations during the year. This is not unexpected, as the aquifer moves to re-establish equilibrium after the flow reversal and stagnation that occurred in late 2008/early 2009.

Overall, nitrate concentrations continued to increase beneath WMA B-BX-BY, the BY Cribs, and the 216-B-8 Crib. The maximum concentration for CY 2010 was beneath the BY Cribs at wells 299-E33-7 and 299-E33-341 (1,540 mg/L). The maximum concentration below WMA B-BX-BY was in well 299-E33-44 (753 mg/L), east of the BY Tank Farm and northwest of the B Tank Farm.

**Nitrite.** Historically, nitrite has been detected in only a few wells in the WMA monitoring network. Nitrite was detected in all of the newly installed wells throughout most of CY 2009 but has decreased to below detection in all but two wells. Well 299-E33-345 (north of the BX Tank Farm) had the highest nitrite concentration (2,650 µg/L) in March 2010. The DWS for nitrite is 3,300 µg/L. The concentration in this well increased sharply from below the detection limit at the start of the year (January), before beginning a declining trend to the end of CY 2010.

Well 299-E33-344, which was recently installed in a perched zone at WMA B-BX-BY, is co-located with well 299-E33-345 and has also shown measurable nitrite concentration, with at a maximum of 4,340 µg/L early in the reporting period. This well has maintained nitrite levels greater than 2,500 µg/L since its installation. Because of the higher concentration in this well, it is likely that the nitrite at well 299-E33-345 is from percolation of perched water.

**Sulfate.** Similar to nitrate, sulfate levels continued to increase in wells around WMA B-BX-BY, with a minor decrease in concentrations during CY 2010. The highest concentrations in wells monitored for WMA B-BX-BY were greater than 200 mg/L in wells in the northern portion of the BY Tank Farm network.

Eight wells exceeded the 250 mg/L secondary DWS for sulfate in CY 2010, four of which are directly associated with the tank farms. Well 299-E33-31 (in the northwestern corner of BY Tank Farm) had a maximum concentration of 264 mg/L in May, which was a decrease from 267 mg/L in 2009. Well 299-E33-44, opposite
well 299-E33-31 and east of the BY Tank Farm, had a CY 2010 maximum value of 290 mg/L in August. Well 299-E33-9, located in the BY Tank Farm, declined slightly from last year’s maximum to a 300 mg/L concentration in September. Finally, new perched well 299-E33-344 had a December 2010 concentration of 529 mg/L.

Other wells that exceeded the DWS include well 299-E33-16 south of the 216-B-8 Crib and Tile Field at 351 mg/L in February; well 299-E33-26 west of the BY Cribs at 296 mg/L in August; and wells 299-E33-38, 299-E33-341, and 299-E33-342, all within the BY Cribs, at 309 mg/L in February, 273 mg/L in August, and 305 mg/L in December, respectively.

9.3.3.3 Performance Assessment Monitoring

Performance assessment monitoring of radionuclides at WMA B-BX-BY, under AEA authority, is designed to complement RCRA assessment monitoring and specifically at monitoring radionuclide materials not regulated under RCRA. The current monitoring plan (PNNL-13022) includes technetium-99 and uranium specifically for performance assessment.

**Technetium-99.** Technetium-99 occurs in wells throughout the WMA B-BX-BY network and is above the DWS of 900 pCi/L in all of the wells associated with the BY Tank Farm, BY Cribs, 216-B-8 Crib, and 216-B-7A/7B Cribs. Only one other well that is part of the network for WMA B-BX-BY was above the DWS. Well 299-E33-339 (between the BX and B Tank Farms) had a maximum concentration of 1,140 mg/L in March but dropped to below the DWS for May and August (799 mg/L and 609 mg/L, respectively).

The overall technetium-99 concentration trends showed the same character as nitrate of an overall increase with a minor decline in CY 2010. The maximum concentration was 31,000 pCi/L, detected in well 299-E33-38 in the southwestern corner of the BY Cribs. The highest value within the WMA B-BX-BY network of 18,000 pCi/L was in August in well 299-E33-18, which is located north of the B Tank Farm, between the tank farm and the 216-B-8 Crib. Similarly, high concentrations are also found in new wells 299-E33-343 and 299-E33-345, which are located slightly west of well 299-E33-18.

Technetium-99 contamination is attributed to discharges to the BY Cribs and the 216-B-7A&B and 216-B-8 Cribs. In CY 2009, mapping the extent of technetium-99 migration indicated some southward movement of this contaminant across the southern border of the BX and B Tank Farms, as indicated by detection in wells 299-E33-49 and 299-E33-339. This was likely related to periods of stagnation and reverse flow that occurred in late 2008/early 2009 (Figure 9-6). Further support of this is the steady decline in concentrations in both wells since their maximum in early 2009. No other suspected source of technetium-99 is present in this area to contribute to groundwater contamination.

**Uranium.** The source of the observed uranium contamination in WMA B-BX-BY is the 1951 overfill event of tank 241-BX-102. The highest average uranium value in CY 2010 was northwest of the B Tank Farm in newly installed well 299-E33-343 (3,670 µg/L). The next highest concentration was 1,140 µg/L in well 299-E33-9, located in the center of the BY Tank Farm and downgradient from well 299-E33-343.

The center of uranium contamination was historically believed to be under the BY Tank Farm based on well 299-E33-9 regularly having the maximum concentration. However, since early 2008, rapid increases in the uranium concentration in BX Tank Farm wells to the northeast (76% in well 299-E33-41) and southeast
(99% in well 299-E33-339, and 78% in well 299-E33-49) seem to support the tank 241-BX-102 release as the source. In addition the uranium concentration in the perched well 299-E33-344 of 1,660 µg/L, northeast of tank 241-BX-102, may be a potential vadose zone source. The strongest support for a 241-BX-102 source comes from uranium isotope ratios. The comparison of these ratios conclusively links uranium in groundwater at this WMA with the uranium in the 241-BX-102 wastes. The methods used and results are detailed in depth in PNNL-19277.

The historic shape of the uranium plume has suggested groundwater flow to the northwest (Figure 9-25). This interpretation is consistent with the recent detailed water-level interpretation in the vicinity of LLWMA-1.

9.3.4 Waste Management Area C

G.S. Thomas

Groundwater monitoring at WMA C is conducted in accordance with WAC 173-303-400 (and by reference, 40 CFR 265, Subpart F) and the AEA. The WMA C is currently in a RCRA groundwater quality assessment program and is monitored quarterly, as detailed in the RCRA assessment plan for WMA C (DOE/RL-2009-77). Table 3-5 in DOE/RL-2009-77 includes the construction dates for the wells, screened interval, depth to water, screened water column, estimated depth to basalt, and percentage of screen in aquifer.

