The extent of strontium-90 at levels greater than the drinking water standard in the 100-K Area is shown in Figure 4.8.26. The maximum concentration detected in 1996 was over 8,000 pCi/L measured in September at well 199-K-109A. The concentration at this well had reached 6,000 pCi/L in April, then dropped significantly after repair of a leaking water supply line located within 5 m (16.4 ft) of the well. A trend plot of strontium-90 in well 199-K-109A is also shown in Figure 4.8.26. It was thought that strontium-90 contamination in the soil column might have been transported to the water table by the water from the leak. However, the reason for the increase in concentration during September is not yet understood. In October, the concentration dropped to 3,200 pCi/L. The derived concentration guide for strontium-90 is 1,000 pCi/L. Strontium-90 is also found near the K-West Reactor, and an extensive plume continues to be found near the liquid waste trench.

Strontium-90 was detected at concentrations greater than the derived concentration guide in the 100-N Area in 1996. The maximum level detected was 19,100 pCi/L at well 199-N-99A in May 1996. However, the average concentration throughout the year was 8,300 pCi/L at this well, compared to 11,600 pCi/L at well 199-N-67. Both wells are located between the 1301-N Liquid Waste Disposal Facility and the Columbia River. As shown in Figure 4.8.26, strontium-90 concentrations at well 199-N-67 increased and then decreased during 1996. Higher than normal river stages during the year may have caused the water table to rise into contaminated sediments, releasing strontium-90 to the aquifer.

The distribution of strontium-90 in the 100-N Area is shown in Figure 4.8.26. The movement of the strontium-90 plume northward in the 1980s is illustrated by the trend data from well 199-N-14. Strontium-90 discharges to the Columbia River in the 100-N Area through springs along the shoreline. Section 4.2, “Surface Water and Sediment Surveillance” and Section 3.2, “Near-Facility Environmental Monitoring,” give the results of spring-water sampling. Remediation of strontium-90 in the 100-N Area by the pump-and-treat method began in 1995.

Strontium-90 in the 200 Areas. Concentrations of strontium-90 in the 200-East Area ranged up to 5,800 pCi/L in well 299-E28-23 near the 216-B-5 injection well. Strontium-90 was also found at 80 pCi/L in well 299-E28-2, which is approximately 150 m (490 ft) from the 216-B-5 injection well. Strontium-90 distribution in the 200-East Area is shown in Figure 4.8.27.

Strontium-90 was detected in 1996 at levels above the drinking water standard in two wells (299-E17-14 and 299-E17-8) near the Plutonium-Uranium Extraction Plant cribs. The maximum concentration of strontium-90 detected in 1996 in this vicinity was 15.7 pCi/L in well 299-E17-14.

Strontium-90 is detected occasionally in the 200-West Area. In 1995, samples from two wells exceeded the drinking water standard, with concentrations of 71.3 pCi/L at well 299-W22-1 and 26.8 pCi/L at well 299-W22-10, located in the southern part of the 200-West Area. These wells were not sampled during 1996, and no concentrations over the drinking water standard were measured in the other sampled wells.

Strontium-90 in the 600 Area. The maximum concentration of strontium-90 detected in the 600 Area was 1,500 pCi/L at well 699-53-48B, which is in the former Gable Mountain Pond area (see Figure 4.8.27). This is the first time in several years that a value greater than the 1,000-pCi/L derived concentration guide has been detected in this area. A trend plot is shown in Figure 4.8.28. Strontium-90 contamination in this area resulted from the discharge of radioactive waste to the former Gable Mountain Pond during its early use. Strontium-90 has since migrated through the sedimentary column to the groundwater, which is relatively close to the surface at that location. Initial breakthrough occurred in 1980 in some areas. The depth to bedrock is also small in the former Gable Mountain Pond area, and strontium-90 has been detected in wells completed in the basalt just below the unconsolidated sediments.

Technetium-99

Technetium-99 is produced as a fission byproduct and is present in waste streams associated with fuel reprocessing. Reactor operations may also result in the release of some technetium-99 associated with fuel element breaches. Under the chemical conditions that exist in Hanford groundwater, technetium-99 is normally present in solution as anions that sorb poorly to sediments. Therefore, technetium-99 is very mobile in Hanford Site groundwater.

Technetium-99 was found at concentrations greater than the 900-pCi/L drinking water standard in several areas of the Hanford Site. One location is downgradient of the 183-H Solar Evaporation Basins in the 100-H Area. These basins were used for storage of waste primarily from fuel fabrication in the 300 Area. Some of the waste leaked into the subsurface, contaminating the groundwater. The

Figure 4.8.26. Concentrations of Strontium-90 in the Unconfined Aquifer in the 100-K and 100-N Areas, 1996, and Concentration Trends in Select Wells

