8.0 Confined Aquifers

C. J. Martin

This chapter describes groundwater flow and groundwater quality within the Ringold confined aquifer and the upper basalt-confined aquifer systems. The Ringold confined aquifer exists beneath much of the Hanford Site, including the 100 and 300 Areas, but it has been described only for the 200 Areas of the Central Plateau because few wells monitor this aquifer outside of this region. The upper basalt-confined aquifer system has also been identified beneath much of the Hanford Site, but it is monitored primarily in the area south of Gable Butte and Gable Mountain.

Information in this chapter covers the period from October 1, 2008, through December 31, 2009. The following date conventions are used throughout this report:

- Fiscal year (FY) 2009: Refers to the fiscal year named (i.e., October 1, 2008, to September 30, 2009).
- Calendar year (CY) 2009: Refers to the calendar year named (i.e., January 1, 2009, to December 31, 2009).
- Reporting period: Refers to the entire 15-month reporting period covered in this report (i.e., October 1, 2008, to December 31, 2009).

Intercommunication between the unconfined aquifer and the underlying upper basalt-confined aquifer system is an important consideration for environmental cleanup activities at the Hanford Site. To establish final Records of Decision for the various groundwater operable units (OUs), the nature and extent of contamination in the groundwater must be understood within a specified degree of uncertainty. This necessarily includes assessing the degree to which the upper basalt-confined aquifer system has been affected by groundwater plumes from the unconfined aquifer. Several studies have been conducted regarding communication between these aquifers, and the following discussion provides a brief summary of the current understanding on this topic. *Hanford Site Groundwater Monitoring for Fiscal Year 2007* (DOE/RL-2008-01) discusses this topic in detail and provides an analysis of the potential for aquifer intercommunication on the Hanford Site.

Intercommunication between the upper basalt-confined aquifer and the overlying unconfined aquifer systems may occur where there is a pathway for the movement of water, as well as a difference in hydraulic head between the two systems. An area of intercommunication between the unconfined and upper basalt-confined aquifer systems was first identified in the northern portion of the 200 East Area (RHO-BWI-ST-5, *Hydrologic Studies Within the Columbia Plateau, Washington: An Integration of Current Knowledge*). Intercommunication between the unconfined and confined aquifers in this region is attributed to erosion of the upper Saddle Mountains Basalt and a downward hydraulic gradient that resulted from groundwater mounding associated with past wastewater disposal to receiver ponds in the area (namely the 216-B-3 and Gable Mountain Ponds). However, the groundwater mound beneath Gable Mountain Pond has dissipated completely, and the mound beneath the 216-B-3 Pond has diminished significantly (over 3 meters) since discharges ceased in 1984.

Additional studies (including PNL-10817, *Hydrochemistry and Hydrogeologic Conditions Within the Hanford Site Upper Basalt Confined Aquifer System*; RHO-ST-38, *Geohydrology of the Rattlesnake Ridge Interbed in the Gable Mountain Pond Area*; and RHO-RE-ST-12P, *An Assessment of Aquifer Intercommunication in*

the B Pond-Gable Mountain Pond Area of the Hanford Site) have delineated areas of erosion in the basalt extending from Gable Gap across the northern portion of the 200 East Area to B Pond. It should be noted that the extent of this area of erosion does not encompass Gable Mountain Pond, but the western lobe of B Pond overlies the area where the Elephant Mountain Basalt has been partially removed by erosion (Figure 8-1).

Another location where intercommunication between aquifers is known to have occurred is centered on well 299-E33-12 in the northwestern portion of the 200 East Area. This well was drilled in 1953 into the Pomona Basalt underlying the Rattlesnake Ridge interbed and was uncased from just above the bottom of the unconfined aquifer through the Rattlesnake Ridge interbed (DOE/RL-2008-1). Contamination is believed to have migrated from the unconfined aquifer, down the open borehole, to the Rattlesnake Ridge interbed (DOE/RL-2008-1). This well was sealed from the unconfined aquifer in the early 1980s, with an additional seal placed in the well that shortened the open interval in 1990. Cyanide, nitrate, technetium-99, and tritium continue to be elevated in this well (see Section 8.2.2).

8.1 Ringold Formation Confined Aquifer

Groundwater quality in the Ringold Formation confined aquifer is monitored to evaluate any impact to the groundwater and to identify potential downward migration of contaminants from the overlying unconfined aquifer.

Confined, water-bearing units are present in the Ringold Formation at various locations within the Hanford Site. The most widespread Ringold confined aquifer is where the lower most sediments of Ringold Unit 9 are overlain by the Ringold lower mud unit. In the 100-HR-3 OU, a locally confined aquifer that occurs beneath the Ringold upper mud is being studied (see Chapter 16.0 in Volume 2).

Another locally confined aquifer occurs within fluvial sand and gravel comprising the lowest sedimentary unit of Ringold Unit 9 (Figure 3-2 in Chapter 3.0). This aquifer is confined between the top of the uppermost basalt and by the bottom of the lower mud unit. Where Unit 9 is overlain by fine-grained units, confined conditions generally exist. Where Unit 9 is absent beneath the lower mud unit, limited vertical groundwater flow may occur. This confined aquifer is of concern because of its location relative to contamination sources in the 200 East Area. Wells completed in the lower portion of the unconfined aquifer above the lower mud unit in regions where Unit 9 is absent provide information on the distribution of contaminants in the lowermost portion of the unconfined aquifer system.

Approximately 29 wells/piezometers are currently used to monitor the Ringold confined aquifer on the Hanford Site. Of these wells/piezometers, sixteen are used for water-level monitoring and have either one or no chemical analysis results; the remaining thirteen have regular analytical results. Five of the thirteen wells/piezometers were sampled in CY 2009.

8.1.1 Groundwater Flow in the Ringold Confined Aquifer

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Figure 8-2 presents the interpreted potentiometric surface for a portion of the Ringold confined aquifer. This map is subject to uncertainty because only a few wells monitor this aquifer. However, generalized flow patterns can be inferred from

available data when the hydrogeologic framework (i.e., extent of the confined unit, presence of basalt subcrops, and influence of the May Junction Fault) is considered.

Groundwater flow in the Ringold confined aquifer is generally west to east near the 200 West Area and along the southern boundary of the aquifer near the Rattlesnake Hills. This flow pattern indicates that recharge occurs west of the 200 West Area in upgradient areas within the Cold Creek Valley, as well as in the Dry Creek Valley and possibly the Rattlesnake Hills. Near the 200 East Area, flow in the Ringold confined aquifer converges from the west, south, and east before discharging to the unconfined aquifer where the lower mud unit is absent (BHI-00184, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*). This water is thought to flow southeast over the top of the confined unit (PNNL-15479*, Groundwater Monitoring Plan for the Hanford Site 216-B-3 Pond RCRA Facility*), although the exact location of the division between northwest and southeast flow within the 200 East Area unconfined aquifer has not been well established. Near the 200 East Area, water-level elevation data from piezometers 299-E25-32P and 299-E25-32Q (used to monitor different depths in the unconfined aquifer) indicate a slight upward gradient along the confined unit boundary. This upward gradient is consistent with discharge of groundwater from the confined aquifer to the overlying unconfined aquifer.

As a remnant of past wastewater discharges to the 216-B-3 Pond (B Pond) artificially elevated water levels are present in the Ringold confined aquifer to the northeast of this facility, which causes a southwest flow beneath B Pond to the 200 East Area. Eastward flow away from the region of elevated water levels does not occur; the May Junction Fault, located east of the B Pond area, is thought to be a hydrologic barrier preventing flow to the east (BHI-00184). South of the B Pond area, the flow of water divides, with some flow moving northwest toward the 200 East Area and some flow moving east or southeast. The exact location of the flow divide is not known due to a lack of water-level data in this area and a need to define the southward extent of the May Junction Fault.

The potentiometric contours for the Ringold confined aquifer (Figure 8-2) are similar to the potentiometric surface contours for the upper basalt-confined aquifer system, indicating that flow patterns in the central portion of the Hanford Site are similar in both aquifers. Basalt bedrock from the topographic low at Gable Gap near the 200 East Area was eroded significantly by late Pleistocene catastrophic flooding (RHO-BWI-LD-5, *Geology of Gable Mountain – Gable Butte Area*), which facilitates intercommunication between the unconfined and confined aquifers. The 200 East Area is a discharge area for both of the confined aquifers, which explains the similar flow patterns.

