2.10 200-BP-5 Operable Unit

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The scope of this section is the 200-BP-5 groundwater interest area, which includes the 200-BP-5 Operable Unit (see Figure 2.1-1 in Section 2.1). The Groundwater Performance Assessment Project (groundwater project) defined groundwater interest areas to aid in planning, scheduling, and interpreting groundwater data. This operable unit includes several *Resource Conservation and Recovery Act* (RCRA) units and *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) past-practice sites in the north part of the 200 East Area and extends to the north to Gable Gap. Figures 2.10-1 and 2.10-2 show facilities and wells in this operable unit. The south part of the 200 East Area lies within the 200-PO-1 Operable Unit and is discussed in Section 2.11. The boundary between the two operable units is shown in Figure 2.10-1.

Technetium-99 is the contaminant of greatest concern in the 200-BP-5 Operable Unit.

Technetium-99 is the contaminant of greatest concern in the 200-BP-5 Operable Unit owing to its mobility and broad areal extent of contamination (DOE/RL-2001-49; PNNL-14049). Groundwater is monitored in this operable unit to define the regional extent of technetium-99 and other significant contaminants across the operable unit as well as the local extent of contamination associated with specific RCRA treatment, storage, and disposal units in the area.

The small differences in water-table elevation across the operable unit make it difficult to determine the direction of groundwater flow from water-table maps (see Figure 2.1-3 in Section 2.1). Groundwater currently entering the 200 East Area from the west divides and flows to the Columbia River along two separate paths: one to the southeast and one to the

Groundwater monitoring in the 200-BP-5 Operable Unit includes the following monitoring activities:

CERCLA Monitoring

- ***CERCLA sampling was conducted at 59 wells in the 200-BP-5 Operable Unit.***
- ***One well located near B Pond could not be sampled because it is dry (see Appendix A).***
- ***One well in the Gable Gap area could not be sampled because it is dry (see Appendix A).***
- ***One well could not be sampled at Gable Mountain Pond because it is dry (see Appendix A).***
- ***One well located in Waste Management Area B-BX-BY could not be sampled because it is currently being used for vadose zone monitoring activities (see Appendix A).***

Facility Monitoring

- ***Twenty-five wells are sampled quarterly to semiannually at Waste Management Area B-BX-BY.***
- ***Sampling at one well at Waste Management Area B-BX-BY has been postponed owing to safety concerns.***
- ***Twelve wells are sampled quarterly to semiannually at the 216-B-63 trench.***
- ***Seventeen wells are sampled semiannually at Low-Level Waste Management Area 1.***
- ***Eleven wells are sampled semiannually at Low-Level Waste Management Area 2.***
- ***Two wells are sampled semiannually at the Liquid Effluent Retention Facility.***
- ***Nine wells are sampled quarterly at Waste Management Area C.***
- ***All RCRA wells were sampled as scheduled (see Appendix B).***

AEA Monitoring

- ***Wells are sampled annually to triennially within the 200-BP-5 Operable Unit for constituents related to general water chemistry.***
- ***Six guard wells are sampled annually at Gable Gap.***
- ***Wells are sampled annually to triennially in the upper basalt-confined aquifers (see Section 2.14.1).***

northwest though Gable Gap. The water table has been generally declining following the decrease in liquid effluent discharges to the soil in the 200 East Area. This appears to have resulted in changes in groundwater flow directions in the northwest part of the 200 East Area. Our ability to describe current flow characteristics, however, is limited owing to the low hydraulic gradients present. The extent of the basalt units above the water table also continues to increase due to the declining water table, resulting in an effect on groundwater flow in this area.

Techniques used to determine groundwater flow in the 200-BP-5 Operable Unit consist of water-table maps, plume and contaminant trend plots, water-level trend surface analysis, water-level hydrographs for multiple wells, and in situ flow measurements at groundwater wells. These techniques have been applied extensively in an effort to understand the direction of groundwater flow around the RCRA units in the 200-BP-5 Operable Unit and are discussed in more detail later in Section 2.10.3. General inferences regarding groundwater flow direction based on plume configurations (especially tritium, nitrate, iodine-129, and technetium-99) are also discussed in Section 2.10.1.

Water-level measurements are generally made in March and are used to construct Hanford Site water-table maps. Small differences in water-elevations make it difficult to define the water-table surface in 200-BP-5 Operable Unit. Other significant sources of error in water-elevation measurements are related to changes in barometric pressure and to borehole deviations from vertical. A set of water-elevation measurements were collected in July 2004, when the variation in barometric pressure was minimal. The results of this effort are presented in the water-table map shown in Figure 2.10-3. The map elevation contours suggest that there is a general water-elevation low trending in a northwest-southeast direction across the 200 East Area, which is consistent with the geometry of contaminant plumes in the region and also with the trend of high-permeability aquifer sediment. The observation that an isopotential contour appears to be roughly parallel to the basalt subcrop, however, also suggests a southwestward component of flow in the vicinity of Waste Management Area B-BX-BY, the 216-B-63 trench, and Low-Level Waste Management Area 2. Several possible water-elevation highs within this trend may be related to local releases of water or, alternatively, may be regions of lower hydraulic conductivity. Significant uncertainty owing to possible errors besides barometric pressure effects, in particular borehole deviations from vertical make interpretation of water-level measurement results somewhat tenuous. Another collection of water-elevation measurements may be undertaken in July 2005. An ongoing effort to provide corrections to borehole deviation error will also continue. These activities may allow more detailed interpretation of water-level information to be presented.

Plume areas (square kilometers) above the drinking water standard at the 200-BP-5 Operable Unit:

Iodine-129 — 3.49
Nitrate — 5.08
Strontium-90 — 0.72
Technetium-99 — 2.18
****Tritium — 3.44***
Uranium — 0.19

****Includes entire plume through Gable Gap and between 100-B/C and 100-K Areas.***

The upper basalt-confined aquifer is also monitored in the 200-BP-5 Operable Unit because of the potential for migration of contaminants from the overlying unconfined aquifer (Section 2.14). The basalt north of the 200 East Area was significantly eroded by late Pleistocene flooding, which may facilitate aquifer intercommunication. Discharge to overlying or underlying aquifers in the vicinity of the Gable Butte/Gable Mountain structural area, for example, may occur through erosional windows in the basalt where removal of the Elephant Mountain basalt has left a region of intercommunication between the Rattlesnake Ridge interbed aquifer and the unconfined aquifer.

Section 2.10.1 provides general information regarding geometry of contaminant plumes and concentration trends for contaminants of concern. Specific information regarding contaminant distribution for RCRA units within the 200-BP-5 Operable Unit is presented in Section 2.10.3.

2.10.1 Groundwater Contaminants

This section describes the distribution of groundwater contaminants of concern in the 200-BP-5 Operable Unit. Specific information is provided for several CERCLA units (the

216-B-5 reverse well, BY cribs, and Gable Mountain Pond) as well as general information regarding regional contaminant distribution, particularly in the Gable Gap area. Contaminants of concern for this operable unit include tritium, uranium, iodine-129, cobalt-60, cyanide, strontium-90, cesium-137, plutonium-239/240, and nitrate (PNNL-14049).

Plume maps presented in this section are based on annual average values from wells completed at the top of the unconfined aquifer.

2.10.1.1 Tritium

Tritium contamination is widespread throughout the northwest part of the 200 East Area. The contamination extends north through the gap between Gable Mountain and Gable Butte and to the Columbia River and southeast through the 200-PO-1 Operable Unit (Figure 2.10-4). Tritium contamination from the 200-BP-5 Operable Unit has declined greatly because of natural decay and dispersion. A number of waste disposal facilities in the 200 East Area have contributed to tritium contamination in the operable unit. Wells in the vicinity of the 216-B-5 injection well had concentrations of tritium below the drinking water standard in fiscal year (FY) 2004.

The tritium plume extends northward through Gable Gap.

Tritium at levels above the drinking water standard can be found between Gable Mountain and Gable Butte (Figure 2.10-3). Concentrations in monitoring well 699-61-62 in Gable Gap continued to decline with a measured value for FY 2004 of 21,000 pCi/L (see Figure 2.1-2 in Section 2.1 and Figure 2.10-2 for locations of 600 Area wells). Tritium concentrations in wells 699-60-60 (25,000 pCi/L) and 699-64-62 (19,000 pCi/L) also declined somewhat in FY 2004. Well 699-72-73, located between the 100-B/C and 100-K Areas, exceeded the drinking water standard for the first time in FY 2001, but tritium concentrations have subsequently declined and a value of 16,000 pCi/L was reported in FY 2004.

Tritium values have increased during the last several years at the south end of Waste Management Area B-BX-BY. The maximum tritium value in this region in FY 2004 was 19,900 pCi/L in well 299-E33-21 (Section 2.10.3.1).

2.10.1.2 Nitrate

A nitrate plume originating in the 200 East Area extends beyond the boundary fence line northwest toward the Columbia River (Figure 2.10-5). The plume within the 200 East Area has two parts: (1) a west plume that extends through the west portion of Low-Level Waste Management Area 1 and (2) an east plume extending from the BY and surrounding cribs toward the northwest. The two plumes appear to join northwest of the 200 East Area and extend through the gap between Gable Butte and Gable Mountain to the Columbia River at levels less than the drinking water standard (45 mg/L).

The west part of the nitrate plume, extending through the west portion of Low-Level Waste Management Area 1, appears to be part of a larger plume extending from the 200-PO-1 Operable Unit. This plume apparently moved to the northwest under past flow conditions during the period of high discharge to 200 East Area facilities and B Pond.

The highest nitrate concentrations are in the vicinity of the BY and 216-B-8 cribs.

The highest nitrate concentrations are in the vicinity of the BY and 216-B-8 cribs. High concentrations of nitrate are associated with the cobalt-60, cyanide, and technetium-99 plume originating from the BY cribs (PNNL-13080). The highest nitrate concentrations measured in FY 2004, were found in well 299-E33-4 (1,070 mg/L), near the BY cribs. The highest value for nitrate associated with the 216-B-8 crib during FY 2004 was a concentration of 575 mg/L reported for well 299-E33-16. The ratio of nitrate to technetium-99 in well 299-E33-16 is high compared to the ratio of nitrate to technetium-99 in wells near the BY cribs, indicating an additional nitrate source associated with the 216-B-8 crib (PNNL-14187).

Nitrate continued to be detected in wells monitoring Gable Mountain Pond at levels above the drinking water standard (Figure 2.10-5). A nitrate value of 90.7 mg/L was measured in FY 2004 at well 699-53-47A.

2.10.1.3 Iodine-129

Iodine-129 contamination is present throughout the west portion of the 200-BP-5 Operable Unit. Like the tritium plume, the iodine-129 plume extends to the northwest toward the Gable Mountain/Gable Butte gap and southeast through the 200-PO-1 Operable Unit (Figure 2.10-6). Unlike tritium, however, levels greater than the iodine-129 drinking water standard (1 pCi/L) have not passed the gap between Gable Mountain and Gable Butte. A band of elevated iodine-129 concentrations (~5 pCi/L) exists in Waste Management Area B-BX-BY but decreased in extent in FY 2004 relative to FY 2003. Interpretation of the iodine-129 configuration in this area is complicated by elevated detection limits that result from interference of technetium-99. In addition, the current laboratory reporting system produced some values reported as not detected at levels greater than the drinking water standard (1 pCi/L) (Appendix C).

2.10.1.4 Technetium-99

A plume of technetium-99 extends from the area of the BY cribs and Waste Management Area B-BX-BY to the northwest (Figure 2.10-7). A significant portion of the plume is north of the 200 East boundary and is interpreted to represent early releases of technetium-99 from the BY cribs (PNNL-13080). Detection of technetium-99 at levels lower than the 900-pCi/L drinking water standard north of the gap between Gable Mountain and Gable Butte indicates that technetium-99 has moved north into, and through, the gap.

Technetium-99 was not routinely measured in groundwater prior to the late 1980s, limiting the information on historical trends. In addition, well coverage is limited. Thus, there is considerable uncertainty in the extent of technetium-99 contamination. Interpretation of the exact configuration and extent of the technetium-99 plume north of the 200 East Area is also complicated by the variable concentrations seen in wells that are relatively close together (see Figure 2.1-2 in Section 2.1 and Figure 2.10-2 for 600 Area well locations). For example, concentrations of technetium-99 less than the drinking water standard were consistently detected in well 699-49-55A since the early 1990s (16 pCi/L in FY 2001 and 249 pCi/L in FY 2004). This well was used as the injection well in 1995 for pump-and-treat operations and has had low technetium-99 values relative to nearby wells since then (Figure 2.10-7).

A plume of technetium-99 extends from the area of the BY cribs to beyond the north boundary of 200 East Area. The plume has moved through Gable Gap at levels below the drinking water standards.

Seven wells were successfully sampled in the Gable Gap area north of the 200 East Area boundary in FY 2004 (Figure 2.10-7). Concentrations of technetium-99 were generally similar for FY 2003 and 2004. Well 699-49-57A has had greater concentrations in FY 2003 and 2004 versus 2001 as shown in Figure 2.10-8, but data is not sufficient to determine if concentrations are currently in a declining or increasing trend.

Well 699-52-57, located north of well 699-49-57A, had consistently low technetium-99 concentrations (<90 pCi/L) throughout the 1990s; however, the water table fell below the screen in 1999 so the well can no longer be sampled. A review of well construction and logging information suggests that this well was not drilled to the top of the basalt and may lie in an erosional window where the Elephant Mountain Member has been removed, thereby juxtaposing the unconfined aquifer in the Hanford formation and the upper basalt-confined aquifer in the Rattlesnake interbed (see Section 2.14.2.1). DOE/RL-2001-49 proposed that well 699-52-57 be deepened, if possible, to permit sampling activities to continue at this location and to obtain additional geological information.

In the late 1990s, rising technetium-99 concentrations were seen in the BY crib area in wells 299-E33-7 and 299-E33-38 (Figure 2.10-8). In early 1999, the trends for both wells began to track together and reached an apparent maximum in late 2000. These trends may reflect pervasive transport of contamination from the vadose zone at the BY cribs and relatively recent breakthrough into the saturated zone. In particular, high concentrations of technetium-99 in well 299-E33-38 (average of 9,800 pCi/L in FY 2003) and 299-E33-4 (11,000 pCi/L reported for a sample collected in June of 2004) suggest a continuing source of contamination from the BY cribs to groundwater. A general correlation of concentration trends for technetium-99, nitrate, cobalt-60, and cyanide in wells 299-E33-7 and 299-E33-38

and local distribution of these constituents suggests that the primary source of technetium-99 contamination is related to past discharges of ferrocyanide containing waste to the BY cribs (PNNL-13080; PNNL-14049).

2.10.1.5 Cobalt-60 and Cyanide

Cobalt-60 and cyanide continued to be detected in a number of wells in the 200-BP-5 Operable Unit. Cobalt-60 has a relatively short half-life (5.3 years) and is currently only found at levels less than the drinking water standard (100 pCi/L). Cyanide is found at levels above the drinking water standard (200 µg/L). These constituents are useful for distinguishing contaminant groups and contaminant sources and are generally associated with ferrocyanide waste streams. Thus, cyanide and cobalt-60 are generally found together in this area.

The maximum cyanide concentrations in this area in FY 2004 was 357 µg/L from well 299-E33-7 located in the northern part of the BY cribs. Cyanide contamination trends in wells 299-E33-7 and 299-E33-38 are similar to those of technetium-99, cobalt-60, and nitrate and may be related to past discharges of ferrocyanide waste to the BY cribs (PNNL-13080; PNNL-14049).

The highest cobalt-60 values in FY 2004 also were detected in wells monitoring the BY cribs, and the cribs are believed to be the source of this contamination. The highest cobalt-60 concentrations in FY 2004 were in wells 299-E33-4 (109 pCi/L) and 299-E33-7 (45.2 pCi/L), located in the north part of the BY cribs. Well 299-E33-38, located in the south part of the cribs, had a maximum cobalt-60 value of 42.6 pCi/L in FY 2004.

2.10.1.6 Uranium

Uranium contamination in the 200-BP-5 Operable Unit is limited to three isolated areas:

- Wells monitoring Waste Management Area B-BX-BY and BY cribs.
- Wells near the 216-B-5 injection well.
- Wells 299-E28-21 and 299-E28-18 at the 216-B-62 crib.

Wells in all three of these areas exceeded the drinking water standard (30 µg/L) during FY 2004.

Uranium contamination in the 200-BP-5 Operable Unit is limited to three isolated areas: Waste Management Area B-BX-BY and surrounding cribs, 216-B-5 injection well, and 216-B-62 crib.

Waste Management Area B-BX-BY. The largest uranium plume in the 200 East Area may have sources at Waste Management Area B-BX-BY. Currently, the highest uranium concentrations in the 200-BP-5 Operable Unit are found within and to the east of the BY Tank Farm (Figure 2.10-9). The contamination is present in a narrow northwest-southeast band but is increasing to the south along the west side of Waste Management Area B-BX-BY. One interpretation is that the plume may originate from a release at tank BX-102 (RPP-10098; PNNL-14187; Christensen et al. 2004) and is migrating through the vadose zone from a perched water table; another is that the plume originates from nearby cribs that received waste similar to tank waste. In FY 2004, the highest concentrations were detected in wells 299-E33-9 and 299-E33-44, with annual average concentrations of 550 and 290 µg/L, respectively. Section 2.10.3.1 includes additional discussion of uranium at Waste Management Area B-BX-BY.

216-B-5 Injection Well. Uranium contamination is associated with the cesium-137, plutonium, and strontium-90 contamination found at the former 216-B-5 injection well. The highest uranium concentration detected in FY 2004 at this site was 62.8 µg/L in well 299-E28-23, located only ~1 meter from the injection well. Uranium concentrations are roughly stable in well 299-E28-23. Uranium values were significantly lower in wells 299-E28-24 and 299-E28-25 located further from the injection well. Uranium values of 35.7 and 36.1 µg/L were reported for well 299-E28-6, located south of the injection well, in FY 2004. Uranium concentrations are declining in well 299-E28-6.