The objectives of groundwater assessment monitoring include determining if dangerous waste or dangerous waste constituents are in the groundwater, assessing the extent and rate of migration of dangerous waste or dangerous waste constituents in groundwater, and determining the levels of dangerous waste or dangerous waste constituents in groundwater. Cyanide is the only dangerous waste constituent determined to presently be impacting the groundwater at WMA C. Based on the small horizontal gradient at WMA C, no determination could be made for the rate of migration. However, using the analytical results associated with the WMA C monitoring network, an estimated extent of cyanide detection is provided in Section 9.3.4.1. Section 9.3.4.1 also includes discussion of multiple conceptual models for flow direction using the AEA constituent technetium-99. The levels of contamination are discussed in Section 9.3.4.2, as well as the assessment constituents being retained and excluded in accordance with the evaluation process in DOE/RL-2009-77.

All of the wells were successfully sampled during this reporting period, except for the December sampling event at well 299-E27-12. Appendix B, Tables B-31, B-32, B-33, and B-34 provide lists of the wells and constituents monitored for the assessment.

9.3.4.1 Network Evaluation and Compliance Status

At the beginning of the reporting period, the WMA C groundwater monitoring network consisted of ten wells. Two additional WMA C monitoring wells (299-E27-24 and 299-E27-25) were drilled during the reporting period in accordance with DOE/RL-2009-77. New well 299-E27-24 is ~61 meters south of well 299-E27-14, where specific conductance was verified as exceeding the critical mean in July 2009. The other well, 299-E27-25, is located to the northeast of the WMA as a new upgradient well.

Groundwater flow at WMA C has been reported to be southwesterly since at least 1997, with the exception of CY 2009 when the direction was indeterminate. In the
past, groundwater flow directions were based on well water-level elevations that did not account for vertical deviations of the wellbores. As has been previously discussed, the use of uncorrected water-level measurements to determine groundwater flow direction as problematic in the 200 East Area because the hydraulic gradient is very small ($\sim 1.5 \times 10^{-3}$ based on regional water-level measurements). In March 2009, 22 wells were resurveyed to a common benchmark and gyroscoped in north-central and northeast regions of the 200 East Area to increase the accuracy of regional groundwater measurements. Presently determining a directional gradient is still uncertain. Using only the corrected groundwater elevations at WMA C to derive a gradient and flow direction is even more problematic due to the variability in the water-level elevation values. When attempting three-point evaluations, certain wells continually dominate the outcome and are inconsistent by comparison. Therefore, the use of water levels to derive the flow direction and rate is not recommended at this time.

Evaluation of groundwater chemistry provides another potential method for deriving approximate flow direction. This method was used for WMA C in FY 2007 (DOE/RL-2008-01). As discussed in Sections 9.1.1.7 and 9.1.3.3, the ion chemistry between wells along the west to south side of WMA C (299-E27-4, 299-E27-21, and 299-E27-23) have a distinct ion chemistry versus the wells to the east or west (Figure 9-23). The ion chemistry for the wells to the east and west (e.g., 299-E27-14 and 299-E27-155, respectively) have noticeably more calcium, chloride, magnesium, and sulfate than the wells mentioned above. Using the AEA constituent technetium-99 activities derived during depth-discrete sampling within the aquifer (as discussed in Section 9.1.3.1), a plume configuration was created (Figure 9-22). Figure 9-22 suggests a generally south to southeast flow direction. If the flow is to the southeast, it also follows that technetium-99 may have infiltrated from the vadose zone near wells 299-E27-4 and 299-E27-23. However, vadose zone investigations have not found evidence for significant vadose zone contamination in this area to support this conceptual model. Therefore, an alternative conceptual flow model is provided below.

The alternative (and not necessarily exclusive) conceptual model is based on the technetium-99 activity as compared with nitrate concentration in the wells along the west and southwest side of the C Tank Farm. The technetium-99 result was divided by the corresponding nitrate result to create a ratio at each well location for evaluation. Figure 9-24 provides a contour of the ratio results. The contours provide the basis for another model that conforms to the previous southwest flow direction interpretations at WMA C. Using this basis, the technetium-99 activities associated with the depth-discrete sample results at ~9 meters below the water table were recontoured (Figure 9-24). A bias is given to this conceptual model because of similar technetium-99 to nitrate ratios for wells along the eastern side of the C Tank Farm. The varying technetium-99 to nitrate ratios in wells to the southeast may also indicate more than one source of groundwater contamination from WMA C. Additional discussion on previous ratio evaluations at WMA C is provided in DOE/RL-2008-01.

Because no measurable gradient can be determined at WMA C, a flow rate is not provided. However, wells to the north and south of the C Tank Farm provide boundary conditions for the lateral extent of cyanide contamination. Wells to the south and southwest of C Tank Farm do not provide as clear of a definition for deriving the south lateral extent of cyanide contamination. Therefore, only an approximation of the extent of cyanide contamination to the south can be provided, and dashed contours are depicted in Figure 9-35 where bounding wells to the south are not present.
The vertical extent of cyanide contamination south of WMA C is the bottom of the aquifer where cyanide is observed in wells 299-E27-24 and 299-E27-155.

9.3.4.2 Groundwater Contaminants

This subsection discusses the analytical results for the dangerous waste constituent cyanide. Discussion is also included on the analytical methods approved to determine if dangerous waste constituents were present, the results of those analyses, and the rationale for exclusion of certain constituents.

During the reporting period, the dangerous waste constituent cyanide was detected in seven of the twelve network monitoring wells, all at levels far below the 200 µg/L DWS (Figure 9-35). Nondetect values were reported in three of the four wells with screen intervals in the upper 1.5 meters of the aquifer. The other nondetect values were in wells to the north and northeast (299-E27-22 and 299-E27-25). The highest concentrations, ranging from 17.5 to 38.7 µg/L, were in well 299-E27-7, located on the east side of WMA C. The next highest concentrations were in well 299-E27-14, located to the south of well 299-E27-7, ranging from 16.2 to 20.6 µg/L. Well 299-E27-14 is the only well screened in the upper 1.5 meters of the aquifer that detected cyanide; the cyanide concentrations in this well have also been trending upward since 2006, when mainly nondetect results were reported previously. Further south in new well 299-E27-24, analytical results indicated the highest concentrations in the lower portion of the aquifer during drilling; therefore, the well was screened in the lower 6.1 meters of the aquifer. Only one quarterly sample was collected from this well in 2010; the concentration reported in December was 15.3 µg/L, which is consistent with the concentration reported in this portion of the aquifer during drilling. Based on the time difference when cyanide was detected at wells 299-E27-7 and 299-E27-14, the dispersive front of cyanide should not have been as concentrated in well 299-E27-24, assuming a southwest flow direction. Thus, the flow direction may be changing to a more southward direction. Also, because higher concentrations are found in the lower portion of the aquifer at well 299-E27-24, contamination appears to be preferentially moving downward through the aquifer beneath WMA C. This is consistent with the vertical head differences between wells screened in the upper portion of the aquifer (e.g., 299-E27-4 and 299-E27-23) and well 299-E27-155 screened in the lower portion of the aquifer.