Water levels declined in the Ringold confined aquifer from March 2008 to March 2009. The decline in individual wells ranged from 0.02 to 0.31 meters within the aquifer and up to 0.27 meters in the 200 West Area along the boundary between the confined and unconfined aquifers. The potentiometric surface is responding to the reduction of liquid effluent discharges to the ground since the discharge volumes peaked in the mid-1980s.

8.1.2 Groundwater Quality in the Ringold Confined Aquifer

The 200 Areas of the Central Plateau and the area near the inactive B Pond system are two known areas where conditions may allow contamination to migrate from the unconfined aquifer into the Ringold confined aquifer. Groundwater chemistry data for the Ringold confined aquifer are limited to wells north of the 200 Areas and near

B Pond, and in the 300 Area. During CY 2009, five wells completed in the Ringold confined aquifer were sampled (Figure 8-3). Table 8-1 provides data for selected contaminants of interest.

Iron and manganese are the only metals to exceed DWSs in the Ringold confined aquifer.

Iron and manganese were the only contaminants detected above their respective secondary drinking water standards (DWSs) (300 µg/L [filtered] and 50 µg/L [filtered], respectively) for wells completed in the Ringold confined aquifer. Only well 699-S29-E16C had iron concentrations above the secondary DWS. The first sample of this well for metals since 1995 (when all constituents were below regulatory limits) occurred in FY 2008. This well is located at the southern end of the 300 Area. Wells 699-S29-E16C, 399-1-9, 399-1-16C, 699-S22-E9C, and 699-S27-E9C (all located in the 300 Area) had manganese concentrations above the secondary DWS of 50 µg/L. Since both iron and manganese are common soil minerals and neither are contaminants of concern in the 300 Area are detected in these wells, the elevated concentrations of these two constituents are likely the result of local groundwater/soil interactions than contamination from Hanford Site operations. These two constituents are also major components of well casing material and may simply reflect long-term degradation (rusting) of the well casing.

Other detected contaminants potentially associated with Hanford Site operations include tritium in well 699-45-42 near B Pond, and uranium in wells 399-1-9 and 399-1-17C in the 300 Area. Concentrations measured during the reporting period were consistent with previous results. Tritium shows a long-term declining trend, while uranium concentrations increased in both wells.

8.2 Upper Basalt-Confined Aquifer System

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Groundwater quality in the upper basalt-confined aquifer system is monitored due to the potential for downward migration of contaminants from the overlying unconfined aquifer. Contaminants that reach the upper basalt-confined aquifer system may have the potential to migrate through the aquifer to areas off the Hanford Site. The upper basalt-confined aquifer system is also monitored to assess the potential migration of contaminants onto the Hanford Site from offsite sources. PNL-10817 and *Groundwater Chemistry and Hydrogeology of the Upper Saddle Mountains Basalt-Confined Aquifer South and Southeast of the Hanford Site* (PNNL-14107) provide additional information on the potential for contaminants to migrate off the Hanford Site.

Within the upper basalt-confined aquifer system, groundwater occurs within basalt fractures and joints, interflow contacts, and sedimentary interbeds within the upper Saddle Mountains Basalt (Figure 3-2 in Chapter 3.0). The thickest and most widespread upper sedimentary unit in this system is the Rattlesnake Ridge interbed, which is present beneath a large area of the Hanford Site. Groundwater also occurs within the Levey interbed, which is present only in the southern portion of the Hanford Site. An interflow zone occurs within the Elephant Mountain Member of the upper Saddle Mountains Basalt and may be significant to the lateral transmission of water where it occurs. Overall, this system is confined by the dense, low-permeability, interior portions of basalt flows and, in some places, by Ringold Formation silts and clays (lower mud unit) overlying the basalt.

There are approximately seventy wells completed in the Columbia River Basalts.

Of this total, 32 wells are completed in deeper interbeds/basalts or are screened across multiple intervals, 16 wells are completed in the Rattlesnake Ridge interbed, 9 wells are completed in the Elephant Mountain Basalt, and 7 wells have completion intervals that include both the Elephant Mountain Basalt and the Rattlesnake Ridge interbed. During CY 2009, a total of fifteen wells were sampled for at least one constituent. Figure 8-3 shows the location of the upper basalt-confined aquifer system monitoring wells on the Hanford Site. Of the fifteen wells sampled, seven wells are in the Rattlesnake Ridge interbed, three wells are across the Elephant Mountain Basalt/Rattlesnake Ridge interbed, two wells are in the Elephant Mountain Basalt, and one well is open across multiple deep intervals. The exact unit monitored by the two remaining wells are unclear, but these two wells are likely completed in the Rattlesnake Ridge interbed based on well depth.

8.2.1 Groundwater Flow in the Upper Basalt-Confined Aquifer System

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Figure 8-4 presents the approximate March 2009 potentiometric surface for the upper basalt-confined aquifer system south of Gable Butte and Gable Mountain. The region to the north of Gable Butte and Gable Mountain was not contoured due to insufficient well control. *Preliminary Potentiometric Map and Flow Dynamic Characteristics for the Upper-Basalt Confined Aquifer System* (PNL-8869) provides a generalized potentiometric surface map of this area. The upper basalt-confined aquifer system does not exist in the Cold Creek Valley and along the west portion of the Gable Mountain/Gable Butte structural area because of the absence of the Rattlesnake Ridge interbed.

Recharge to the upper basalt-confined aquifer system likely occurs from upland areas along the margins of the Pasco Basin and results from the infiltration of precipitation and surface water where the basalt and interbeds are exposed at or near ground surface. Recharge may also occur from the overlying aquifers (i.e., the unconfined aquifer or confined aquifer in the Ringold Formation) in areas where the hydraulic gradient is downward and from deeper basalt aquifers where an upward gradient is present. The Yakima River may also be a source of recharge to this aquifer system. The Columbia River represents a discharge area for this aquifer system in the southeastern portion of the Hanford Site where the river has a lower head than the upper basalt-confined aquifer, but not for the northern portion of the site where the river head is higher (PNL-8869). Discharge also occurs to the overlying aquifers in areas where the hydraulic gradient is upward. Discharge to the overlying unconfined aquifer near the Gable Butte/Gable Mountain structural area is believed to occur through erosional windows in the basalt.

South of Gable Butte and Gable Mountain, groundwater in the upper basalt-confined aquifer system generally flows from west to east across the Hanford Site, toward the Columbia River. The north-south trending May Junction Fault, located east of B Pond, acts as a barrier to groundwater flow in the unconfined aquifer and the confined aquifer within the Ringold Formation (BHI-00184). It may also impede the movement of water in the upper basalt-confined aquifer system by juxtaposing permeable units opposite impermeable units. As with the Ringold confined aquifer, a flow divide is interpreted to exist southeast of the 200 East Area and B Pond in the upper basalt-confined aquifer system, but the exact location of this divide is uncertain due to a lack of wells in the area.

Groundwater flow rates within the Rattlesnake Ridge interbed have been estimated between 0.7 and 2.9 meters per year (PNL-10817), which is a considerably lower flow rate than most estimates for the overlying unconfined aquifer system. The sediment comprising the interbed consists mostly of sandstone (with silts and clays) and is much less permeable than the sediments in the unconfined aquifer. Also, the magnitude of the hydraulic gradient is generally lower than in the unconfined aquifer.

The vertical hydraulic gradient between the upper basalt-confined aquifer system and the overlying aquifer varies spatially, as shown by comparison of observed heads (Figure 8-5). A downward gradient exists in the central portion of the Hanford Site, near the B Pond recharge mound, as well as in regions north and east of the Columbia River. Near the B Pond, the vertical head gradient between the unconfined aquifer system and the upper basalt-confined aquifer system has diminished in recent years but remains downward. In other areas of the Hanford Site, the hydraulic gradient is upward from the upper basalt-confined aquifer system to the overlying aquifer system.

In the 200 East Area, the potentiometric surface (Figure 8-4) is similar to the potentiometric surface for the Ringold confined aquifer (Figure 8-2). The basalt in this area was significantly eroded by late Pleistocene catastrophic flooding, which facilitates aquifer intercommunication (RHO-BWI-LD-5). In the 200 East Area and to the immediate north, the vertical hydraulic gradient between the upper basalt-confined aquifer system and the overlying aquifer is upward. It is likely that the upper basalt-confined aquifer system currently discharges to the overlying aquifer in this region.