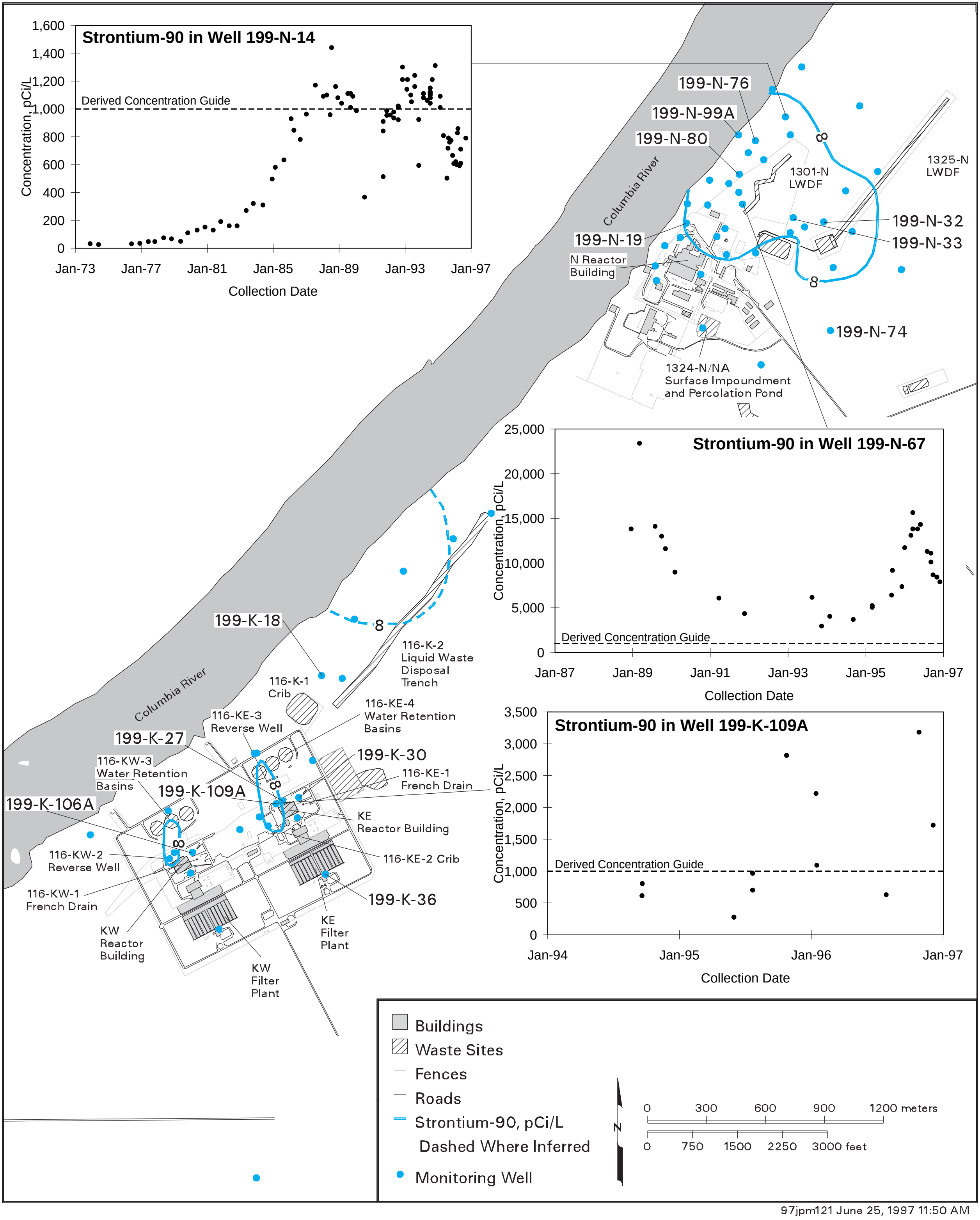
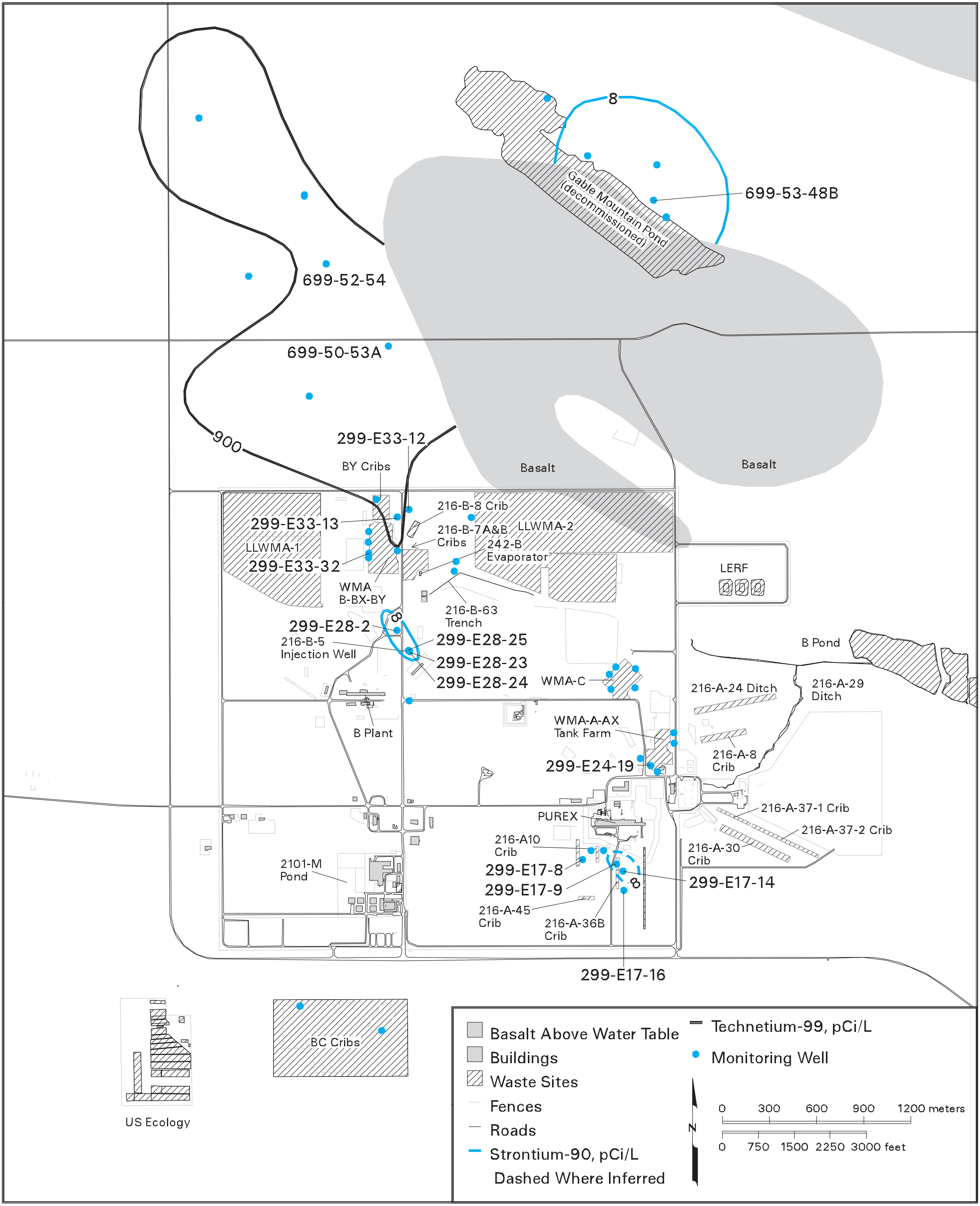

Strontium-90 in Well 199-N-14
Derived Concentration Guide
Concentration, pCi/L
Collection Date
Jan-73
Jan-77
Jan-81
Jan-85
Jan-89
Jan-93
Jan-97
Strontium-90 in Well 199-N-67
Jan-87
Jan-91
Jan-95
Strontium-90 in Well 199-K-109A
Jan-94
Jan-96
Columbia River
199-N-76
199-N-99A
199-N-80
199-N-19
199-N-32
199-N-33
199-N-74
N Reactor Building
1301-N LWDF
1325-N LWDF
1324-N/NA Surface Impoundment and Percolation Pond
199-K-18
116-K-2 Liquid Waste Disposal Trench
116-K-1 Crib
116-KE-3 Reverse Well
116-KE-4 Water Retention Basins
199-K-27
116-KW-3 Water Retention Basins
199-K-30
116-KE-1 French Drain
199-K-109A
199-K-106A
KE Reactor Building
116-KW-2 Reverse Well
116-KE-2 Crib
116-KW-1 French Drain
199-K-36
KW Reactor Building
KE Filter Plant
KW Filter Plant
Buildings
Waste Sites
Fences
Roads
Strontium-90, pCi/L
Dashed Where Inferred
Monitoring Well
0 300 600 900 1200 meters
0 750 1500 2250 3000 feet
N
97jpm121 June 25, 1997 11:50 AM

