2.14 Confined Aquifers

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This section describes groundwater flow and quality within the Ringold Formation and upper basalt-confined aquifers. The Ringold Formation confined aquifer exists beneath much of the Hanford Site including the 100 Areas and 300 Area but is described only for the 200 Areas Central Plateau and the area near the inactive B Pond system because few wells monitor this aquifer. The upper basalt-confined aquifer is described for much of the Hanford Site, primarily the area south of Gable Butte and Gable Mountain.

Intercommunication between the upper basalt-confined aquifer and the overlying sedimentary aquifer system may occur where there is a pathway for the movement of water as well as a difference in hydraulic head between the two systems. The area in the vicinity of the 200 Areas and the inactive B Pond system meets these criteria. Evidence for communication between aquifers in this region is discussed in Section 2.14.2.3.

2.14.1 Ringold Formation Confined Aquifer

Groundwater quality in the Ringold Formation confined aquifer is monitored to evaluate impacts to groundwater and potential future for downward migration of contaminants from the overlying unconfined aquifer.

The Ringold Formation confined aquifer occurs within fluvial sand and gravel comprising the lowest sedimentary unit of the Ringold Formation (unit 9) shown in Figure 2.14-1. It is confined below by basalt and above by the lower mud unit (unit 8). Where Unit 9 is overlain by fines comprising units, confined conditions generally exist. Where Unit 9 is absent beneath unit 8, limited groundwater flow may occur. Wells completed in the lower portion of unit 8 in regions where unit 9 is absent provide information on the distribution of contaminants in the lower most portion of the sedimentary aquifer system.

Groundwater in the Ringold Formation confined aquifer flows generally west to east in the vicinity of the 200 West Area and west to east along the south boundary of the aquifer.

DOE has begun to investigate groundwater conditions in other portions of the Ringold Formation including the "horn" between the 100-D and 100-H Areas (see Section 2.6).

2.14.1.1 Groundwater Flow in the Ringold Formation Confined Aquifer

Figure 2.14-2 presents the interpreted potentiometric surface for a portion of the Ringold Formation confined aquifer. This map is subject to uncertainty because only a few wells monitor this aquifer. However, generalized flow patterns can be inferred from the available data when the hydrogeologic framework (i.e., extent of the confining unit, presence of basalt subcrops, influence of the May Junction Fault) is taken into account.

Groundwater flow in the Ringold Formation confined aquifer is generally west to east near the 200 West Area and west to east along the south 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. In the vicinity of the 200 East Area, flow in the Ringold Formation confined aquifer converges from the west, south, and east before discharging to the unconfined aquifer where the confining mud unit (unit 8) is absent (PNNL-12261). This water is thought to flow southeastward over the top of the confining unit (PNNL-15479), although the exact location of the division between northwest and southeast flow within the 200 East Area unconfined aquifer is not known. In the vicinity of the 200 East Area, water-level elevation data from well pair 299-E25-28 and 299-E25-34 that monitor different depths of the unconfined aquifer (Figure 2.14-3), as well as from piezometers 299-E25-32P and 299-E25-32Q also monitoring different depths, suggest a slight upward gradient along the confining unit boundary. This upward gradient is consistent with the discharge of groundwater from the confined aquifer to the overlying unconfined aquifer.

Elevated water levels are present in the Ringold Formation confined aquifer northeast of B Pond as a remnant of past waste water discharges to this facility. This causes southwest flow beneath B Pond to the 200 East Area. Eastward flow away from the region of elevated water levels does not occur; this is attributed to the May Junction Fault, located east of B Pond, which is thought to be a hydrologic barrier preventing flow to the east (PNNL-12261). South of the B Pond area, the flow of water divides with some moving northwest toward the 200 East Area and some moving toward the east or southeast. The location of this flow divide is not accurately known, due partly to a lack of water-level data in this area and because the southward extent of the May Junction Fault is not well defined.

Groundwater quality in the upper basalt-confined aquifer is monitored due to the potential for downward migration of contaminants from the overlying unconfined aquifer.

The potentiometric contours for the Ringold Formation confined aquifer, shown in Figure 2.14-2, are similar to the potentiometric surface contours for the upper basalt-confined aquifer (see Section 2.14.2.1), indicating that flow patterns in the central portion of the Hanford Site are similar in both aquifers. Basalt bedrock from the topographic low between Gable Butte and Gable Mountain (Gable Gap) in the 200 East Area vicinity was significantly eroded by late Pleistocene catastrophic flooding (RHO-BWI-LD-5), which facilitates intercommunication between the unconfined and confined aquifers (see Section 2.14.3). The 200 East Area vicinity is a discharge area for both of the confined aquifers, which explains the similar flow patterns.

Water levels declined in the Ringold Formation confined aquifer during the period from April/May 2006 to March 2007. The declines in individual wells ranged from 0.01 to 0.18 meter within the aquifer and up to 0.32 meter in the 200 West Area along the boundary between the confined and unconfined aquifers. The potentiometric surface is responding to the curtailment of liquid effluent discharges to ground since the discharge volume peaked in the mid 1980s. The declines were largest in the 200 West Area (up to 0.32 meter) and the 200 East Area (up to 0.15 meter) along the boundary between the confined and unconfined aquifers.

2.14.1.2 Groundwater Quality in the Ringold Formation Confined Aquifer

The 200 Areas Central Plateau and the area near the inactive B Pond system are the two known areas where contamination can migrate from the unconfined aquifer into the Ringold Formation confined aquifer (see Section 2.14.2.3). Groundwater chemistry data for the Ringold Formation confined aquifer are limited to wells near the 200 Area Treated Effluent Disposal Facility and B Pond facilities. During fiscal year (FY) 2007, eighteen wells were sampled that are completed in the Ringold Formation confined aquifer (Figure 2.14-4). Data for potential contaminants of interest are listed in Table 2.14-1. No contaminants were detected above the drinking water standard for wells completed in the Ringold Formation confined aquifer.

2.14.2 Upper Basalt-Confined Aquifer

Groundwater quality in the upper basalt-confined aquifer is monitored because of the potential for downward migration of contaminants from the overlying unconfined aquifer. Contaminants that reach the upper basalt-confined aquifer have the potential to migrate through the aquifer and deeper confined aquifers to areas off the Hanford Site. The upper basalt-confined aquifer is also monitored to assess the potential migration of contaminants onto the Hanford Site from offsite sources. Additional information regarding the potential for contaminants to migrate off the Hanford Site can be found in PNL-10817 and PNNL-14107.

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 2.14-1). The thickest and most widespread sedimentary unit in this system is the Rattlesnake Ridge interbed, which is present beneath much of the Hanford Site. Groundwater also occurs within the Levey interbed, which is present only in the south portion of the site. An interflow zone occurs within the Elephant Mountain Member of the upper Saddle Mountains Basalt and also may be significant to the lateral transmission of water. This system is confined by the dense, low-permeability, interior portions of basalt flows and in some places by Ringold Formation silt and clay units overlying the basalt.

Groundwater in the upper basalt-confined aquifer system generally flows from west to east across the Hanford Site toward the Columbia River.

Figure 2.14-4 shows the location of the upper basalt-confined aquifer monitoring wells on the Hanford Site. Most of the wells are completed in the Rattlesnake Ridge interbed near the 200 East Area in the central part of the Hanford Site. A few wells are completed in the Elephant Mountain interflow zone, the Levey interbed, or a composite of one or more interbeds and/or interflow zones within the upper Saddle Mountains Basalt.

2.14.2.1 Groundwater Flow in the Upper Basalt-Confined Aquifer

Figure 2.14-5 presents an approximation of the March 2007 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. (See PNL-8869 for a generalized potentiometric surface map of this area.) The upper basalt-confined aquifer is interpreted to not exist in Cold Creek Valley and along the west portion of the Gable Mountain/Gable Butte structural area due to the absence of the Rattlesnake Ridge interbed.

Recharge to the upper basalt-confined aquifer system is believed to occur 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 but not for the north portion (PNL-8869). Discharge also occurs to the overlying aquifers in areas where the hydraulic gradient is upward. Discharge to overlying or underlying aquifers in the vicinity of the Gable Butte/Gable Mountain structural area may occur through erosional windows in the basalt.

The small amount of contamination detected in the upper basalt-confined aquifer is attributed to areas where confining units of basalt have been partially removed by erosion, are absent, or where wells provided a pathway for migration.

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 May Junction Fault, located east of B Pond and in a north-south trend, acts as a barrier to groundwater flow in the unconfined aquifer and the confined aquifer within the Ringold Formation (PNNL-12261). 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 Formation 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 well control in the area.

Groundwater flow rates within the Rattlesnake Ridge interbed have been estimated to be between 0.7 and 2.9 meters/year (PNL-10817). This flow rate is considerably slower than most estimates for the overlying unconfined aquifer system. The sediment comprising the interbed consists mostly of sandstone along with silts and clays, and is 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 (Figure 2.14-6). A downward gradient exists in the west portion of the Hanford Site, near the B Pond recharge mound, as well as in the regions north and east of the Columbia River. In the B Pond vicinity, 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 to the overlying aquifer system.

In the 200 East Area vicinity, the potentiometric surface in Figure 2.14-5 is similar to the potentiometric surface for the Ringold Formation confined aquifer (compare with Figure 2.14-2). 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. Therefore, it is likely the upper basalt-confined aquifer system currently discharges to the overlying aquifer in this region.