Water levels in the upper basalt-confined aquifer system declined throughout the Hanford Site from March 2008 to March 2009, with the exception of an increase in one well in the 300 Area near the Columbia River. In the 200 East Area and to the immediate north and east (near B Pond), water-level declines in wells were up to 0.18 meters, and water levels declined up to 0.20 meters in wells near the 200 West Area. These declines are in response to reduced effluent disposal activities in the 200 Areas and are consistent with water-level declines in the overlying unconfined aquifer and confined aquifer in the Ringold Formation. The largest decline occurred in well 699-S24-19P (0.28 meters) near the Yakima River, and the maximum water-level increase was 0.29 meters in well 399-5-2.

8.2.2 Groundwater Quality in the Upper Basalt-Confined Aquifer System

The upper basalt-confined aquifer system is affected by contamination much less than the overlying unconfined aquifer system. Contamination found in the upper basalt-confined aquifer system is most likely to occur in areas where the basalt-confined units have been eroded away or were never deposited and where past disposal of large amounts of wastewater resulted in downward hydraulic gradients. Although areas of intercommunication between the contaminated unconfined aquifer and the upper basalt-confined aquifer are well documented to date, groundwater monitoring data do not indicate that substantial contamination has migrated from the unconfined aquifer into the upper basalt-confined aquifer. In some areas, wells constructed prior to implementation of Washington Administrative Code (WAC) 173-160 ("Minimum Standards for Construction and Maintenance of Wells") and penetrating the upper basalt-confined aquifer system lacked an impermeable seal between the well casing and the borehole wall. This provided a direct conduit between the upper unconfined and deeper confined aquifers. When this situation is realized, the wells are either modified by installing an impermeable seal or are decommissioned by a method that

isolates the aquifer. As a result of poor well seals, intercommunication between the aquifers permitted groundwater flow from the unconfined aquifer to the underlying confined aquifer, increasing the potential to spread contamination. Section 2.14.2.3 of DOE/RL-2008-01 discusses the communication between the upper basalt-confined aquifer system and the overlying aquifers.

Wells completed in the upper basalt-confined aquifer system are routinely sampled on the Hanford Site. Most of these wells are sampled every 3 years, but a few wells are sampled annually. During CY 2009, fifteen wells were sampled and 348 analyses were performed for chemical and radiological constituents. Many of the samples were analyzed for tritium, iodine-129, and nitrate, which are the most widespread constituents in the overlying unconfined aquifer and are some of the most mobile constituents in groundwater. Detection of tritium, iodine-129, and nitrate provides an early warning for potential contamination in the upper basalt-confined aquifer system. Groundwater samples from the upper basalt-confined aquifer system were also analyzed for anions (other than nitrate), major cations, cyanide, gross alpha, gross beta, gamma emitters, strontium-90, technetium-99, and uranium isotopes. Data for selected contaminants of interest are provided in Table 8-2. A full data set is included in the data files accompanying this report.

Initially high concentrations of contaminants (above DWSs) in new well 299-E33-340 declined significantly during the reporting period.

Well 299-E33-340 was installed as part of the 200-BP-5 OU remedial investigation in FY 2008 within the upper basalt-confined aquifer system. Data reported in the FY 2008 groundwater report (DOE/RL-2008-66) were collected shortly after the well was completed and, more importantly, prior to well development. The concentrations of cyanide, nitrate, nitrite, and technetium-99 were all well above their respective DWSs at that time. This well was developed on October 13, 2008, with the next samples collected January 12, 2009. Concentrations of cyanide, nitrate, nitrite, and technetium-99 (as well as elevated concentrations of chloride, sulfate, tritium, and uranium) all showed a significant decline (over 90% for cyanide, nitrate, nitrite, technetium-99, and tritium) (Figure 8-6). For the remainder of the reporting period, this well showed constituent concentrations consistent with the nearby upper basalt-confined aquifer well 299-E33-50.

8.2.2.1 Anions

Nitrate and cyanide remain elevated in the 200 East Area during the reporting period, but neither constituent exceeded DWSs.

Because of their negative charge, anions are more mobile than most other contaminants. The anions most related to contamination from Hanford Site operations are nitrate and cyanide. During the reporting period, neither of these constituents exceeded their respective DWS. Concentrations of cyanide and nitrate in well 299-E33-340 declined to levels consistent with other upper basalt-confined wells. It is likely that the initial high concentrations were the result of contamination drawn down during the drilling process and that concentrations have since returned to normal levels. Well 299-E33-12 was the only other well with elevated levels of cyanide and nitrate, which is consistent with previous years and is attributed to migration of contaminated groundwater from the unconfined aquifer moving down the borehole during well construction when it was open to both the unconfined and confined aquifers (RHO-RE-ST-12P).

The only anion to exceed a DWS was fluoride in well 699-S2-34B, which is located in the south-central portion of the Hanford Site. The concentration of fluoride in this well has always been reported above the DWS. Because this well is removed from any potential contamination source, the fluoride levels are likely naturally occurring in that portion of the aquifer.

Iron and manganese are the only metals to exceed DWSs.

8.2.2.2 Metals

Contamination associated with metals from Hanford Site operations tends to be rapidly sorbed before reaching the unconfined aquifer. The major metal of concern is chromium, which is more prevalent along the River Corridor than in the Central Plateau area. Chromium concentrations in the upper basalt-confined aquifer wells were all below the detection limit during the reporting period. The concentrations of the major soil minerals (i.e., calcium, magnesium, potassium, and sodium) and most trace minerals (e.g., barium, strontium, vanadium, and zinc) remained at levels similar to those of previous years.

Two metals (iron and manganese) exceeded their secondary DWS concentrations in filtered samples from several wells in the upper basalt-confined aquifer. Iron was above the secondary DWS of 300 µg/L in well 699-56-43 at 599 µg/L (adjacent to Gable Mountain) and well 699-2-E14, with an average of 889.5 µg/L (adjacent to the Columbia River).

The manganese secondary DWS of 50 µg/L was exceeded in three wells: 299-E33-50, 299-E33-340, and 699-56-43. The maximum concentration measured during the reporting period, 186 µg/L, was in well 299-E33-50 in January 2009. Two possible reasons for the elevated levels of manganese and iron in upper-basalt-confined aquifer wells are (1) natural variation related to the breakdown of basalt minerals high in manganese and iron, and (2) degradation of the well casing releasing these metals to the groundwater. The latter reason seems unlikely, however, as wells 299-E33-340 and 299-E33-50 were installed less than 2 years ago.

No radionuclides exceeded DWSs during the reporting period.

8.2.2.3 Radionuclides

Radionuclide contamination is a concern in the upper basalt-confined aquifer system due to the large amounts released to the subsurface during Hanford Site operations. Radionuclides are also of concern due to their mobility (e.g., tritium and technetium-99) and/or their long half-lives (e.g., iodine-129 at 17 million years).

None of the wells exceeded the DWS for tritium (20,000 pCi/L) during CY 2009. The maximum concentration measured during the reporting period was 3,900 pCi/L in well 699-42-40C, which is located near the B Pond and is in the area of intercommunication with the unconfined aquifer. Tritium concentrations in this well have declined steadily since 1996. Low levels of tritium (less than 1,000 pCi/L) were measured in the basalt-confined aquifer near the center of the Hanford Site in CY 2009. Most of the positive tritium results are located in the 200 East Area/Gable Mountain region, which is in an area of intercommunication with the overlying contaminated unconfined aquifer. Nearby wells completed in the unconfined aquifer in the Ringold Formation (e.g., well 699-43-41G) show elevated but declining trends. A slight downward hydraulic gradient continues to exist at this location.

In the northern portion of the 200 East Area, technetium-99 continued to be elevated in the upper basalt-confined aquifer system in wells 299-E33-12, 299-E33-50, and 299-E33-340. These wells are located within the technetium-99 plume in the overlying unconfined aquifer (see discussion in Chapter 4.0). The maximum technetium-99 concentration during the reporting period was in well 299-E33-50 at 43 pCi/L. Concentrations in well 299-E33-340 declined significantly from 9,400 pCi/L (which is well above the 900 pCi/L DWS) to 75 pCi/L in January 2009 and continued to decrease to 20 pCi/L in September 2009. These concentrations are more representative of the basalt-confined aquifer and consistent with the technetium-99 concentration in well 299-E33-50.

Samples collected from upper basalt-confined aquifer system wells were also analyzed for iodine-129. Iodine-129 was detected in three wells (299-E26-8, 299-E33-50, and 699-42-40C) in the upper basalt-confined aquifer system during CY 2009 (Table 8-2). The maximum concentration reported was 0.345 pCi/L in well 299-E26-8. Concentrations in well 299-E33-340 decreased to below the DWS of 1 pCi/L and then to below the detection limit by September 2009.