Figure 4.8.27. Concentrations of Strontium-90 and Technetium-99 in the Unconfined Aquifer Near the 200-East Area, 1996



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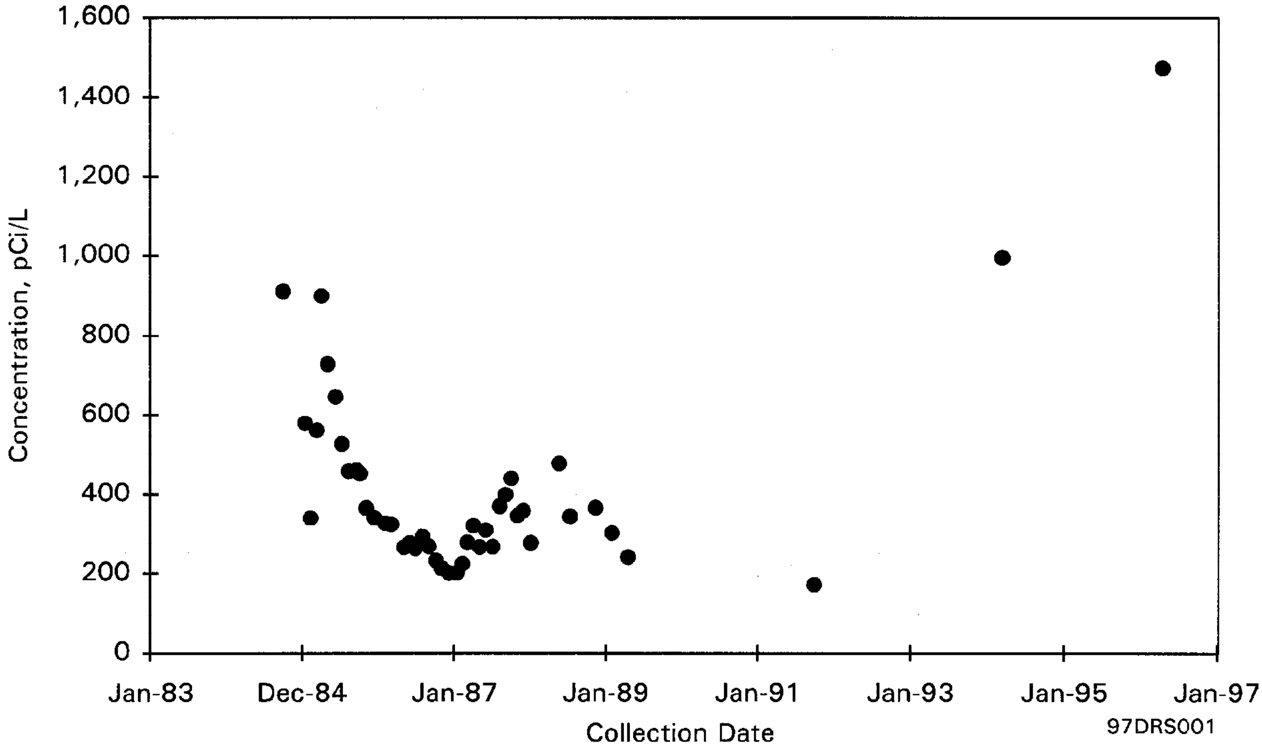


Figure 4.8.28. Strontium-90 Concentrations in Well 699-53-48B, 1984 Through 1996

maximum concentration of technetium-99 detected in this area in 1996 was 5,140 pCi/L at well 199-H4-3. Technetium-99 was also detected above the drinking water standard at wells 199-H4-4 and 199-H4-18.

Groundwater from the northwestern part of the 200-East Area and a part of the 600 Area extending north toward the gap between Gable Mountain and Gable Butte contains technetium-99 at concentrations above the drinking water standard (see Figure 4.8.27). The source of this technetium was apparently the BY Cribs (Dresel et al. 1995). The technetium-99 plume is associated with cobalt-60, cyanide, and tritium contamination. The maximum technetium-99 concentration detected in this plume in 1996 was 2,900 pCi/L at well 699-52-54. A concentration of 9,910 pCi/L was observed at well 699-50-53A during 1995. This well, however, was not sampled in 1996 because it was being used for a groundwater treatment study. The technetium-99 trend for well 699-52-54 shows the progress of this plume as it migrates north (Figure 4.8.29).

Technetium-99 is also detected at levels greater than the drinking water standard in the 200-West Area and the adjacent 600 Area (Figure 4.8.30). The largest technetium-99 plume in the 200-West Area originates in the cribs that received effluent from U Plant. The maximum technetium-99 concentration detected in the 200-West Area in 1996 was in well 299-W19-30, which had a maximum concentration of 29,300 pCi/L. This plume extends into the 600 Area toward the 200-East Area. The part of this plume with the highest concentration is currently undergoing remediation by the pump-and-treat method.

Several smaller areas with technetium-99 concentrations greater than the drinking water standard were also found in the 200-West Area. One well near the T-TX-TY Tank Farms contained technetium-99 at levels above the drinking water standard. Technetium-99 concentrations in this well declined sharply in 1996. However, as shown in Figure 4.8.31, technetium-99 levels increased sharply in well 299-W11-27 near the T Tank Farm. The maximum concentration detected in this well was 21,500 pCi/L, and the source of this increased technetium-99 is being assessed.

The southernmost plume in the 200-West Area originates near the S-SX Tank Farms and nearby disposal facilities. During 1996, all samples were below the drinking water standard. Leakage from the SX single-shell tanks is being investigated as a potential source of the technetium-99 in this vicinity.

