2.4 100 N Area

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The 100 N Area contains a single reactor that operated from 1963 through 1987. Waste sites and proposed corrective measures are described in DOE/RL-95-111 and DOE/RL-96-102. The most significant groundwater contamination is associated with the 1301-N and 1325-N facilities, which will be remediated in coming years. Characterization of sediment from those facilities is described in Section 3.1.2. Other sources of contamination include the 1324-N/NA facilities and various spills or leaks of petroleum products. Groundwater flow and contamination for each of these contaminant source areas are discussed in the following sections.

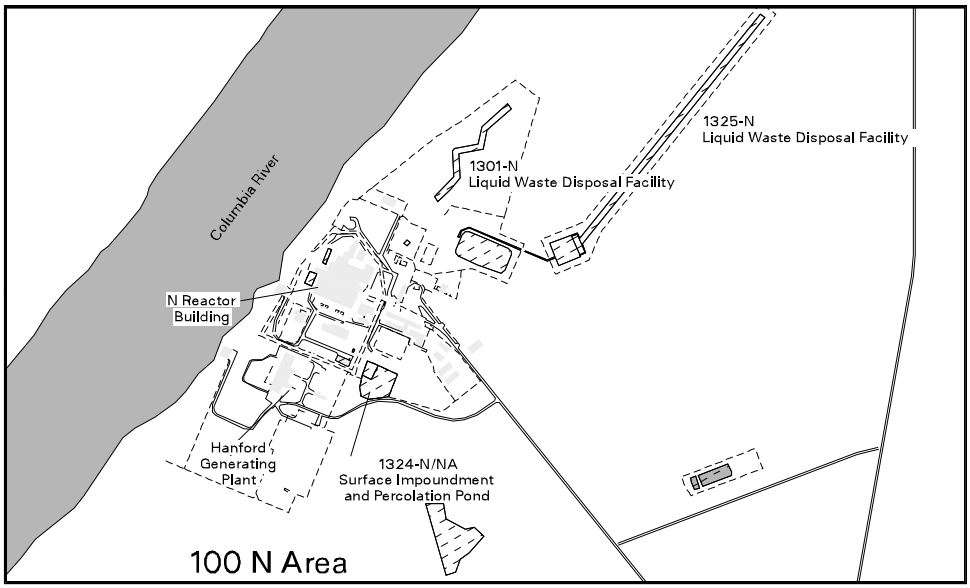
2.4.1 1301-N and 1325-N Liquid Waste Disposal Facilities

This section describes groundwater flow and contamination beneath the 1301-N and 1325-N facilities. The principal groundwater contaminants are strontium-90 and tritium. Groundwater remediation and riverbank water sampling also are discussed. Fiscal year 1999 data indicate few changes in groundwater quality beneath these facilities compared to previous years.

2.4.1.1 Groundwater Flow

Groundwater generally flows to the northwest, toward the Columbia River, beneath the 1301-N site and toward the north beneath the 1325-N site (see Plate 2). When the stage of the Columbia River is high, the gradient beneath the 1301-N facility reverses, creating a potential for groundwater to flow toward the northeast, approximately parallel to the Columbia River. Estimated flow velocities in March 1999 were 0.04 to 0.82 meter per day at 1301-N and 0.02 to 0.38 meter per day at 1325-N (see Table A.2). Movement of a peak in specific conductance indicates a flow velocity at the upper end of this range at the 1325-N site, 0.3 meter per day.

Extraction of groundwater from wells near the 1301-N facility, and injection of treated water near 1325-N, affect groundwater flow. These effects are clearly visible on the water-table map (see Plate 2) and are discussed in Section 2.4.1.6.



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Water levels beneath both facilities fluctuate with the stage of the Columbia River. In Figure 2.4-1, water levels near the 1301-N facility are represented by well 199-N-2. Because the well is relatively close to the Columbia River, the well shows the greatest fluctuation in the elevation of the water table. Well 199-N-34, representing water levels near the 1325-N facility, showed slightly less variation. The range of water levels was smaller than in the previous several years when river stage was unusually high.

Monitoring Objectives in 100 N Area

Groundwater monitoring is conducted in the 100 N Area:

- triennially to annually to describe the nature and extent of contamination
- semiannually to detect the possible impact of three RCRA sites
- semiannually to monitor trends in variable constituents/wells
- various time intervals to evaluate the performance of a pump-and treat system for strontium-90.

2.4.1.2 Tritium

The 1301-N and 1325-N facilities contaminated groundwater with tritium, which forms a widespread plume at levels exceeding the 20,000-pCi/L drinking water standard (see Plate 3). The core of the plume (i.e., the highest concentration) was formerly beneath the 1325-N facility and has migrated to the north and northwest. The highest concentrations of tritium currently are near the Columbia River. Tritium is also present in upgradient wells 199-N-74 and 199-N-52. The current upgradient tritium is believed to have been moved inland by mounding during 1325-N operations.

Tritium concentrations are declining in most 100 N Area wells (Figure 2.4-2). The general decline is expected to continue because of plume migration and radioactive decay.

2.4.1.3 Strontium-90

Groundwater beneath the 1301-N and 1325-N facilities is contaminated with strontium-90 at levels up to 18,000 pCi/L (Figure 2.4-3). Contamination is concentrated in an area between the 1301-N facility and the Columbia River and its distribution has not changed significantly in recent years. The contours of Figure 2.4-3 take into account the strontium-90 remaining in the treated water that is injected into wells 199-N-29 and 199-N-104A, near the 1325-N facility. The average strontium-90 concentration of the injected water in fiscal year 1999 was 382 pCi/L.

Concentrations in the heart of the plume near the 1301-N facility remained about the same as last year (Figure 2.4-4). However, strontium-90 levels in well 199-N-67 are four or five times higher than they were from 1991 through 1995. The high water table in 1996-1997 may have caused the increase by mobilizing strontium-90 that had been sorbed to sediment in the vadose zone. Changes in flow direction caused by the pump-and-treat system, which began to operate in 1995, also may have contributed to the rise in concentrations.

The pattern of seasonal fluctuation in wells farther from the 1301-N facility, where the vadose zone is not contaminated with strontium-90, is illustrated

Strontium-90 concentrations in 100 N Area groundwater continued to be among the highest on the Hanford Site in fiscal year 1999. Levels were more than 1,000 times the drinking water standard in wells near the Columbia River. This plume is the target of a pump-and-treat system.

by well 199-N-14. Concentrations increased in this well in the mid-to-late 1980s as the plume migrated toward the north. Since then, strontium-90 has ranged from 500 to 1,500 pCi/L, with no overall increasing or decreasing trend. Concentrations tend to be lower when the river stage is higher, because of a dilution effect from the Columbia River.

Near the 1325-N facility in recent years, strontium-90 levels have increased in well 199-N-81 (Figure 2.4-5). The peak level in this well was about the same as the peak in well 199-N-29, adjacent to the crib, when waste was being disposed, and the recent increase may represent movement of the contamination downgradient. This would equate to a transport rate of ~0.1 meter per day for strontium-90. The rate of movement of strontium-90 would be expected to be less than the rate of groundwater flow (0.3 meter per day) because strontium-90 sorbs to the sediment. Strontium-90 levels in well 199-N-81 also may be affected by the influx of water from wells 199-N-29 and 199-N-104A, which are used to inject treated water from the pump-and-treat system. This water may mobilize strontium-90, causing it to migrate northward to well 199-N-81. Other wells near 1325-N neither confirm nor refute this idea. The only well between 199-N-29 and 199-N-81 that can be sampled is 199-N-32, which has always had very low strontium-90 concentrations and does not appear to be representative of concentrations in the larger area.

The strontium-90 plume in groundwater appears to be limited to the upper few meters of the aquifer. Wells 199-N-69 and 199-N-70, completed at the bottom of the upper unconfined aquifer, have no detectable strontium-90, though they are in the heart of the contaminant plume.

2.4.1.4 Chromium

In fiscal year 1999, dissolved chromium exceeded the maximum contaminant level in only one well, which is completed in a thin, confined aquifer in the Ringold Formation. Concentrations in well 199-N-80 are steady at ~180 µg/L. The source for chromium in this deep horizon is unknown. Chromium was disposed of in the 1301-N crib until the early 1970s, and it was identified as a contaminant of potential concern based on soil data (Section 2.5 in DOE/RL-96-39). There are no chromium data from wells that monitored the facility in the early 1970s, and chromium was not detected in significant concentrations in wells near the crib in the 1980s. The presence of chromium in well 699-87-55, which is located east of the northern part of the 1325-N facility, illustrates the possible inland influence of past disposal from the 100 N or 100 D areas.

A filtered sample from well 199-N-64, located upgradient of the 1301-N facility, contained 124 µg/L of chromium in fiscal year 1998. The result from a sample collected in September 1999 was 26 µg/L.

2.4.1.5 RCRA Parameters

Monitoring for the *Resource Conservation and Recovery Act of 1976* (RCRA) in fiscal year 1999 indicated the 1301-N and 1325-N facilities are not contaminating groundwater with hazardous constituents.