Groundwater samples from upper basalt-confined aquifer system wells were also analyzed for gamma-emitting radionuclides and uranium isotopes. During CY 2009, gamma-emitting radionuclides were not detected in the upper basalt-confined aquifer system on the Hanford Site, including the Gable Mountain/200 East Area.

Uranium isotopes were observed in this aquifer in four wells near the 200 East Area during CY 2009. Uranium-234 was detected at a concentration of 0.43 pCi/L in well 299-E16-1 (southeast of the 200 East Area); 1.33 pCi/L in well 699-42-40C (east of the 200 East Area, near B Pond); and 1.18 pCi/L in well 699-50-53 (north of the 200 East Area). Uranium-238 was detected in well 699-42-40C at 1.06 pCi/L, well 699-50-53B at 0.43 pCi/L, and well 699-32-33B (southeast of the 200 East Area) at 0.21 pCi/L.

8.2.2.4 Field Parameters

A series of general water quality parameter measurements were made in CY 2009. The parameters for dissolved oxygen, oxygen-reduction potential, specific conductance, temperature, and turbidity are collected in the field at the time of sampling, while other parameters (e.g., alkalinity) are measured in the laboratory to ensure accuracy. These parameters provide information on the overall character of the upper basalt-confined aquifer system.

There are no regulatory guidelines for the values of these parameters, and the value ranges tend to be very narrow. The ranges, as well as minimum and maximum values, are presented in Table 8-3.

Table 8-1. Potential Contaminants of Interest in the Ringold Confined Aquifer, Fiscal Year 2007 Through Calendar Year 2009.

Well	Sample Date	Specific Conductance (µS/cm)	Nitrate (mg/L)		Uranium (µg/L)		Tritium (pCi/L)		Chromium (Filtered) (µg/L)		Iron (Filtered) (µg/L)		Manganese (Filtered) (µg/L)	
199-H4-15CQ	12/6/2007	206	0.872						16.9		59.9	C	4	U
199-H4-15CQ	11/24/2008	244												
199-H4-15CQ	6/9/2009	281												
399-1-9	1/4/2007	360	0.018	U	0.0384	U			4	U	190	C	**69.6**	
399-1-9	1/18/2008	370	0.44	UD	0.05	U			4	U	173		**65.6**	
399-1-9	1/6/2009	361	0.089	UD	0.05	U			13	U	164		**60.9**	
399-1-9	12/28/2009	371	0.274		1.41	D			13	U	116	C	**62.2**	
399-1-16C	1/24/2006	374					9.16							
399-1-16C	12/8/2006	369	0.018	U	0.0246	U			47	U	85		**52.4**	
399-1-16C	1/31/2008	367	0.25	U	0.05	U			4	U	77.6		**50.4**	
399-1-16C	12/31/2008	380	0.106	UD	0.05	U			13	U	80.9	B	49.6	
399-1-16C	12/14/2009	377	0.274		0.1	UD			13	U	85.7	B	49.5	
399-1-17C	12/8/2006	381	0.018	U	-0.00756	U			7	U	54.2		26.8	
399-1-17C	1/17/2008	381	0.047	BDX	0.05	U			4	U	52.7		17.7	
399-1-17C	12/30/2008	384	0.173	BD	0.0885	B			10	U	46.2.	B	17.9	
399-1-17C	12/28/2209	392	0.274		0.698	D			13	U	60.5	BC	23.1	
699-43-69	3/12/2008	499	38.0		1.13		33.7	U						
699-43-69	3/14/2008	1,195	39.0		0.94		25.6	U						
699-43-69	3/18/2008	490	42.0		1.05		-35.6	U						
699-43-69	3/26/2008	486	31.0		1.48		113	U						
699-43-69	4/1/2008	499	30.0		1.24		9.36	U					32.1	
699-43-69	4/2/2008	449	35.0		1.08		0	U						
699-43-69	4/4/2008	498	26.0		0.6		-94.6	U						
699-43-69	4/9/2008	415	23.0		1.12		-85.5	U						
699-43-69	6/10/2008	515	32.4	D										
699-43-69	9/28/2008	506	31.5	D										
699-43-69	11/23/2008	497	32.0	D										
699-43-69	3/4/2009	517	30.6	D										
699-45-42	7/20/2007	276	3.69				7,300							
699-45-42	10/26/2009	281	4.47	D			7,000							
699-S22-E9C	9/28/2007	372					7.36	U						
699-S22-E9C	2/28/2008	367	0.44	UD			4	U	**112**		204	C	**65.1**	
699-S27-E9C	8/28/2007	376					6.51	U						
699-S27-E9C	2/11/2008	381	0.44	UD	0.05	U	4	U	95.1		202	C	**95**	
699-S29-E16C	7/7/2006	387					6.15							
699-S29-E16C	7/3/2007	366					5.06	U						
699-S29-E16C	8/19/2008	381	0.107	UD	0.05	U	-23.1	U	13	U	**3,290**		**139**	
699-S29-E16C	4/16/2009	383												

Notes:
Blank cells indicate not analyzed during the reporting period.
Cells with **bold type** indicate values above secondary drinking water standard (chromium = 100 µg/L, iron = 300 µg/L, manganese = 50 µg/L).

B = analyte was detected at a concentration less than the contract required detection limit
C = analyte was detected in both the sample and the associated quality control blank, and the sample concentration was less than or equal to five times the blank concentration
D = analyte was identified in an analysis at a secondary dilution factor
U = undetected (value is below the detection limit)
X = additional result specific information is available

Table 8-2. Potential Contaminants of interest in the Upper Basalt-Confined Aquifer, Fiscal Year 2007 through Calendar Year 2009.

Well Name	Date	Specific Conductance (µS/cm)	Gross Alpha (pCi/L)		Gross Beta (pCi/L)		Technetium-99 (pCi/L)		Tritium (pCi/L)		Uranium (µg/L)		Cesium-137 (pCi/L)		Cobalt-60 (pCi/L)		Iodine-129 (pCi/L)		Strontium-90 (pCi/L)		Nitrate (mg/L)		Cyanide (µg/L)	
199-H4-2	7/17/2006	241	1.07	U	10.50				7.33												0.42			
199-H4-2	1/3/2007	254	1.23	U	8.54				2.65	U											4.34	DG		
199-H4-2	8/25/2009	262	0.78	U	9.60				-25.6	U											1.27	D		
199-H4-15CP	12/6/2007	363					8.21	U	-8.1	U	1.43										19.26	D		
199-H4-15CP	11/24/2008	368																						
199-H4-15CP	6/9/2009	335																						
299-E16-1	6/14/2006	312	0.28	U	9.37				-38.2	U							-0.03	U			0.02	U		
299-E16-1	11/3/2008	194.5 (Y)	0.23	U	13.80		-4.1	U			0.12	B					-1.0	U	-1.29	U	0.09	UD		
299-E16-1	6/24/2009	293	0.63	U	22												0.04	U			0.27	UD		
299-E26-8	6/14/2006	288	1.84		14.1				7.81								-0.13	U			2.35			
299-E26-8	10/30/2006	313	2.0		8.7				5.54	U							0.19	U			4.03	DN		
299-E26-8	7/9/2009	292	1.8		9.8				-1.73	U							0.35				2.13	D		
299-E33-12	4/18/2006	340					**1,060**																	
299-E33-12	6/26/2007	352	1.2	U	**840**		**1,150**		134		2.8		2.23	U	3.71	U	-0.09	U			43.20	D	31.6	
299-E33-12	6/25/2008	351	1.0	U	**690**		**1,300**		140	U	3.2		-3.18	U	4.27	U	0.09	U			40.20	D	31.3	
299-E33-40	7/26/2007	265	2.4		10		6.92	U	6.64		3.94		0.929	U	0.22	U					0.08	B	4	U
299-E33-40	12/8/2007	267	1.94		11.7		5.16	U	-63	U	3.87		-4.58	U	2.48	U	-0.31	U			0.04	UD	4	U
299-E33-40	3/30/2008	272	2.0		10		7.48	U	-130	U	4.56		6.09	U	7.82	U	0.49	U			0.10	BD	4	U
299-E33-40	6/25/2008	268	1.9		4.6		-6	U	93	U	5.1		2.92	U	-2.05	U	0.01	U			0.32	UD	4	U
299-E33-40	9/16/2008	256	1.4		14		0.57	U	86	U	5.94	X	-1.6	U	-1.46	U	-0.24	U			0.25	U	4	U
299-E33-50	3/2/2007	281					2	U	128	U	2.52		0.432	U	0.57	U	-0.73	U	2.3		1.15		4	U
299-E33-50	3/6/2007						0.6	U	8.63	U	2.62		-7.52	U	1.44	U	0.17	U	-1.4	U	1.37		4	U
299-E33-50	3/7/2007						-0.6	U	25.5	U	2.66		4.75	U	-3.41	U	-0.67	U	-3.4	U	1.15		4	U
299-E33-50	3/7/2007						-1	U	-33	U	2.76		-0.988	U	-1.38	U	-0.41	U	-2.8	U	1.15		4	U
299-E33-50	6/28/2007	264					24.1		-64	U	1.91		0.96	U	1.69	U					1.25		4	U
299-E33-50	9/9/2007	268	2.05		15.7		24		19	U	2.04	X	-0.262	U	0.44	U	0.05	U	0.001	U	1.15	N	4	U
299-E33-50	2/14/2008	265	1.78		20.8		26		59	U	1.81		-0.0689	U	0.11	U	-0.08	U	0.08	U	1.28	D	4	U
299-E33-50	3/24/2008	271	0.94	U	20.1		31		76	U	2.31		0.51	U	0.78	U	0.02	U	0.09	U	1.71	D	4	U
299-E33-50	1/12/2009	260	0.19	U	17.8		43		50	U	2.29		-0.27	U	-1.49	U	0.11	U	-2.8	U	1.36	D	4	U
299-E33-50	6/25/2009	263	0.01	U	**52**				-100	U	2.35		-0.65	U	-0.48	U	0.18		-1.6	U	1.93	D	4	UX
299-E33-340	6/26/2008						**20,000**		5,270		5.64		-1.03	U	**49.6**		**2.11**		-4.6	U	**912.00**	**D**	**548**	
299-E33-340	6/26/2008						**15,400**														**810.10**	**D**		
299-E33-340	7/2/2008						**17,000**		4,270		5.71		-2.20	U	**40.5**		**1.46**	**U**	-0.65	U	**695.00**	**D**	**860**	**DX**