Water levels in the upper basalt-confined aquifer declined over most of the Hanford Site from April/May 2006 to March 2007. In the 200 East Area and to the immediate north and east (near B Pond), water-level declines in wells ranged from 0.04 to 0.32 meter. Water-level declines in wells near the 200 West Area ranged from 0.15 to 0.20 meter. The declines are in response to curtailed 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.

Water levels in the upper basalt-confined aquifer along the Columbia River in the east part of the site (i.e., wells 699-13-1C and 699-24-1P) rose from 1990 to 2003 and have subsequently declined but remain above pre-1992 levels (Figure 2.14-7). The long-term increase is interpreted to be the result of offsite irrigation east of the Columbia River (PNL-8869).

2.14.2.2 Groundwater Quality in the Upper Basalt-Confined Aquifer

The upper basalt-confined aquifer is affected by contamination much less than the overlying unconfined aquifer system. Contamination found in the upper basalt-confined aquifer is most likely attributed to areas where confining units of basalt have been eroded away or were never deposited and where past disposal of large amounts of waste water resulted in downward hydraulic gradients. In some areas, wells penetrating the upper basalt-confined aquifer system constructed prior to implementation of WAC 173-160 lacked an impermeable seal between the well casing and the borehole wall. When recognized, these wells were rehabilitated with the installation of an impermeable seal or were decommissioned by a method that isolated the aquifer. Because of these factors, intercommunication between the aquifers permitted groundwater flow from the unconfined aquifer to the underlying confined aquifer, thereby increasing the potential to spread contamination. A discussion of the communication between the upper basalt-confined aquifer and the overlying aquifers is presented in Section 2.14.2.3.

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, and a few are sampled annually. During FY 2005 through 2007, 38 samples were collected from 22 wells and analyzed for chemical and radiological constituents. Many of the samples were analyzed for tritium, iodine-129, and nitrate because these constituents (1) are the most widespread in the overlying unconfined aquifer, (2) are some of the most mobile constituents in groundwater, and (3) provide an early warning for potential contamination in the upper basalt-confined aquifer system. Groundwater samples from the upper basalt-confined aquifer were also analyzed for anions (besides nitrate), cations, cyanide, gross alpha, gross beta, gamma-emitters, strontium-90, technetium-99, tritium, and uranium isotopes. Data for the potential contaminants of interest are listed in Table 2.14-2. A full data set is included in the data files that accompany this report.

Distribution of sample results for selected constituents and wells across the Hanford Site for FY 2005 through 2007 is shown in Figure 2.14-8. Tritium at the Hanford Site ranged from less than the detection limit near the discharge area in the east-southeast portion of the Hanford Site to 4,640 pCi/L in well 699-42-40C, east of the 200 East Area. Concentrations have been decreasing at this location since 1996 (Figure 2.14-9). This elevated tritium is located in the 200 East Area/Gable Mountain region, an area of intercommunication with the overlying contaminated unconfined aquifer. Nearby wells completed in the Ringold Formation (e.g., 699-43-41E) show elevated but declining trends. Near the 618-11 burial ground, where a source of tritium has contaminated the unconfined aquifer at high levels, tritium in the upper basalt-confined aquifer has declined from a concentration of 31.6 pCi/L detected in FY 2004 to less than the detection level in FY 2007. An upward hydraulic gradient exists at this location.

Cyanide, nitrate, and technetium-99 were elevated in one well in the 200 East/Gable Mountain region, an area of intercommunication between the upper basalt-confined aquifer and the overlying unconfined aquifer.

In the north part of the 200 East Area, technetium-99 continued to be elevated in the upper basalt-confined aquifer in one well (299-E33-12) (Figure 2.14-8). This well is located in the vicinity of a technetium-99 plume in the overlying unconfined aquifer (Section 2.10.1). The technetium-99 concentration was 1,150 pCi/L in this well (299-E33-12) in 2007. This level, which exceeds the drinking water standard (900 pCi/L), is slightly lower than concentrations observed immediately after a seal which shortened the open interval was placed in the well in 1990 (Figure 2.14-10).

Cyanide and nitrate are also elevated in well 299-E33-12 (Figure 2.14-11). However, these co-contaminants are at levels that do not exceed their respective drinking water standards. Concentrations of cyanide and nitrate have declined slightly at this well since the early 1990s. Cyanide and nitrate are co-contaminants with much higher concentrations in the unconfined aquifer in the north part of the 200 East Area. Contamination in this well is attributed to migration of high-salt waste down the borehole during construction when it was open to both the unconfined and confined aquifers (RHO-RE-ST-12 P). A seal was placed in this well to prevent intercommunication between the unconfined and confined aquifers during the 1980s.

Gamma-emitting isotopes were not detected in the upper basalt-confined aquifer on the Hanford Site.

Nitrate levels in the upper basalt-confined aquifer typically range from less than detectable to ~43 mg/L across the Hanford Site. Higher levels indicate intercommunication with the overlying contaminated unconfined aquifer (RHO-BWI-ST-5; RHO-RE-ST-12 P; PNL-10817). The majority of wells with higher nitrate in the upper basalt-confined aquifer occur near Gable Mountain and the 200 East Area (Table 2.14-2).

Some samples collected from upper basalt-confined aquifer wells were analyzed for iodine-129. These wells are located beneath or near the iodine-129 plume contained within the overlying unconfined aquifer. Iodine-129 was not detected in the upper basalt-confined aquifer during FY 2005 through 2007 (Table 2.14-2).

A few samples collected from upper basalt-confined aquifer wells were analyzed for gamma-emitting and uranium isotopes. Gamma-emitting isotopes were not detected in the upper basalt-confined aquifer on the Hanford Site, including the Gable Mountain/200 East Area. Uranium isotopes were not observed above background levels in this aquifer in the eastern part of the Hanford Site during FY 2005 through 2007.

In summary, cyanide, nitrate, and technetium-99 were elevated in an upper basalt-confined aquifer well in the north part of the 200 East Area. Migration of high-salt waste via the well bore during its construction is responsible for this contamination. Tritium was predominantly detected at low levels or was not detected. One elevated tritium concentration near the 200 East Area is associated with intercommunication between the upper basalt-confined aquifer and the overlying unconfined aquifer but was less than the drinking water standard. Iodine-129, strontium-90, gamma-emitting isotopes, and uranium isotopes were not detected above the minimum detection limits or background levels in the upper basalt-confined aquifer.

2.14.2.3 Communication Between Aquifers

Intercommunication between the unconfined aquifer and the underlying upper basalt-confined aquifer system is an important consideration for environmental cleanup activities at Hanford. To establish final records of decision for the various groundwater operable units, the nature and extent of contamination in the groundwater must be understood with a reasonable degree of uncertainty. This necessarily includes an assessment of 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 summary of the historical work on this topic.

For aquifer intercommunication to occur, there must be a pathway for the movement of water between the aquifers as well as a difference in hydraulic head between the two systems (i.e., a vertical hydraulic gradient) to provide the driving force for water movement. The uppermost basalt flow at Hanford, the Elephant Mountain Basalt, forms the base of the unconfined aquifer system and serves as the confining unit for the upper basalt-confined aquifer system (i.e., Rattlesnake Ridge interbed beneath most of the Hanford Site). Water may migrate through this unit along joints and fractures if a sufficiently strong vertical hydraulic gradient exists. The limited areas in which the Elephant Mountain Basalt has been thinned or completely removed by erosion represent the most likely locations where communication may occur.

An area of intercommunication between the unconfined and upper basalt-confined aquifer systems was first identified in the north part of the 200 East Area (RHO-BWI-ST-5; RHO-RE-ST-12 P). Several confined aquifer wells north and east of the 200 East Area have shown evidence of intercommunication with the overlying unconfined aquifer (PNL-10817). Intercommunication between the unconfined and confined aquifers in this region has been 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 the ground. However, this groundwater mounding has diminished in recent years (see Section 2.14.1).

Aquifer intercommunication may occur wherever the basalt has been eroded or where remaining basalt is fractured.

It has been well documented that in the area north of the 200 East Area to Gable Gap, that the Elephant Mountain Basalt has been eroded by the ancestral Columbia River as well as by Pleistocene cataclysmic flooding. In 1982, surface geophysical investigations consisting of magnetic, gravity, and electrical resistivity surveys performed to delineate the basalt surface and identify areas of erosion were reported in RHO-ST-38. It was concluded that both the Elephant Mountain Basalt and the underlying Pomona Basalt had been completed removed from Gable Gap by erosion, and the Elephant Mountain Basalt had been removed from the vicinity of West Lake to the southeast of Gable Gap. These are areas where the unconfined aquifer is in direct communication with the underlying confined aquifer(s). Further, RHO-ST-38 identified "hydrologically significant areas of erosion" of the Elephant Mountain Basalt extending from Gable Gap southeast to the northwest part of the 200 East Area and also at the northeast part of the 200 East Area. It was noted that the Elephant Mountain Basalt is absent from well 699-53-55A and significantly eroded in well 699-47-50. Where the Elephant Mountain member of the Saddle Mountains Basalt has been removed by erosion, the potential for aquifer intercommunication is apparent.