Total organic carbon exceeded the critical mean value in one well (199-N-3) downgradient of the 1301-N facility in September 1998. Results from January 1999 confirmed the exceedance, and the U.S. Department of Energy (DOE) notified Washington State Department of Ecology (Ecology). No organic constituents of concern have been identified in 1301-N waste or sediment, and the contamination is assumed to come from a source other than the 1301-N facility. The elevated total organic carbon is probably related to the detection of petroleum products in other wells near 199-N-3 (Section 2.4.3). Total organic carbon levels remained fairly stable in well 199-N-3 in fiscal year 1999. For the September 1999 evaluation, the critical mean value was revised based on more recent upgradient data (see Table A.5). The new value is higher (2,383 µg/L) and was not exceeded.

Specific conductance of groundwater near the 1301-N facility is relatively low (200 to 300 µS/cm) compared to typical Hanford Site groundwater because the facility is close to the Columbia River. A plume of high-conductance (500 to 1,000 µS/cm) groundwater

from an upgradient source affects groundwater chemistry in downgradient well 199-N-3 and upgradient well 199-N-57.

Critical mean values for the 1301-N and 1325-N facilities were revised in December 1999, based on recent data from the upgradient wells (1997 through 1999; see Tables A.5 and A.7). The new values were used to evaluate data from July through September 1999. Specific conductance in two downgradient wells at the 1325-N facility (199-N-41 and 199-N-81) exceeded the new critical mean value. The previous critical mean value was 689.9 µS/cm (Table B.6 in PNNL-12086), based on data from upgradient well 199-N-74 from March 1992 through March 1993, when specific conductance was ~500 µS/cm. Specific conductance declined in well 199-N-74 from 1993 to 1995. The new critical mean value is 470.9 µS/cm.

The 1301-N and 1325-N RCRA facilities do not appear to have contaminated groundwater with hazardous, non-radioactive constituents.

DOE notified Ecology of the exceedance and submitted an assessment report. The report concluded that the source of the high specific conductance was not the 1325-N facility, as evident from the following:

- Specific conductance exceeded the critical mean value only after the critical mean value was revised (lowered) based on 1997 to 1999 concentrations in the upgradient well. The older critical mean value was not exceeded.
- Downgradient wells 199-N-41 and 199-N-81 are in a plume of high-sulfate groundwater that was observed in the upgradient well from 1991 to 1995. Based on the rate of groundwater flow in the area, the plume will pass the downgradient wells in 2 to 4 years.

No further assessment of the high specific conductance at 1325-N is needed. The site should remain in detection monitoring as described in the existing monitoring plan (WHC-SD-EN-AP-038, Rev. 2).

Groundwater at the 1301-N and 1325-N facilities is also analyzed for other constituents discharged to these facilities during their use. These analytes include cadmium, chromium, and nitrate (see Appendix A). Cadmium and chromium (in filtered samples) were not detected in significant concentrations in 1301-N or 1325-N downgradient wells. Nitrate was elevated in some of the downgradient wells, as discussed in Section 2.4.3, but the sources are unclear.

2.4.1.6 Groundwater Remediation

The 100-NR-2 Operable Unit pump-and-treat system, located along the 1301-N facility, is part of an expedited response action that began operating in 1995. An action memorandum (Ecology and EPA 1994) contains the following objectives that pertain to operation of the pump-and-treat system:

- reduce strontium-90 contaminant flux from the groundwater to the Columbia River
- evaluate commercially available treatment options for strontium-90
- provide data necessary to set demonstrable strontium-90 groundwater cleanup standards.

On September 29, 1999, DOE, Ecology, and U.S. Environmental Protection Agency (EPA) signed an interim record of decision for the 100-NR-1 and 100-NR-2 Operable Units (Ecology 1999). This record of decision specifies the selected remedy and activities for the 100-NR-2 Operable Unit, including continued operation of the pump-and-treat system with the objectives listed above.

The pump-and-treat system made progress toward the remedial action objectives in fiscal year 1999. Figure 2.4-6 shows the flow lines and hydraulic capture estimated to occur during a low-flow period in the Columbia River (November 1998), when groundwater flow to the Columbia River is greatest. The flow lines

represent simulations of the paths that groundwater would follow from upgradient locations, including the injection wells. The flow paths curve toward the extraction wells, which capture the groundwater from beneath much of the 1301-N strontium-90 plume (DOE/RL-99-79).

During fiscal year 1999, the pump-and-treat system extracted over 108 million liters of groundwater and removed ~0.2 curies of strontium-90 (Table 2.4-1). Combined, the three active extraction wells delivered an average concentration of 2,276 pCi/L to the treatment system during the fiscal year. After treatment, the effluent contained 382 pCi/L, which was returned to the aquifer through wells 199-N-29 and 199-N-104A.

A pump-and-treat system in the 100 N Area is intended as an interim remedial measure to reduce strontium-90 contamination reaching the Columbia River. It is not an efficient way to remove strontium-90 from the aquifer.

The extraction wells create a hydraulic sink between the 1301-N facility and the Columbia River and thus reduce or reverse the hydraulic gradient in the groundwater toward the Columbia River. The reduction or reversal of the hydraulic gradient results in less groundwater and strontium-90 discharging to the Columbia River through the N Springs area.

The pump-and-treat system has not reduced the concentration of strontium-90 in the aquifer, nor has it removed a significant quantity of strontium-90 mass compared to the estimated existing inventory. The distribution of strontium-90 in the aquifer remained essentially unchanged in recent years, with concentrations returning to the levels observed prior to the 1996 and 1997 high water years in the Columbia River. Since operations began in 1995, the pump-and-treat system has removed 0.7 curie of strontium-90, compared to a total inventory in the aquifer estimated to exceed 75 curies. Current estimates indicate that the pump-and-treat system would have to operate for more than 300 years before the strontium-90 concentrations reach permissible levels (DOE/RL-95-110). For this reason, DOE is investigating and evaluating alternative remediation technologies.

2.4.1.7 Water Quality at Shoreline Monitoring Locations

Water quality near the Columbia River in the 100 N Area is evaluated by sampling wells near the river (199-N-46, 199-N-92A, 199-N-96A, and 199-N-99A) and riverbank seepage. The sampling points are located on the shoreline downgradient of the 1301-N facility. The fiscal year 1999 environmental restoration report for the 100-NR-2 Operable Unit (DOE/RL-99-79) provides details of samples analyzed from the near-river sampling points. The following are brief summaries.

Near-River Wells

Strontium-90 concentrations in samples from these wells in fiscal year 1999 ranged from undetected in well 199-N-92A to 13,100 pCi/L in well 199-N-46. Well 199-N-99A, near the middle of the plume, detected a peak of strontium-90 in 1996 (19,000 pCi/L). Levels of strontium-90 remain above the 1,000-pCi/L derived concentration guide (1,890 pCi/L in September 1999).

The highest tritium concentration in fiscal year 1999 in a near-river well was 10,300 pCi/L in well 199-N-92A. Concentrations also were relatively high in well 199-N-46 (9,190 pCi/L in September 1999). Tritium averaged ~1,000 pCi/L in well 199-N-96A, and was undetected in well 199-N-99A.

Riverbank Seepage

The Sitewide Environmental Surveillance Project collected a sample from one seep along the 100 N Area shoreline in October 1998. The sample contained 2.3 pCi/L gross beta, 24,400 pCi/L tritium, and 21 mg/L nitrate. The specific conductance of the sample was 290 µS/cm, suggesting that there was relatively little dilution of the groundwater by river water in bank storage. Low gross beta and high tritium concentrations are typical for this seep, located downstream of

the main strontium-90 plume. Another seep located in the heart of the strontium-90 plume could not be sampled in fall 1998.

2.4.2 1324-N Surface Impoundment/ 1324-NA Percolation Pond

Groundwater near these RCRA facilities contains high levels of sodium and sulfate, caused by past influence of the percolation pond. Nitrate increased in fiscal year 1999, but its source is unknown.

2.4.2.1 Groundwater Flow

Groundwater flows toward the northwest beneath the 1324-N/NA site, perpendicular to the Columbia River (see Plate 2). The average rate of flow is 0.09 to 1.6 meters per day (see Table A.2). Movement of the sulfate plume between 1990 and 1993 indicated a flow velocity of ~0.5 meter per day (Section 3.2 in DOE/RL-93-88). The gradient in those years was approximately the same as it was in March 1999, so the flow estimate is still valid.

Water levels are influenced by the stage of the Columbia River. In Figure 2.4-1, well 199-N-72 represents water levels near the 1324-N/NA site. Water levels were higher than normal in 1996 through 1998, and declined to more normal conditions in fiscal year 1999.

2.4.2.2 RCRA Parameters

RCRA monitoring in fiscal year 1999 indicated the 1324-N/NA site has not contaminated groundwater with hazardous constituents. Specific conductance and total organic carbon were elevated in downgradient wells but were not caused by dangerous constituents from the site.

Specific conductance has been elevated at this site since monitoring began in 1988, primarily caused by non-dangerous constituents that were present in the waste, such as sodium and sulfate. Specific conductance and sulfate are discussed in Section 2.4.2.3.

Total organic carbon in downgradient well 199-N-59 exceeded the critical mean value in March 1999, continuing a previously reported trend (Figure 2.4-7). Critical mean values were revised for the September 1999 sampling, based on more recent upgradient data (see Table A.6). The critical mean value for total organic carbon at the 1324-N/NA site increased from 1,373.2 to 1,840.1 µg/L. In September 1999, total organic carbon in well 199-N-59 averaged 1,535 µg/L, which is below the revised critical mean though still above the previous mean.

The groundwater at the 1324-N/NA RCRA site does not appear to be contaminated with hazardous constituents. However, this site has added non-hazardous constituents, such as sulfate and sodium, to groundwater.