216-B-62 Crib. Uranium was detected consistently at levels slightly above the drinking water standard (30 µg/L) in wells monitoring the 216-B-62 crib, located west of B Plant. Uranium concentrations were over 200 µg/L in the mid-1980s, but declined to current levels by the early 1990s. The maximum FY 2004 uranium concentration at the 216-B-62 crib was 36 µg/L reported for well 299-E28-18. Uranium also has been found along the west side of Low-Level Waste Management Area 1, but no wells exceeded the drinking water standard in FY 2004. The uranium detected near Low-Level Waste Management Area 1 may have originated at the 216-B-62 crib.

2.10.1.7 Cesium-137 and Strontium-90

Cesium-137 and strontium-90 have relatively low mobility and are generally found near their source. Several wells near the 216-B-5 injection well have had elevated concentrations of strontium-90. Four wells (299-E28-2, 299-E28-23, 299-E28-24, and 299-E28-25) had concentrations of strontium-90 above the drinking water standard (8.0 pCi/L) in FY 2004. Two of the wells have had concentrations greater than the U.S. Department of Energy (DOE) derived concentration guide (1,000 pCi/L) in past years and in FY 2004 (Figure 2.10-10). The highest strontium-90 concentration was reported for well 299-E28-23, which averaged 5,990 pCi/L in FY 2004. Strontium-90 also exceeded the DOE derived concentration guide in well 299-E28-25, which averaged 2,080 pCi/L in FY 2004.

Wells near the 216-B-5 injection well have elevated concentrations of low-mobility contaminants including cesium-137, plutonium, and strontium-90.

Well 299-E28-23 near the 216-B-5 injection well has consistently had concentrations of cesium-137 greater than the drinking water standard (200 pCi/L) but less than the DOE derived concentration guide (3,000 pCi/L). In FY 2004, an average value of 1,195 pCi/L was reported for this well, which exhibits a generally declining trend. An increase in cesium-137 was observed in well 299-E28-25 (238 pCi/L). All other wells sampled at this site had cesium-137 concentrations below the drinking water standard in FY 2004.

Strontium-90 concentrations showed a declining trend in 1997, 2000, 2003, and 2004 versus a rising trend before FY 1999 in several wells near Gable Mountain Pond. Strontium-90 was detected in groundwater at levels above the DOE derived concentration guide in the only well that was sampled at Gable Mountain Pond in FY 2000, but was below it in FY 2003 and 2004. The concentration in samples from that well, 699-53-47A, was 806 pCi/L in FY 2003 and 720 pCi/L in FY 2004 versus 1,210 pCi/L in FY 2000 (Figure 2.10-11).

2.10.1.8 Plutonium

Plutonium-239 and plutonium-240 were detected in past years in samples taken from several wells near the 216-B-5 injection well. Plutonium contamination is relatively immobile and, therefore, is found only near the source, which was the injection well. The highest reported plutonium concentration in FY 2004 was for well 299-E28-23, which had a filtered value of 5.27 pCi/L and an unfiltered value of 66.2 pCi/L. Thus, the unfiltered value for this well exceeded the DOE derived concentration guide for plutonium (30 pCi/L), but the filtered value was below it. The lower concentration in the filtered versus unfiltered samples suggests that a portion of the plutonium is associated with particulates. For comparison, the gross alpha drinking water standard is 15 pCi/L. The concentration of plutonium in well 299-E28-33 has not exhibited a change in trend in recent years. Other wells sampled at the 216-B-5 injection well site have indicated plutonium levels were below the DOE derived concentration guide in recent years.

2.10.1.9 Other Constituents

Several other constituents exceeded drinking water standards in the 200-BP-5 Operable Unit in FY 2004. A maximum of 11.7 µg/L was reported for arsenic versus the drinking water standard of 10 µg/L. This may be a laboratory analytical problem since there are no known sources of arsenic in the 200-BP-5 Operable Unit. Numerous measurements of gross alpha and gross beta exceeding their drinking water standard have also been reported during FY 2004 and are related to radionuclide contaminants discussed in the preceding sections.

2.10.2 Operable Unit Monitoring

CERCLA monitoring requirements in the 200-BP-5 Operable Unit have been defined in the sampling and analysis plan (DOE/RL-2001-49). CERCLA monitoring includes regional plumes, the 216-B-5 injection well site, the BY cribs, and Gable Mountain Pond. Results of monitoring are discussed in Section 2.10.1. An interim or final record of decision has not been established yet for the 200-BP-5 Operable Unit. This report is the only formal report presently being prepared on a regular basis for the unit.

CERCLA monitoring in the 200-BP-5 Operable Unit includes sampling of the regional plumes, 216-B-5 injection well site, BY cribs, and Gable Mountain Pond.

The 200-BP-5 monitoring network and analytes are listed in Appendix A. In FY 2004, sampling was planned for 63 wells. Of these, 59 wells were successfully sampled and 4 wells could not be sampled. Three of the wells that could not be sampled were determined to be dry. These wells included 699-43-40 near B Pond, 699-50-53A in the Gable Gap area, and 699-53-48B at Gable Mountain Pond. The fourth well, 299-E33-46, is being used for vadose zone monitoring activities and cannot be sampled. The sampling and analysis plan was revised in late FY 2004 to integrate *Atomic Energy Act of 1954* (AEA) monitoring and make slight modifications in the 200-BP-5 monitoring network. The monitoring plan (DOE/RL-2001-49) has been revised and will be implemented in FY 2005.

DOE/RL-2001-49 proposed that an additional monitoring well be installed south of Gable Gap and on the west margin of the technetium-99 plume (see DOE/RL-2001-49 for specific location). This well, which has been approved for drilling in FY 2005, will serve to better define plume extent and geometry. Installation of new wells in this area is also important from a hydrogeological standpoint because additional wells will provide information regarding groundwater flow (based on the gradient of the water table) and will help to better define the elevation of the top of the basalt in this area and the geometry of the anticlinal structure in the gap. The latter information is needed to support predictions of future groundwater flow and contaminant migration through the gap.

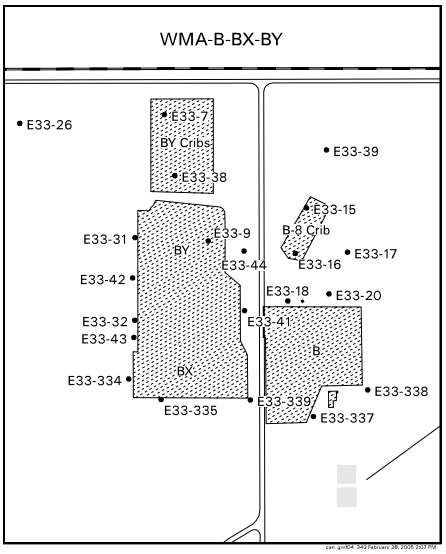
2.10.3 Facility Monitoring

This section describes results of monitoring of individual units such as treatment, storage, and disposal units or tank farms. Some of these facilities are monitored under the requirements of RCRA for hazardous waste constituents and AEA for source, special nuclear, and by-product materials. Data from facility-specific monitoring are also integrated into the CERCLA groundwater investigations. Hazardous constituents and radionuclides are discussed jointly in this section to provide comprehensive interpretations of groundwater contamination for each facility. As discussed in Section 2.1, pursuant to RCRA, the source, special nuclear and by-product material components of radioactive mixed waste are not regulated under RCRA and are regulated by DOE acting pursuant to its AEA authority.

The 200-BP-5 Operable Unit contains six RCRA sites with groundwater monitoring requirements: Waste Management Area B-BX-BY, 216-B-63 trench, Low-Level Waste Management Areas 1 and 2, Liquid Effluent Retention Facility, and Waste Management Area C. This section summarizes results of statistical comparisons, assessment studies, and other developments for FY 2004. Groundwater data are available in the Hanford Environmental Information System (HEIS 1994) and on the data files accompanying this report. Additional information including well and constituent lists, maps, flow rates, and statistical tables are included in Appendix B.

2.10.3.1 Waste Management Area B-BX-BY

Single-shell tank farms B, BX, and BY, located in the northwest part of the 200 East Area, along with ancillary waste transfer lines and diversion boxes comprise Waste Management Area B-BX-BY. It is monitored under the requirements of RCRA and AEA. The site was placed in a RCRA groundwater quality assessment program in 1996 (40 CFR 265.93[d] as referenced by WAC 173-303-400) when specific conductance at a downgradient well became



elevated above the critical mean. In a first determination assessment report (PNNL-11826), released in 1998, it was shown that residual waste in the vadose zone related to a tank farm leak in 1951 had, most likely, been driven to the groundwater close to well 299-E33-41 by recent fresh water flooding from leaking water lines. Based on 40 CFR 265.93 [d] paragraph (7), the site must continue in quarterly monitoring to determine contaminant levels and the rate/extent of migration until final facility closure (PNNL-11826).

RCRA wells were sampled quarterly to assess the rate and extent of groundwater contamination associated with the waste management area B-BX-BY (Appendix B). One exception is well 299-E33-9, located in the BY Tank Farm. This well has not been sampled since March 2004 because access to the tank farm is restricted due to health concerns associated with hazardous vapors from the tanks. This well usually marks the highest uranium concentrations found at this waste management area and the surrounding area. During FY 2004, three new downgradient RCRA monitoring wells were installed according to the assessment plan (PNNL-13022) along the south and southeast side of the waste management area to improve the monitoring network. These wells were sampled beginning in November 2004.

In addition, outlying wells were sampled to provide coverage of surrounding past-practice liquid effluent disposal facilities to distinguish non-tank farm sources that may have impacted groundwater quality from tank-related sources. Radionuclides are tracked under AEA monitoring at the site. Appendix B includes a well location map, a list of wells and the constituents monitored for Waste Management Area B-BX-BY.

In summary, assessment studies have identified several distinct groups of contaminants based on chemical associations, spatial and temporal relationships, historic plume movement, knowledge of process chemistry, pattern matching and characteristic chemical ratios of constituent concentrations (PNNL-13116; PNNL-14187; PNNL-14548; PNNL-SA-39825):

Assessment studies at Waste Management Area B-BX-BY have identified several distinct groups of contaminants.

- ***Uranium, technetium-99, nitrate, sulfate, and nitrite***. These contaminants are located under and east of the BY Tank Farm. The highest levels of uranium, both spatially and temporally, are found in this location with significantly lower levels of co-varying contaminants, such as nitrate, compared to concentrations in surrounding areas such as the 241-B 8 crib. Additionally, the nitrate-to-technetium ratio indicates a local source different from the surrounding areas. This area is the only location, until recently, that shows elevated nitrite (PNNL-13788; PNNL-14187; PNNL-SA-39825). Past leaks of processing waste from the tank farms have left contaminated soils under the farms, which are, most likely, the source of this contamination found in the groundwater. Further assessment of this plume is ongoing.
- ***Tritium***. This contamination is found on the southwest corner and along the south border of the waste management area. The tritium concentration has been found to rise sharply from the local background value of ~1,800 pCi/L to levels close to the drinking water standard (20,000 pCi/L) in seven wells at nearly the same time beginning in early 1999. There are only low levels of nitrate, technetium-99, and uranium associated with this local tritium plume. The sharply rising trends shown in Figure 2.10-12 indicate the wells are close to the area where the tritium is entering the groundwater (PNNL-13788, PNNL-14187, PNNL-SA-39825). Movement through the vadose zone from a perched water table with elevated tritium located ~4.5 meters above the water table under the BX Tank Farm is, most likely, the source of this contamination. The tritium in this perched water table may be related to tank condensate collected from the tanks in the past.
- ***Technetium-99, nitrate, cobalt-60, and cyanide***. These contaminants are found under the BY cribs and may be impacting the groundwater under the north edge of the BY Tank

Farm. Until recently, this location had the highest concentrations of technetium-99 and cyanide found in areas surrounding the waste management area. The maximum technetium-99 concentration was over 13,000 pCi/L, higher than seen to the south and southeast. The maximum cyanide level, which co-varies with the technetium-99, was over 400 µg/L during the peak of the contamination observed in late 2000 to early 2001. This is also the location of elevated cobalt-60 contamination that co-varies with the cyanide. The nitrate-to-technetium-99 ratios also indicated that the sources of groundwater contamination observed under the BY cribs are different from those observed under the tank farms or near the other surrounding discharge facilities (PNNL-13788; PNNL-14187; PNNL-SA-39825). These contaminants are attributed to residual waste in the vadose zone associated with the original discharges of tank supernatant to the BY cribs in the mid-1950s. At present, it is not clear whether the uranium found in one well (299-E33-38) located between the BY cribs and BY Tank Farm is associated with discharges to the BY cribs or a 1951 unplanned release in the BX Tank Farm.

- ***Nitrate and technetium-99***. Located under the 241-B-8 crib is another unique grouping of contaminants. Until recently, this was the location of the maximum nitrate concentration (695 mg/L in November 2000) found in the area. This area lacks the cyanide and cobalt-60 found under the BY cribs and the high levels of uranium and nitrite associated with the contamination under the BY Tank Farm. Additionally, there does not appear to be a connection with the tritium plume found under the BX Tank Farm. The contaminant signature has a distinctly different nitrate-to-technetium-99 ratio signature than the other groups. Residual waste left in the vadose zone under and around the 241-B-8 crib is, most likely, the source for groundwater contamination in this location and is not associated with the waste management area (PNNL-13788; PNNL-14187; PNNL-SA-39825).

Sources within Waste Management Area B-BX-BY have contaminated groundwater with uranium, technetium-99, tritium, and nitrate.

The first two contaminant groups are attributed to the tank farms. Consequently the following discussion, which covers the FY 2004 assessment monitoring, will focus on contamination under and near the B-BX-BY Tank Farms. References to the other two groups are made, as necessary, to distinguish between the sources.

The hydraulic gradient is nearly flat across Waste Management Area B-BX-BY, making it difficult to determine upgradient versus downgradient wells based on water elevations alone. Consequently, inaccuracies in water elevations caused by measurement errors, deviations from vertical of the borehole, errors in well elevation surveys, and temporal pressure effects associated with changing weather conditions become more important when the difference in elevations between wells is <7 centimeters as at Waste Management Area B-BX-BY (PNNL-12086; PNNL-13116; PNNL-13022; PNNL-13023; and PNNL-13078). Consequently, flow directions were estimated using an in situ flow technique, the colloidal borescope (PNNL-13404; Narbutovskih et al. 2002; PNNL-14187) and local hydrographs. The results of these studies indicate a southward flow direction across the waste management area. The direction of groundwater flow tends to be west-southwest from the BY cribs across the north part of the BY Tank Farm and south to southeast along the south boundary of the waste management area. Local structural highs in the basalt, however, may affect flow directions near any specific well.

Based on in situ techniques, the flow rate appears to be nearly stagnant area under the BY cribs and the BY Tank Farm where the aquifer is as thin as 0.5 meter because the water table is receding to pre-Hanford conditions. In situ flow measurements indicate a faster flow rate in the south where the aquifer is over ~4.6 meters thick. An estimated flow rate in the south is based on hydraulic conductivities calculated from a recent multi-stress slug test (PNNL-14186). This test was performed over several depth intervals during the drilling of well 299-E33-49 in FY 2004. Estimated hydraulic conductivity values ranged from 1,270 to 2,520 meters per day, which is expected for the highly permeable lower Hanford formation found in the aquifer. The estimated groundwater flow rates calculated using the Darcy

equation range from 0.6 to 1.2 meters per day (Appendix B, Table B.1). The average water-table decline beneath the waste management area was 12 centimeters in FY 2004. If the water table declines to pre-Hanford levels, the edge of the unconfined aquifer will recede, leaving dry sediment under the BY cribs and most of the BY Tank Farm with no aquifer below. For example, well 299-E33-6 at the BY cribs is already dry down to basalt.

Since the initial assessment investigation (PNNL-11826), a further determination was conducted to identify the source of rising technetium-99, nitrate, nitrite, and uranium observed under and east of the BY Tank Farm. With 180-degree changes in flow directions from pre-Hanford times to conditions during peak operations and with the existence of a significant perching horizon, located ~4.6 meters above the water table, distinguishing contaminant sources has been difficult. The results of this investigation, presented in PNNL-SA-39825 and PNNL-14187, show that the contamination observed in downgradient wells around Waste Management Area B-BX-BY is due, primarily, to vertical movement of residual waste left in the soil under the tank farms. Although the source of the water driver and vadose zone migration pathways are not clearly understood, the water driver appears to be related to long-term steady-state recharge from natural precipitation and leaks from nearby fresh water lines. At this time, it has been reasonably established that most of the contamination found in the groundwater at Waste Management Area B-BX-BY is from local, residual soil contamination associated with past tank farm operations.

Contamination from the vadose zone appears to be moving down to groundwater.

General trends for nitrate have continued to remain steady or fluctuated with no defined trend during FY 2004 as shown in wells 299-E33-32, 299-E33-42, and 299-E33-43 (Figure 2.10-13). The measures taken in the last few years to control surface run off water into and around the farm may be having some effect by controlling or redirecting infiltration. However, nitrate levels remain elevated above pre-1997 values that were at or close to groundwater background levels of less than 12 mg/L (WHC-EP-0595). The steady trend shown in wells 299-E33-32, 299-E33-42, and 299-E33-43 is also seen in other wells around the site. The exception is well 299-E33-44 where nitrate levels have increased sharply over the last quarter of the FY 2004 from 268 to 403 µg/L. Other wells in the area displaying distinct increases are wells 299-E33-7, located in the BY cribs to the north, and 299-E33-15, located to the northeast in the 241-B-8 crib, both upgradient of Waste Management Area B-BX-BY (PNNL-14548). Downgradient from the 241-B-8 crib, a center for some of the highest nitrate in the area, well 299-E33-17 is also increasing in nitrate. Current changes in nitrate in well 299-E33-9, where the highest uranium concentrations have been detected, are not known since this well cannot be sampled as explained above.

Technetium-99 concentrations show trends similar to nitrate (Figure 2.10-14), although the corresponding technetium-99 increase in well 299-E33-15 is not as evident as it is for nitrate. It can be seen by comparing the temporal offset of peak technetium-99 levels between wells 299-E33-7 and 299-E33-44 versus 299-E33-16, the contamination appears to be moving from the northwest to the southeast. Alternatively, the water source forcing the contamination to migrate through the vadose zone may be moving in a southeastward direction.