Recent work has demonstrated that the basalt need not be absent for communication to occur. A water-level barometric response analysis in Rattlesnake Ridge interbed well 699-49-57B indicated an unconfined aquifer response, even though the basalt is 16 meters thick at this location. Based on this finding, it was concluded that "… the underlying Rattlesnake Ridge interbed aquifer is unconfined and likely in direct communication with the overlying unconfined aquifer system"[(a)] at this location where remaining basalt is fractured. Thus, aquifer intercommunication may occur wherever the basalt has been eroded or where remaining basalt is fractured.

In 1984, RHO-RE-ST-12 P further delineated areas of erosion in the basalt extending from Gable Gap across the northern part of the 200 East Area to B Pond. The extent of this area, as reported in RHO-RE-ST-12 P, is shown in Figure 2.14-12. It should be noted that this area of erosion does not encompass Gable Mountain Pond but that the western lobed B Pond overlies the area where the Elephant Mountain Basalt has been partially removed by erosion.

(a) Memo from FA Spane (Pacific Northwest National Laboatory) to SP Luttrell (Pacific Northwest National Laboratory), Assessment of the Vertical Hydraulic Gradient and Groundwater-Flow Potential Between the Unconfined Aquifer and Upper-Basalt Confined Aquifer System: Well Site 699-49-57A and B, dated October 23, 2001.

For aquifer intercommunication to occur, there must be a hydraulic head difference between the unconfined and upper basalt-confined aquifers. Downward gradients existed around B Pond and Gable Mountain Pond when these facilities were active (RHO-RE-ST-12 P), and the downward gradient at B Pond persists to the present day (Figure 2.14-12). RHO-RE-ST-12 P further notes that the area of downward gradient may have been larger in the 1960s and 1970s due to a higher water-table elevation. Thus, in the region at and to the northwest of B Pond, a downward gradient occurs within the area of basalt erosion (compare Figures 2.14-6 and 2.14-12), so this area has been deemed the most likely pathway for contaminants to migrate from the unconfined aquifer to the underlying upper basalt-confined aquifer (RHO-ST-38; RHO-RE-ST-12 P). An upward gradient exists elsewhere in the 200 East Area/Gable Gap region, so it is expected that the upper basalt-confined aquifer discharges to the overlying unconfined aquifer, especially within Gable Gap where the Elephant Mountain Basalt was removed by erosion.

The groundwater chemistry of the unconfined and upper basalt-confined aquifers indicates that some intercommunication has actually occurred in the region northwest of B Pond. During the early 1980s, stable isotope ratios for deuterium and oxygen-18 were investigated to determine if mixing between the two systems had occurred (RHO-RE-ST-12 P). The ratio of deuterium (2H) to hydrogen (1H) had values between -139 and -144 parts per thousand (‰) below the mean ratio in sea water for the unconfined aquifer, and between -145 and -156 ‰ for water within the Rattlesnake Ridge interbed flowing into the study area. Within the Rattlesnake Ridge interbed northwest of B Pond, values ranged from -142 to -144 ‰, indicating mixing of the unconfined and upper basalt-confined aquifers. Investigation of the oxygen-18 (18O) to oxygen-16 (16O) ratio resulted in a similar conclusion. Background values for this ratio varied from -16.5 to -17.2 ‰ in the unconfined aquifer, and -17.6 to -18.7 ‰ for the Rattlesnake Ridge interbed. Within the Rattlesnake Ridge interbed northwest of B Pond, values ranged from -16.8 to -17.8 ‰, indicating mixing between the two systems.

Analyses of major cations and anions have also indicated mixing between the two aquifers in the 200 East Area/Gable Mountain region (RHO-RE-ST-12 P; PNL-10817). Water within the unconfined aquifer, as well as near recharge areas within the Rattlesnake Ridge interbed, is a calcium-magnesium-bicarbonate type. With increasing residence time, the water in the Rattlesnake Ridge interbed evolves to a sodium-bicarbonate type. However, a calcium-magnesium-bicarbonate water type occurs within the Rattlesnake Ridge interbed in the 200 East Area/Gable Mountain region, indicating recharge from the unconfined aquifer. Analyses of the trace metal barium in the early 1980s also indicated mixing between the two aquifers northwest of B Pond (RHO-RE-ST-12 P). Barium concentrations ranged from 14.7 to 58.7 µg/L within the unconfined aquifer, and from 105 to 129 µg/L in Rattlesnake Ridge interbed water flowing into the study area. Within the Rattlesnake Ridge interbed northwest of B Pond, barium concentrations ranged from 44.3 to 96.4 µg/L, consistent with mixing of waters between the two aquifers.

Analyses of major cations and anions have also indicated mixing between the two aquifers in the 200 East Area/Gable Mountain region.

Finally, contaminants present in the unconfined aquifer have also been detected in the upper basalt-confined aquifer in the 200 East Area/Gable Mountain region, confirming that communication between the two systems has occurred (RHO-RE-ST-12 P; PNL 10817). Elevated levels of tritium and nitrate have been found in the

Rattlesnake Ridge interbed at B Pond and to the northwest. The highest measured tritium concentration was 8,300 pCi/L in well 699-42-40C at B Pond in 1993, but the highest (on trend) concentration to the northwest of B Pond was only 370 pCi/L in well 699-47-50 in 1986. Concentrations of these constituents in the Rattlesnake Ridge interbed at and northwest of B Pond have never been measured above a drinking water standard (20,000 pCi/L for tritium and 45 mg/L for nitrate).

Communication between the unconfined and upper basalt-confined aquifers has also occurred at well 299-E33-12 in the northwest part of the 200 East Area (see Section 2.14.2.2). 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 (RHO-RE-ST-12 P). High-salt waste is believed to have migrated from the unconfined aquifer down the open borehole by density flow to the Rattlesnake Ridge interbed (RHO-RE-ST-12 P). This well was sealed from the unconfined aquifer in the early 1980s. In 1990, an additional seal was placed in the well that shortened the open interval. Contaminant concentrations rose sharply after the seal was installed. Cyanide, nitrate, technetium-99, and tritium continue to be elevated in this well that monitors the confined aquifer, but only nitrate and technetium-99 have exceeded their respective drinking water standards (45 mg/L for nitrate and 900 pCi/L for technetium-99). The highest historical technetium-99 concentration was 1,800 pCi/L and the highest nitrate concentration was 63 mg/L, both measured in 1991.

Contamination associated with intercommunication between the upper basalt-confined aquifer and the overlying unconfined aquifer appears to be limited to the northern part of the 200 East Area and vicinity to the north where the Elephant Mountain member of the Saddle Mountains Basalt has been partially or completely removed by erosion.

Table 2.14-1. Potential Contaminants of Interest in Ringold Formation Confined Aquifer, FY 2005 through FY 2007

Well	Sample Date	Iodine-129 (pCi/L)	Nitrate (mg/L)	Specific Conductance (uS/cm)	Tritium (pCi/L)	Uranium (ug/L)
199-H4-15CQ	20-Oct-04		0.438	287		
399-1-9	04-Jan-07		0.0177 U	360		0.0384 U
399-1-16C	04-Jan-05			380	2.58 U	
	24-Jan-06			374	9.16	
	08-Dec-06		0.0177 U	369		0.0246 U
399-1-17C	08-Dec-06		0.0177 U	381		-0.00756 U
699-45-42	20-Jul-07	4.08	3.69	276	7300	
699-S22-E9C	28-Sep-07			372	7.36 U	
699-S27-E9C	28-Aug-07			376	6.51 U	
699-S29-E16C	28-Jun-05			375	2.45 U	
	07-Jul-06			387	6.15	
	03-Jul-07			366	5.06 U	

U = Below detection limit
Empty cells = Not analyzed

Table 2.14-2. Potential Contaminants of Interest in Upper Basalt-Confined Aquifer, FY 2005 through 2007

