# 1999 INTEGRATED SITE ENVIRONMENTAL REPORT

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## 1999 ENVIRONMENTAL SUMMARY
## (Appendices A through E)

## VOLUME I

**FERNALD ENVIRONMENTAL MANAGEMENT PROJECT**
**FERNALD, OHIO**

**MAY 2000**

**U.S. DEPARTMENT OF ENERGY**

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# 1999 ENVIRONMENTAL SUMMARY

## VOLUME I

## (Appendices A through E)

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# APPENDIX A

## SUPPLEMENTAL GROUNDWATER INFORMATION

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# LIST OF ACRONYMS

| | |
|---|---|
| AMSL | above mean sea level |
| BRSR | Baseline Remedial Strategy Report |
| DOE | U.S. Department of Energy |
| EPA | U.S. Environmental Protection Agency |
| FEMP | Fernald Environmental Management Project |
| FRL | final remediation level |
| gpm | gallons per minute |
| gpd | gallons per day |
| IEMP | Integrated Environmental Monitoring Plan |
| lbs/Mgal | pounds per million gallons |
| LCS | leachate collection system |
| LDS | leak detection system |
| mg/L | milligrams per liter |
| NTU | nephelometric turbidity units |
| OEPA | Ohio Environmental Protection Agency |
| OMMP | Operations and Maintenance Master Plan |
| PRRS | Paddys Run Road Site |
| µg/L | micrograms per liter |

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# APPENDIX A

Appendix A presents additional groundwater data and analysis in support of Chapter 3 of this 1999 Integrated Site Environmental Report. This appendix consists of six attachments as follows:

- Attachment A.1 provides operational data for the South Field (Phase I) Extraction Module, the South Plume Module, and the Re-Injection Demonstration Module for 1999.
- Attachment A.2 provides total uranium data and plume maps for all four quarters of 1999 with statistical trend results. The summary statistics and Mann-Kendall test for trend are based on unfiltered samples from the Operable Unit 5 remedial investigation/feasibility study data set (1988 through 1993) and 1994 through 1999 groundwater data, except for the newer modules, whose statistics and trends are based on 1998 and 1999 data.
- Attachment A.3 evaluates the capture zone of the Aquifer Restoration System by analyzing groundwater flow directions based on groundwater elevation data. It includes groundwater elevation maps from all four quarters of 1999 and hydrographs for specific wells.
- Attachment A.4 provides an analysis of the 1999 non-uranium final remediation level (FRL) exceedances both inside and outside the 10-year, uranium-based restoration footprint.
- Attachment A.5 provides detailed data from the miscellaneous, compliance-based monitoring activities in 1999 (i.e., the KC-2 Warehouse well monitoring program).
- Attachment A.6 presents 1999 leak detection and leachate monitoring results associated with the On-Site Disposal Facility Monitoring Program.

## REFERENCES



Cullimore, D. R., 1993, "Practical Manual of Groundwater Microbiology," Lewis Publishers, Boca Raton, Florida.

ERM Midwest Inc., 1994, "Remedial Investigation and Risk Assessment, Paddys Run Road Site", Crosby Township, Hamilton, OH, Rev. 1, Vol 1-5.

HydroGeoLogic, Inc., 1999, "Integration of Data Fusion Modeling (DFM) with VAM3DF Contaminant Transport Code," Draft, Herndon, Virginia.

U.S. Dept. of Energy, 2000a, "Integrated Environmental Monitoring Status Report for Fourth Quarter 1999," Final, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 2000b, "Re-Injection Demonstration Test Report for the Aquifer Restoration and Wastewater Project, Rev. 0," Draft, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 2000c, "Responses to OEPA Comments to Responses to OEPA Comments on the Integrated Environmental Monitoring Status Report for Second Quarter 1999," Fernald Environmental Management Project, U.S. Dept. of Energy, Cincinnati, OH.

U.S. Dept. of Energy, 2000d, "Responses to OEPA Comments to Responses to OEPA Comments on Proposed Changes Resulting from the 1999 Annual Review of the Integrated Environmental Monitoring Plan, Revision 1," Fernald Environmental Management Project, U.S. Dept. of Energy, Cincinnati, OH.

U.S. Dept. of Energy, 2000e, "The Great Miami Aquifer VAM3D Flow Model Recalibration April 2000," Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1999a, "1998 Integrated Site Environmental Report," Final, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1999b, "Integrated Environmental Monitoring Plan, Rev. 1," Final, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1999c, "Integrated Environmental Monitoring Status Report for Second Quarter 1999," Final, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1999d, "Operations and Maintenance Master Plan for the Aquifer Restoration and Wastewater Treatment Project," Final, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1998a, "1997 Integrated Site Environmental Report," Final, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1998b, "Restoration Area Verification Sampling Program Summary Report," Draft, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1998c, "Sitewide CERCLA Quality Assurance Project Plan," Revision 1, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1997a, "Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration (Task 1)," Final, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1997b, "On-Site Disposal Facility Final Design Calculation Package," Volume 2 of 4, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1997c, "On-Site Disposal Facility Groundwater/Leak Detection and Leachate Monitoring Plan," Final, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1997d, "Restoration Area Verification Sampling Program, Project-Specific Plan," Final, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1997e, "South Plume Removal Action Design Monitoring Evaluation Program Plan System Evaluation Report for July 1 to December 31, 1996", Final, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. Of Energy, 1996, "Record of Decision for Remedial Actions at Operable Unit 5," Final, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

# ATTACHMENT A.1

# OPERATIONAL ASSESSMENT

# ATTACHMENT A.1



In 1999 the South Field (Phase I) Extraction, South Plume, and Re-Injection Demonstration Modules continued to operate. The South Field (Phase I) Extraction Module encompasses Extraction Wells 31550, 31560, 31561, 31562, 31563, 31564, 31565, 31566, 31567, and 32276. These extraction wells encircle the southern waste unit excavations and the Storm Sewer Outfall Ditch in the South Field area of the Fernald Environmental Management Project (FEMP) from Paddys Run to just west of the South Access Road. The South Plume Module is comprised of Extraction Wells 3924, 3925, 3926, 3927, 32308, and 32309. Extraction Wells 32308 and 32309 were previously part of the South Plume Optimization Module. These wells are located south of Willey Road and north of New Haven Road. The Re-Injection Demonstration Module is comprised of Re-Injection Wells 22107, 22018, 22109, 22111, and 22240. These wells stretch along the southern border of the FEMP just north of Willey Road between Paddys Run and the South Access Road. Figure A.1-1 depicts the location of extraction and re-injection wells in these modules and identifies monitoring wells near each module. Table A.1-1 provides a summary of gallons pumped, total uranium removed, and uranium removal indices for 1999 and for August 1993 through 1999.

## South Field (Phase I) Extraction Module

The South Field (Phase I) Extraction Module operated at 1,500 gallons per minute (gpm) in 1999 except for maintenance shutdowns and the January 1999 temporary shutdown to mitigate high total uranium concentrations at the Parshall Flume. Tables A.1-2 through A.1-11 provide individual extraction well performance data for the South Field (Phase I) Extraction Module. The footnotes explain individual extraction well or system outages of greater than 24 hours.

During 1999, 753.2 million gallons of groundwater were pumped by the nine active wells in the South Field (Phase I) Extraction Module and 464.15 pounds of total uranium were removed from the Great Miami Aquifer. The Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration (Task 1) (DOE 1997a) indicated that 788.4 million gallons of water and 618.0 pounds of uranium would be removed by the South Field (Phase I) Extraction Module in 1999. The 1999 gallons pumped represented 95.5 percent of the design-specified amount and the pounds of uranium removed from the aquifer were 75.1 percent of the design-predicted amount (618 pounds) for this module.

There were three principal changes to the South Field (Phase I) Extraction Module since operation was initiated in 1998, as discussed below. First, Extraction Well 31566 was shut down in 1998 and remained

off throughout 1999 for reasons consistent with those in Attachment A.1 of the 1998 Integrated Site Environmental Report (DOE 1999a). To compensate, pumping rates were increased to 200 gpm at Extraction Well 31562 and 300 gpm at Extraction Well 32276 in August 1998 and continued through 1999. Both of these wells are in areas of relatively high total uranium concentrations.

The second change occurred in November 1999 when operations personnel were notified that the pumping rate at Extraction Well 31567 could be adjusted from 100 to 300 gpm, as needed, to use available treatment capacity. This is known as the "swing well" concept, which allows the pumping rate at Extraction Well 31567 to increase as additional capacity to treat groundwater becomes available at the site's water treatment facilities during periods of low storm water flow. While the concentration of total uranium in Extraction Well 31567 did not provide justification to increase this well's pumping rate, the following reasons did:

- The water levels observed during April and July 1999 in the vicinity of Extraction Well 31567 were slightly higher than the surrounding area, indicating that additional pumping was needed to provide the desired drawdown of the aquifer in this area.
- This was the closest extraction well downgradient of the plume emanating from the former inactive flyash pile area. If the pumping rate was to be increased, then the plume might have been drawn toward it more quickly.

Accordingly, the pumping rate at Extraction Well 31567 was increased to 150 gpm on November 5, 1999, and increased again to 200 gpm on November 8, 1999.

The third change occurred during the fourth quarter of 1999, when two new extraction wells (32446 and 32447) were installed (refer to Figure A.1-1). The wells were installed in response to high concentrations of total uranium found in the eastern, on-property area of the southern plume during Geoprobe® investigations. The Geoprobe® work was conducted as part of remedy performance monitoring. The new extraction wells were located as agreed with the U.S. Environmental Protection Agency (EPA) and the Ohio Environmental Protection Agency (OEPA) during a conference call on May 18, 1999 (reference Facsimile Number F:SWP[ARWWP]:990008, dated May 17, 1999). It is anticipated that the new wells will begin pumping during the first quarter of 2000.

As reported in Table A.1-9, uranium concentrations in Extraction Well 31566 trended downward throughout the first eight months of 1999. In early September 1999, the pump from this well was relocated to replace a failed pump at Extraction Well 31550. Sampling for total uranium will

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recommence at Extraction Well 31566 in 2000, as soon as a smaller pump has been installed in the well. The EPA and OEPA were informed of these changes through the weekly site status conference calls.

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South Plume Module

The South Plume Module, which includes the South Plume Optimization Module, operated at 2,000 gpm in 1999 except during re-injection system shutdowns, shutdowns for maintenance events, and rehabilitation activities. Tables A.1-12 through A.1-17 provide individual extraction well performance data for the South Plume Module. The footnotes explain individual extraction well or system outages of greater than 24 hours.

During 1999, 946.79 million gallons of groundwater were pumped by the six wells in the South Plume Module and 259.11 pounds of total uranium were removed from the Great Miami Aquifer. The Baseline Remedial Strategy Report indicated that 998.64 million gallons of water and 179.9 pounds of uranium would be removed by the South Plume Module in 1999. The 1999 gallons pumped were on track in that they were 94.8 percent of design-specified amount and the pounds of uranium removed from the aquifer (259.11 pounds) were 1.44 times the design-predicted amount (179.9 pounds) for this module.

The South Plume Module continued to meet the primary objectives of:

- Preventing further southward movement of the total uranium plume while capturing the main lobe of the South Plume without adversely affecting the Paddys Run Road Site (PRRS) plume (Extraction Wells 3924, 3925, 3926, and 3927)
- Actively remediating the higher-concentration region of the off-property plume (Extraction Wells 32308 and 32309).

Attachment A.3 presents additional details concerning the capture zone, along with supporting data. In 1999, as in previous years, PRRS constituents of concern (arsenic, phosphorus, potassium, sodium, and volatile organic compounds) were monitored at 11 monitoring well locations immediately south of the South Plume Module to ensure that the operation of the system does not adversely impact the PRRS plume. The 11 wells monitored are 2128, 2625, 2636, 2898, 2899, 2900, 3128, 3636, 3898, 3899, and 3900 (refer to Figure A.1-1).

Consistent with previous reporting, the Mann-Kendall test for trend was run on PRRS data collected from these wells. As indicated in Table A.1-18, one well monitored for PRRS constituents of concern had an Up, Significant trend based on the Mann-Kendall test for trend:

- Monitoring Well 2899 had an Up, Significant trend for potassium with a concentration increasing from 3.71 milligrams per liter (mg/L) in the second quarter to 4.66 mg/L in the third quarter, as shown in Figure A.1-2. The well was not sampled in the fourth quarter because it was dry. The third quarter 1999 result is the maximum historical potassium concentration observed at Monitoring Well 2899. The regional drop in water levels may have affected the water quality of the sample. Concentrations at this well will continue to be monitored in Integrated Environmental Monitoring Plan (IEMP) quarterly status reports and annual integrated site environmental reports.

The monitoring activity for PRRS constituents of concern also included volatile organic compounds. Note that no volatile organic compounds were detected in 1999. These compounds are monitored because they were found to be present in the PRRS plume, which is not of FEMP origin (ERM Midwest Inc. 1994).

Re-Injection Demonstration Module

In 1999 a one-year re-injection demonstration was completed to determine whether large-scale enhanced flushing of the aquifer is feasible at the FEMP. A report discussing the results of the demonstration is scheduled for release in June of 2000. At the end of 1999, the preliminary evaluation indicated that the testing results are favorable regarding the viability of re-injection at the FEMP, that a reliable source of injection water can be maintained, and that an acceptable injection rate can be sustained without negative effects on the plume or aquifer.

The Re-Injection Demonstration Module operated in the five-well, 1,000 gpm design configuration in 1999 except during maintenance shutdowns and for the January 1999 temporary shutdown to mitigate high total uranium concentrations at the Parshall Flume. Tables A.1-19 through A.1-23 contain individual re-injection well performance data for the Re-Injection Demonstration Module. The footnotes explain individual re-injection well or system outages of greater than 24 hours.

During 1999, 433.147 million gallons of groundwater containing 25.39 pounds of uranium were re-injected into the Great Miami Aquifer. The Baseline Remedial Strategy indicated that 525.6 million gallons of water containing 21.9 pounds of uranium would be re-injected by the Re-Injection Demonstration Module in 1999. The 1999 gallons of re-injected water (also called "injectate") were 82.4 percent of the design specified amount. The reason that the gallons injected were less than planned

is because the re-injection wells were shut down for various reasons at various times of the year as indicated in Tables A.1-19 through A.1-23. The pounds of uranium injected into the aquifer were slightly higher than planned due to the injectate source water containing higher uranium concentrations than the planned 5 micrograms per liter (µg/L). The injectate uranium concentrations for 1999 are provided on Figure A.1-3. The reasons for the higher than anticipated concentrations are discussed below.

Increasing uranium concentration in the injectate was a concern in 1999. Figure A.1-3 displays the injectate concentrations for 1999. Total uranium concentrations in the injectate water began increasing significantly in the second quarter and this trend continued into the third quarter. In accordance with the Operations and Maintenance Master Plan for the Aquifer Restoration and Wastewater Project (DOE 1999d), regeneration of the ion exchange resins in the advanced wastewater treatment facility expansion plant, the source for injectate, began in July. The regeneration efforts were undertaken to bring the uranium concentration in the injectate back down to low levels. Total uranium concentrations in the injectate significantly decreased in November and December due to successful regeneration of the ion exchange resins. During the fourth quarter, total uranium concentrations in the injectate were reduced from a monthly average of 9.6 µg/L in October to 1.1 µg/L in December.

Total Uranium Data

Figures A.1-4 through A.1-19 depict the total uranium concentration data for each of the extraction wells comprising the South Plume and South Field (Phase I) Extraction Modules since start-up through the end of 1999. Extraction well uranium concentrations are measured in process control samples that are currently collected weekly and in monthly samples per the IEMP. The weekly uranium concentrations are used to graphically track the uranium concentrations over time and to support the statistical trend analysis presented in Attachment A.2. The uranium concentrations are also used to determine which wells' water needs to be sent to treatment and which wells' water can be bypassed around the treatment facilities. Figure A.1-20 is a graph of the monthly gallons of groundwater pumped versus the monthly gallons of groundwater treated for 1999.

Pumping Rates

Daily pumping rate data for each extraction well were presented in IEMP quarterly status reports for each quarter of 1999; therefore, those plots have not been repeated here. The footnotes in the well-specific operational tables explain individual well or system outages of greater than 24 hours.

In 1999 as shown in Table A.1-24, the extraction systems were operated at target pumping rates that did not radically differ from those established in the Baseline Remedial Strategy Report. As discussed in the South Field (Phase I) Extraction System Module section above, Extraction Well 31566 was shut down and Extraction Wells 31562 and 32276 were increased to 200 gpm and 300 gpm respectively, to compensate. As additional operational experience is gained with the three active restoration modules, additional pumping rate changes are anticipated as efforts to maximize the effectiveness of each module are made. For instance, in 2000, more aggressive pumping rates are being incorporated into the wellfield management strategy; these and other enhancements will be discussed in upcoming IEMP reports

# TABLE A.1-1

## AQUIFER RESTORATION SYSTEM OPERATIONAL SUMMARY SHEET

| | Reporting Period | | | | | |
|---|---|---|---|---|---|---|
| | January 1999 through December 1999 | | | August 1993 through December 1999 | | |
| | Gallons Pumped/Re-Injected (M gal) | Total Uranium Removed/Re-Injected (lbs) | Uranium Removal Index[a] (lbs/M gal) | Gallons Pumped/Re-injected (M gal) | Total Uranium Removed/Re-Injected (lbs) | Uranium Removal Index[a] (lbs/M gal) |
| South Field (Phase1) Extraction Module | 753.2 | 464.15 | 0.62 | 1,106.899 | 703.88 | 0.64 |
| South Plume Module | 946.79 | 259.11 | 0.27 | 4,530.124 | 833.72 | 0.18 |
| Re-Injection Demonstration Module | 433.147 | 25.39 | NA | 559.718 | 28.62 | NA |
| Aquifer Restoration Systems Totals | | | | | | |
| (Extraction Wells) | 1699.99 | 723.26 | 0.43 | 5,637.023 | 1,537.60 | 0.27 |
| (Re-Injection Wells) | 433.147 | 25.39 | NA | 559.718 | 28.62 | NA |
| (net) | 1266.843 | 697.87 | NA | 5,077.305 | 1,508.98 | NA |

[a]NA = not applicable



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## TABLE A.1-2

## EXTRACTION WELL 31550
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 572.11 (top of well)
Northing Coordinate ('83) - 477,018.5
Easting Coordinate ('83) - 1,348,979.8

Hours in reporting period - 8,759 | Hours pumped - 7,973 | Target pumping rate - 100 gpm
Hours not pumped - 787 | Operational percent - 91.0

| Monthly Measurements at Wellfield | | | | |
|---|---|---|---|---|
| Month | Monthly Average Pumping Rate (gpm) | Million Gallons Pumped | Monthly Uranium Concentration (µg/L) | Uranium Removal Index (Pounds of Total Uranium Removed/Million Gallons Pumped) |
| 1/99[a] | 70 | 3.144 | 65.2 | 0.54 |
| 2/99 | 100 | 4.041 | 73.9 | 0.62 |
| 3/99 | 100 | 4.460 | 74.7 | 0.62 |
| 4/99 | 114 | 4.925 | 77.4 | 0.65 |
| 5/99 | 90 | 4.073 | 66.3 | 0.55 |
| 6/99 | 105 | 4.423 | 70.7 | 0.59 |
| 7/99 | 100 | 4.475 | 67.7 | 0.56 |
| 8/99 | 100 | 4.473 | 65.6 | 0.55 |
| 9/99[b] | 67 | 2.916 | 66.7[c] | 0.56[c] |
| 10/99 | 101 | 4.493 | 65.1[d] | 0.54 |
| 11/99[e,f] | 78 | 3.328 | 66.7 | 0.56 |
| 12/99 | 88 | 3.953 | 63.6 | 0.53 |
| Average | 92.75 | Total 48.704 | Average 68.6 | Average 0.573 |

[a]Extraction well was shut down for nine days in an effort to mitigate the high total uranium concentrations at the Parshall Flume.
[b]Extraction well was out of service for 11 days due to replacement of pump, motor and piping.
[c]Sampling port was plugged. The value is third quarter average.
[d]Sampling port was plugged. The value is fourth quarter average.
[e]Extraction well was out of service for three days due to construction tie-in.
[f]Extraction well was out of service for three days due to chlorination.

## TABLE A.1-3

## EXTRACTION WELL 31560
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 574.93 (top of well)
Northing Coordinate ('83) - 477,403.1
Easting Coordinate ('83) - 1,349,028.9

Hours in reporting period - 8,746 Hours pumped - 8,253 Target pumping rate - 100 gpm
Hours not pumped - 493 Operational percent - 94.4

| Monthly Measurements at Wellfield | | | | |
|---|---|---|---|---|
| Month | Monthly Average Pumping Rate (gpm) | Million Gallons Pumped | Monthly Uranium Concentration (µg/L) | Uranium Removal Index (Pounds of Total Uranium Removed/Million Gallons Pumped) |
| 1/99[a] | 63 | 2.833 | 118.2 | 0.99 |
| 2/99 | 99 | 4.000 | 124.4 | 1.04 |
| 3/99 | 99 | 4.430 | 115.4 | 0.96 |
| 4/99 | 110 | 4.791 | 109.0 | 0.91 |
| 5/99 | 99 | 4.432 | 90.0 | 0.75 |
| 6/99 | 102 | 4.391 | 97.9 | 0.82 |
| 7/99 | 101 | 4.487 | 92.5 | 0.77 |
| 8/99 | 100 | 4.484 | 101.9 | 0.85 |
| 9/99 | 100 | 4.341 | 97.1 | 0.81 |
| 10/99 | 101 | 4.512 | 97.6 | 0.81 |
| 11/99 | 89 | 3.819 | 97.3 | 0.81 |
| 12/99 | 88 | 3.945 | 94.0 | 0.78 |
| Average | 95.9 | Total 50.465 | Average 102.9 | Average 0.86 |

[a]Extraction well was shut down for nine days in an effort to mitigate the high total uranium concentrations at the Parshall Flume.

# TABLE A.1-4

## EXTRACTION WELL 31561
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 578.77 (top of well)
Northing Coordinate ('83) - 477,660.8
Easting Coordinate ('83) - 1,349,254.5

Hours in reporting period - 8,759 Hours pumped - 8,247 Target pumping rate - 100 gpm
Hours not pumped - 512 Operational percent - 94.2

| Monthly Measurements at Wellfield | | | | |
|---|---|---|---|---|
| Month | Monthly Average Pumping Rate (gpm) | Million Gallons Pumped | Monthly Uranium Concentration (µg/L) | Uranium Removal Index (Pounds of Total Uranium Removed/Million Gallons Pumped) |
| 1/99[a] | 70 | 3.121 | 40.0 | 0.33 |
| 2/99 | 95 | 3.815 | 41.3 | 0.34 |
| 3/99 | 100 | 4.476 | 42.8 | 0.36 |
| 4/99 | 97 | 4.169 | 37.5 | 0.31 |
| 5/99 | 91 | 4.034 | 42.9 | 0.36 |
| 6/99 | 100 | 4.295 | 36.3 | 0.30 |
| 7/99 | 101 | 4.491 | 37.7 | 0.31 |
| 8/99 | 101 | 4.519 | 45.7 | 0.38 |
| 9/99 | 101 | 4.361 | 44.7 | 0.30 |
| 10/99 | 102 | 4.542 | 42.6 | 0.36 |
| 11/99 | 91 | 3.888 | 44.5 | 0.37 |
| 12/99 | 89 | 4.013 | 45.5 | 0.38 |
| Average | 95 | Total 49.724 | Average 41.8 | Average 0.34 |

[a]Extraction well was shut down for nine days in an effort to mitigate the high total uranium concentrations at the Parshall Flume.

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## TABLE A.1-5

## EXTRACTION WELL 31562
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 576.21 (top of well)
Northing Coordinate ('83) - 477,953.1
Easting Coordinate ('83) - 1,349,499.9

Hours in reporting period - 8,759
Hours not pumped - 387

Hours pumped - 8,372
Operational percent - 95.6

Target pumping rate - 200 gpm[a]

| Monthly Measurements at Wellfield | | | | |
|---|---|---|---|---|
| Month | Monthly Average Pumping Rate (gpm) | Million Gallons Pumped | Monthly Uranium Concentration (µg/L) | Uranium Removal Index (Pounds of Total Uranium Removed/Million Gallons Pumped) |
| 1/99 | 151 | 6.724 | 108.3 | 0.90 |
| 2/99 | 189 | 7.602 | 111.2 | 0.93 |
| 3/99 | 198 | 8.846 | 106.5 | 0.89 |
| 4/99 | 199 | 8.528 | 97.3 | 0.81 |
| 5/99 | 183 | 8.136 | 120.1 | 1.00 |
| 6/99 | 201 | 8.683 | 113.6 | 0.95 |
| 7/99 | 201 | 8.949 | 106.8 | 0.89 |
| 8/99 | 200 | 8.971 | 120.9 | 1.01 |
| 9/99 | 200 | 8.657 | 111.8 | 0.93 |
| 10/99 | 202 | 8.993 | 114.7 | 0.96 |
| 11/99 | 178 | 7.612 | 105.0 | 0.88 |
| 12/99 | 175 | 7.888 | 106.5 | 0.89 |
| Average | 190 | Total 99.589 | Average 110.2 | Average 0.92 |

[a]To compensate for the shutdown of Extraction Well 31566 and to increase module efficiency, the pumping rate for the first quarter continued at 200 gpm at Extraction Well 31562.

# TABLE A.1-6

## EXTRACTION WELL 31563
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 544.36 (top of well)
Northing Coordinate ('83) - 477,066.4
Easting Coordinate ('83) - 1,348,330

Hours in reporting period - 8,760 Hours pumped - 8,335 Target pumping rate - 200 gpm
Hours not pumped - 425 Operational percent - 95.1

| Monthly Measurements at Wellfield | | | | |
|---|---|---|---|---|
| Month | Monthly Average Pumping Rate (gpm) | Million Gallons Pumped | Monthly Uranium Concentration (µg/L) | Uranium Removal Index (Pounds of Total Uranium Removed/Million Gallons Pumped) |
| 1/99[a] | 160 | 7.134 | 36.3 | 0.30 |
| 2/99 | 190 | 7.658 | 37.2 | 0.31 |
| 3/99 | 193 | 8.638 | 32.8 | 0.27 |
| 4/99 | 201 | 8.720 | 36.4 | 0.30 |
| 5/99 | 184 | 8.203 | 37.0 | 0.31 |
| 6/99 | 203 | 8.775 | 34.4 | 0.29 |
| 7/99 | 201 | 8.985 | 31.7 | 0.26 |
| 8/99 | 202 | 9.039 | 30.4 | 0.25 |
| 9/99 | 202 | 8.727 | 27.9 | 0.23 |
| 10/99 | 203 | 9.035 | 25.7 | 0.21 |
| 11/99 | 172 | 7.336 | 24.6 | 0.21 |
| 12/99 | 186 | 8.370 | 26.4 | 0.22 |
| Average | 191 | Total 100.620 | Average 31.7 | Average 0.26 |

[a]Extraction well was shut down for six days in an effort to mitigate the high total uranium concentrations at the Parshall Flume.

## TABLE A.1-7

## EXTRACTION WELL 31564
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 538.65 (top of well)
Northing Coordinate ('83) - 477,124.7
Easting Coordinate ('83) - 1,347,880.4

Hours in reporting period - 8,760 Hours pumped - 7,855 Target pumping rate - 200 gpm
Hours not pumped - 906 Operational percent - 89.7

| Monthly Measurements at Wellfield | | | | |
|---|---|---|---|---|
| Month | Monthly Average Pumping Rate (gpm) | Million Gallons Pumped | Monthly Uranium Concentration (µg/L) | Uranium Removal Index (Pounds of Total Uranium Removed/Million Gallons Pumped) |
| 1/99[a] | 141 | 6.304 | 14.9 | 0.12 |
| 2/99 | 189 | 7.640 | 16.8 | 0.14 |
| 3/99 | 196 | 8.751 | 13.3 | 0.11 |
| 4/99 | 203 | 8.808 | 14.4 | 0.12 |
| 5/99 | 177 | 7.883 | 14.4 | 0.12 |
| 6/99 | 201 | 8.688 | 14.3 | 0.12 |
| 7/99 | 203 | 9.057 | 13.8 | 0.12 |
| 8/99 | 203 | 9.082 | 14.5 | 0.12 |
| 9/99 | 201 | 8.716 | 14.6 | 0.12 |
| 10/99 | 201 | 8.953 | 14.3 | 0.12 |
| 11/99 | 199 | 8.503 | 14.1 | 0.12 |
| 12/99 | 63[b] | 2.854 | 13.5 | 0.11 |
| Average | 165 | Total 95.239 | Average 14.4 | Average 0.11 |

[a]Extraction well was shut down for nine days in an effort to mitigate the high total uranium concentrations at the Parshall Flume.
[b]Low pumping rate due to variable frequency drive malfunctioning

# TABLE A.1-8

## EXTRACTION WELL 31565
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 540.72 (top of well)
Northing Coordinate ('83) - 477,648.3
Easting Coordinate ('83) - 1,347,629.9

Hours in reporting period - 8,760
Hours not pumped - 382
Hours pumped - 8,378
Operational percent - 95.6
Target pumping rate - 200 gpm

| Monthly Measurements at Wellfield | | | | |
|---|---|---|---|---|
| Month | Monthly Average Pumping Rate (gpm) | Million Gallons Pumped | Monthly Uranium Concentration (µg/L) | Uranium Removal Index (Pounds of Total Uranium Removed/Million Gallons Pumped) |
| 1/99[a] | 144 | 6.409 | 12.6 | 0.11 |
| 2/99 | 185 | 7.473 | 16.4 | 0.14 |
| 3/99 | 189 | 8.416 | 13.0 | 0.11 |
| 4/99 | 203 | 8.794 | 14.5 | 0.12 |
| 5/99 | 184 | 8.214 | 14.9 | 0.12 |
| 6/99 | 201 | 8.689 | 15.1 | 0.13 |
| 7/99 | 203 | 9.048 | 15.1 | 0.13 |
| 8/99 | 204 | 9.144 | 13.6 | 0.11 |
| 9/99 | 203 | 8.788 | 13.0 | 0.11 |
| 10/99 | 203 | 9.039 | 12.5 | 0.10 |
| 11/99 | 201 | 8.570 | 11.7 | 0.10 |
| 12/99 | 187 | 8.427 | 11.4 | 0.10 |
| Average | 192 | Total 101.011 | Average 13.7 | Average 0.12 |

[a]Extraction well was shut down for eight days in an effort to mitigate the high total uranium concentrations at the Parshall Flume.

000024

# TABLE A.1-9

## EXTRACTION WELL 31566[a]
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) – 575.16 (top of well)
Northing Coordinate ('83) - 477,576.1
Easting Coordinate ('83) - 1,348,361.3

Hours in reporting period - NA[b] Hours pumped - NA[b] Target pumping rate - BRSR: 200 gpm
Hours not pumped - NA[b] Operational percent - NA[b] Present: 0 gpm

| Monthly Measurements at Wellfield | | | | |
|---|---|---|---|---|
| Month | Monthly Average Pumping Rate (gpm) | Million Gallons Pumped | Monthly Uranium Concentration[c] (µg/L) | Uranium Removal Index (Pounds of Total Uranium Removed/Million Gallons Pumped)[b] |
| 1/99 | 0 | 0.001 | 29.2 | NA |
| 2/99 | 0 | 0 | 8.8 | NA |
| 3/99 | 0 | 0 | 7.7 | NA |
| 4/99 | 0 | 0 | 7.1 | NA |
| 5/99 | 0 | 0.002 | 9.7 | NA |
| 6/99 | 0 | 0 | 5.0 | NA |
| 7/99 | 0 | 0.002 | 7.2 | NA |
| 8/99 | 0 | 0.008 | 7.5 | NA |
| 9/99 | 0 | 0 | 7.4 | NA |
| 10/99 | 0 | 0 | NS | NA |
| 11/99 | 0 | 0 | NS | NA |
| 12/99 | 0 | 0 | NS | NA |
| | Average 0 | Total 0.013 | Average 10.0 | Average NA |

[a]Due to the change in operational status of Extraction Well 31566, the pump assembly was removed and used to replace the pump assembly in Extraction Well 31550.
[b]NA = not applicable
[c]NS = not sampled

## TABLE A.1-10

## EXTRACTION WELL 31567
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 574.84 (top of well)
Northing Coordinate ('83) - 477,905.5
Easting Coordinate ('83) - 1,348,854.1

Hours in reporting period - 8,760 Hours pumped - 8,348 Target pumping rate - 100 gpm
Hours not pumped - 412 Operational percent - 95.3

| Monthly Measurements at Wellfield | | | | |
|---|---|---|---|---|
| Month | Monthly Average Pumping Rate (gpm) | Million Gallons Pumped | Monthly Uranium Concentration (µg/L) | Uranium Removal Index (Pounds of Total Uranium Removed/Million Gallons Pumped) |
| 1/99[a] | 71 | 3.176 | 38.9 | 0.32 |
| 2/99 | 96 | 3.865 | 41.2 | 0.34 |
| 3/99 | 100 | 4.459 | 36.5 | 0.30 |
| 4/99 | 113 | 4.875 | 38.4 | 0.32 |
| 5/99 | 93 | 4.142 | 40.9 | 0.34 |
| 6/99 | 100 | 4.298 | 36.5 | 0.30 |
| 7/99 | 100 | 4.470 | 36.7 | 0.31 |
| 8/99 | 101 | 4.497 | 45.3 | 0.38 |
| 9/99 | 100 | 4.337 | 45.7 | 0.38 |
| 10/99 | 101 | 4.521 | 42.5 | 0.35 |
| 11/99 | 185 | 7.906 | 41.5 | 0.35 |
| 12/99 | 172 | 7.761 | 39.4 | 0.33 |
| Average | 111 | Total 58.307 | Average 40.3 | Average 0.34 |

[a]Extraction well was shut down for nine days in an effort to mitigate the high total uranium concentrations at the Parshall Flume.

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# TABLE A.1-11

## EXTRACTION WELL 32276
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 567.14 (top of well)
Northing Coordinate ('83) - 476,447.3
Easting Coordinate ('83) - 1,348,857.3

Hours in reporting period - 8,760
Hours not pumped - 373
Hours pumped - 8,386
Operational percent - 95.7
Target pumping rate - 300 gpm

| Monthly Measurements at Wellfield | | | | |
|---|---|---|---|---|
| Month | Monthly Average Pumping Rate (gpm) | Million Gallons Pumped | Monthly Uranium Concentration (µg/L) | Uranium Removal Index (Pounds of Total Uranium Removed/Million Gallons Pumped) |
| 1/99 | 277 | 12.357 | 180.7 | 1.51 |
| 2/99 | 277 | 11.165 | 180.7 | 1.51 |
| 3/99 | 292 | 13.029 | 175.0 | 1.46 |
| 4/99 | 293 | 12.706 | 179.5 | 1.50 |
| 5/99 | 271 | 12.062 | 161.2 | 1.34 |
| 6/99 | 303 | 13.091 | 176.8 | 1.47 |
| 7/99 | 301 | 13.430 | 157.3 | 1.31 |
| 8/99 | 298 | 13.321 | 175.4 | 1.46 |
| 9/99 | 300 | 12.993 | 178.5 | 1.49 |
| 10/99 | 302 | 13.441 | 174.2 | 1.45 |
| 11/99 | 262 | 11.186 | 165.2 | 1.38 |
| 12/99 | 239 | 10.752 | 161.2 | 1.34 |
| Average | 285 | Total 149.533 | Average 172.1 | Average 1.44 |

# TABLE A.1-12

## EXTRACTION WELL 3924
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 533.51 (top of well)
Northing Coordinate ('83) - 474,219.7
Easting Coordinate ('83) - 1,348,314.3

Hours in reporting period - 8,761 Hours pumped - 8,441 Target pumping rate - 300 gpm
Hours not pumped - 320 Operational percent - 96.3

| Monthly Measurements at Wellfield | | | | |
|---|---|---|---|---|
| Month | Monthly Average Pumping Rate (gpm) | Million Gallons Pumped | Monthly Uranium Concentration (µg/L) | Uranium Removal Index (Pounds of Total Uranium Removed/Million Gallons Pumped) |
| 1/99 | 299 | 13.331 | 50.0 | 0.42 |
| 2/99 | 297 | 11.970 | 48.5 | 0.40 |
| 3/99 | 297 | 13.240 | 37.2 | 0.31 |
| 4/99 | 291 | 12.615 | 38.9 | 0.32 |
| 5/99 | 284 | 12.676 | 33.4 | 0.28 |
| 6/99[a] | 276 | 11.895 | 29.1 | 0.24 |
| 7/99 | 295 | 13.149 | 30.6 | 0.26 |
| 8/99 | 298 | 13.290 | 38.1 | 0.32 |
| 9/99[b] | 273 | 11.781 | 36.7 | 0.31 |
| 10/99 | 294 | 13.159 | 40.3 | 0.34 |
| 11/99[c] | 276 | 11.941 | 40.6 | 0.34 |
| 12/99[c] | 264 | 11.772 | 40.7 | 0.34 |
| Average | 287 | Total 150.819 | Average 38.7 | Average 0.32 |

[a]Extraction well was out of service for two days due to screen rehabilitation.
[b]Extraction well was out of service due to replacement of motor.
[c]Extraction well was out of service for two days in November and one day in December due to construction tie-in and distribution system pressure control valve preventive maintenance.

000028

## TABLE A.1-13

## EXTRACTION WELL 3925
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 542.01 (top of well)
Northing Coordinate ('83) - 474,319.7
Easting Coordinate ('83) - 1,348,565.4

Hours in reporting period - 8,745 | Hours pumped - 8,413 | Target pumping rate - 300 gpm
Hours not pumped - 332 | Operational percent - 96.2

| Monthly Measurements at Wellfield | | | | |
|---|---|---|---|---|
| Month | Monthly Average Pumping Rate (gpm) | Million Gallons Pumped | Monthly Uranium Concentration (µg/L) | Uranium Removal Index (Pounds of Total Uranium Removed/Million Gallons Pumped) |
| 1/99 | 296 | 13.215 | 32.5 | 0.27 |
| 2/99 | 289 | 11.658 | 36.1 | 0.30 |
| 3/99 | 295 | 13.179 | 35.3 | 0.29 |
| 4/99 | 288 | 12.490 | 35.2 | 0.29 |
| 5/99 | 283 | 12.609 | 35.4 | 0.30 |
| 6/99[a] | 275 | 11.873 | 32.0 | 0.27 |
| 7/99 | 298 | 13.282 | 29.5 | 0.25 |
| 8/99 | 298 | 13.293 | 34.1 | 0.28 |
| 9/99 | 297 | 12.855 | 32.4 | 0.27 |
| 10/99 | 295 | 13.192 | 32.1 | 0.27 |
| 11/99[b] | 273 | 11.833 | 30.2 | 0.25 |
| 12/99[b] | 268 | 11.683 | 31.9 | 0.27 |
| Average | 288 | Total 151.162 | Average 33.1 | Average 0.28 |

[a]Extraction well was out of service for two days due to screen rehabilitation.
[b]Extraction well was out of service for two days in November and one day in December due to construction tie-in and distribution system pressure control valve preventive maintenance.

# TABLE A.1-14

## EXTRACTION WELL 3926
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 586.73 (top of well)
Northing Coordinate ('83) - 474,428.6
Easting Coordinate ('83) - 1,348,837.5

Hours in reporting period - 8,761 Hours pumped -7,936 Target pumping rate - 400 gpm
Hours not pumped - 825 Operational percent - 90.6

| Monthly Measurements at Wellfield | | | | |
|---|---|---|---|---|
| Month | Monthly Average Pumping Rate (gpm) | Million Gallons Pumped | Monthly Uranium Concentration (µg/L) | Uranium Removal Index (Pounds of Total Uranium Removed/Million Gallons Pumped) |
| 1/99 | 382 | 17.045 | 19.9 | 0.17 |
| 2/99 | 393 | 15.864 | 23.7 | 0.20 |
| 3/99 | 395 | 17.626 | 19.9 | 0.17 |
| 4/99 | 376 | 16.303 | 21.3 | 0.18 |
| 5/99 | 362 | 16.140 | 21.0 | 0.18 |
| 6/99 | 376 | 16.215 | 19.6 | 0.16 |
| 7/99 | 374 | 16.689 | 21.9 | 0.18 |
| 8/99[a] | 346 | 15.451 | 23.4 | 0.20 |
| 9/99 | 384 | 16.579 | 22.8 | 0.19 |
| 10/99 | 370 | 16.547 | 23.1 | 0.19 |
| 11/99[b] | 344 | 14.883 | 24.6 | 0.21 |
| 12/99[b,c] | 152[d] | 6.753 | 23.6 | 0.20 |
| Average | 355 | Total 186.095 | Average 22.1 | Average 0.19 |

[a]Extraction well was out of service for two days due to screen rehabilitation.
[b]Extraction well was out of service for two days in November and one day in December due to construction tie-in and distribution system pressure control valve preventive maintenance.
[c]Extraction well was out of service for 18 days due to well rehabilitation.
[d]Low pumping rate due to well rehabilitation

000030

## TABLE A.1-15

## EXTRACTION WELL 3927
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 591.84 (top of well)
Northing Coordinate ('83) - 474,541.8
Easting Coordinate ('83) - 1,349,127.3

Hours in reporting period - 8,745 Hours pumped - 7,986 Target pumping rate - 500 gpm
Hours not pumped - 759 Operational percent - 91.3

| Monthly Measurements at Wellfield | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Month | Monthly Average Pumping Rate (gpm) | | Million Gallons Pumped | | Monthly Uranium Concentration (µg/L) | | Uranium Removal Index (Pounds of Total Uranium Removed/Million Gallons Pumped) | |
| 1/99 | | 493 | | 22.025 | | 1.2 | | 0.01 |
| 2/99 | | 478 | | 19.280 | | 1.2 | | 0.01 |
| 3/99 | | 483 | | 21.555 | | 1.7 | | 0.01 |
| 4/99 | | 465 | | 20.130 | | 1.3 | | 0.01 |
| 5/99 | | 464 | | 20.703 | | 1.6 | | 0.01 |
| 6/99 | | 484 | | 20.910 | | 1.3 | | 0.01 |
| 7/99 | | 480 | | 21.417 | | 1.6 | | 0.01 |
| 8/99 | | 477 | | 21.296 | | 1.7 | | 0.01 |
| 9/99 | | 489 | | 21.121 | | 1.6 | | 0.01 |
| 10/99 | | 463 | | 20.710 | | 1.6 | | 0.01 |
| 11/99[a,b] | | 193[c] | | 8.374 | | 1.5 | | 0.01 |
| 12/99[a,b] | | 375 | | 16.348 | | 2.1 | | 0.02 |
| | Average | 445 | Total | 233.869 | Average | 1.5 | Average | 0.01 |

[a]Extraction well was out of service for two days in November and one day in December due to distribution system pressure control valve preventive maintenance.
[b]Extraction well was out of service for 15 days in November and six days in December for well screen rehabilitation.
[c]Low pumping rate due to well rehabilitation

# TABLE A.1-16

## EXTRACTION WELL 32308
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 582.05 (top of casing)
Northing Coordinate ('83) - 475,078.83
Easting Coordinate ('83) - 1,348,693.9

Hours in reporting period - 8,745 Hours pumped - 7,438 Target pumping rate - 250 gpm
Hours not pumped - 1,307 Operational percent - 85.1

| Monthly Measurements at Wellfield | | | | |
|---|---|---|---|---|
| Month | Monthly Average Pumping Rate (gpm) | Million Gallons Pumped | Monthly Uranium Concentration (µg/L) | Uranium Removal Index (Pounds of Total Uranium Removed/Million Gallons Pumped) |
| 1/99[a] | 112 | 5.010 | 63.0 | 0.53 |
| 2/99 | 245 | 9.897 | 70.4 | 0.59 |
| 3/99[b] | 242 | 10.787 | 71.0 | 0.59 |
| 4/99[b] | 225 | 9.754 | 70.0 | 0.58 |
| 5/99 | 224 | 9.995 | 60.9 | 0.51 |
| 6/99 | 246 | 10.609 | 68.3 | 0.57 |
| 7/99 | 250 | 11.181 | 63.9 | 0.53 |
| 8/99 | 246 | 10.976 | 73.4 | 0.61 |
| 9/99[c] | 166 | 7.192 | 73.0 | 0.61 |
| 10/99[d] | 221 | 9.872 | 75.7 | 0.63 |
| 11/99[e,f] | 189[h] | 8.164 | 73.2 | 0.61 |
| 12/99[f,g] | 227 | 9.913 | 71.5 | 0.60 |
| Average | 216 | Total 113.350 | Average 69.5 | Average 0.58 |

[a]Extraction well was out of service for 15 days in an effort to mitigate the high total uranium concentrations at the Parshall Flume.
[b]Extraction well was out of service for two days in March and two days in April due to treatment plant maintenance per the OMMP.
[c]Extraction well was shut down for nine days per the OMMP.
[d]Extraction well was out of service for two days per the OMMP (high uranium in injectate).
[e]Extraction well was out of service for four days per the OMMP (construction).
[f]Extraction well was out of service for two days in November and one day in December due to construction tie-in and distribution system pressure control valve preventive maintenance.
[g]Extraction well was out of service for two days per the OMMP (high uranium in injectate).
[h]Low pumping rate due to well being down for construction tie-ins.