Further evidence that the peak contamination observed in late 2000 to early 2001 was driven from the vadose zone to the groundwater can be found by comparing chloride trends across the site (PNNL-14187; PNNL-SA-39825). Groundwater background chloride values at the Hanford site are generally less than 9 mg/L (WHC-EP-0595). There are no direct chloride sources associated with tank waste. Chloride levels can be increased in the groundwater, however, by infiltrating raw water (non-chlorinated) from the surface that dissolves chloride deposited naturally over geologic time in near surface sediment. As the water moves through the vadose zone, the chloride concentration increases resulting in values above background as shown at the State-Approved Land Disposal Site (PNNL-14038; PNNL-11633). Figure 2.10-15 shows chloride trends for wells where the groundwater displayed the maximum concentrations of nitrate, technetium-99, and uranium at the waste management area during the late 2000 event. As can be seen, chloride levels were

the highest under the BY Tank Farm in well 299-E33-9 at 53 mg/L, 6 times the background value. Other high chloride values (greater than 5 times background) are found under the BY cribs to the north in well 299-E33-7 where the high levels of nitrate and technetium-99 are accompanied by elevated cyanide and cobalt-60. Also displayed are elevated chloride values in late 2000 for wells 299-E33-31 and 299-E33-26. These wells are located around the 216-B-57 crib. Ponded precipitation or runoff water from the crib cap may have contributed to this water source. Variations in chloride levels provide insight to the sources of water drivers, both natural and manmade that are the key to understanding the complex groundwater chemistry patterns at Waste Management Area B-BX-BY.

When discussing sources for the high uranium found under the BY Tank Farm, it is important to recognize that the uranium contamination does not travel alone but is associated with the mobile contaminants from the original processing source. For example, as shown in Figure 2.10-16, uranium levels under the BY Tank Farm, east, southeast, and north of the farm are correlated with the rising technetium-99 and nitrate contamination. However, the peak values from late 2000 to early 2001 indicate that the uranium's movement is retarded with respect to the mobile technetium-99. As shown by nitrate-to-technetium-99 ratios in previous studies (PNNL-14187; PNNL-SA-39825), multiple sources are contributing to the groundwater in this area. The co-variation of technetium-99, although offset in time, shows that the uranium has a common source with the technetium-99. The correlation between the technetium-99 and uranium trends in Figure 2.10-16 shows that the uranium is traveling with the technetium-99 and is, most likely, from the same contaminated soils as the elevated technetium-99, nitrate, and other corresponding contaminants.

When uranium trends are compared, as in Figure 2.10-17, for wells located south and north of well 299-E33-9, it can be seen that the center of the uranium plume in the groundwater is located under the BY Tank Farm as indicated by the high concentration in wells 299-E33-9 and 299-E33-44. The uranium value in the groundwater under the BY Tank Farm was 590 µg/L and rising when last sampled in March 2004. This location is also where the corresponding maximum chloride levels indicate the recent water driver was centered or close to it. The difference in trend relationships between uranium and technetium-99 may have occurred when the contaminants migrated through the vadose zone in the past, possibly when the waste was released in 1951, while the chloride trends reflect the more recent water driver impacting the groundwater in late 2000 and early 2001. This two part scenario accounts for past multiple releases of waste both intentional and unplanned in multiple locations, mixing of waste sources in the vadose zone over time, which, when combined with one or more recent fresh water incursions produces the numerous and complex groundwater plumes observed today.

Another plume with locally high tritium, exceeding the drinking water standard of 20,000 pCi/L at times, is found along the south border of the waste management area (Figure 2.10-12). This plume is migrating to the south to southeast as seen by the offset and decreased concentration in newly installed wells 299-E33-335, 299-E33-337, and 299-E33-339 with respect to well 299-E33-43. At present, it is unknown why the initial values at wells 299-E33-337 and 299-E33-339 were high in 2001. Recent small increases in uranium (less than 10 µg/L) along this southern boundary also indicate movement to the south. Migration through the vadose zone from a tritium-rich perched water table located ~4.6 meters above the top of the unconfined aquifer under the B and BX Tank Farms is probably the cause of this contamination (RPP-10098). Maximum levels exceeded the drinking water standard on the southwest corner of the BX Tank Farm at 20,600 pCi/L in August 2003.

The historical discharge of effluent to the ground in and around Waste Management Area B-BX-BY resulted in complex patterns of groundwater contamination. The highest level of technetium-99 was located beneath the BY cribs to the north and is attributed to discharges to the cribs in the mid-1950s. Associated with high concentrations of nitrate, cyanide, and some cobalt-60, this contamination forms a plume that possibly affects the

The historical discharge of effluent to the ground in and around Waste Management Area B-BX-BY resulted in complex patterns of groundwater contamination.

groundwater under the north part of Waste Management Area B-BX-BY. Elevated uranium with technetium-99, nitrate, sulfate, and nitrite is found locally beneath the BY Tank Farm while a small tritium plume exists along the southern margin of the waste management area. Evidence was discussed in PNNL-14187 with further data shown above that indicate the contamination seen in and around Waste Management Area B-BX-BY is entering the groundwater in multiple areas from the vadose zone and is sourced in the contaminated soils under both the tank farms and the surrounding cribs. Residual wastes left in the vadose zone from unplanned releases associated with the waste management area are, most likely, contributing to the uranium, nitrate, technetium-99, tritium, and other contamination in the vicinity of the BY and BX Tank Farms (PNNL-SA-39825; PNNL-14187). Quarterly monitoring of the groundwater at Waste Management Area B-BX-BY will continue.

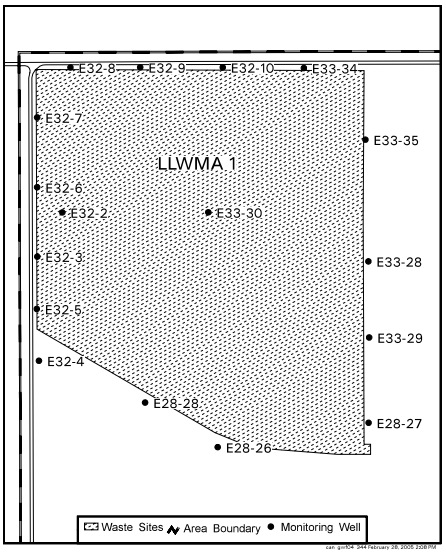
2.10.3.2 216-B-63 Trench

This RCRA unit continued to be monitored under an interim status detection program [40 CFR 265.93(b) as referenced by WAC 173-303-400] in FY 2004. The monitoring network was sampled twice, as scheduled, for 12 wells during the year (PNNL-14112, Appendix B). Wells 299-E33-33 and 299-E33-36 exceeded the critical mean for total organic carbon in April, May, and June 2004. The exceedances occurred at a time when a series of anomalously high total organic carbon results were reported across the Hanford Site. Preliminary results indicate that laboratory error may have contributed to the elevated results.

Sampling results for the 216-B-63 trench have historically supported the interpretation that the facility has not affected groundwater.

Several non-hazardous constituents that had been rising in concentration slowly and persistently over a decade have, in most instances, stabilized or have declined in concentration. Results from past sampling efforts have indicated stable or declining concentration of anions. The result from FY 2004 shows a pattern of increase in anions in wells on both ends of the 216-B-63 trench, with wells in the center still exhibiting either slight downward trend changes, or with no significant change in trend. Sulfate continues to be the exception, showing an increase in nearly every well tested in FY 2004. The greatest increases in concentration, however, follow the same pattern as the anions; the increases in trend are greatest at the two opposing ends of the trench.

The monitoring well network for the 216-B-63 trench is shared with both the Low-Level Waste Management Area 2 and the B-BX-BY Tank Farms. Samples are gathered twice a year in spring and fall (see Appendix B). Due to the low hydraulic gradient and the highly transmissive media in 200 East Area, the rate of groundwater movement near the 216-B-63 trench is low, approximating 0.1 meter per day (see Appendix B). The monitoring network for the 216-B-63 trench currently meets RCRA requirements as defined in the monitoring plan.



Vadose zone characterization activities conducted at the 216-B-63 trench in FY 2004 are discussed in Section 3.1.1.

2.10.3.3 Low-Level Waste Management Area 1

Groundwater at Low-Level Waste Management Area 1 continued to be monitored under RCRA and AEA. Under 40 CFR 265.93(b) as referenced by WAC 173-303-400, the well network was sampled semiannually for RCRA indicator and site-specific parameters (WHC-SD-EN-AP-015; DOE/RL-2000-72; Appendix B). All 17 wells were successfully sampled during both samplings.

An application was submitted to the Washington State Department of Ecology (Ecology) in June 2002 to incorporate the low-level burial grounds into the Hanford Facility RCRA Permit (Ecology 1994a). This would have the effect of changing the groundwater monitoring requirements for the burial grounds from interim status monitoring to final status monitoring. As part of the application, new groundwater monitoring constituents and statistical evaluations are proposed. Workshops with the Ecology to address this application are in progress and include discussions on the adequacy of the well network.

The groundwater gradient in this part of the 200 East Area is almost flat making the determination of groundwater flow direction difficult (Figure 2.10-3). Based on contaminant plumes, flow direction to the northwest over the long-term is indicated (Figures 2.10-4 through 2.10-7). Past analysis of water-level data also indicate flow toward the northwest. Trend surface analysis performed on FY 2003 water-level data indicated flow direction ranging from northwest to east-southeast (PNNL-14548). Trend surface analysis performed on FY 2004 data indicated flow direction ranging from 305 degrees to 355 degrees (approximately west-northwest to north) for three of the four data sets. The December 2003 data indicated a flow direction of 105 degrees (approximately east-southeast). The December data could be responding to water-level trends noted in FY 2003 (PNNL-14548) or be the result of greater measurement uncertainty. The calculated gradient is ~0.00002 with flow rate estimates ranging from ~0.005 to 0.2 meter per day. The data suggest that the flow direction remains largely to the northwest but is dynamic due to the influence of minor relative water level variation between wells. For this reason, no attempt will be made to update the interim status designation of upgradient and downgradient wells until a stable flow direction is re-established.

Specific conductance continued to exceed the statistical upgradient/downgradient comparison value (critical mean) in downgradient well 299-E33-34, with values ranging from 1,048 to 1,195 µS/cm. In FY 2004, well 299-E32-10, west of well 299-E33-34, also exceeded the statistical comparison value. The exceedance is related to a regional nitrate plume (Figure 2.10-5). DOE notified Ecology of the exceedance in 1999. Other indicator parameters remained below critical mean values in downgradient wells. Statistical comparison values to be used for indicator parameters in FY 2005 are listed in Appendix B.

Contaminant levels beneath Low-Level Waste Management Area 1 are consistent with regional plumes.

Performance assessment monitoring of radionuclides at Low-Level Waste Management Area 1 is designed to complement the RCRA detection monitoring and is aimed specifically at monitoring radionuclide materials that are not regulated under RCRA. The current goal of performance assessment monitoring at Low-Level Waste Management Area 1 is to gather data to assess changes in concentrations at downgradient wells using statistical tests and to provide sufficient supporting information from upgradient wells to interpret the changes. Under the current monitoring plan (DOE/RL-2000-72), only technetium-99 is monitored specifically for performance assessment.

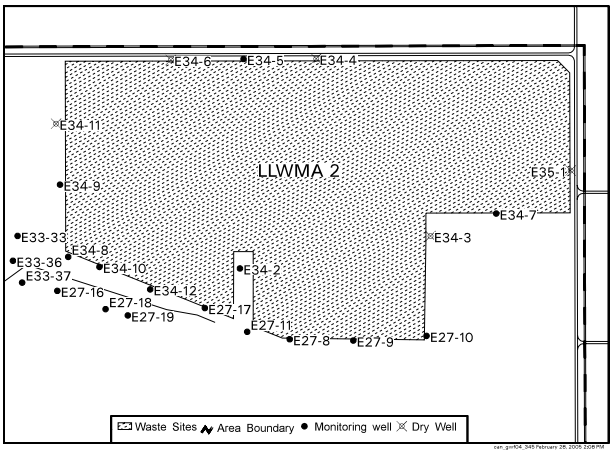
Contaminant characteristics at Low-Level Waste Management Area 1 include the following:

- Technetium 99 concentrations continued to be elevated in several wells (299-E33-34, 299-E32-10, 299-E33-35) near the northeast corner of Low-Level Waste Management Area 1. Concentrations in FY 2004 (maximum of 7,730 pCi/L in well 299-E33-34) were lower than the maximum concentration seen in 2001 (8,170 pCi/L in well 299-E33-34). The contamination levels are consistent with regional plumes (Figure 2.10-7).
- Uranium values increased only slightly to 107 µg/L at well 299-E33-34 in the northeast corner of the waste management area after a steep increase in 2002. This is associated with a relatively recent plume originating in the vicinity of Waste Management Area B-BX-BY (Figure 2.10-9). The uranium plume has impacted other wells surrounding this part of the waste management area, but concentrations are not as high.
- Uranium levels are increasing in a number of wells on the west side of Low-Level Waste Management Area 1 but remained below the drinking water standard (30 µg/L). A maximum of 21.3 µg/L was detected in well 299-E32-3. Comparable or higher concentrations have been seen in past years in wells farther south (e.g., wells 299-E28-26, 299-E28-28, and 299-E32-5), so it is possible that the increases indicate a shift in preexisting plumes and not new contamination from the waste management area. This conceptual model cannot be confirmed at present, however.

- Tritium contamination is also believed to be from regional plumes, not related to the burial grounds (Figure 2.10-4). Tritium concentrations were less than the drinking water standard in FY 2004.
- Iodine-129 contamination in this area is consistent with regional plumes and believed to be from liquid waste facilities, not related to the burial grounds (Figure 2.10-6).
- Nitrate contamination at Low-Level Waste Management Area 1 is mapped as two separate plumes at the drinking water standard, both extending from areas outside of the burial ground. The contours shown in Figure 2.10-5 are similar to those from previous years. The highest concentrations are in the northeast plume, coincident with the technetium-99 plume discussed above. Thus, the northeast nitrate plume has a likely source in the BY cribs.
- Low levels of chromium contamination are seen in filtered samples from well 299-E33-34, in the northeast corner of Low-Level Waste Management Area 1. The FY 2004 average chromium concentration was 19 µg/L. This is consistent with other contaminant trends observed in the area and near Waste Management Area B-BX-BY where the concentrations ranged up to 48 µg/L in FY 2004. The drinking water standard for chromium is 100 µg/L.

2.10.3.4 Low-Level Waste Management Area 2

Groundwater at Low-Level Waste Management Area 2 continued to be monitored under RCRA and AEA. Under 40 CFR 265.93(b) as referenced by WAC 173-303-400, the well network was sampled semiannually for RCRA indicator and site-specific parameters (WHC-SD-EN-AP-015; DOE/RL-2000-72; Appendix B). The well network was sampled twice for indicator and site-specific parameters. Sampling was successful at 11 wells for both sampling rounds. Other wells in the unit have gone dry in recent years.



An application was submitted to Ecology in June 2002 to incorporate the low-level burial grounds into the Hanford Facility RCRA Permit (Ecology 1994a). This would have the effect of changing the groundwater monitoring requirements for the burial grounds from interim status monitoring to final status monitoring. As part of the application, new groundwater monitoring constituents and statistical evaluations are proposed. No new wells were proposed, in spite of wells going dry, because the water-table elevation is receding below the top of the basalt. Deeper aquifers are isolated from the burial grounds by the low-permeability basalts (see as-built diagrams in Appendix B, PNNL-6820). Workshops with Ecology to address this application are in progress and include discussions on the adequacy of the well network.

The groundwater gradient in this part of the 200 East Area is almost flat making the determination of groundwater flow direction difficult. Groundwater flow appears to be generally to the west based on small differences in head at wells along the south boundary of Low-Level Waste Management Area 2. Trend surface analysis performed on FY 2002 data indicated flow generally to the southwest; however, no realistic flow direction could be determined from trend surface analysis of FY 2003 data due to further flattening of the water table (PNNL-14548). FY 2004 trend surface analysis also produced no consistent flow direction unless well 299-E34-5 is included in the analysis. The current interpretation of the basalt surface and water levels suggests well 299-E34-5 is isolated from the rest of the aquifer under Low-Level Waste Management Area 2 by basalt extending above the water table. If it is assumed this well is in communication with the unconfined aquifer and it is included in the trend surface analysis, the calculated flow is to the south or south-southwest. Flow to the southwest is also indicated by the movement of the nitrate plume from well 299-E34-7

to well 299-E27-10 (discussed further below). For this reason, no attempt will be made to update upgradient well designations used in the statistical tests until a stable flow direction is evident. The basalt surface above the water table in the north part of Low-Level Waste Management Area 2 constrains possible flow directions for the unconfined aquifer. However, it is possible that the flow is influenced by continued drainage of the unsaturated sediment and recharge moving laterally on the basalt surface to the saturated aquifer sediment. The gradient calculated from wells along the south boundary of the burial ground is 0.00003. The estimated flow rate at Low-Level Waste Management Area 2, using this gradient, is 0.04 to 0.6 meter per day (Appendix B).

Statistical comparison values for indicator parameters were not exceeded for any downgradient wells in FY 2004. Upgradient well 299-E34-7, however, is no longer used to calculate critical mean values because of the anomalous chemistry in this well. Appendix B lists the statistical comparison values based on data for the other upgradient wells.

Well 299-E34-7 has high specific conductance, total organic carbons, and total organic halides. The major contributors to the elevated specific conductance are sulfate, chloride, nitrate, and calcium. The source of the elevated specific conductance is not known. The specific conductance declined during FY 2004.

Levels of specific conductance, total organic carbon, and total organic halides in an upgradient well at Low-Level Waste Management Area 2 are elevated. The source is unknown.