Well	Sample Date	Cesium-137 (pCi/L)	Cobalt-60 (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Iodine-129 (pCi/L)	Nitrate (mg/L)	Specific Conductance (uS/cm)	Sr-90 (pCi/L)	Tc-99 (pCi/L)	Tritium (pCi/L)	Uranium (ug/L)
199-H4-15CP	03-Nov-04						17.3 D	371		1.53 U	-3.56 U	1.61
199-H4-2	17-Jul-06			1.07 U	10.5		0.416	241			7.33	
	03-Jan-07			1.23 U	8.54		4.34 D	254			2.65 U	
299-E16-1	14-Jun-06			0.284 U	9.37	-0.0269 U	0.0177 U	312			-38.2 U	
299-E26-8	14-Jun-06			1.84	14.1	-0.132 U	2.35	288			7.81	
	30-Oct-06			2	8.7	0.192 U	4.03 DN	313			5.54 U	
299-E33-12	18-Apr-06							340		1060		
	26-Jun-07	2.23 U	3.71 U	1.2 U	840	-0.0856 U	43.2 D	352		1150	134	2.8
299-E33-40	26-Jul-07	0.929 U	0.223 U	2.4	10		0.0784 B	265		6.92 U	6.64	3.94
299-E33-50	28-Jun-07	0.96 U	1.69 U				1.25	264		24.1	-64 U	1.91
	09-Sep-07	-0.262 U	0.444 U	2.05	15.7	0.0462 U	1.15 N	268	0.00145 U	24	19 U	2.04 X
399-5-2	29-Jun-07			0.28 U	11		0.0221 U	349			5.74 U	
699-13-1C	13-Dec-06			1.44	7.64		0.0177 UN	317			-31 U	
699-24-1P	28-Oct-05			0.569 U	5.99		0.0443 U	374			11.2 U	
	06-Jul-06			1.33 U	8.91		0.248	357			113 U	
699-32-22B	28-Jun-06			1.27 U	12.5	0.0329 U	0.0177 U	377			-37.8 U	
	07-Nov-06			0.238 U	11	-0.0355 U	0.0531 B	383			5.9	
699-42-40C	02-Nov-06			2.19	10.5	0.171 U	5.31 DN	340			4640	
699-42-E9B	12-Oct-05	1.12 U	0.785 U	0.276 U	10.6	0.0962 U	0.0443 U	428			7.15	
	25-Jul-06	-0.669 U	0.425 U	0.0592 U	13	-0.00338 U	0.0177 U	425			8.04	
		0.253 U	-1.4 U	0.985 U	11.2	0.0222 U	0.124				4.38 U	
699-49-55B	06-Aug-07	0.615 U	1.67 U	2.6	9.6		0.691	274		-3.33 U	1.8 U	4.09
699-49-57B	21-Mar-05	0.423 U	-1.2 U			-0.0396 U	1.06 N	304		1.35 U	14.3 U	
	13-Mar-06	0.651 U	-1.56 U			0.067 U	1.11	300		0.295 U	-63.8 U	
	11-Apr-07	2.48 U	-0.339 U	0.907 U	5.86	0.0399 U	1.06	302		-0.683 U	-1.27 U	2.22 B
699-50-53B	28-Jun-06					0.0167 U	12 D	360		-0.42 U	4.16 U	
	02-Nov-06					-0.161 U	11.5 DN	378		1.84 U	119 U	
699-52-46A	30-Jun-07			3.6	7.6		1.84	326	0.223 U		7.92	

Table 2.14-2. (cont.)

Well	Sample Date	Cesium-137 (pCi/L)	Cobalt-60 (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Iodine-129 (pCi/L)	Nitrate (mg/L)	Specific Conductance (uS/cm)	Sr-90 (pCi/L)	Tc-99 (pCi/L)	Tritium (pCi/L)	Uranium (ug/L)
699-54-34	28-Sep-07			1.8	5.1		20.5	340			6.96 U	
699-54-45B	04-Dec-06						0.416	2036				
699-56-43	07-Jul-06			1.6	5.14		4.87 D	319			0.815 U	
	07-Nov-06			3.1	3.2 U		4.56 D	325			8.06	
				2.01	19		4.38 D					
699-56-53	26-Jan-07			5.81	10.9		1.02 N	360			-59.4 U	
699-S2-34B	31-Mar-05						0.0177 U	604			72.7 U	
	10-Jan-06						0.0443 U	609			-74.2 U	
	30-Jan-07						0.0177 UN	611			-94.7 U	
699-S11-E12AP	01-Feb-05							362			-0.298 U	
	29-Jun-06			-0.216 U	8.54		0.0177 U	360			128 U	
699-S24-19P	28-Sep-07						1.77	306			17.7	

B = Analyte detected at a value less than the contract required detection limit
D = Analyzed at a secondary dilution factor
N = Spike sample recovery is outside control limits
U = Below detection limit
X = Result specific informaton may be in the result comment field
Empty cells = Not analyzed