## TABLE A.1-17

## EXTRACTION WELL 32309
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 581.73 (top of casing)
Northing Coordinate ('83) - 475,109.60
Easting Coordinate ('83) - 1,348,366.34

Hours in reporting period - 8,745 Hours pumped - 7,427 Target pumping rate - 250 gpm
Hours not pumped - 1,318 Operational percent - 84.9

| Monthly Measurements at Wellfield | | | | |
|---|---|---|---|---|
| Month | Monthly Average Pumping Rate (gpm) | Million Gallons Pumped | Monthly Uranium Concentration (µg/L) | Uranium Removal Index (Pounds of Total Uranium Removed/Million Gallons Pumped) |
| 1/99[a] | 105 | 4.676 | 81.4 | 0.68 |
| 2/99 | 245 | 9.860 | 73.2 | 0.61 |
| 3/99[b] | 228 | 10.195 | 72.8 | 0.61 |
| 4/99[b] | 225 | 9.726 | 68.1 | 0.57 |
| 5/99[c] | 212 | 9.469 | 59.3 | 0.49 |
| 6/99 | 245 | 10.589 | 65.9 | 0.55 |
| 7/99 | 249 | 11.138 | 62.0 | 0.52 |
| 8/99 | 246 | 10.978 | 72.4 | 0.60 |
| 9/99[d] | 164 | 7.082 | 74.7 | 0.62 |
| 10/99[e] | 220 | 9.834 | 77.5 | 0.65 |
| 11/99[f,g] | 188[i] | 8.121 | 77.7 | 0.65 |
| 12/99[g,h] | 226 | 9.831 | 75.6 | 0.63 |
| Average | 213 | Total 111.499 | Average 71.7 | Average 0.60 |

[a]Extraction well was out of service for 15 days in an effort to mitigate the high total uranium concentrations at the Parshall Flume.
[b]Extraction well was out of service for two days in March and two days in April due to treatment plant maintenance per the OMMP.
[c]Extraction well was out of service for two days due to screen rehabilitation.
[d]Extraction well was out of service for 10 days per the OMMP.
[e]Extraction well was out of service for two days per the OMMP (high uranium in injectate).
[f]Extraction well was out of service for four days per the OMMP (construction).
[g]Extraction well was out of service for two days in November and one day in December due to construction tie-in and distribution system pressure control valve preventive maintenance.
[h]Extraction well was out of service for two days per the OMMP (high uranium in injectate).
[i]Low pumping rate due to well being down for construction tie-ins.

# TABLE A.1-18

## PADDYS RUN ROAD SITE GROUNDWATER SUMMARY STATISTICS AND TREND ANALYSIS

| Constituent | Monitoring Well | Number of Samples[a,b,c] | Min.[a,b,c,d] (mg/L) | Max.[a,b,c,d] (mg/L) | Avg.[a,b,c,d] (mg/L) | SD[a,b,c,d] (mg/L) | Trend[a,b,c,d] |
|---|---|---|---|---|---|---|---|
| Arsenic | 2128 | 211 | 0.00041 | 0.1876 | 0.013 | 0.022 | Down, Significant |
| | 2625 | 199 | 0.0048 | 0.05 | 0.012 | 0.008 | Down, Significant |
| | 2636 | 171 | 0.01 | 0.0939 | 0.04 | 0.02 | Down, Significant |
| | 2898 | 26 | 0.00035 | 0.0063 | 0.0015 | 0.0013 | No Significant Trend |
| | 2899 | 25 | 0.00032 | 0.0032 | 0.0013 | 0.00082 | No Significant Trend |
| | 2900 | 208 | 0.00032 | 0.0548 | 0.0051 | 0.0051 | Down, Significant |
| | 3128 | 29 | 0.00085 | 0.234 | 0.011 | 0.043 | No Significant Trend |
| | 3636 | 28 | 0.0006 | 0.014 | 0.002 | 0.0024 | Down, Marginal |
| | 3898 | 26 | 0.0006 | 0.0062 | 0.002 | 0.0012 | No Significant Trend |
| | 3899 | 27 | 0.00032 | 0.003 | 0.0013 | 0.0008 | No Significant Trend |
| | 3900 | 27 | 0.000395 | 0.0045 | 0.0023 | 0.0010 | Down, Significant |
| Phosphorus | 2128 | 37 | 0.04 | 16.2 | 2 | 3 | Down, Significant |
| | 2625 | 24 | 0.307 | 12.3 | 3.38 | 3.24 | No Significant Trend |
| | 2636 | 23 | 9.6 | 170 | 95 | 50 | No Significant Trend |
| | 2898 | 27 | 0.005 | 1.05 | 0.08 | 0.2 | No Significant Trend |
| | 2899 | 24 | 0.005 | 0.11 | 0.04 | 0.03 | No Significant Trend |
| | 2900 | 25 | 0.07 | 0.96 | 0.45 | 0.26 | Down, Significant |
| | 3128 | 36 | 0.005 | 13 | 0.4 | 2 | No Significant Trend |
| | 3636 | 27 | 0.00955 | 1.1 | 0.099 | 0.21 | No Significant Trend |
| | 3898 | 25 | 0.00955 | 1.24 | 0.120 | 0.246 | Down, Marginal |
| | 3899 | 26 | 0.00955 | 0.83 | 0.13 | 0.17 | Down, Significant |
| | 3900 | 27 | 0.005 | 1.26 | 0.1 | 0.24 | Down, Marginal |
| Potassium | 2128 | 29 | 0.83 | 18 | 4.0 | 4.6 | Down, Significant |
| | 2625 | 24 | 0.64 | 6.26 | 3.4 | 1.7 | Up, Marginal |
| | 2636 | 23 | 8.51 | 218 | 82.4 | 54.7 | Down, Marginal |
| | 2898 | 27 | 1.11 | 5.05 | 3.65 | 0.805 | No Significant Trend |
| | 2899 | 25 | 1.36 | 4.66 | 3.57 | 0.626 | Up, Significant |
| | 2900 | 26 | 0.0095 | 6 | 1.8 | 1.2 | Down, Marginal |
| | 3128 | 29 | 1.085 | 3.7 | 2.4 | 0.66 | Down, Significant |
| | 3636 | 27 | 1.09 | 4.24 | 2.54 | 0.592 | Down, Significant |
| | 3898 | 26 | 0.61 | 3.93 | 2.3 | 0.70 | No Significant Trend |
| | 3899 | 27 | 0.875 | 3.22 | 2.38 | 0.442 | Down, Significant |
| | 3900 | 27 | 0.975 | 3.19 | 1.87 | 0.519 | No Significant Trend |
| Sodium | 2128 | 29 | 22.9 | 75.2 | 38.2 | 12.6 | No Significant Trend |
| | 2625 | 24 | 16.5 | 50.7 | 33.8 | 7.88 | Down, Significant |
| | 2636 | 23 | 23 | 79.9 | 47 | 16 | Down, Significant |
| | 2898 | 27 | 4.945 | 29.2 | 18.1 | 4.81 | Down, Significant |
| | 2899 | 25 | 11.2 | 22.9 | 17.0 | 3.16 | No Significant Trend |
| | 2900 | 26 | 0.01355 | 43.3 | 28.9 | 9.69 | No Significant Trend |
| | 3128 | 29 | 3.56 | 13.4 | 6.60 | 3.31 | Down, Significant |
| | 3636 | 27 | 3.98 | 13 | 7.9 | 3.0 | Down, Significant |
| | 3898 | 26 | 7.29 | 14.6 | 9.19 | 1.72 | No Significant Trend |
| | 3899 | 27 | 6.24 | 12.1 | 8.66 | 1.42 | Down, Significant |
| | 3900 | 27 | 3.56 | 10.8 | 6.17 | 1.91 | Down, Significant |

[a]The data are based on unfiltered samples from the Operable Unit 5 remedial investigation/feasibility study data set (1988 through 1993) and 1994 through 1999 groundwater data.
[b]If more than one sample is collected per well per day (e.g., duplicate), then only one sample is counted for the total number of samples, and the sample with the maximum concentration is used to determine the summary statistics (minimum, maximum, average, and standard deviation [SD]).
[c]Rejected data qualified with either a R or Z were not included in this count or the summary statistics.
[d]Where concentrations are below the detection limit, each result used in the summary statistics is set at half the detection limit.
[e]NS = not sampled due to well being dry.
[f]Validation qualifier codes are provided in Appendix D of the Sitewide CERCLA Quality Assurance Project Plan (DOE 1998c).
[g]NA = not applicable

## TABLE A.1-19

## RE-INJECTION WELL 22107
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 540.6 (top of well)
Northing Coordinate ('83) - 476,196.2
Easting Coordinate ('83) - 1,347,978.2

Hours in reporting period - 8,752 Hours re-injected - 7,363 Target re-injection rate - 200 gpm
Hours not re-injected - 1,390 Operational percent - 84.1

| Monthly Measurements at Wellfield | | |
|---|---|---|
| Month | Monthly Average Re-Injection Rate (gpm) | Million Gallons Re-Injected |
| 1/99[a,b] | 126 | 5.638 |
| 2/99[c] | 175 | 7.056 |
| 3/99[c,d] | 164 | 7.335 |
| 4/99[e] | 179 | 7.752 |
| 5/99[f] | 167 | 7.464 |
| 6/99 | 195 | 8.416 |
| 7/99 | 200 | 8.931 |
| 8/99 | 194 | 8.643 |
| 9/99[g,h,i] | 91 | 3.915 |
| 10/99[j] | 176 | 7.862 |
| 11/99[k,l] | 156 | 6.668 |
| 12/99[l] | 161 | 7.278 |
| Average | 165 | Total 86.958 |

[a]Re-injection well was out of service for two days due to mechanical problems at the treatment plant.
[b]Re-injection well was out of service for 10 days in an effort to mitigate the high total uranium concentrations at the Parshall Flume.
[c]Re-injection well was out of service for three days in February and three days in March due to screen rehabilitation.
[d]Re-injection well was out of service for two days for maintenance.
[e]Re-injection well was out of service for three days due to treatment plant maintenance
[f]Re-injection well was out of service for seven days due to screen rehabilitation.
[g]Re-injection well was out of service for six days due to screen rehabilitation.
[h]Re-injection well was out of service for five days for treatment plant maintenance, per the OMMP.
[i]Re-injection well was out of service for seven days per the OMMP (high uranium in injectate).
[j]Re-injection well was out of service for two days per the OMMP (regenerate resin).
[k]Re-injection well was out of service for four days due to construction tie-in.
[l]Re-injection well was out of service for two days in November and one day in December due to construction tie-in and distribution system pressure control valve preventive maintenance.

## TABLE A.1-20

## RE-INJECTION WELL 22108
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 578.56 (top of well)
Northing Coordinate ('83) - 476,255.7
Easting Coordinate ('83) - 1,348,384

Hours in reporting period - 8,772 Hours re-injected - 7,125 Target re-injection rate - 150/200 gpm[a]
Hours not re-injected - 1,647 Operational percent - 81.2

| Monthly Measurements at Wellfield | | |
|---|---|---|
| Month | Monthly Average Re-Injection Rate (gpm) | Million Gallons Re-Injected |
| 1/99[b] | 109 | 4.847 |
| 2/99 | 144 | 5.787 |
| 3/99[c,d] | 133 | 5.933 |
| 4/99[e] | 154 | 6.661 |
| 5/99[f] | 175 | 7.829 |
| 6/99 | 195 | 8.409 |
| 7/99 | 197 | 8.794 |
| 8/99 | 193 | 8.631 |
| 9/99[g,h] | 129 | 5.678 |
| 10/99[i] | 175 | 7.802 |
| 11/99[j,k] | 153 | 6.543 |
| 12/99[k,l] | 68[m] | 3.081 |
| | Average 152 | Total 79.995 |

[a]Target re-injection rate increased from 150 gpm to 200 gpm in March.
[b]Re-injection well was out of service for 10 days in an effort to mitigate the high total uranium concentrations at the Parshall Flume.
[c]Re-injection water diverted from the auxillary 150 gpm injection pipe back to the main 200 gpm injection pipe.
[d]Re-injection well was out of service for two days for maintenance.
[e]Re-injection well was out of service for five days due to treatment plant maintenance.
[f]Re-injection well was out of service for two days due to power outage.
[g]Re-injection well was out of service for five days for treatment plant maintenance, per the OMMP.
[h]Re-injection well was out of service for seven days per the OMMP (high uranium in injectate).
[i]Re-injection well was out of service for two days to regenerate resin.
[j]Re-injection well was out of service for four days due to construction tie-in.
[k]Re-injection well was out of service for two days in November and one day in December due to construction tie-in and distribution system pressure control valve preventive maintenance.
[l]Re-injection well was out of service for 17 days due to well rehabilitation.
[m]Low re-injection rate due to well rehabilitation

000036

## TABLE A.1-21

## RE-INJECTION WELL 22109
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 577.53 (top of well)
Northing Coordinate ('83) - 476,175.6
Easting Coordinate ('83) - 1,348,861

Hours in reporting period - 8,760 | Hours re-injected - 7,230 | Target re-injection rate - 200 gpm
Hours not re-injected - 1,531 | Operational percent - 82.5

| Monthly Measurements at Wellfield | | |
|---|---|---|
| Month | Monthly Average Re-Injection Rate (gpm) | Million Gallons Re-Injected |
| 1/99[a] | 123 | 5.478 |
| 2/99 | 189 | 7.601 |
| 3/99[b] | 182 | 8.132 |
| 4/99[c,d] | 123 | 5.346 |
| 5/99 | 185 | 8.250 |
| 6/99 | 194 | 8.364 |
| 7/99 | 197 | 8.808 |
| 8/99 | 191 | 8.522 |
| 9/99[e,f,g] | 45 | 1.970 |
| 10/99[h] | 175 | 7.788 |
| 11/99[i,j] | 151 | 6.471 |
| 12/99[j] | 168 | 7.579 |
| Average | 160 | Total 84.309 |

[a]Re-injection well was out of service for 11 days to mitigate the high total uranium concentrations at the Parshall Flume.
[b]Re-injection well was out of servcice for two days due to maintenance.
[c]Re-injection well was out of service for seven days due to well screen rehabilitation.
[d]Re-injection well was out of service for three days due to treatment plant maintenance.
[e]Re-injection well was out of service for 10 days due to well screen rehabilitation.
[f]Re-injection well was out of service for five days for treatment plant maintenance, per the OMMP.
[g]Re-injection well was out of service for seven days per the OMMP (high uranium in injectate).
[h]Re-injection well was out of service for two days to regenerate resin.
[i]Re-injection well was out of service for four days due to construction tie-in.
[j]Re-injection well was out of service for two days in November and one day in December due to construction tie-in and distribution system pressure control valve preventive maintenance.

## TABLE A.1-22

## RE-INJECTION WELL 22111
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 583.62 (top of well)
Northing Coordinate ('83) - 476,518.6
Easting Coordinate ('83) - 1,350,105

Hours in reporting period - 8,759 Hours re-injected - 7,642 Target re-injection rate - 200 gpm
Hours not re-injected - 1,117 Operational percent - 87.2

| Monthly Measurements at Wellfield | | |
|---|---|---|
| Month | Monthly Average Re-Injection Rate (gpm) | Million Gallons Re-Injected |
| 1/99[a] | 127 | 5.675 |
| 2/99 | 189 | 7.604 |
| 3/99[b] | 182 | 8.133 |
| 4/99[c] | 176 | 7.652 |
| 5/99 | 186 | 8.268 |
| 6/99 | 195 | 8.416 |
| 7/99 | 197 | 8.804 |
| 8/99 | 194 | 8.669 |
| 9/99[d,e] | 131 | 5.663 |
| 10/99[f] | 175 | 7.820 |
| 11/99[g,h] | 155 | 6.650 |
| 12/99[h,i] | 164 | 7.407 |
| | Average 173 | Total 90.761 |

[a]Re-injection well was out of service for 11 days to mitigate the high total uranium concentrations at the Parshall Flume.
[b]Re-injection well was out of servcice for two days due to maintenance.
[c]Re-injection well was out of service for three days for treatment plant maintenance.
[d]Re-injection well was out of service for five days per the OMMP.
[e]Re-injection well was out of service for seven days per the OMMP (high uranium in injectate).
[f]Re-injection well was out of service for two days to regenerate resin.
[g]Re-injection well was out of service for four days due to construction tie-in.
[h]Re-injection well was out of service for two days in November and one day in December due to construction tie-in and distribution system pressure control valve preventive maintenance.
[i]Re-injection well was out of service for two days due to malfunction of programmable control system-tracking module.

000038

# TABLE A.1-23

## RE-INJECTION WELL 22240
## OPERATIONAL SUMMARY SHEET FOR 1999

Reference Elevation (feet AMSL) - 577.61 (top of well)
Northing Coordinate ('83) - 476,422.8
Easting Coordinate ('83) - 1,349,387

Hours in reporting period - 8,759 | Hours re-injected - 7,728 | Target re-injection rate - 200 gpm
Hours not re-injected - 1,031 | Operational percent - 88.2

| Monthly Measurements at Wellfield | | |
|---|---|---|
| Month | Monthly Average Re-Injection Rate (gpm) | Million Gallons Re-Injected |
| 1/99[a] | 131 | 5.829 |
| 2/99 | 188 | 7.598 |
| 3/99[b] | 180 | 8.036 |
| 4/99[c] | 174 | 7.561 |
| 5/99 | 187 | 8.344 |
| 6/99 | 195 | 8.419 |
| 7/99 | 198 | 8.847 |
| 8/99 | 193 | 8.653 |
| 9/99[d,e] | 131 | 5.640 |
| 10/99[f] | 177 | 7.905 |
| 11/99[g,h] | 156 | 6.667 |
| 12/99[h] | 169 | 7.624 |
| | Average 173 | Total 91.123 |

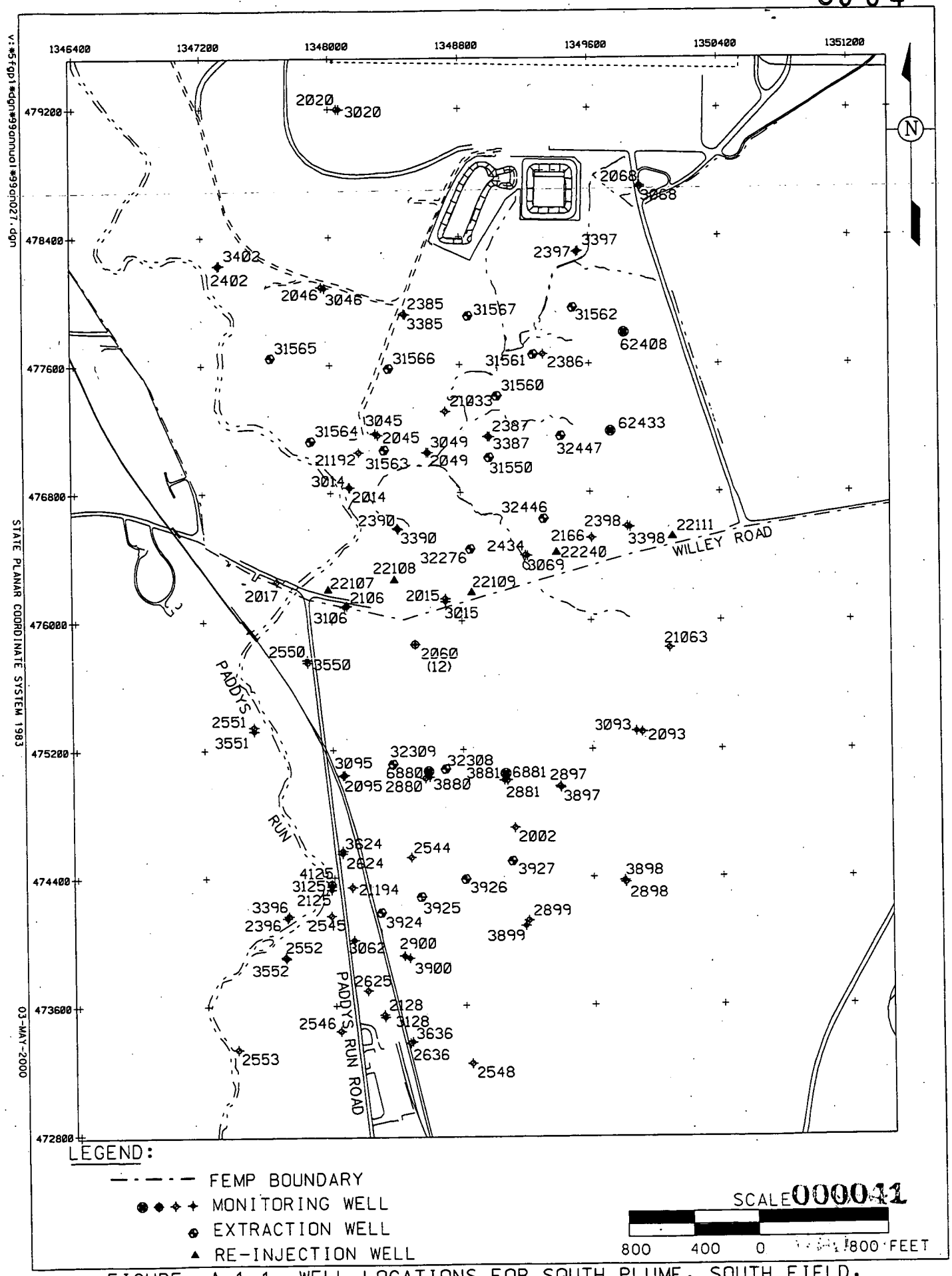
[a]Re-injection well was out of service for 11 days to mitigate the high total uranium concentrations at the Parshall Flume.
[b]Re-injection well was out of servcice for two days due to maintenance.
[c]Re-injection well was out of service for three days for treatment plant maintenance.
[d]Re-injection well was out of service for five days per the OMMP.
[e]Re-injection well was out of service for seven days per the OMMP (high uranium in injectate).
[f]Re-injection well was out of service for two days to regenerate resin.
[g]Re-injection well was out of service for four days due to construction tie-in.
[h]Re-injection well was out of service for two days in November and one day in December due to construction tie-in and distribution system pressure control valve preventive maintenance.

## TABLE A.1-24

## 1999 EXTRACTION WELL TARGET PUMPING RATES

| Module | Extraction Well | Initial Rates[a] | Target Rates[b] (gpm) |
|---|---|---|---|
| South Plume | 3924 | 300 | 300 |
| | 3925 | 300 | 300 |
| | 3926 | 400 | 400 |
| | 3927 | 500 | 500 |
| | 32308 | 250 | 250 |
| | 32309 | 250 | 250 |
| Sub-Total | | 2000 | 2000 |
| South Field (Phase 1) Extraction | 31550 | 100 | 100 |
| | 31560 | 100 | 100 |
| | 31561 | 100 | 100 |
| | 31562 | 100 | 200 |
| | 31563 | 200 | 200 |
| | 31564 | 200 | 200 |
| | 31565 | 200 | 200 |
| | 31566[c] | 200 | 0 |
| | 31567 | 100 | 100 |
| | 32276 | 200 | 300 |
| Sub-Total | | 1500 | 1500 |
| Total Pumping | | 3500 | 3500 |

[a]With the exception of the pumping rate for Extraction Well 3927, these pumping rates are identical to the design pumping rates presented in Table 5-1 of the Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration. The pumping rate for Extraction Well 3927 was increased from 400 to 500 gpm on November 6, 1997 to maximize the extent of the eastern edge of the capture zone in this area.
[b]The target pumping rates for some wells are different from the Baseline Remedial Strategy Report pumping rates shown in the first column and were changed based on operational experience with the extraction system. These rates were established on August 7, 1998, when Extraction Well 31566 was shut down and Extraction Wells 31562 and 32276 were increased.
[c]This well was shut off on August 7, 1998 after operational experience demonstrated its continued operation may have been detrimental in meeting system objectives. Pumping rates for Extraction Wells 31562 and 32276 were increased at that time to compensate for the shut down of Extraction Well 31566.




LEGEND:

FEMP BOUNDARY

MONITORING WELL

EXTRACTION WELL

RE-INJECTION WELL

SCALE 800 400 0 800 FEET

STATE PLANAR COORDINATE SYSTEM 1983

03-MAY-2000

v:\5fp1\dgn\96gn027.dgn

000041

FIGURE A.1-1. WELL LOCATIONS FOR SOUTH PLUME, SOUTH FIELD, RE-INJECTION AND PADDYS RUN ROAD SITE MONITORING ACTIVITES

000042

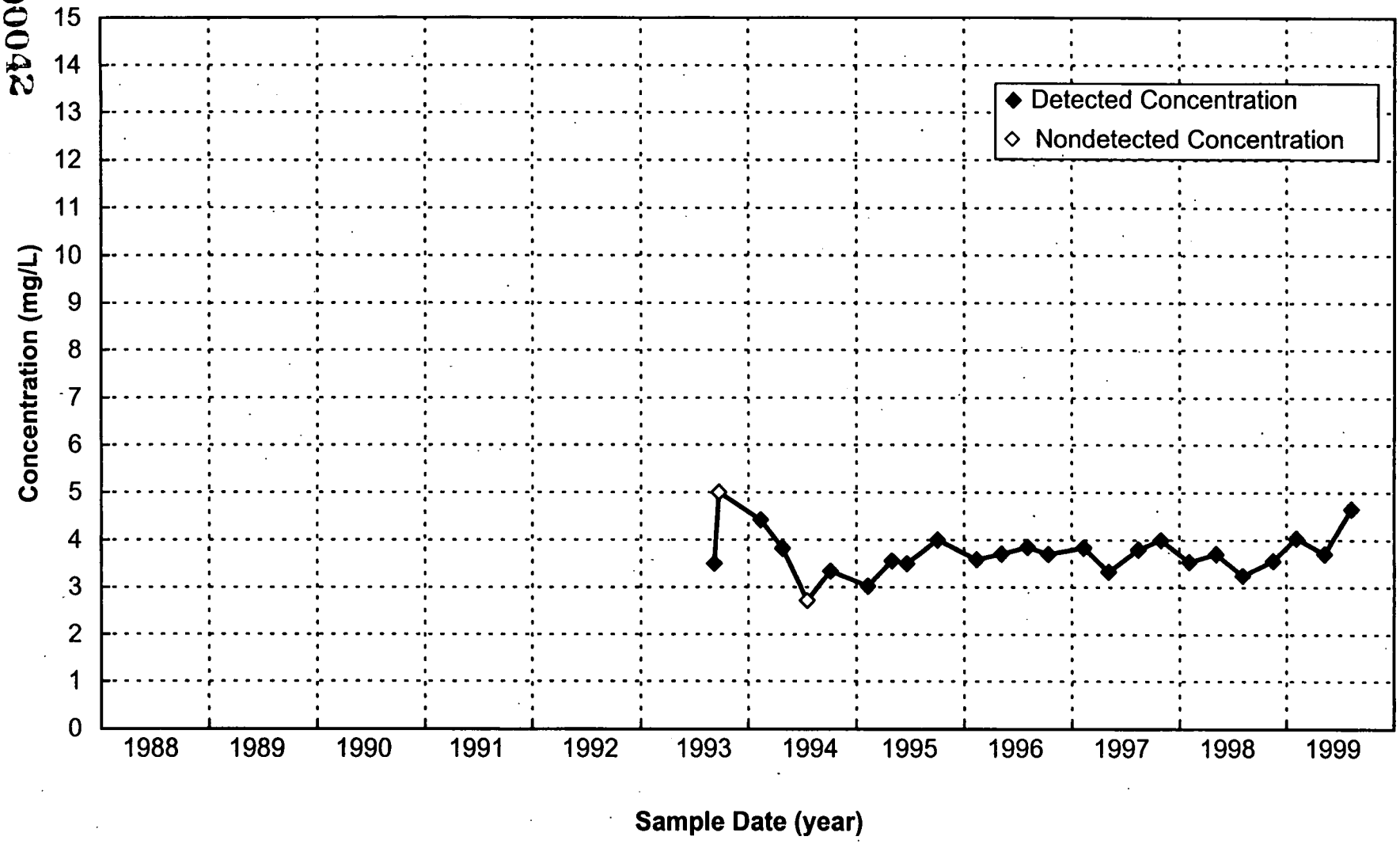
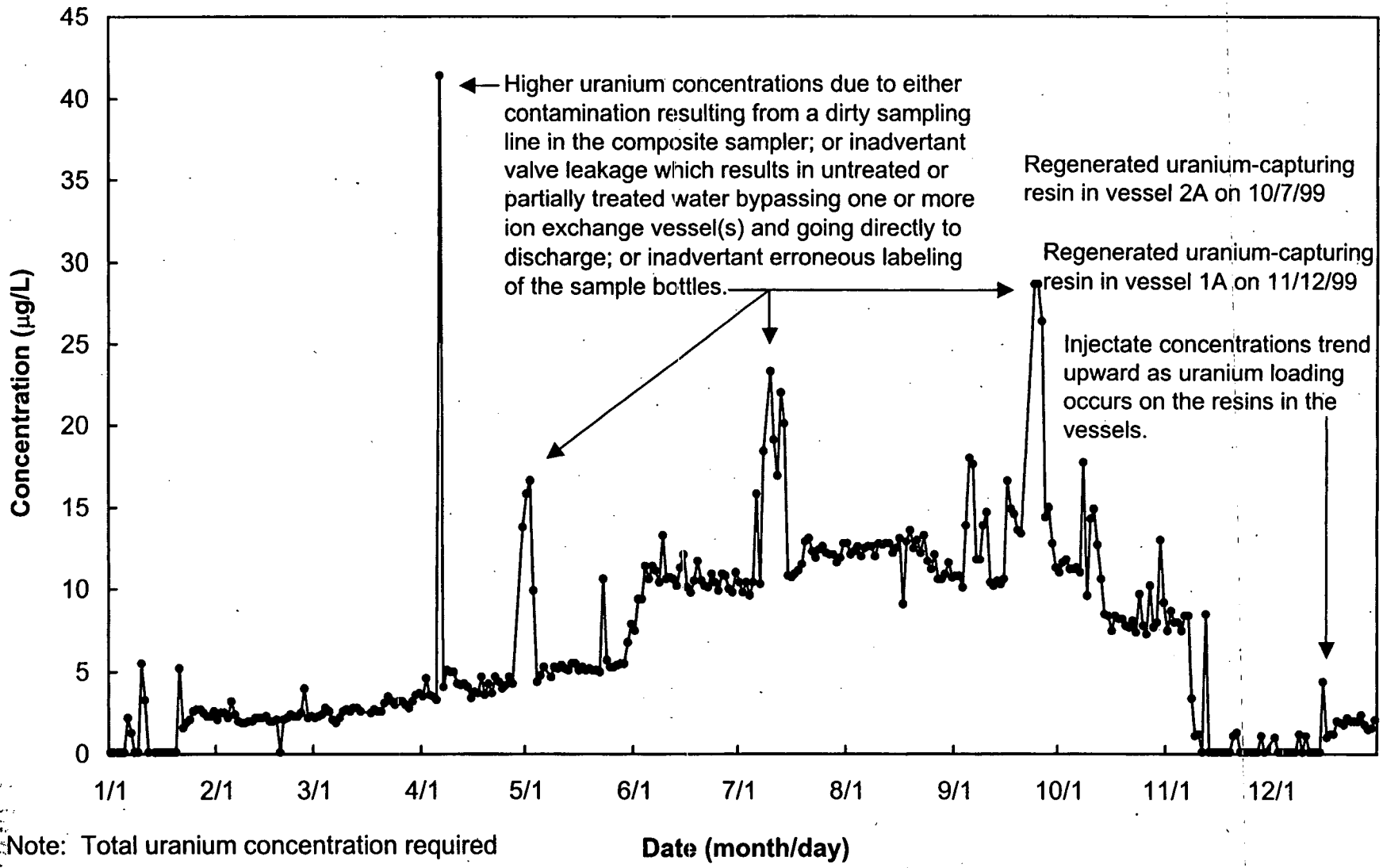



FIGURE A.1-2. POTASSIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2899




Note: Total uranium concentration required to be less than 20 µg/L.