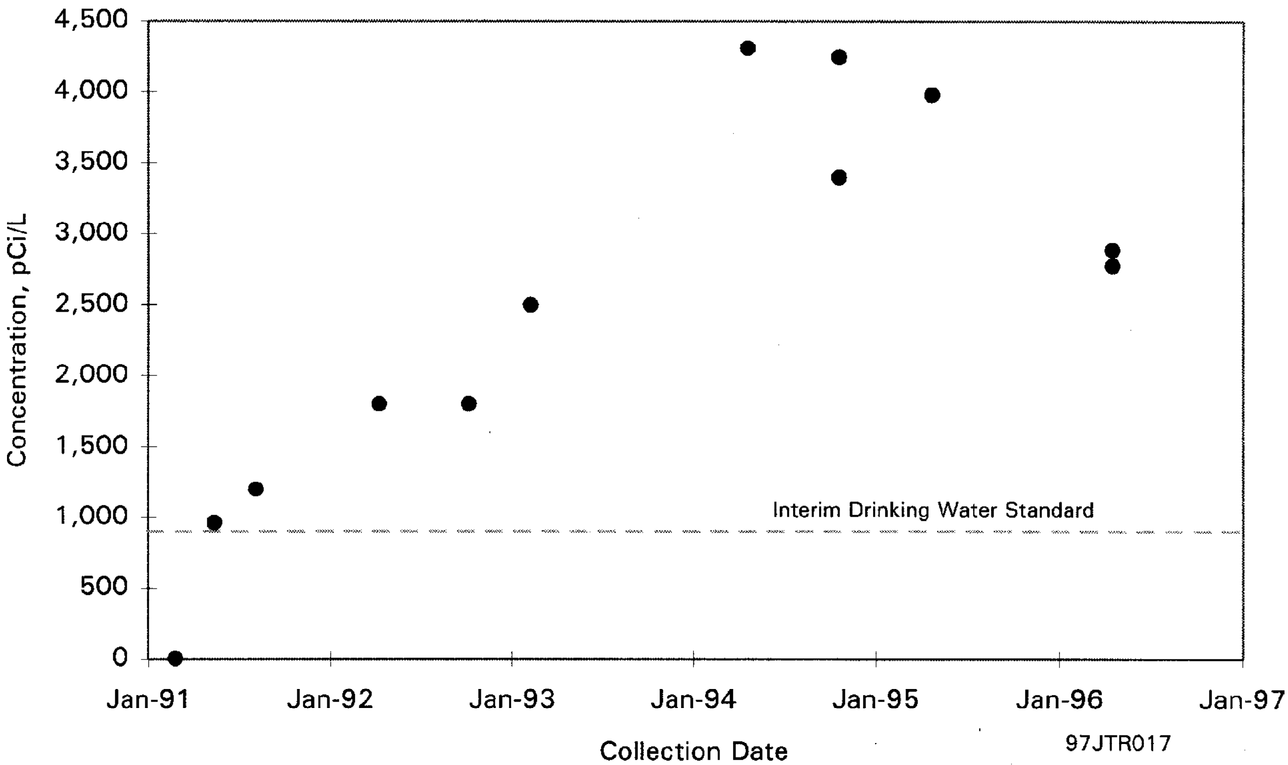


Figure 4.8.29. Technetium-99 Concentrations in Well 699-52-54, 1991 Through 1996

Uranium

There are numerous possible sources of uranium released to the groundwater at the Hanford Site, including fuel fabrication, fuel reprocessing, and uranium recovery operations. Uranium may exist in several states including elemental uranium or uranium oxide as well as tetravalent and hexavalent cations. Only the hexavalent form has significant mobility in groundwater, largely by forming dissolved carbonate species. Uranium mobility is thus dependent on both oxidation state and pH. Uranium is observed to migrate in Hanford groundwater but is retarded relative to more-mobile species such as technetium-99 and tritium. The EPA's proposed drinking water standard is 20 µg/L for uranium.

Uranium has been detected at concentrations greater than the proposed drinking water standard in the 100-F, 100-H, 200, 300, and 600 Areas. The highest concentrations detected at Hanford in 1996 were in the 200-West Area near U Plant.

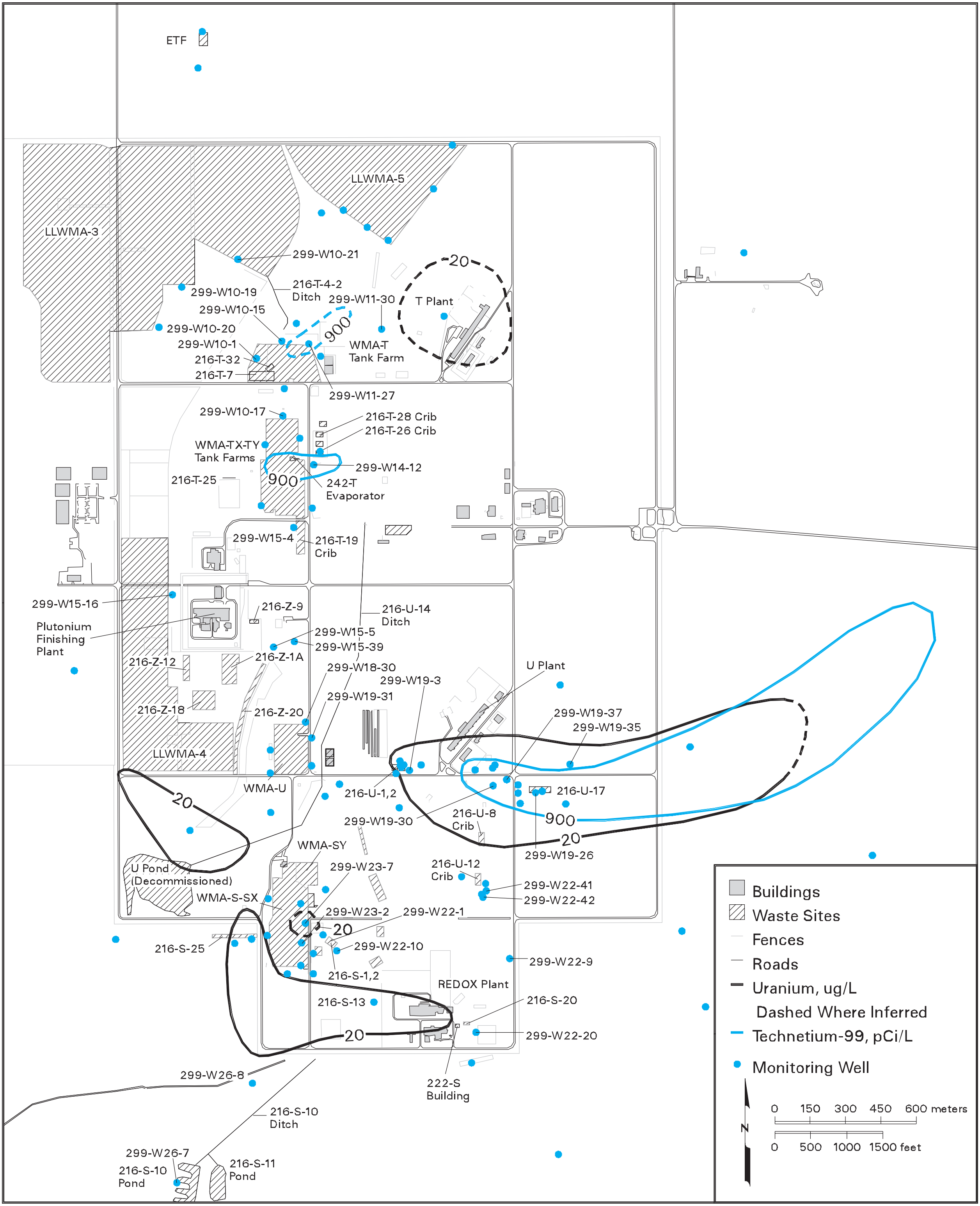
Uranium in the 100 Areas. In 1996, uranium was detected at concentrations greater than the proposed drinking water standard near F Reactor in the 100-F Area (see Figure 4.8.24). The maximum concentration detected was 27.7 µg/L in well 199-F8-1.