The source of organic contamination in well 199-N-59 is not the 1324-N/NA site. Organic constituents were not included in waste disposed to the site. Oil and grease were detected in this well in fiscal years 1998 and 1999. This contamination is believed to have originated at one of several nearby storage tanks or waste sites (PNNL-11885).

2.4.2.3 Sulfate and Specific Conductance

The 1324-NA percolation pond has added non-hazardous constituents, including sulfate and sodium, to groundwater, creating high specific conductance (more than 1,000 µS/cm) (Figure 2.4-8). The plume extends in a wedge shape to the north-northwest, presumably discharging to the Columbia River.

Specific conductance and sulfate have declined from their peaks (Figure 2.4-9). When high conductance waste was being discharged, sulfate concentrations were over 1,500 mg/L. The secondary drinking water standard is 250 mg/L. Sulfate and specific conductance in well 199-N-59 and other downgradient wells remain much higher than in upgradient well 199-N-74.

2.4.3 Other Groundwater Contamination

This section describes miscellaneous contaminants in 100 N Area: petroleum products, nitrate, and manganese.

2.4.3.1 Petroleum Hydrocarbons

Petroleum hydrocarbons are present as dissolved and free-product phases at several locations in the 100 N Area. Wells 199-N-8T, 199-N-16, 199-N-17, 199-N-18, and 199-N-54 monitor the most prominent area. During fiscal year 1999, most of these wells had detectable oil and grease, ranging from 1 mg/L in wells 199-N-8T and 199-N-54 to 34 mg/L in well 199-N-18. Total petroleum hydrocarbons were only detected in well 199-N-18 (5.4 mg/L). Field samplers look for an oil sheen or odor each time they sample wells in this area of diesel contamination. The samplers noted an oil odor at wells 199-N-17 and 199-N-18 during sampling in fiscal year 1999.

Groundwater chemistry in the petroleum-contaminated area suggests that bacterial degradation of the product is taking place, creating reducing conditions in the aquifer. Chemical reduction may explain anomalous, low nitrate and high manganese concentrations in wells 199-N-16 and 199-N-18 (see discussions below).

As mentioned in Section 2.4.2, well 199-N-59 in the 1324-N/NA monitoring network has elevated total organic carbon. No volatile organic constituents have been detected in this well, but oil and grease were detected at 2 and 26 mg/L in duplicate samples in September 1999. The data are being evaluated to explain the large difference between duplicates. Oil and grease were detected in fiscal year 1998. This contamination is believed to have originated at one of several nearby storage tanks or waste sites (PNNL-11885).

2.4.3.2 Nitrate

Nitrate exceeds the 45-mg/L maximum contaminant level in three portions of the 100 N Area, but the sources are unknown (Figure 2.4-10). Virtually the entire area has nitrate at levels above 20 mg/L.

The first area with nitrate above the maximum contaminant level is in the southern 100 N Area, near the 1324-N/NA site and to the north and west of this site. Nitrate or related constituents were not discharged in significant quantities to this facility (DOE/RL-96-39). Nitrate increased to ~100 mg/L in fiscal year 1999 in well 199-N-59, but decreased in well 199-N-19, where it reached a peak of >200 mg/L in 1996 (Figure 2.4-11).

Wells 199-N-2 and 199-N-32 represent the second and third regions of nitrate contamination (see Figure 2.4-11). These trend plot are typical of many wells in the 100 N Area, showing peaks in nitrate in the mid 1980s and in 1997 and 1998. The 1301-N and 1325-N facilities received nitrate-bearing waste while they were in use, which could explain the 1980s peaks. No satisfactory explanation has been made for the recent nitrate peaks. See Section 5.5 of PNNL-12086 for more discussion of elevated nitrate.

Several wells with anomalous, low nitrate values appear to separate the southern part of the plume from the portion near the 1301-N facility. Nitrate has been historically below detection limits in well 199-N-18, which is very unusual in the unconfined aquifer. Nitrate is highly variable in well 199-N-16, ranging from 0.9 mg/L in September 1998 to >35 mg/L in September 1999 (Figure 2.4-12) Groundwater is not diluted by the Columbia River or leaking utility lines in this area, as evident from the specific conductance, which is >1,000 μS/cm in these wells. Low nitrate may be related to chemical reduction of petroleum hydrocarbons in the aquifer, as discussed above.

2.4.3.3 Manganese

Manganese exceeds the 50-μg/L maximum contaminant level in several 100 N Area wells, and may be associated with reducing conditions in the aquifer (Figure 2.4-13). Well 199-N-16 had fairly stable manganese concentrations in recent years, at ~1,000 μg/L. Well 199-N-18 has more limited data, but reached 5,780 μg/L in fiscal year 1999.

Table 2.4-1. Summary of 100 N Area Pump-and-Treat Performance for Fiscal Year 1999

Well ID or Sample Location	Annual Average Flow Rate (L/min)	Total Volume Pumped (x 10^6 L)	Average Strontium-90 Concentration (pCi/L)	Strontium-90 Mass Removed (Ci)
199-N-75	49.4	104.5	445	NA
199-N-103A	64.6	136.6	NS	NA
199-N-105A[(a)]	0	0	1,857	0
199-N-106A	109	230.6	NS	NA
N-Influent	223	108	2,276	0.2
N-Effluent	223	108	382	NA

(a) Backup extraction well; not operating in fiscal year 1999.
NA = Not applicable.
NS = Not sampled.
Total strontium-90 removed since startup is ~0.7 curie. Total in aquifer estimated at 75 curies.

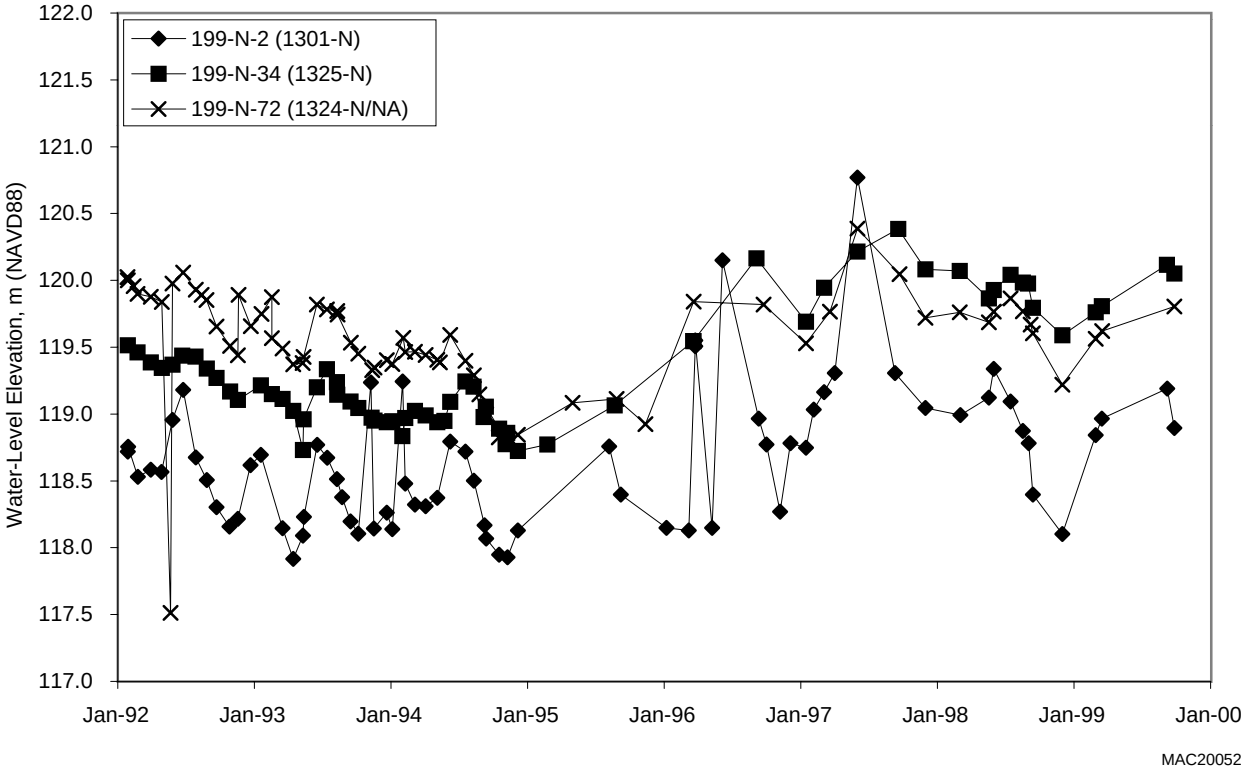
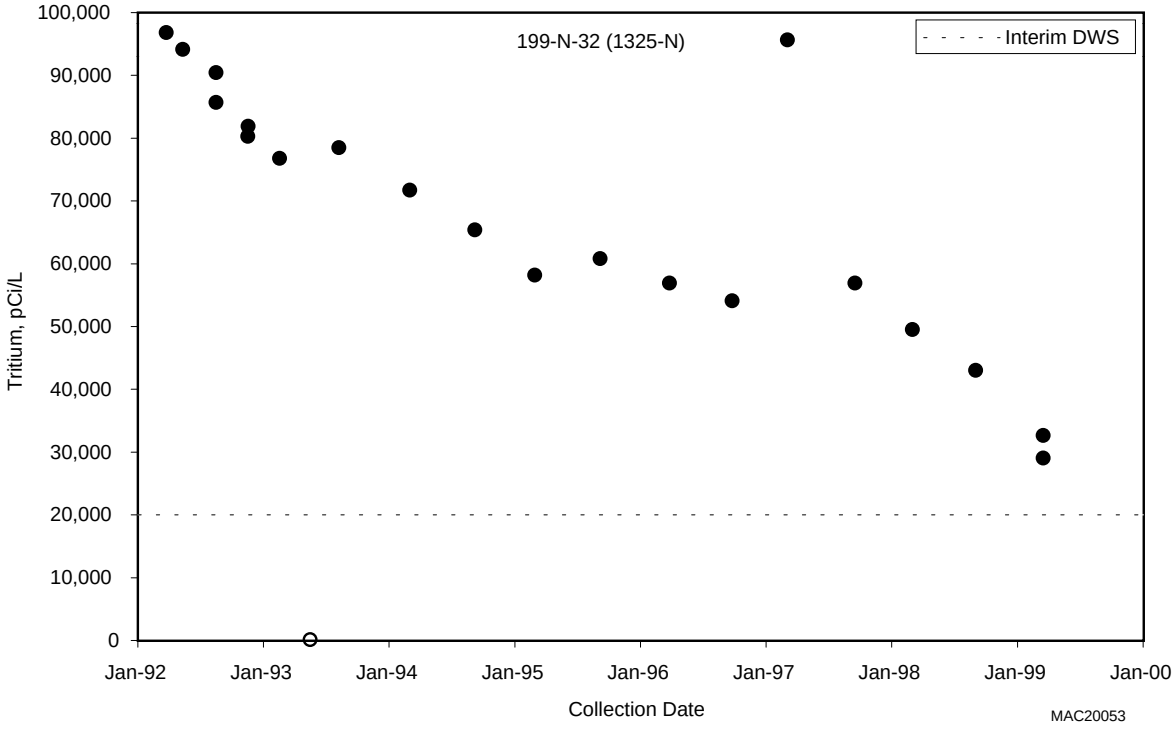