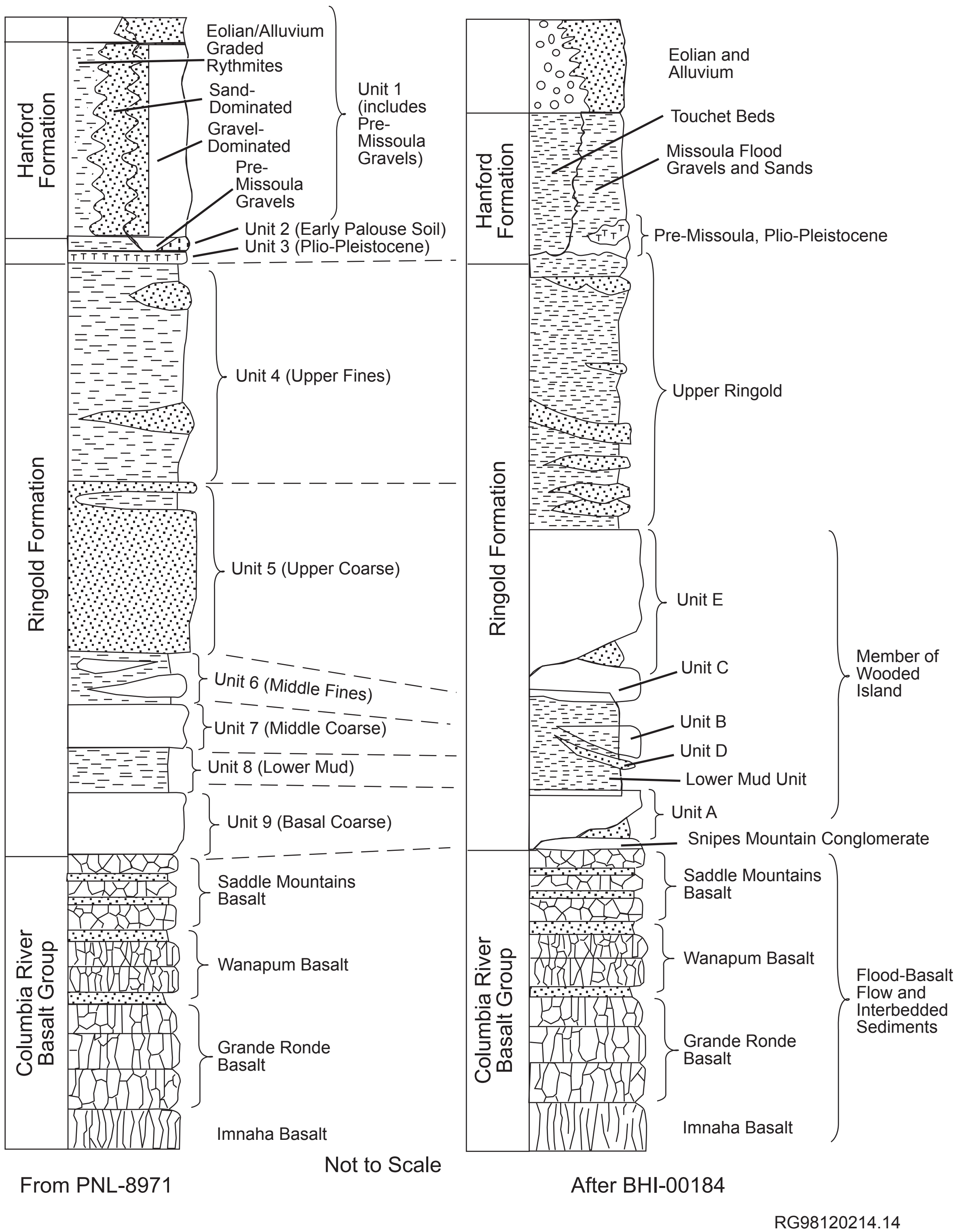

Figure 2.14-1. Hydrostratigraphy of the Hanford Site

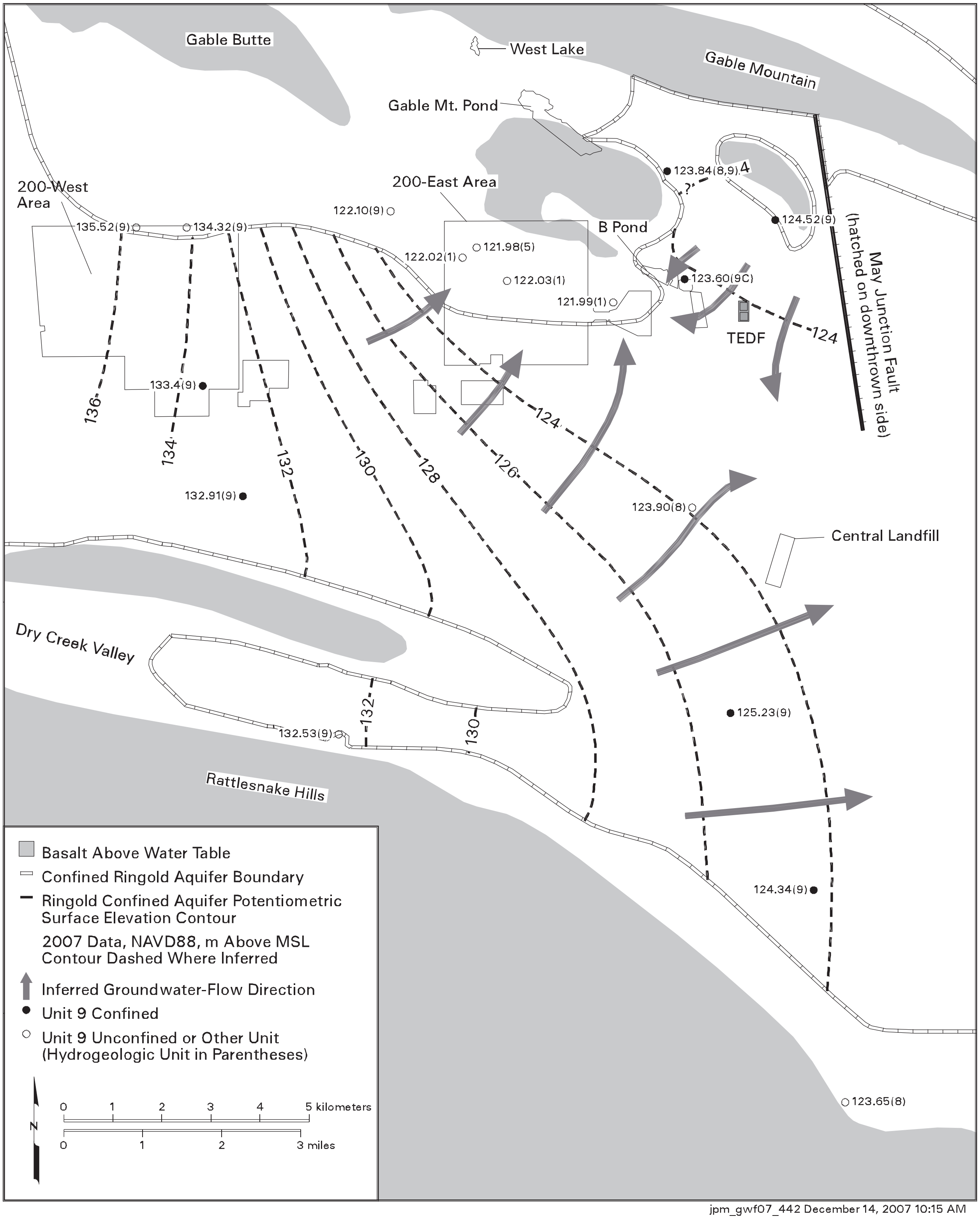

Figure 2.14-2. Potentiometric Surface Map of Ringold Formation Confined Aquifer (Unit 9), Central Hanford Site, March 2007

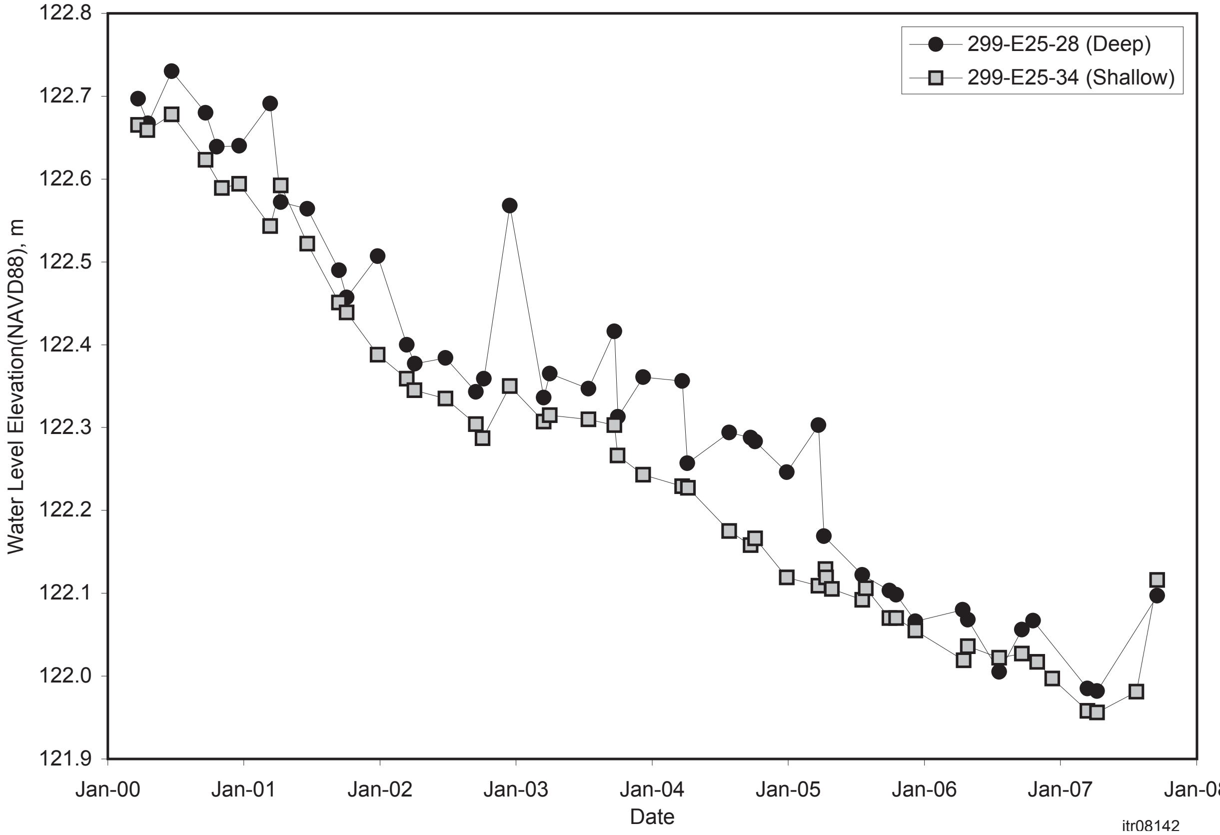

Figure 2.14-3. Water-Level Elevation in Wells Monitoring Different Depths of the Unconfined Aquifer Near 200 East Area

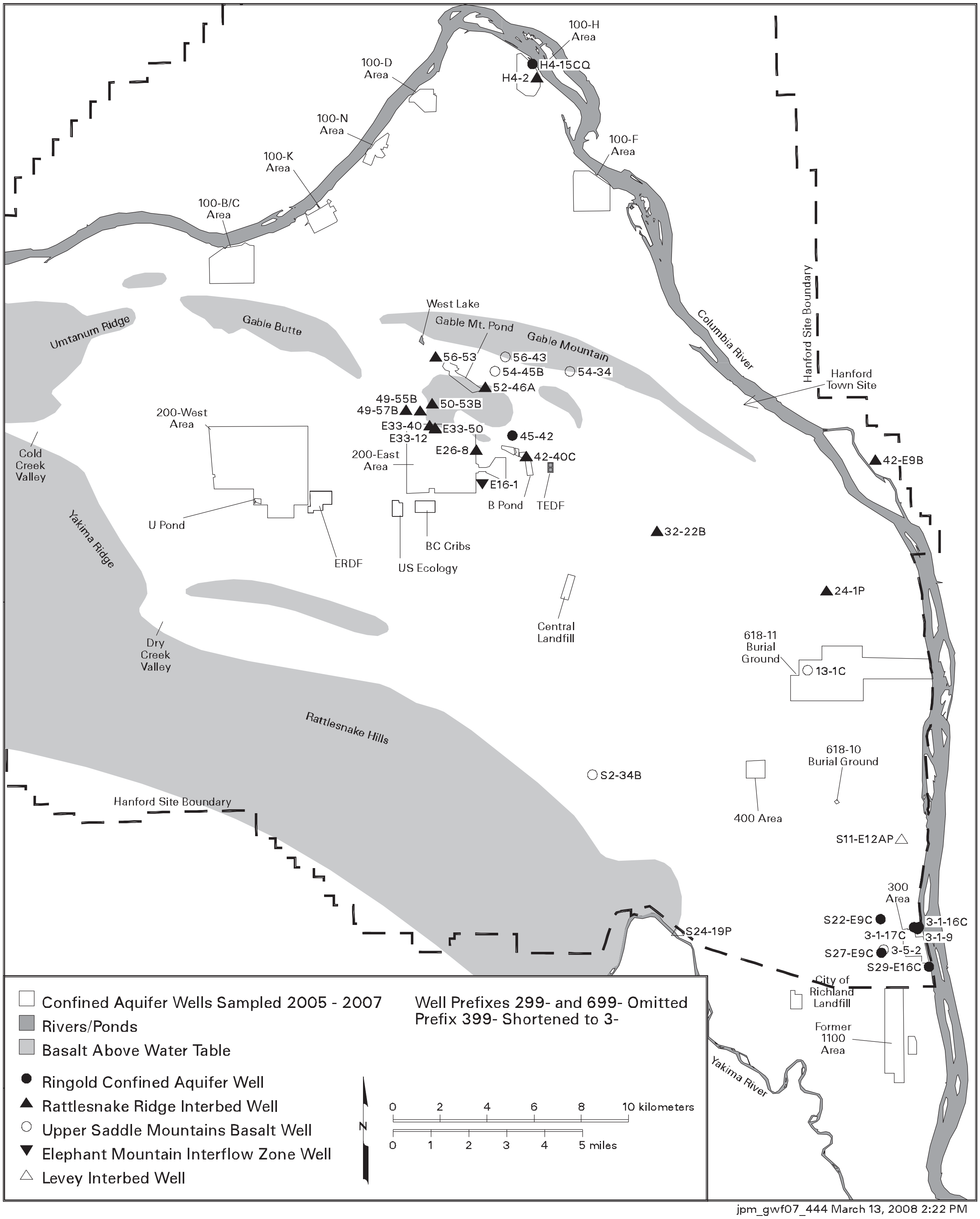

Figure 2.14-4. Groundwater Monitoring Wells Sampled in Ringold Formation Confined and Upper Basalt-Confined Aquifers, FY 2005 through 2007