The cause of the elevated levels of total organic carbon and total organic halides is also not known. Total organic carbon levels declined slightly from FY 2003. The FY 2004 average total organic carbon concentration was 3,940 µg/L. The average total organic halide concentration was 16.7 µg/L, lower than in FY 2003. FY 2003 and 2004 samples from well 299-E34-7 were analyzed for an extensive list of constituents and other possible contaminants identified in 40 CFR 264, Appendix IX. No organic constituents were detected consistently and those detected were at low levels, often associated with blank contamination that appears to be false-positive results (Table 2.10-1). The levels of Appendix IX constituents are far lower than the total organic carbon.

The constituents causing the increased specific conductance seen in well 299-E34-7 are beginning to impact wells farther southwest, well 299-E27-10 and well 299-E27-9. Sulfate, chloride, nitrate, and calcium are all increasing in these wells but remain at lower concentrations than seen in well 299-E34-7. The concentrations in well 299-E27-10 are higher than in well 299-E27-9, indicating the plume is spreading toward the southwest and west. The nitrate trend for these three wells is shown in Figure 2.10-18 as an example of the increases.

Performance assessment monitoring of radionuclides at Low-Level Waste Management Area 2 is designed to complement the RCRA detection monitoring and is aimed specifically at monitoring radionuclide materials that are not regulated under RCRA. The current goal of performance assessment monitoring at Low-Level Waste Management Area 2 is to gather data to assess changes in concentrations at downgradient wells using statistical tests and to provide sufficient supporting information from upgradient wells to interpret the changes. Under the current monitoring plan (DOE/RL-2000-72), technetium-99, iodine-129, and uranium are monitored specifically for performance assessment.

Contaminant characteristics at Low-Level Waste Management Area 2 include the following:

- Technetium-99 concentration continued to increase in upgradient well 299-E27-10 southeast of Waste Management Area 2, where the concentration reached 64 pCi/L in FY 2004. This contamination is believed to be from past disposal of liquid waste in the 200 East Area and unrelated to Low-Level Waste Management Area 2 because this is an upgradient well. Other wells in the monitoring network have lower technetium-99 concentrations.
- Tritium contamination is found at levels less than the drinking water standard. The tritium concentrations are consistent with regional plumes (Figure 2.10-4 and Section 2.10.1.1).

- Iodine-129 concentrations are <5 pCi/L in Low-Level Waste Management Area 2 wells. The levels are consistent with the regional iodine-129 plume (Figure 2.10-6 and Section 2.10.1.3) and do not appear to be related to a burial ground source.
- Uranium concentrations in Low-Level Waste Management Area 2 samples are <5 µg/L and do not indicate a burial ground source.
- Nitrate contamination at levels above the drinking water standard is restricted to upgradient wells on the eastern side of Low-Level Waste Management Area 2.

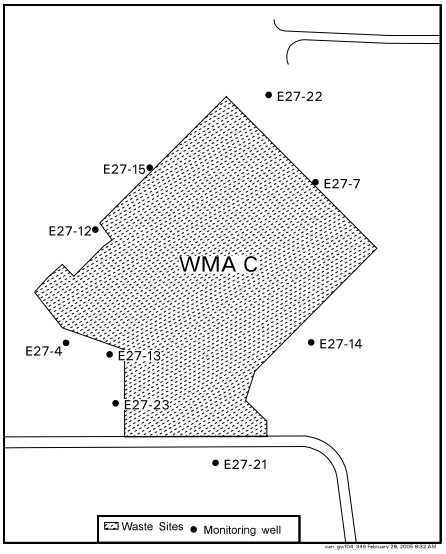
2.10.3.5 Liquid Effluent Retention Facility

The Liquid Effluent Retention Facility is monitored by two wells.

The Liquid Effluent Retention Facility is an active, lined facility that is identified in the Hanford Facility RCRA Permit (Ecology 1994a). Groundwater at this facility is monitored to meet requirements of RCRA under 40 CFR 265.93(b) as referenced by WAC 173-303-400. A RCRA final status detection-monitoring program was in place at the Liquid Effluent Retention Facility until June 1999 when downgradient well 299-E26-9 no longer provided representative groundwater information (i.e., went dry). Ecology granted a variance in September 1999 to allow DOE to operate the remaining network wells as the compliance system. This variance gave DOE 18 months, or until the next downgradient well became non-functional, to develop and deploy an alternative monitoring system. Ecology rescinded the variance in January 2001 when downgradient well 299-E35-2 no longer produced representative samples. A letter from Ecology directed DOE to discontinue statistical evaluation of groundwater sample results effective January 14, 2001. Since that time, DOE has continued to sample the remaining wells according to WHC-SD-EN-AP-024, but no longer performs statistical evaluations of the results. The groundwater monitoring network is not compliant with the groundwater monitoring requirements of WAC 173-303-645. DOE and Ecology are exploring alternative approaches to environmental groundwater monitoring at the facility to meet compliance with hazardous waste regulations.

Two wells were successfully sampled semiannually at the Liquid Effluent Retention Facility in FY 2004 (Appendix B). Results for specific conductance (consisting largely of elevated levels of sulfate) have been rising in concentration since 1994 mirroring a regional trend (PNNL-14187). The FY 2004 increase in specific conductance and sulfate has not been as dramatic as in past fiscal year sampling efforts. No other contamination indicator parameters have shown increases over FY 2004.

2.10.3.6 Waste Management Area C



Located in the northeast part of the 200 East Area, Waste Management Area C consists of the C Tank Farm, the 244-CR vault, ancillary waste transfer lines, and seven diversion boxes. Groundwater at this waste management area is monitored to meet requirements of RCRA under 40 CFR 265.93(b) as referenced by WAC 173-303-400 and AEA. The objective of RCRA monitoring at this site is to determine if groundwater quality has been compromised by dangerous waste constituents associated with the tank farm. Groundwater monitoring at the C Tank Farm continued under an interim status indicator evaluation program in FY 2004 [40 CFR 265.93(b) as referenced by WAC 173-303-400]. Wells were sampled quarterly at the request of Ecology. In addition, the required detection sampling was conducted twice per year for indicator and site-specific parameters (Appendix B). Radionuclides are tracked under AEA monitoring at the site. Appendix B includes a well location map, a list of wells, and the constituents monitored for Waste Management Area C. The following discussion covers monitoring conducted during FY 2004 and the local hydrogeology of the waste management area. Vadose zone characterization activities conducted at Waste Management Area C in FY 2004 are discussed in Section 3.1.3. Waste retrieval operations and related borehole logging activities are also included in Section 3.3.

In summary, contamination in the groundwater began rising between 1995 and 1998 depending on the location and continued to increase downgradient during FY 2004. Contamination consists primarily of elevated nitrate, technetium-99, sulfate, chloride, and cyanide. The original upgradient well 299-E27-7 is close to the northeast fence line and to ancillary equipment used for farm activities. Furthermore, contaminant levels have been rising in the groundwater at this location making upgradient/downgradient comparisons difficult due to varying levels of specific conductance. Consequently in FY 2003, a new upgradient well was installed to the north (well 299-E27-22) along with three new downgradient wells (wells 299-E27-4, 299-E27-21 and 299-E27-23) to improve the monitoring network at the site as required by the site monitoring plan (PNNL-13024).

Upgradient/downgradient comparisons were temporarily suspended for specific conductance until data from the new upgradient well, providing a more stable baseline, could be included in the statistical analysis. A new critical mean for specific conductance has been calculated (Appendix B), and upgradient/downgradient comparisons began in FY 2005. The remaining indicator parameters (pH, total organic carbon, and total organic halide) did not exceed the upgradient/downgradient comparison values in downgradient wells during FY 2004.

A general flow direction ranging from south-southwest to southwest has been determined for this site using in situ flow measurements with the colloidal borescope, plume tracking, and water elevations corrected for borehole deviations from vertical (PNNL-13788). Hydrographs (Figure 2.10-19) confirm that the flow direction has not changed and remains to the southwest, which is consistent with the regional water-table map (PNNL-14187). The rate of groundwater flow is based on hydraulic conductivities calculated from a multi-stress slug test performed over four depth intervals during the drilling of well 299-E27-22 (PNNL-14186). Estimated conductivity values ranged from 1,890 to 6,888 meters per day, as expected for the highly permeable lower Hanford formation sediments found in the aquifer at Waste Management Area C. The estimated groundwater flow rates calculated using the Darcy equation range from 1.4 to 4.8 meters per day (Appendix B). The rate of water table decline beneath Waste Management Area C was 9 to 10 centimeters this last year. If this rate continues, older wells from the original network should be usable for at least 6 years.

Contaminant concentrations, including technetium-99, continued to rise in groundwater at Waste Management Area C.

In the following discussion, data values are given for the September 2004 sampling event. Specific conductance was elevated in upgradient in wells 299-E27-22 (495 µS/cm) and 299-E27-7 (629 µS/cm). Although an increasing trend is observed in well 299-E27-7, there are not enough data to discern a trend for well 299-E27-22 (Figure 2.10-20). The highest value downgradient (736 µS/cm) was found south of the farm in well 299-E27-14. Values downgradient on the southwest side of the farm range from 399 to 335 µS/cm. The increasing specific conductance is caused primarily by rising sulfate and calcium along with nitrate and some chloride (PNNL-14187). Sulfate dominates with the highest values for FY 2004 found in the east corner of the farm ranging from 179 mg/L in downgradient well 299-E27-14 to 150 mg/L in upgradient well 299-E27-7. Although there have been high values for anions, with a maximum of 671 mg/L for sulfate observed upgradient, there is a good correlation between sulfate and increasing technetium-99 (2,450 pCi/L) in the downgradient well 299-E27-14 (Figure 2.10-21). Thus, downgradient of the site, the rising specific conductance appears to be related to a chemical nuclear processing source. It was shown in PNNL-13404 that the rising contamination of both technetium-99 and nitrate in well 299-E27-14 began approximately in 1994, peaking in September 1998. Sluicing activities began in November 1998. Thus, there is not a clear indication from trend plots that the contamination in the groundwater at Waste Management Area C is directly related to the tank sluicing activities. On the north side of the site where technetium-99 levels are low in the new upgradient well 299-E27-22 (77.4 pCi/L) and in 299-E27-7 (95.4 pCi/L) but the sulfate concentration is high, there may be influences from the high sulfate concentrations further upgradient (PNNL-14548).

To date, the highest value of technetium-99 observed in the groundwater at the farm is 8,370 pCi/L (June 2004). This elevated technetium-99 was found with low levels of nitrate (22 mg/L) in the new downgradient well 299-E27-4, located south of the west corner of the farm. Technetium-99 values at the other downgradient wells ranged from 2,450 pCi/L at well 299-E27-14 to 1,800 pCi/L at well 299-E27-23. Further downgradient, a September 2004 value of 718 pCi/L was observed at well 299-E27-21. The nitrate to technetium-99 ratio at well 299-E27-4 is 2.6, indicating the source of this contaminated groundwater may be related to a tank source, the same as nearby well 299-E27-13, as discussed in PNNL-14187 and PNNL-14548. In general, nitrate to technetium-99 ratios lower than 10 suggest the source is related to residual tank waste in the vadose zone.

Cyanide levels have risen and become more steady in the groundwater at this site, especially in upgradient well, 299-E27-7, with a maximum value of 44.6 µg/L observed in September 2004. The presence of cyanide in the groundwater also suggests the source is associated with tank-related waste left in the vadose zone, because the C Tank Farm is the only known local source for cyanide (HNF-SD-WM-TI-740). Additionally, the sharp rise and fall of the technetium-99 peak at well 299-E27-7 (Figure 2.10-22) indicates a short travel distance from the point of entry into the groundwater to the well (PNNL-14548) implying the source is close to the farm. A comparison to the data in well 299-E27-22, confirms that technetium-99 levels upgradient are presently low. Further insight into the source of the groundwater contamination at this waste management area may be possible when trends become recognizable in the new downgradient wells.

Table 2.10-1. Organic Constituents Reported in Well 299-E34-7, Low-Level Waste Management Area 2, FY 2004

Constituent	Number of Detects	Number of Results	Maximum Reported (µg/L)	Notes
1,2,3,4,7,8-Hexachlorodibenzofuran	1	2	0.00000063	Contamination in associated blank; not all qualitative identification criteria met
Acetone	2	6	3.6	Common laboratory contaminant
Bis(2-ethylhexyl) phthalate	1	6		Common laboratory contaminant
Bromomethane	3	6	0.57	Blank contamination in two-thirds reported detects
Chloromethane	2	6	0.3	
Di-n-octylphthalate	1	6	2.5	Common laboratory contaminant
Dicamba	1	6	0.17	
Diethylphthalate	1	6	2.4	Common laboratory contaminant
Endrin aldehyde	1	6	0.076	
Hexachlorodibenzofurans	1	2	0.00000063	Contamination in associated blank; not all qualitative identification criteria met
Methylene chloride	1	6	0.78	Contamination in associated blank; common laboratory contaminant
Octachlorodibenzo-p-dioxin	2	2	0.0000025	Contamination in associated blank; not all qualitative identification criteria met in one sample
Octachlorodibenzofuran	1	2	0.0000022	Contamination in associated blank
Oil and grease	1	6	1,200	

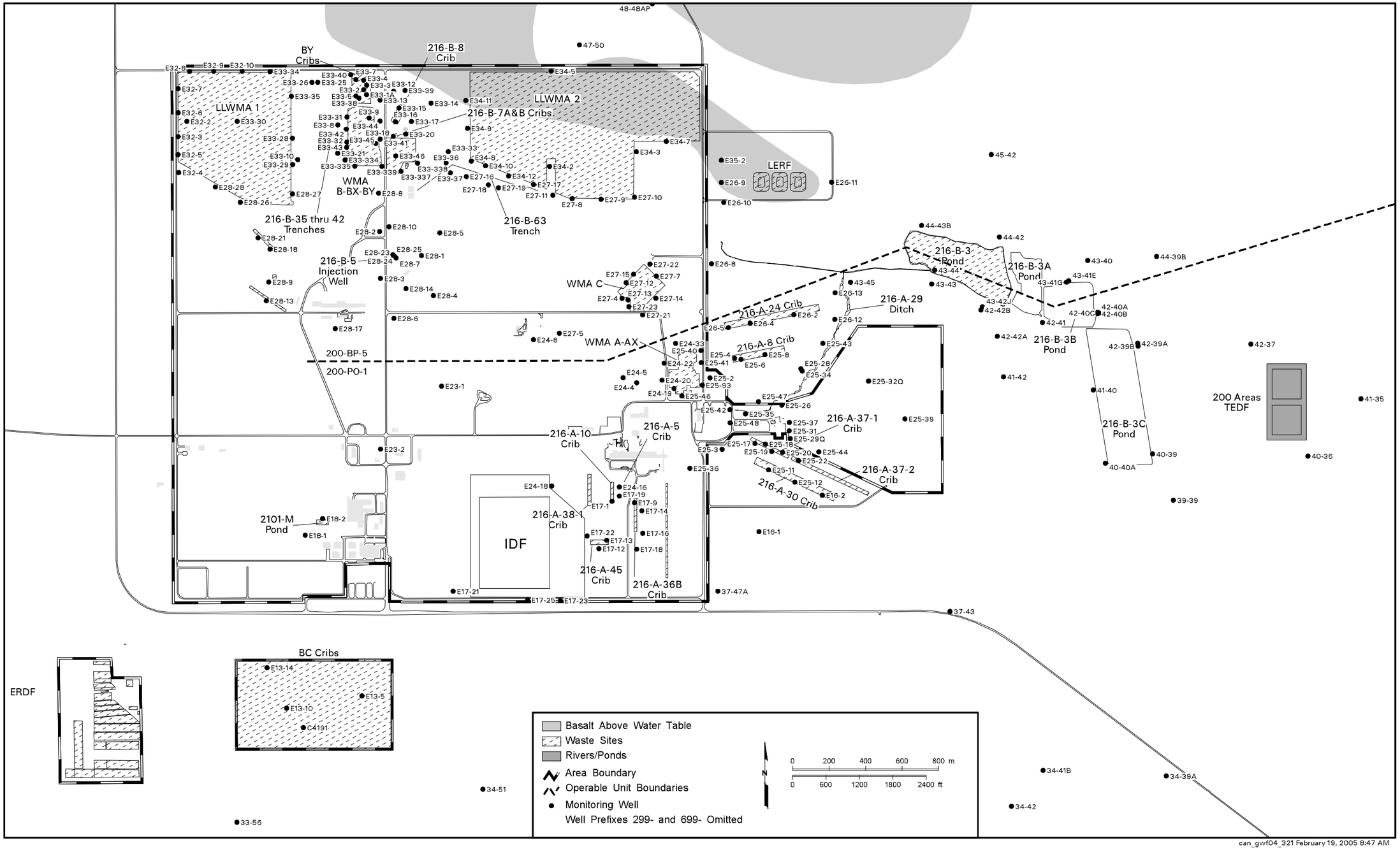


Figure 2.10-1. Groundwater Monitoring Wells in the 200 East Area

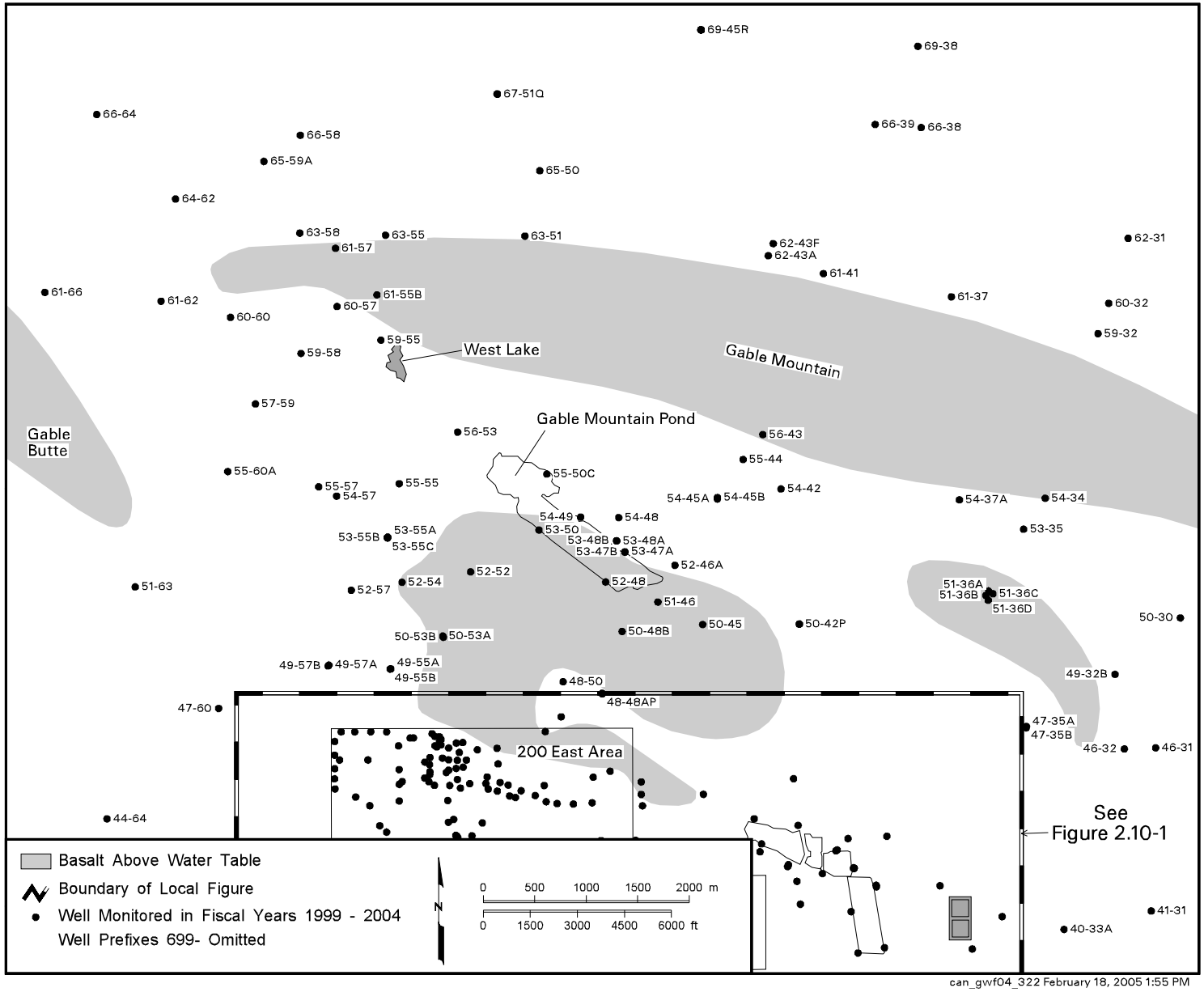


Figure 2.10-2. Groundwater Monitoring Wells Located in the 600 Area Associated with the 200-BP-5 Operable Unit