Figure 2.4-1. Water Levels in Wells Monitoring 100 N Area



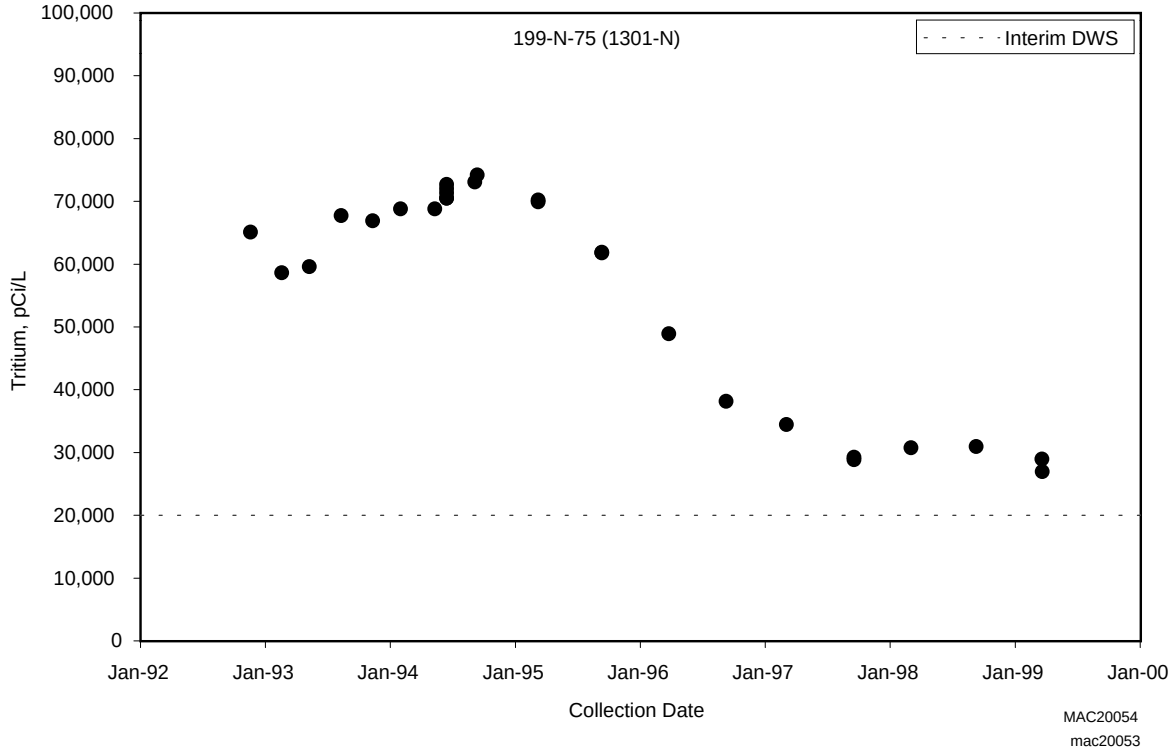


Figure 2.4-2. Tritium in Wells Monitoring 100 N Area

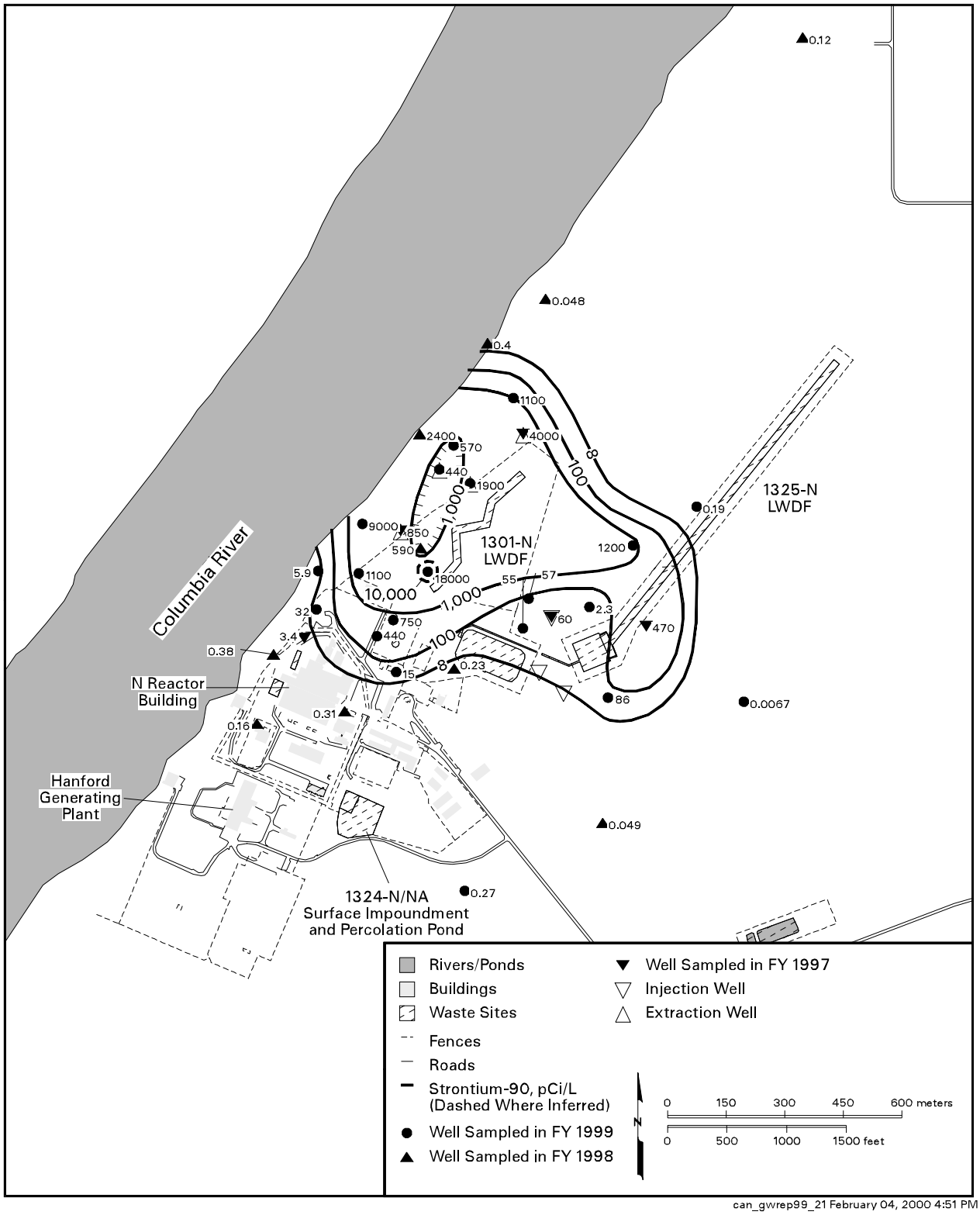


Figure 2.4-3. Average Strontium-90 Concentrations in 100 N Area, Top of Unconfined Aquifer