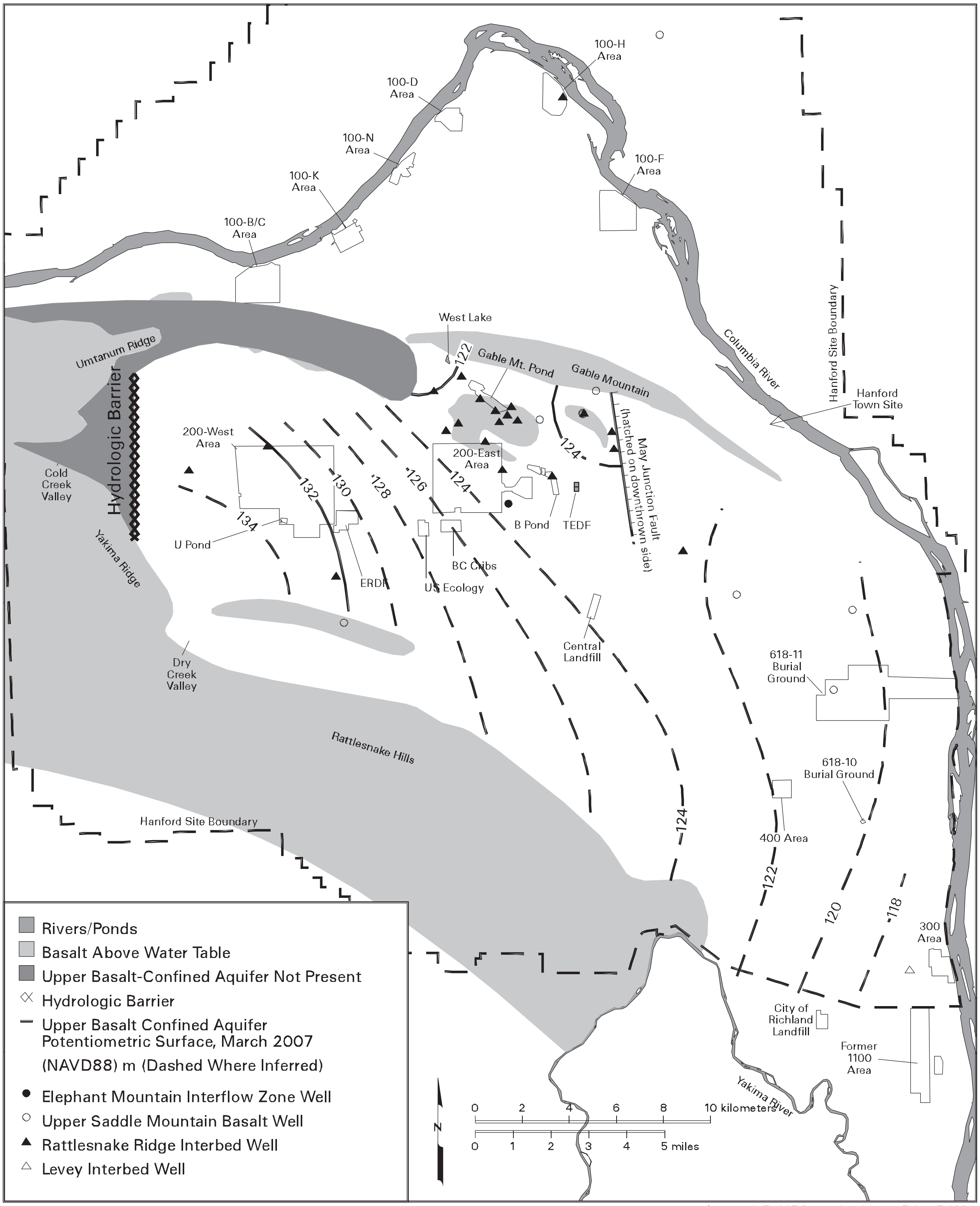

Figure 2.14-5. Potentiometric Surface Map of Upper Basalt-Confined Aquifer System, March 2007

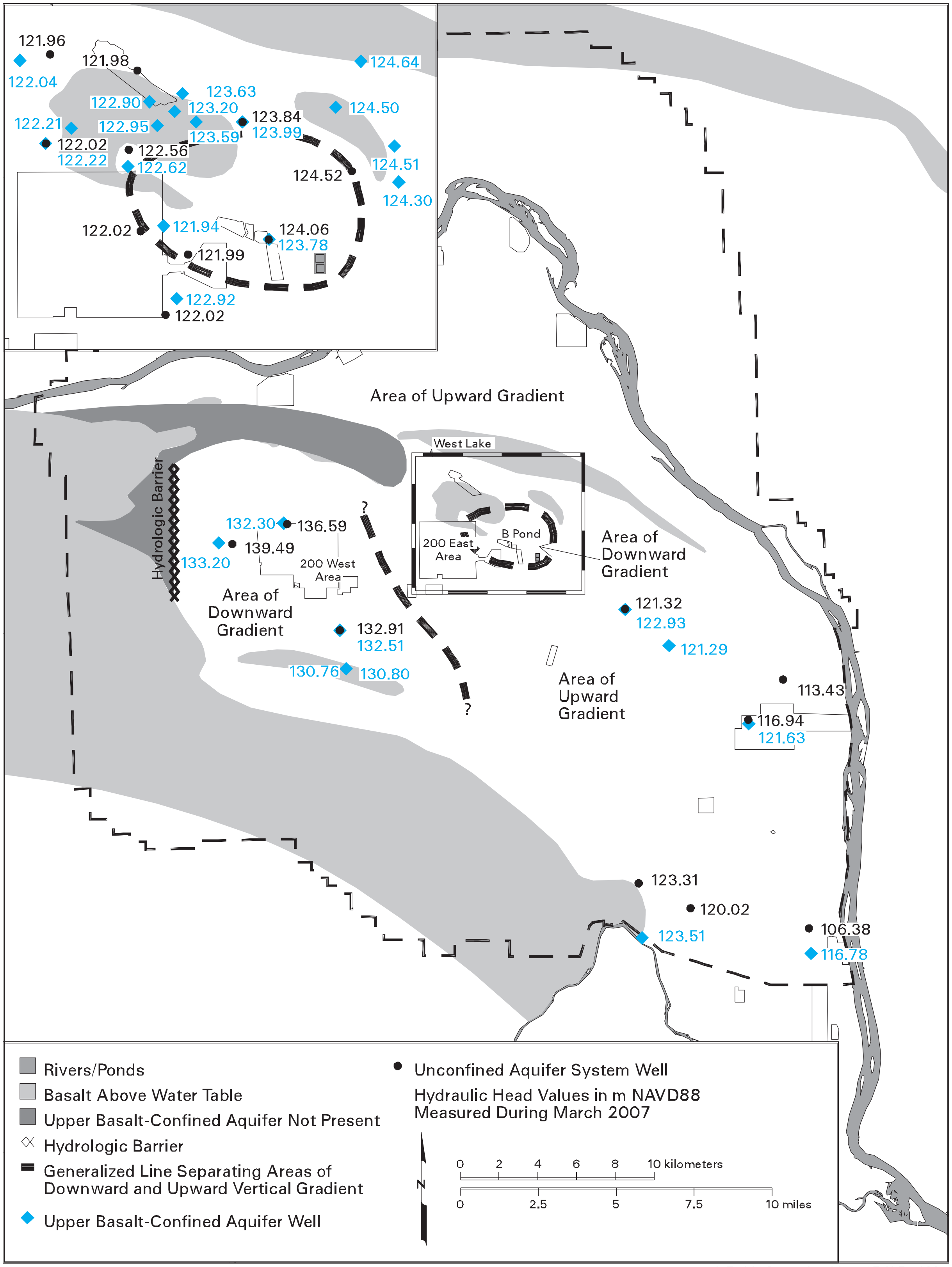

Figure 2.14-6. Comparison of Observed Heads for Upper Basalt-Confined Aquifer and Overlying Unconfined Aquifer