FIGURE A.1-3. 1999 TOTAL URANIUM CONCENTRATIONS IN INJECTATE

000044

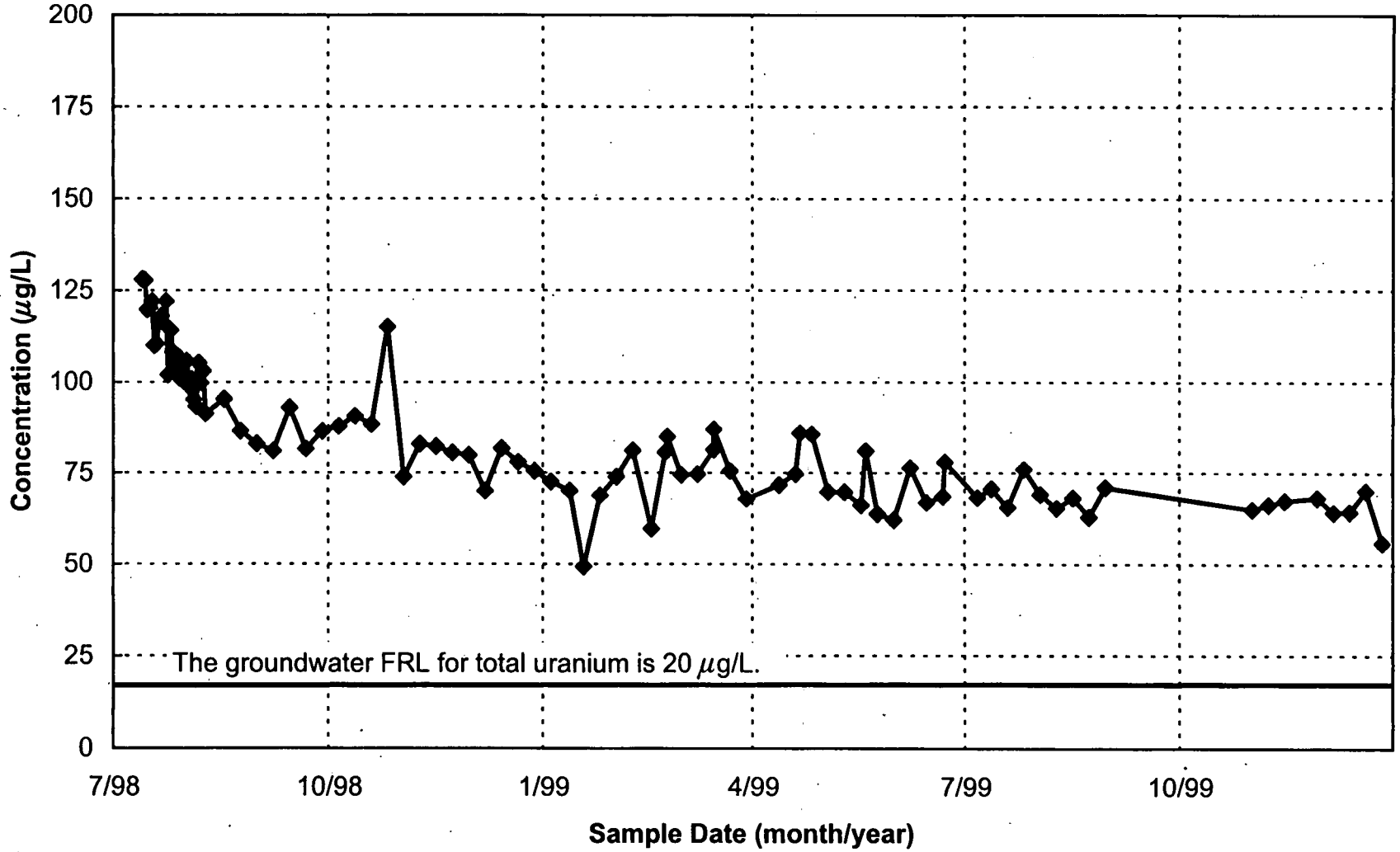



FIGURE A.1-4. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 31550

Modeled Concentration = 16.9 μg/L
Developed Concentration = 130 μg/L

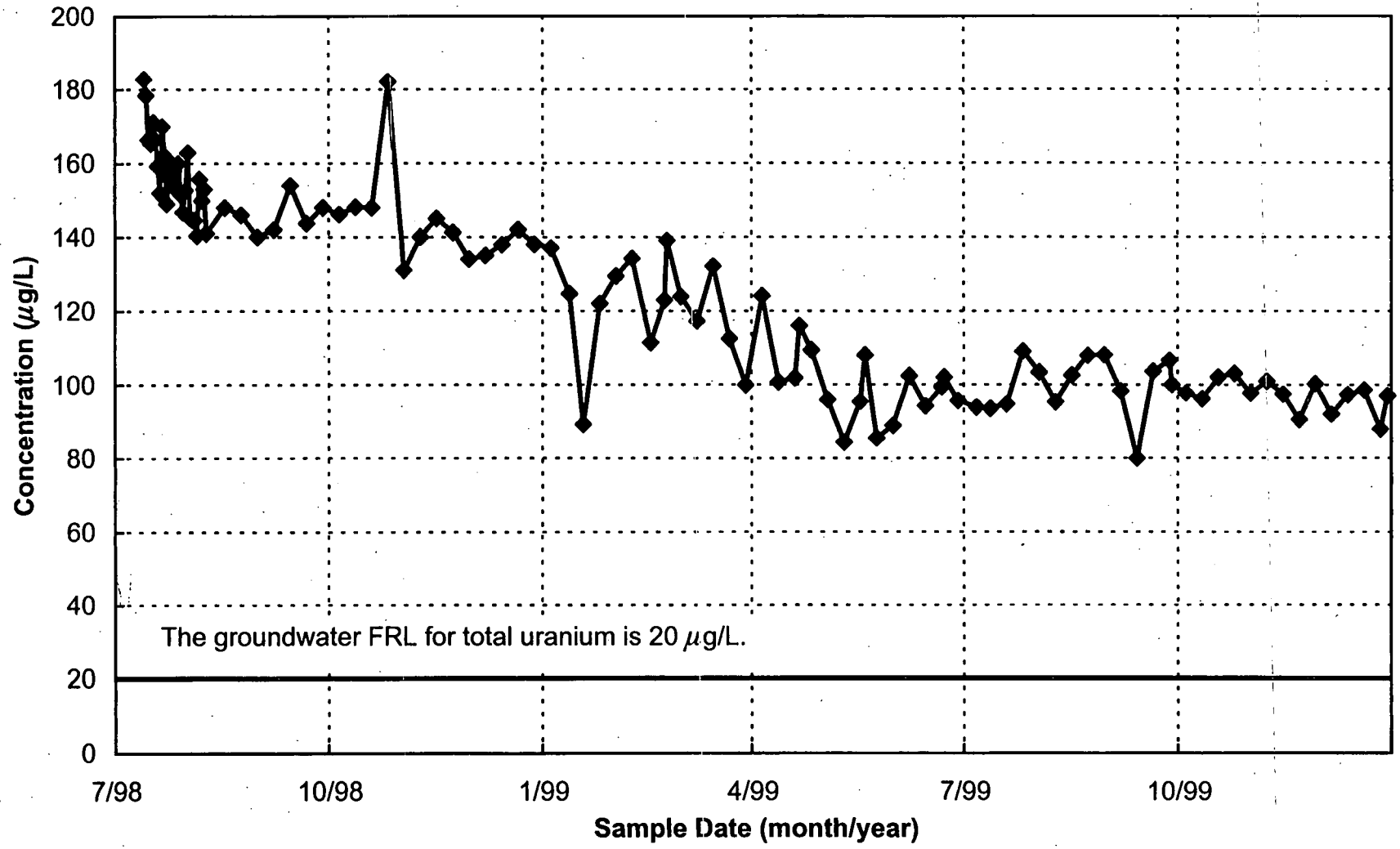



FIGURE A.1-5. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 31560

Modeled Concentration = 62.7 μg/L
Developed Concentration = 217 μg/L

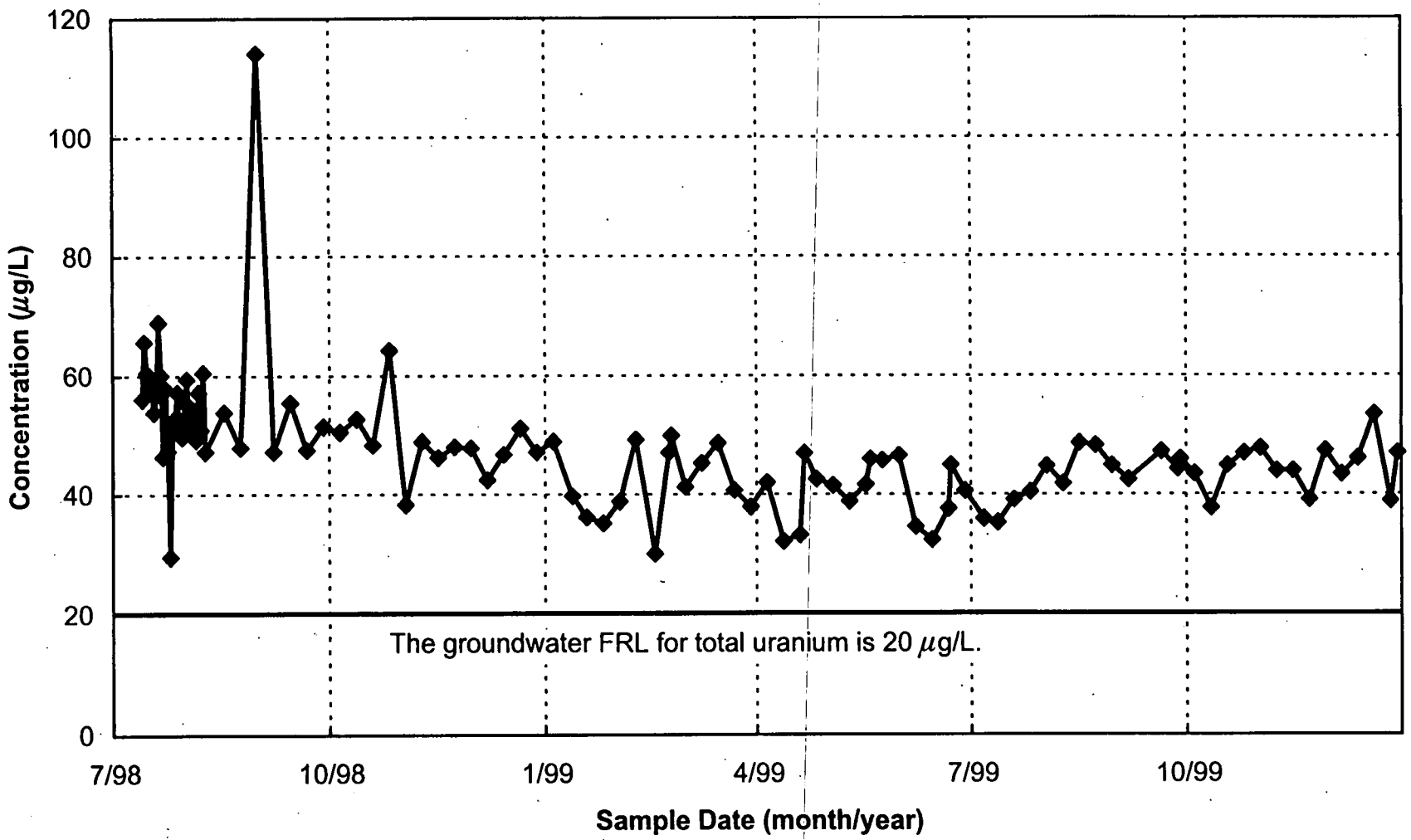



FIGURE A.1-6. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 31561

Modeled Concentration = 64.8 μg/L
Developed Concentration = 49 μg/L

000046

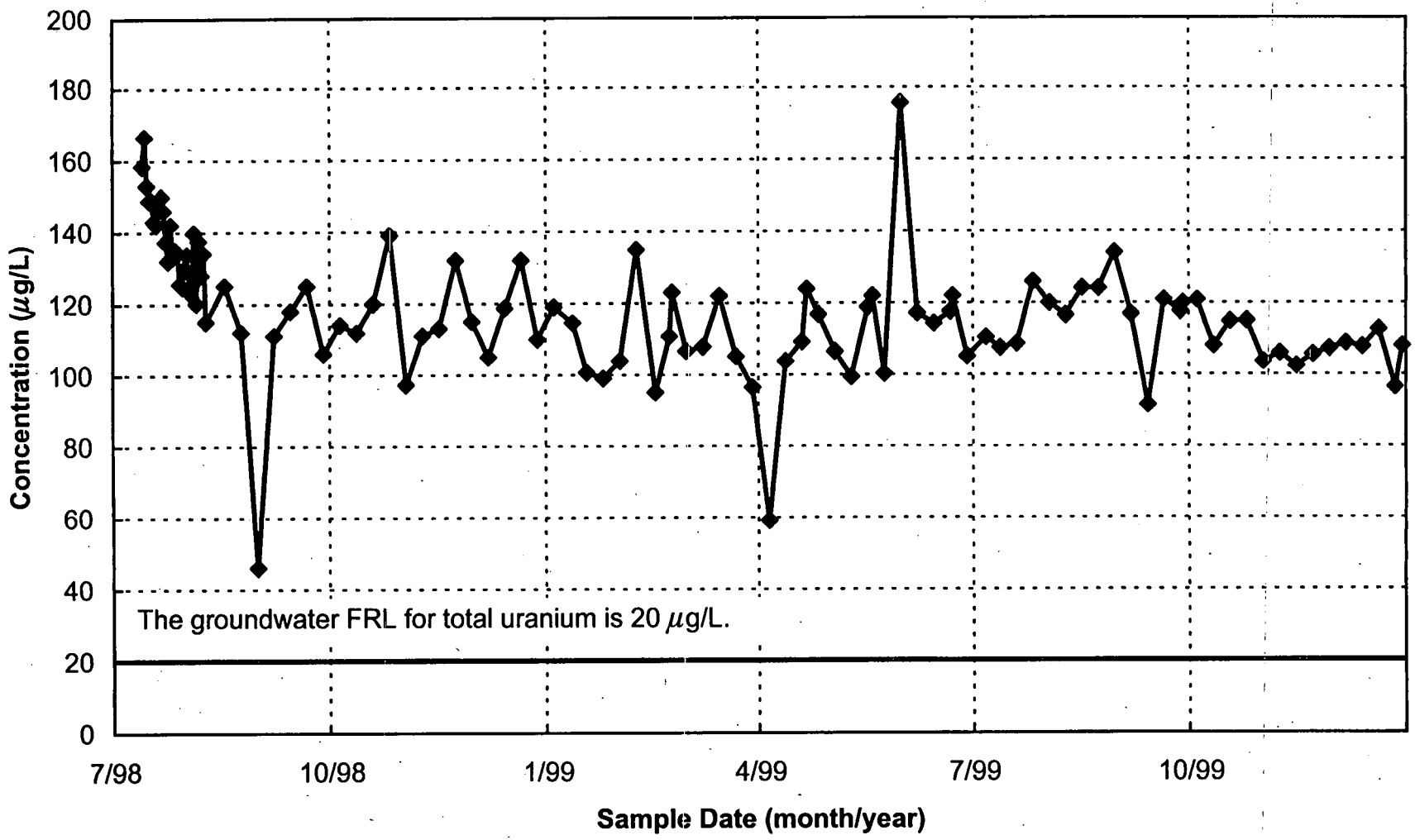



FIGURE A.1-7. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 31562

Modeled Concentration = 231.4 μg/L
Developed Concentration = 177 μg/L

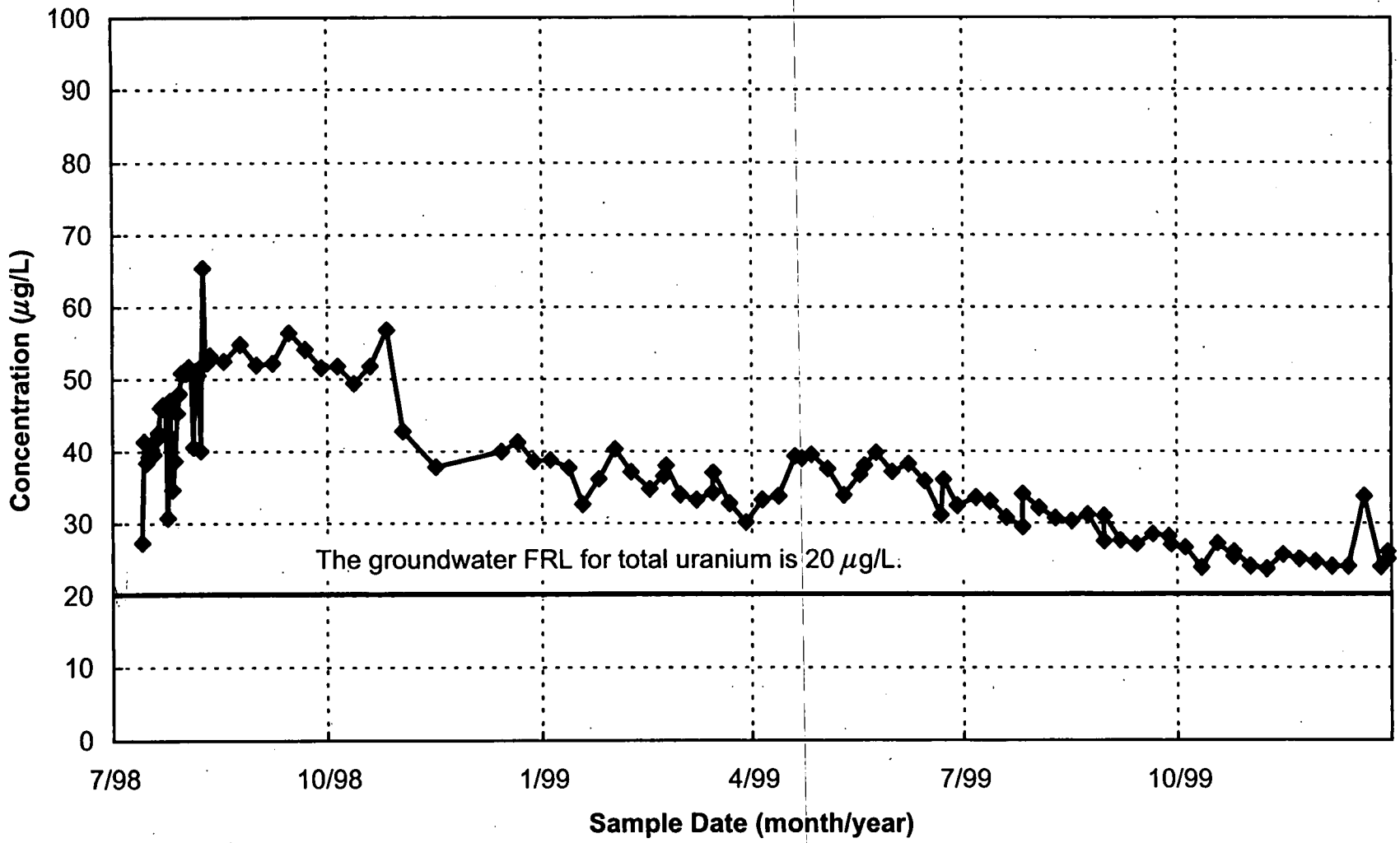



FIGURE A.1-8. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 31563

Modeled Concentration = 79.8 μg/L
Developed Concentration = 30 μg/L

000048

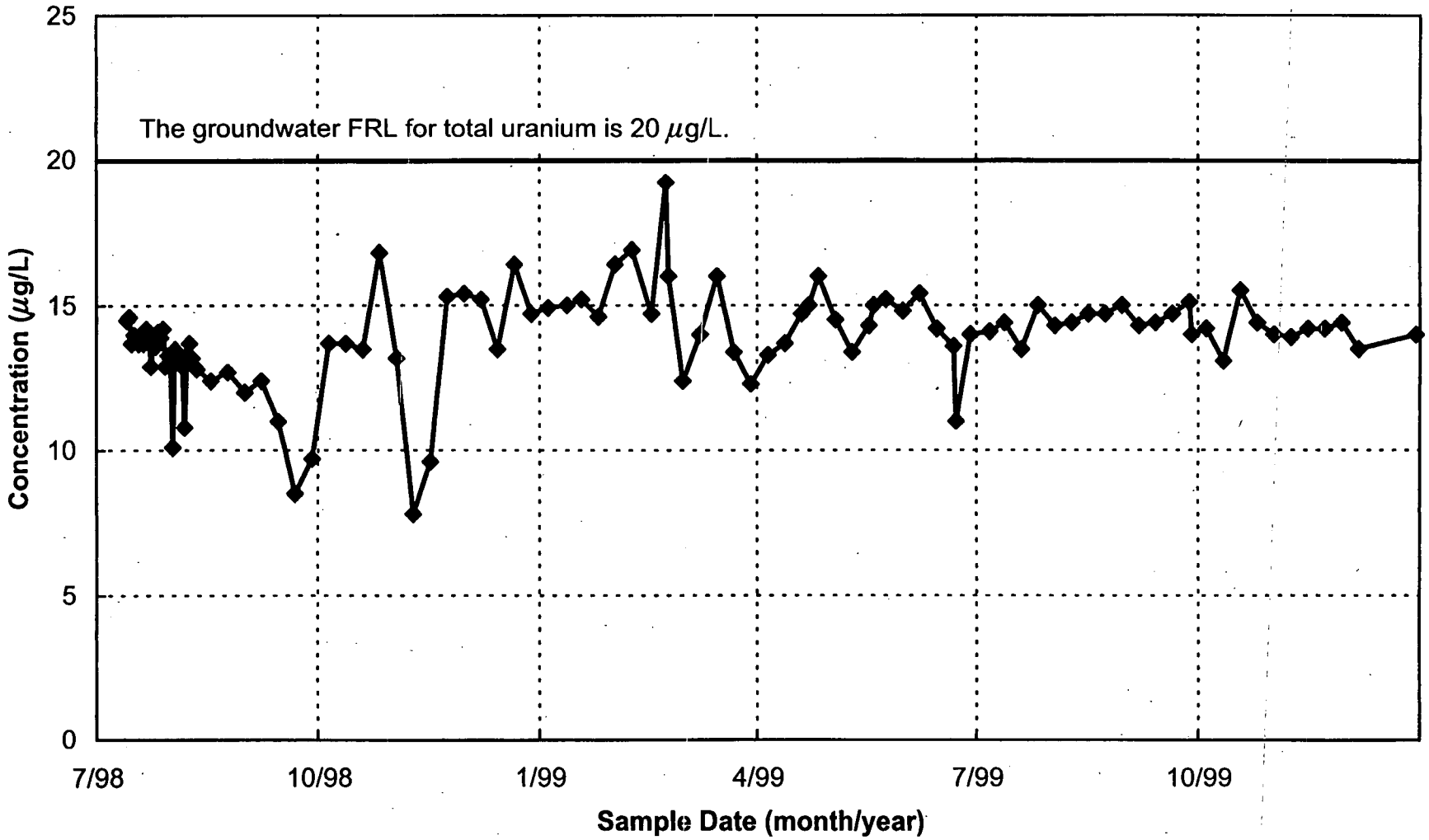



FIGURE A.1-9. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 31564

Modeled Concentration = 11.9 μg/L
Developed Concentration = 18 μg/L

000030

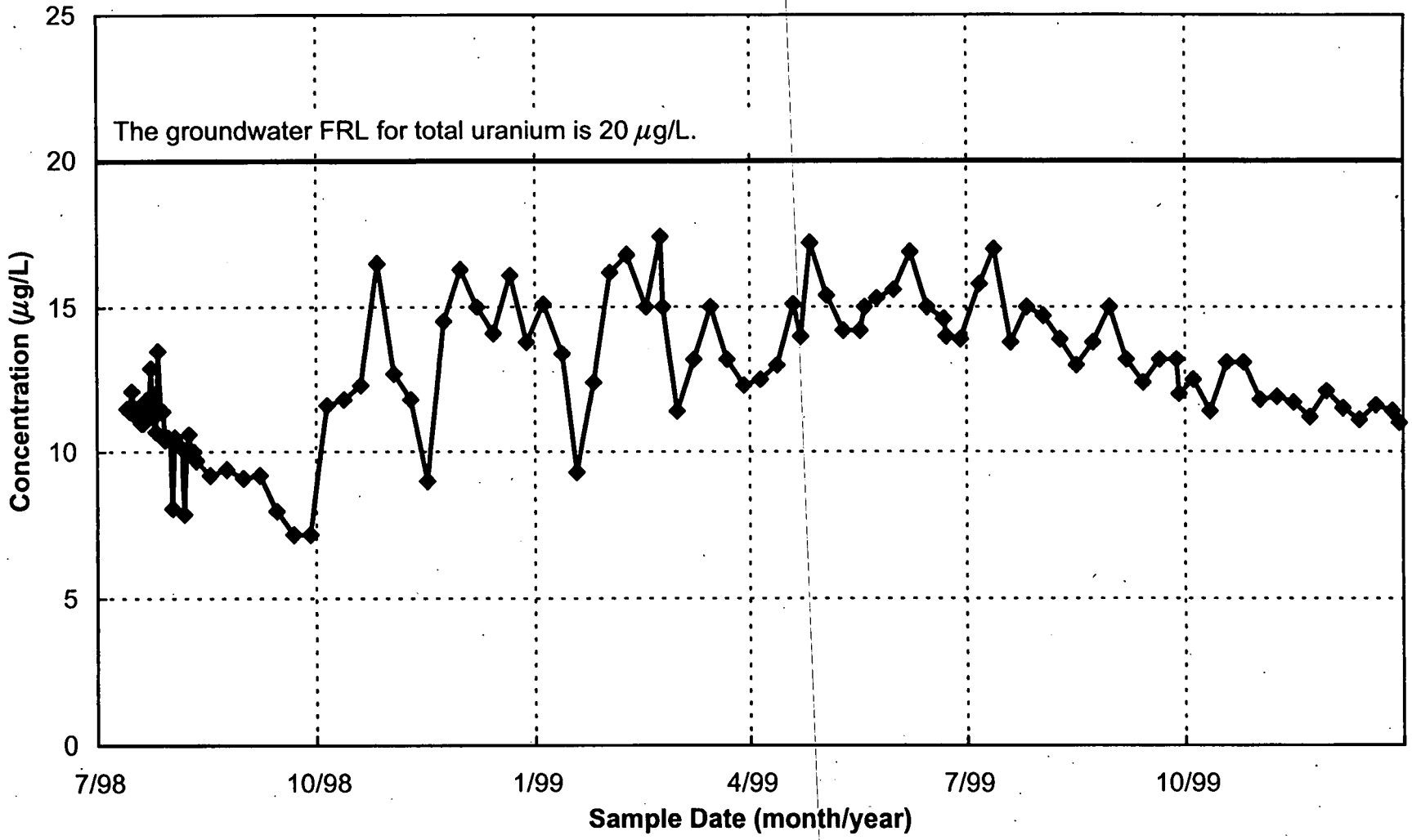



FIGURE A.1-10. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 31565

Modeled Concentration = 139.2 μg/L
Developed Concentration = 15 μg/L

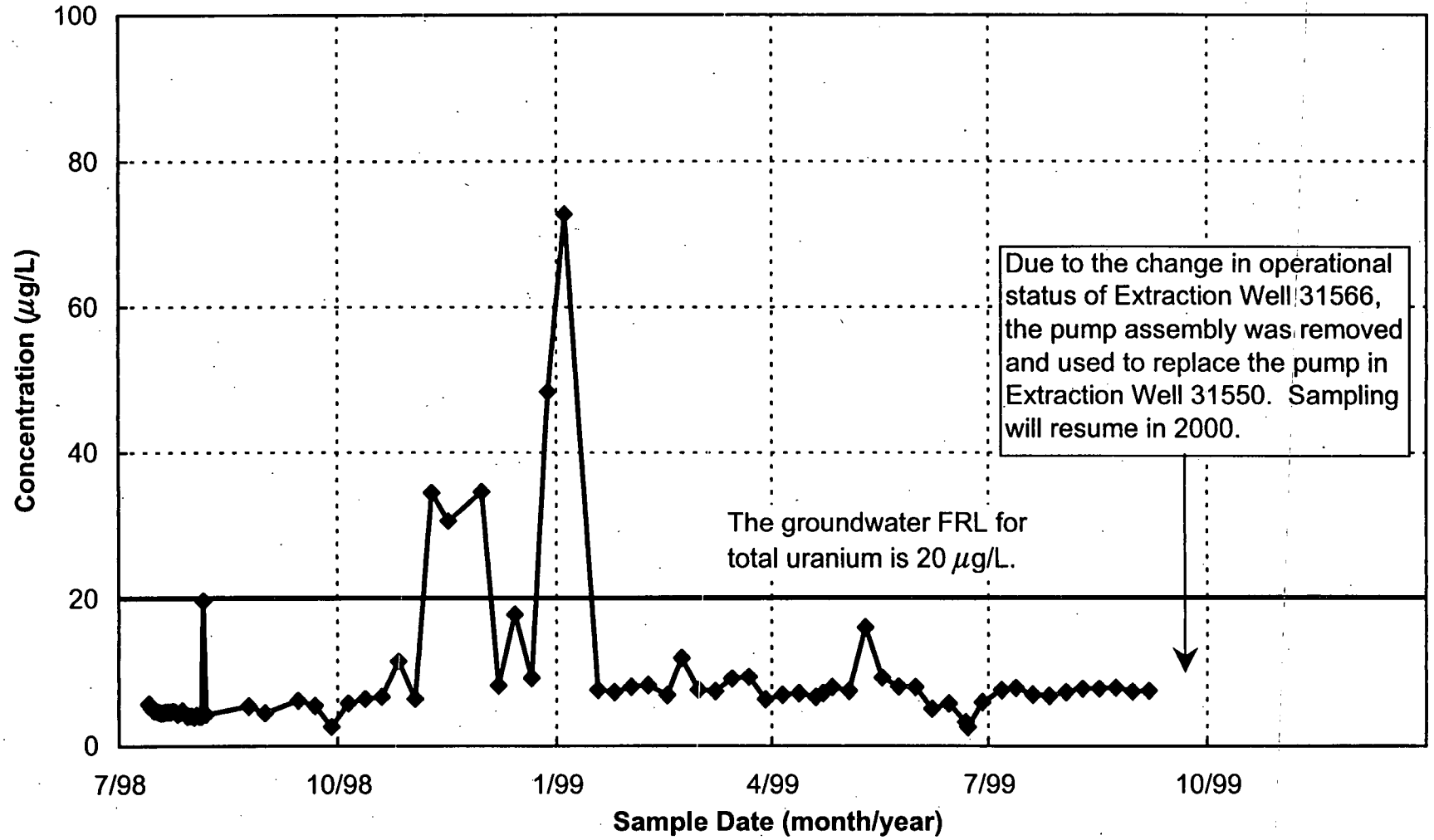



FIGURE A.1-11. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 31566

Modeled Concentration = 63.3 μg/L
Developed Concentration = 4.8 μg/L

000051

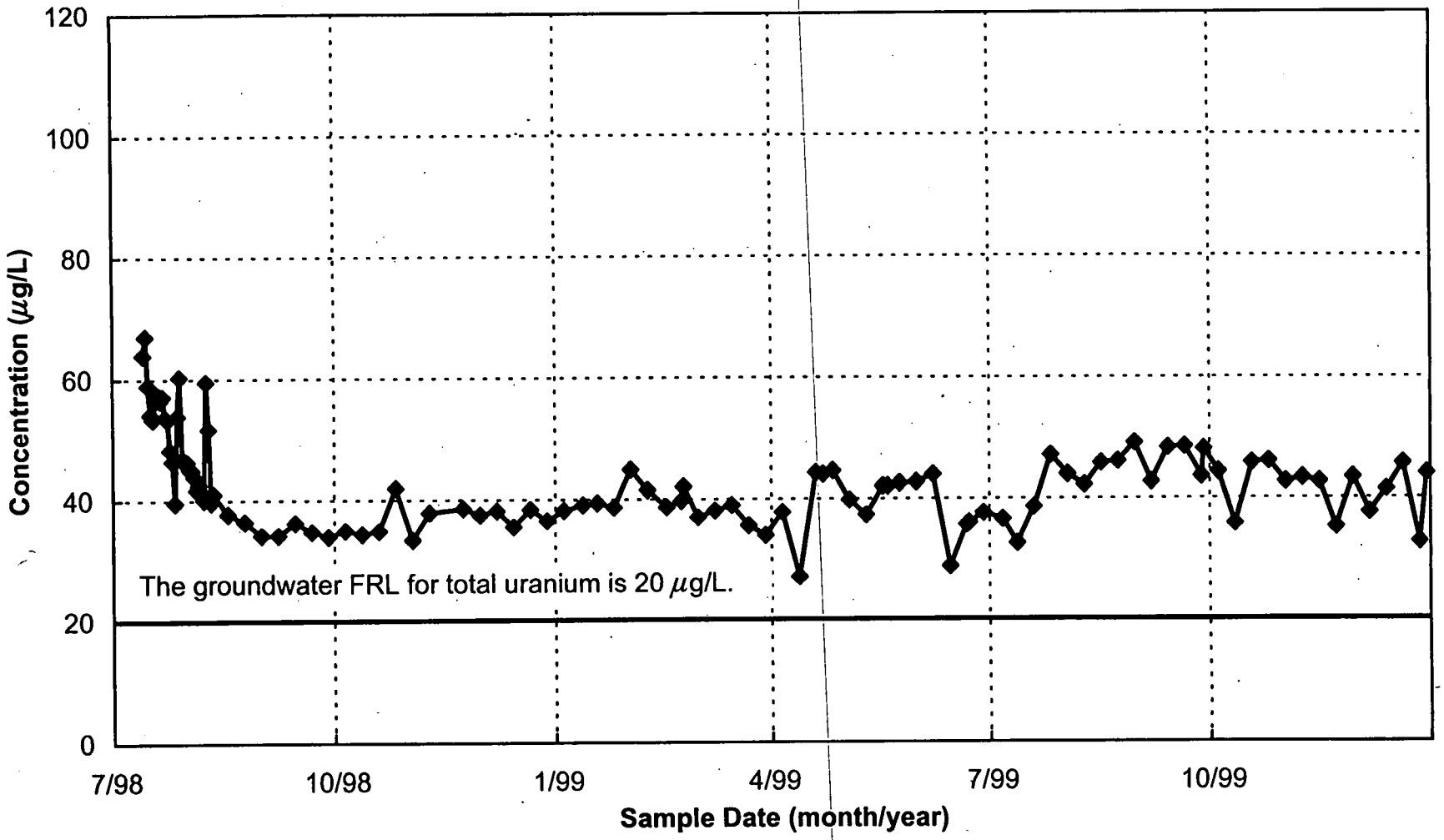



FIGURE A.1-12. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 31567

Modeled Concentration = 9.6 µg/L
Developed Concentration = 14 µg/L

000052

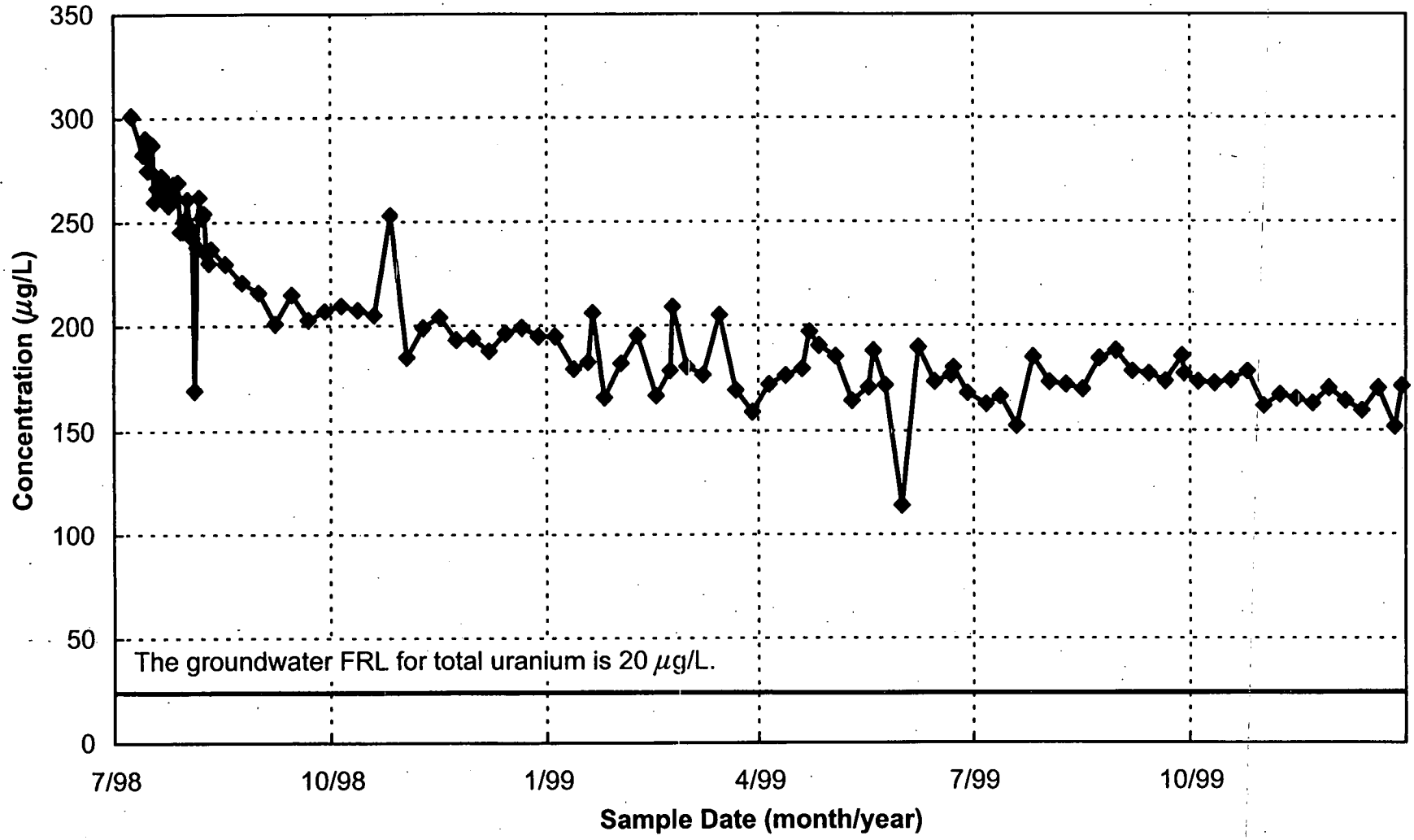



FIGURE A.1-13. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 32276

Modeled Concentration = 239.4 µg/L
Developed Concentration = 400 µg/L



000038

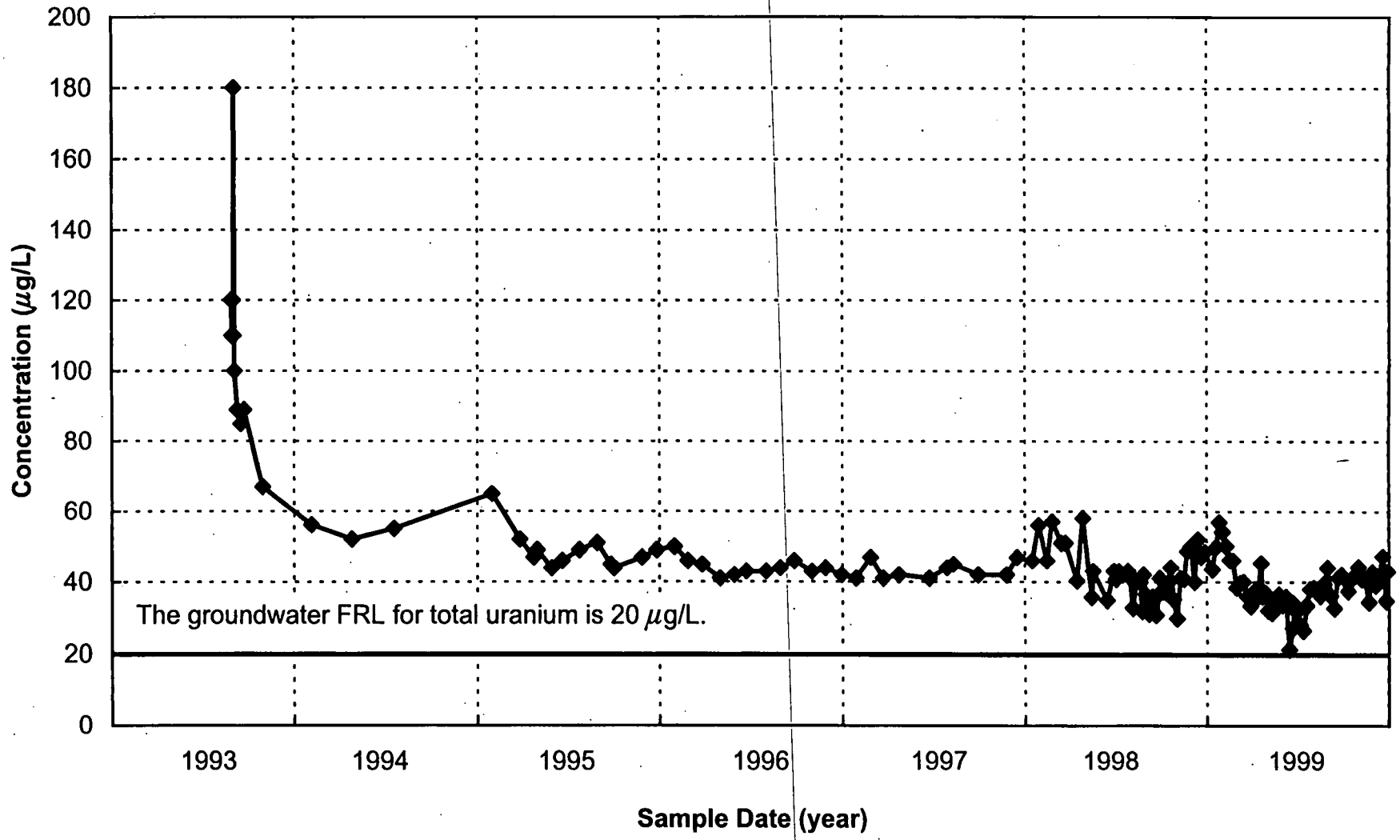



FIGURE A.1-14. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 3924

000054

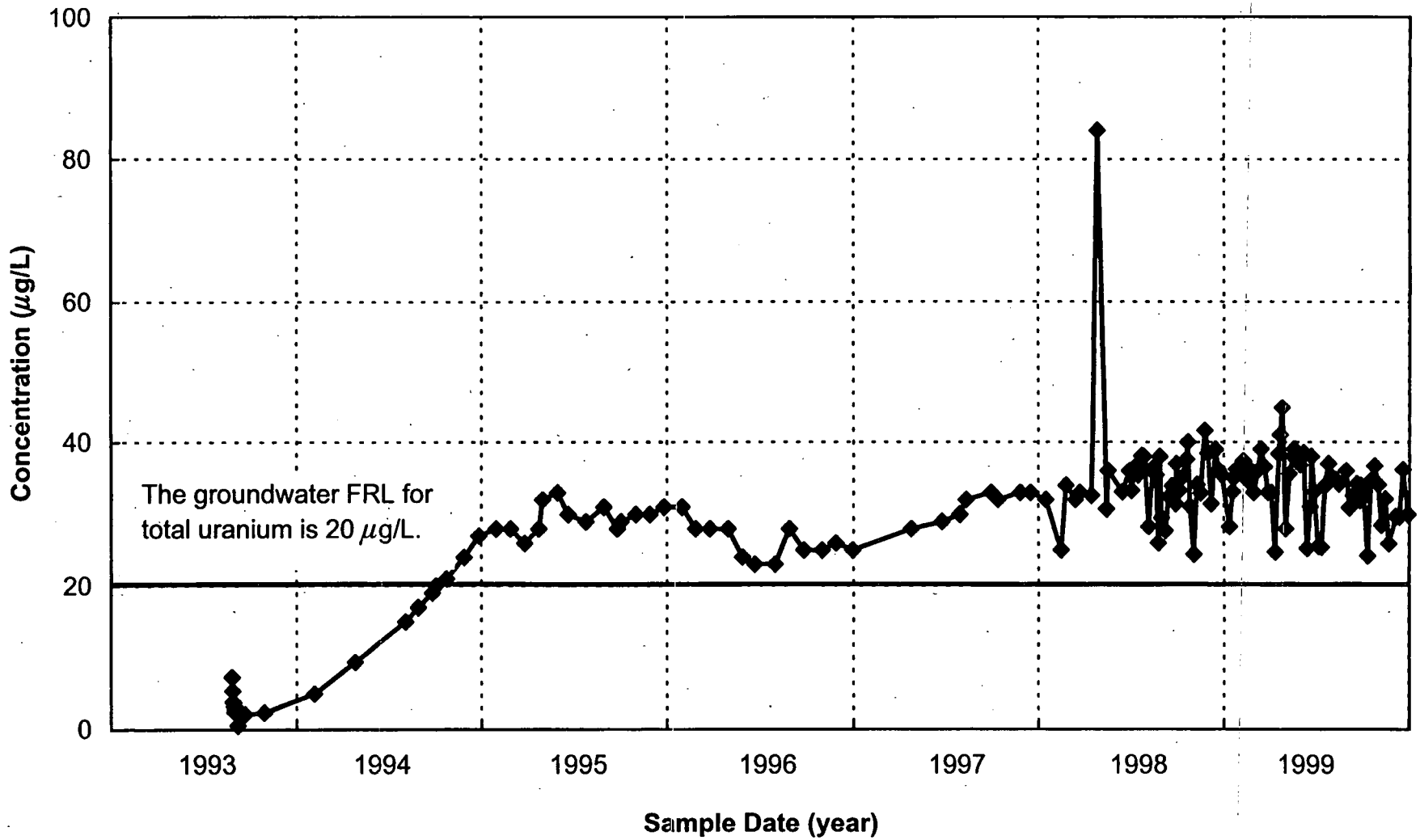



FIGURE A.1-15. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 3925



000055

000036

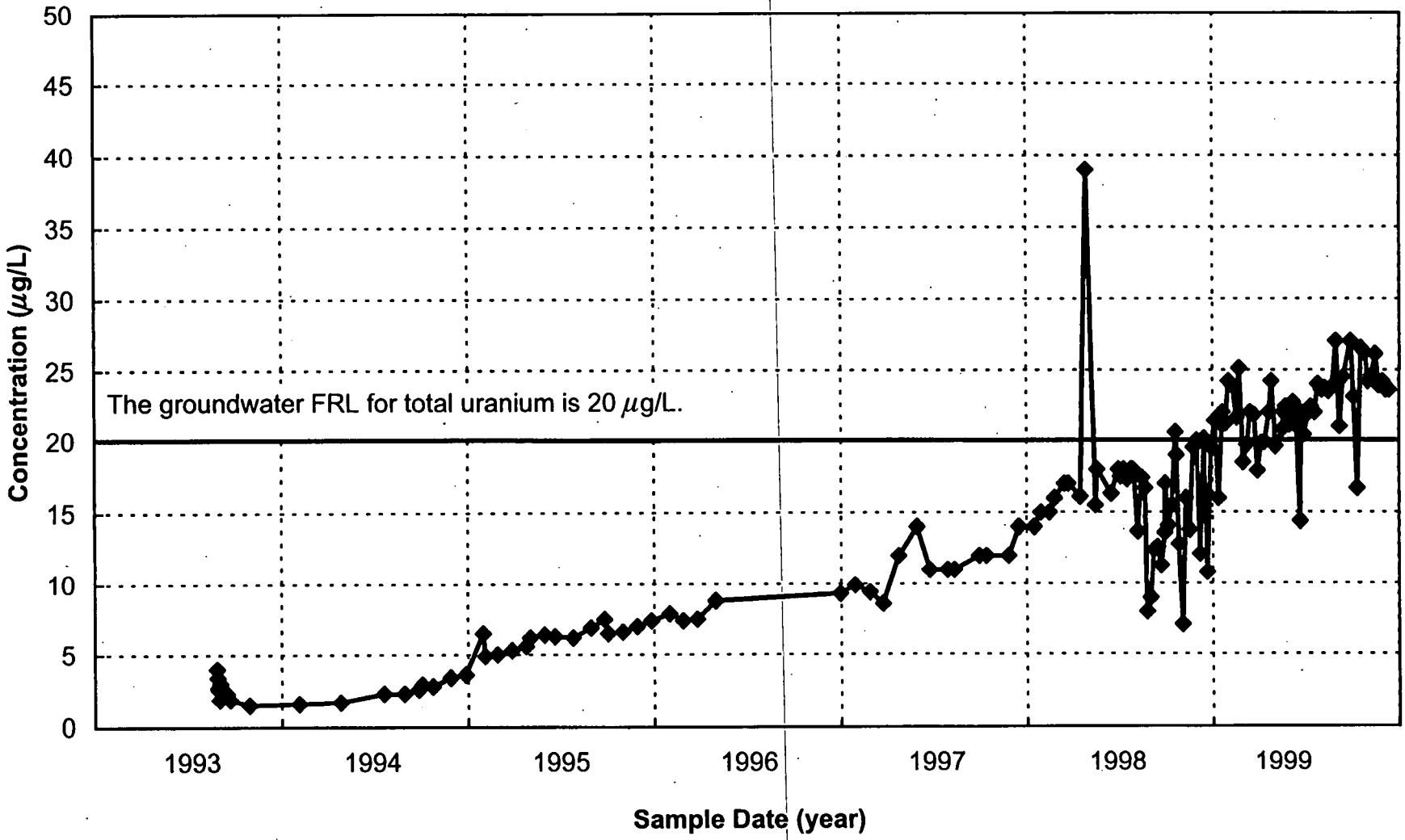



FIGURE A.1-16. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 3926

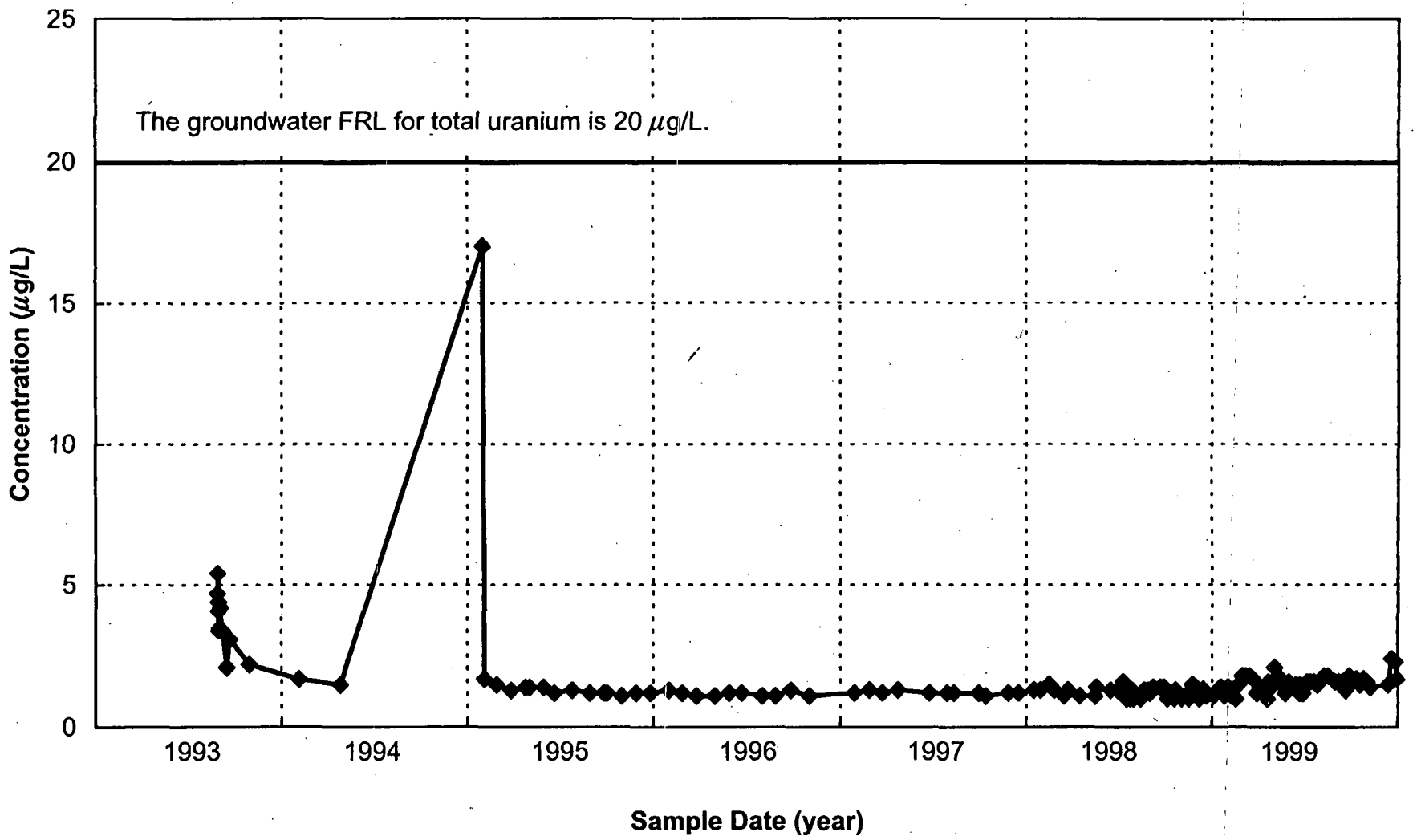



FIGURE A.1-17. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 3927

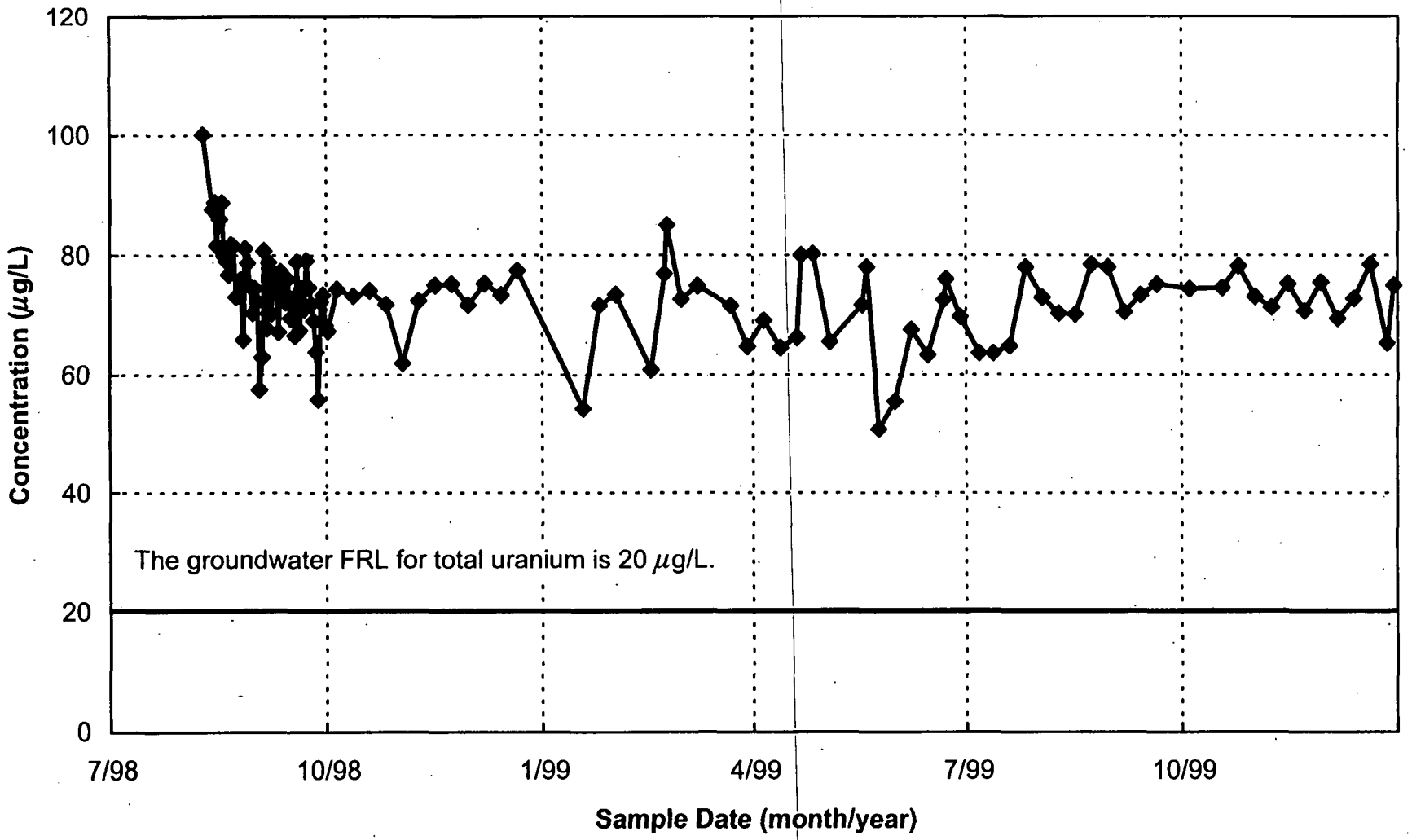



FIGURE A.1-18. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 32308

Modeled Concentration = 27.8 μg/L
Developed Concentration = 123 μg/L

000058

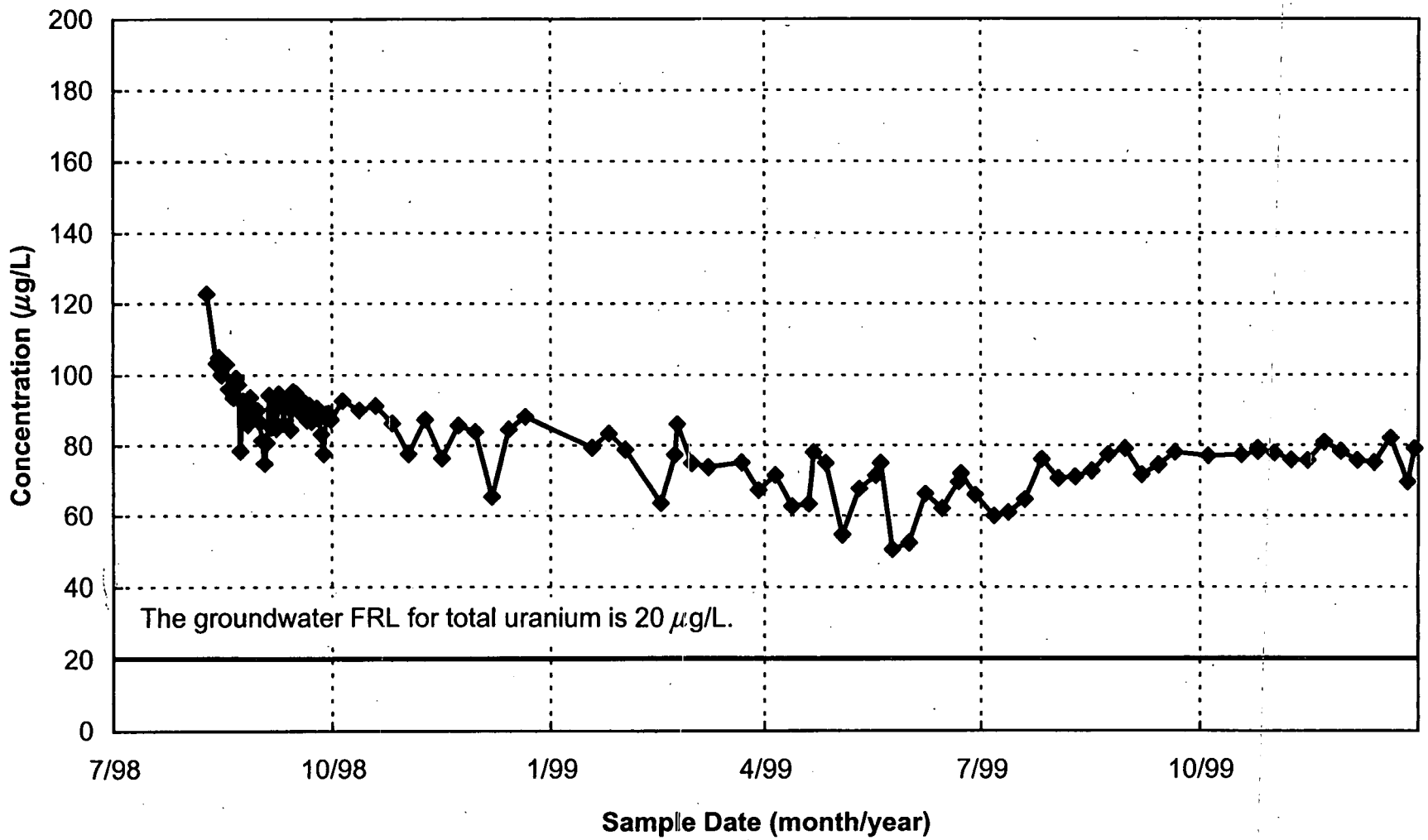



FIGURE A.1-19. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR EXTRACTION WELL 32309

Modeled Concentration = 45.6 μg/L

Developed Concentration = 143 μg/L

000060

Note: 2000 gpm = 87.6 million gallons/month

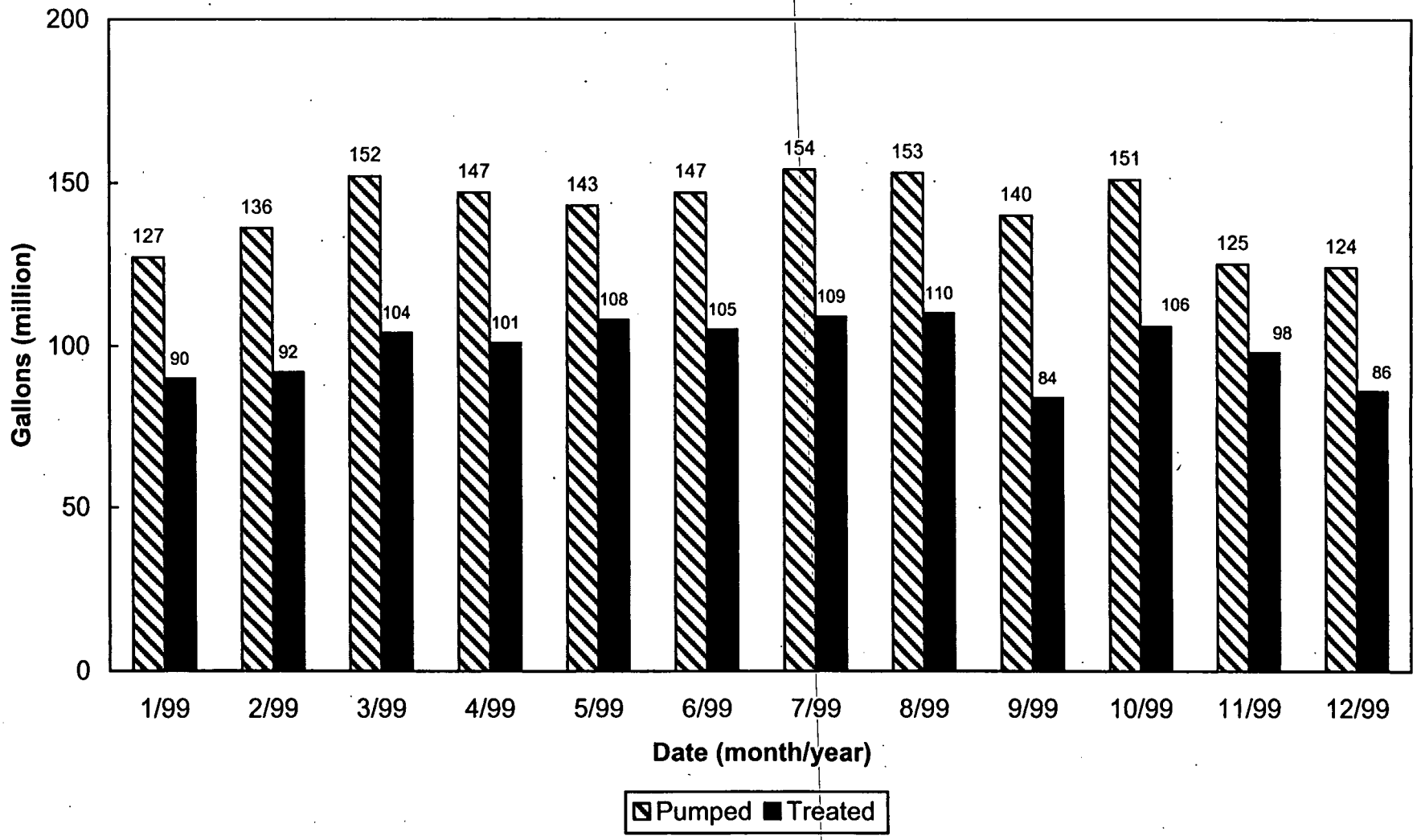



FIGURE A.1-20. TOTAL GROUNDWATER PUMPED VS. GROUNDWATER TREATED FOR 1999

# ATTACHMENT A.2

## ASSESSMENT OF TOTAL URANIUM RESULTS

# ATTACHMENT A.2

This attachment discusses the plume maps for all four quarters of 1999 in addition to well and Geoprobe® total uranium results and statistical trends. Monitoring and extraction well locations associated with the IEMP are shown in Figure A.2-1 and listed in Table A.2-1 according to the area designations from Figure A.2-1.

Figures A.2-2 through A.2-5 represent the maximum total uranium plume updated with data from the four quarters of 1999, respectively. Data collected quarterly from the aquifer are used to progressively update the total uranium plume in the following manner:

- Total uranium concentration data from the most recent quarter are posted on a map with the contours from the previous IEMP quarterly status report. The highest total uranium value of Type 2, 3, or 4 wells at a cluster is selected. The highest concentration associated with each Geoprobe® location is also selected.
- If the most recent quarterly concentration from a well is greater than the concentration contour value at that location, then the plume is re-contoured to honor the higher value.
- At some locations, the plume is migrating beneath the Type 2 well screen and above the Type 3 well screen based on Geoprobe® profile sampling data in the area. At these locations, if the quarterly concentration measurement from a well is less than what is contoured for that location, then the new data are posted but the plume contours are not adjusted to honor the new data.

A comparison of these four figures shows that in 1999, the size of the maximum total uranium plume increased most significantly in the eastern portion of the South Field area. The changes to the total uranium plume maps are explained below by quarter, including changes based on Geoprobe® results.

First Quarter Total Uranium Plume

The first quarter 1999 total uranium plume map shown in Figure A.2-2 changed significantly from the fourth quarter 1998 map in the northeastern region of the southern uranium plume. Groundwater samples collected at Geoprobe® Location 12408 had a total uranium concentration of 184 μg/L. This area of the aquifer had been previously mapped as being below 20 μg/L for total uranium. The total uranium plume contours were also modified due to higher total uranium concentrations at Monitoring Wells 2060 and 3069. Both of these wells lie in the midsection of the South Plume, in proximity to Willey Road.

Second Quarter Total Uranium Plume

From the first to the second quarter of 1999, the total uranium plume interpretation was modified in the vicinity of Monitoring Wells 3027, 2390, and 2546. Data collected at 11 Geoprobe® locations (12409, 12410, 12411, 12415, 12416, 12431, 12432, 12433, 12434, 12442, and 12443) in the South Field area also resulted in significant contour changes in the eastern and southern areas of the plume. The plume also changed in the vicinity around the following wells: Monitoring Well 2390 in the South Field area, had a total uranium concentration which rose above 100 µg/L to 123.3 µg/L and Monitoring Well 2546 had a total uranium concentration of 110 µg/L. Figure A.2-3 presents these changes.

Additionally, a total uranium concentration of 179.6 µg/L in Monitoring Well 3027 (located in the waste storage area [Figure A.2-3]) was reported as suspect because it was much higher than previous total uranium results, which were generally below 20 µg/L. Additional efforts to determine the source of the unusually high total uranium concentration in Monitoring Well 3027 were undertaken during the fourth quarter of 1999 and are discussed below.

Third Quarter Total Uranium Plume

From the second to the third quarter of 1999, the total uranium plume interpretation was modified in the vicinity of Monitoring Wells 2385 and 2049. The total uranium concentration at Monitoring Well 2385 increased to 255 µg/L, so the area around this well was re-contoured. The concentration at Monitoring Well 2049 increased to 178 µg/L, so the area around this well was also re-contoured. Figure A.2-4 depicts these changes.

During the second and third quarter, turbidity was high in some groundwater samples. Specifically, if the turbidity was high, the measured total uranium concentrations more than likely is not representative of mobile uranium in the aquifer. During the sampling/analysis process, non-mobile uranium, contained within the sediments causing the turbidity, is dissolved/digested along with the mobile uranium. This results in a uranium concentration that is too high to be representative of the mobile uranium portion of the plume. In the groundwater restoration industry, this phenomenon is a recognized issue for all metals analyses of turbid, unfiltered samples. The U.S. Department of Energy (DOE) is working with EPA and OEPA to modify the sampling protocol to include filtering the sample when the turbidity of the sample collected is greater than 5 nephelometric turbidity units (NTU). It is anticipated that the revised protocol will be established during the latter portion of 2000.

Third quarter total uranium concentration results for Monitoring Wells 2546 and 2900 exemplified this issue. At Monitoring Wells 2546 and 2900, the total uranium concentrations were 123 and 20 µg/L, and the turbidity of these samples was >999 and 49 NTU, respectively. These total uranium concentrations are shown in Figure A.2-4, but because the data are considered non-representative, the contours do not honor the data. Note that the second quarter 1999 total uranium result (110 µg/L) for Monitoring Well 2546, was also associated with a high turbidity (>999 NTU) sample. Therefore, Figure A.2-4 does not carry over the 20 µg/L circular contour found around Monitoring Well 2546 in Figure A.2-3.

Fourth Quarter Total Uranium Plume

Total uranium plume contours in the fourth quarter 1999 map were modified in the vicinity of Monitoring Wells 2552, 2385, 2049, 62433, and 62408. Furthermore, turbidity was a factor in the selection of concentration values at Monitoring Wells 2546 and 3027. Figure A.2-5 shows the fourth quarter 1999 total uranium plume map and results.

The fourth quarter sample collected from Monitoring Well 2552 had a total uranium concentration of 33 µg/L. This well is located at the extreme southern tip of the South Plume. Therefore, the 20 µg/L uranium plume contour shown on Figure A.2-5 was extended to the southwest to include this location. In doing so, it shows that this small portion of the plume was not within the capture zone. This shift in total uranium concentration at Monitoring Well 2552 has been observed in the past. In the past it has been reported that Monitoring Well 2552 is sometimes within the capture zone of the recovery system and sometimes outside the capture zone, as water levels in the aquifer fluctuate from seasonal drawdown and recharge (DOE 1997e). Turbidity was not an issue with this sample, as the turbidity of the sample was 1 NTU.

The plume was additionally modified in the vicinity of Monitoring Well 2385, where contours were adjusted to show that Extraction Well 31567 is pulling contaminated water eastward. In addition, contours were adjusted in the vicinity of Monitoring Wells 2049, 62433, and 62408. Remediation of groundwater in the area of Monitoring Wells 62433 and 62408 is expected to improve as soon as the two new extraction wells (32446 and 32447) come on line in 2000.

Turbidity was an issue for two other locations (Monitoring Wells 2546 and 3027). Several groundwater samples were collected from these wells in the fourth quarter. For Monitoring Well 2546, the final result for the extra sampling was a total uranium concentration of 2.1 µg/L, taken from a filtered sample, as the unfiltered turbidity was >999 NTU. For Monitoring Well 3027, the final result of the extra sampling was

a total uranium concentration of 45.15 µg/L, taken from an unfiltered sample, as the turbidity was 0 NTU. As previously identified, additional efforts to determine the source of the unusually high total uranium concentration in Monitoring Well 3027, which occurred during the second quarter, were undertaken during the fourth quarter of 1999. These efforts included a camera survey of the well to determine if perched water was leaking into the well; removing the dedicated pump and cleaning it; pumping the well to remove accumulated sediment; and collecting samples with varying turbidity and analyzing them for total uranium. Results of the camera survey indicated that the well was not leaking. As indicated above, it is more than likely that the higher concentrations were caused by higher turbidity samples.

Geoprobe® Sample Results

As previously noted, uranium plume profiling via the direct push Geoprobe® method was also conducted in 1999 and incorporated into the quarterly uranium plume map interpretations. The Geoprobe® work was completed to address three separate needs. These needs were:

- Support of the Re-Injection Demonstration along the southern property boundary
- Remedy performance monitoring in the South Field area
- Pre-design sampling in the waste storage area.

Six rounds of direct-push sampling for total uranium in groundwater were conducted from May 1998 through November 1999 in support of the Re-Injection Demonstration, which is located along the southern property boundary.

- Round A: May through June 1998
- Round B: July 1998
- Round C: December 1998 through January 1999
- Round D: March 1999
- Round E: June through July 1999
- Round F: September through November 1999.

These data were used to create eight cross-sections: A-A' and B-B' for Round A (Figures A.2-6 and A.2-7); C-C' for Round B (Figure A.2-8); D-D' for Round C (Figure A.2-9); E-E' for Round D (Figure A.2-10); F-F' for Round E (Figure A.2-11); and G-G' and H-H' for Round F (Figures A.2-12 and A.2-13).

The locations comprising Cross-Section A-A' are downgradient of each re-injection well. This cross-section serves as a benchmark for the total uranium plume's shape (out in front of the five re-injection wells) prior to the start of the active restoration in this area. At the end of the one-year Re-Injection Demonstration, Geoprobe® samples were collected from the same five locations to determine the effect that one year of active pumping and re-injection in this area had on the plume (refer to Cross-Section H-H').

Cross-Section B-B' consists of three locations, immediately east, west, and downgradient of Re-Injection Well 22109. Re-Injection Well 22109 is located in an area of the total uranium plume that has total uranium concentrations over 400 µg/L. This cross-section will serve as a benchmark for the total uranium plume's shape around Re-Injection Well 22109 prior to the start of the active restoration in this area. A draft Re-Injection Demonstration Test Report for the Aquifer Restoration and Wastewater Project (DOE 2000b) was issued in June 2000 with a complete interpretation of these results.

These three locations were re-sampled using the Geoprobe® on a quarterly basis during the Re-Injection Demonstration to determine the effect of re-injection and pumping on the plume (Cross Sections B-B', C-C', D-D', E-E', F-F', and G-G'). Rounds of Geoprobe® sampling at these three locations occurred in July 1998, January 1999, March 1999, June and July 1999, and September and November 1999, and were presented in the 1999 IEMP quarterly status reports.

Geoprobe® sampling to support remedy performance monitoring were collected at 12 locations (12408, 12409, 12410, 12411, 12415, 12416, 12431, 12432, 12433, 12434, 12442, and 12443) in the South Field area. As previously noted, this sampling resulted in significant contour changes in the eastern and southern areas of the plume in the South Field area. This Geoprobe® sampling effort also identified the need for the installation of additional extraction wells on the eastern side of the on-property portion of the southern plume. The installation of these additional extraction wells during 1999 was not required to maintain capture of the plume; however, they were necessary to support the accelerated aquifer remediation schedule. This information was communicated to the EPA and OEPA through conference calls. The new extraction wells (32446 and 32447) were installed in the fourth quarter of 1999 as indicated in Attachment A.1.

Pre-design Geoprobe® results from direct-push sampling in the waste storage area at Geoprobe® Locations 12614, 12615, 12616, 12618, and 12619 were posted to the fourth quarter total uranium plume map but did not change the contours. This sampling is being conducted to support the design of the Waste Storage Area Aquifer Restoration Module. This sampling is scheduled for completion in 2000; subsequently, the data will be used to develop a conceptual design report. The report will identify the proposed locations of extraction wells and will contain the data used to select the proposed locations.

Early in 2000, the pre-design characterization continued utilizing a total of 30 direct-push sampling locations in the waste pit and Plant 6 areas. The specific objectives of this characterization were to better define the vertical and lateral extent of the uranium plume so that the number and location of extraction wells required for the remediation could be defined. Although the information was not collected as part of the 1999 IEMP monitoring program, the significance of the new data warrants its mention in this report.

Prior to this characterization effort, uranium contamination in the waste storage area was interpreted as a single large uranium plume. As a result of the recent data, this interpretation has been refined to depict three individual plumes beneath the waste storage area. The most significant is a relatively narrow east-west trending plume that parallels and extends east of the Pilot Plant Drainage Ditch. The source of this plume, which has uranium concentrations up to 566 μg/L is thought to be infiltration through the bed of the drainage ditch. The second plume, whose boundaries may not have been fully defined due to the inability to sample beneath portions of Operable Unit 4 and the Bio-Surge Lagoon, is located south of the Bio-Surge Lagoon and east of Operable Unit 4. The plume appears to be shallow with a maximum uranium concentration of 31 μg/L measured at the water table. Further definition of this plume will be required after removal of Operable Unit 4 sources and the Bio-Surge Lagoon. The third, northernmost plume is located east of the Waste Pit 1, 3 and clearwell area. To be conservative, it has been characterized as existing beneath these features. Confirmation of its actual presence beneath the waste pits/clearwell will have to wait until the waste pits/clearwell have been remediated. A maximum uranium concentration of 30 μg/L was measured approximately 10 feet below the water table.

Additional characterization of the Plant 6 area detected no uranium concentrations above the FRL of 20 μg/L at any of the sampling points.

Additional discussion and illustrations of the results of this characterization effort will be presented in the Engineering Design of the Great Miami Aquifer Remedy in the waste storage and Plant 6 areas and summarized in forthcoming IEMP quarterly status reports.