Cyanide concentrations also ranged from 5.2 to 8.43 µg/L in the lower portion of the aquifer at well 299-E27-155, located to the southwest of the C Tank Farm. This well is located ~290 meters southwest of well 299-E27-7 and has had consistent cyanide concentrations ranging between 4 and 8.43 µg/L since monitoring began in January 2008; thus, flow to the southwest appears to have occurred in the past. Because cyanide has been consistently detected in wells 299-E27-7, 299-E27-14, and 299-E27-155 the cyanide plume is shown as extending beyond these wells (Figure 9-35).

As approved in DOE/RL-2009-77, a common subset of constituents from two lists of potential COCs were used to determine if dangerous waste or dangerous waste constituents have impacted the groundwater. The lists used and rationale for selection of the contaminant of potential concern are discussed in Section 2.7 of DOE/RL-2009-77. Based on the resulting list of constituents (Appendix B, Tables B-31, B-32, B-33, and B-34), the following analytical analyses were performed to determine if dangerous waste or dangerous waste constituents were present in the groundwater at WMA C:

- SW-846, Method 8260, “Volatile Organics”
SW-846, Method 8270, “Semi-Volatile Organics”
EPA Method 8081 “Pesticides”
EPA/600 Method 200.8 and SW-845 Method 6010, “Metals”
EPA/600 Method 335.2 “Cyanide”
Sulfides-9030, “Sulfide”
EPA/600 Method 300.0, “Anions”
EPA Standard Method 2320 “Alkalinity.”

According to DOE/RL-2009-77, a minimum of two quarterly sampling events are necessary to determine whether a constituent should be excluded from the assessment. The sampling events occurred in December 2009 and March 2010. In accordance with the evaluation process, if questions arose regarding a potential dangerous waste or dangerous waste constituent, then additional samples would be collected. Since the assessment began in December 2009, eight volatile organics and ten metals were detected above site-wide background concentrations during quarterly sampling events, requiring further evaluation as possible dangerous waste or dangerous waste constituents. The following two paragraphs discuss the additional evaluation of these constituents. The remaining constituents were excluded per the evaluation process outlined in DOE/RL-2009-77. Thus, the currently applicable tables of constituents being collected and analyzed are provided in Appendix B, Tables B-31 and B-32.

Volatile organic compounds have been sampled four times since the assessment began, and samples continue to be taken and evaluated. Three of the eight volatile organics (e.g., bromomethane, chloromethane, and tetrachloroethane) were detected in blank samples at concentrations near the reported value, which was also near the detection limit, and are therefore not considered representative of groundwater contamination.

- Carbon disulfide was detected in two wells (299-E27-13 and 299-E27-155) at 0.07 and 0.12 µg/L, respectively. The result in well 299-E27-13 was the only detect value in four samples since the assessment began, and the result was within the error margin of the laboratory method detection limit (0.05 µg/L). The result for well 299-E27-155 was the only detected result during the assessment for this well, and it was also the only detection in nineteen samples from the previous 3 years; in addition, the duplicate result was nondetect. Therefore, both carbon disulfide results are considered false positives.

- Acetone was detected in two wells (299-E27-23 and 299-E27-155) at 1.90 and 5.60 µg/L, respectively. The result in well 299-E27-23 was the only detect value in six samples since the assessment began, and the result is considered a false positive because the duplicate result was nondetect. The detected result in well 299-E27-155 also had a duplicate result reported as nondetect. In addition, the detected value was the only detected value in nineteen samples over the past 3 years when this well was first installed. Therefore, both acetone results are considered false positives.

- The constituent 2-hexanone was detected in well 299-E27-155. The result at this well was the only detected value in nine samples over the previous 3 years, and the result is considered a false positive because the duplicate result was nondetect.

- Carbon tetrachloride was detected in well 299-E27-13 once in four samples since the assessment began. The result, 0.22 µg/L, is less than five times the laboratory method detection limit (0.06 to 0.012 µg/L) and is being evaluated.
• Chloroform was detected in three wells: 299-E27-12, 299-E27-24, and 299-E27-155. Two results were reported in well 299-E27-12 (e.g., 0.15 and 0.13 in March and August, respectively) and were within the error margin of the laboratory method detection limit (0.10 µg/L). One result of 0.13 µg/L was reported in well 299-E27-24 in December and was within the error margin of the laboratory method detection limit. Chloroform was also detected once at 0.16 µg/L in nineteen analyses from well 299-E27-155 during the previous 3 years and was within the error margin of the laboratory method detection limit. Chloroform is being retained for further evaluation during 2011 in accordance with DOE/RL-2009-77.

The evaluation process of the metals in accordance with DOE/RL-2009-77 is discussed below. Seven of the ten metals detected above background concentrations during the assessment period were associated with one or more of the following: unfiltered results, filtered results associated with elevated concentrations in the quality control blank, and/or results during drilling from an uncased well (e.g., 299-E27-24 and 299-E27-25). Therefore, these seven constituents were excluded from further consideration. Below is a discussion of the other three metals detected above background concentrations.

• Cobalt was detected once during the assessment period in well 299-E27-7, with a concentration of 5.6 µg/L. Although this value is above the Hanford Site background concentration, it is the only detected cobalt concentration above background in the monitoring network since assessment began and only the second detect reported value in 61 sample results over the past 10 years in this well. Therefore, this cobalt result is not considered representative of the groundwater.

• Filtered nickel results were reported above Hanford Site background in seven WMA C monitoring wells. The filtered results in upgradient well, 299-E27-22, was also reported above background. Although the highest concentration was not in the upgradient well, regional wells have shown higher results than this well. Therefore, nickel is continuing to be evaluated but is not considered to be a dangerous waste constituent associated with the C Tank Farm at this time.