Uranium was detected at levels higher than the proposed drinking water standard in two wells in the 100-H Area (see Figure 4.8.25). The maximum concentration detected in 1996 was 358 µg/L in well 199-H4-3. Uranium concentrations in this well fluctuate widely. The average concentration measured at this well in 1996 was 167 µg/L. Past leakage from the 183-H Solar Evaporation Basins is considered to be the source of the 100-H Area uranium contamination. These basins were demolished during 1996.

Uranium in the 200 Areas. A few wells in the 200-East Area contained uranium at concentrations greater than the proposed drinking water standard. The highest concentration detected was 128 µg/L at well 299-E33-13, located on the northern edge of the 200-East Area. Uranium concentrations in this well have increased greatly in the last several years but the source of the contamination is unclear.

The highest uranium concentrations in Hanford groundwater occurred near U Plant in the 200-West Area, at

Figure 4.8.30. Concentrations of Technetium-99 and Uranium in the Unconfined Aquifer in the 200-West Area, 1996



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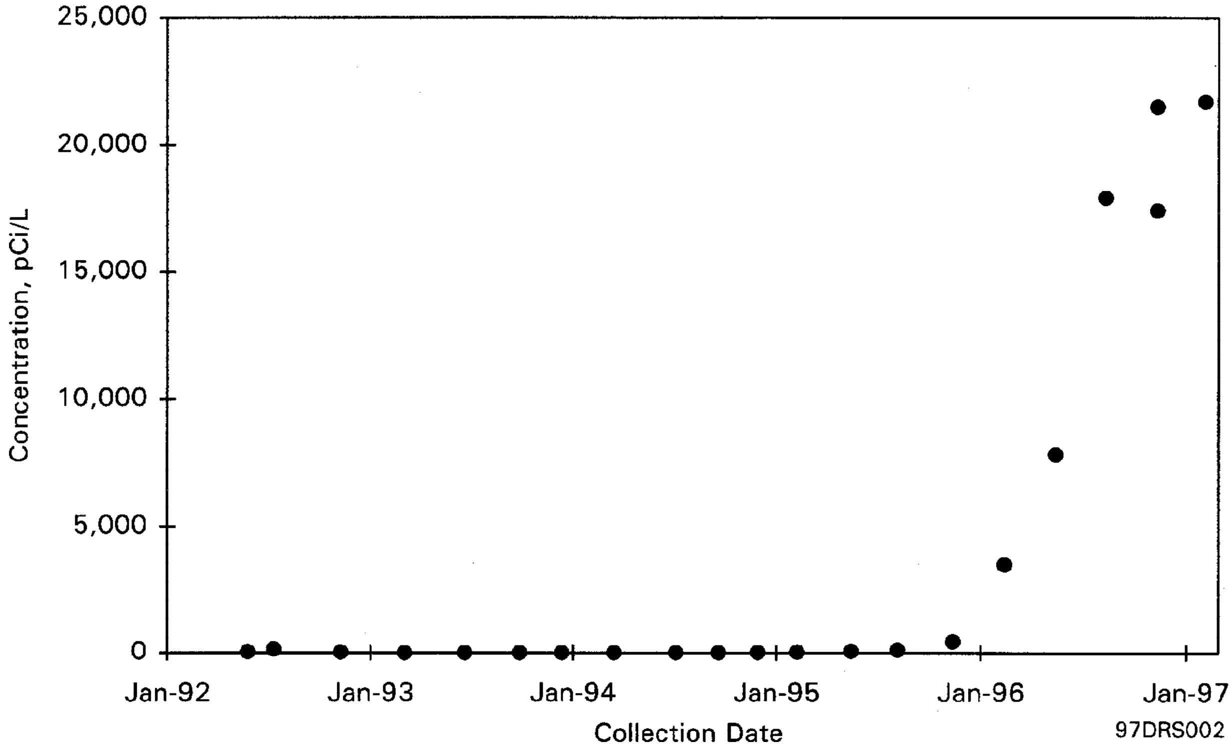


Figure 4.8.31. Technetium-99 Concentrations in Well 299-W11-27, 1992 Through 1996

wells adjacent to the inactive 216-U-1, 216-U-2, and 216-U-17 Cribs (see Figure 4.8.30). The maximum uranium detected in this area in 1996 was 3,790 µg/L at well 299-W19-37, a new well installed to monitor groundwater remediation activities. Uranium concentrations in this area have been decreasing over the last 5 years following remediation activities with the cribs. A trend plot of uranium concentrations in samples from well 299-W19-3, immediately downgradient from the 216-U-1 and 216-U-2 Cribs, is shown in Figure 4.8.32. The uranium levels in this well continue to decrease slowly but remain greater than the proposed drinking water standard. This uranium plume extends east into the 600 Area along with the technetium-99 plume discussed above. Other areas within the 200-West Area with uranium contamination are also shown in Figure 4.8.30, including fairly widespread areas west and northwest of the Reduction-Oxidation Plant. Uranium concentrations in those areas are considerably lower than the concentrations detected near U Plant.

Uranium in the 300 Area. A plume of uranium contamination exists in the unconfined aquifer beneath the 300 Area in the vicinity of uranium fuel fabrication facilities and inactive sites known to have received uranium waste. The plume extends downgradient from inactive liquid waste disposal facilities to the Columbia River (Figure 4.8.33). In recent years, uranium concentrations have fallen in the northern part of the plume, risen in the central part, and remained fairly constant in the southern part, as shown in the trend plots in Figure 4.8.33. The maximum concentration of uranium detected in the 300 Area in 1996 was 300 µg/L in well 399-1-17A, located adjacent to the 300 Area Process Trenches. An expedited response action performed on the 300 Area Process Trenches in mid-1991 was aimed at reducing the uranium source in that area. Use of the trenches for disposal of cooling water and small quantities of nonhazardous maintenance and process waste (Borghese 1994) was resumed following completion of the remedial action, though discharge to the trenches was much lower than before the expedited response action and ceased completely in 1995. Uranium levels in well 399-1-17A were lower following that remedial action. However, levels increased sharply in late 1994 and 1995. This increase is probably related to the cessation of discharge of water to the trenches. Recent discharges have been low in uranium because fuel fabrication activities have ceased. The sudden increase after discharges were terminated is most likely related to redistribution of contamination in the aquifer or reequilibration of the water with the sediments.