1999 Total Uranium Statistics and Trends

Figures A.2-15 through A.2-139 present total uranium concentration versus time plots for all IEMP monitoring wells. All figures show unfiltered and detected results with the exception of Monitoring Wells 2546 and 3027, where some of the unfiltered results were not used as the associated turbidity readings were high.

Tables A.2-2 and A.2-3 list the monitoring wells and extraction wells, respectively, where total uranium concentrations exceeded the 20 μg/L FRL during 1999. Included in the tables are statistical summaries for total uranium concentrations at each well and a calculated statistical trend. Additionally, as indicated in Tables A.2-2 and A.2-3 and Figure A.2-14, 11 wells with total uranium FRL exceedances had Up, Significant trends based on the Mann-Kendall test for trend. However, these 11 wells with exceedances and Up, Significant trends were within the 10-year, uranium-based restoration footprint:

- Monitoring Well 3027 is located in the waste storage area east of Waste Pit 6. The total uranium concentration was 45.15 µg/L in fourth quarter 1999, with an associated turbidity of 0 NTU. As shown in Figure A.2-82, the graphical trend of the data for 1999 is decreasing from a second quarter 1999 high of 179.6 µg/L with an associated turbidity of >999 NTU.

- Monitoring Well 2648 is also located in the waste storage area. The total uranium concentration was 21.04 µg/L in fourth quarter 1999, with an associated turbidity of 1 NTU. As reported in the Integrated Environmental Monitoring Status Report for Second Quarter 1999 (DOE 1999c), in December of 1998, the integrity of this well was compromised for a period of time due to surface water infiltration. As shown on Figure A.2-69, total uranium concentrations decreased from 57.3 µg/L in fourth quarter 1998 to 19 µg/L in first quarter 1999. Sample turbidity also decreased (172 and 86 NTU, respectively) for those samples. However, the second quarter 1999 result was 73.7 µg/L, with an associated turbidity of 44 NTU. The lower concentrations in this well indicate that surface water infiltration problems noted in previous IEMP reports have been curtailed. However, sample turbidity may also be a factor with the concentrations associated with this well. Future samples may be filtered pending EPA and OEPA concurrence with revised sampling protocol previously discussed.

- Monitoring Well 2397 is located in the eastern portion of the South Field area. This well is within the capture zone created by the South Field (Phase I) Extraction Module. The well appears to be monitoring the progression of the more concentrated plume from the west on its way to Extraction Well 31562. Samples were not collected from this well in fourth quarter 1999 or first quarter 2000 due to it being dry. Three sample attempts were made in the fourth quarter. The first time was December 22, 1999, when the sample technicians could not get water out of the dedicated pump. The second time was December 28, 1999, when the QED MicroPurge® dedicated pump was pulled and the well was bailed dry. The third time was December 29, 1999, when the well went dry before enough water was obtained to take water quality measurements. Although this well was not sampled in the fourth quarter of 1999, the third quarter total uranium concentration was 414.9 µg/L. Refer to Figure A.2-49 for total uranium concentration results.

- Monitoring Well 2385 is located just east of the former inactive flyash pile. The total uranium concentration was 592.2 µg/L in fourth quarter 1999, which is the maximum result from 1988 through 1999. As noted in Attachment A.1, uranium contamination from the plume emanating from the area beneath the former inactive fly ash pile area is being drawn toward the extraction wells to the east of Monitoring Well 2385. Refer to Figure A.2-43 for total uranium concentration results.

- Monitoring Well 2049 is located near the geographic center of the South Field (Phase I) Extraction Module. The total uranium concentration was 164.4 µg/L in fourth quarter 1999, which was slightly less than the third quarter 1999 concentration of 177 µg/L. As shown in Figure A.2-30, the overall trend for total uranium concentrations is increasing since the third quarter of 1997. As noted in the Integrated Environmental Monitoring Status Report for Fourth Quarter 1999 (DOE 2000a), this increase may be due to the pumping of Extraction Well 31563, which could be drawing the uranium plume back toward it from the east. Continued sampling will determine whether the concentration trend continues to increase.

- Monitoring Wells 2398 and 3069 are located near the northeastern lobe of the southern uranium plume. The overall Up, Significant trends in both wells were also reported in the 1997 and 1998 Integrated Site Environmental Reports. However, Figures A.2-50 and A.2-91 (for Monitoring Wells 2398 and 3069, respectively) show downward trends in concentration for 1999. It is anticipated that two new South Field extraction wells installed in the fourth quarter of 1999 will accelerate remediation of the plume in this area.

- Extraction Wells 3925 and 3926 are South Plume extraction wells; the Up, Significant trends indicate that contamination was being drawn to the wells from the higher concentrations in the central portion of the plume to the north. In addition, Up, Significant trends were calculated for South Plume Monitoring Wells 2544 and 3095, which are situated north of Extraction Well 3925. The last total uranium result in 1999 for Monitoring Well 2544 was 41 µg/L, which is greater than the last uranium result in 1998 of 12 µg/L (Figure A.2-60). A slight decreasing trend is shown for Monitoring Well 3095 (Figure A.2-94), where total uranium concentrations were 36 and 40 µg/L in the fourth quarters of 1999 and 1998, respectively. Although their overall calculated trends are increasing, the total uranium concentration at Extraction Well 3925 was 30 µg/L in fourth quarter 1999 which is less than the total uranium concentration of 38.85 µg/L detected in this well during fourth quarter 1998 (Figure A.1-13). In addition, the concentration at Extraction Well 3926 for fourth quarter 1999 was 25 µg/L, which is increasing compared to 20.14 µg/L in fourth quarter 1998 (Figure A.1-14).

As restoration progresses, it will become increasingly important to follow Down, Significant trends as well. In 1999, 13 monitoring wells with total uranium FRL exceedances displayed Down, Significant trends (refer to Table A.2-2). With the exception of Monitoring Well 2128, these wells are located in the South Plume and South Field areas (Figure A.2-14), where active groundwater restoration pumping began in 1998. Down, Significant trends were also observed at 10 extraction wells (Table A.2-1) in the South Field and South Plume areas (Figure A.2-14). Trending of uranium concentrations in monitoring wells and extraction wells will continue as restoration progresses. These trends will be useful in tracking the progress of the groundwater restoration, as well as, identifying operational changes to the aquifer restoration.

It should be noted that the trend at South Field Extraction Well 31566 is no longer increasing in 1999. In the 1998 Integrated Site Environmental Report, this well's total uranium concentrations indicated an Up, Significant trend. This well was shut down in August 1998 because of lower than expected uranium concentrations and water yields.

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## TABLE A.2-1

## LISTING OF IEMP GROUNDWATER WELLS

| Well ID | Well Location[a] | Monitoring Activity |
|---|---|---|
| 13 | D,E,F | Private Well Monitoring |
| 14 | NA[b] | Private Well Monitoring |
| 67 | H | KC-2 Warehouse |
| 2002 | D | South Plume Module |
| 2008 | A | Waste Storage Area Module |
| 2009 | A | Waste Storage Area Module |
| 2014 | B | South Field Extraction System Module<br>South Plume Module |
| 2015 | D,E | Re-Injection Demonstration Module |
| 2017 | D,E | South Plume Module |
| 2027 | A | Waste Storage Area Module |
| 2032 | A | Waste Storage Area Module |
| 2033 | A | Waste Storage Area Module |
| 2034 | A | Waste Storage Area Module |
| 2045 | B | South Field Extraction System Module |
| 2046 | B | South Field Extraction System Module |
| 2049 | B | South Field Extraction System Module |
| 2051 | F | Property Boundary Monitoring |
| 2054 | C | Plant 6 Area Module<br>South Plume Module |
| 2060 (12) | D,E | Re-Injection Demonstration Module |
| 2068 | B | South Field/ Extraction System Module<br>Property Boundary Monitoring |
| 2070 | E,F | Re-Injection Demonstration Module |
| 2093 | D | South Plume Module |
| 2095 | D | South Plume Module<br>South Plume Module<br>Property Boundary Monitoring |
| 2106 | D,E,F | Re-Injection Demonstration Module |
| 2118 | C | Plant 6 Area Module |
| 2125 | D | South Plume Module |
| 2128 | D | South Plume Module<br>South Plume Modules<br>Property Boundary Monitoring |
| 2166 | D,E,F | Re-Injection Demonstration Module |
| 2385 | B | South Field Extraction System Module |
| 2386 | B | South Field Extraction System Module |
| 2387 | B | South Field Extraction System Module |
| 2389 | C | Plant 6 Area Module |
| 2390 | B | South Field Extraction System Module |
| 2396 | D | South Plume Module |
| 2397 | B | South Field Extraction System Module<br>South Plume Module<br>Property Boundary Monitoring |
| 2398 | D,E,F | Re-Injection Demonstration Module |
| 2402 | B | South Field Extraction System Module |
| 2417 | F | Property Boundary Monitoring |
| 2424 | F | Property Boundary Monitoring |
| 2426 | F | Property Boundary Monitoring |

**TABLE A.2-1**
**(Continued)**

| Well ID | Well Location[a] | Monitoring Activity |
|---|---|---|
| 2429 | F | Property Boundary Monitoring |
| 2430 | F | Property Boundary Monitoring |
| 2431 | F | Property Boundary Monitoring |
| 2432 | F | Property Boundary Monitoring |
| 2434 | D,E,F | South Plume Module |
| 2544 | D | South Plume Module |
| 2545 | D | South Plume Module |
| 2546 | D | South Plume Module |
| 2550 | D | South Plume Module |
| 2551 | D | South Plume Module |
| 2552 | D | South Plume Module |
| 2553 | D | South Plume Module |
| 2625 | D | South Plume Module |
| 2636 | D | South Plume Module |
| 2648 | A | Waste Storage Area Module |
| 2649 | A | Waste Storage Area Module |
| 2733 | F | Property Boundary Monitoring |
| 2821 | A | Waste Storage Area Module |
| 2880 | D | South Plume Module |
| 2881 | D | South Plume Module |
| 2897 | D | South Plume Module |
| 2898 | D | South Plume Module |
| 2899 | D | South Plume Module |
| 2900 | D | South Plume Module |
| 3009 | A | Waste Storage Area Module |
| 3014 | B | South Field Extraction System Module |
| 3015 | D,E | South Plume Module |
| 3027 | A | Waste Storage Area Module |
| 3032 | A | Waste Storage Area Module |
| 3034 | A | Waste Storage Area Module |
| 3045 | B | South Field Extraction System Module |
| 3046 | B | South Field Extraction System Module |
| 3049 | B | South Field Extraction System Module |
| 3054 | C | Plant 6 Area Module |
| 3067 | F | Property Boundary Monitoring |
| 3068 | B | South Field Extraction System Module |
| 3069 | D,E,F | South Plume Module |
| 3070 | E,F | Property Boundary Monitoring |
| 3093 | D | South Plume Module |
| 3095 | D | South Plume Module |
| 3106 | D,E,F | South Plume Module |
| 3125 | D | South Plume Module |
| 3128 | D | South Plume Module |
| 3385 | B | South Field Extraction System Module |
| 3387 | B | South Field Extraction System Module |
| 3390 | B | South Field Extraction System Module |
| 3396 | D | South Plume Module |
| 3397 | B | South Field Extraction System Module |
| 3398 | D,E,F | South Plume Module |
| 3402 | B | South Field Extraction System Module |
| 3417 | F | Property Boundary Monitoring |
| 3424 | F | Property Boundary Monitoring |
| 3426 | F | Property Boundary Monitoring |
| 3429 | F | Property Boundary Monitoring |

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**TABLE A.2-1**
**(Continued)**

| Well ID | Well Location[a] | Monitoring Activity |
|---|---|---|
| 3431 | F | Property Boundary Monitoring |
| 3432 | F | Property Boundary Monitoring |
| 3550 | D | South Plume Module |
| 3551 | D | South Plume Module |
| 3552 | D | South Plume Module |
| 3636 | D | South Plume Module |
| 3733 | F | Property Boundary Monitoring |
| 3821 | A | Waste Storage Area Module |
| 3880 | D | South Plume Module |
| 3881 | D | South Plume Module |
| 3897 | D | South Plume Module |
| 3898 | D | South Plume Module |
| 3899 | D | South Plume Module |
| 3900 | D | South Plume Module |
| 3924 | D | South Plume Module |
| 3925 | D | South Plume Module |
| 3926 | D | South Plume Module |
| 3927 | D | South Plume Module |
| 4067 | F | Property Boundary Monitoring |
| 4125 | D | South Plume Module |
| 4398 | D,E,F | South Plume Module |
| 4424 | F | Property Boundary Monitoring |
| 4426 | F | Property Boundary Monitoring |
| 4432 | F | Property Boundary Monitoring |
| 6880 | D | South Plume Module |
| 6881 | D | South Plume Module |
| 1033 | B | South Field Extraction System Module |
| 1063 | D | South Plume Module |
| 1192 | B | South Field Extraction System Module |
| 1194 | D | South Plume Module |
| 2198 | F | Property Boundary Monitoring |
| 31217 | F | Property Boundary Monitoring |
| 32308 | D | South Plume Optimization Module |
| 32309 | D | South Plume Optimization Module |
| 31550 | B | South Field Extraction (Phase I) Module |
| 31560 | B | South Field Extraction (Phase I) Module |
| 31561 | B | South Field Extraction (Phase I) Module |
| 31562 | B | South Field Extraction (Phase I) Module |
| 31563 | B | South Field Extraction (Phase I) Module |
| 31564 | B | South Field Extraction (Phase I) Module |
| 31565 | B | South Field Extraction (Phase I) Module |
| 31566 | B | South Field Extraction (Phase I) Module |
| 31567 | B | South Field Extraction (Phase I) Module |
| 32276 | B | South Field Extraction (Phase I) Module |
| 41217 | F | Property Boundary Monitoring |
| 62408 | B | South Field Extraction System Module |
| 62433 | B | South Field Extraction System Module |

[a]Well location refers to Figure A.2-1.
[b]NA = not applicable. This well is located near the southeast corner of the FEMP.



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# TABLE A.2-2

## SUMMARY STATISTICS AND TREND ANALYSIS OF MONITORING WELLS FOR TOTAL URANIUM WITH 1999 RESULTS ABOVE FINAL REMEDIATION LEVEL

| Well | No. of Samples Since 1988[a,b,c] | Minimum[a,b,c,d,e] (µg/L) | Maximum[a,b,c,d,e] (µg/L) | Average[a,b,c,d,e] (µg/L) | Standard Deviation[a,b,c,d,e] (µg/L) | Trend[a,b,c,d,e] |
|---|---|---|---|---|---|---|
| 13 | 17 | 27 | 64 | 41 | 11 | Down, Marginal |
| 2008 | 16 | 5 | 25.4 | 18 | 5 | No Significant Trend |
| 2009 | 12 | 13.6 | 39.2 | 23.3 | 6.80 | No Significant Trend |
| 2015 | 42 | 1.3 | 290 | 150 | 41 | Down, Significant |
| 2033 | 8 | 3.3 | 104.288 | 65 | 34 | Up, Marginal |
| 2045 | 22 | 30.707 | 462 | 233 | 120 | Down, Significant |
| 2046 | 21 | 56.6 | 907 | 364 | 263 | Down, Significant |
| 2049 | 20 | 3 | 177.893 | 90 | 60 | **Up, Significant** |
| 2060 (12) | 47 | 8.4 | 332 | 80 | 72 | Down, Significant |
| 2095 | 33 | 27 | 208 | 130 | 42 | Down, Marginal |
| 21033 | 11 | 15.724 | 43.2 | 27.7 | 8.94 | Down, Significant |
| 2106 | 38 | 6.059 | 88.6 | 49.4 | 17.0 | Down, Significant |
| 2166 | 22 | 48 | 95.1 | 69 | 11 | No Significant Trend |
| 2385 | 14 | 76.648 | 592.164 | 204.98 | 135.28 | **Up, Significant** |
| 2386 | 14 | 6.67 | 43.431 | 23.1 | 11.4 | Up, Marginal |
| 2387 | 14 | 68.7 | 492 | 166 | 122 | Down, Significant |
| 2390 | 13 | 79.104 | 163 | 100 | 24.2 | No Significant Trend |
| 2397 | 14 | 212 | 500.937 | 341 | 71.1 | **Up, Significant** |
| 2398 | 32 | 0.663 | 35.697 | 16.9 | 9.70 | **Up, Significant** |
| 2544 | 24 | 0.4 | 521 | 30 | 100 | **Up, Significant** |
| 2545 | 26 | 7.6 | 106 | 32 | 21 | Down, Significant |
| 2546[f] | 14 | 0.4 | 144 | 20 | 37 | No Significant Trend |
| 2550 | 26 | 3.3 | 120 | 72 | 21 | Down, Significant |
| 2552 | 25 | 12 | 33 | 19 | 4.8 | Down, Significant |
| 2648 | 13 | 9.61 | 73.74 | 29.7 | 18.7 | **Up, Significant** |
| 2821 | 7 | 22.3 | 32.6 | 27.5 | 3.56 | Down, Significant |
| 3027[f] | 9 | 0.2 | 45.151 | 17 | 17 | **Up, Significant** |
| 3068 | 16 | 0.028 | 50.657 | 3.8 | 13 | Down, Marginal |
| 3069 | 40 | 0.5 | 398.33 | 130 | 120 | **Up, Significant** |
| 3095 | 34 | 2 | 94 | 17 | 18 | **Up, Significant** |
| 3125 | 31 | 19.3 | 82 | 49 | 16 | No Significant Trend |
| 3390 | 12 | 70.525 | 110 | 88 | 13 | Down, Significant |
| 3550 | 26 | 2.5 | 58 | 6.5 | 11 | Down, Significant |
| 4398 | 29 | 0 | 25.2 | 1.01 | 4.66 | No Significant Trend |
| 62408 | 2 | 86.479 | 152.342 | NA | NA | NA |
| 62433 | 2 | 331.94 | 450.478 | NA | NA | NA |
| 6880 | 1 | 145 | NA | NA | NA | NA |
| 6881 | 1 | 30 | NA | NA | NA | NA |

[a]Summary statistics and Mann-Kendall test for trend are based on unfiltered samples from the Operable Unit 5 remedial investigation/feasibility study data set (1988 through 1993) and 1994 through 1999 groundwater data.
[b]If more than one sample is collected per well per day (e.g., duplicate), then only one sample is counted for the number of samples, and the sample with the maximum concentration is used for determining the summary statistics (minimum, maximum, average, and standard deviation [SD]) and Mann-Kendall test for trend.
[c]Rejected data qualified with either a R or Z were not included in this count, the summary statistics, or Mann-Kendall test for trend.
[d]For results where the concentrations are below the detection limit, the results used in the summary statistics and Mann-Kendall test for trend are each set at half the detection limit.
[e]If the number of samples is greater than or equal to four, then the Mann-Kendall test for trend and all of the summary statistics are reported. If the number of samples is equal to three, then the minimum, maximum, and average are reported. If the number of samples is equal to two, the minimum and maximum are reported. If the number of samples is equal to one, then the data point is reported as the minimum.
[f]Some results from 1999 were excluded from summary statistics and trend analysis because of high turbidity.