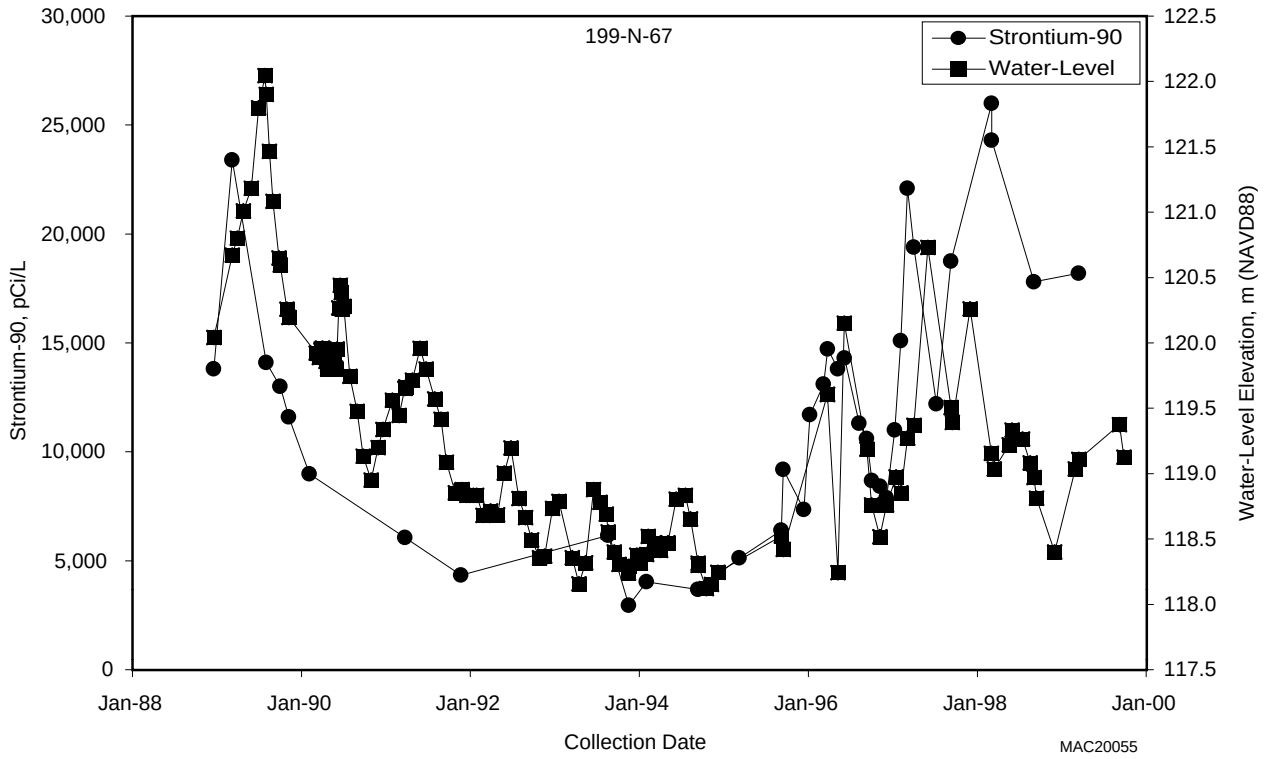


Figure 2.4-4. Strontium-90 and Water Levels in Well 199-N-67 Near 1301-N Facility

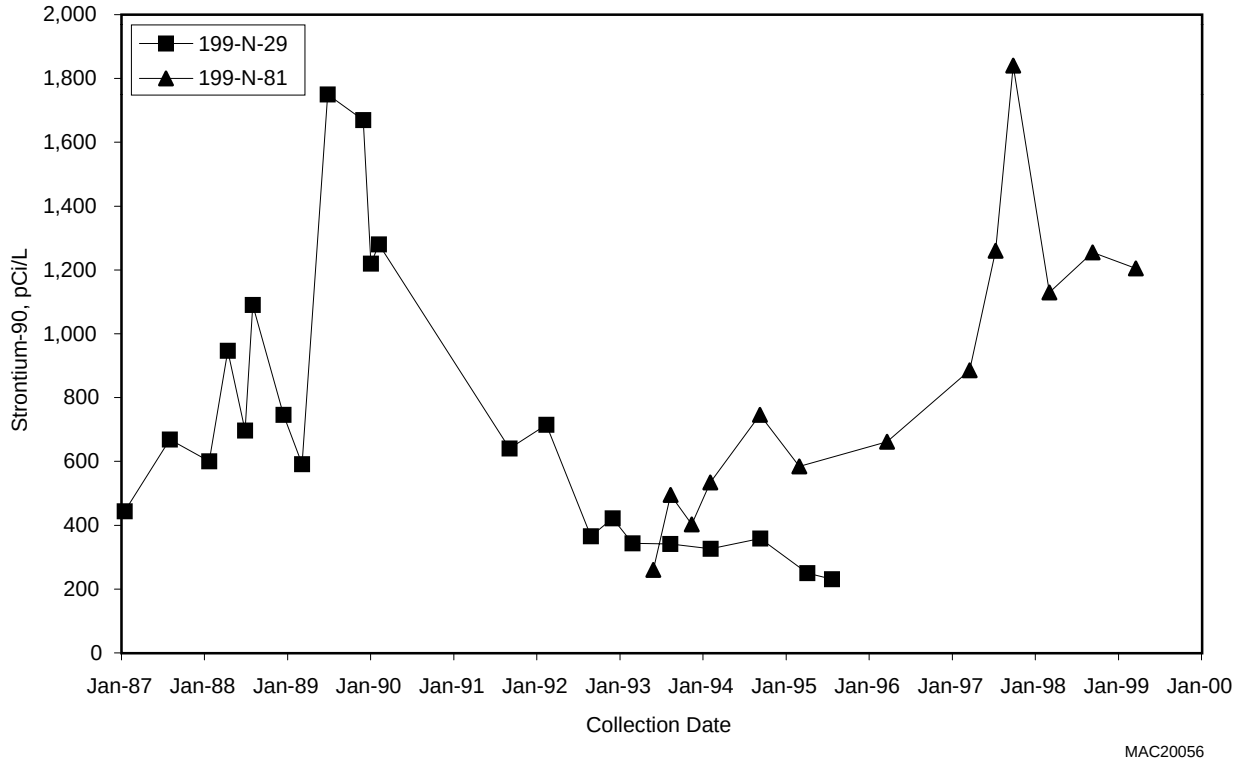


Figure 2.4-5. Strontium-90 in Wells Near 1325-N Facility

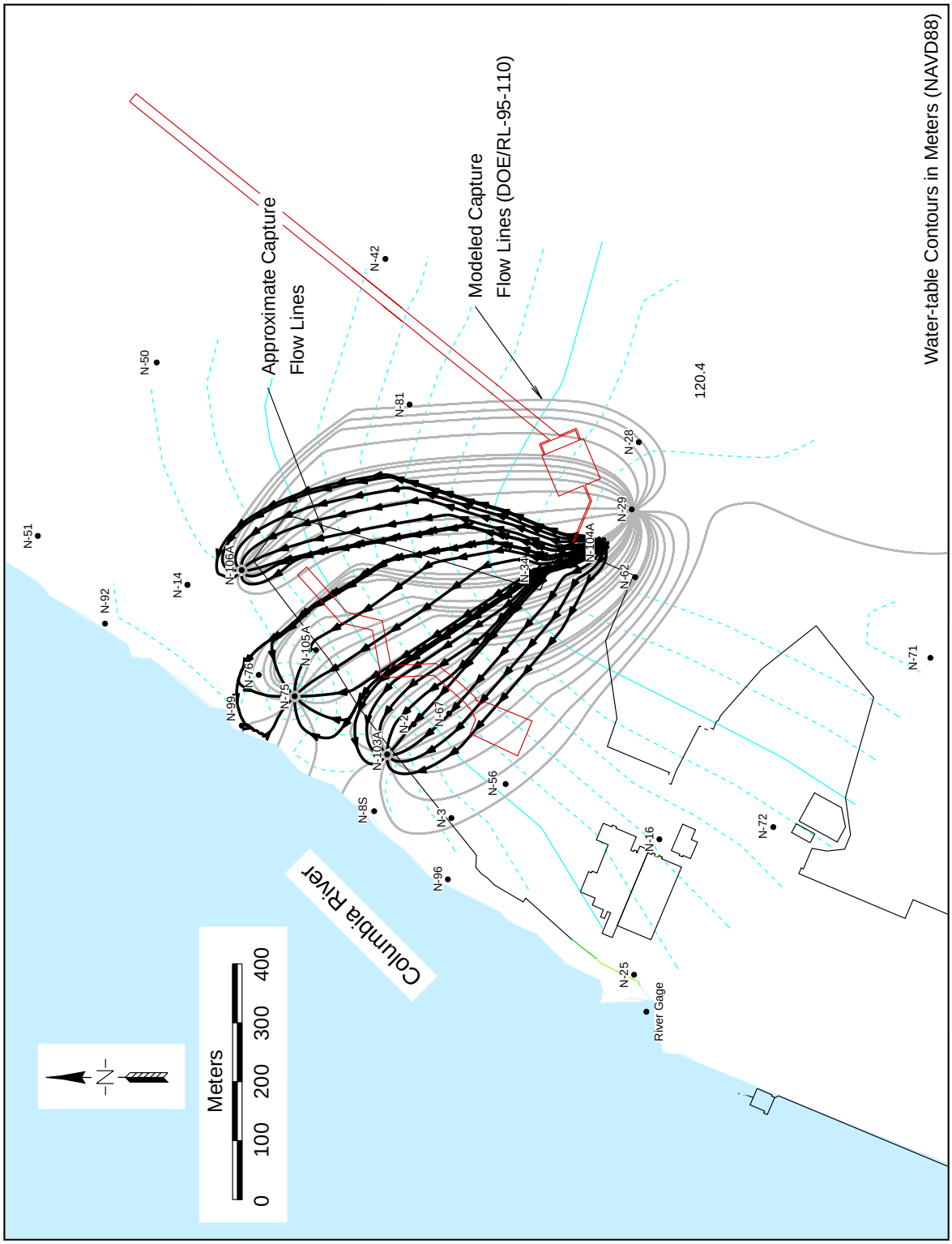


Figure 2.4-6. Groundwater Capture Zone from 100 N Area Pump-and-Treat System (DOE/RL-99-79)