Table 8-2. (cont.)

Well Name	Date	Specific Conductance (µS/cm)	Gross Alpha (pCi/L)		Gross Beta (pCi/L)		Technetium-99 (pCi/L)		Tritium (pCi/L)		Uranium (µg/L)		Cesium-137 (pCi/L)		Cobalt-60 (pCi/L)		Iodine-129 (pCi/L)		Strontium-90 (pCi/L)		Nitrate (mg/L)		Cyanide (µg/L)	
299-E33-340	7/2/2008						**13,900**		4,160		5.66		-3.42	U	**45.1**		**1.43**	**U**	-0.69	U	**650.74**		**825**	**DX**
299-E33-340	7/2/2008						**17,000**														**708.00**	**D**		
299-E33-340	7/2/2008						**13,700**														**725.995**			
299-E33-340	7/18/2008						**9,400**		2,510		4.58		-0.06	U	**38.6**		**1.08**	**U**	-0.51	U	**419.00**	**DY**	**366**	**X**
299-E33-340	7/18/2008						**10,100**														**316.96**	**DG**		
299-E33-340	1/12/2009		2.82		27.1		75		100	U	3.24		0.43	U	2.06	U	0.1	U	-3.7	U	7.17	D	6.40	
299-E33-340	4/2/2009	319	2.20		31		23		52	U	3.05		0.74	U	-0.51	U	0.24		-3.4	U	3.46	D	4.40	BDN
299-E33-340	6/26/2009	310	0.48	U	30		28		86	U	3.27		-1.42	U	1.53	U	0.07	U	0.48	U	3.05	D	4	UX
299-E33-340	9/3/2009	318	2.30		28	Q	20		120	U	3.05		-0.2	U	-1.04	U	0.07	U	-1.2	U	2.96	D	5.04	B
399-5-2	6/29/2007	349	0.28	U	11				5.74	U											0.02	U		
699-2-E14	8/25/2009	427	0.73	U	6.8		-3.9	U	-110	U	0.05	U			0.23	U	-0.07	U	-0.61	U	0.27	UD		
699-2-E14	10/26/2009	435	4.0		8.9		-6.7	U	-50.3	U	0.1	UD	-0.14	U							0.27	UD		
699-32-22B	6/28/2006	377	1.27	U	12.5				-37.8	U							0.03	U			0.02	U		
699-32-22B	11/07/2006	383	0.24	U	11				5.9								-0.04	U			0.05	B		
699-32-22B	11/13/2008	402	0.59	U	11		2.3	U	21	U	0.11	B					0.57	U	-1.43	U	0.09	UD		
699-32-22B	9/24/2009	380	0.01	U	5.5	U			220	U							0.06	U			0.27	UD		
699-42-40C	11/2/2006	340	2.19		10.5				4,640								0.17	U			5.31	DN		
699-42-40C	11/4/2008	341	1.16	U	12.5		-3.2	U	3,900		2.39						-0.13	U	-3.34	U	5.89	D		
699-42-40C	7/8/2009	341	2.2		14				3,900								0.25				6.24	D		
699-42-E9B	10/12/2005	428	0.276	U	10.6				7.15				1.12	U	0.79	U	0.102	U			0.04	U		
699-42-E9B	7/25/2006	425	0.985	U	13				4.38	U			-0.67	U	0.43	U	-0.003	U			0.02	U		
699-42-E9B	7/25/2006		0.059	U	11.2				8.04				0.25	U	-1.4	U	0.02	U			0.12			
699-42-E9B	9/30/2007	427	0.14	U	1.2	U			8.36				0.30	U	-0.48	U	0.08	U			0.02	U		
699-42-E9B	9/19/2008	401	0.004	U	6.9				-110	U			0.88	U	-1.82	U	-0.12	U			0.298	BD		
699-42-E9B	9/19/2008		-0.18	U	10				-110	U			0.24	U	1.31	U	-0.10	U			0.18	BD		
699-42-E9B	9/27/2009	392	-0.19	U	13				78	U			0.57	U	-0.13	U	0.04	U			0.27	UD		
699-49-55B	8/6/2007	274	2.6		9.6		-3.33	U	1.8	U	4.09		0.62	U	1.67	U					0.69		4	U
699-49-55B	2/6/2008	278	2.96		7.97		1.23	U	-170	U	3.32		-0.28	U	0.96	U	-0.26	U			0.66	BD	4	U
699-49-57B	3/13/2006	300					0.30	U	-63.8	U			0.65	U	-1.56	U	0.07	U			1.11		2.4	UN
699-49-57B	4/11/2007	302	0.907	U	5.86		-0.68	U	-1.27	U	2.22	B	2.48	U	-0.34	U	0.04	U			1.06		2.4	UN
699-49-57B	4/11/2007																						4	U

Table 8-2. (cont.)

Well Name	Date	Specific Conductance (µS/cm)	Gross Alpha (pCi/L)		Gross Beta (pCi/L)		Technetium-99 (pCi/L)		Tritium (pCi/L)		Uranium (µg/L)		Cesium-137 (pCi/L)		Cobalt-60 (pCi/L)		Iodine-129 (pCi/L)		Strontium-90 (pCi/L)		Nitrate (mg/L)		Cyanide (µg/L)	
699-49-57B	3/30/2008	303	0.781	U	6.24		-0.9	U	-6.3	U	2.27		-0.98	U	0.03	U	0.03	U			1.40	DH	4	U
699-49-57B	4/1/2009	305					-7.1	U	-9.0	U			1.61	U	-1.04	U	-0.02	U			1.23	D	2	UDN
699-50-53B	6/28/2006	360					-0.42	U	4.16	U							0.02	U			12.00	D		
699-50-53B	11/2/2006	378					1.84	U	119	U							-0.16	U			11.50	DN		
699-50-53B	9/20/2009	372							-0.83	U							-0.09	U						
699-52-46A	6/30/2007	326	3.6		7.6				7.92										0.22	U	1.84			
699-54-34	9/28/2007	340	1.8		5.1				6.96	U											20.50	Q		
699-54-45B	12/4/2006	2,036																			0.42			
699-56-43	7/7/2006	319	1.6		5.14				0.82	U											4.87	D		
699-56-43	11/7/2006	325	3.1		3.2	U			8.06												4.38	D		
699-56-43	11/7/2006		2.01		19				-18.1	U											4.56	D		
699-56-43	9/24/2009	322	2.0	U	6.9																5.05	D		
699-56-53	12/6/2007	360	5.81		10.9				-59.4	U											1.02	NH		
699-S2-34B	1/10/2006	609							-74.2	U							0.01	U			0.04	U		
699-S2-34B	1/30/2007	611							-94.7	U							-0.02	U			0.01	UN		
699-S2-34B	3/20/2008	618							97	U							-0.001	U			0.04	UD		
699-S2-34B	11/11/2008	612	-1.34	U	9.11		0.9	U	47.3	U	0.05	U					0.28	U	0.27	U	0.09	UD		
699-S2-34B	2/4/2009	624	2.7	U	10				-110	U											0.11	UD		
699-S11-E12AP	6/29/2006	360	-0.22	U	8.54				128	U											0.02	U		
699-S11-E12AP	11/6/2008	342	-0.10	U	8.68		-4.2	U	78.4	U	0.05	U					**1.18**	**U**	-0.14	U	0.09	UD		
699-S11-E12AP	8/25/2009	356	0.87	U	8.80				-54	U											0.27	UD		
699-S24-19P	9/28/2007	306							17.7	Q											1.77	Q		
699-S24-19P	2/28/2008	201							19.9	U											2.05	D		