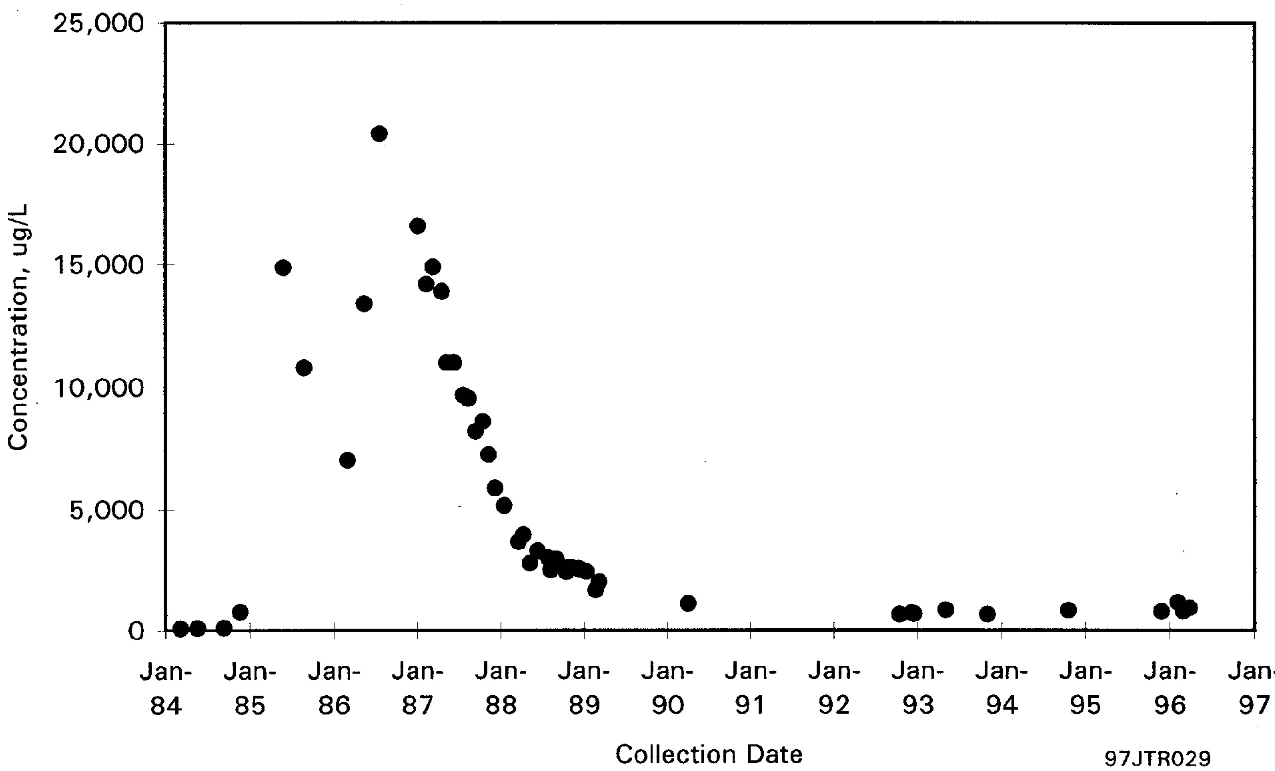


Figure 4.8.32. Uranium Concentrations in Well 299-W19-3, 1984 Through 1996

A trend plot showing the uranium concentrations in well 399-1-17A is shown in Figure 4.8.34.

Uranium in the 600 Area. The measured uranium concentration in well 699-S6-E4A, which is located southeast of the 400 Area, dropped from 768 µg/L in 1995 to 108 µg/L in 1996, following renovation of the well. The contamination at this well is attributed to the nearby 316-4 Crib (Hartman and Dresel 1997). The 618-10 burial grounds are also located near this well.

Cobalt-60

Cobalt-60 is a neutron activation product typically associated with wastes generated by reactor effluent. Cobalt-60 is normally present as a divalent transition metal cation and, as such, tends to be highly immobile in groundwater. However, complexing agents may mobilize it. The derived concentration guide for cobalt-60 is 5,000 pCi/L.