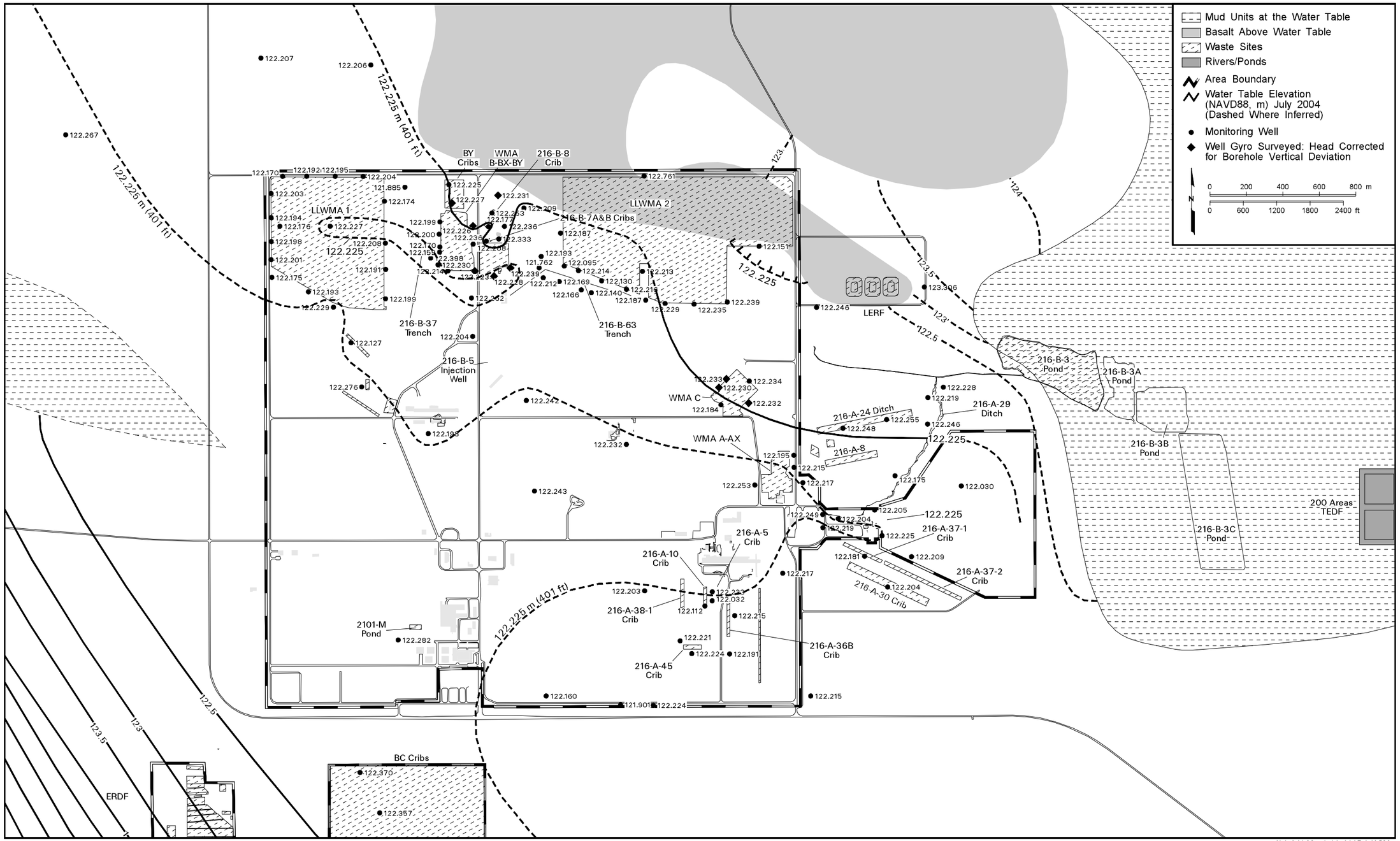


Figure 2.10-3. 200 East Area Water-Table Map, July 2004

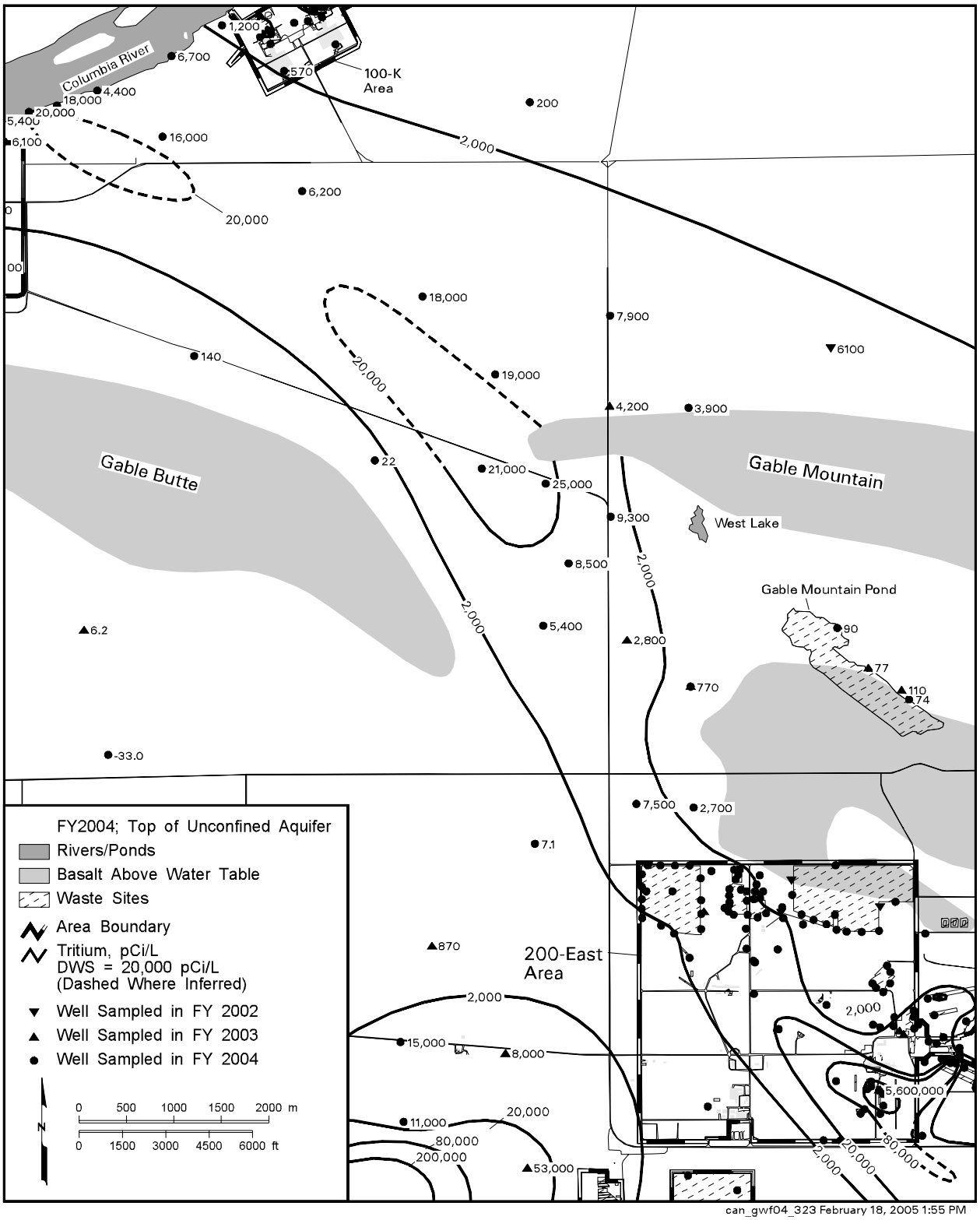


Figure 2.10-4. Average Tritium Concentrations in the 200-BP-5 Operable Unit and Vicinity, Top of Unconfined Aquifer

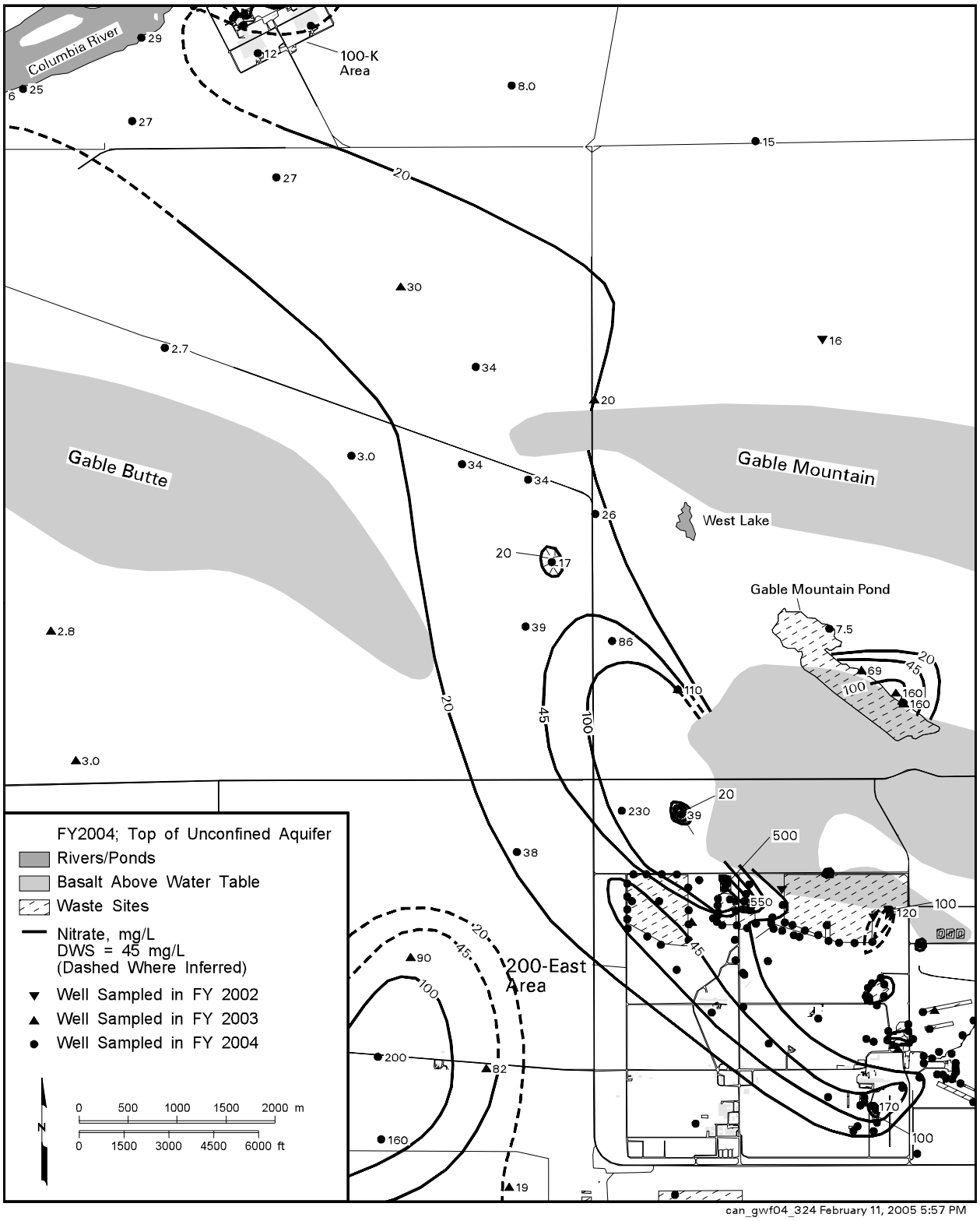


Figure 2.10-5. Average Nitrate Concentrations in the 200-BP-5 Operable Unit and Vicinity, Top of Unconfined Aquifer

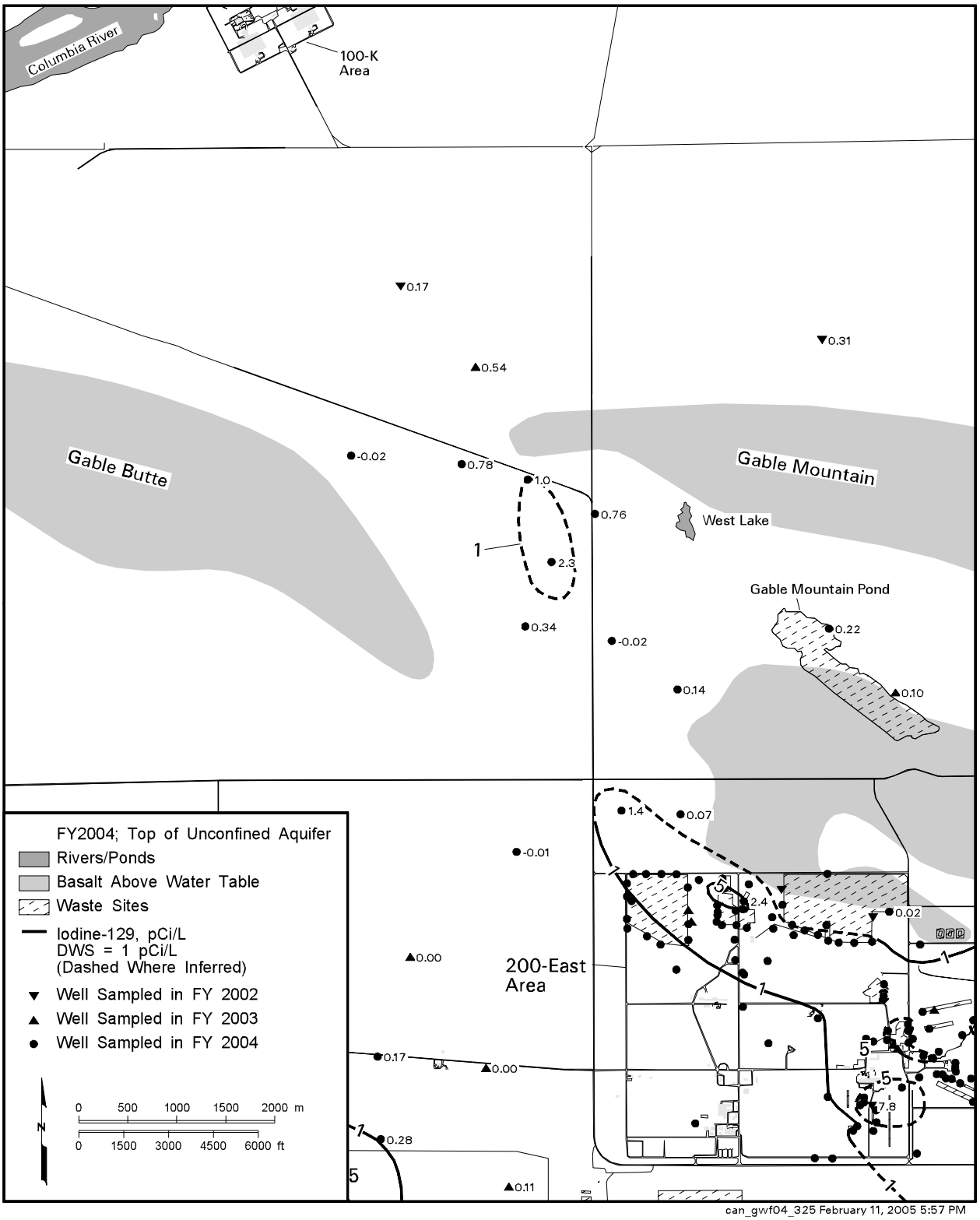


Figure 2.10-6. Average Iodine-129 Concentrations in the 200-BP-5 Operable Unit and Vicinity, Top of Unconfined Aquifer