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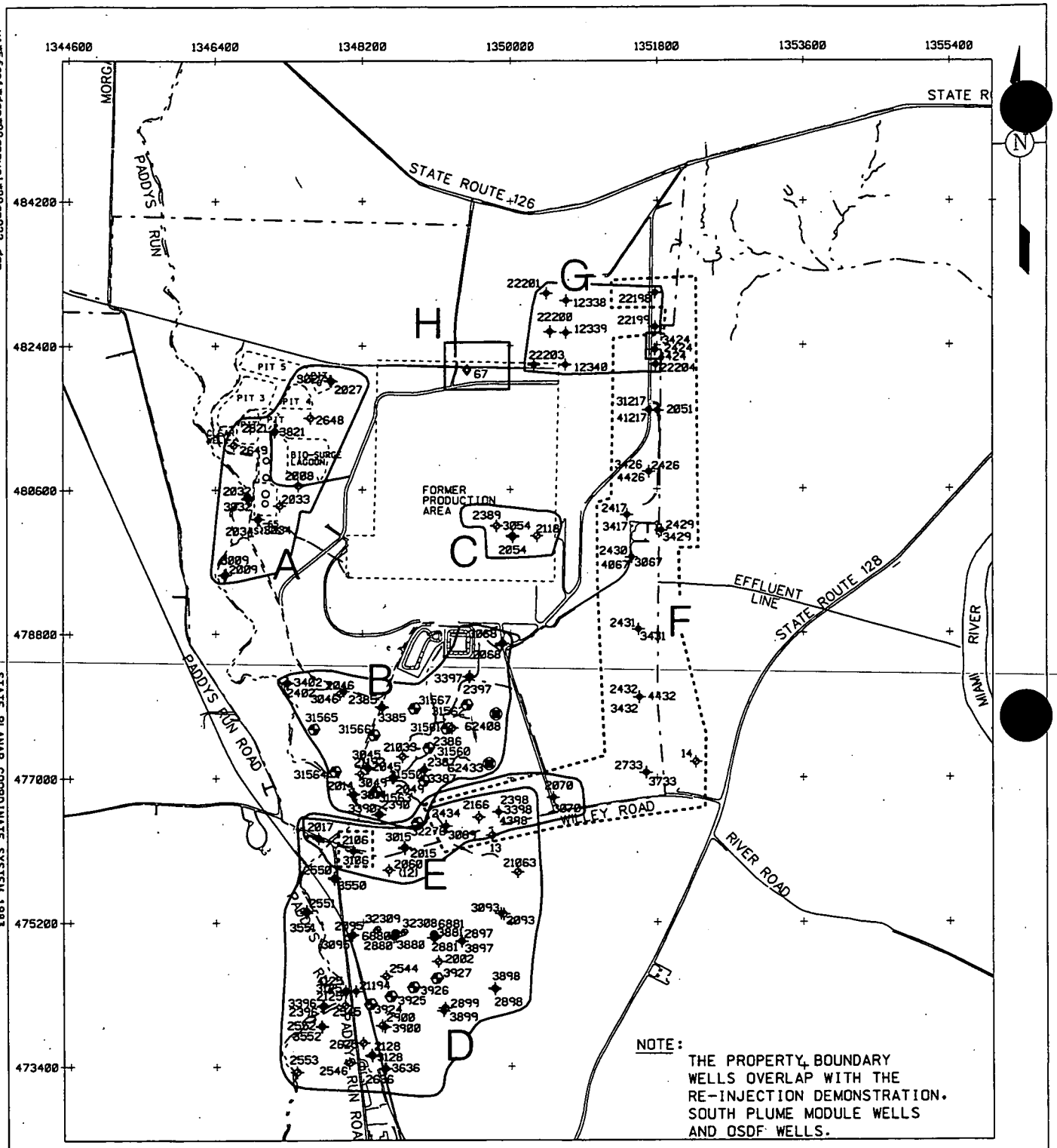
# TABLE A.2-3

## SUMMARY STATISTICS AND TREND ANALYSIS OF EXTRACTION WELLS WITH 1999 RESULTS ABOVE FINAL REMEDIATION LEVEL

| Well | No. of Samples Since 1988[a,b] | Minimum[a,b,c] (µg/L) | Maximum[a,b,c] (µg/L) | Average[a,b,c] (µg/L) | Standard Deviation[a,b,c] (µg/L) | Trend[a,b,c] |
|---|---|---|---|---|---|---|
| South Plume Module (August 27, 1993 through December 31, 1998) | | | | | | |
| 3924 | 148 | 21.4 | 180 | 47 | 20 | Down, Significant |
| 3925 | 154 | 0.5 | 84 | 30 | 10 | **Up, Significant** |
| 3926 | 151 | 1.5 | 39 | 15 | 7.8 | **Up, Significant** |
| South Plume Optimization Module (August 9, 1998 through December 31, 1998) | | | | | | |
| 32308 | 120 | 50.8 | 100.1 | 72.8 | 7.29 | Down, Significant |
| 32309 | 118 | 50.5 | 122.8 | 81.8 | 12.1 | Down, Significant |
| South Field (Phase I) Extraction Module (July 13, 1998 through December 31, 1998) | | | | | | |
| 31550 | 104 | 49.3 | 127.9 | 85.0 | 18.7 | Down, Significant |
| 31560 | 107 | 79.9 | 182.8 | 126 | 27.1 | Down, Significant |
| 31561 | 106 | 29.6 | 114[d] | 47.6 | 10.1 | Down, Significant |
| 31562 | 106 | 46.1[e] | 175.7 | 119 | 18.4 | Down, Significant |
| 31563 | 104 | 23.6 | 65.4 | 38.5 | 9.50 | Down, Significant |
| 31566 | 96 | 2.5 | 72.8 | 9.0 | 10 | No Significant Trend |
| 31567 | 107 | 27.2 | 67 | 43 | 7.4 | Down, Significant |
| 32276 | 109 | 114 | 290.2 | 203 | 39.0 | Down, Significant |

[a]If more than one sample is collected per well per day (e.g., duplicate), then only one sample is counted for the number of samples, and the sample with the maximum concentration is used for determining the summary statistics (minimum, maximum, average, and standard deviation [SD]) and Mann-Kendall test for trend.
[b]Rejected data qualified with either a R or Z were not included in this count, the summary statistics, or Mann-Kendall test for trend.
[c]For results where the concentrations are below the detection limit, the results used in the summary statistics and Mann-Kendall test for trend are each set at half the detection limit.
[d]This result (sampled 8/31/98) appears to be an outlier. It is suspected that the sample for this well was switched with the sample for Extraction Well 31562 (refer to Figures A.1-6 and A.1-7).
[e]This result (sampled 8/31/98) appears to be an outlier. It is suspected that the sample for this well was switched with the sample for Extraction Well 31561 (refer to Figures A.1-6 and A.1-7).




LEGEND:

A – WASTE STORAGE AREA
B – SOUTH FIELD EXTRACTION AREA
C – PLANT 6 AREA
D – SOUTH PLUME AREA
E – RE-INJECTION DEMONSTRATION AREA
F – PROPERTY BOUNDARY WELLS
G – OSDF MONITORING WELLS
H – KC-2 WAREHOUSE WELL

FEMP BOUNDARY
MONITORING WELL
EXTRACTION WELL

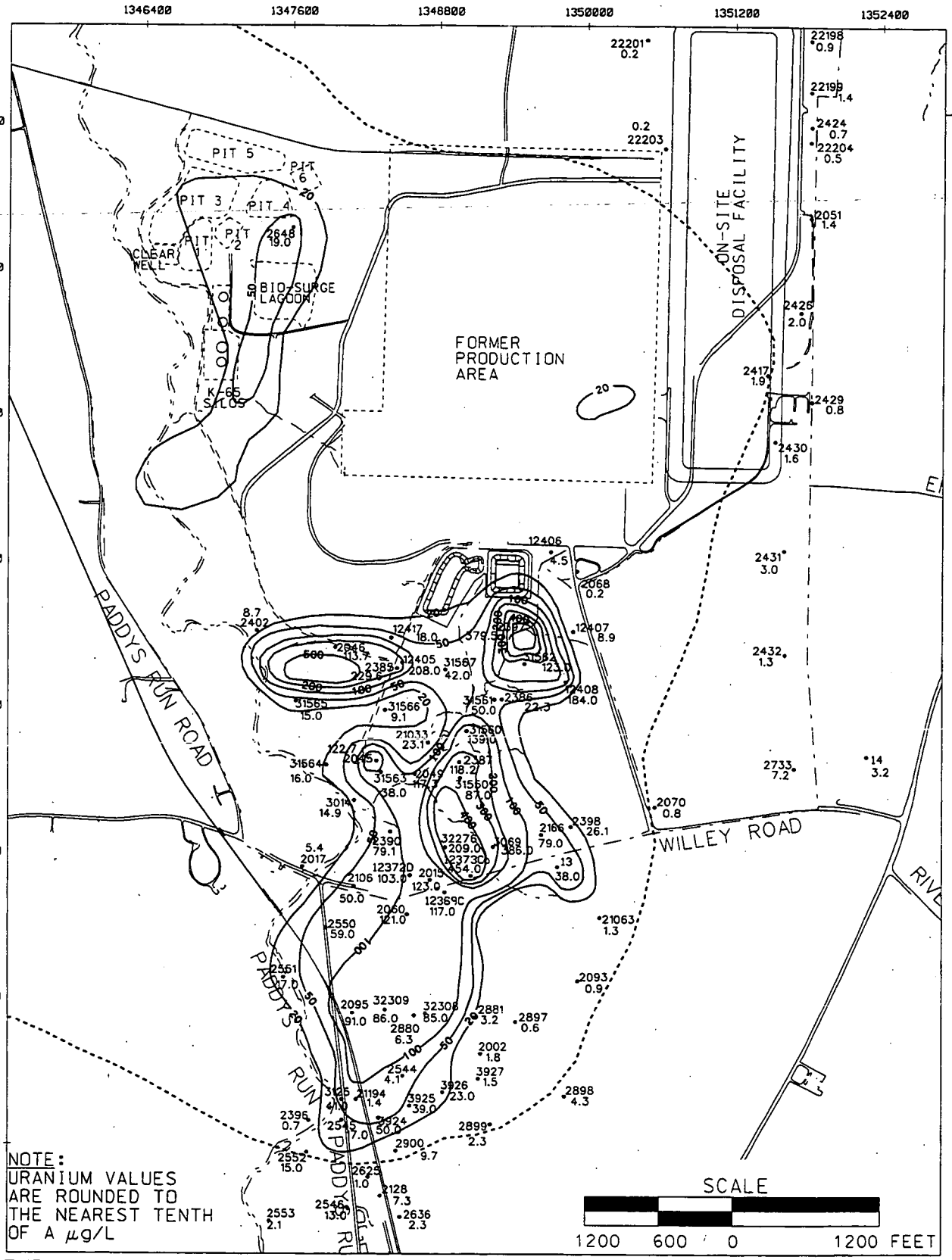
SCALE
1800 900 0 1800 FEET

STATE PLANAR COORDINATE SYSTEM 1983

26-APR-2000

000075

FIGURE A.2-1. IEMP WATER QUALITY MONITORING WELLS AND EXTRACTION WELLS




LEGEND:

2553● MONITORING WELL OR GEOPROBE LOCATION

5.1 TOTAL URANIUM CONCENTRATION MEASURED IN FIRST QUARTER 1999

— · — · — FEMP BOUNDARY

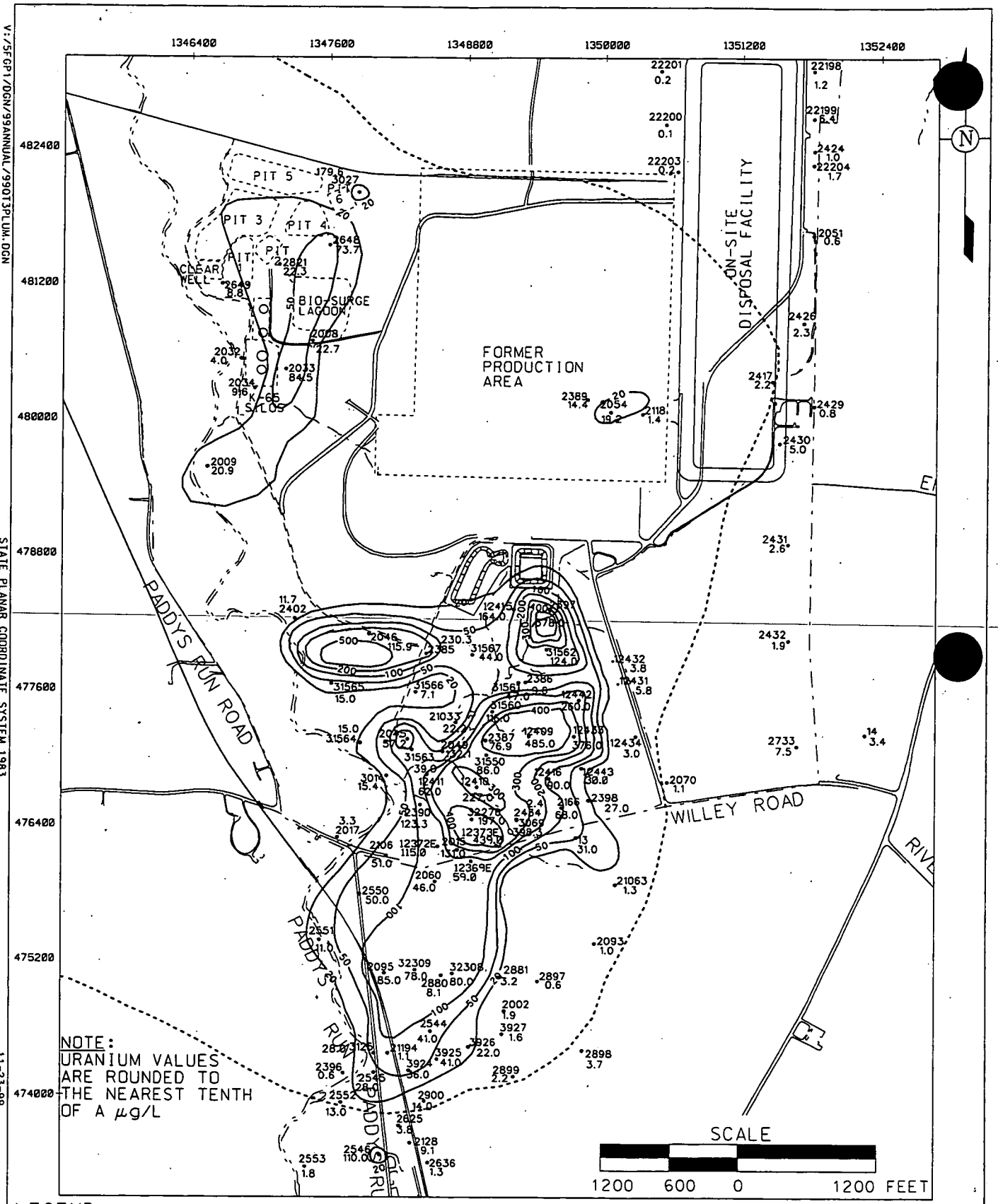
50 MAX TOTAL URANIUM CONTOUR IN μg/L FROM BASELINE MODIFIED QUARTERLY

- - - - - - 10-YEAR, URANIUM-BASED RESTORATION FOOTPRINT

FIGURE A.2-2. TOTAL URANIUM PLUME MAP, FIRST QUARTER 1999



v:*51fgp1*dgn*99annual*99qt2plum.dgn
STATE PLANAR COORDINATE SYSTEM 1983
06-APR-2000




LEGEND:

2553● MONITORING WELL OR GEOPROBE LOCATION

5.1 TOTAL URANIUM CONCENTRATION MEASURED IN SECOND QUARTER 1999

— · — · — FEMP BOUNDARY

50 MAX TOTAL URANIUM CON. IN µg/L FROM BASELINE MODIFIED QUARTERLY

..... 10-YEAR, URANIUM-BASED RESTORATION FOOTPRINT

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FIGURE A.2-3. TOTAL URANIUM PLUME MAP, SECOND QUARTER 1999

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STATE PLANAR COORDINATE SYSTEM 1983

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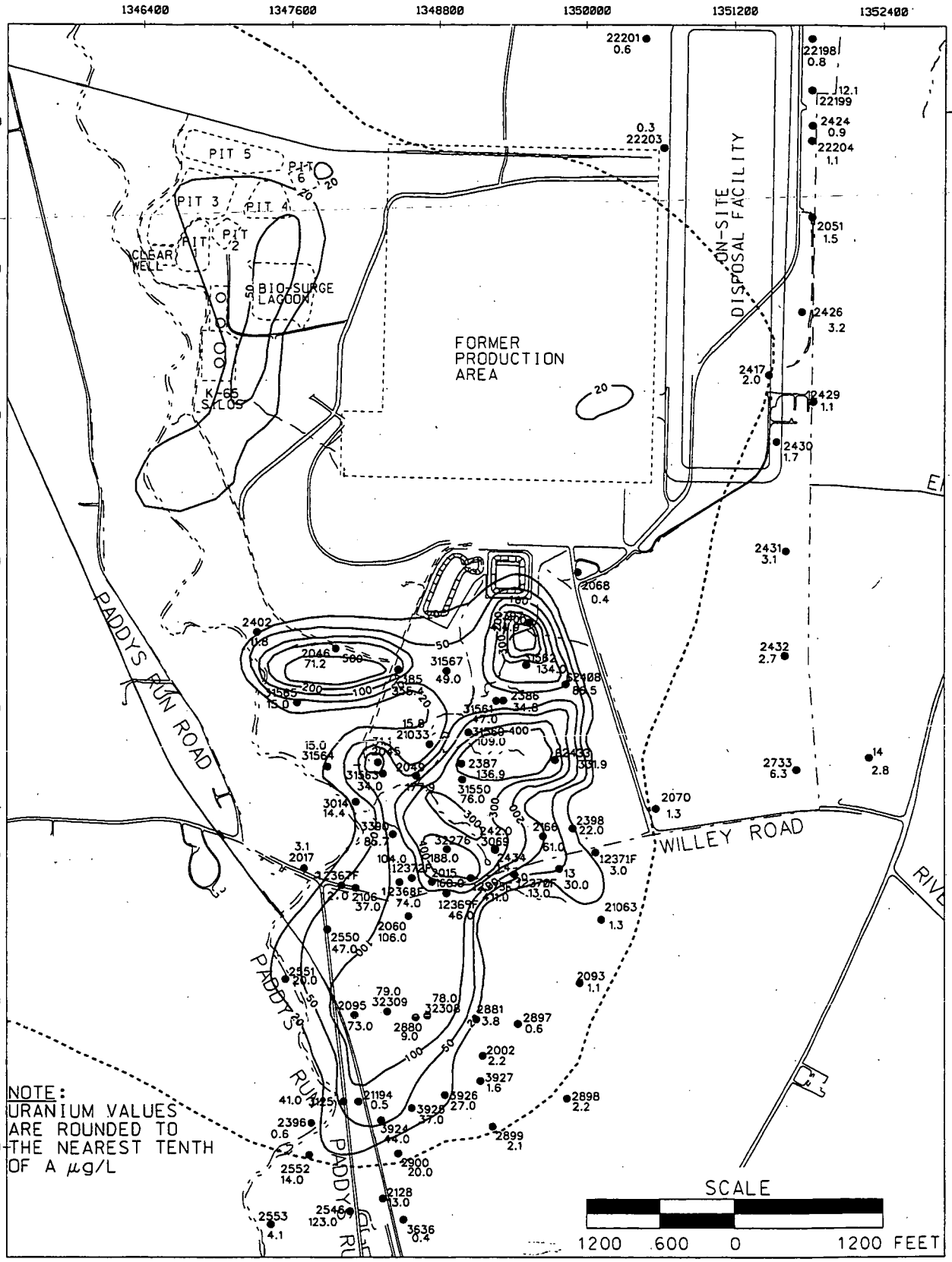


NOTE:
URANIUM VALUES ARE ROUNDED TO THE NEAREST TENTH OF A $\mu g/L$

LEGEND:

2553● MONITORING WELL OR GEOPROBE LOCATION

5.1 TOTAL URANIUM CONCENTRATION MEASURED IN THIRD QUARTER 1999

FEMP BOUNDARY

50 MAX TOTAL URANIUM CONTOUR IN $\mu g/L$ FROM BASELINE MODIFIED QUARTERLY

10-YEAR, URANIUM-BASED RESTORATION FOOTPRINT

FIGURE A.2-4. TOTAL URANIUM PLUME MAP, THIRD QUARTER 1999

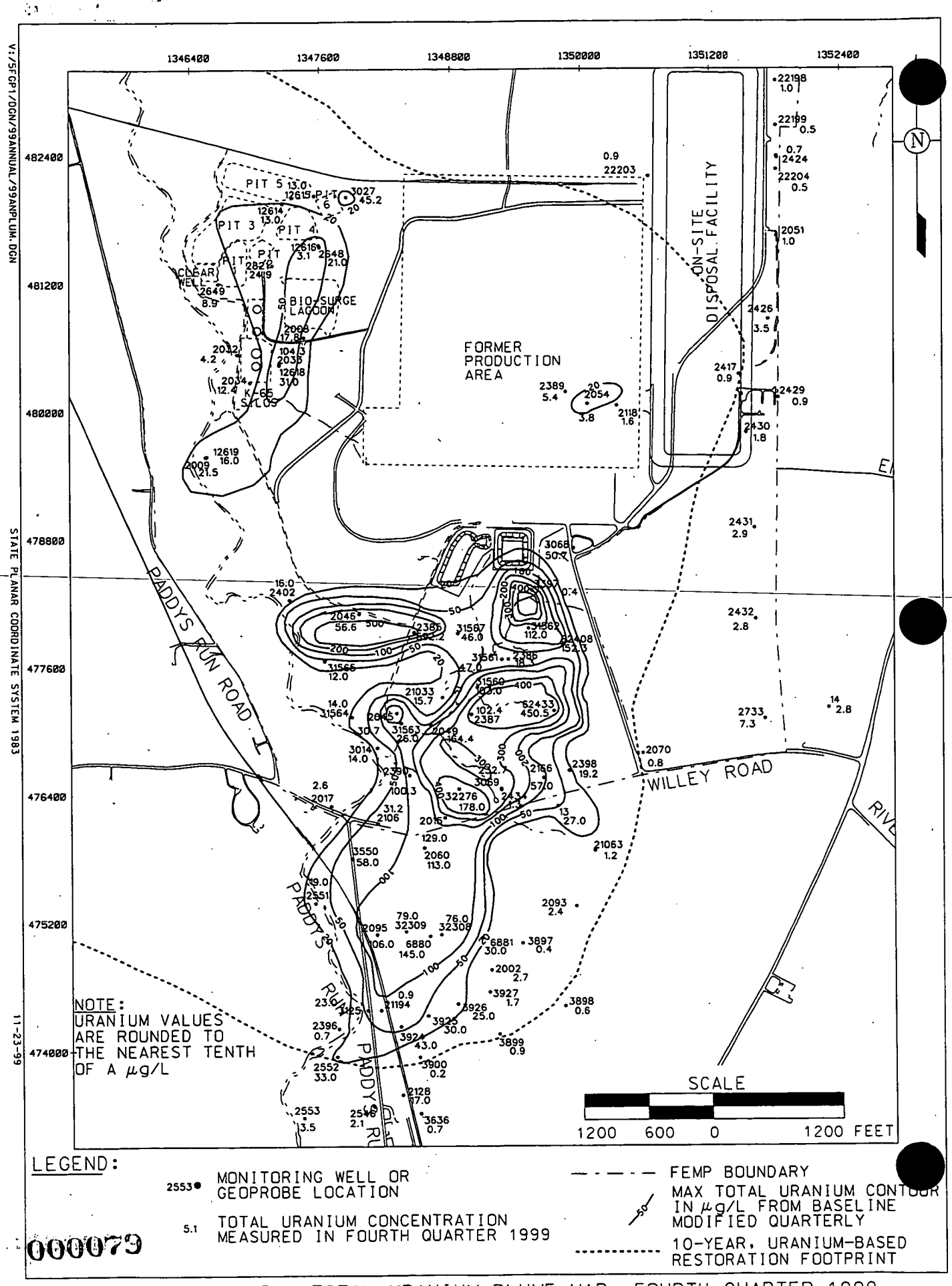


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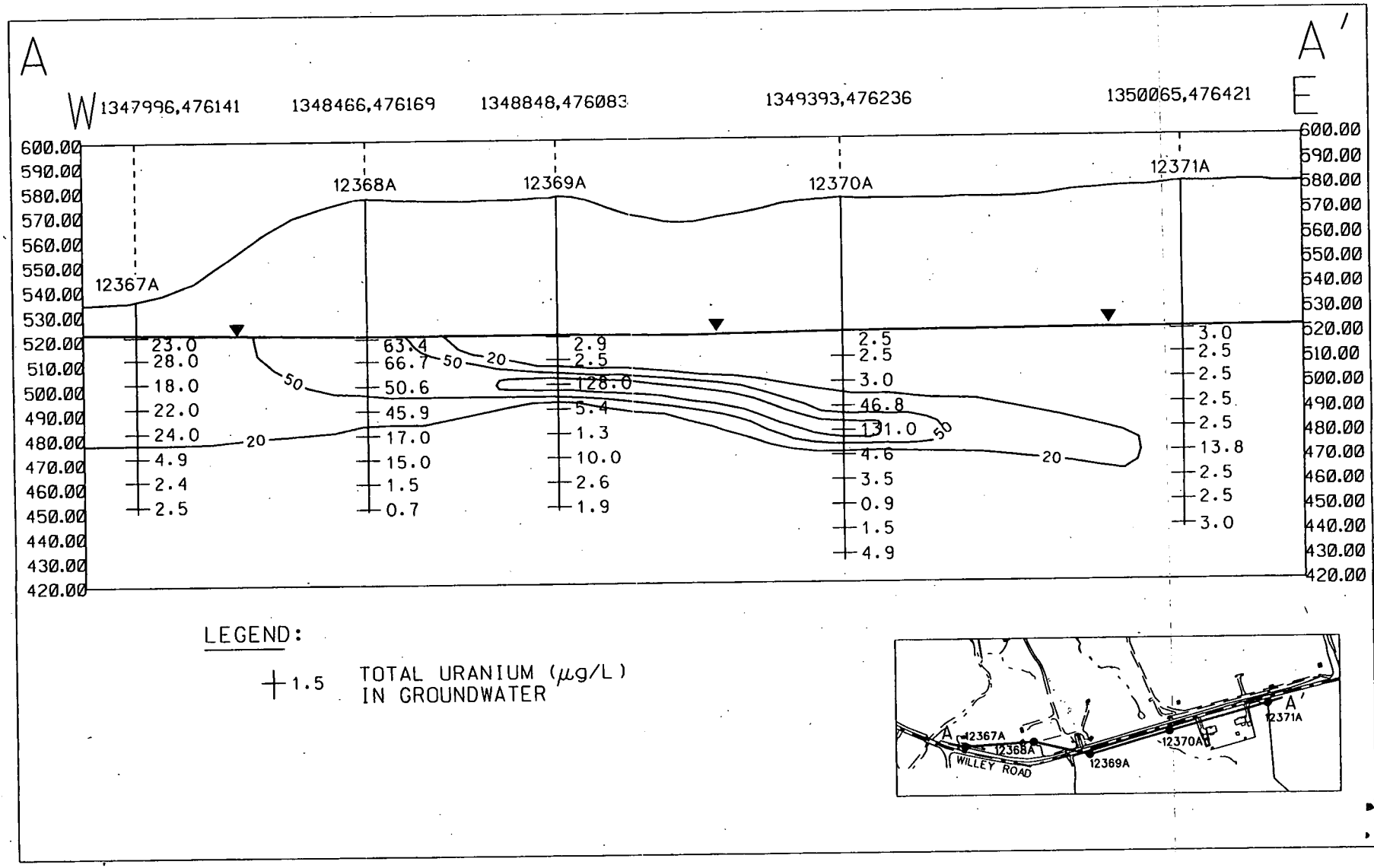
FIGURE A.2-5. TOTAL URANIUM PLUME MAP, FOURTH QUARTER 1999

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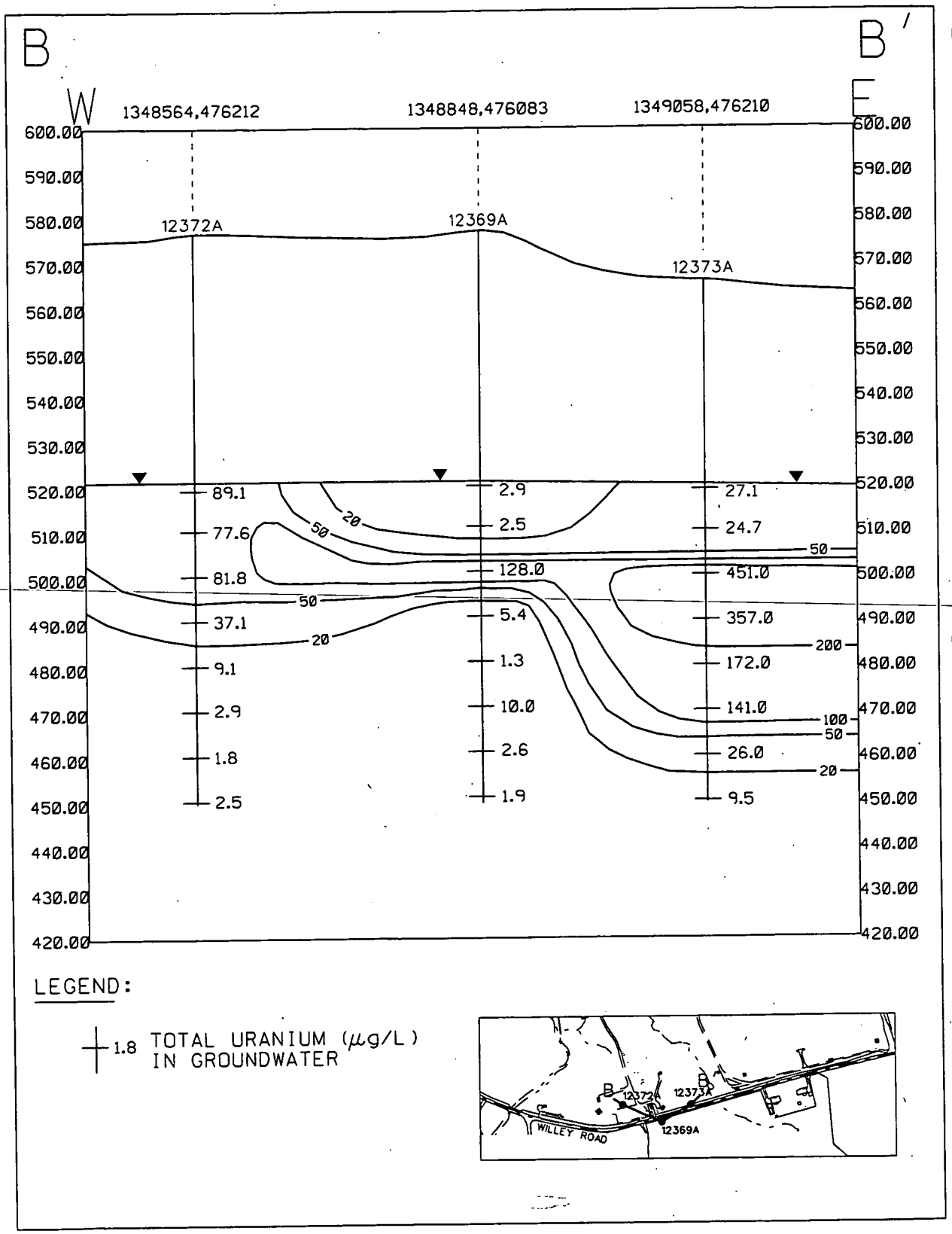
STATE PLANAR COORDINATE SYSTEM 1983

19-APR-2000

FIGURE A.2-6. CROSS-SECTION A-A', GEOPROBE RESULTS FOR TOTAL URANIUM IN GROUNDWATER, ROUND A, MAY THROUGH JUNE 1998




V:/5CRW2/DGN/99ANNUAL/99AN002.DGN

STATE PLANAR COORDINATE SYSTEM 1983

19-APR-2000

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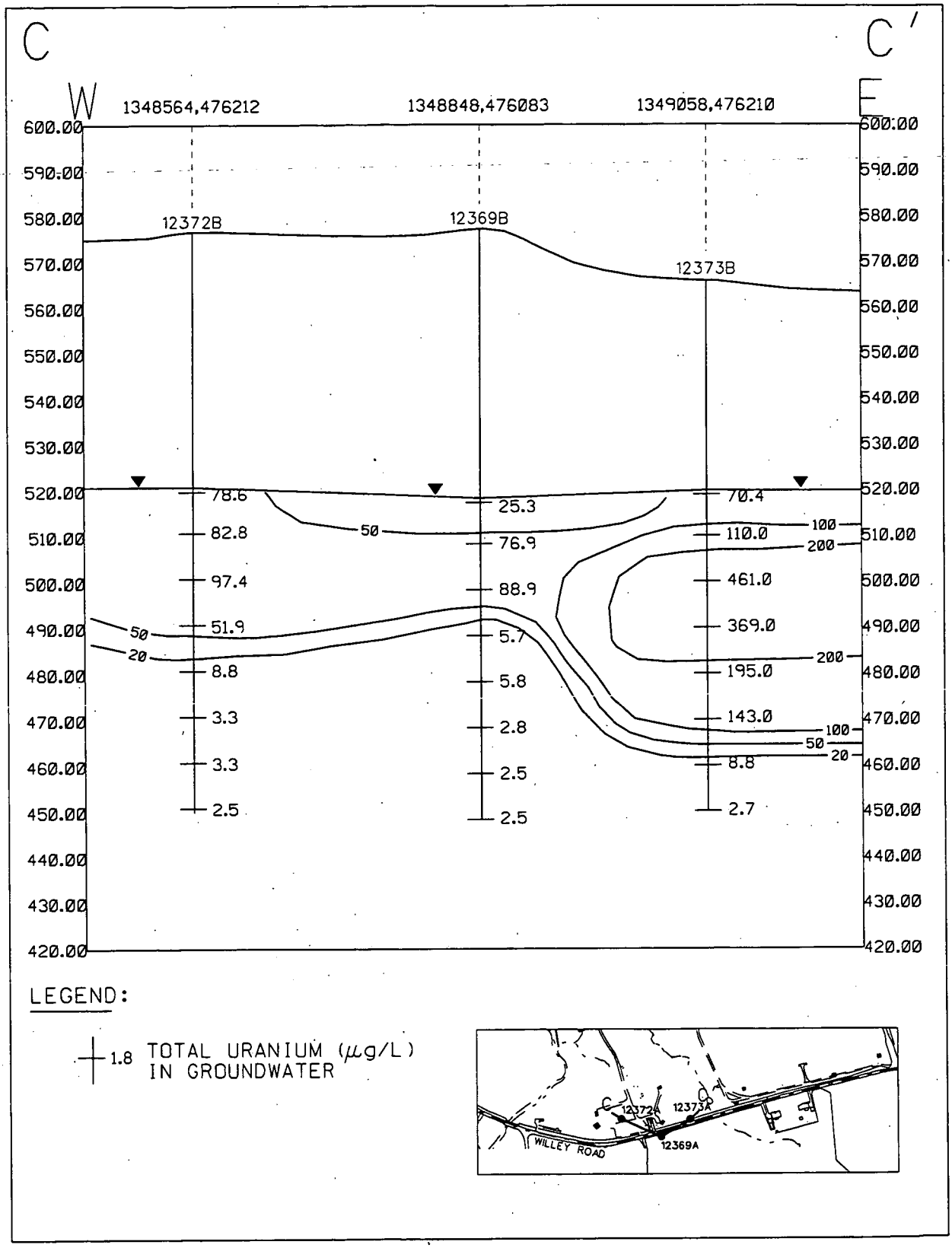
FIGURE A.2-7. CROSS-SECTION B-B', GEOPROBE RESULTS FOR TOTAL URANIUM IN GROUNDWATER, ROUND A, MAY THROUGH JUNE 1998




V:/SFGP1/DGN/99ANNUAL/99AN003.DGN

STATE PLANAR COORDINATE SYSTEM 1983

19-APR-2000

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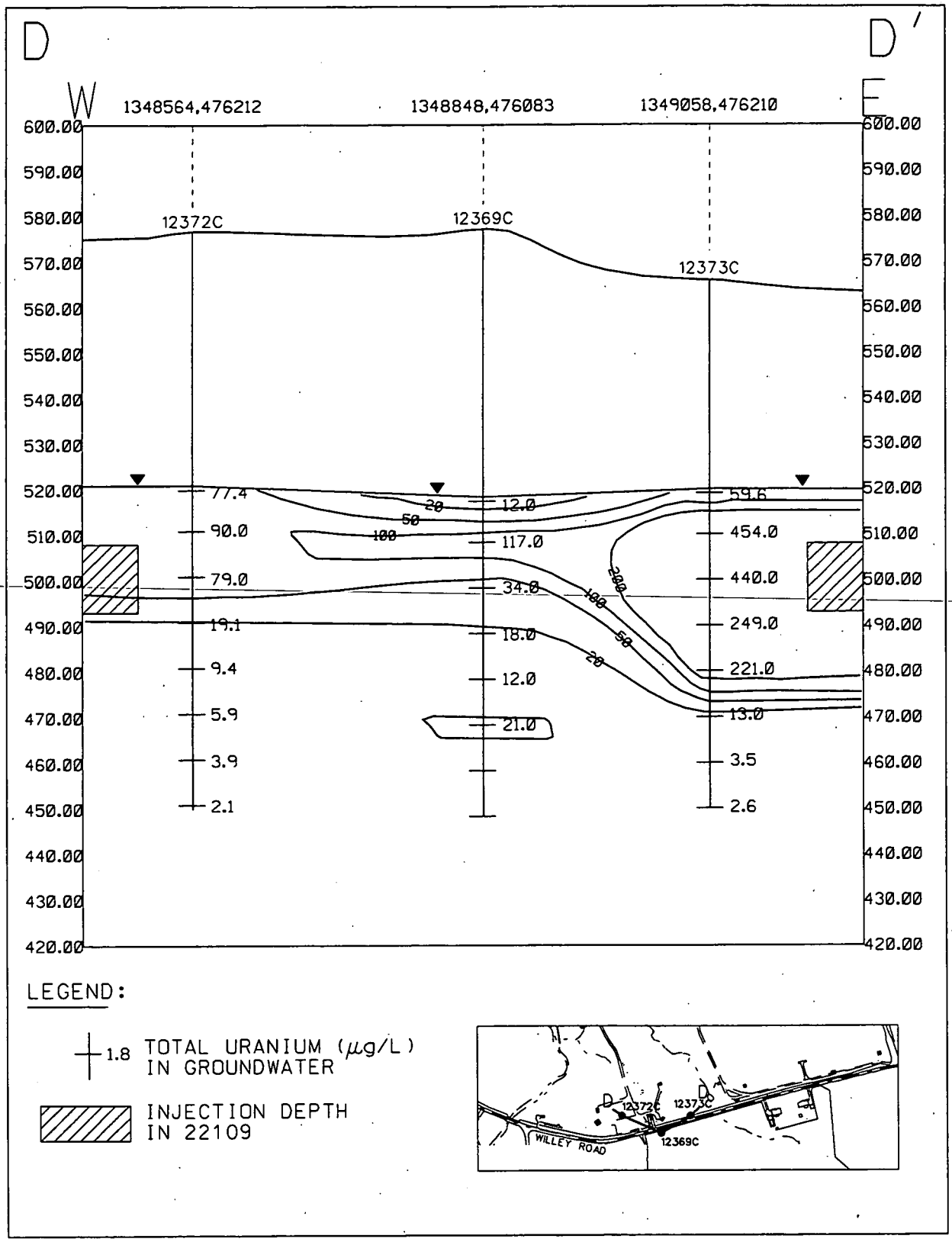
FIGURE A.2-8. CROSS-SECTION C-C', GEOPROBE RESULTS FOR TOTAL URANIUM IN GROUNDWATER, ROUND B, JULY 1998




V:/5FGP1/DGN/99ANNUAL/99AN004.DGN

STATE PLANAR COORDINATE SYSTEM 1983

19-APR-2000

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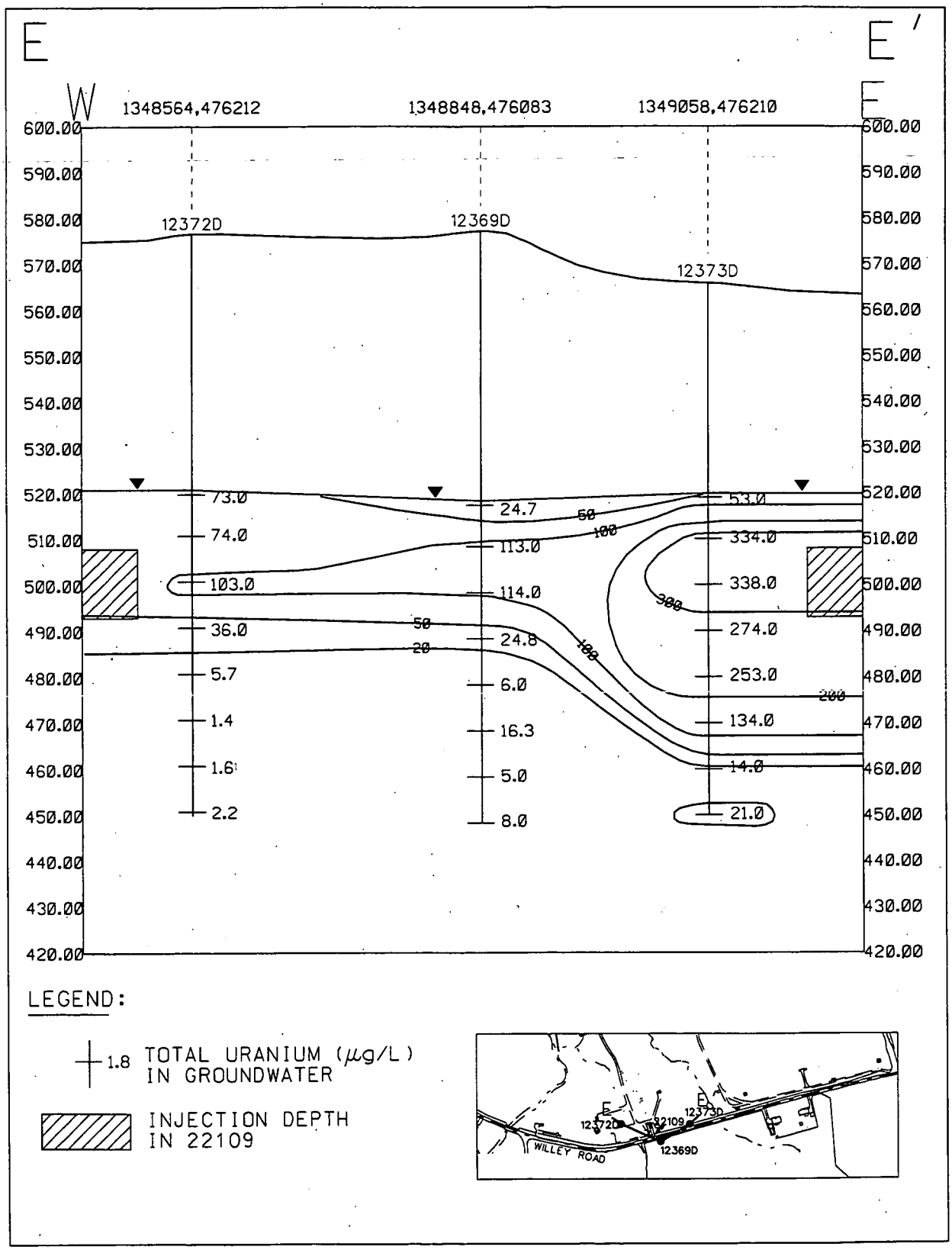
FIGURE A.2-9. CROSS-SECTION D-D', GEOPROBE RESULTS FOR TOTAL URANIUM IN GROUNDWATER, ROUND C, DECEMBER 1998 THROUGH JANUARY 1999