• Filtered vanadium results were reported above Hanford Site background in all but two of the WMA C monitoring wells. The filtered results in the two upgradient wells, 299-E27-22 and 299-E27-25, were also reported above background. Although the highest concentration was not in the upgradient well, regional wells have shown comparable results with the highest value at WMA C. Therefore, vanadium is continuing to be evaluated but is not considered a dangerous waste constituent associated with the C Tank Farm at this time.

9.3.5 Liquid Effluent Retention Facility

D.C. Weekes

Located on the eastern boundary of the 200 East Area, the LERF consists of three lined surface impoundment basins. Construction of the complex was completed in 1991. The basins are arranged side by side, with 18.2-meter separation between each basin. The dimensions of each basin (cell) are 100.5 meters by 82.2 meters, with a maximum fluid depth of 6.7 meters.

The latest stratigraphic interpretation beneath the LERF was constructed from the four original and two additional boreholes drilled for the groundwater monitoring network. Correlations were also made with data from nearby sites. The thickness
of the sediments near the LERF basins is ~61 meters. Three principal stratigraphic units present near the LERF are the Hanford formation, the Ringold Formation, and the Elephant Mountain Member of the Saddle Mountains Basalt. The vadose zone beneath the LERF is in the Hanford formation and portions of the Elephant Mountain Member where it occurs above the water table, as well as potentially some of the Ringold Formation or a paleosol resulting from the weathering of the Elephant Mountain Member flow top near well 299-E26-11. Perched water table conditions are not observed near the LERF basins. The uppermost aquifer directly beneath the LERF consists of thin aquifer(s) in the Hanford formation and Elephant Mountain Member flow top. The aquifer in the Hanford formation is unconfined; however, recent analysis of water-level data for barometric pressure responses indicates that the aquifer near well 299-E26-11 is semiconfined. Well 299-E26-11 is still considered capable of yielding representative samples from the same hydrostratigraphic unit as the other three wells associated with the LERF groundwater monitoring program.

Groundwater at LERF continued to be monitored under RCRA final status permit conditions. The LERF is a RCRA-regulated unit under the Revised Code of Washington (RCW) 70.105 (“Hazardous Waste Management”) and is subject to groundwater monitoring requirements pursuant to WAC 173-303-645 (“Releases from Regulated Units”). The well network was sampled semiannually for RCRA indicator and site-specific parameters (PNNL-11620, Liquid Effluent Retention Facility Final-Status Groundwater Monitoring Plan).

9.3.5.1 Network Evaluation and Compliance Status

The current groundwater monitoring network consists of one upgradient well (299-E26-11) and three downgradient wells (299-E26-10, 299-E26-77, and 299-E26-79), which are sampled semiannually. The initial groundwater monitoring network was installed at the LERF in 1990 before final construction of the complex. During CY 2008, two additional monitoring wells (299-E26-77 and 299-E26-79) were installed to replace two original network wells that went dry. Well 299-E26-77 is west of the basins (near dry well 299-E26-9), and well 299-E26-79 is south of the western edge of Basin 43. The other two monitoring wells are well 299-E26-10 (in the southwestern corner of the unit) and upgradient well 299-E26-11 (at the eastern end of the unit). All monitoring wells are compliant with WAC 173-160 (“Minimum Standards for Construction and Maintenance of Wells”).

Work began in FY 2008 to better understand the groundwater flow direction beneath the LERF. Vertical elevation surveys and gyroscopic surveys were performed at three wells (299-E26-10, 299-E26-77, and 299-E26-79) in CY 2009 due to the flatness of the water table. Trend-surface analyses were applied to the measurements to determine gradient magnitudes and flow directions on two data sets: one data set without barometric corrections, and the second data set with barometric corrections. The two sets are very similar, so only the corrected set will be discussed. Since well 299-E26-11 is considered to be in the semiconfined aquifer and possibly not in direct hydraulic communication the other three wells, it shows ~0.8 meters higher head than the remainder of the wells and was excluded from the analyses. The semiconfined aquifer is in communication with the unconfined aquifer; however, it is a different hydrostratigraphic unit with different properties. Trend-surface analysis was performed for the three remaining wells in the network (exclusive of well 299-E26-11), and the data set corrected for barometric effects showed average groundwater flow direction to be south-southwest at 199 (±28) degrees and the average gradient magnitude was 2.6 x 10^-4 (±5.8 x 10^-4) m/m, with a calculated groundwater flow of ~0.02 meters per day (see Appendix B, Table B-1). This analysis
is similar to the CY 2009 groundwater flow direction of 199 degrees. The gradient magnitude increased from the CY 2009 value of $1.3 \times 10^{-4} \text{ m/m}$.

The uppermost aquifer beneath the LERF is being evaluated as part of a groundwater evaluation plan. This plan will be part of a revision of the LERF operating permit that will form the basis for future groundwater monitoring at the unit. The results from drilling new wells suggest that the fractured basalt flow top makes up the basal portion of the unconfined aquifer. One new borehole will be drilled on the north side of the LERF in CY 2011 to determine whether sufficient water is available for installing a well to further delineate groundwater flow direction. It is anticipated that the water table is present within the basalt flow top.

### 9.3.5.2 Groundwater Contaminants

The constituents currently monitored are alkalinity, gross alpha, ammonium, anions, gross beta, metals, phenols, and volatile organics. Nitrate, total organic halogen, total organic carbon, tritium, and gross alpha- and gross beta-emitting isotopes are COCs.

Analyses of samples collected during the reporting period indicate that all constituents in the permit were either undetected or below DWSs, except for nitrate. Specific conductance and sulfate results slightly increased in well 299-E26-10. Nitrate exceeds the DWS in wells 299-E26-10 and 299-E26-77, with maximum concentrations of 50.9 and 53.6 mg/L, respectively. Nitrate has been increasing in well 299-E26-10 since 2003 and in wells south and east of the LERF. The regional increase of anions and cations is evident in wells located in the central and eastern portions of the 200 East Area. Wells installed prior to LERF operations showed increasing nitrate from a regional plume.

### 9.3.6 216-B-63 Trench

**C.J. Martin**

Located southwest of LLWMA-2, the 216-B-63 Trench is one of three nonoperational TSD units in the 200-CS-1 Chemical Sewer OU that is currently undergoing closure negotiations. The 216-B-63 Trench is a regulated unit because it received nonradioactive dangerous waste regulated by 40 CFR 261 (“Identification and Listing of Hazardous Waste”) after November 19, 1980. The 216-B-63 Trench is regulated as a surface impoundment, as defined in WAC 173-303-040 (“Dangerous Waste Regulations,” “Definitions”).