Notes:
Blank cells indicate not analyzed between October 1, 2006, and December 31, 2009.
Cells with **bold type** indicate values greater than drinking water standards. Technetium-99 = 900 pCi/L, cobalt-60 = 100 pCi/L, iodine-129 = 1 pCi/L, nitrate = 45,000 µg/L, and cyanide = 200 µg/L.

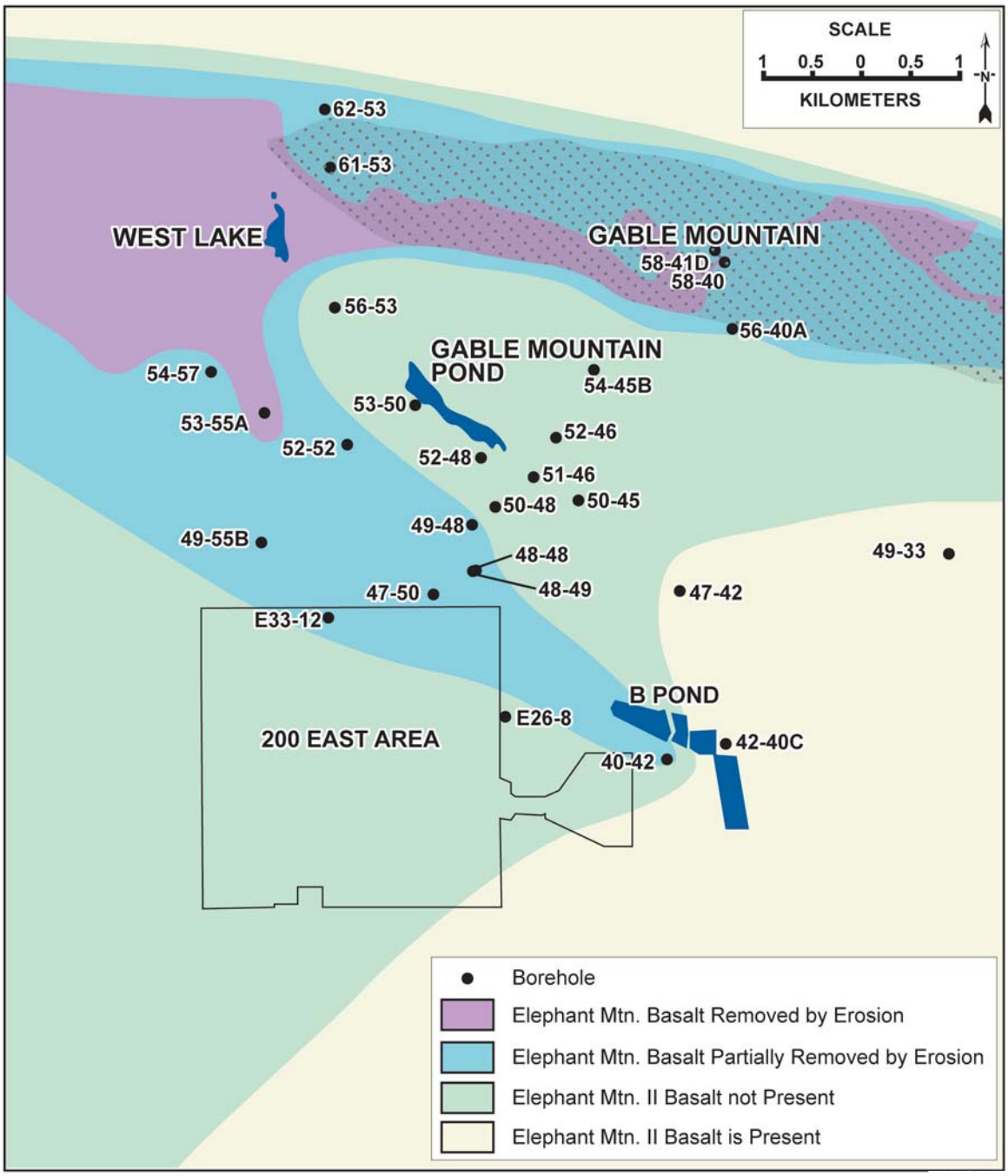
B = analyte was detected at a concentration less than the contract required detection limit
D = analyte identified in an analysis at a secondary dilution factor
H = laboratory holding time exceeded before sample was analyzed
N = spike sample recovery is outside control limits
Q = associated quality control sample is out of limits
U = undetected (value is below detection limit)
X = additional result-specific information is available
Y = result is suspect; review had insufficient data to show result valid or invalid

Table 8-3. Upper Basalt-Confined Aquifer Field Parameters for Calendar Year 2009.

Parameter	Unit	Range	Minimum	Well	Maximum	Well
Dissolved oxygen	mg/L	10.83	0.03	699-32-22B	10.86	699-50-53B
Oxidation-reduction potential	mV	344.8	-3.8	699-42-E9B	341	699-50-53B
pH	Standard units	2.43	7.49	699-56-43	9.92	699-32-22B
Specific conductivity	µS/cm	364	260	299-E33-50	624	699-S2-34B
Temperature	°C	20.4	10.1	199-H4-15CP	30.5	699-S2-34B
Turbidity	NTU	10.06	0.34	199-H4-15CP	10.4	699-32-22B

Notes:
NTU = nephelometric turbidity units

Figure 8-1. Extent of Partial or Complete Erosion of the Elephant Mountain Basalt in the 200 East Area/Gable Mountain Region (from DOE/RL-2008-01).



gwf09246

Figure 8-2. Potentiometric Surface Map of Ringold Formation Confined Aquifer (Unit 9), Central Hanford Site, March 2009.