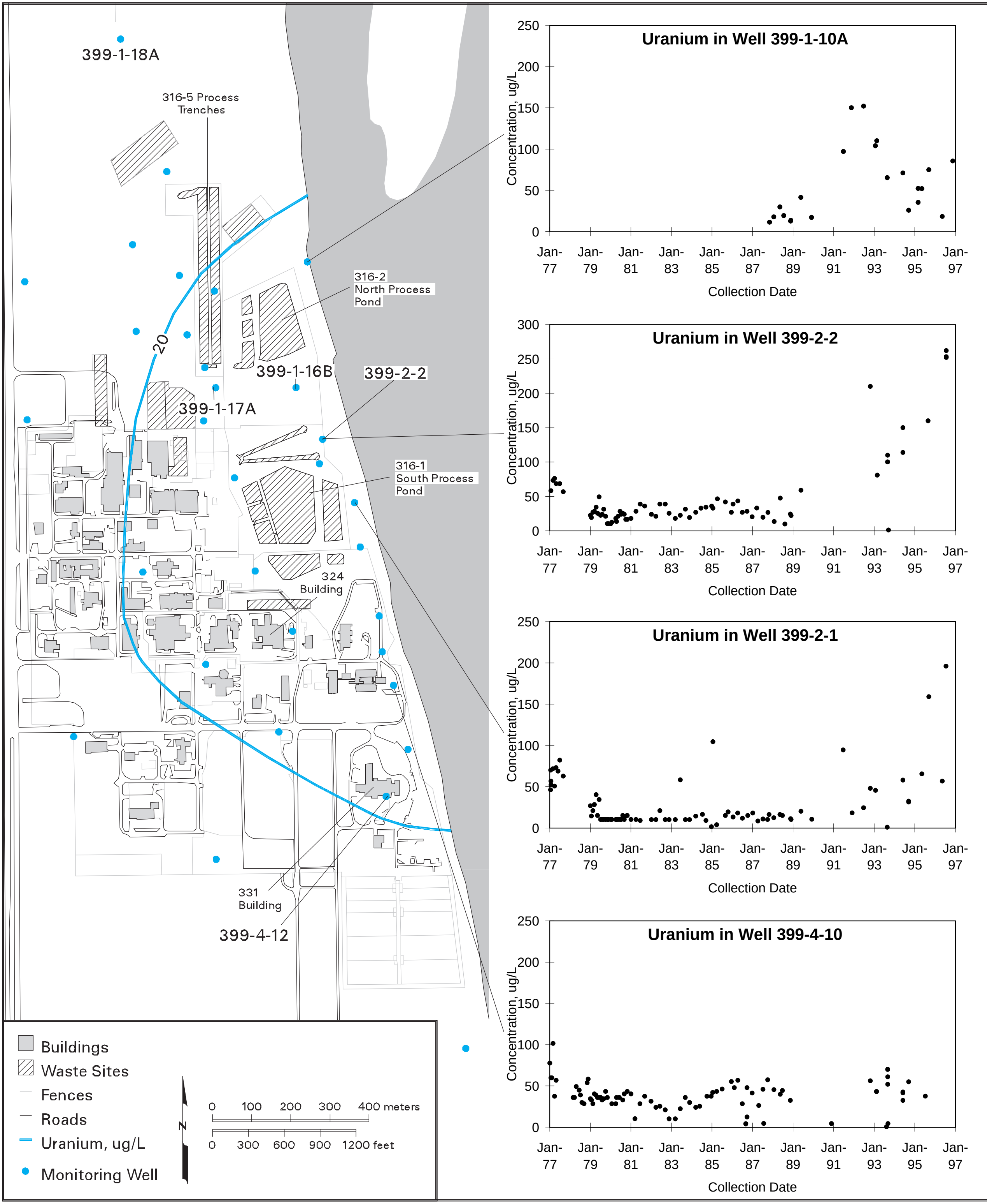
The maximum concentration of cobalt-60 detected in 100-N Area wells during 1996 was 648 pCi/L in an unfiltered sample from well 199-N-32. A filtered sample taken at the same time from the same well resulted in a concentration of 5.5 pCi/L. The difference in these results indicates that the bulk of cobalt-60 in the unfiltered sample was adsorbed on particles suspended in the water rather than in solution.

A cobalt-60 plume is found north of the 200-East Area in the same area as the technetium-99 contamination associated with the BY Cribs. Apparently, cobalt in this plume is mobilized by reaction with cyanide or ferrocyanide in the waste stream, forming a dissolved cobalt species. During 1995, cobalt-60 was detected in this area at levels above the 100-pCi/L drinking water standard, with a maximum concentration of 166 pCi/L detected at well 699-50-53A (Dirkes and Hanf 1996). However, this well was not analyzed for cobalt-60 in 1996.

Cobalt-60 was detected at well 299-E17-16, near the Plutonium-Uranium Extraction Plant, in June 1994 at a concentration of 40.1 pCi/L. This well has consistently shown detectable but low levels of cobalt-60. However, samples from this well were not analyzed for cobalt-60 in 1995 or 1996.

Cobalt-60 was occasionally detected at low levels in a few 200-West Area wells. Well 299-W14-12 continued to contain detectable cobalt-60 in 1996 samples. The

Figure 4.8.33. Uranium Concentrations in the Unconfined Aquifer in the 300 Area, 1996, and Concentration Trends for Select Wells



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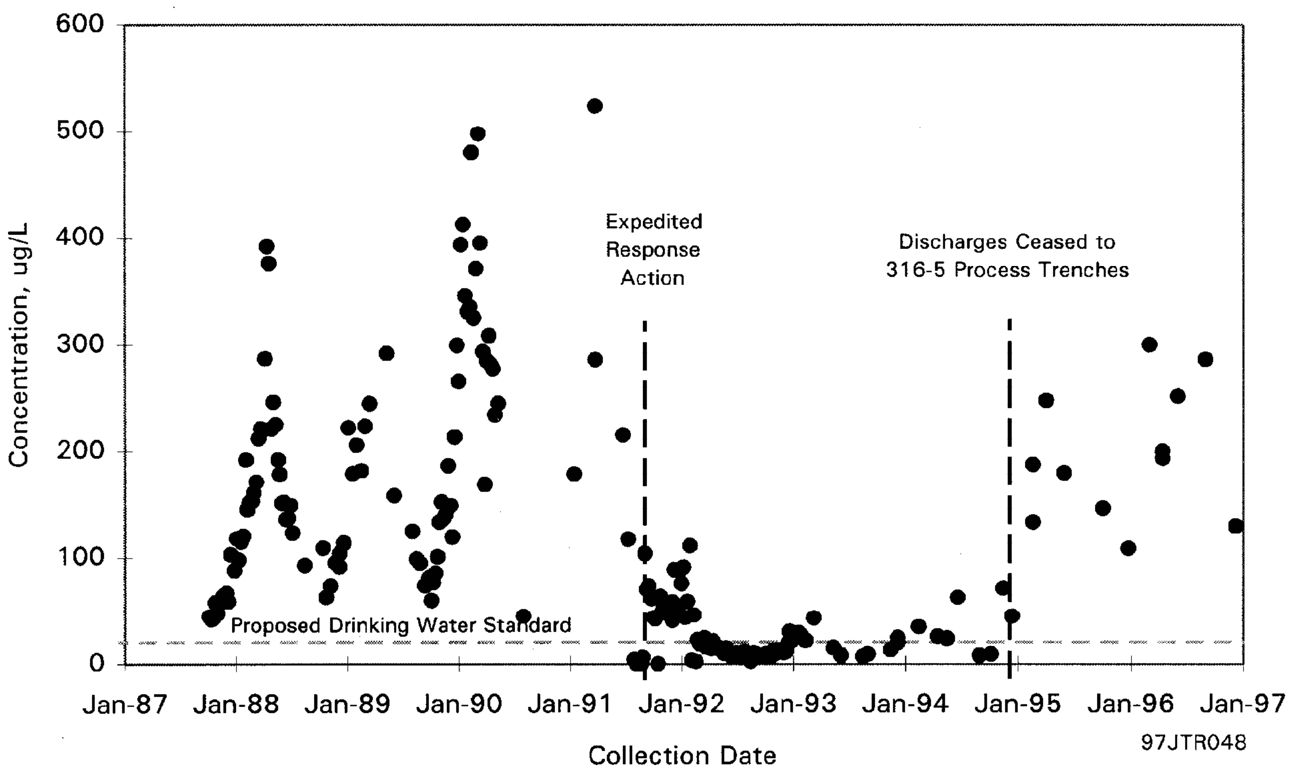

Figure 4.8.34. Uranium Concentrations in Well 399-1-17A, 1987 Through 1996

highest value reported in this well was 4.5 pCi/L, down from 17.2 pCi/L in 1995. This well is located to the east of the TX-TY Tank Farms. It is not known if the presence of cobalt-60 in the groundwater results from tank leaks or discharge to nearby cribs. The levels of cobalt-60 are well below regulatory standards, and the concentrations and extent of the plume appear stable with time.