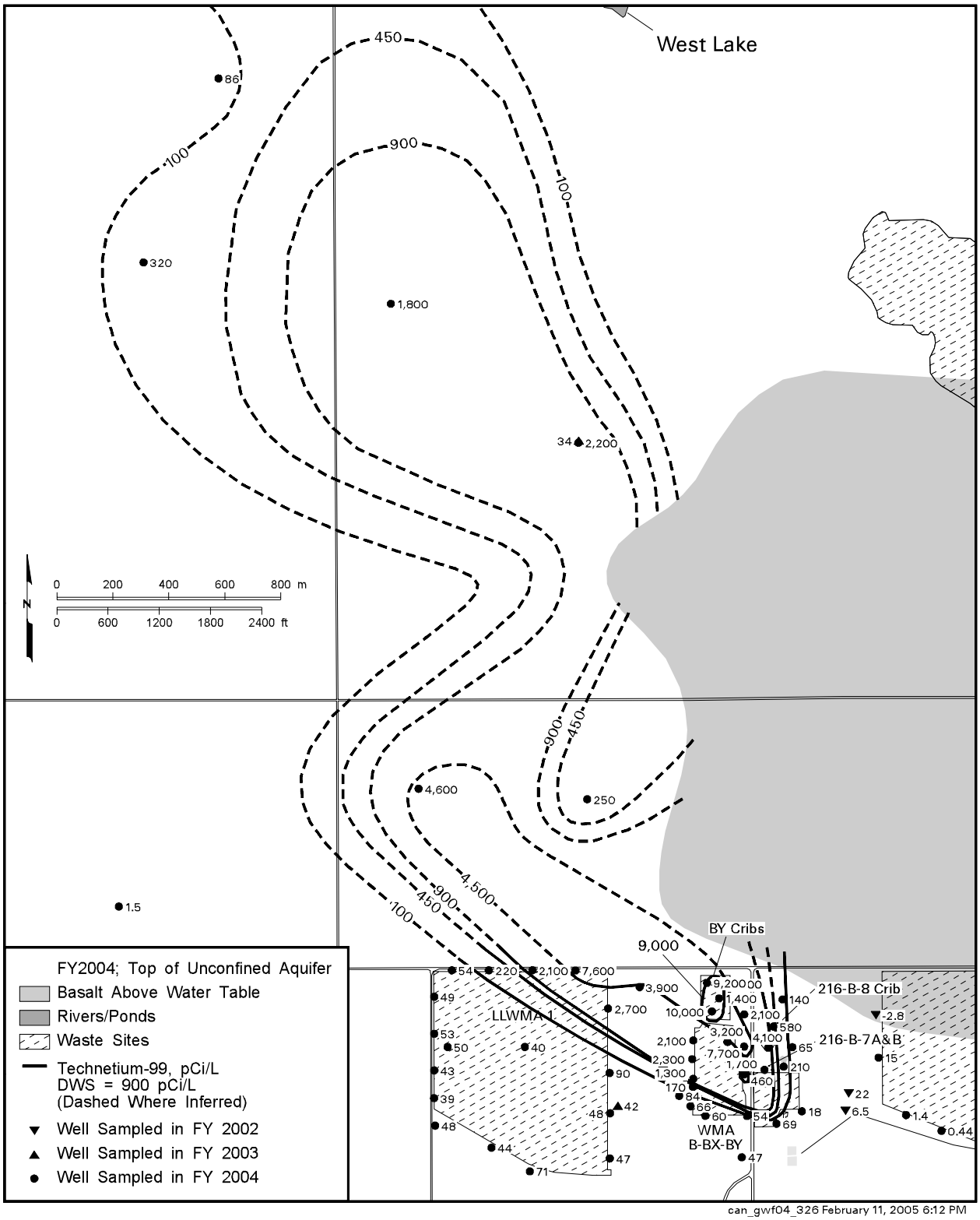


Figure 2.10-7. Average Technetium-99 Concentrations in the North 200 East Area, Top of Unconfined Aquifer

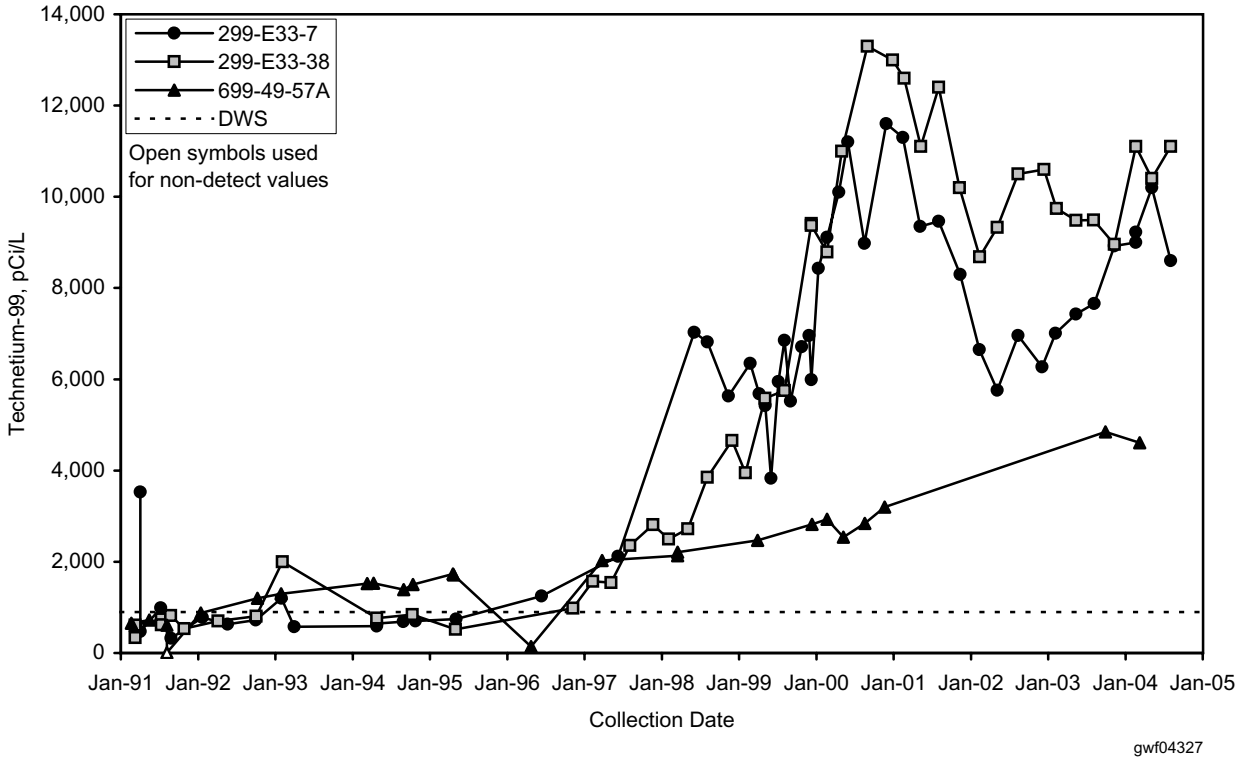


Figure 2.10-8. Technetium-99 Concentrations in Wells 299-E33-7 and 299-E33-38 at the BY Cribs and Well 699-49-57A North of 200 East Area

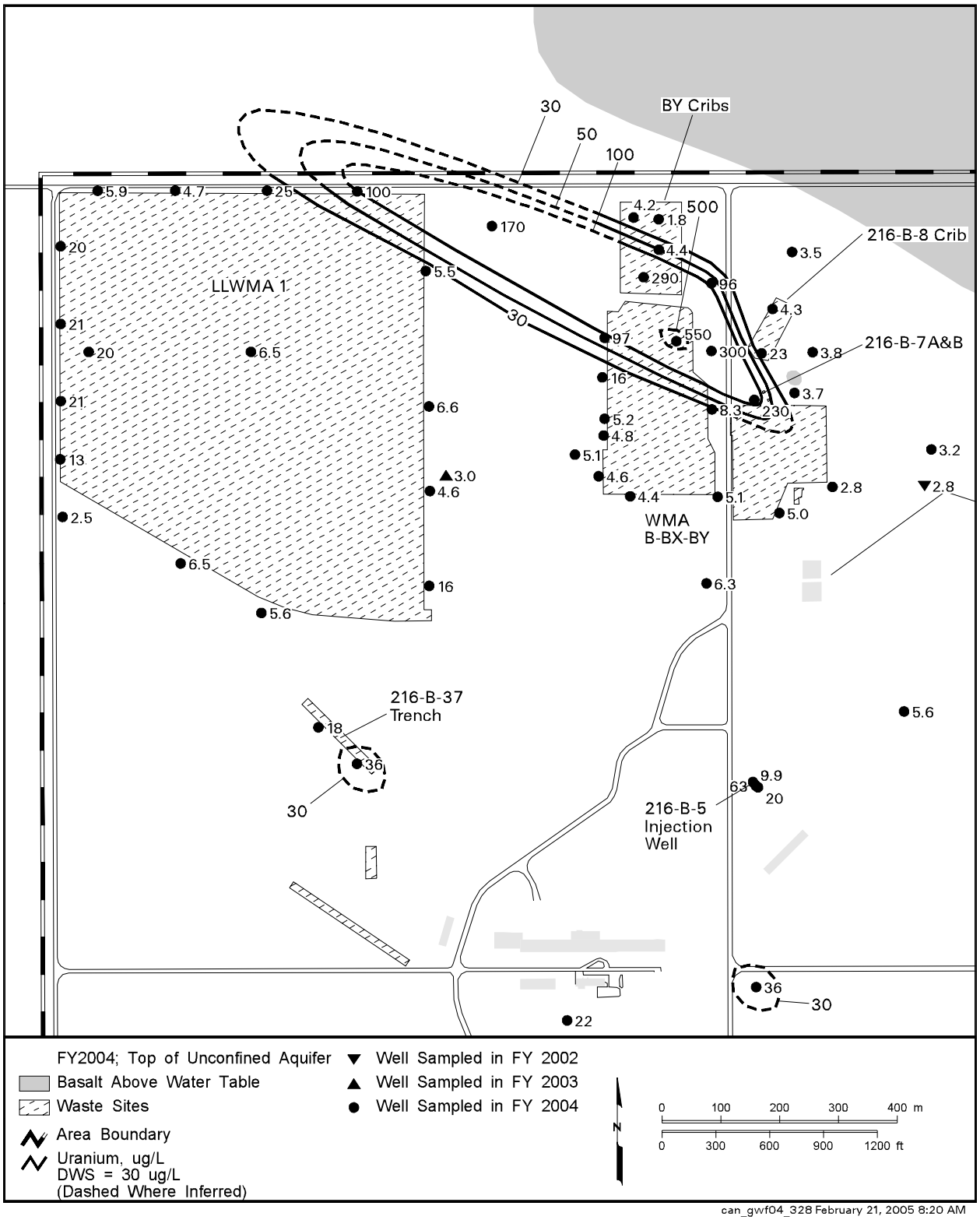


Figure 2.10-9. Average Uranium Concentrations in the Vicinity of BY Cribs, Top of Unconfined Aquifer

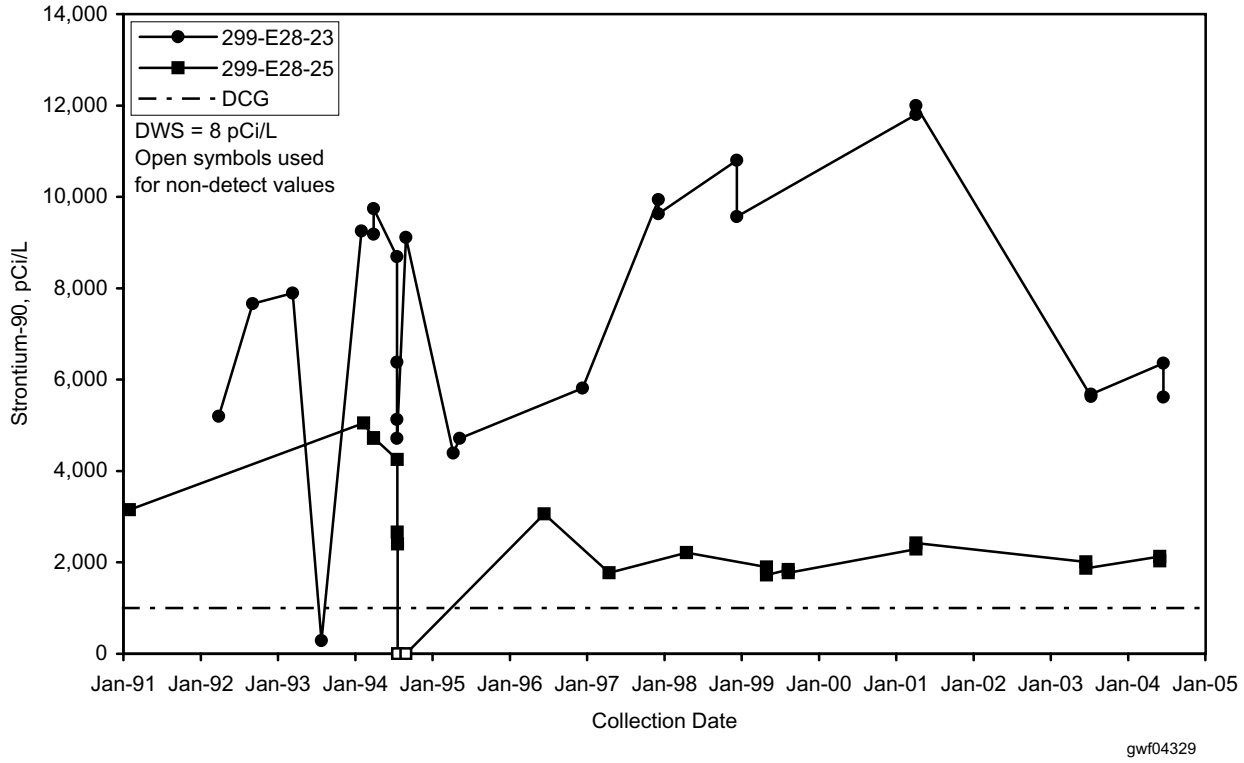


Figure 2.10-10. Strontium-90 Concentrations in Wells 299-E28-23 and 299-E28-25 at the 216-B-5 Injection Well Site, Top of Unconfined Aquifer

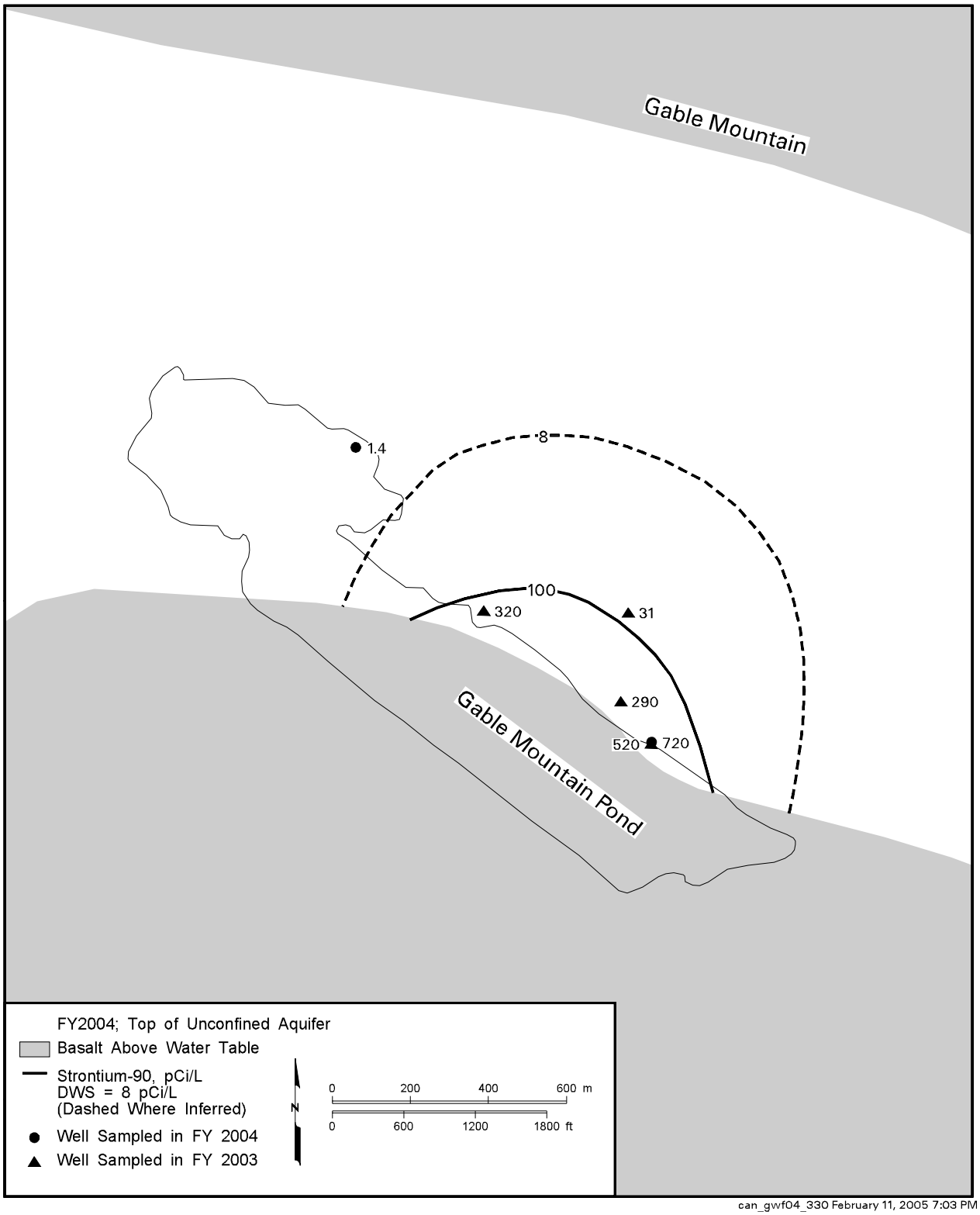


Figure 2.10-11. Strontium-90 Concentrations at Gable Mountain Pond, Top of Unconfined Aquifer