The groundwater beneath the 216-B-63 Trench is monitored in accordance with WAC 173-303-400 and 40 CFR 265.93(b) to detect the impact of potential dangerous waste/dangerous waste constituent to groundwater. A revised and updated groundwater monitoring plan for this unit was issued in June 2010 (DOE/RL-2008-60, *Interim Status Groundwater Monitoring Plan for the 216-B-63 Trench*). The revised plan reduced the number of wells in the network from twelve to seven. Each well is sampled semiannually for contamination indicator parameters (i.e., pH, specific conductance, total organic carbon, and total organic halides) and annually for groundwater quality parameters (i.e., alkalinity, metals, phenols, and anions) and site-specific constituents (DOE/RL-2008-60). Appendix B, Table B-12 lists the network wells and the groundwater constituents monitored.

The 216-B-63 Trench was an open, unlined, manmade excavation, ~427 meters in length. The trench boundary is located at the southwestern perimeter of LLWMA-2 (218-E-12B Burial Ground) in the 200 East Area. During its operational period,
the trench was ~1.2 meters wide, with an average depth of 3 meters, and it had an earthen shielding berm and a side slope of ~10:6. Operations at the 216-B-63 Trench began on March 22, 1970, when it received cooling water from both B Plant and in-tank solidification unit #2. From May 1970 until February 1992, the trench also received B Plant chemical sewer effluent. A total of ~970,000 liters per day of total flow reached the trench. The regulated discharges constituted a minor portion of this flow (less than 1,900 liters per day). The 216-B-63 Trench was removed from service in 1992. Interim stabilization measures were completed at the trench in November 1994, and the site was permanently isolated by filling the weir box at the head end of the ditch with concrete on December 12, 1994.

From 1945 to 1995, groundwater flow direction and hydraulic gradients near the 216-B-63 Trench were highly influenced by hydraulic mounding associated with discharges to the 216-B-3 Pond. Decommissioning of the ponds resulted in a dramatic decline in groundwater elevations throughout the 200 East Area, which has in turn lead to a region of essentially flat groundwater gradients across the 200 East Area. This lack of appreciable gradient results in high uncertainty in the groundwater flow rate and direction. As discussed for LLWMA-2 (Section 9.3.2.1), determining a gradient and flow direction in this area is problematic for the reporting period, therefore these parameters are considered indeterminate at the 216-B-63 Trench.

### 9.3.6.1 Network Evaluation and Compliance Status

The interim status monitoring requirements of 40 CFR 265, Subpart F and WAC 173-303-400 require upgradient and downgradient monitoring wells that ensure immediate detection of any statistically significant change in concentrations (e.g., above the statistically derived critical mean for the four indicator parameters) of dangerous waste or dangerous waste constituents at the limit of the TSD unit within the uppermost aquifer. These requirements also include an annual evaluation of the monitoring network to determine if it remains adequate to monitor the unit. The current network consists of seven wells that essentially surround the unit. This subsection discusses if the network remains capable of monitoring the 216-B-63 Trench in accordance with these requirements.

Based on the current configuration of the monitoring network, the wells remain capable of detecting potential releases from the 216-B-63 Trench, regardless of the groundwater flow direction. Because the wells essentially surround the unit and are all sampled on the same frequency and for the same constituents, when a flow direction is determined, the wells to be used for the specified upgradient/downgradient comparisons can be selected. Critical means for use during 2011 (Appendix B, Table B-13) were determined using upgradient wells based on historical flow directions.

To date, no dangerous waste subject to WAC 173-303 from the 216-B-63 Trench has contaminated groundwater; therefore, the site will continue in an interim status indicator evaluation monitoring program for the upcoming year. During CY 2010, all groundwater samples were collected and analyzed as scheduled, with the exception of the final sample from well 299-E27-16, as noted below.

A revised and updated monitoring plan (including the well network, COCs, sampling and analysis procedure, and a conceptual model) was completed and issued in June 2010.
9.3.6.2 Groundwater Contaminants

As required in accordance with WAC 173-303-400 and RCRA (40 CFR 295.93[b]) in regard to interim status facility indicator parameter monitoring, the required indicator parameters (i.e., pH, specific conductance, total organic carbon, and total organic halides) are statistically compared between upgradient and downgradient wells using the most recent data. No statistical comparison values for any of the indicator parameters were exceeded at the 216-B-63 Trench during the reporting period.

Groundwater samples were collected and analyzed as scheduled in CY 2010 at all seven wells monitoring the 216-B-63 Trench, with the exception of the final sample from well 299-E27-16. A site-wide sampling stop work went into effect on September 27, 2010, and was completely lifted by November 8, 2010. This work stoppage impacted all groundwater sampling at the site. Six of the seven wells had been sampled before a RCRA recovery plan could be implemented. By the time the plan was implemented, the CY had ended, thus negating the ability to collect the second semiannual sample from this well.

The groundwater beneath the 216-B-63 Trench is monitored for detection of dangerous waste/dangerous waste constituent impact to groundwater. The seven wells in the groundwater monitoring network are sampled semiannually for contamination indicator parameters (i.e., pH, specific conductance, temperature, total organic carbon, and total organic halides). Required groundwater quality parameters (i.e., alkalinity, metals, phenols, and anions) are monitored annually (DOE/RL-2008-60). Additional parameters (i.e., dissolved oxygen, temperature, and turbidity) are measured as indicators of sample quality and general aquifer/well environmental conditions. Appendix B, Table B-12 provides a list of wells in the monitoring network, their locations, and the groundwater constituents monitored. Water-level measurements are taken before each sampling event.

Specific conductance is the only required parameter showing a trend. Specific conductance continues to increase, which is consistent with corresponding increases in major cations (e.g., calcium, magnesium, potassium, and sodium) and anions (e.g., chloride and sulfate) throughout the region. Well 299-E27-9, which is the furthest away from the actual trench, shows the most rapid increase. The increases associated with well 299-E27-9 are discussed in Section 9.3.2.2.

Concentrations of the indicator parameters remained steady in CY 2010. Total organic carbon and total organic halides were undetected in all network wells, with the exception of well 299-E34-10. Concentrations of both constituents in this well were just above the detection limit.

During the reporting period, no detected constituents were above their respective DWSs. No evidence of dangerous waste/dangerous waste constituents impacting groundwater was detected at the 216-B-63 Trench during CY 2009.

9.4 Conclusions and Recommendations

The conclusions and recommendations for the 200-BP-5 OU are presented in the following subsections.