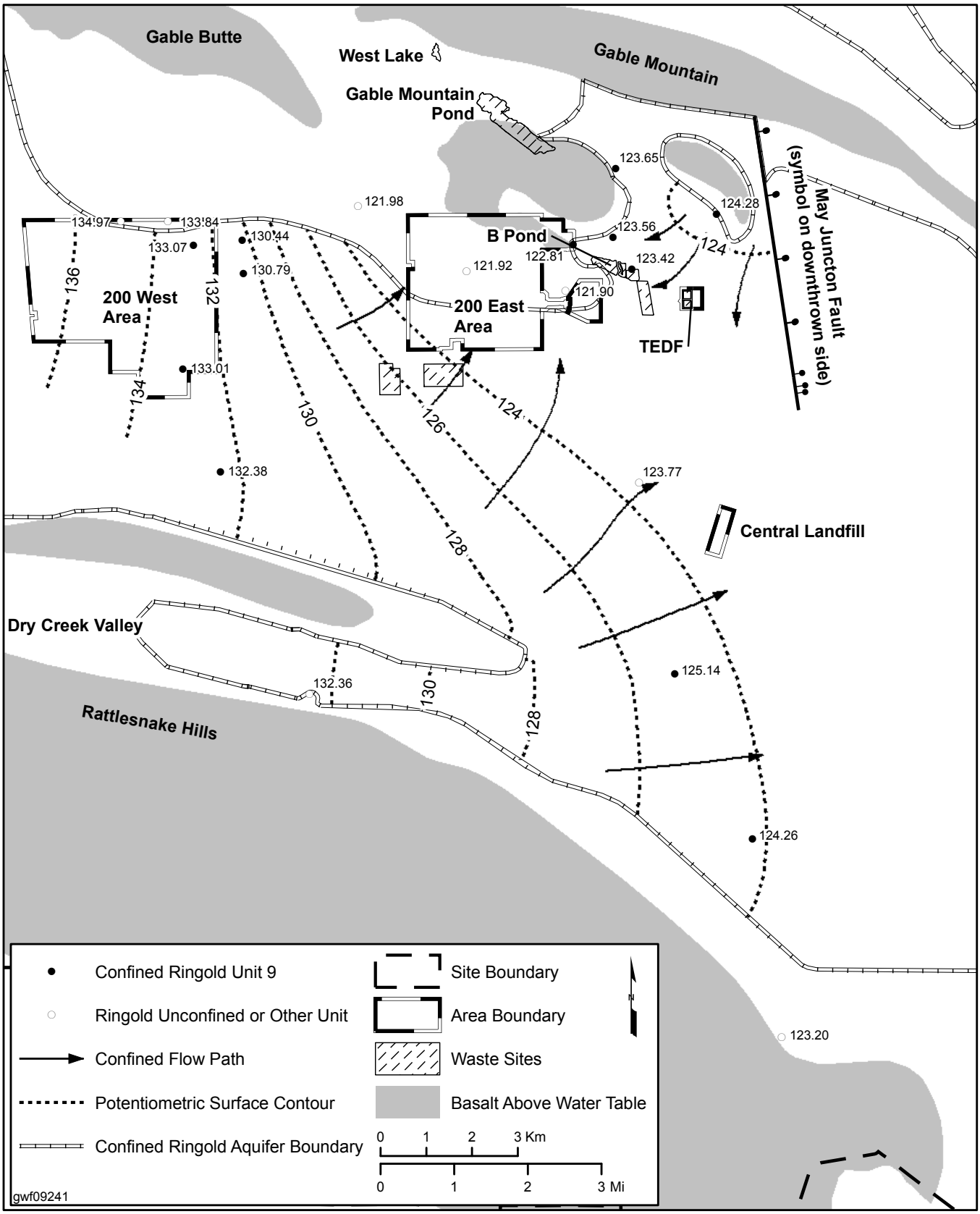


Figure 8-3. Groundwater Monitoring Wells Sampled in Ringold Formation Confined and Upper Basalt-Confined Aquifers, Fiscal Years 2007 Through Calendar Year 2009.

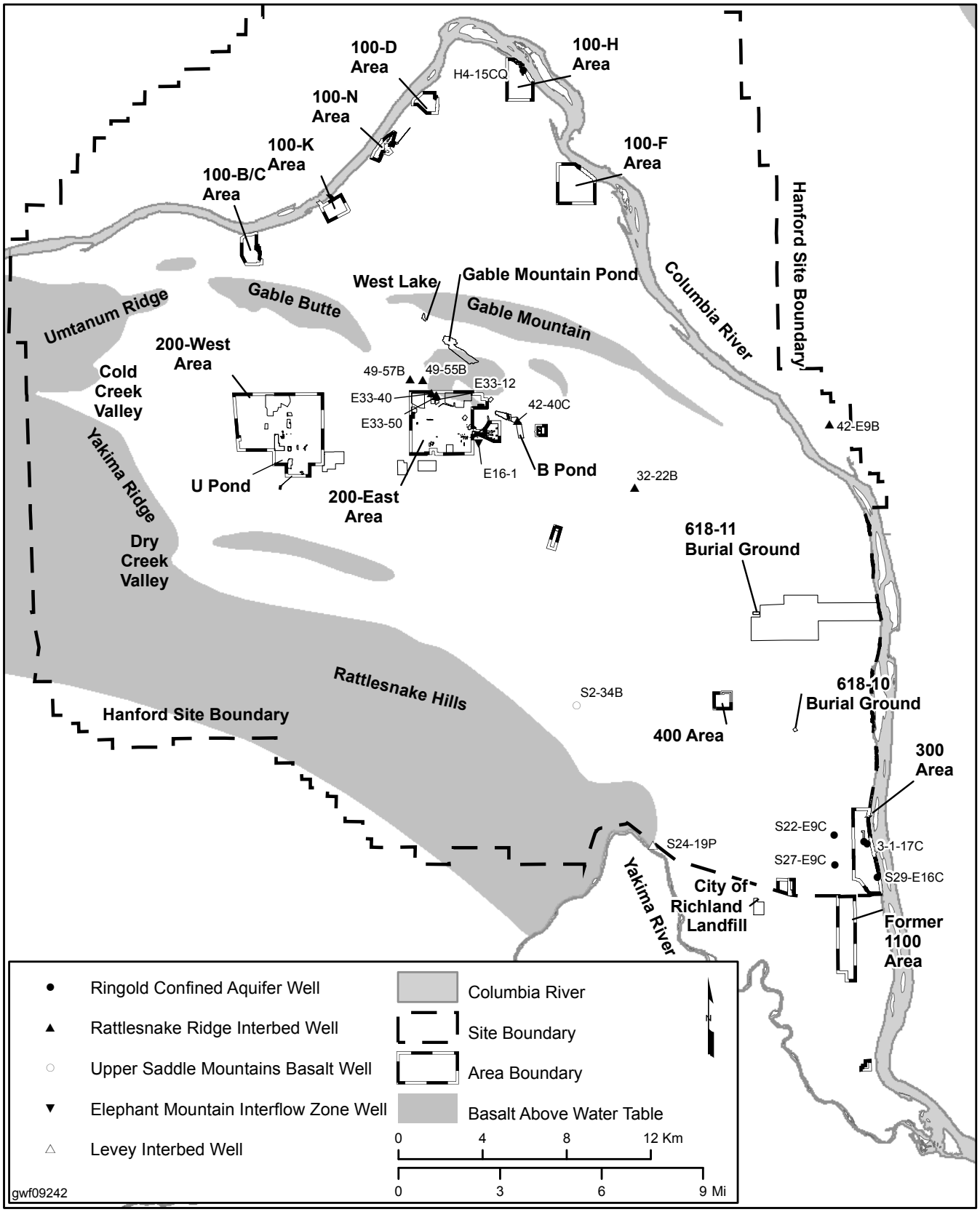


Figure 8-4. Potentiometric Surface Map of Upper Basalt-Confined Aquifer System, March 2009.