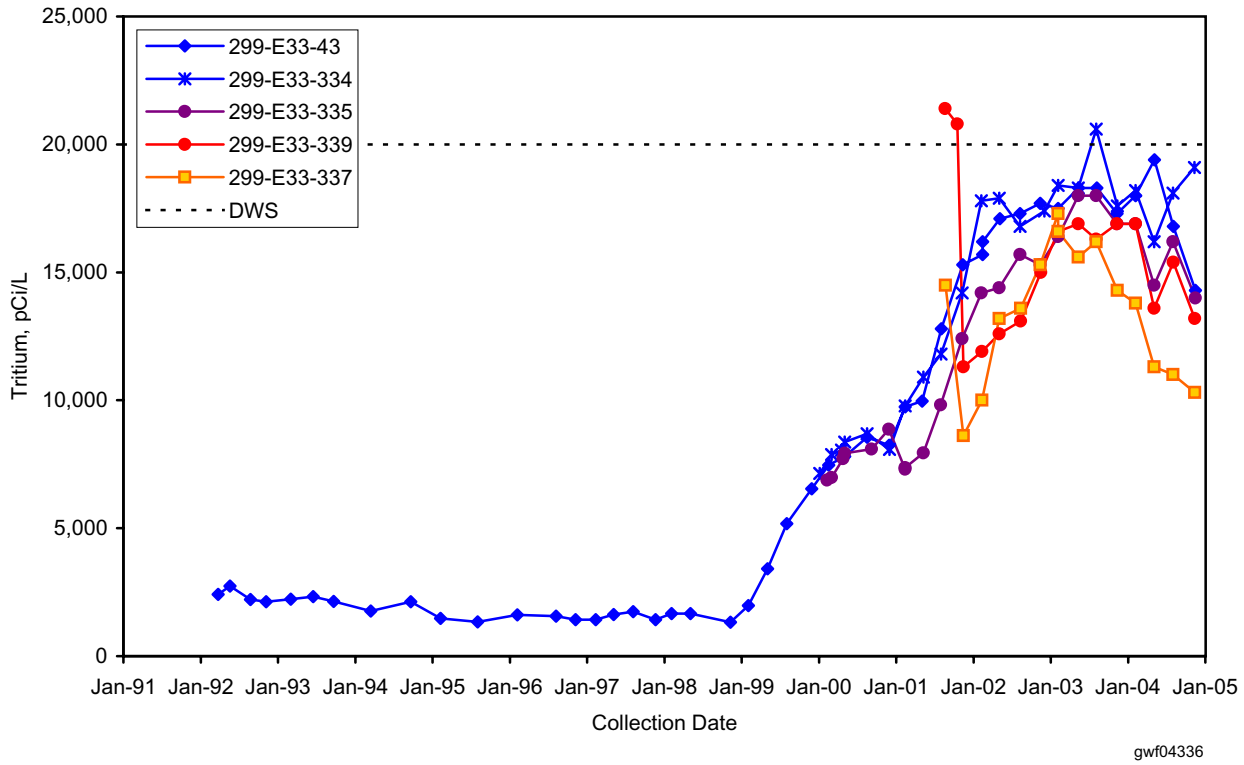


Figure 2.10-12. Trend Plots of Tritium at Waste Management Area B-BX-BY

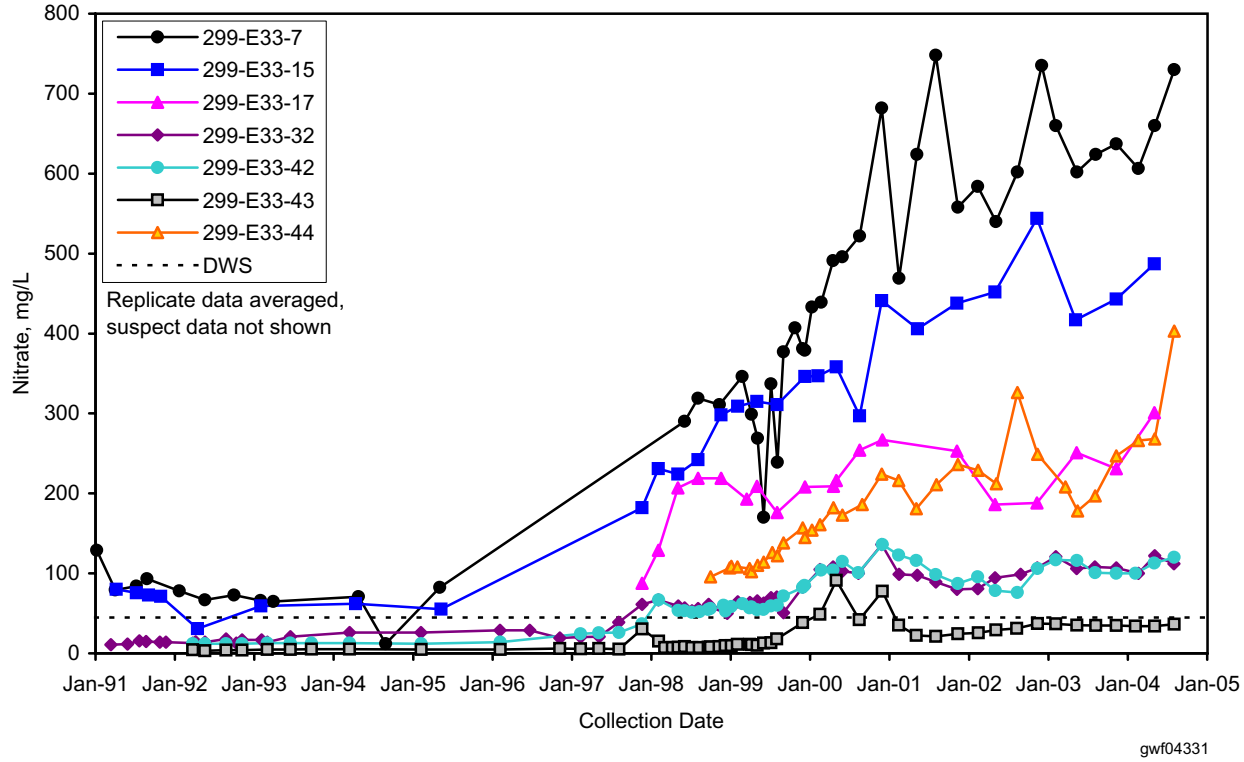


Figure 2.10-13. Trend Plots of Nitrate Concentrations at Waste Management Area B-BX-BY

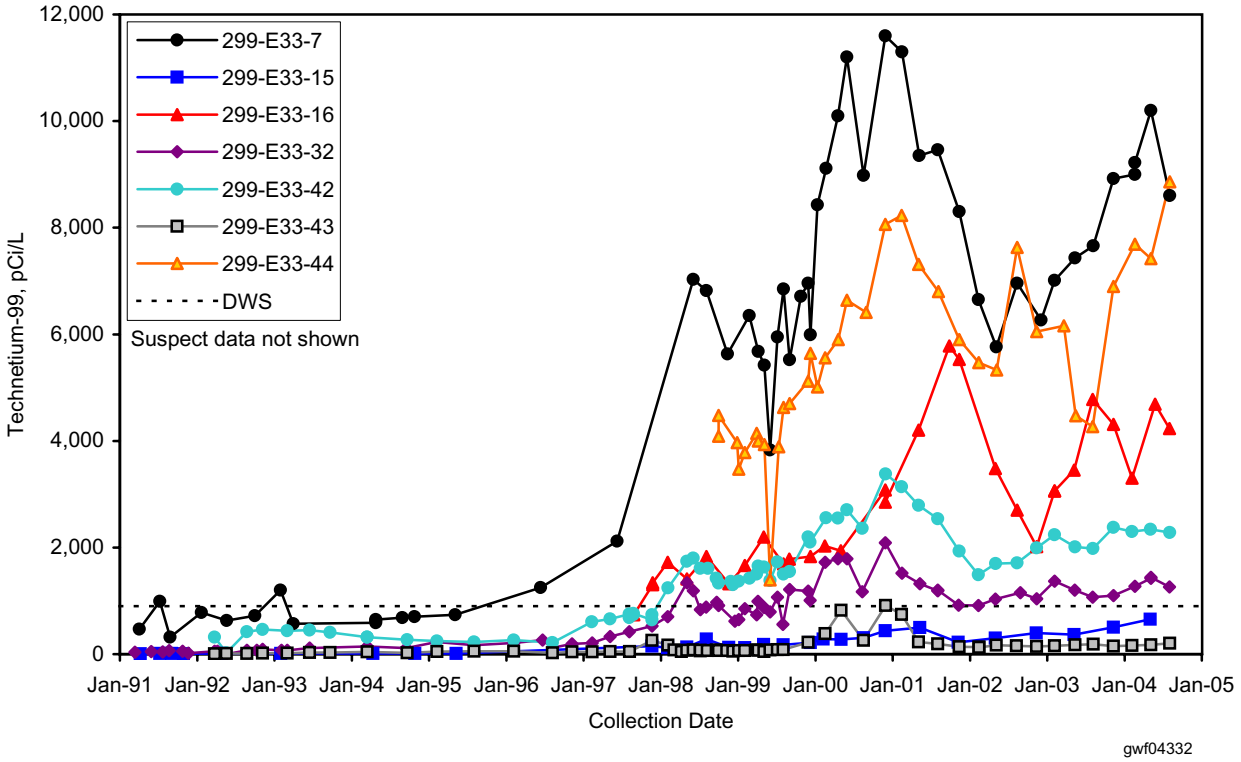


Figure 2.10-14. Trend Plots of Technetium-99 Concentrations at Waste Management Area B-BX-BY

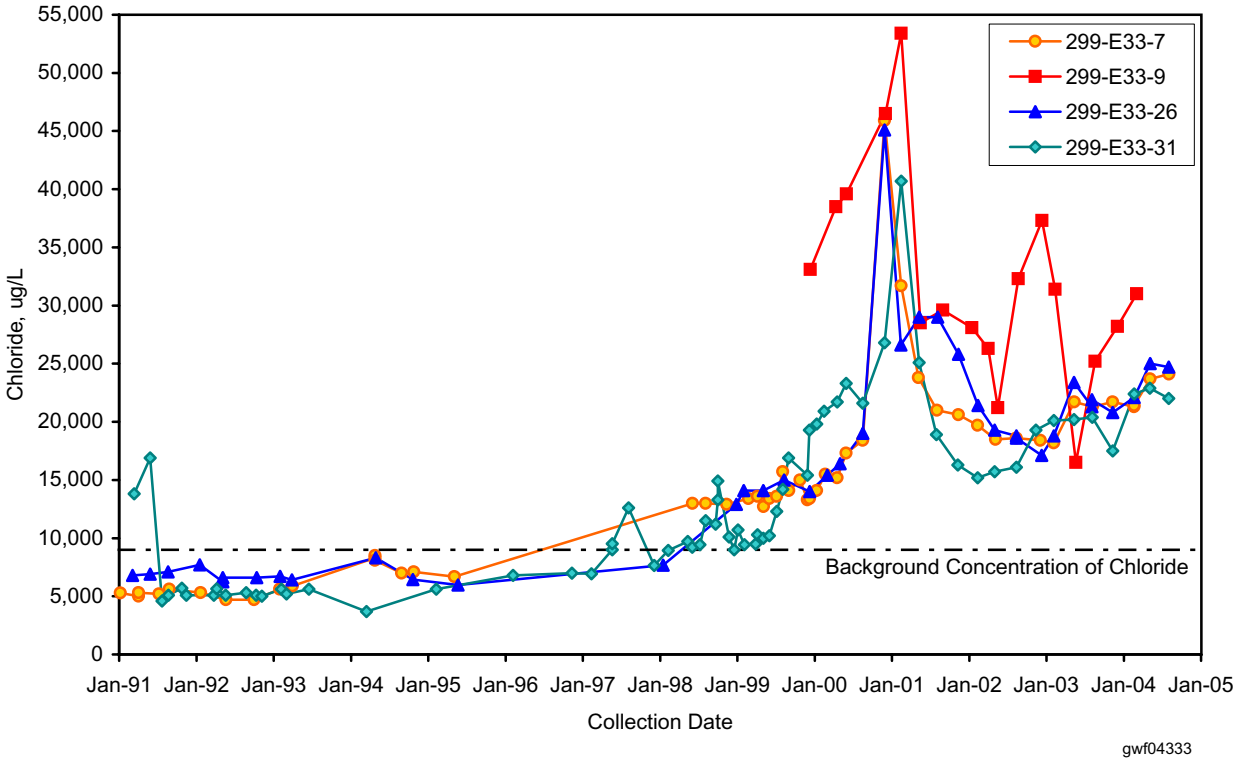


Figure 2.10-15. Trend Plots of Chloride at Waste Management Area B-BX-BY

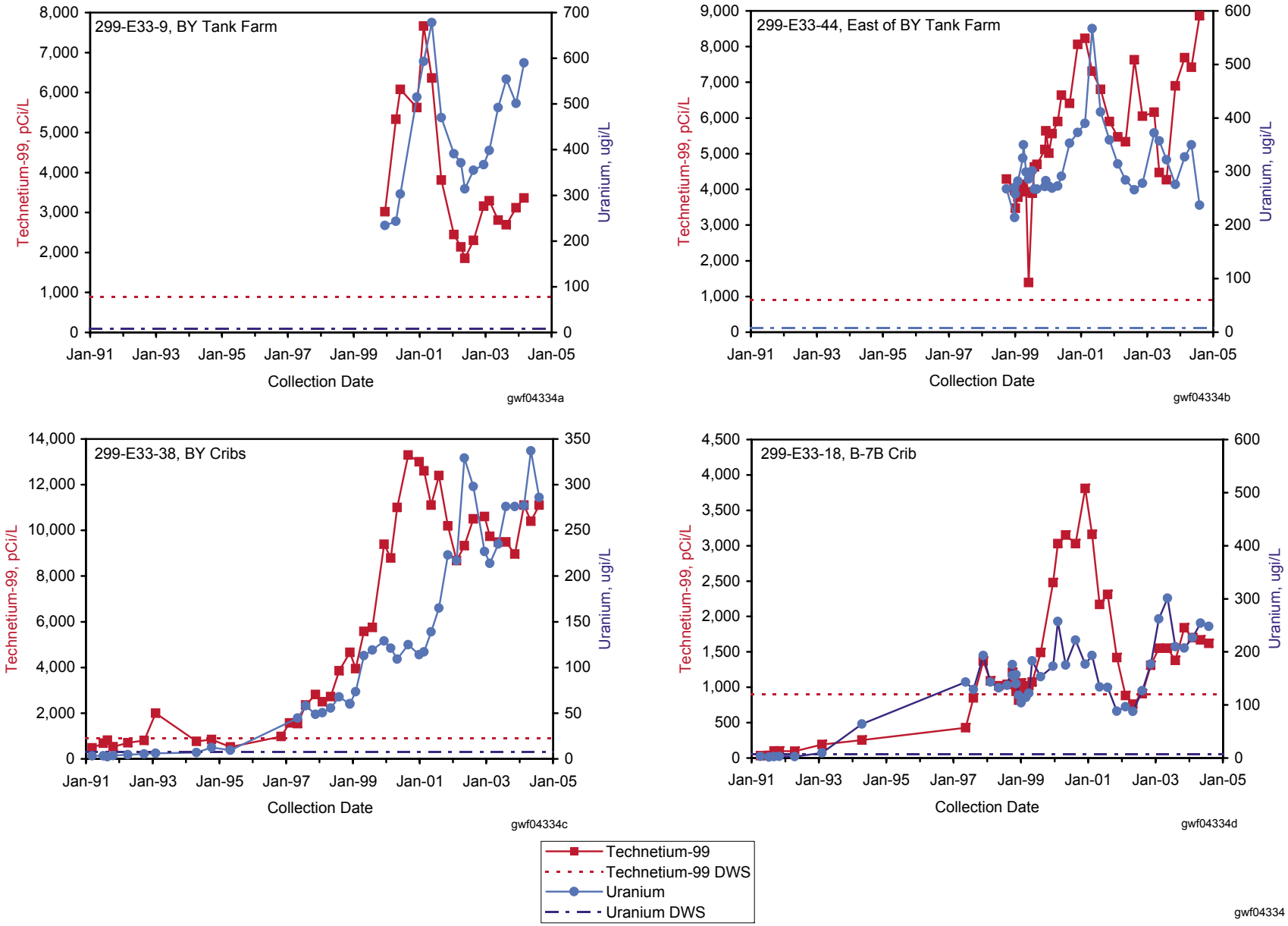


Figure 2.10-16. Trend Plots of Technetium-99 versus Uranium for Waste Management Area B-BX-BY