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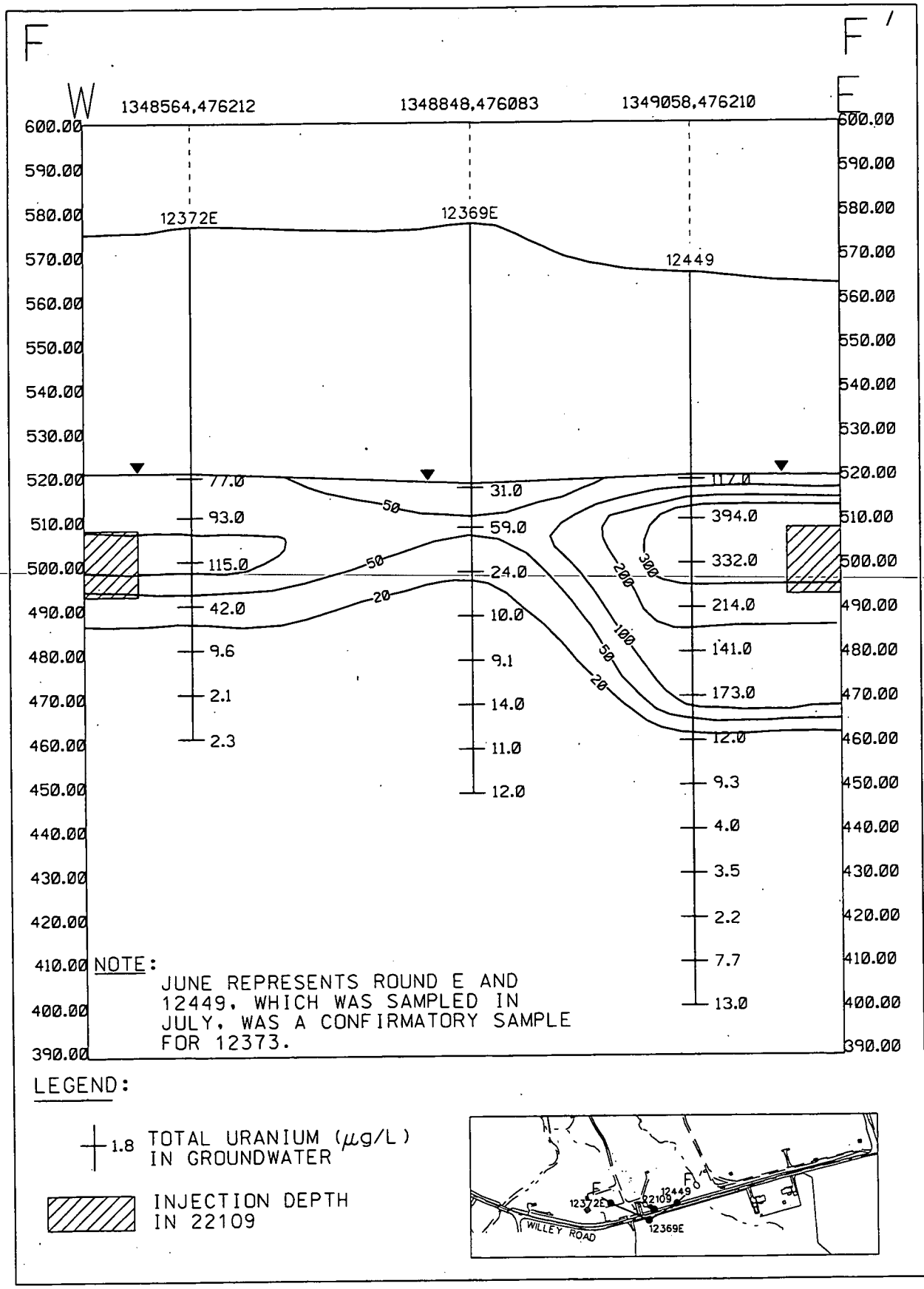
STATE PLANAR COORDINATE SYSTEM 1983

19-APR-2000



FIGURE A.2-10. CROSS-SECTION E-E', GEOPROBE RESULTS FOR TOTAL URANIUM IN GROUNDWATER, ROUND D, MARCH 1999

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STATE PLANAR COORDINATE SYSTEM 1983

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FIGURE A.2-11. CROSS-SECTION F-F', GEOPROBE RESULTS FOR TOTAL URANIUM IN GROUNDWATER, ROUND E, JUNE THROUGH JULY 1999

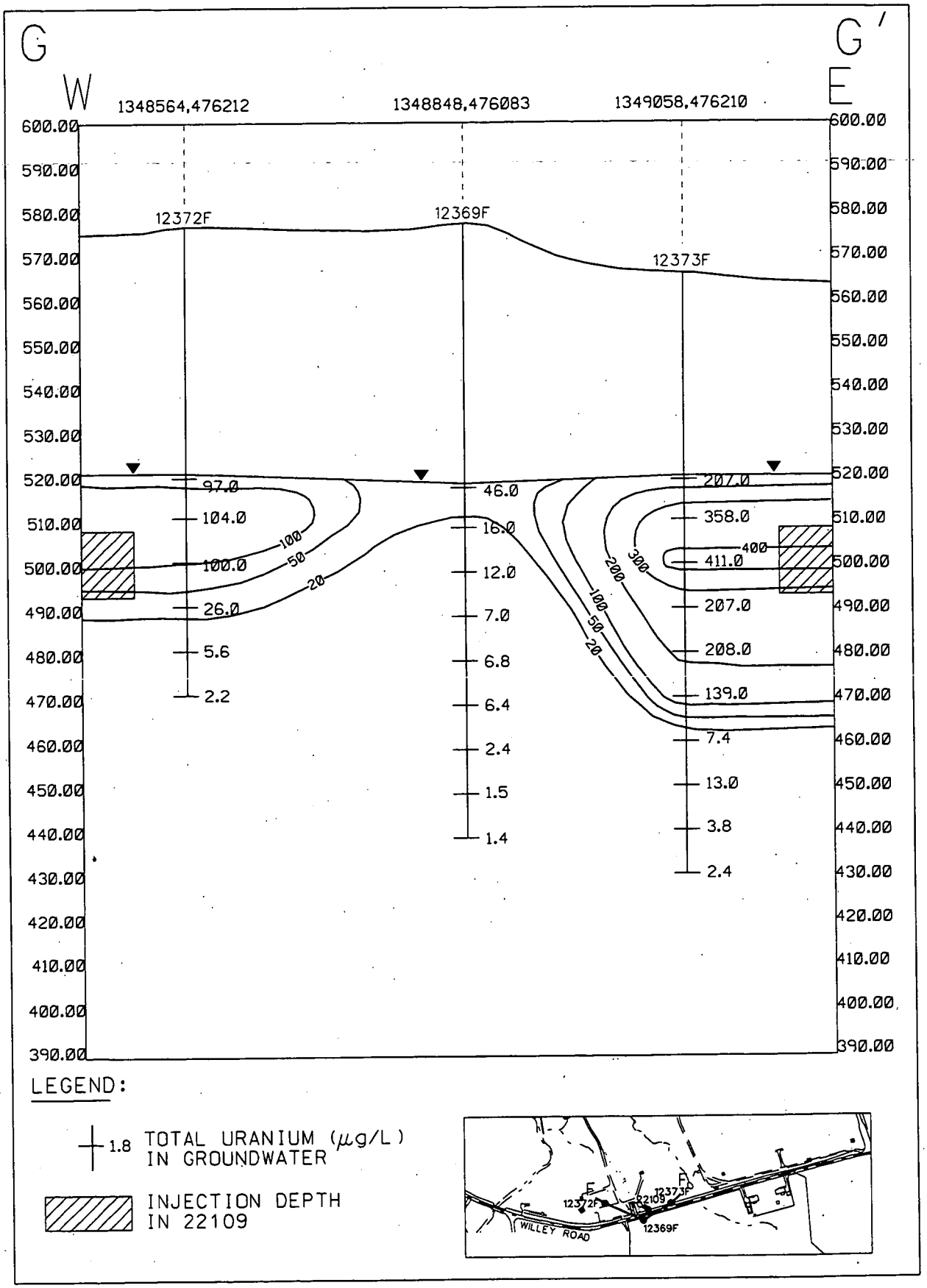




FIGURE A.2-12. CROSS-SECTION G-G', GEOPROBE RESULTS FOR TOTAL URANIUM IN GROUNDWATER, ROUND F, SEPTEMBER THROUGH NOVEMBER 1999

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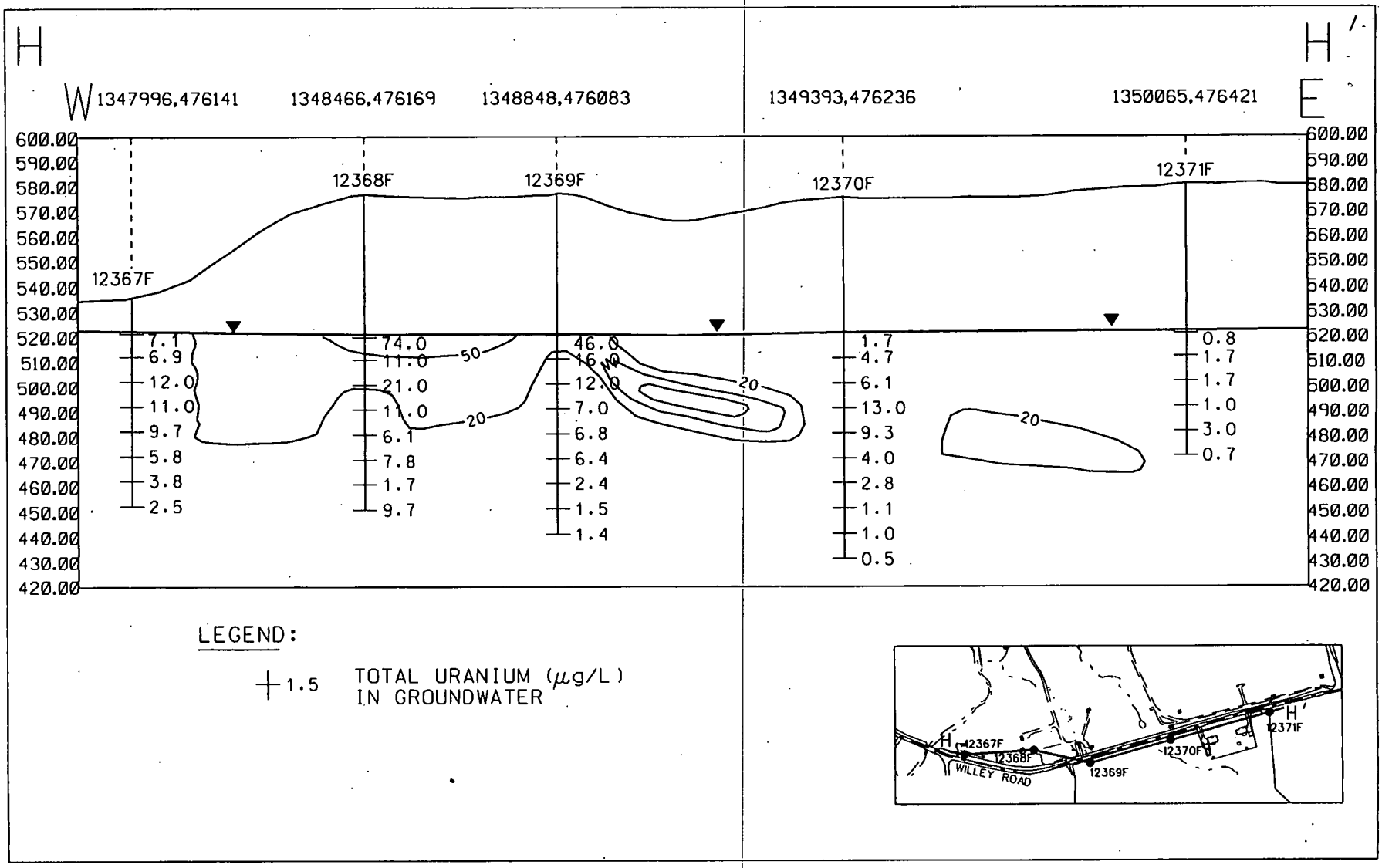
STATE PLANAR COORDINATE SYSTEM 1983
19-APR-2000

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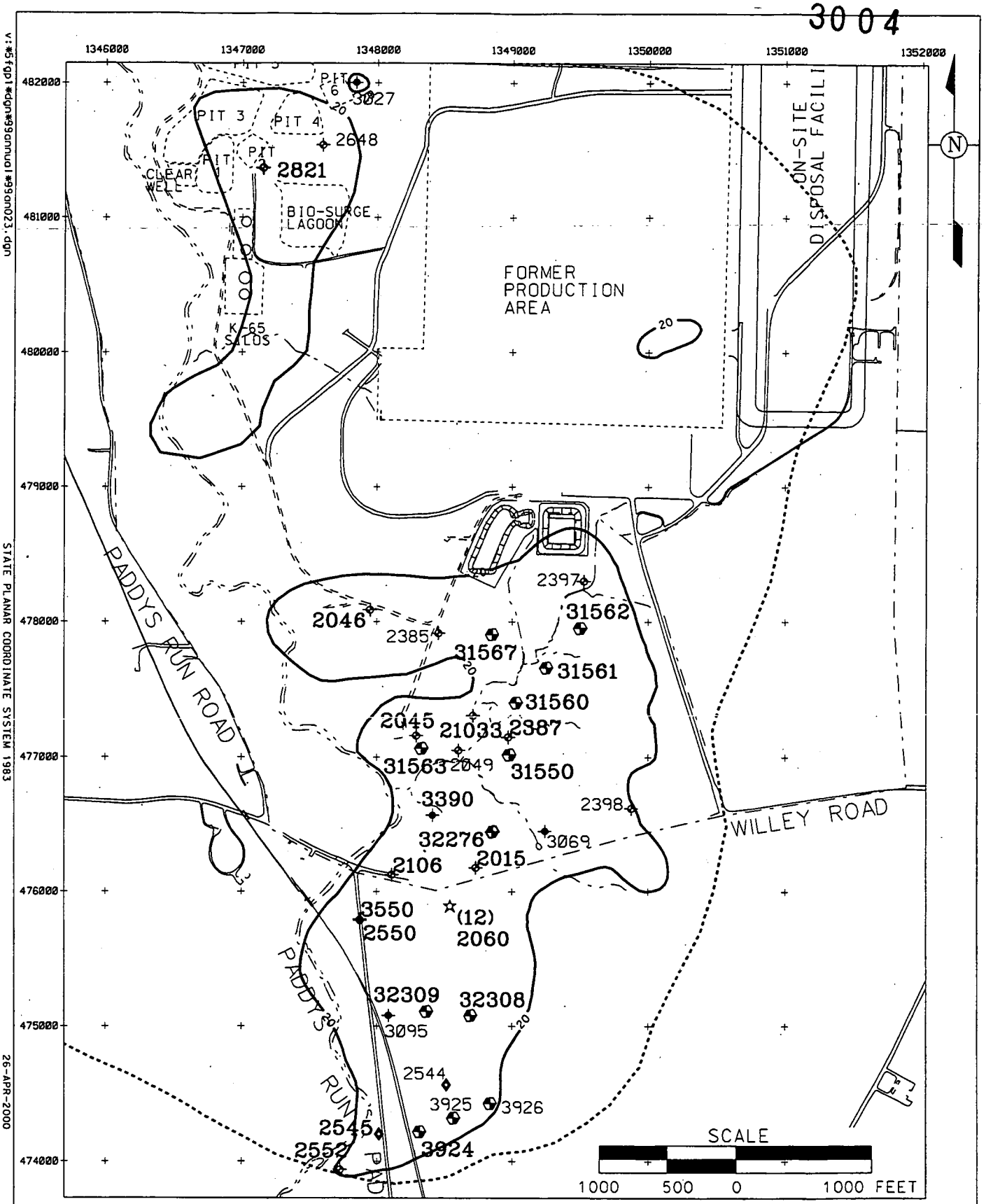
STATE PLANAR COORDINATE SYSTEM 1983

19-APR-2000

FIGURE A.2[illegible]. CROSS-SECTION H-H', GEOPROBE RESULTS F[illegible] TOTAL URANIUM IN GROUNDWATER, ROUND F, SEPTEMBER THROUGH NOVEMBER 1999

000087




LEGEND:

- FEMP BOUNDARY
- 10-YEAR, URANIUM-BASED RESTORATION FOOTPRINT
- ☆ ◆ ✧ ✦ MONITORING WELL
- ● EXTRACTION WELL
- 20 μg/L TOTAL URANIUM PLUME FROM FOURTH QUARTER 1999
- **3927** DOWN, SIGNIFICANT TREND
- 2544 UP, SIGNIFICANT TREND

FIGURE A.2-14. WELLS WITH 1999 FRL EXCEEDANCES FOR TOTAL URANIUM WITH UP, SIGNIFICANT AND DOWN, SIGNIFICANT TRENDS



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STATE PLANAR COORDINATE SYSTEM 1983
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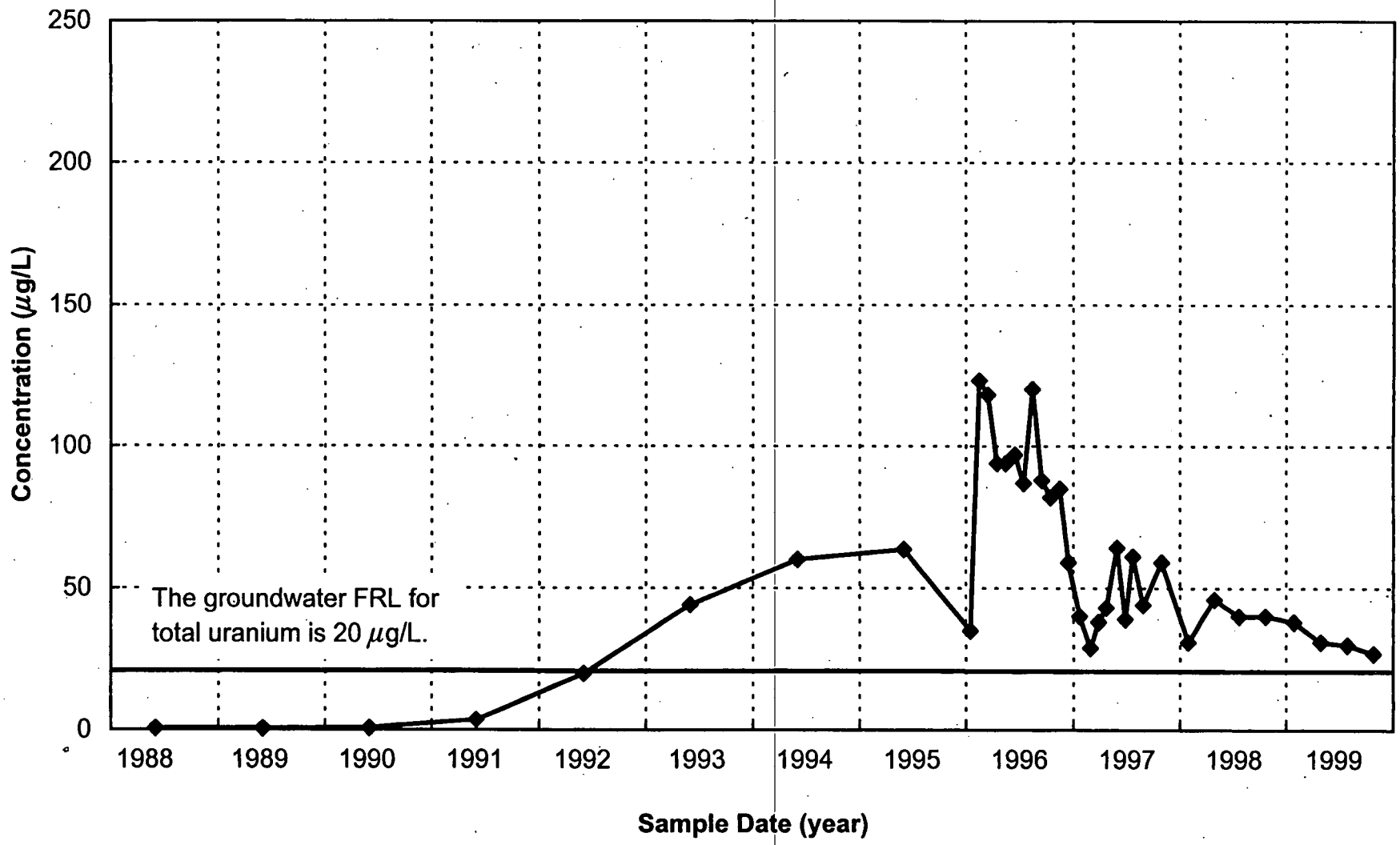


FIGURE A.2-15. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 13

680000

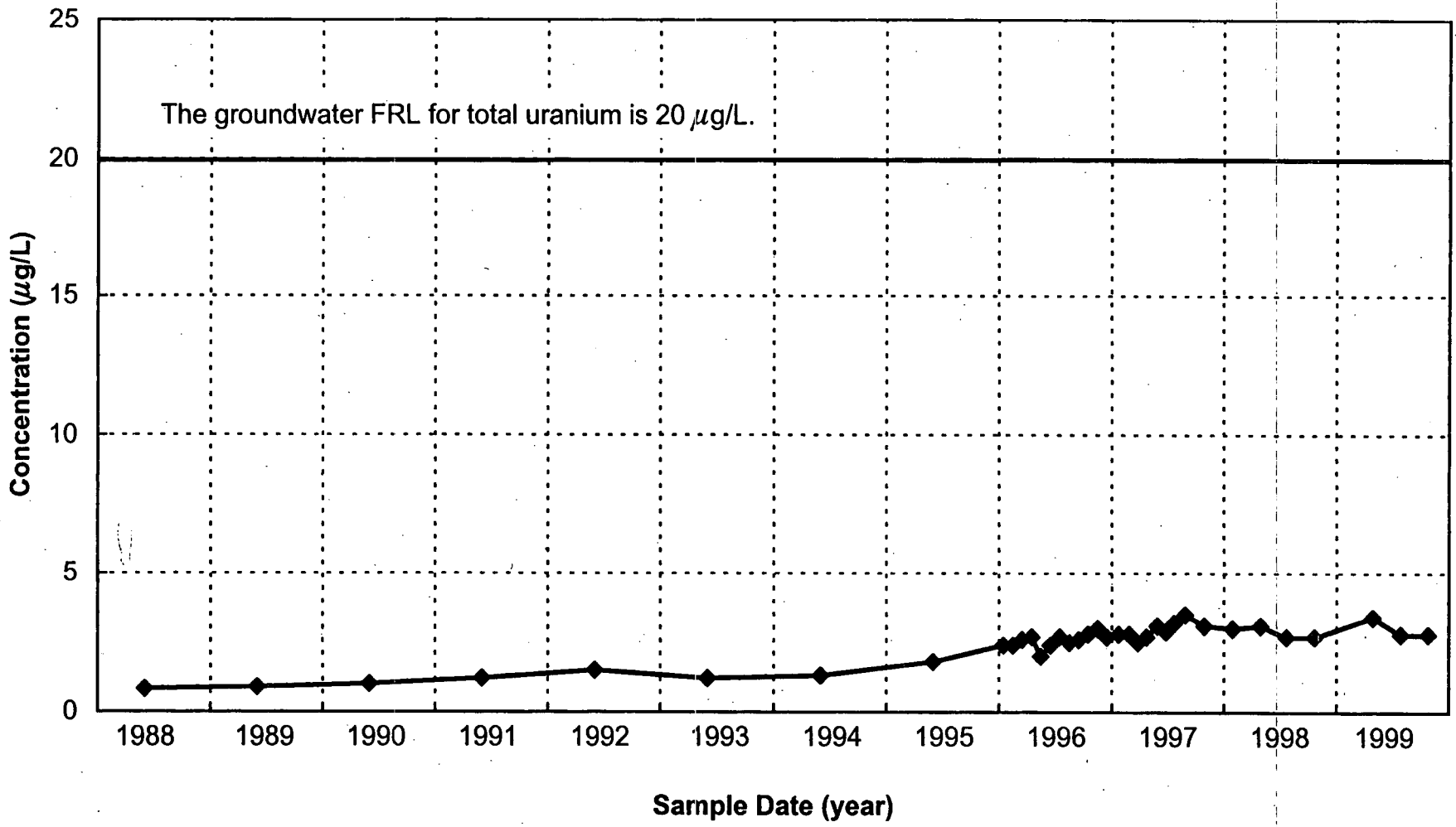


FIGURE A.2-16. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 14



000090

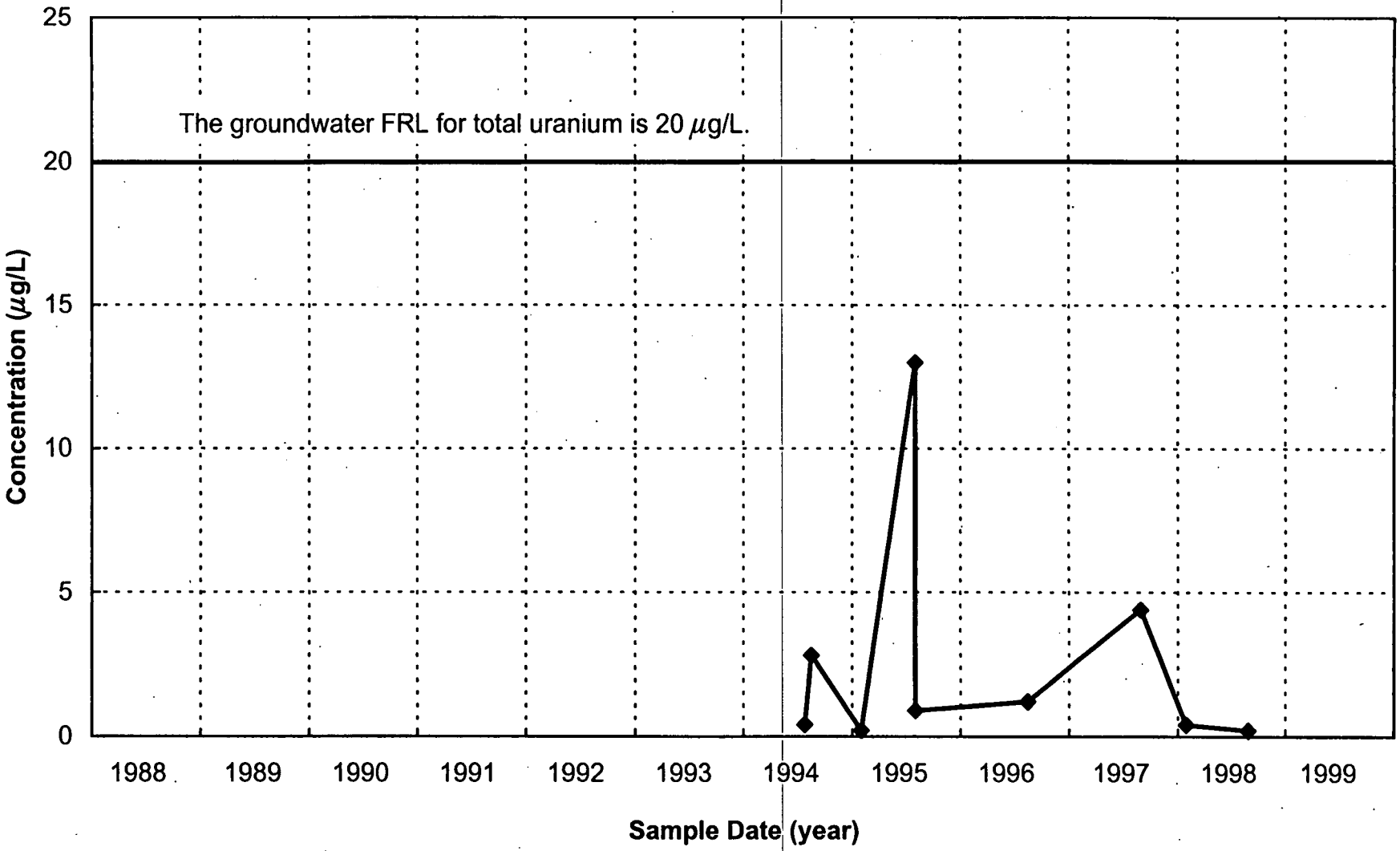


FIGURE A.2-17. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 67

000091

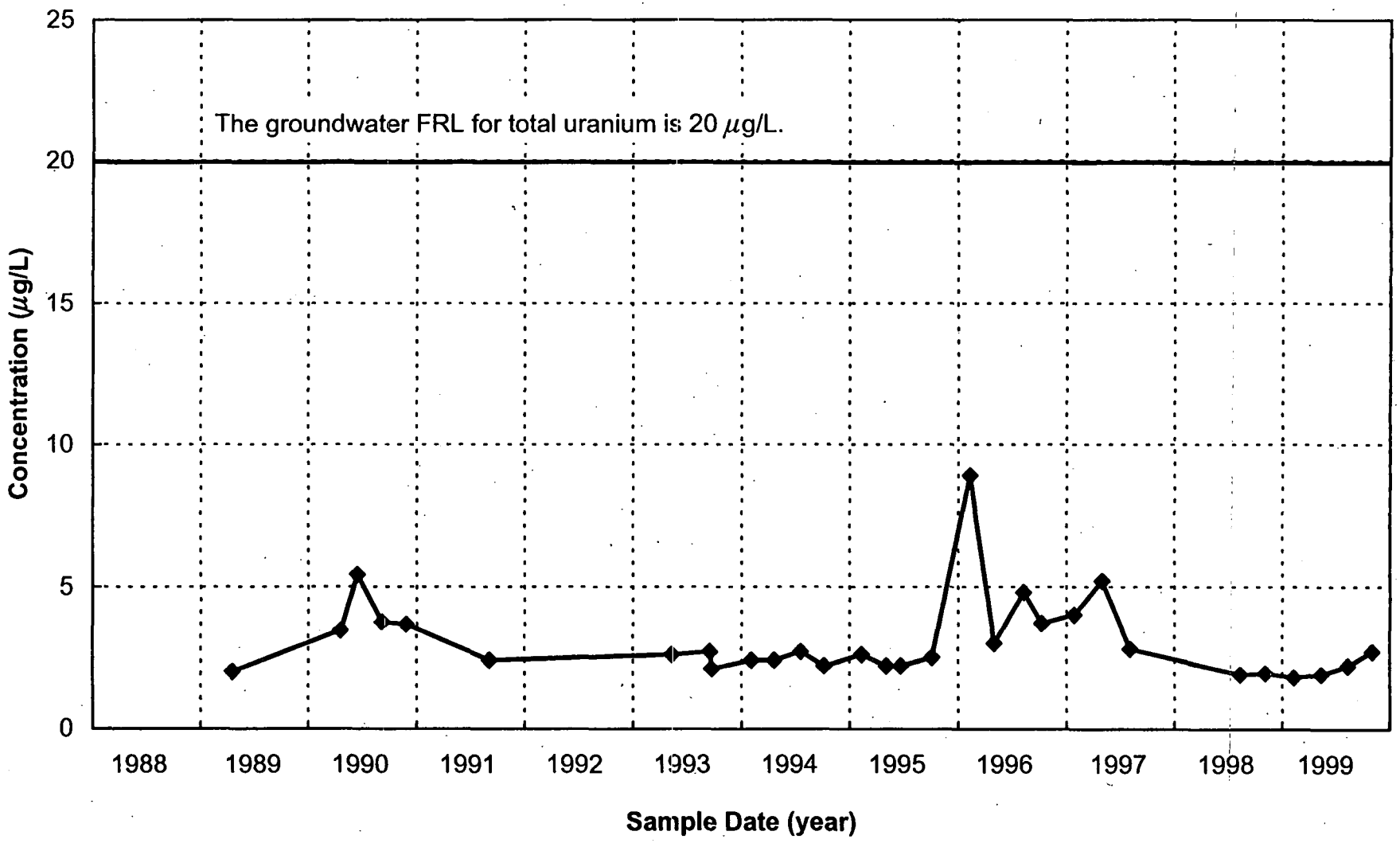


FIGURE A.2-18. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2002



260092

000093

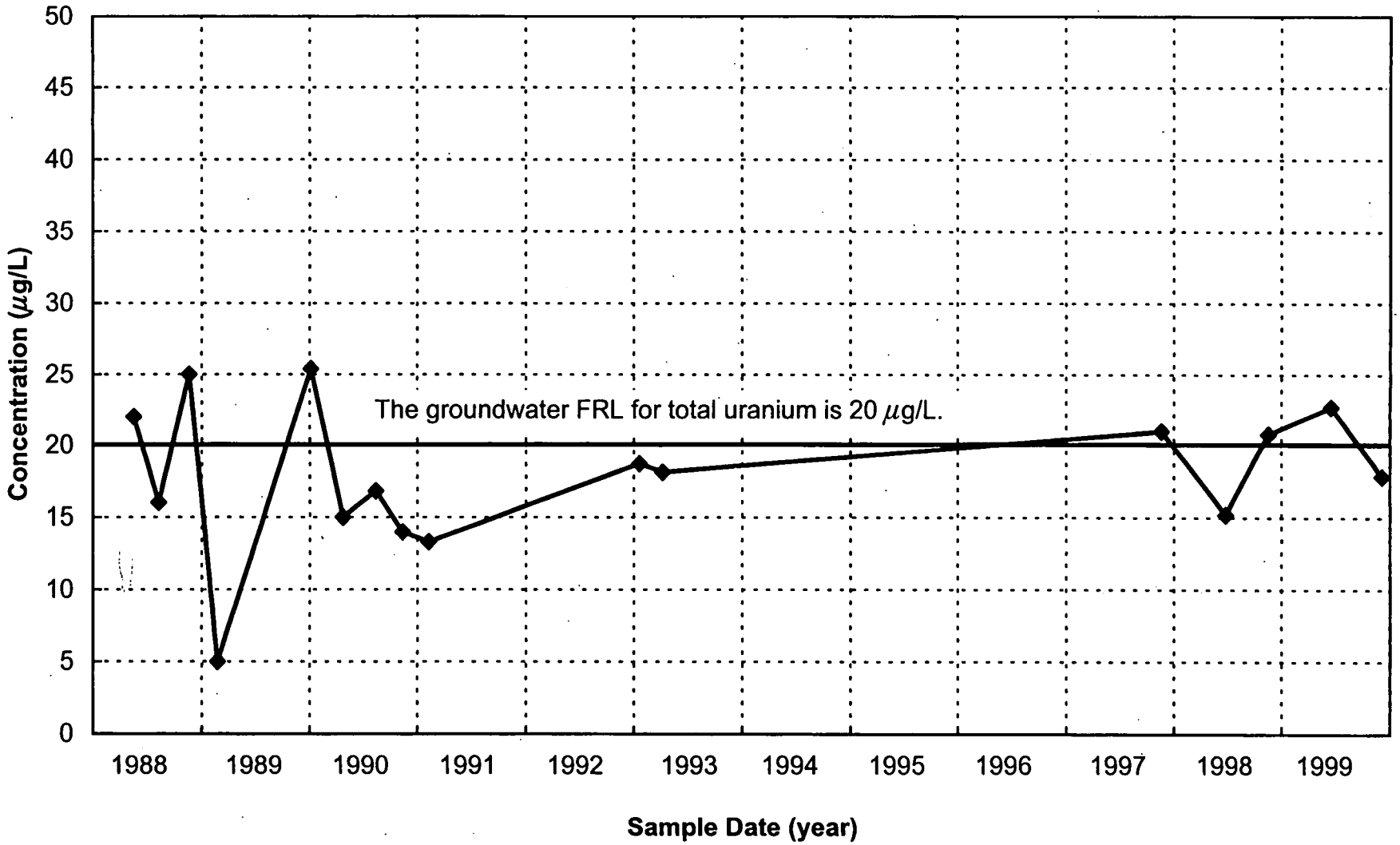


FIGURE A.2-19. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2008

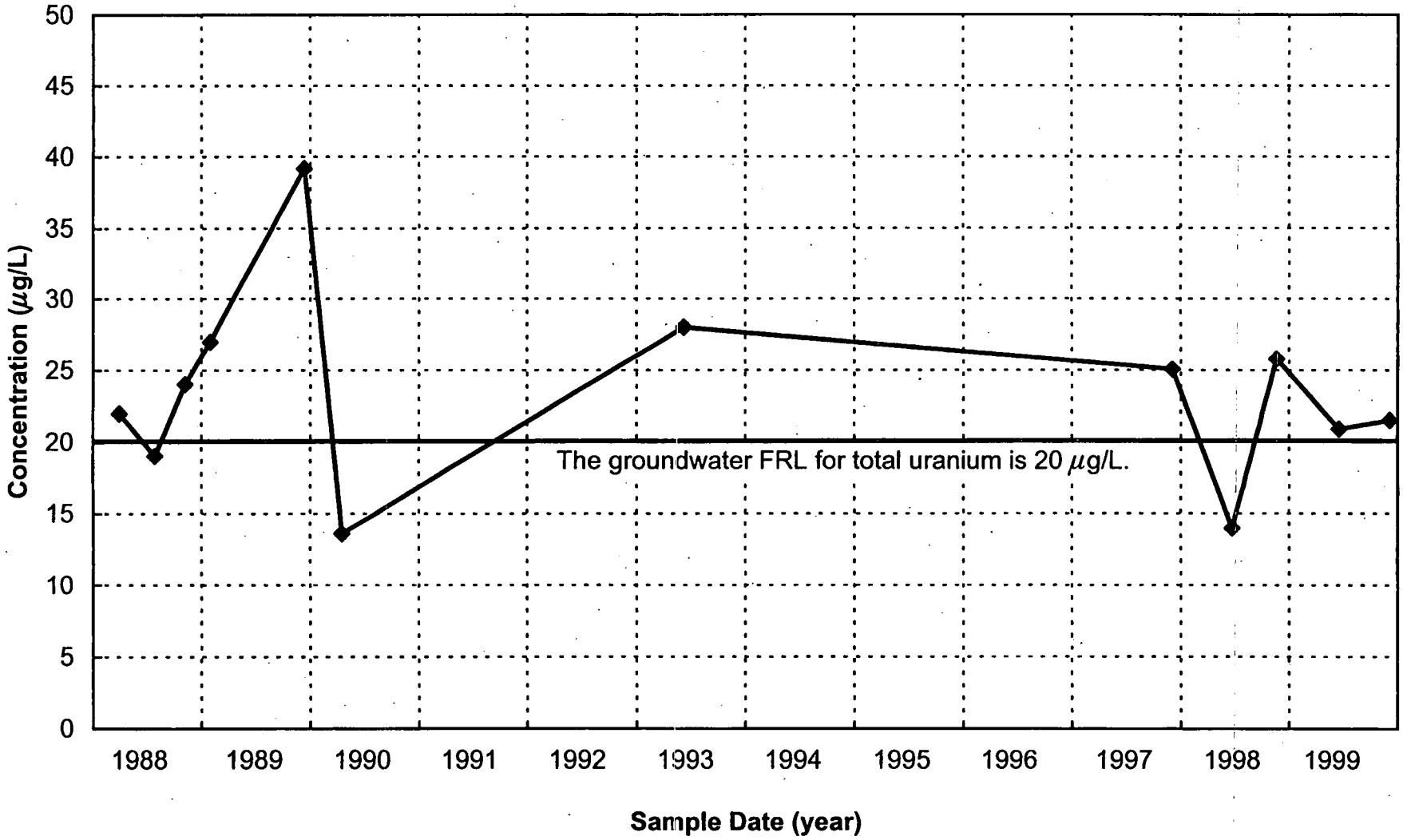


FIGURE A.2-20. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2009



000094

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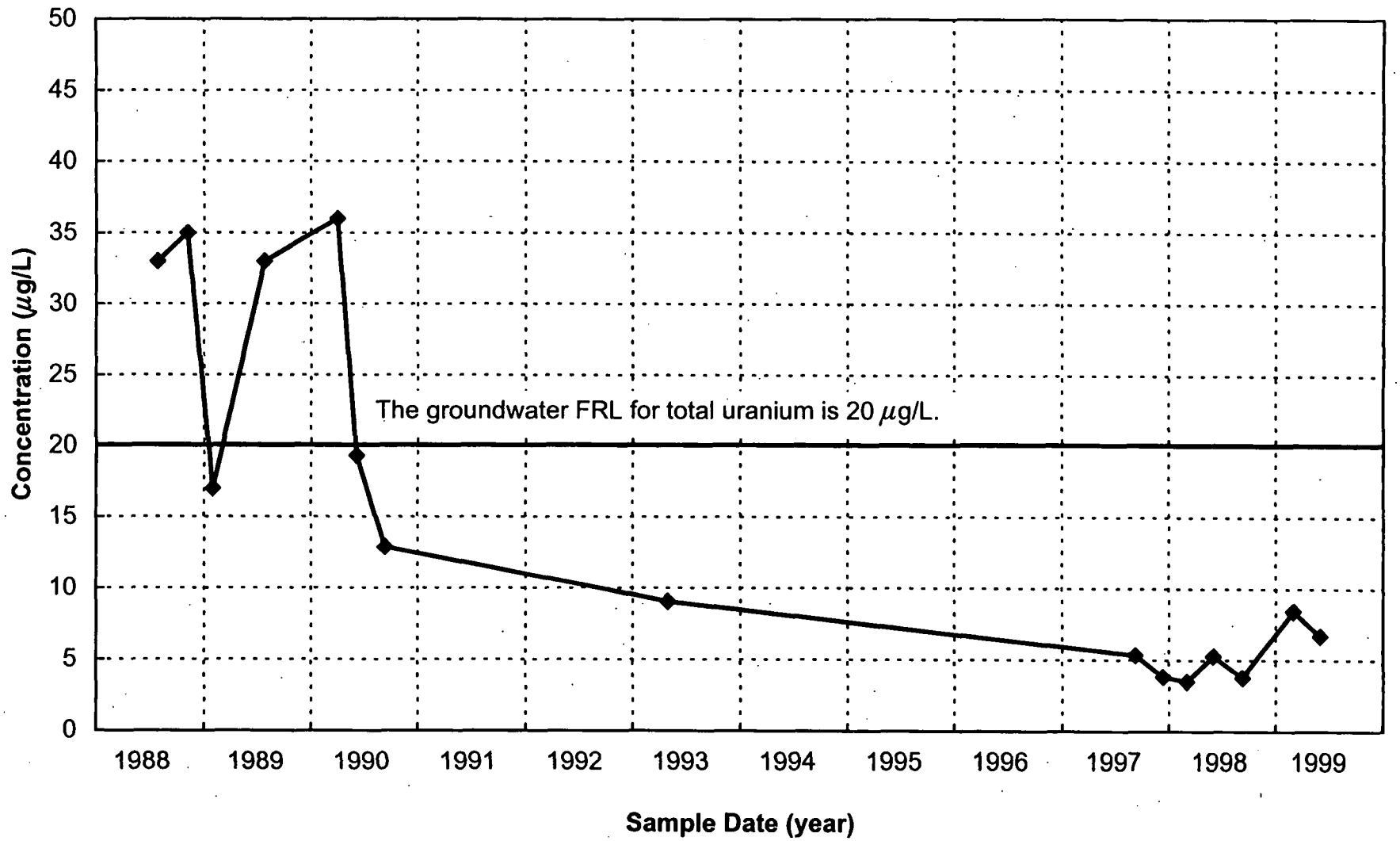