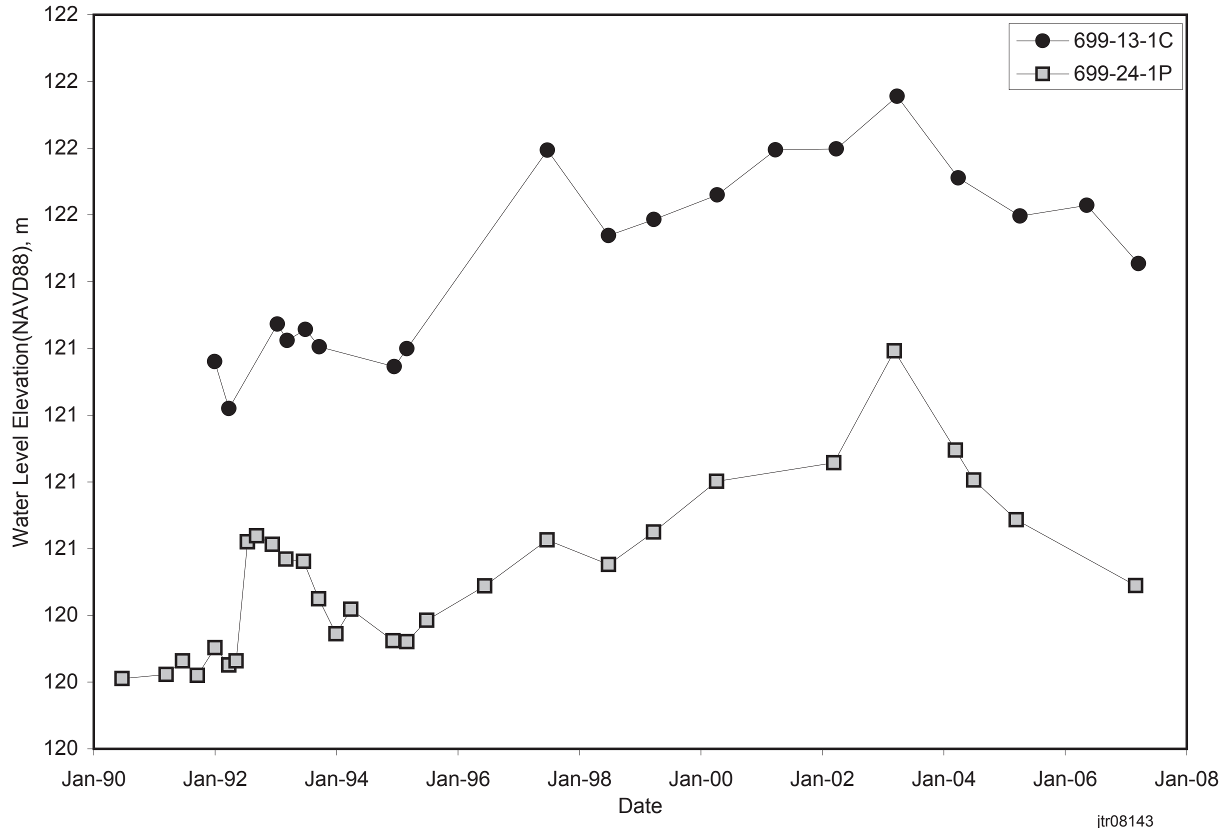

Figure 2.14-7. Water-Level Trends in Upper Basalt-Confined Aquifer Along Columbia River, East Part of Hanford Site

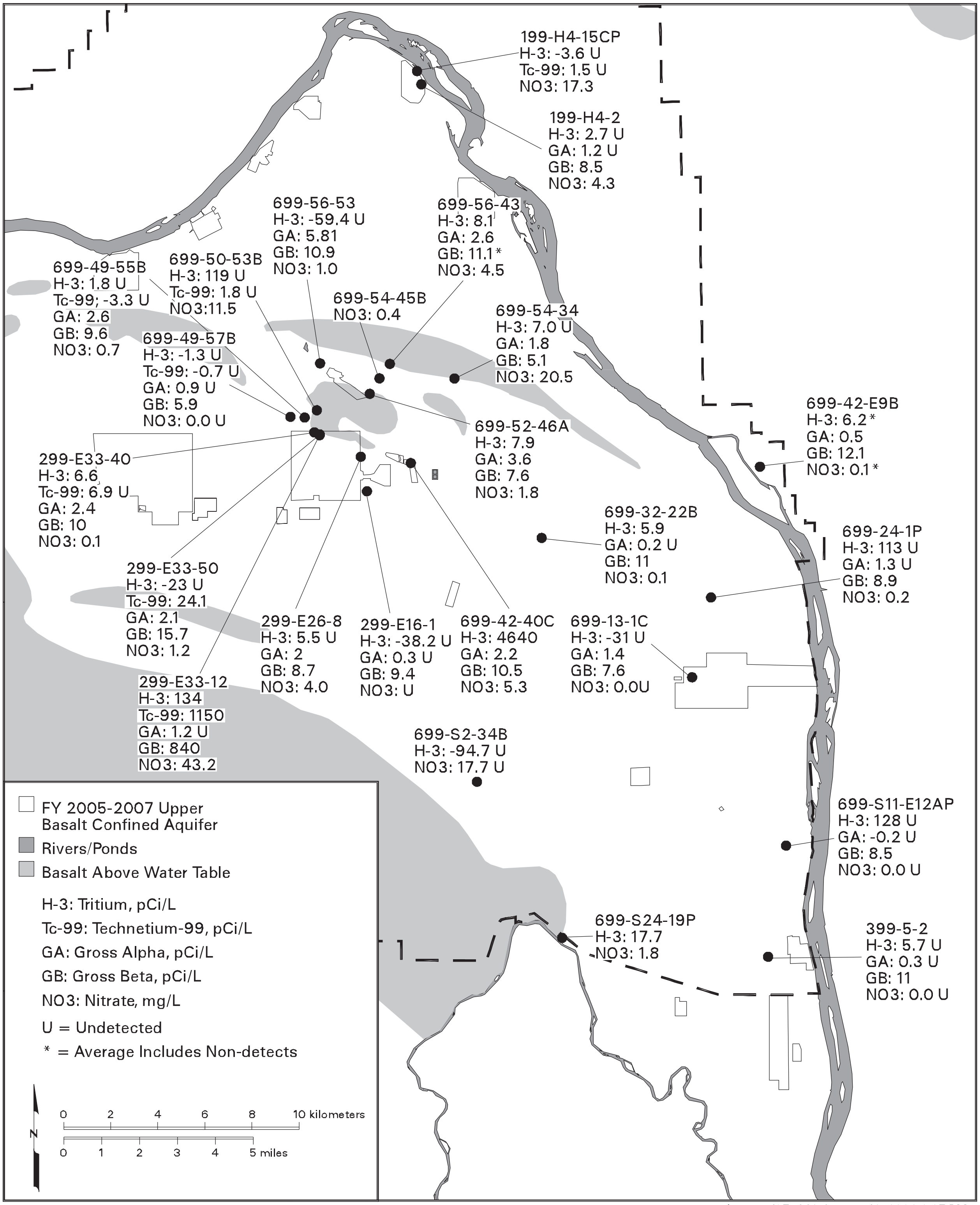

Figure 2.14-8. Distribution of Chemical and Radiological Constituents in Upper Basalt-Confined Aquifer, FY 2005 through 2007

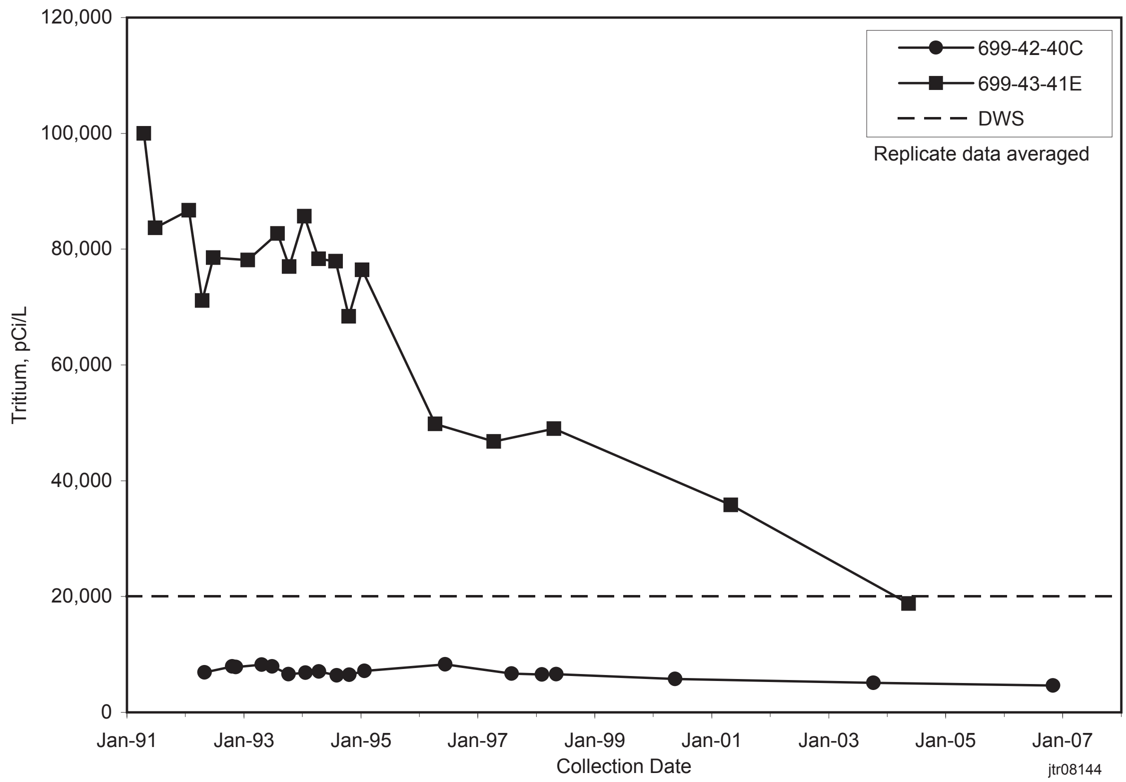

Figure 2.14-9. Tritium Concentrations in Wells 699-42-40C (Upper Basalt-Confined Aquifer) and 699-43-41E (Unconfined Aquifer)