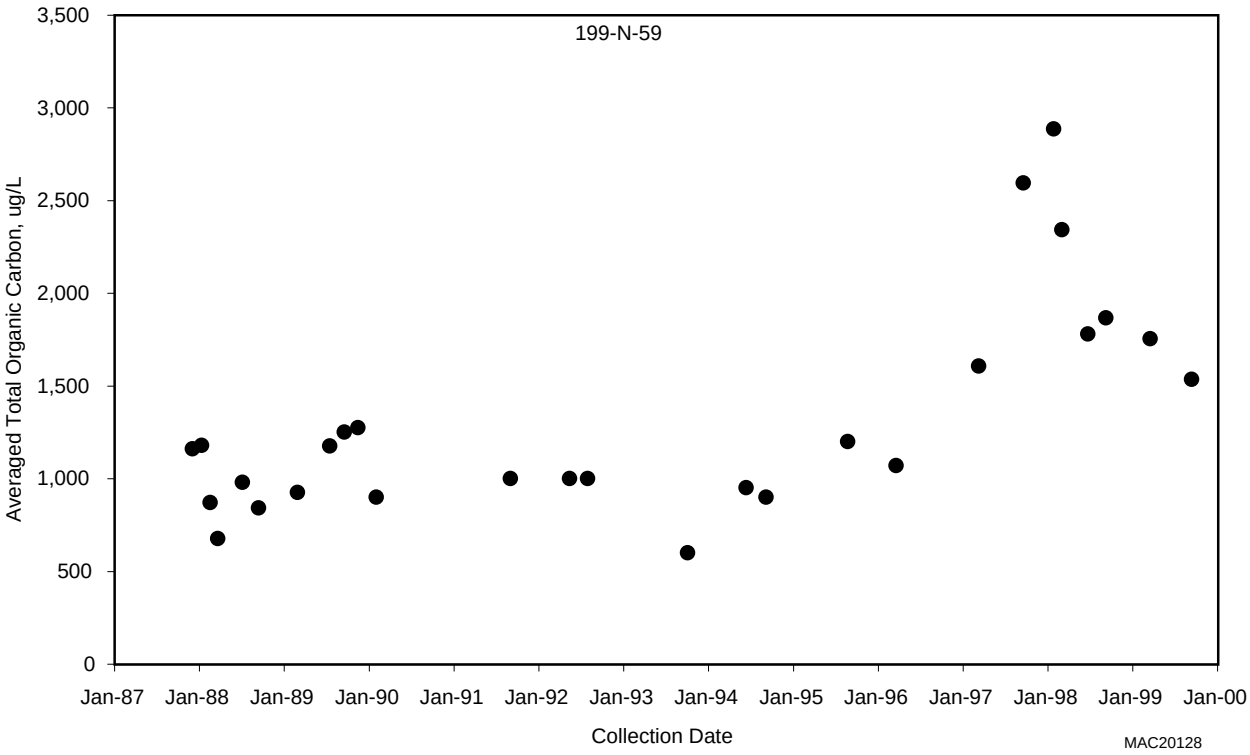


Figure 2.4-7. Total Organic Carbon in Well 199-N-59 Monitoring 1324-N/NA Site

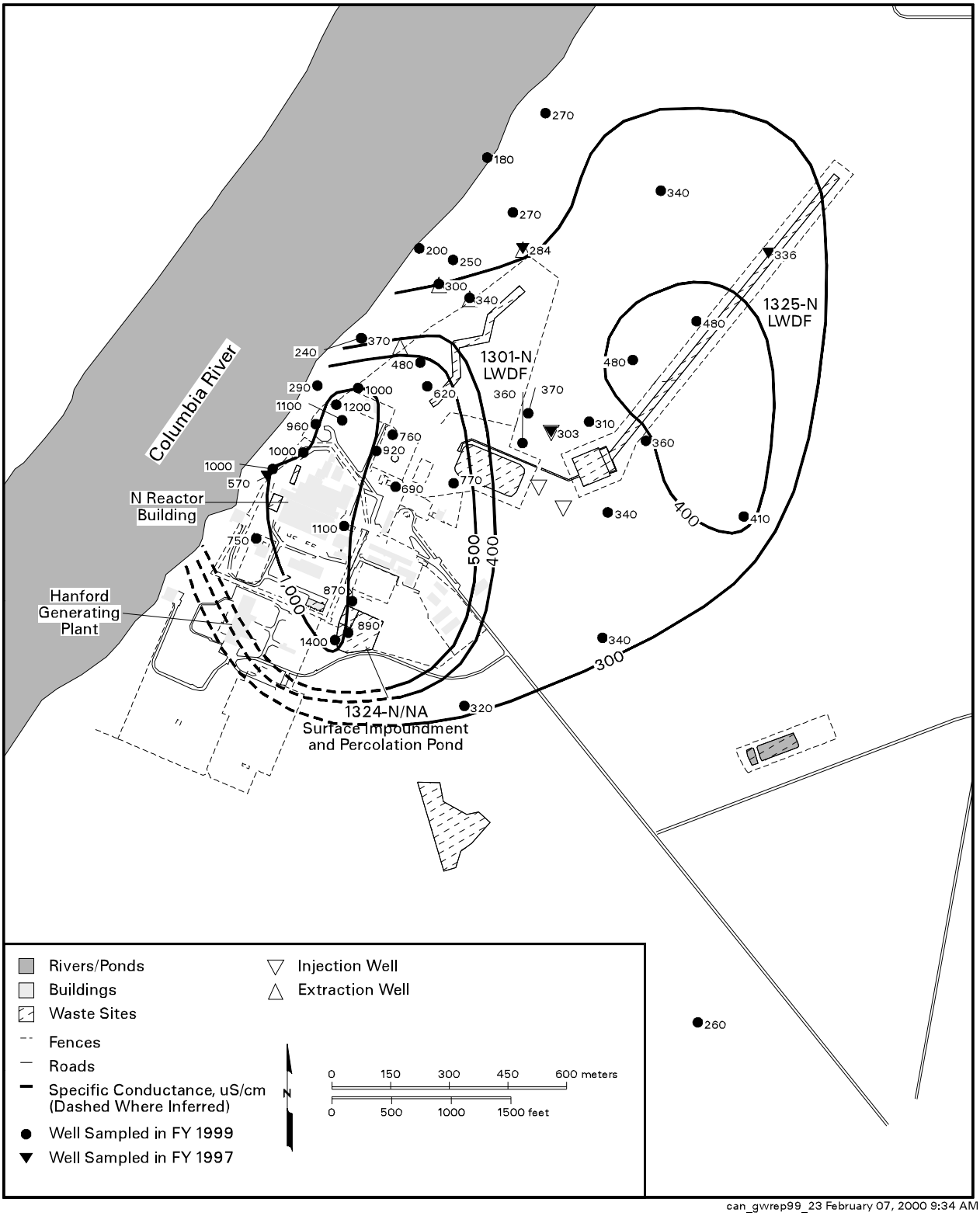


Figure 2.4-8. Specific Conductance in 100 N Area, Top of Unconfined Aquifer

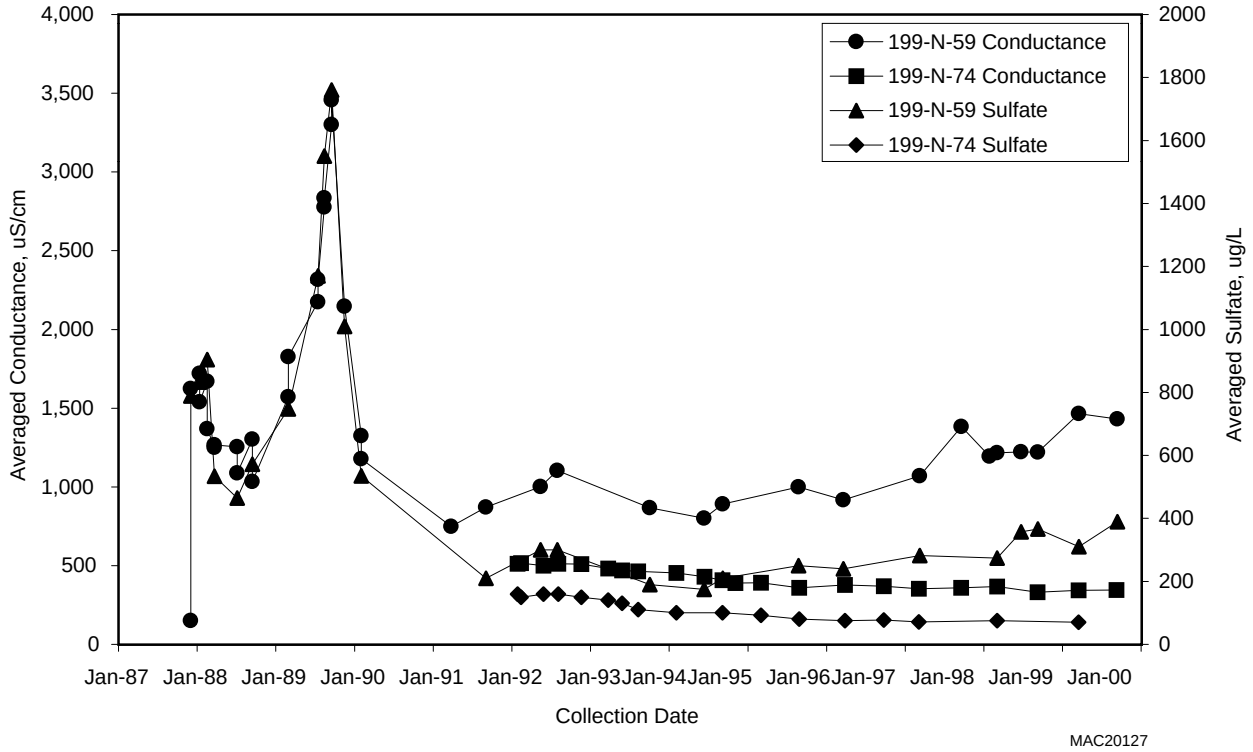


Figure 2.4-9. Specific Conductance and Sulfate in Wells Monitoring 1324-N/NA Facilities