9.4.1 Conclusions

Other than expansion of the nitrate plume south of LLWMA-2, no significant changes in the distribution of the ten contaminant plumes within the 200-BP-5 OU were observed during the monitoring period. This is mainly because groundwater
within the northern portion of the 200 East Area moves slowly. Eleven additional conclusions are as follows:

- The TEDF discharges during CY 2010 were associated with increased water levels across the 200 East Area and a statistically significant north groundwater flow gradient at LLWMA-1. The periodic TEDF discharges slow the southeast flow from the 200 East Area (Figure 9-5). Consequently, flow in the northwest corner of the 200 East Area diverted more prominently toward Gable Gap. An indicator of this result was the increased flow rate between wells 299-E33-26 and 299-E33-38, located at the BY Cribs and extending to the northwest. The flow between these two wells reverted back to the north in 2009 after a flow reversal in 2008. Between 2009 and 2010, the average flow rate was calculated at ~0.75 meters per day. The longevity of this pathway to Gable Gap is questionable due to the decreasing water levels and the decreasing aquifer thickness (Section 9.1.1.1). Although the aquifer thickness is questionable, the influence of this pathway to divert water to the north appears to reach the southern portion of B Plant.

- In the north-central and northeast portion of the 200 East Area, flow measurement methods indicate that groundwater flow is likely less than 0.1 meter per day.

- Groundwater monitoring within the 200 East Area has helped to identify areas where continuing contaminant infiltration from the vadose zone is impacting the groundwater. Contaminant infiltration at the following sites and associated contaminants are either confirmed or highly probable. (Note that B Pond and Gable Mountain Pond, which are both inactive, remain as contributors but are not summarized below.)
  - BY Cribs: Current cyanide, nitrate, sulfate, technetium-99, and tritium.
  - 241-BX-102 unplanned release: Current nitrate, technetium-99, uranium, and possibly iodine-129. The main source of iodine-129 in the 200-BP-5 OU appears to be associated with sites in the 200-PO-1 OU during the late 1980s and early 1990s, when the flow divide was further south.
  - 216-B-57 Crib: Current contributor of nitrate and tritium.
  - 216-B-8 Crib: Current contributor of nitrate with elevated chromium.
  - 216-B-7A&B Cribs: Current contributor of nitrate.
  - WMAC: Current contributor of cyanide, nitrate, sulfate, and technetium-99.
  - 216-B-2 Ditches: Current contributor of nitrate and sulfate.
  - 216-B-12 Crib: Past contributor of nitrate, tritium, and uranium.

- Contaminants associated with high specific gravity wastes have apparently sunk through the aquifer in the past at well 299-E33-12. Depth-discrete sampling and analysis of groundwater near the BY Cribs and south of the BX Tank Farm found higher concentrations of several contaminants/constituents at depth (i.e., cyanide, chloride, nitrate, sulfate, and technetium-99). The depth-discrete results, although not conclusive, indicate possible density-type transport of various contaminants as far as the south side of the BX Tank Farm. This conclusion is based on the northern flow direction in this area and the lack of a known source of contaminant infiltration to the south.
• Depth-discrete sample results near WMA C found higher concentrations of several contaminants/constituents at depth. Unlike the possible density theory at the B Complex, the deep contamination at WMA C appears to be associated with a downward gradient based on the much lower head in well 299-E27-155 than the head in wells 299-E27-4 and 299-E27-23 screened higher in the aquifer (Section 9.3.4.1).

• Well 699-53-55A, located west of Gable Mountain Pond, appears to be poorly sealed and does not provide samples representative of groundwater in the Rattlesnake Ridge Interbed or upper Pomona basalt.

• Directly north of Gable Gap, groundwater seems to be moving very slowly or is stagnant near wells 699-64-62 and 699-66-64. Tritium activity has essentially decreased in accordance with the decay rate over the past 8 to 10 years in these wells. North and east of Gable Gap, however, preferential migration of tritium is apparent along the north side of Gable Mountain and to the northeast. This is based on the slight increase over the past 6 years in well 699-67-51, which was reported at 1,810 pCi/L in October 2004 and by November 2010 had increased to 2,600 pCi/L.

• None of the data from the RCRA TSD units in interim indicator evaluation monitoring suggested an impact to the groundwater during CY 2010. Indicator parameter results did not indicate a significant increase (above the critical mean), with one exception. The specific conductance critical mean was exceeded at LLWMA-1, but the increase is associated with an upgradient source; therefore, the status remains the same. In addition, the monitoring networks were determined to be satisfactory in all but one of the RCRA sites. The one exception was the LERF site, where an additional well is planned for installation in 2011.

• Cyanide was determined to be a dangerous waste constituent in groundwater that has a source at the C Tank Farm. The assessment of other constituents is continuing in accordance with DOE/RL-2009-77.

• Tri-Party Agreement Milestone M-015-082 was achieved with submittal of Draft A of the 200-BP-5 OU treatability test plan (DOE/RL-2010-74). Two test sites were identified to evaluate the practicality of implementing a groundwater pump-and-treat system for the extraction of uranium and technetium-99 contaminant plumes near WMA B-BX-BY. The test is planned for early to mid-FY 2012 (based on available funding).

9.4.2 Recommendations

The recommendations listed below are based on the evaluation of contaminant trends, data from new RI wells, spatial examination of contaminants, and evaluation of corrected groundwater-level measurements locally and regionally:

• Revise the 200-BP-5 OU sampling and analysis plan (DOE/RL-2001-49) to achieve the following:
  – Modify the sampling and analysis requirements for distal wells monitoring sources associated with low mobility contaminants. This will include reducing the monitoring frequency for contaminants such as cesium-137, plutonium-239/240, and strontium-90.
  – Include ion chemistry in key wells as an alternative means for evaluating flow direction. The major ions will be used (Section 9.1.1.2).
  – Incorporate key new 200-BP-5 RI wells.
– Update well list by removing decommissioned wells.
– Provide a new conceptual model based on revisions to the geologic framework.
– Propose new well locations for refinement of plume configuration.
– Include radionuclides that have been removed from RCRA monitoring plans.
• Decommission well 699-53-55A because it appears to be poorly constructed and provides a possible pathway for contaminant migration near the base of the Rattlesnake Ridge interbed.
Table 9-1. Monthly Corrected Groundwater Elevations in Northwest Corner of 200 East Area Used to Derive Groundwater Flow Direction and Rate