FIGURE A.2-21. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2014

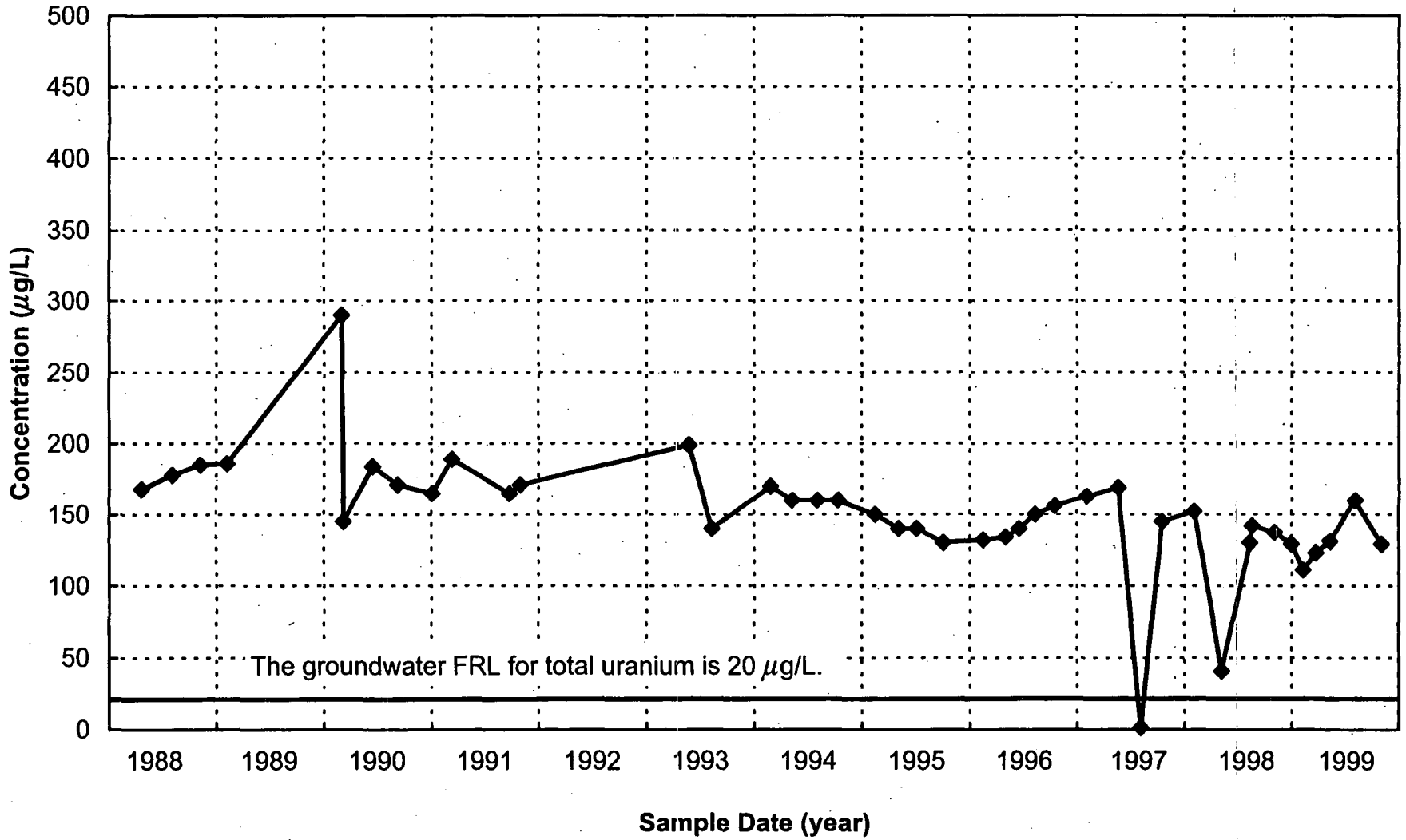


FIGURE A.2-22. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2015



000096

000097

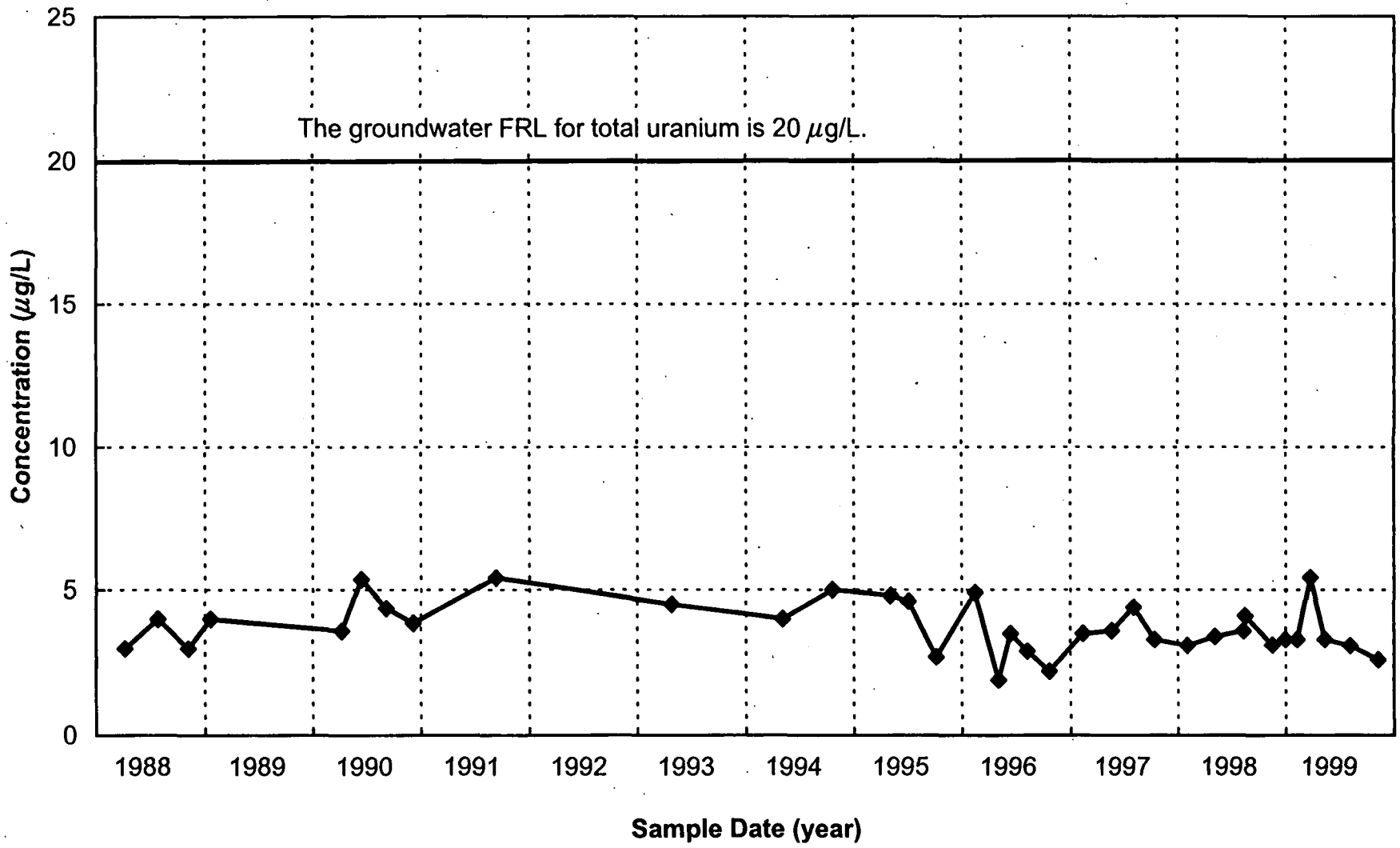


FIGURE A.2-23. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2017

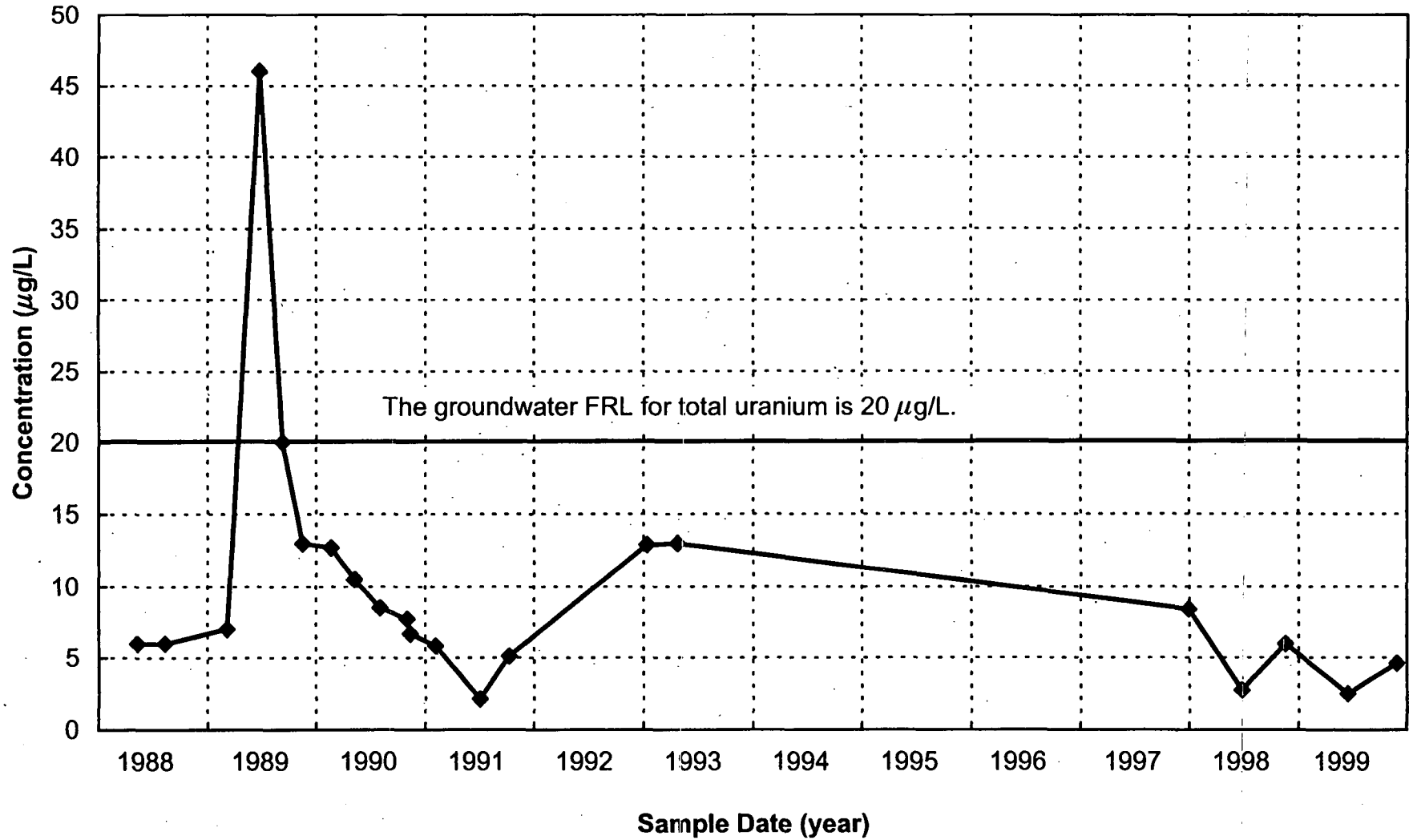


FIGURE A.2-24. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2027



000098

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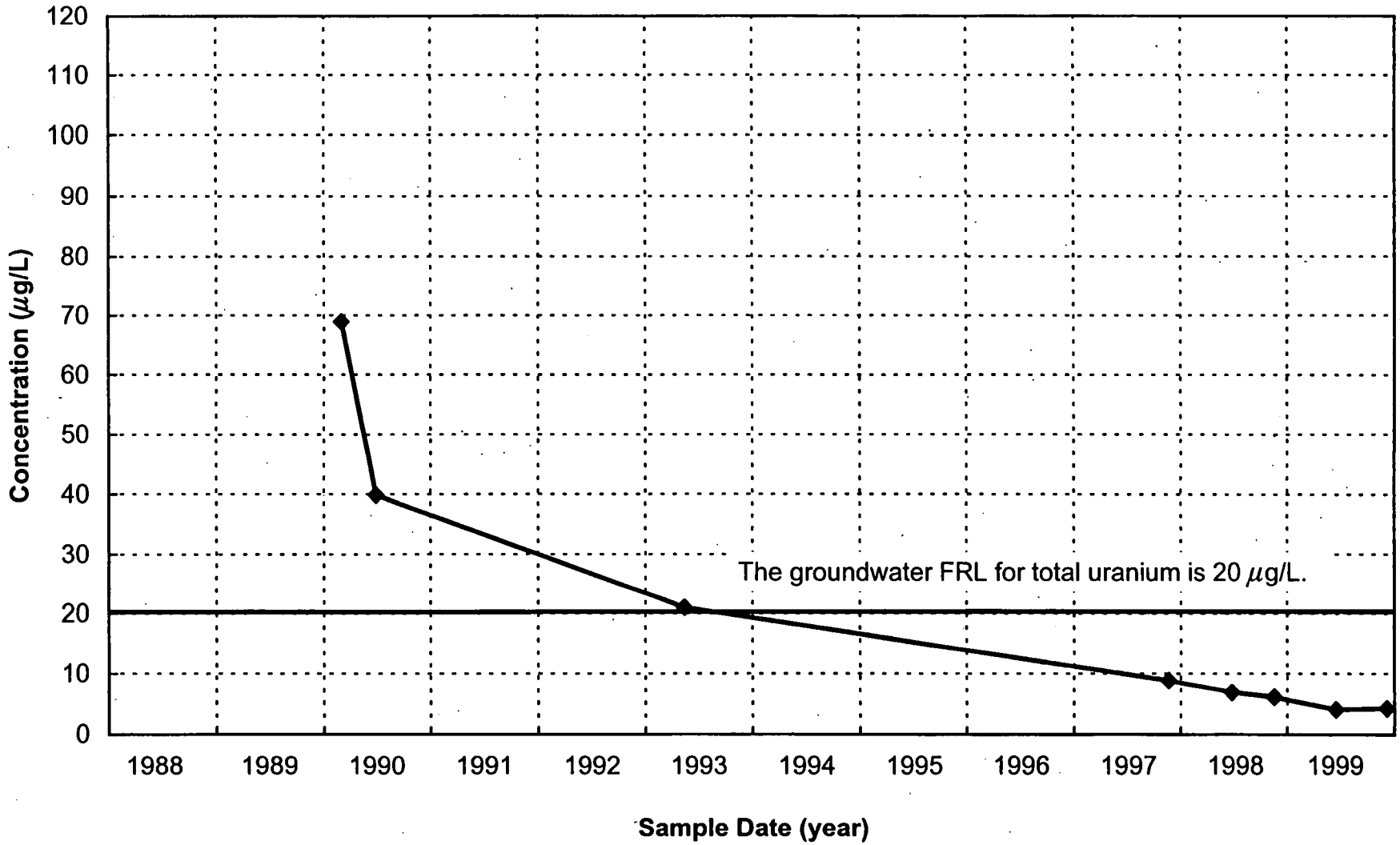


FIGURE A.2-25. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2032

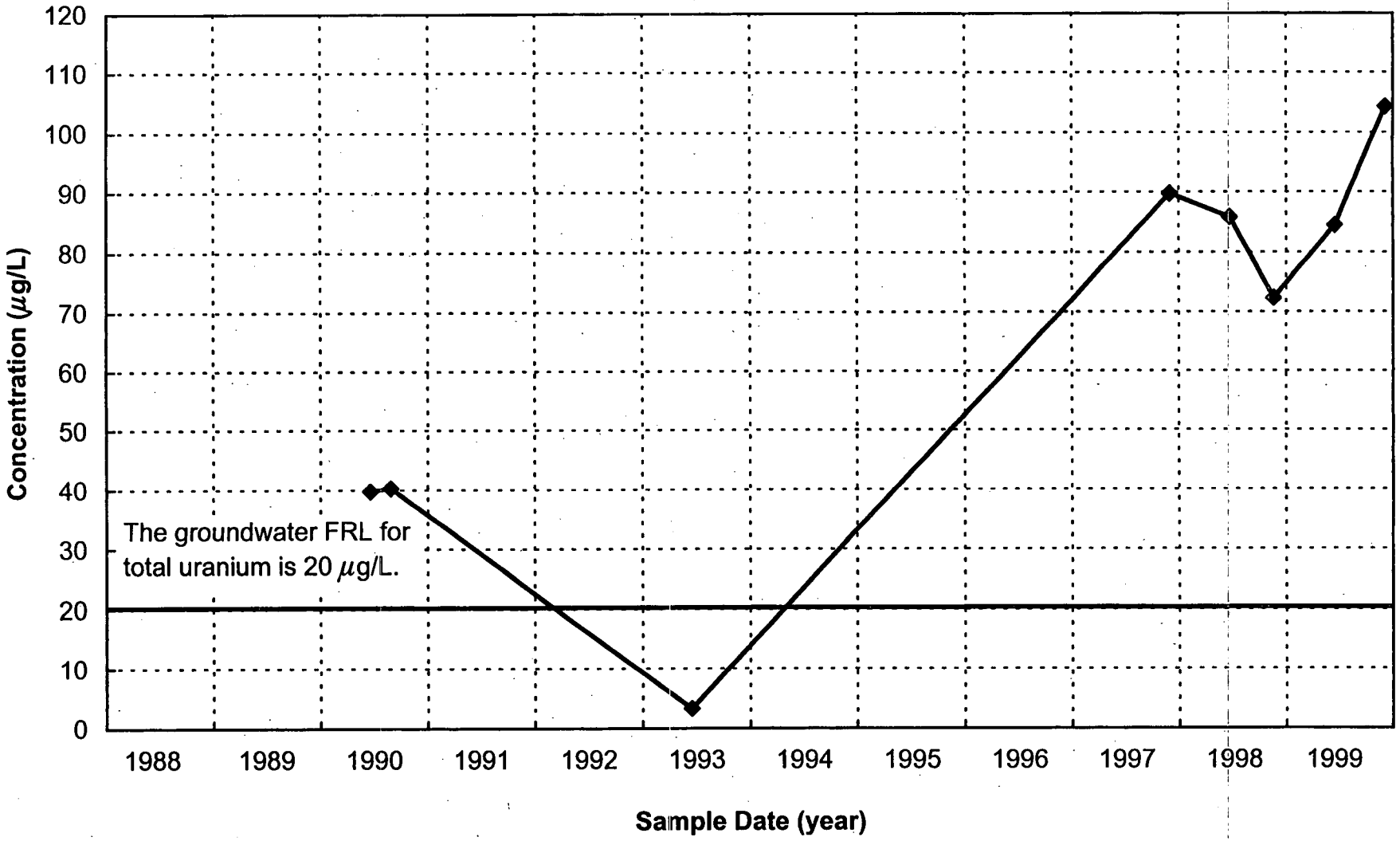


FIGURE A.2-26. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2033



000100

0001101

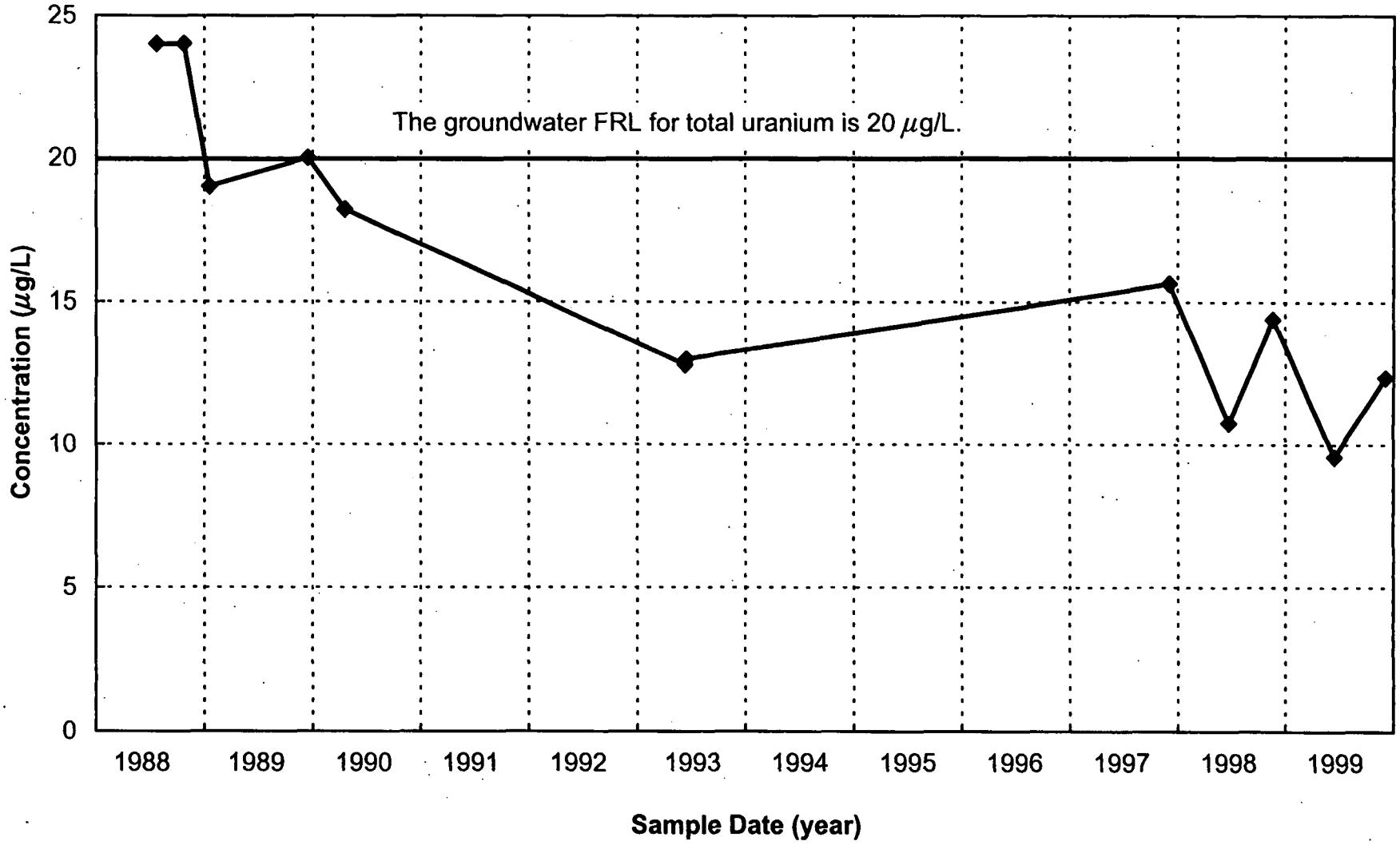


FIGURE A.2-27. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2034

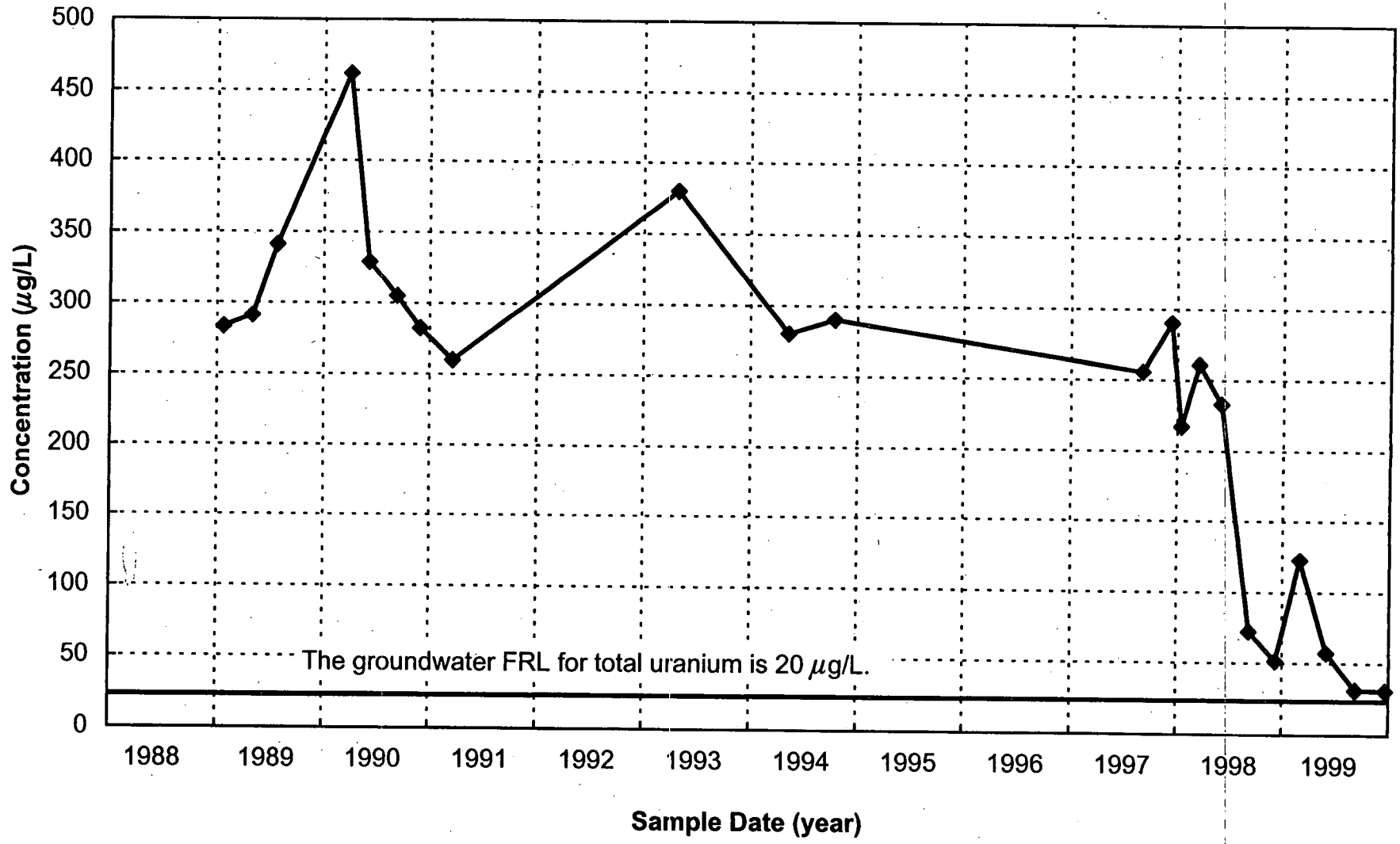


FIGURE A.2-28. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2045



000102

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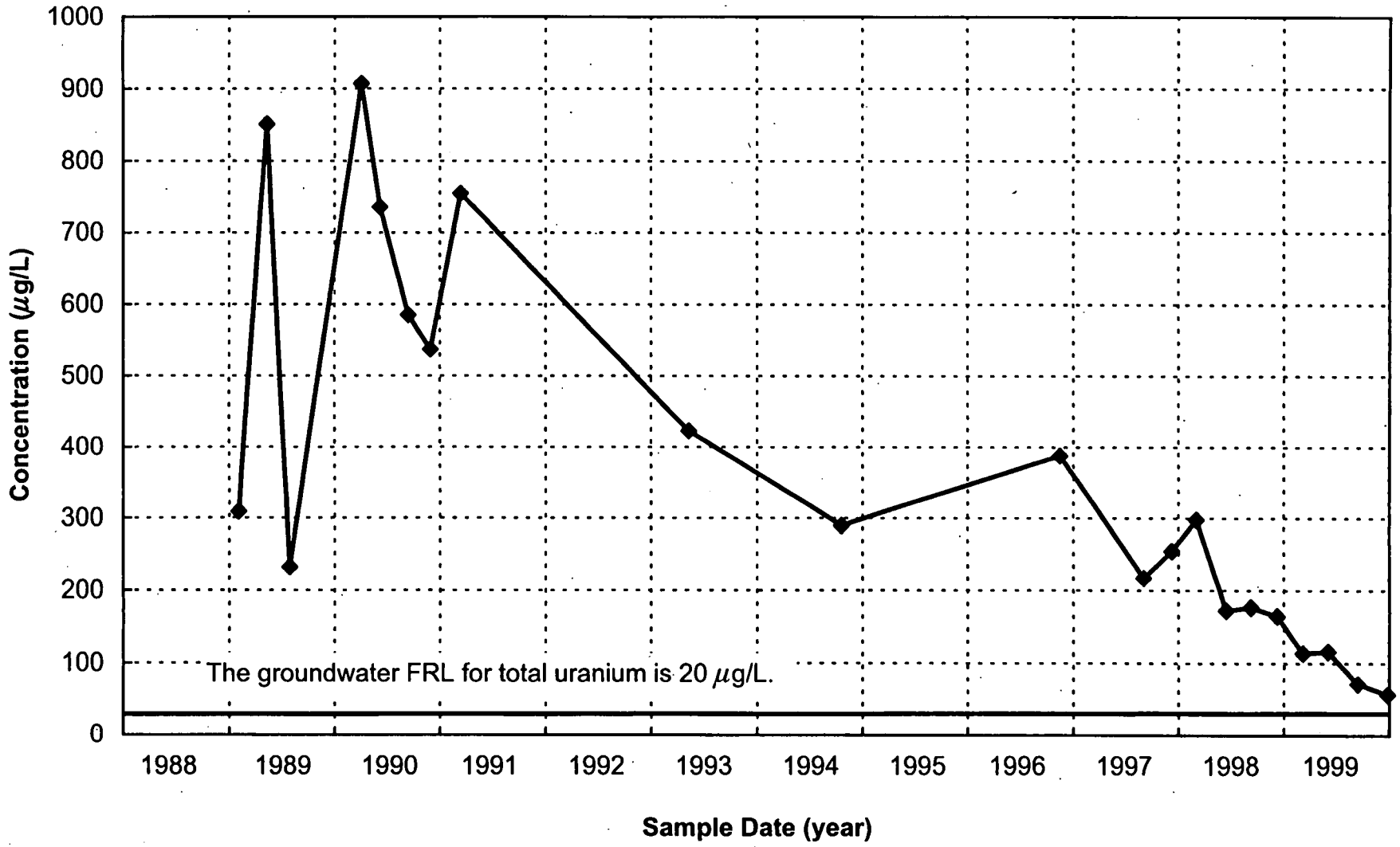


FIGURE A.2-29. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2046

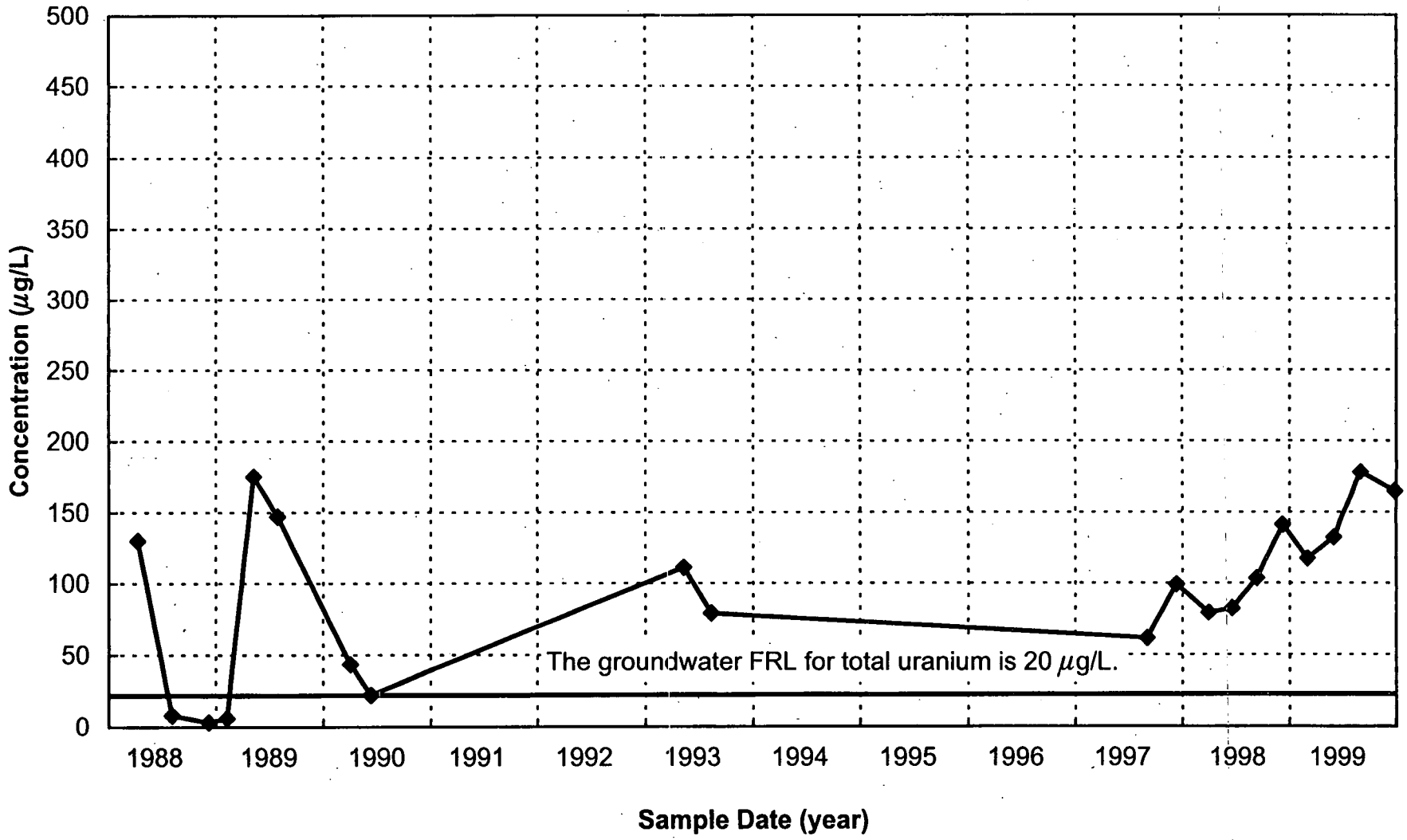


FIGURE A.2-30. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2049



000104

000105

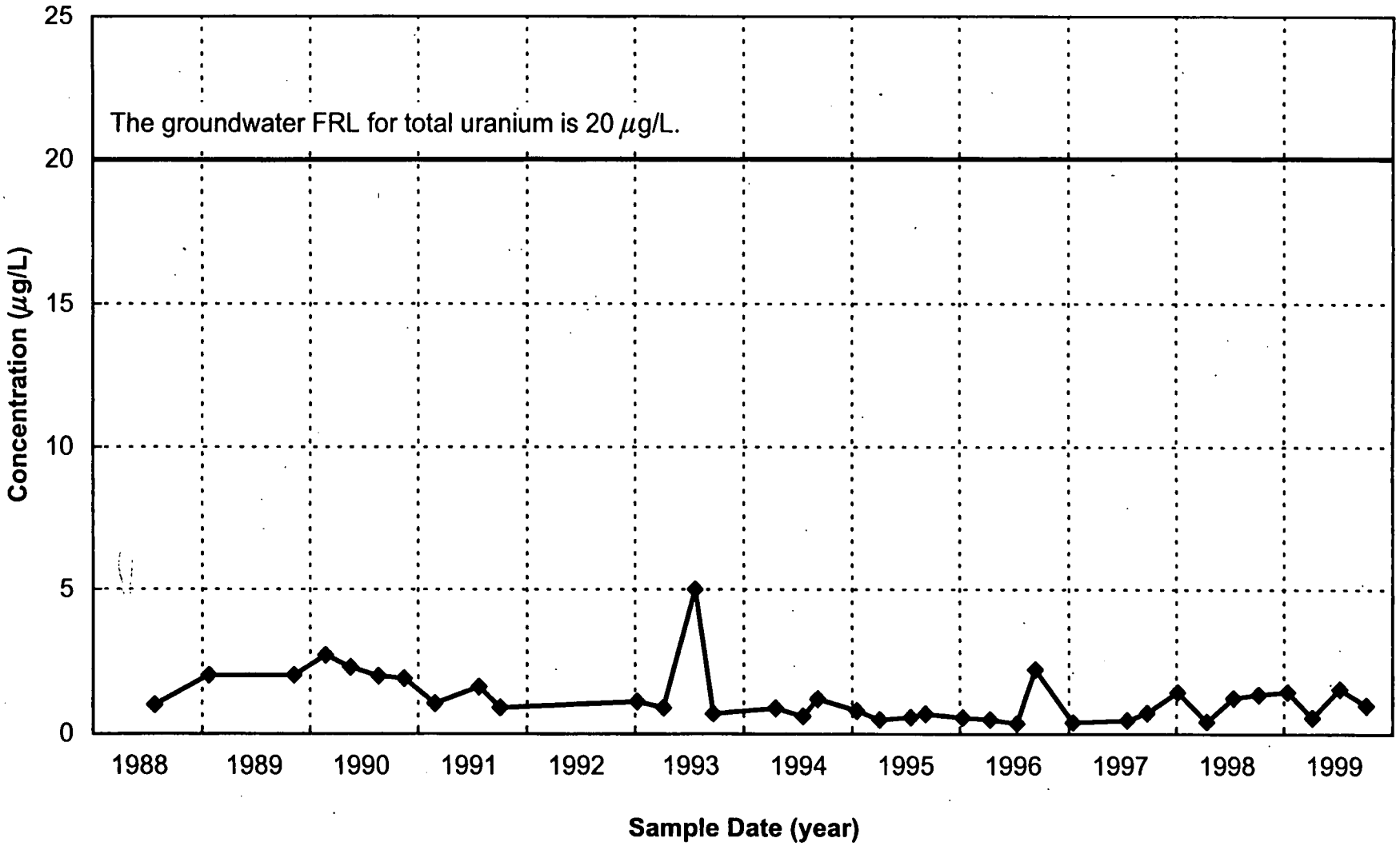


FIGURE A.2-31. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2051

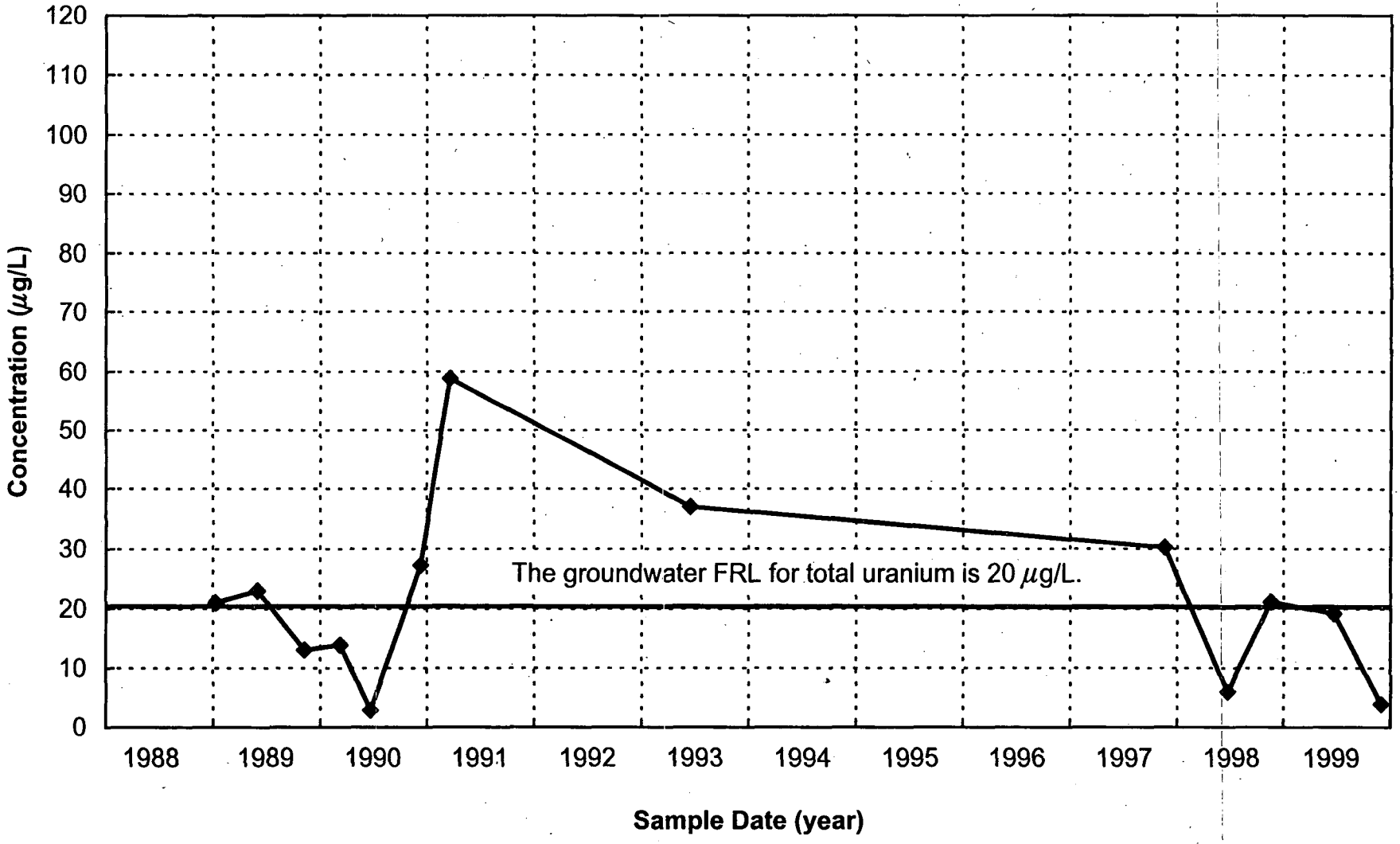


FIGURE A.2-32. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2054



000106

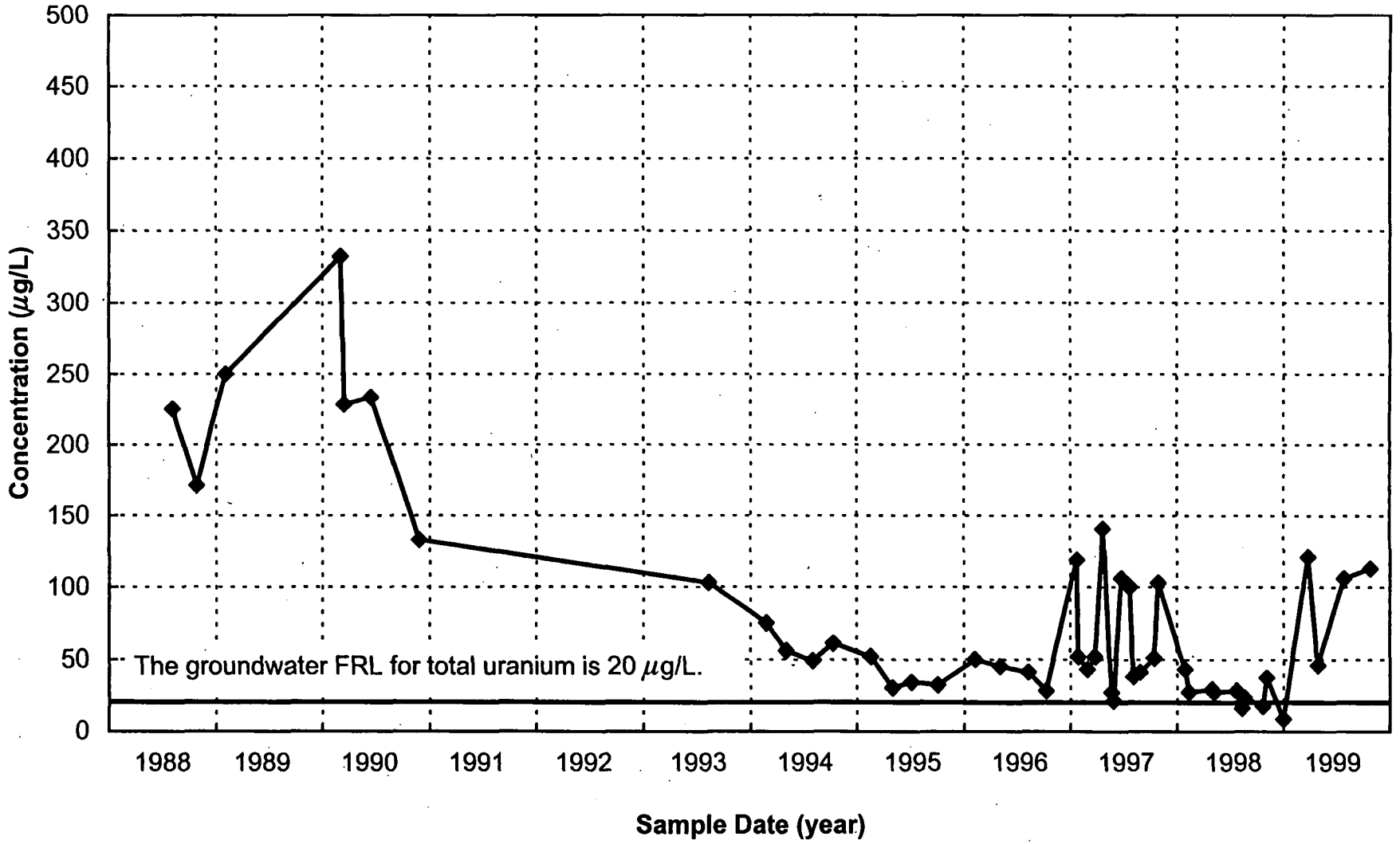


FIGURE A.2-33. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2060 (12)