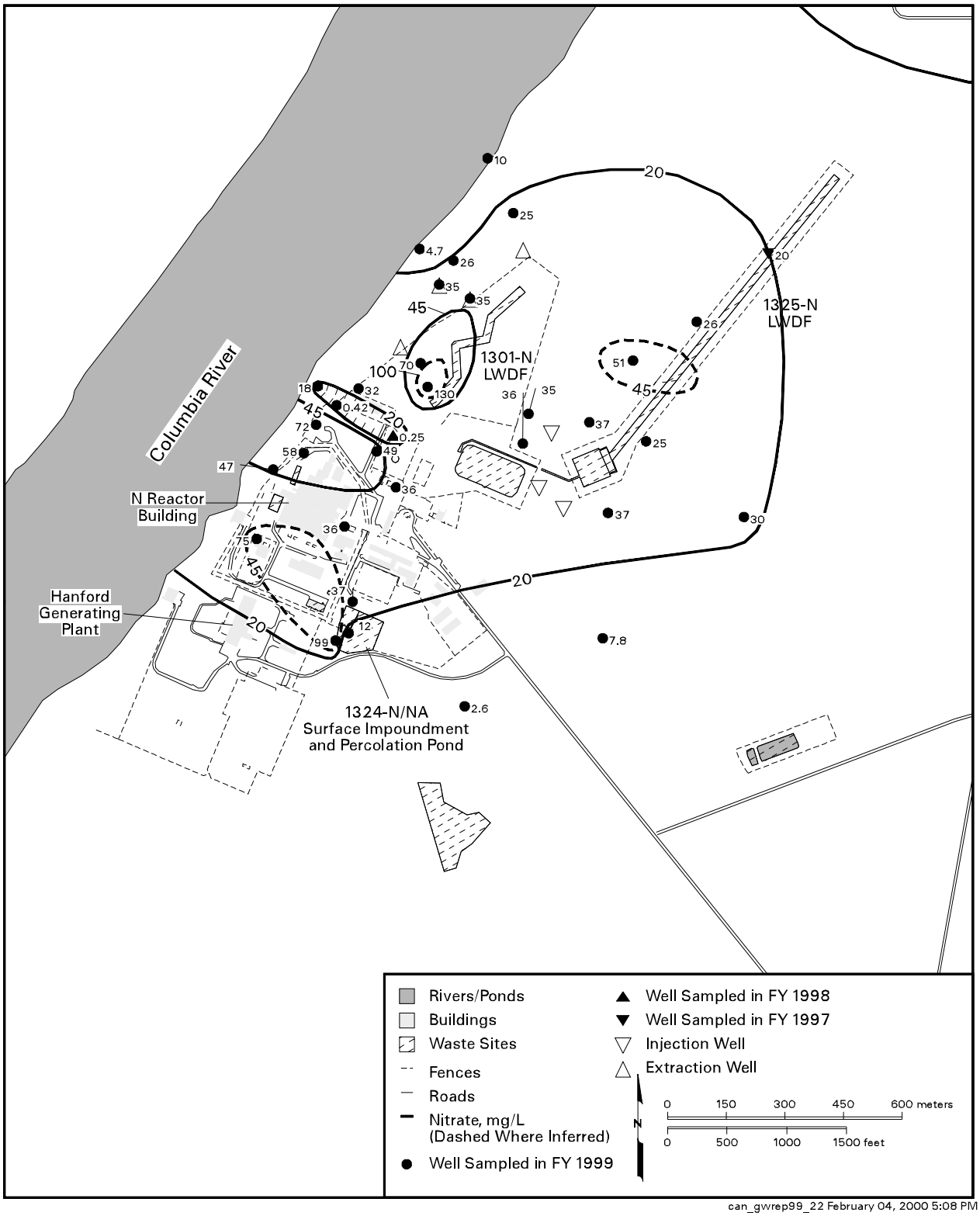


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Figure 2.4-10. Nitrate Concentrations in 100 N Area, Top of Unconfined Aquifer

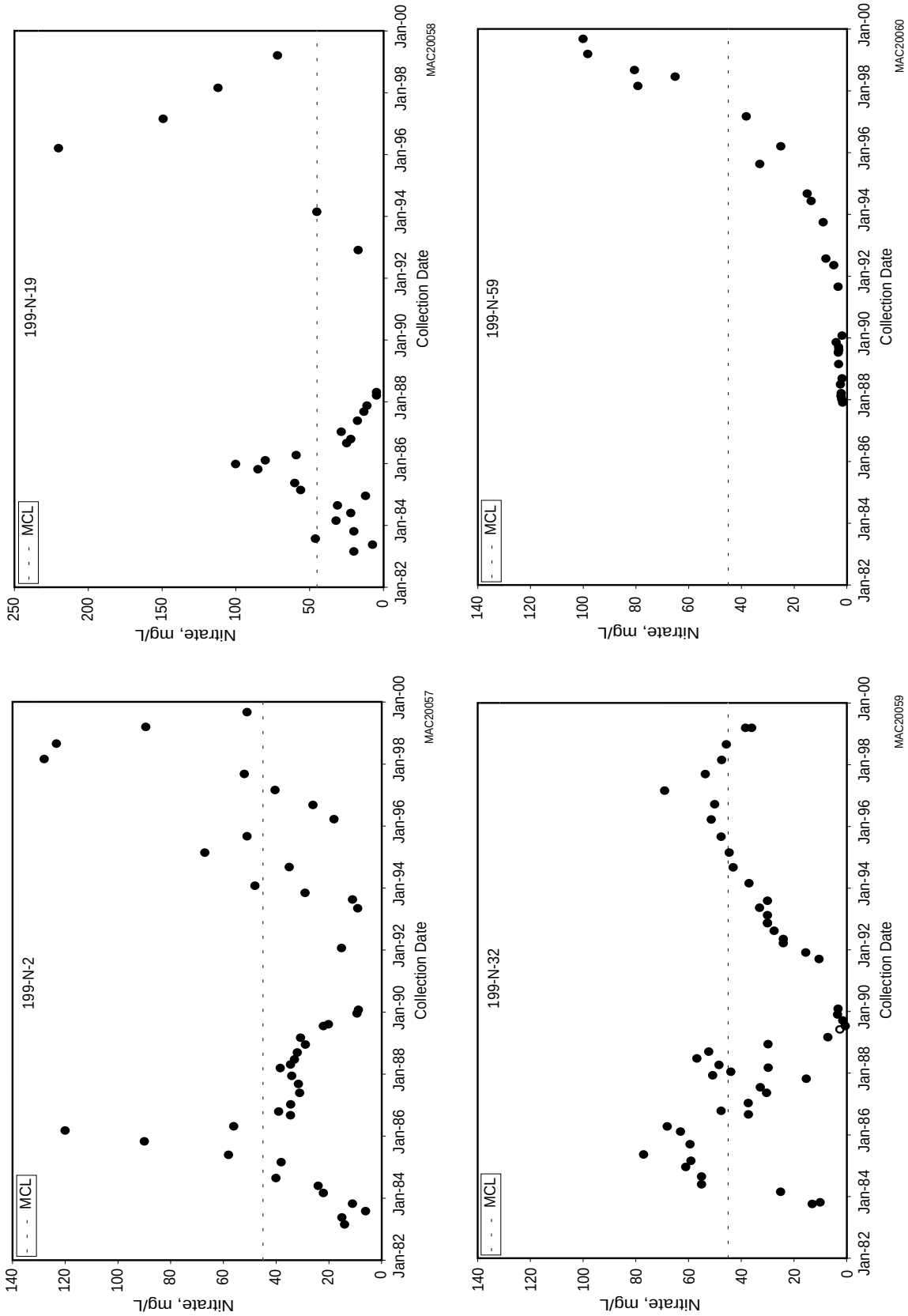
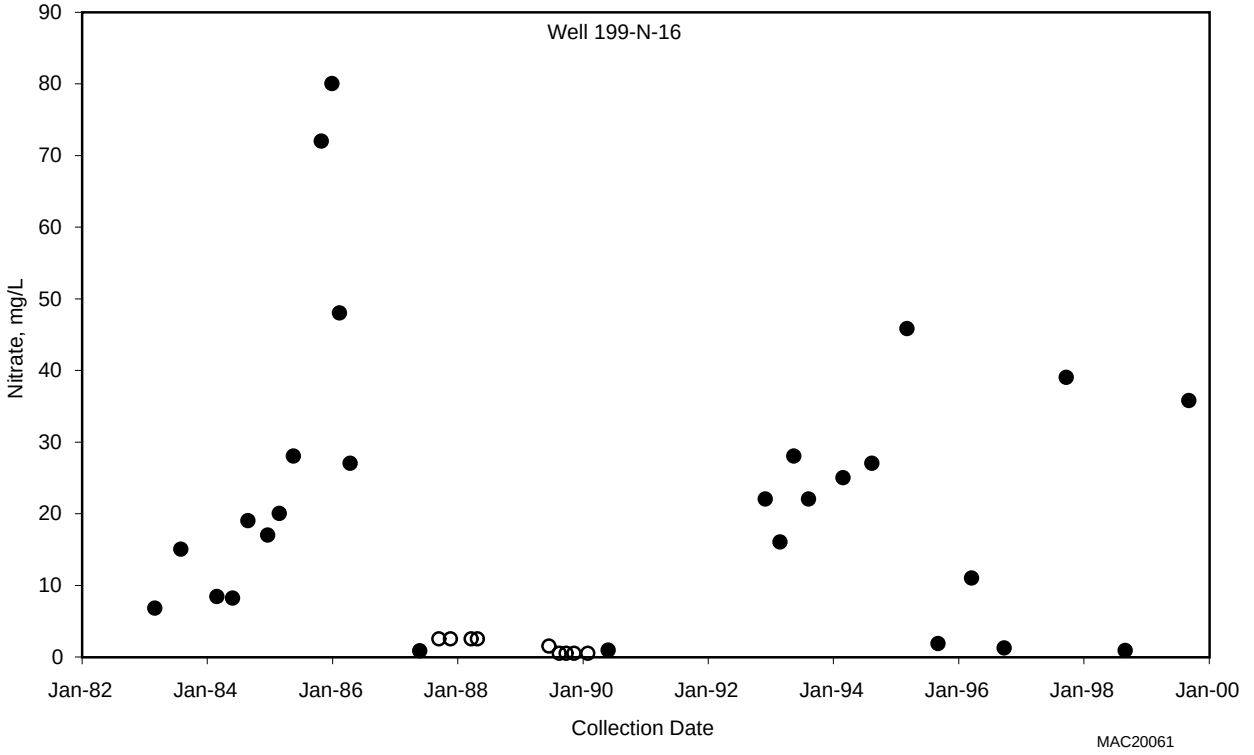