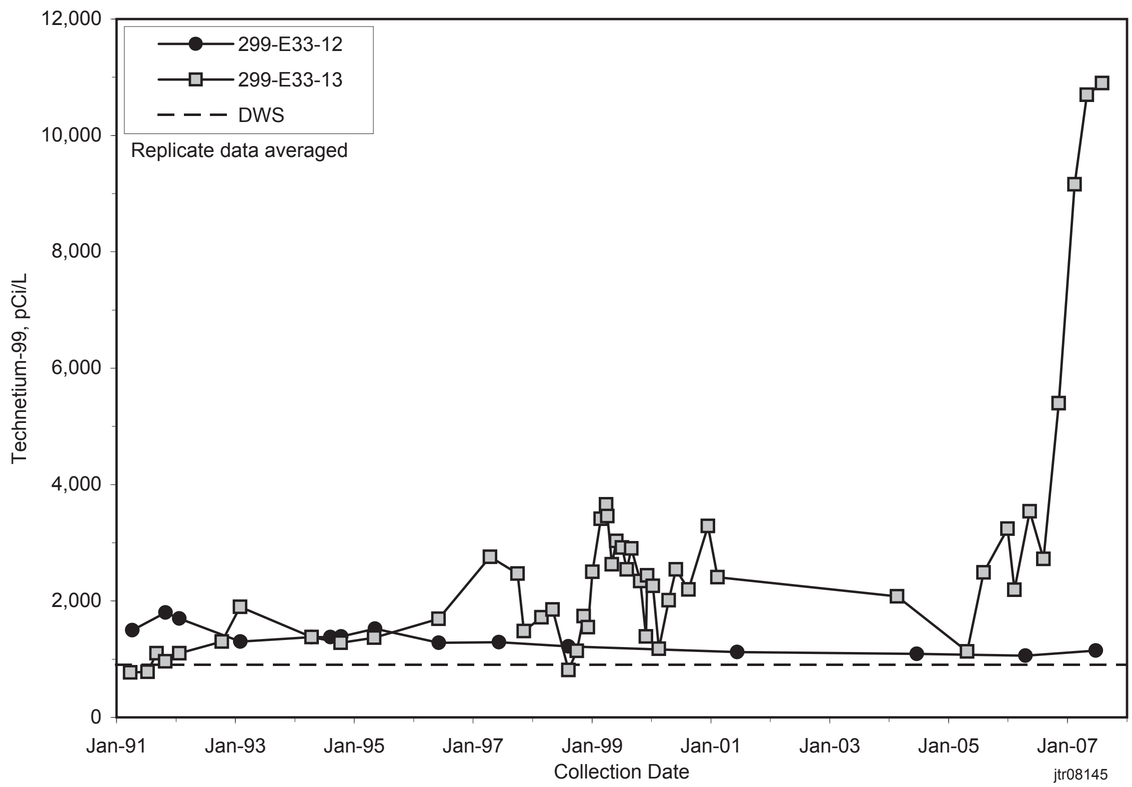

Figure 2.14-10. Technetium-99 Concentrations in Wells 299-E33-12 (Upper Basalt-Confined Aquifer) and 299-E33-13 (Unconfined Aquifer)

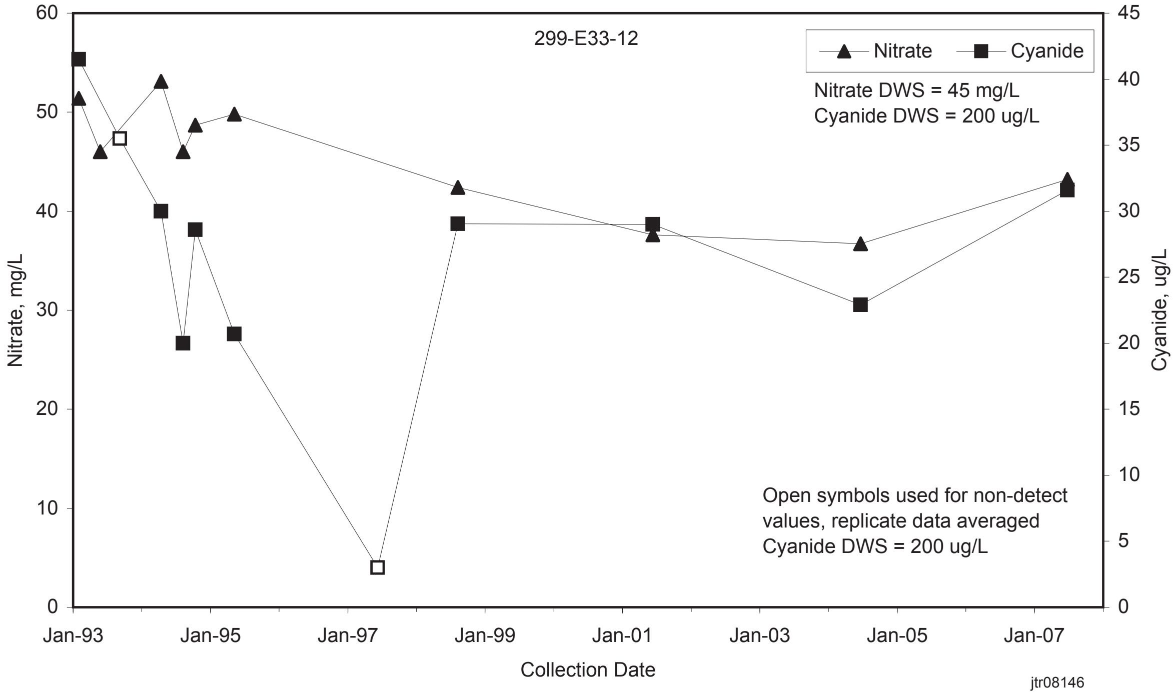

Figure 2.14-11. Cyanide and Nitrate Concentrations in Well 299-E33-12

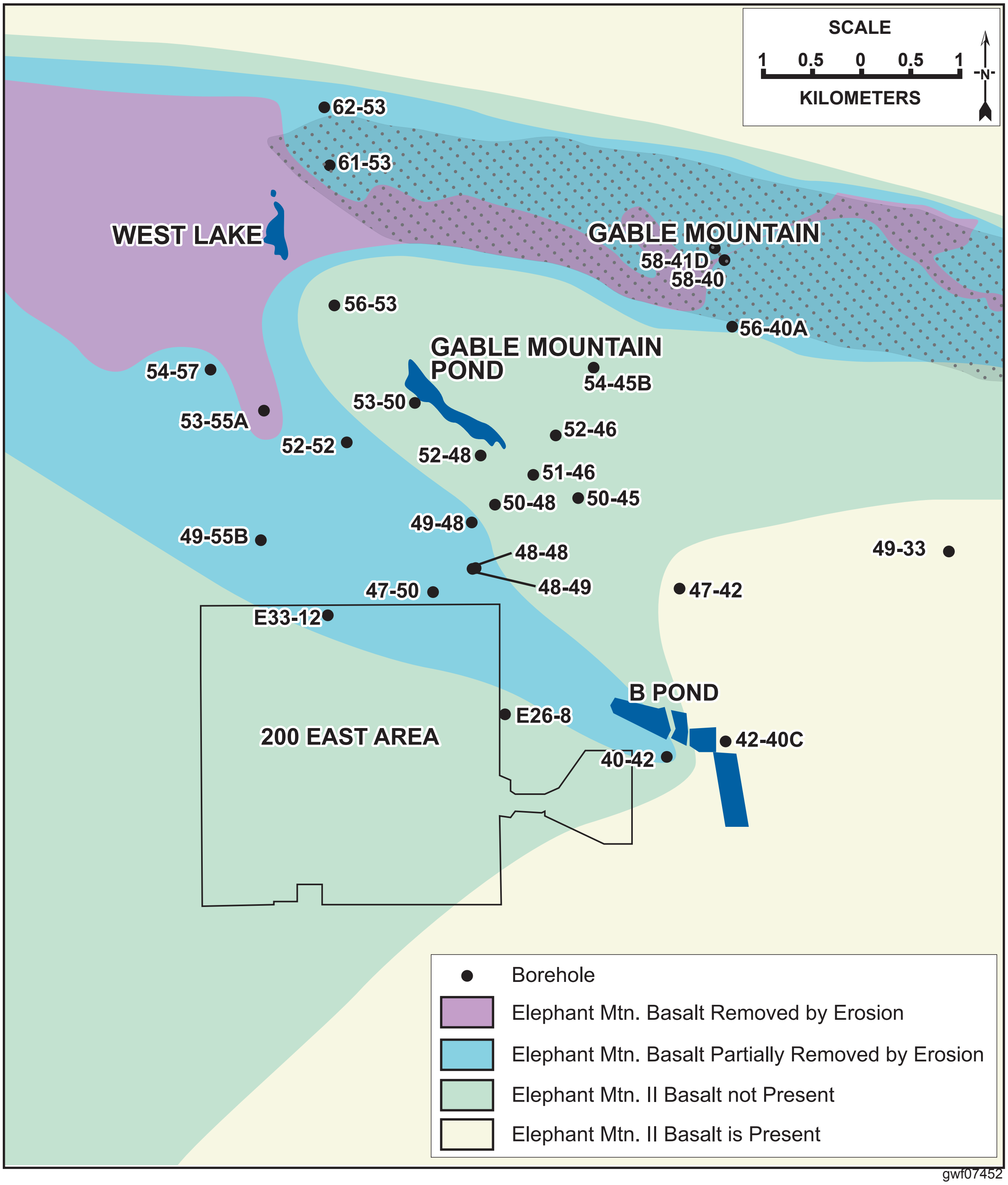

Figure 2.14-12. Extent of Partial or Complete Erosion of the Elephant Mountain Basalt in the 200 East Area/Gable Mountain Region (updated from RHO-RE-ST-12 P)