<table>
<thead>
<tr>
<th>Well Name</th>
<th>1/21/10</th>
<th>2/25/10</th>
<th>3/8/10 and 3/16/10</th>
<th>4/29/10</th>
<th>5/23/10</th>
<th>6/30/10</th>
<th>7/13/10</th>
<th>8/10/10</th>
<th>9/15/10</th>
<th>1/4/11</th>
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<tr>
<td>299-E33-38*</td>
<td>121.9042</td>
<td>121.8682</td>
<td>121.8822</td>
<td>121.9372</td>
<td>121.8522</td>
<td>121.8512</td>
<td>121.8492</td>
<td>121.8332</td>
<td>121.8442</td>
<td>121.8532</td>
</tr>
<tr>
<td>299-E33-34*</td>
<td>121.8801</td>
<td>121.8631</td>
<td>121.8611</td>
<td>121.8401</td>
<td>121.8451</td>
<td>121.8501</td>
<td>121.8441</td>
<td>121.8331</td>
<td>121.8461</td>
<td>121.8501</td>
</tr>
</tbody>
</table>

| Difference in elevation* | 0.0241 | 0.0051 | 0.0211 | 0.0971 | 0.0071 | 0.0011 | 0.0051 | 0.0001 | -0.0019 | 0.0031 |
| Distance between wells* | 509 | 509 | 509 | 509 | 509 | 509 | 509 | 509 | 509 | 509 |
| Monthly gradient calculation (elevation over distance) | 4.73E-05 | 1.00E-05 | 4.145E-05 | 1.91E-04 | 1.395E-05 | 2.16E-06 | 1.002E-05 | 1.965E-07 | 1.965E-07 | 3.733E-06 | 6.090E-06 |
| Estimated direction | Northwest | Northwest | Northwest | Northwest | Northwest | Northwest | Northwest | Indeterminant | Southeast | Northwest |

Range in gradient -3.73E-06 to 1.96E-07
Gradient range (after removing the two highest and lowest) 1.00E-05 to 2.16E-06
Average of the six remaining gradients 2.083E-05
Average groundwater flow rate 0.781

Notes:

1. Yellow-shaded cells indicate the two highest and lowest monthly gradients.
2. Calculation used to derive average groundwater flow rate: \[ V = \frac{K(h_1 - h_2)L}{n} \]
   where:
   \( V \) = average groundwater flow
   \( K \) = hydraulic gradient (7500 m)
   \( h_1 \) = upgradient groundwater elevation
   \( h_2 \) = downgradient groundwater elevation
   \( L \) = distance between wells
   \( n \) = porosity (0.2).
3. \( (h_1-h_2)/L \) = average of remaining gradients from above.

* All values are in meters.
Figure 9-1. Boundaries of 200-BP-5 Groundwater Operable Unit and Adjacent Operable Units
Figure 9-2. Facilities and Groundwater Monitoring Wells in 200-BP-5 Operable Unit Portion of 200 East Area

- Monitoring Well in CY 2006 - 2010
- Decommissioned Well
- Well prefix ‘299’ omitted
- B - B’ Cross Section for Section 9.1.1.1
- C - C’ Cross Section for Section 9.1.1.2
- Waste Site
- Facility
- Former Operational Area
- Groundwater Operable Unit
- Basalt Above Water Table
- Mud Unit Above Water Table

Legend:
- B - B' Cross Section for Section 9.1.1.1
- C - C' Cross Section for Section 9.1.1.2
- Waste Site
- Facility
- Former Operational Area
- Groundwater Operable Unit
- Basalt Above Water Table
- Mud Unit Above Water Table

Scale:
- 0 0.1 0.2 0.3 0.4 mi
- 0 0.2 0.4 0.6 km

gwf10232
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Figure 9-3. Facilities and Groundwater Monitoring Wells in 600 Area Associated with 200-BP-5 Operable Unit
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Figure 9-4. 200 East Area Water Table Map, March 2010
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Figure 9-5. Comparison of Treated Effluent Disposal Facility Discharges with 200 East Area Groundwater Elevations
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Figure 9-6. Low-Level Waste Management Area 1 Historical Trend Surface Results and Associated Azimuth Directional Vectors

**LLWMA-1 Trend Surface Results**

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<td>0.060</td>
<td>No</td>
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<td>336</td>
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**Averages:** 8.2E-06  338

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<td>1.1E-05</td>
<td>002</td>
<td>0.144</td>
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Figure 9-7. Average Groundwater Nitrate Concentrations in 200 East Area and 600 Area in 200-BP-5 Operable Unit, CY 2010
Figure 9-9. Cross Section B-B’ of the B Complex Conceptual Model Density Plume for Nitrate

Legend:
- 371 Nitrate concentrations in mg/L
- ▼ Groundwater surface
- ▼ Groundwater flow direction
- Color gradient reflective of nitrate concentration
- Grout plug
- Well screen

Basalt
Hanford/Cold Creek Sediments
299-E33-1A
299-E33
299-E33-342
299-E33-9
299-E33-205
299-E33-49
241-BY Tank Farm
241-BY Tank
BY Crib
216
1131
761
1540
371
40.8
54
371
North
South
This page intentionally left blank.
Figure 9-9. Cross Section L2-L2′ of the Nitrate Plume and Top of Basalt Conceptualization from the B Complex to the Gable Gap.
Figure 9-10. Comparison of Historical Groundwater Elevation Trends for Wells 299-E33-18 and 699-60-60

Replicate data averaged. The nitrate DWS (10 mg/L NO₃-N) is shown expressed as nitrate ion (45 mg/L NO₃⁻).
Figure 9-12. Cross Section C-C' for the Nitrate Distribution Conceptual Model for Wells 299-E28-18, 299-E28-26, and 299-E28-30
Figure 9-13. Nitrate Trend Results for Wells 299-E28-9 and 299-E28-16
Figure 9-14. 450 mg/L Nitrate Contour Near Well 299-E28-30 at Approximately 7 meters Below Groundwater Table
Figure 9-15. Cross Section A-A’ of the Nitrate Contaminant Portrayal Through Wells 699-50-53A to 699-53-55A
Figure 9-16. Nitrate Trend Plot at Waste Management Area C Monitoring Well 299-E27-14

- Replicate data averaged

Collection Date

Nitrate, mg/L

Jan-90 Jan-92 Jan-94 Jan-96 Jan-98 Jan-00 Jan-02 Jan-04 Jan-06 Jan-08 Jan-10 Jan-12

299-E27-14
Figure 9-17. Average Groundwater Iodine-129 Concentrations in 200 East Area and 600 Area in 200-BP-5 Operable Unit, CY 2010

Iodine-129 In The Upper Unconfined Aquifer, CY 2010
- Well Sampled in CY 2010
- Well Sampled in CY 2009
- Well Sampled in CY 2008
U= Undetected
* = Mixed Detects and Nondetects
- Iodine-129, pCi/L (Dashed Where Inferred)
- DWS = 1 pCi/L

Legend:
- Waste Site
- Facility
- Former Operational Area
- Groundwater Operable Unit
- Mud Unit Above Water Table
- Basalt Above Water Table