Figure 2.4-11. Nitrate in Wells Monitoring 100 N Area



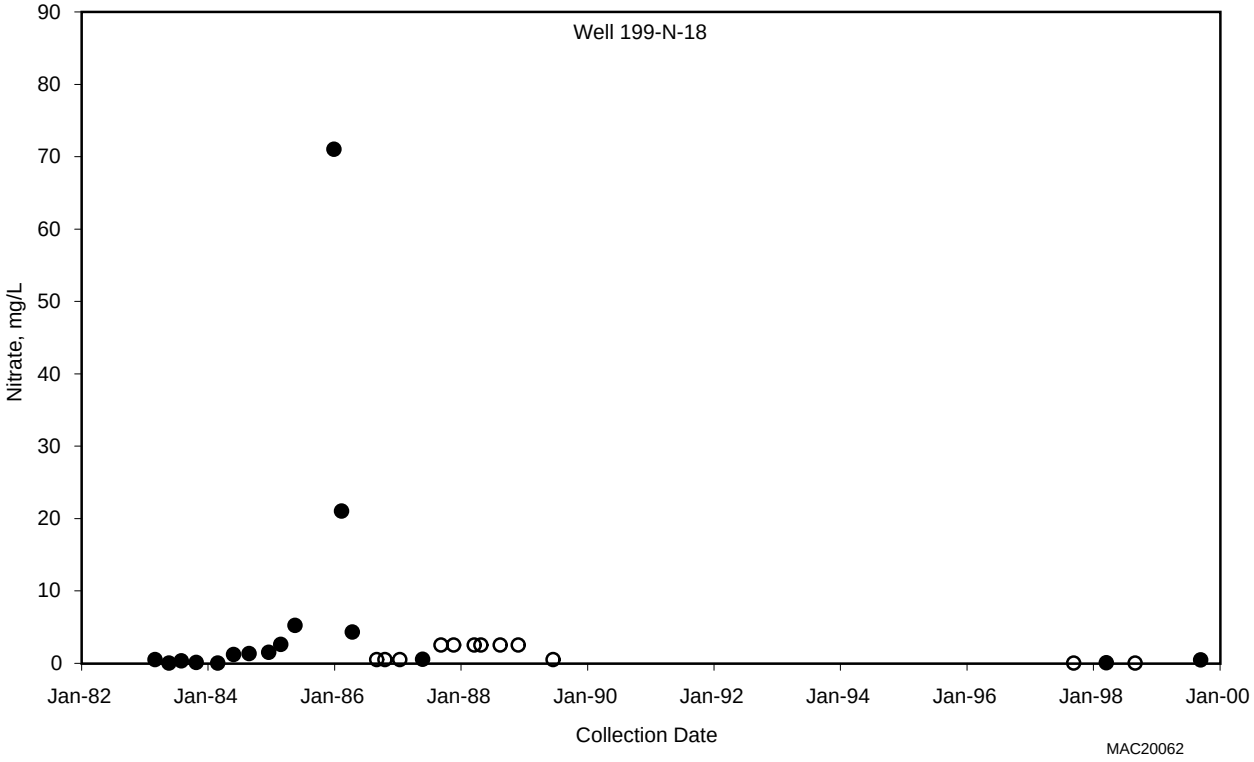


Figure 2.4-12. Nitrate in Wells 199-N-16 and 199-N-18

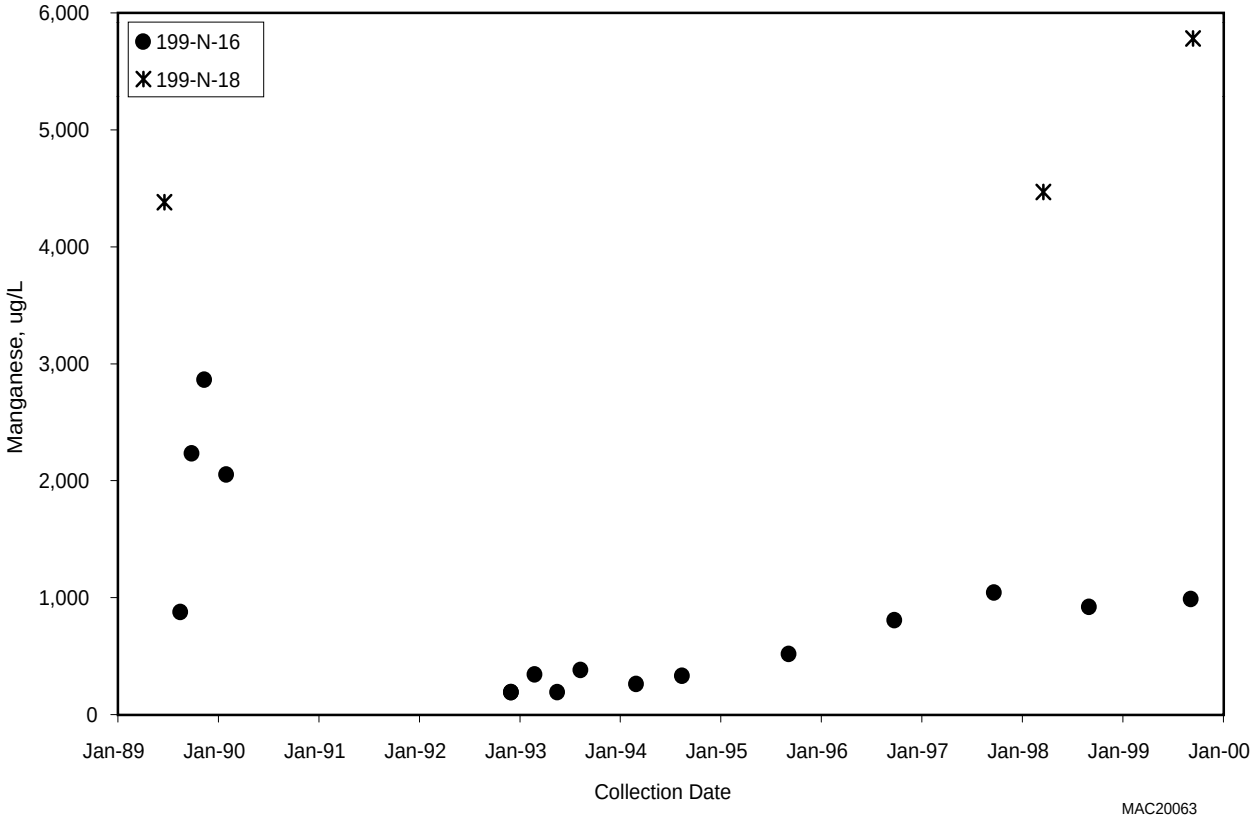


Figure 2.4-13. Manganese in Wells 199-N-16 and 199-N-18