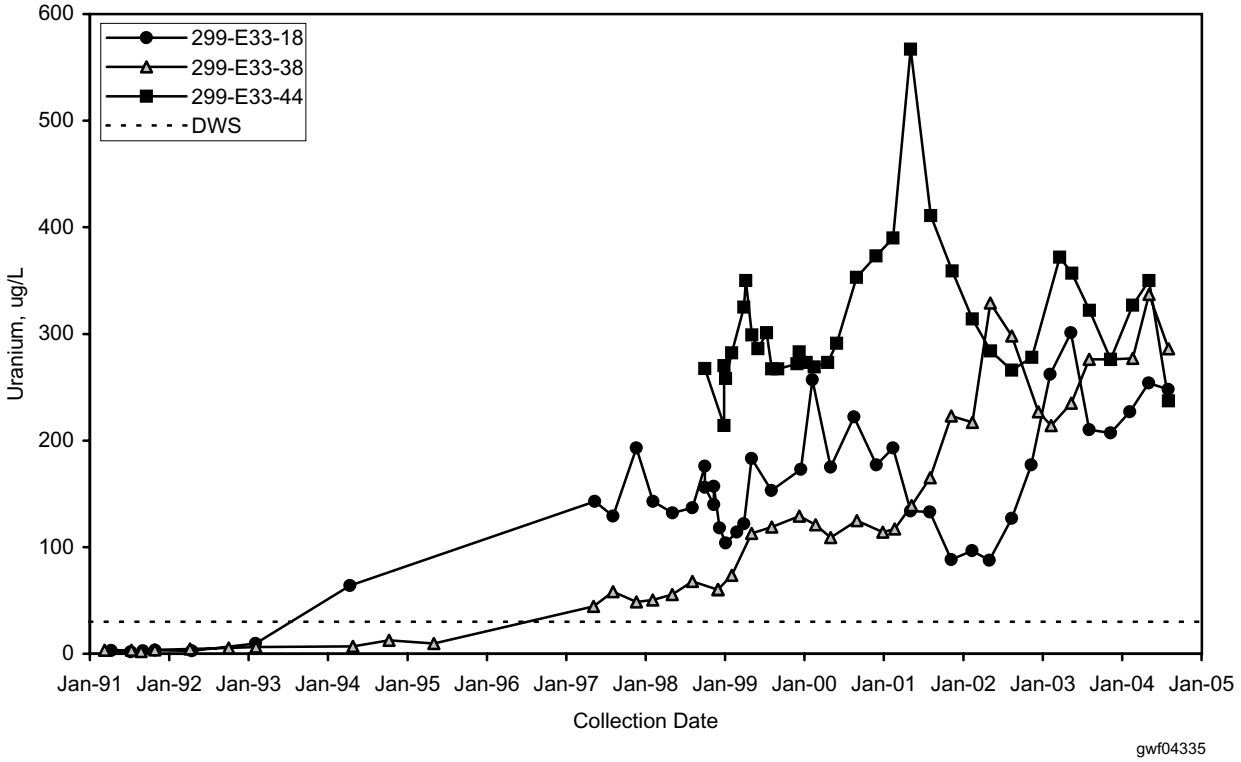


Figure 2.10-17. Trend Plots of Uranium at Waste Management Area B-BX-BY

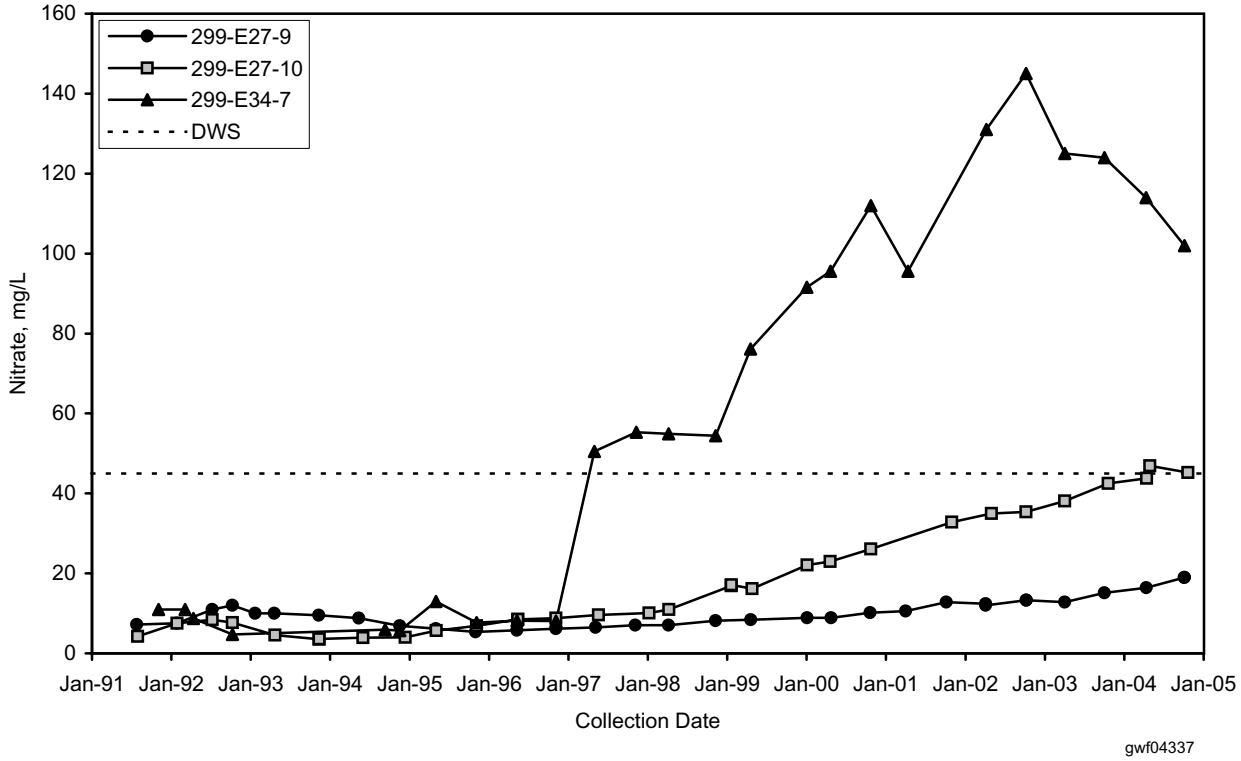


Figure 2.10-18. Nitrate Concentrations in Low-Level Waste Management Area 2 Wells 299-E34-7, 299-E27-10, and 299-E27-9

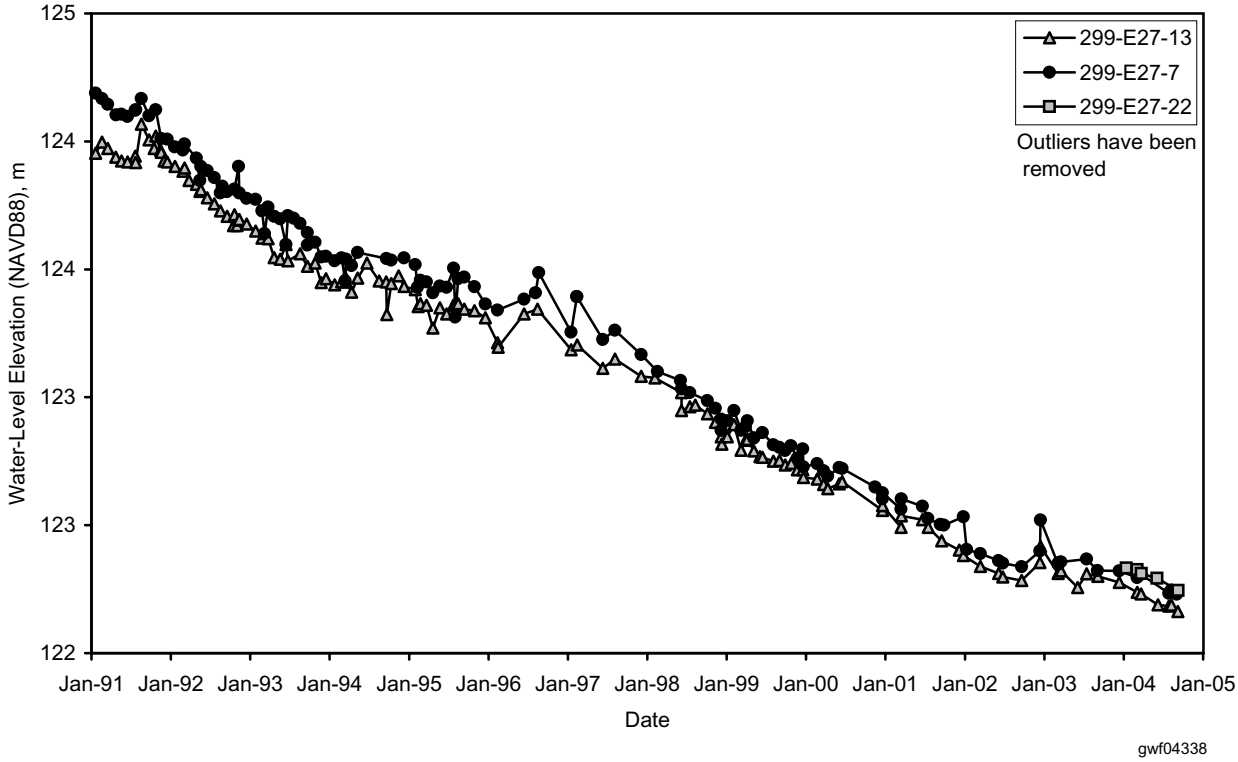


Figure 2.10-19. Hydrographs Comparing Water Levels from Upgradient Wells 299-E27-22 and 299-E27-7 to Downgradient Well 299-E27-13 at Waste Management Area C

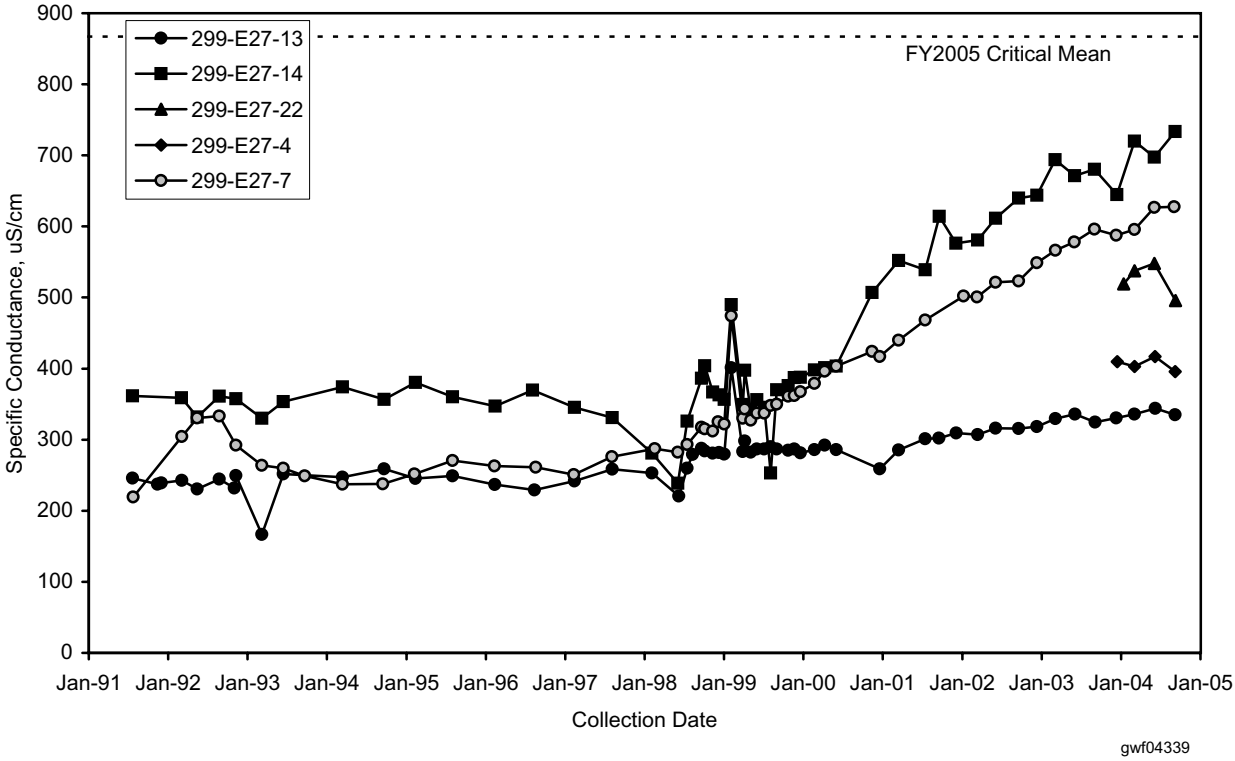


Figure 2.10-20. Specific Conductance Trends in the Groundwater at Waste Management Area C

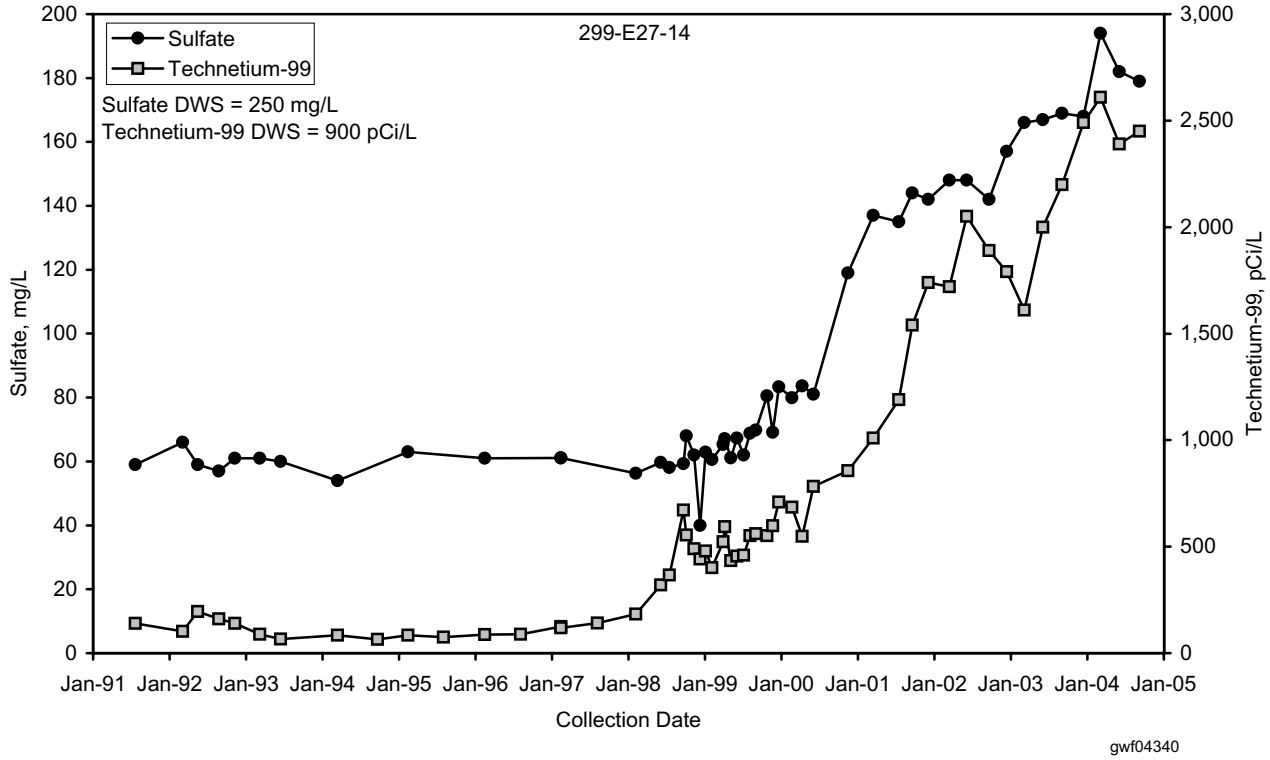


Figure 2.10-21. A Comparison of the Sulfate Trend to the Technetium-99 Trend in Downgradient Well 299-E27-14 at Waste Management Area C

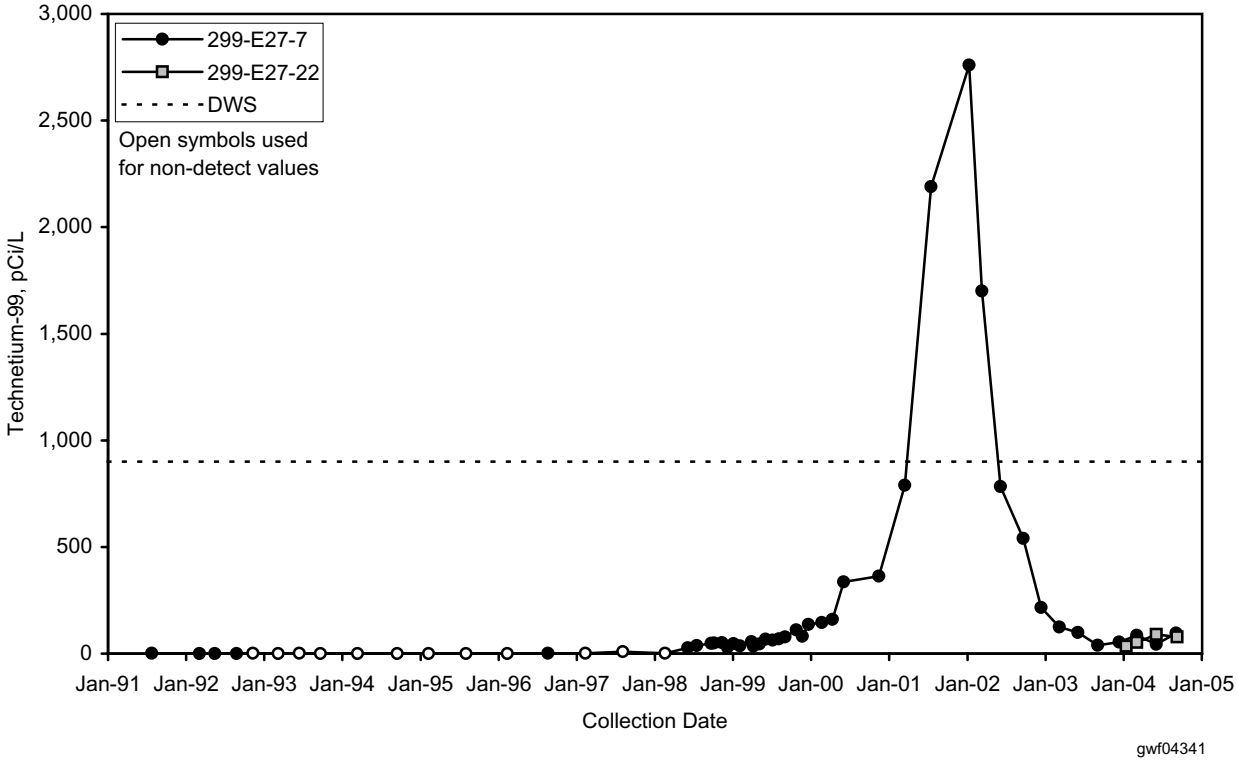


Figure 2.10-22. Technetium-99 Concentrations for Upgradient Wells 299-E27-7 and 299-E27-22 at Waste Management Area C