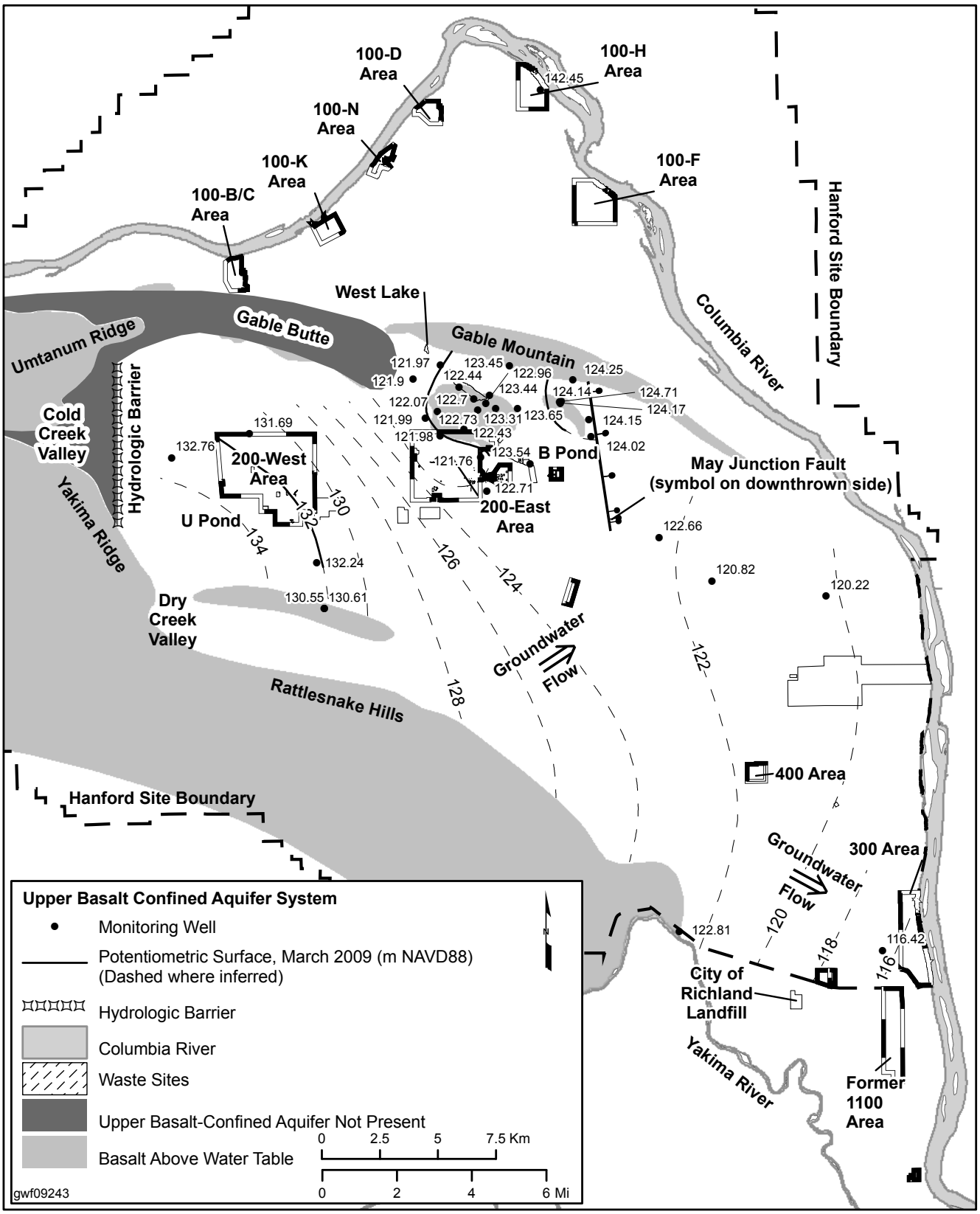


Figure 8-5. Comparison of Observed Heads for Upper Basalt-Confined Aquifer and Overlying Unconfined Aquifer.

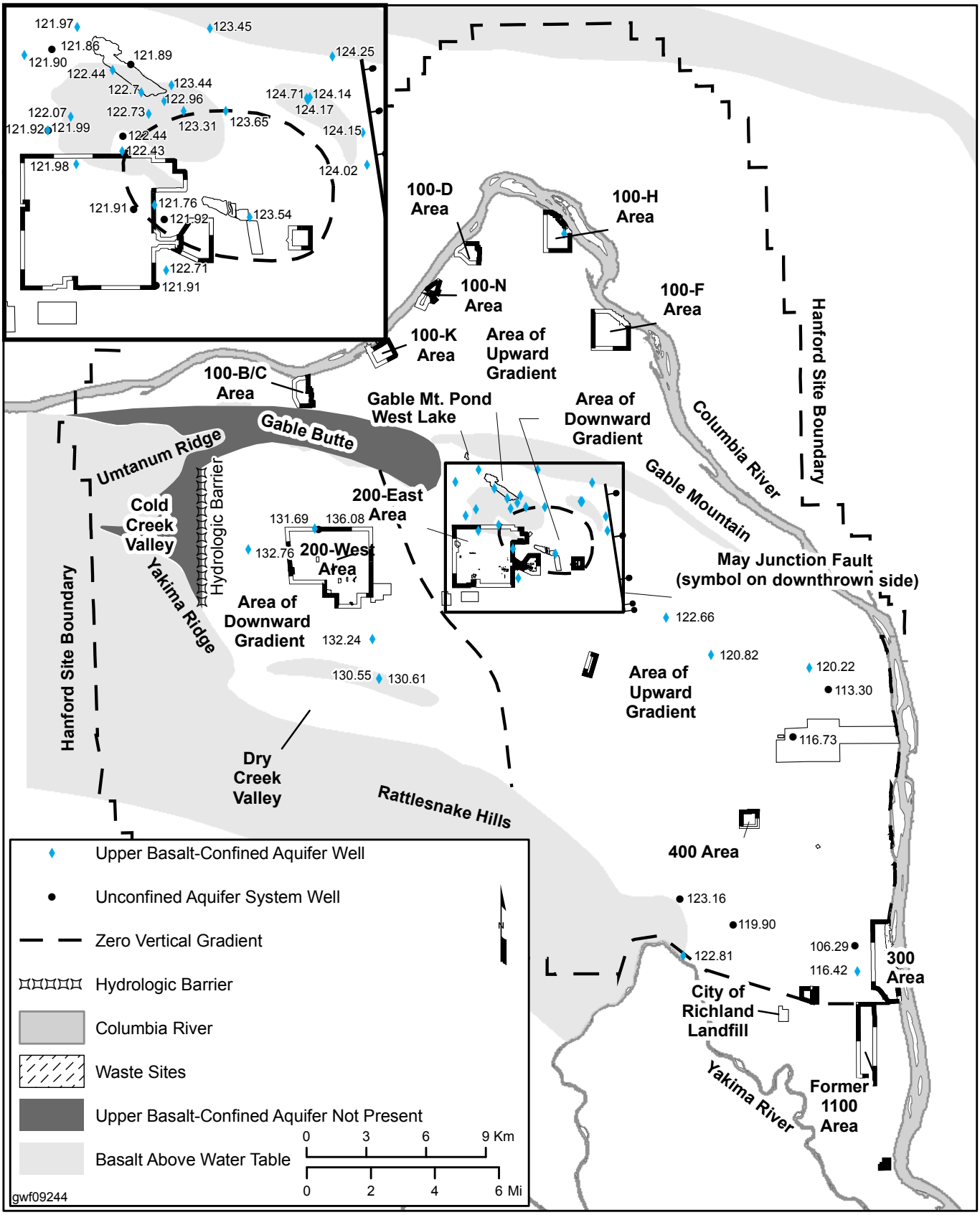
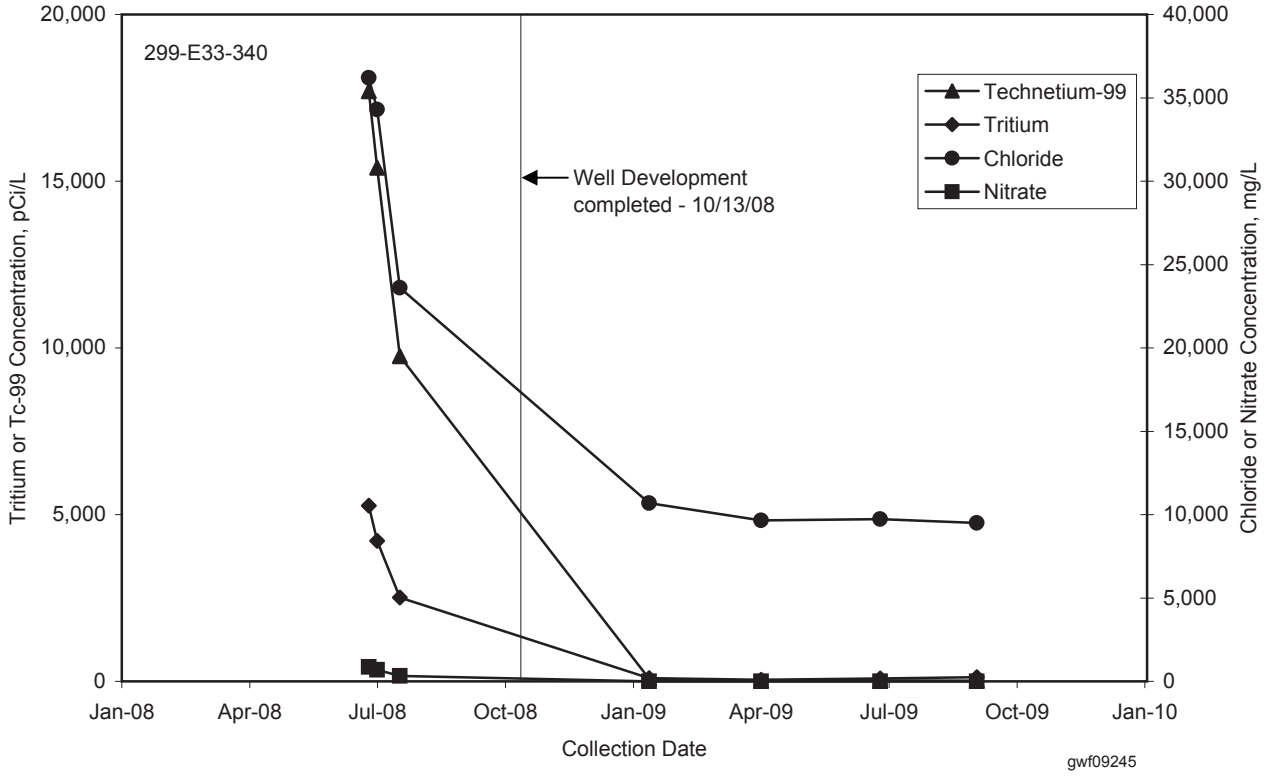



Figure 8-6. Trend Plot of Chloride, Nitrate, Technetium-99, and Tritium with Time in Well 299-E33-340.