Figure 9-17: Map showing average groundwater iodine-129 concentrations in 200 East Area and 600 Area in 200-BP-5 Operable Unit, CY 2010. The map includes various symbols representing different locations and concentrations, with a legend for interpretation.
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Figure 9-18. Average Groundwater Technetium-99 Concentrations in 200 East Area and 600 Area in 200-BP-5 Operable Unit, CY 2010

Technetium-99 in The Upper Unconfined Aquifer, CY 2010
- Well Sampled in CY 2010
- Well Sampled in CY 2009
- Well Sampled in CY 2008

Technetium-99, pCi/L
(Dashed Where Inferred)
DWS = 900 pCi/L
* = Mixed Detects and Nondetects
U = Undetected

Waste Site
Facility
Former Operational Area
Groundwater Operable Unit
Mud Unit Above Water Table
Basalt Above Water Table

Legend:

Legend: Waste Site, Facility, Former Operational Area, Groundwater Operable Unit, Mud Unit Above Water Table, Basalt Above Water Table.

Legend: Waste Site, Facility, Former Operational Area, Groundwater Operable Unit, Mud Unit Above Water Table, Basalt Above Water Table.

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Figure 9-19. Groundwater Elevation Comparison Between the Confined and Unconfined Aquifers
Figure 9-20. Technetium-99 Trend Plot Between Wells 299-E33-41, 299-E33-339, and 299-E33-343
Figure 9-21. Trend Plot Comparison of Technetium-99 Between Wells 299-E33-26 and 299-E33-38
Figure 9-22. Map View of the Interpreted Technetium-99 Plume Associated with Depth-Discrete Sample Results at 3.05 and 9.14 meters Beneath Water Table Southwest of Waste Management Area C

3.05 Meters Below Top of Water Table

9.14 Meters Below Top of Water Table
Figure 9-23. Comparison of Ion Chemistry for Five Waste Management Area C Wells
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Figure 9-24. Technetium-99 to Nitrate Ratio Contour Map at WMA C and Alternative Technetium-99 Contour Plume Map at WMA C
Figure 9-25. Average Groundwater Uranium Concentrations in 200 East Area and 600 Area in 200-BP-5 Operable Unit, CY 2010
**Figure 9-26. Average Groundwater Strontium-90 Concentrations in 200 East Area and 600 Area in 200-BP-5 Operable Unit, CY 2010**

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<td>▼ Well Sampled in CY 2008</td>
</tr>
<tr>
<td>* = Mixed Detects and Nondetects</td>
</tr>
<tr>
<td>U = Undetected</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Strontium-90, pCi/L (Dashed Where Inferred)</td>
</tr>
<tr>
<td>DWS = 8 pCi/L</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Waste Site</td>
</tr>
<tr>
<td>Facility</td>
</tr>
<tr>
<td>Former Operational Area</td>
</tr>
<tr>
<td>Basalt Above Water Table</td>
</tr>
</tbody>
</table>

![Map of Strontium-90 Concentrations](image)

Gable Mountain Pond

**Legend:**
- 0 0.25 0.5 km
- 0 0.1 0.2 0.3 mi

- LLWMA-1
- LLWMA-2
- BY Cribs
- 216-B-8 Crib
- 216-B-7 A&B Cribs
- WMA B-BX-BY
- 216-B-57 Crib
- 216-B-63 Trench
- L 0.35
- R 0.32
- G 1.8
- H 1.6
- I 1.2
- J 0.2

- 2.5U
- 3.2U
- 4.8U
- 3.6U
- 3.0U
- 2.2U
- 1.6U
- 1.2U
- 0.2

- 0 80
- 100
- 120
- 140
- 160
- 180
- 200
- 220
- 240
- 260

- 0 80
- 100
- 120
- 140
- 160
- 180
- 200
- 220
- 240
- 260

- 0 2 4 6 mi

- 0 2 4 6 mi

- 0 1.7
- 3.5
- 4.2
- 4.9
- 5.0

- 5.0U
- 3.2U
- 1.1U
- 0.3U

- 350
- 360
- 370
- 380
- 390
- 400
- 410
- 420
- 430

- -0.24
- 0.35

- 350
- 360
- 370
- 380
- 390
- 400
- 410
- 420
- 430

- 4.9U
- 2.2U
- 1.1U
- 1.1U

- 3.2U
- 1.1U
- 1.1U

- 350
- 360
- 370
- 380
- 390
- 400
- 410
- 420

- 0.3U

- 3.9U
- 4.8U
- 3.6U
- 3.2U
- 3.6U
- 3.2U
- 3.6U
- 3.2U

- 350
- 360
- 370
- 380
- 390
- 400
- 410
- 420

- 4.9U

- -0.78
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Figure 9-27. Average Groundwater Cyanide Concentrations in 200 East Area and 600 Area in 200-BP-5 Operable Unit, CY 2010
Figure 9-28. Average Groundwater Tritium Concentrations in 200 East Area and 600 Area in 200-BP-5 Operable Unit, CY 2010
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Figure 9-29. Average Groundwater Sulfate Concentrations in 200 East Area and 600 Area in 200-BP-5 Operable Unit, CY 2010
Figure 9-30. Trend Plot of Wells 299-E27-10 and 299-E34-7

Replicate data averaged

Sulfate, unfiltered, mg/L

Collection Date

Jan-95 Jan-97 Jan-99 Jan-01 Jan-03 Jan-05 Jan-07 Jan-09 Jan-11

299-E27-10

299-E34-7
Figure 9-31. 216-E-10 Burial Ground Site Map and LLWMA-1 Well Network
Figure 9-33. Ion Chemistry for Groundwater Sample at Well 299-E34-13
Figure 9-34. Trends of Selected Anions and Metals for Well 299-E33-47

Concentration, Anions (mg/L) and Metals (µg/L)

- Chloride
- Nitrate
- Sulfate
- Barium
- Vanadium
- Sodium
- Calcium
- Specific Conductance

Collection Date

Concentration, Calcium (µg/L) and Conductance (µS/cm)

Jan-04  Jan-05  Jan-06  Jan-07  Jan-08  Jan-09  Jan-10  Jan-11
Figure 9-35. Interpreted Extent of Detectable Cyanide at Waste Management Area C

Cyanide In The Upper Unconfined Aquifer, CY 2010
- Well Sampled in CY 2010
- Cyanide, µg/L
  - 4 µg/L Detection Limit
  - DWS = 200 µg/L
- * = Mixed Detects and Nondetects
- U = Undetected

- Waste Site
- Facility
- Former Operational Area
- Groundwater Operable Unit
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