Cesium-137

Cesium-137 is produced as a high-yield fission product and is present in waste streams associated with fuel processing. Reactor operations may also result in the release of some cesium-137 associated with fuel element breaches. Cesium-137 is normally strongly sorbed on soil and, thus, is very immobile in Hanford groundwater. The drinking water standard for cesium-137 is 200 pCi/L; the derived concentration guide is 3,000 pCi/L.

Cesium-137 is consistently detected in two wells (299-E28-23 and 299-E28-25) located in the 200-East Area near the 216-B-5 Injection Well. The injection well received cesium-137-bearing wastes from 1945 to 1947. The maximum 1996 concentration of cesium-137 in well 299-E28-25 was 114 pCi/L. Well 299-E28-23 was not sampled in 1996; however, the 1995 concentration was 1,470 pCi/L. Cesium-137 appears to be restricted to the immediate vicinity of the injection well by its extremely low mobility in groundwater.

In the 200-West Area, a sample from well 299-W23-7 contained 18 pCi/L of cesium-137 in 1996. This well is located in the S-SX Tank Farms area and was sampled to confirm the presence of cesium-137 in groundwater at this location.

Plutonium

Plutonium has been released to the soil column in several locations in both the 200-West and 200-East Areas. Plutonium is generally considered to sorb strongly to sediments and, thus, has limited mobility in the aquifer. The derived concentration guide for either plutonium-239 or plutonium-240 is 30 pCi/L. There is no explicit drinking water standard for plutonium-239; however, the total alpha drinking water standard of 15 pCi/L would be applicable at a minimum. Alternatively, if the derived concentration guide, which is based on a 100-mrem dose standard, is converted to the 4-mrem dose equivalent used for the drinking water standard, 1.2 pCi/L would be the relevant guideline.

Groundwater sampled during 1996 at 200-East Area wells located near the 216-B-5 Injection Well ranged up to 81 pCi/L of plutonium-239,240 at well 299-E28-25. A concentration of 51 pCi/L was measured at well 299-E28-24 in 1996. This value is similar to that measured in 1995. Plutonium-238 was also detected at wells 299-E28-24 and 299-E28-25 in 1996, but at considerably lower levels of 0.257 and 0.569 pCi/L, respectively. Plutonium has been detected continuously in this area. Because plutonium is strongly adsorbed to sediments and may have been injected into the aquifer as suspended particles, it is likely that the values measured result in part from solid rather than dissolved material. However, plutonium-239,240 was also previously detected in a sample from well 299-E28-2, which is approximately 150 m (490 ft) from the 216-B-5 Injection Well. The injection well received an estimated 244 Ci of plutonium-239,240 during its operation from 1945 to 1947 (Stenner et al. 1988).

Antimony-125

Antimony-125 is produced as a fission product and is present in waste streams associated with fuel reprocessing. Reactor operations may also result in the release of some antimony-125 associated with fuel element breaches. Antimony-125 tends to migrate in Hanford groundwater with low retardation, but generally has not been observed in recent years because of its relatively short half-life (2.7 yr). The drinking water standard for antimony-125 is 300 pCi/L.

Antimony-125 was detected at 52 pCi/L in an unfiltered sample from well 199-N-33 in the 100-N Area during 1996. However, the concentration measured in a filtered sample from the same well was 6.5 pCi/L, indicating that the antimony was adsorbed on particles suspended in the water sample. Levels below the drinking water standard have also been historically detected in the 100-B and 100-K Areas. A maximum concentration of 12.8 pCi/L was measured at well 199-K-109A, down from 44.8 pCi/L at this well in 1995. No samples from the 100-B Area were analyzed for this radionuclide in 1996. During 1995, antimony-125 was detected at a concentration of 21.1 pCi/L in well 699-35-70, which is located to the east of the 200-West Area Reduction-Oxidation Plant. However, this well was not analyzed for antimony-125 in 1996.

Chemical Monitoring Results for the Unconfined Aquifer

In recent years, chemical analyses performed by various monitoring programs at the Hanford Site have identified nine hazardous chemicals in groundwater at significant concentrations. These are nitrate, cyanide, fluoride, chromium, carbon tetrachloride, chloroform, trichloroethylene, tetrachloroethylene, and cis-1,2-dichloroethylene.

A number of parameters such as pH, specific conductance, total carbon, total organic carbon, and total organic halogens are used as indicators of contamination. These are mainly discussed in the section, “Resource Conservation and Recovery Act Summary.” Other chemicals and parameters listed in Table 4.8.3 are indicators of the natural chemical composition of groundwater and are usually not contaminants from operations at the Hanford Site. These include alkalinity, aluminum, calcium, iron, magnesium, manganese, potassium, silica, and sodium. Chloride and sulfate naturally occur in groundwater and can also be introduced as contaminants from site operations. There is no primary drinking water standard for chloride or sulfate. The secondary standard for each is 250 mg/L and is based on aesthetic rather than health considerations. Therefore, they will not be discussed in detail. The analytical technique used to determine the concentration of metals in groundwater provides results for a number of constituents such as antimony, barium, beryllium, boron, cadmium, copper, nickel, silver, strontium, vanadium, and zinc that are rarely observed at greater than background concentrations.

The following presents additional information on the nine chemical constituents occurring in groundwater at concentrations greater than existing or proposed drinking water standards (40 CFR 141 and EPA 1996; see Appendix C).

Nitrate

Many groundwater samples collected in 1996 were analyzed for nitrate. Nitrate was measured at concentrations greater than the drinking water standard (45 mg/L as nitrate ion) in wells in all operational areas, except the 100-B and 400 Areas. Nitrate is associated primarily with process condensate liquid wastes, though other liquids discharged to the ground also contained nitrate. Nitrate contamination in the unconfined aquifer reflects the extensive use of nitric acid in decontamination and chemical reprocessing operations. However, additional sources of nitrate are located offsite to the south, west, and southwest. The distribution of nitrate on the Hanford Site is shown in Figure 4.8.35; this distribution is similar to previous evaluations. Although nitrate contamination can be detected over large areas of the site, the areas impacted by levels greater than the drinking water standard are smaller.