000107

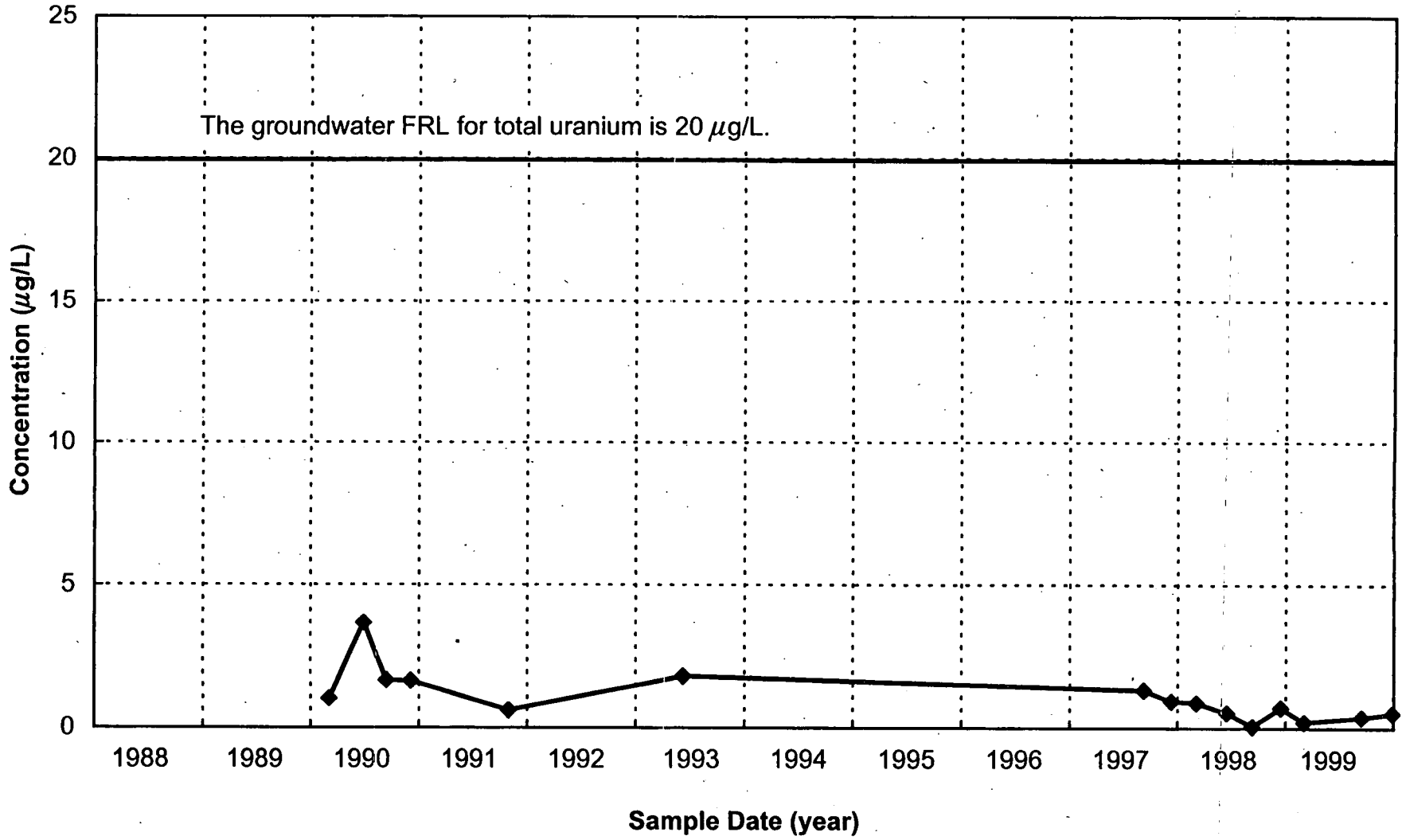


FIGURE A.2-34. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2068



000108

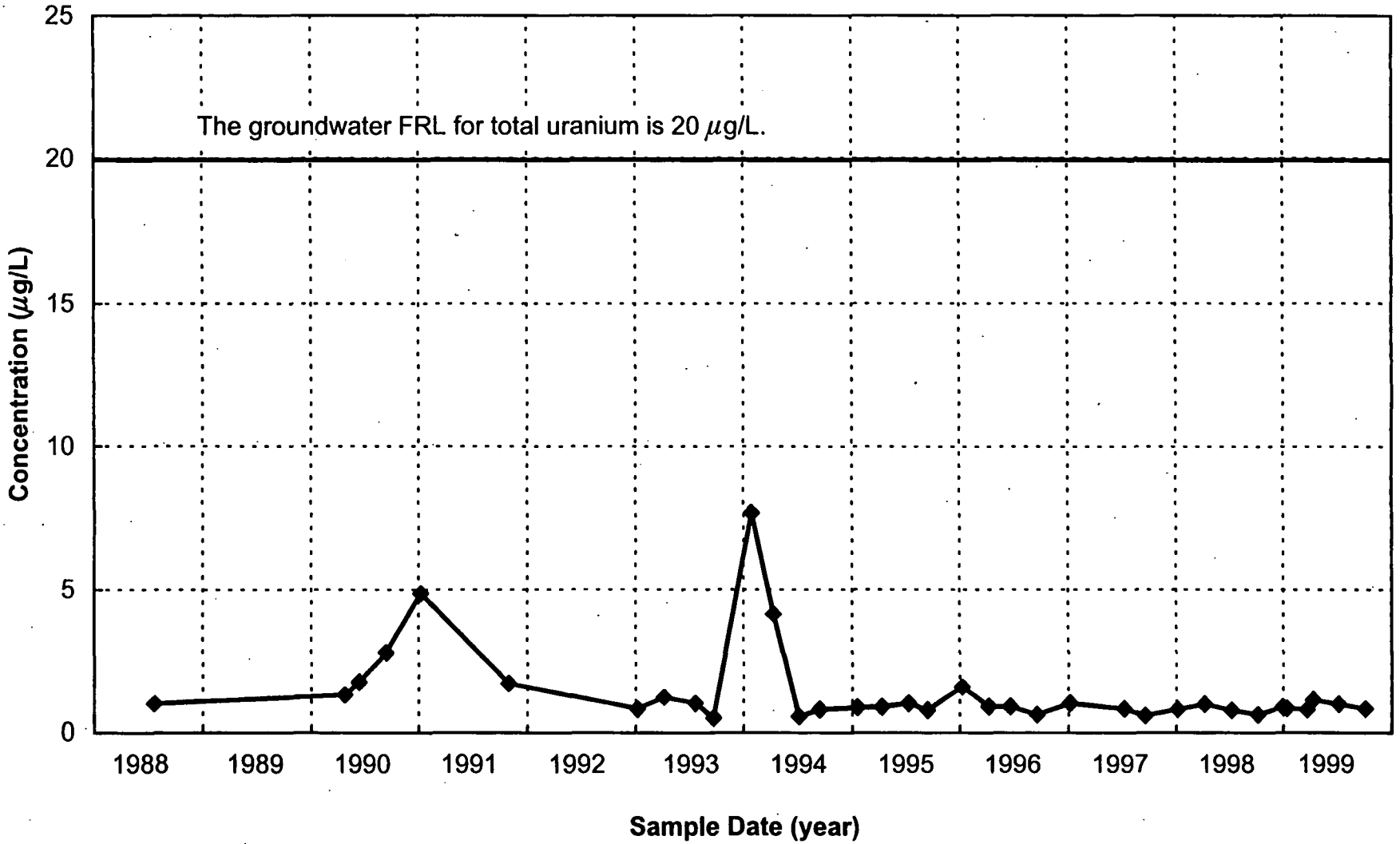


FIGURE A.2-35. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2070

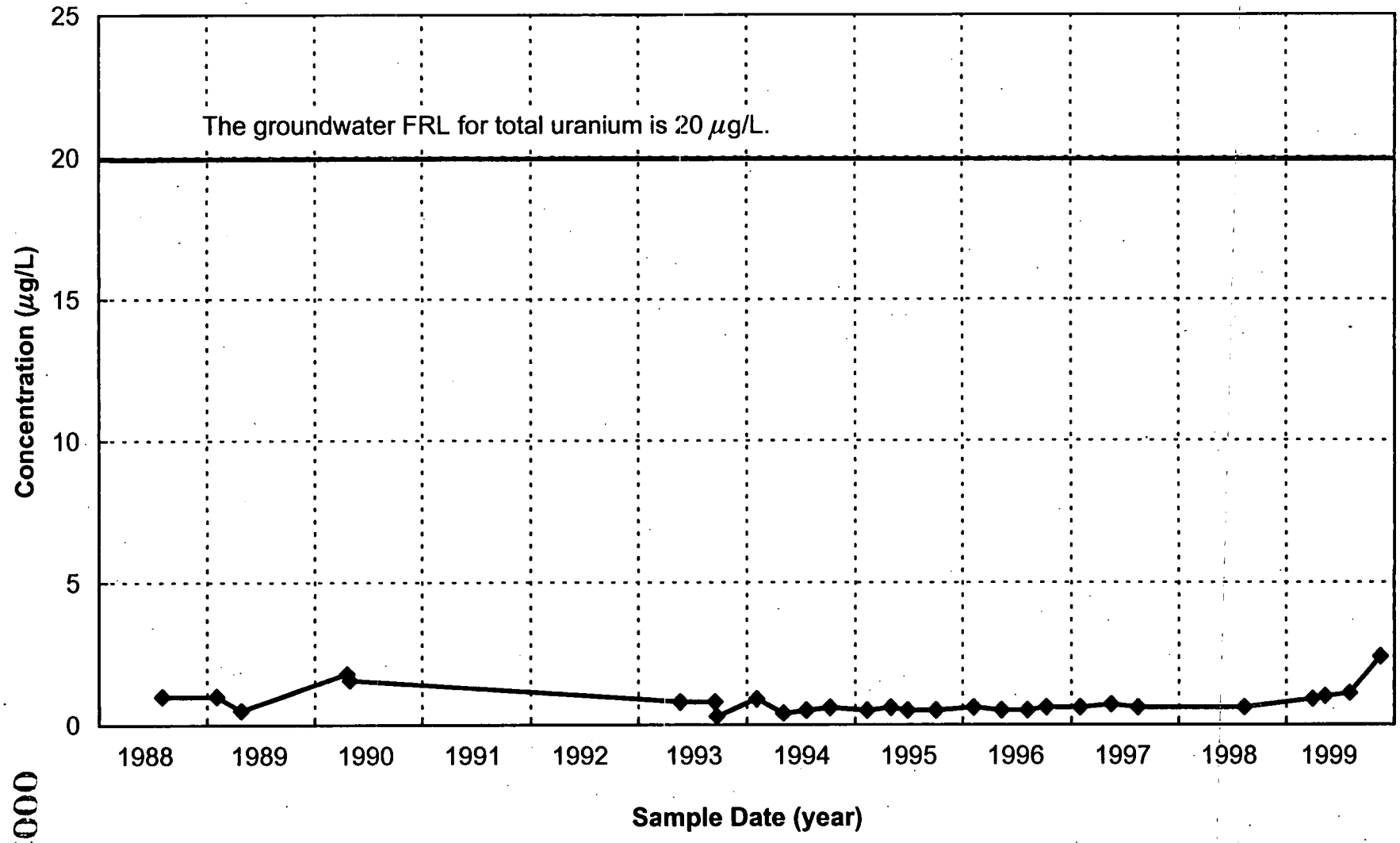


FIGURE A.2-36. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2093

000111

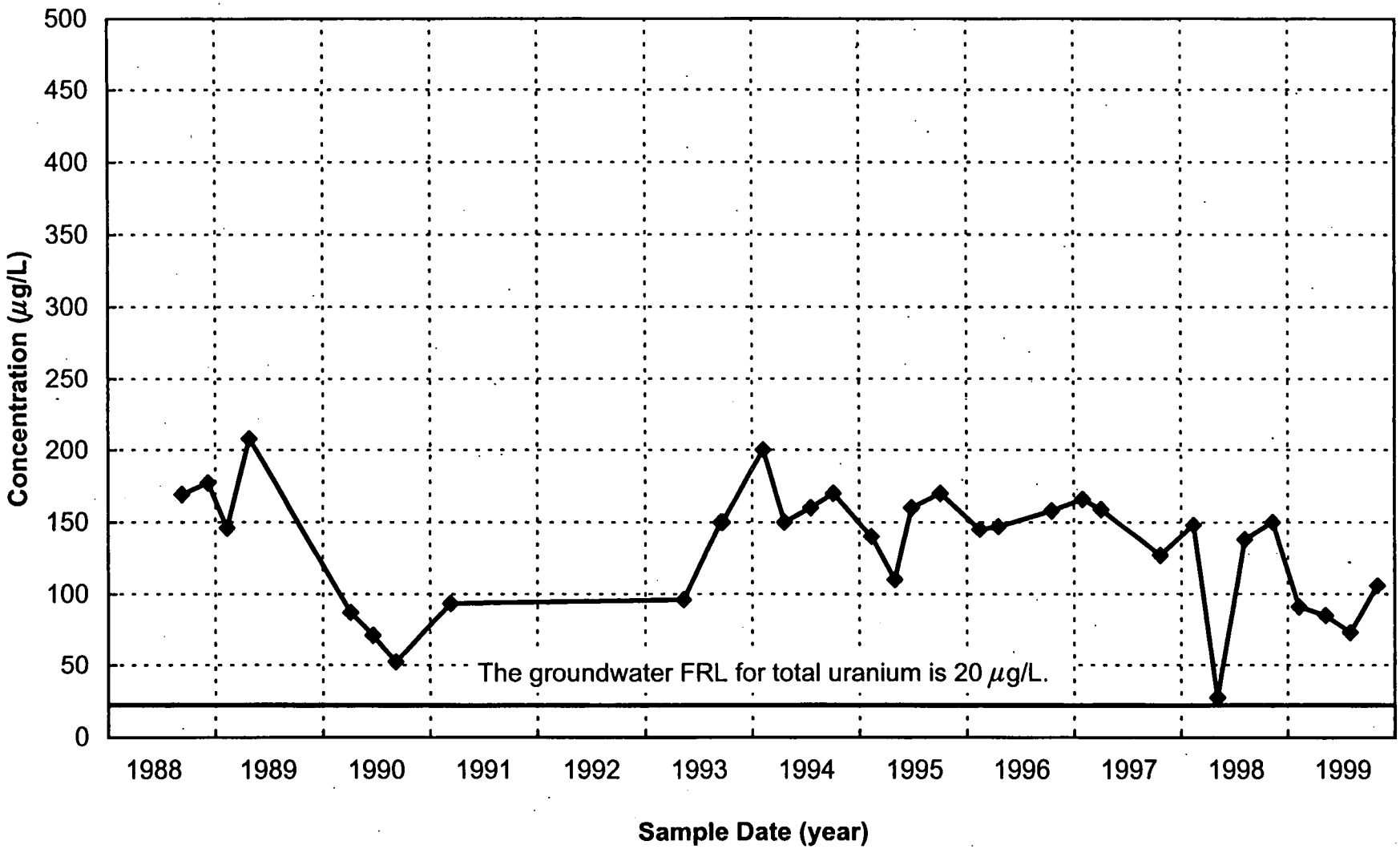


FIGURE A.2-37. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2095

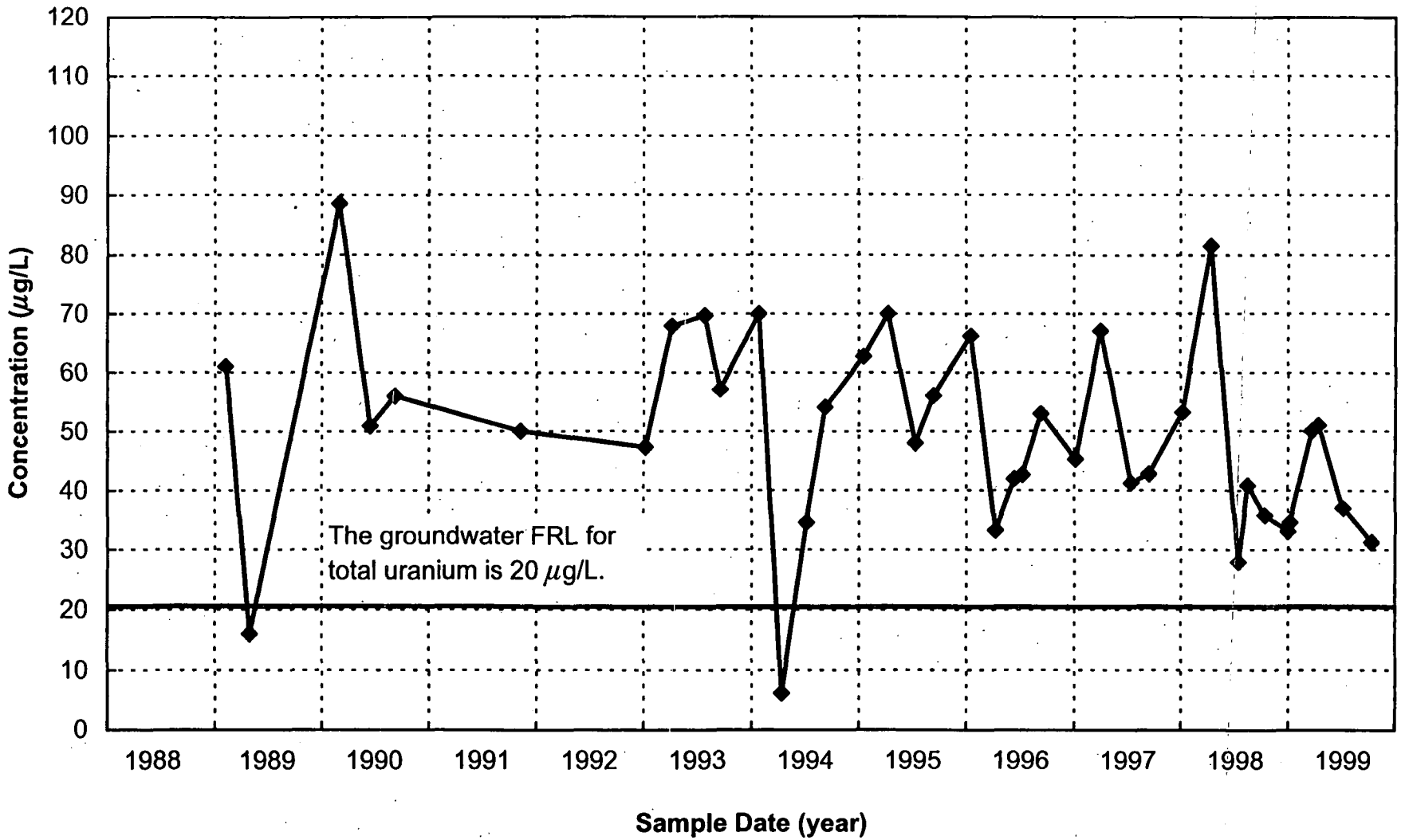


FIGURE A.2-38. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2106

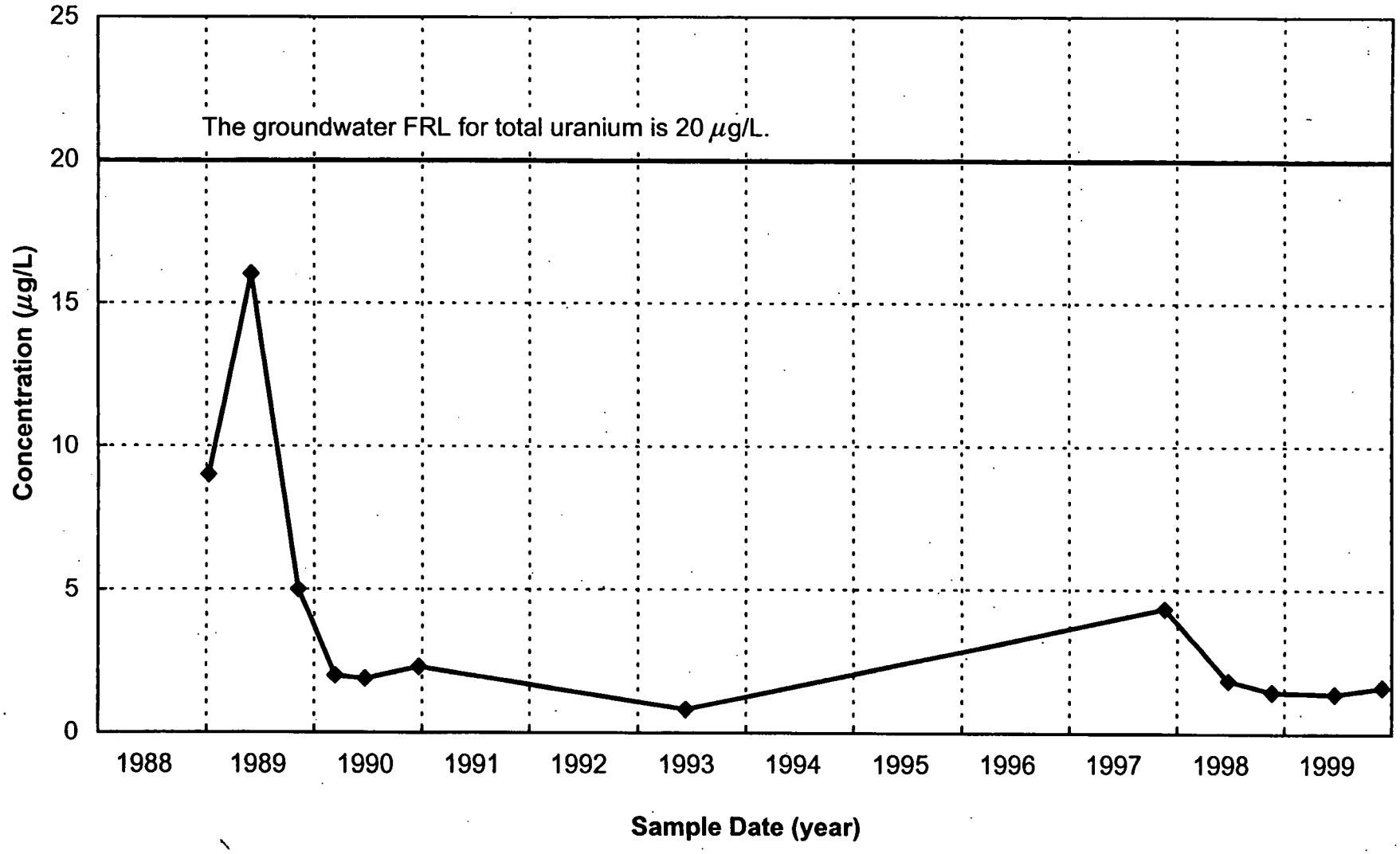


FIGURE A.2-39. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2118

000443

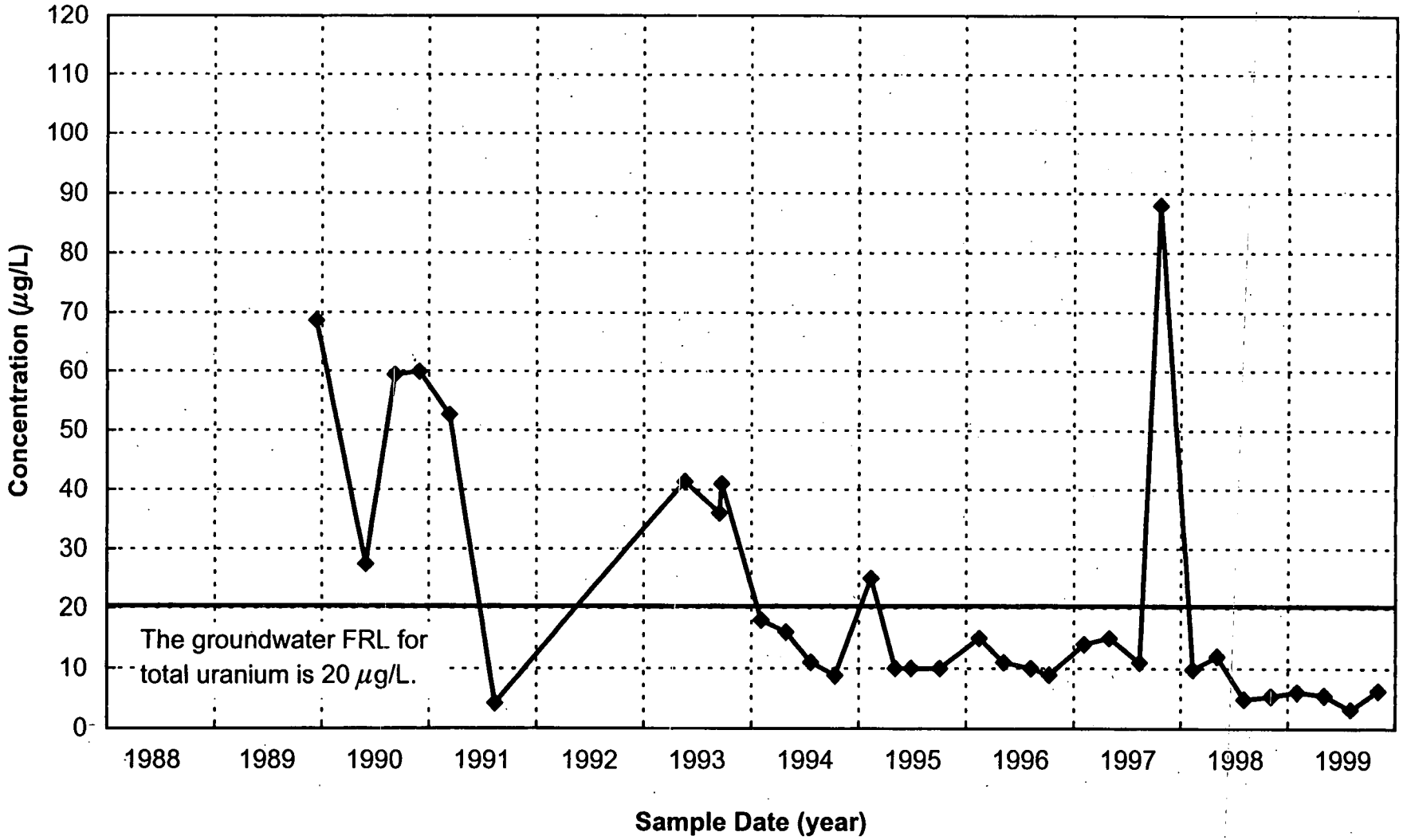


FIGURE A.2-40. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2125

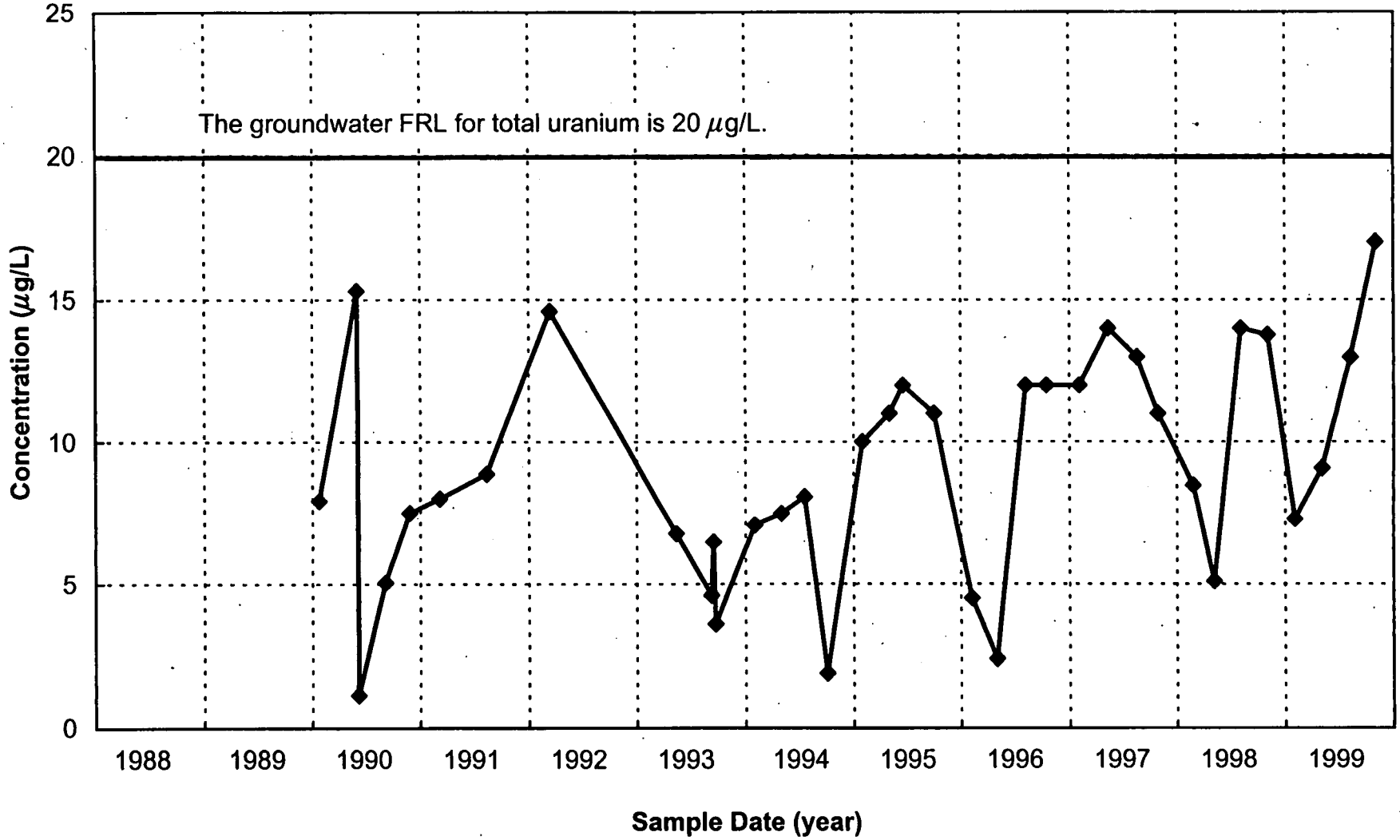


FIGURE A.2-41. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2128

000115

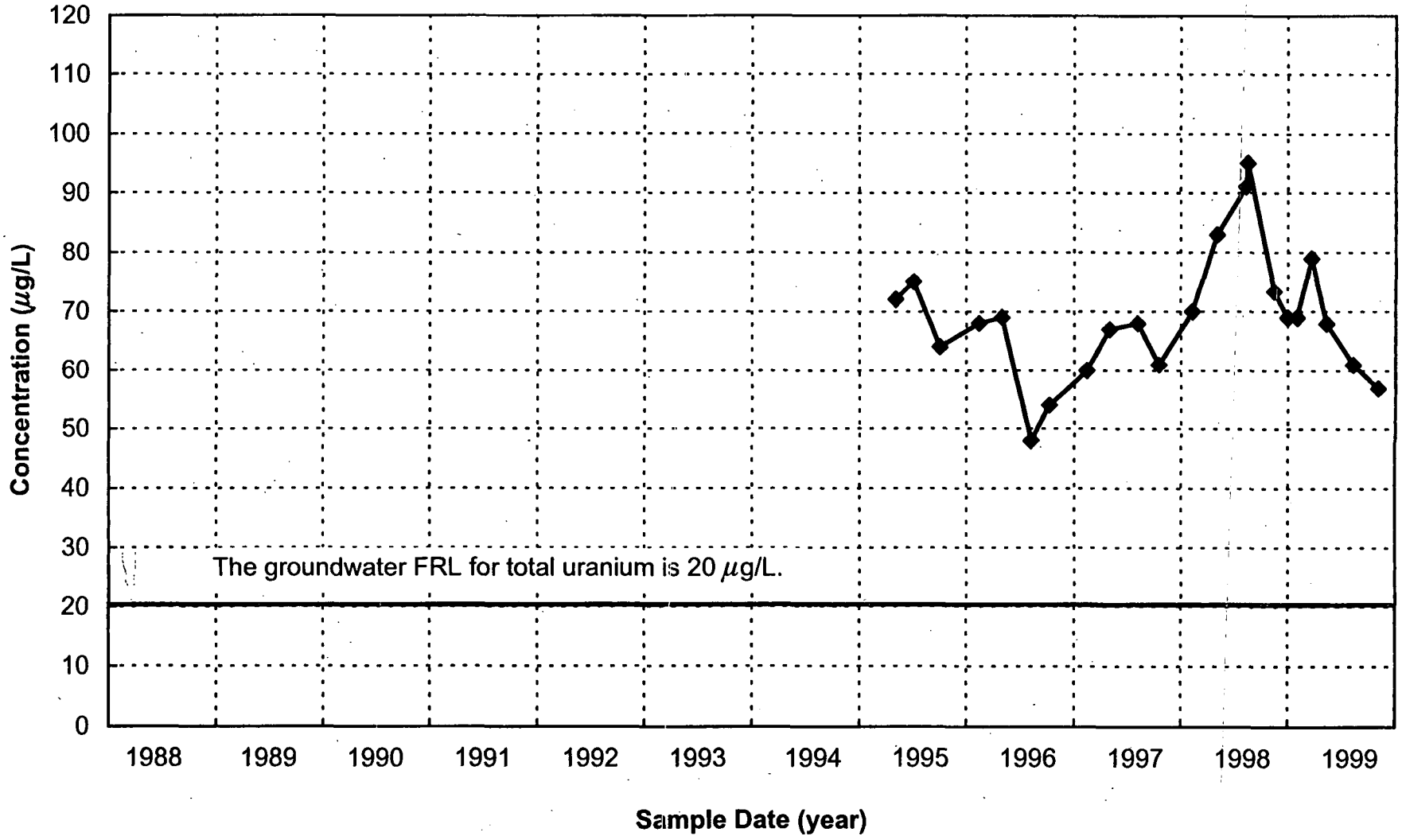


FIGURE A.2-42. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2166

000117

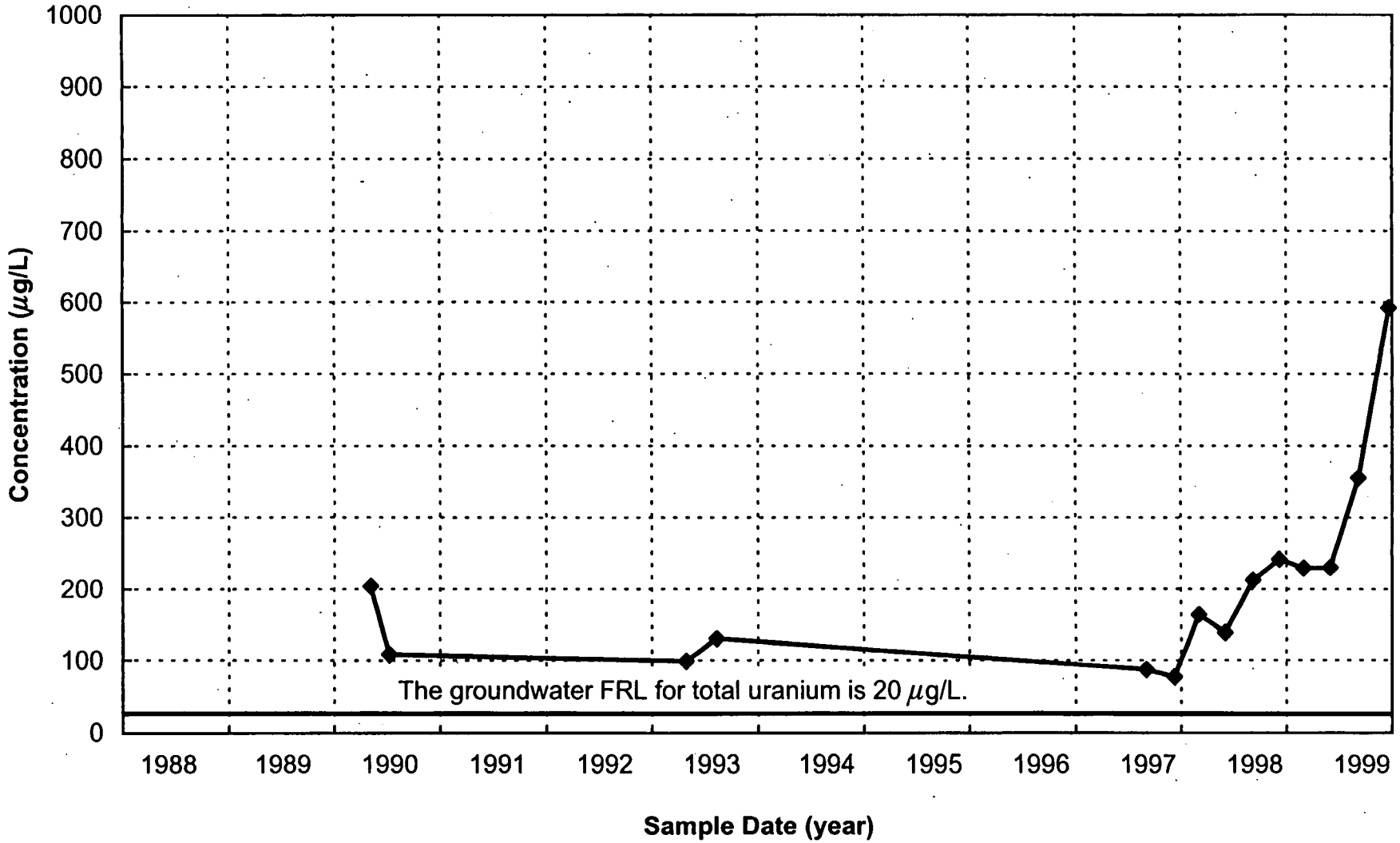


FIGURE A.2-43. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2385

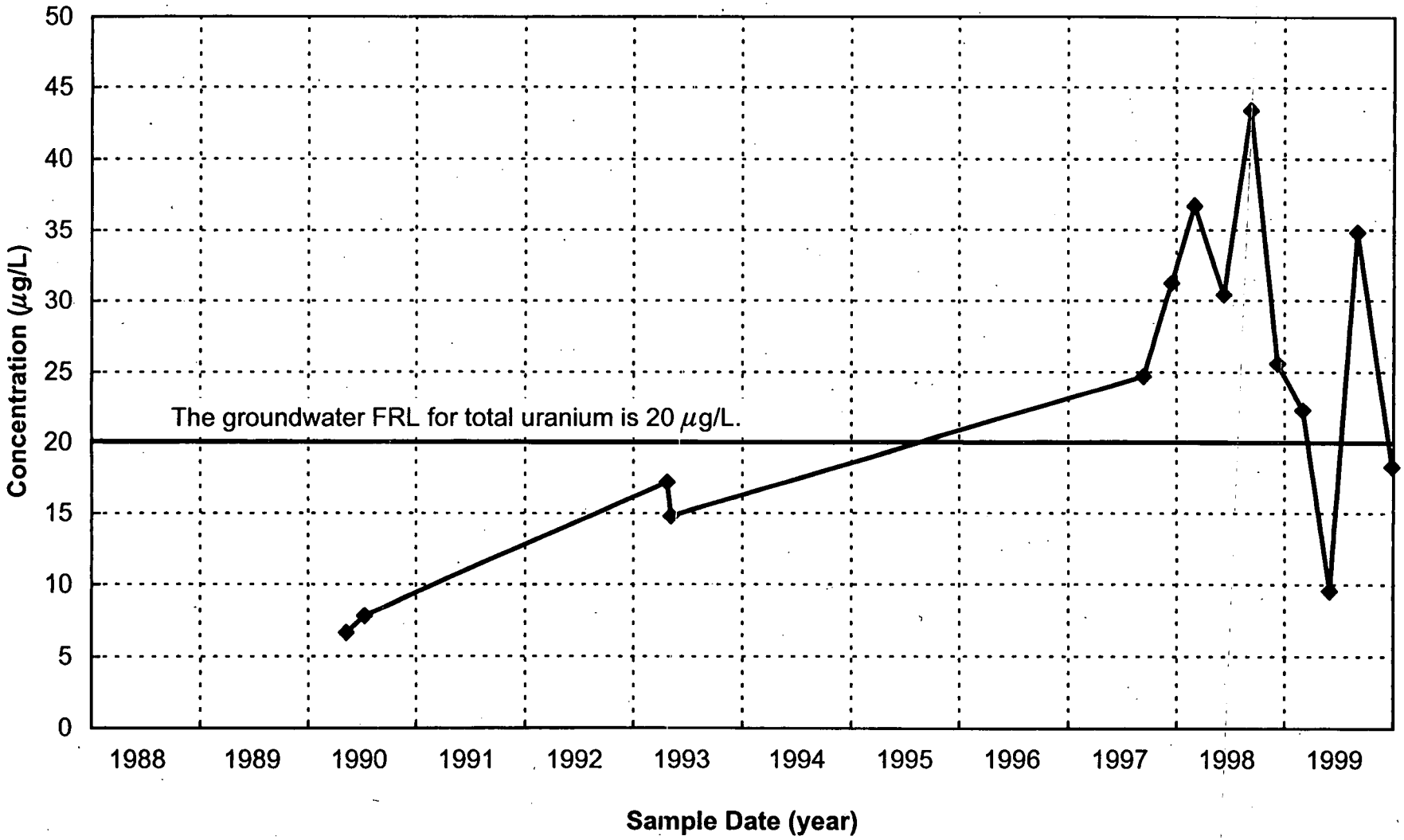


FIGURE A.2-44. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2386



000118

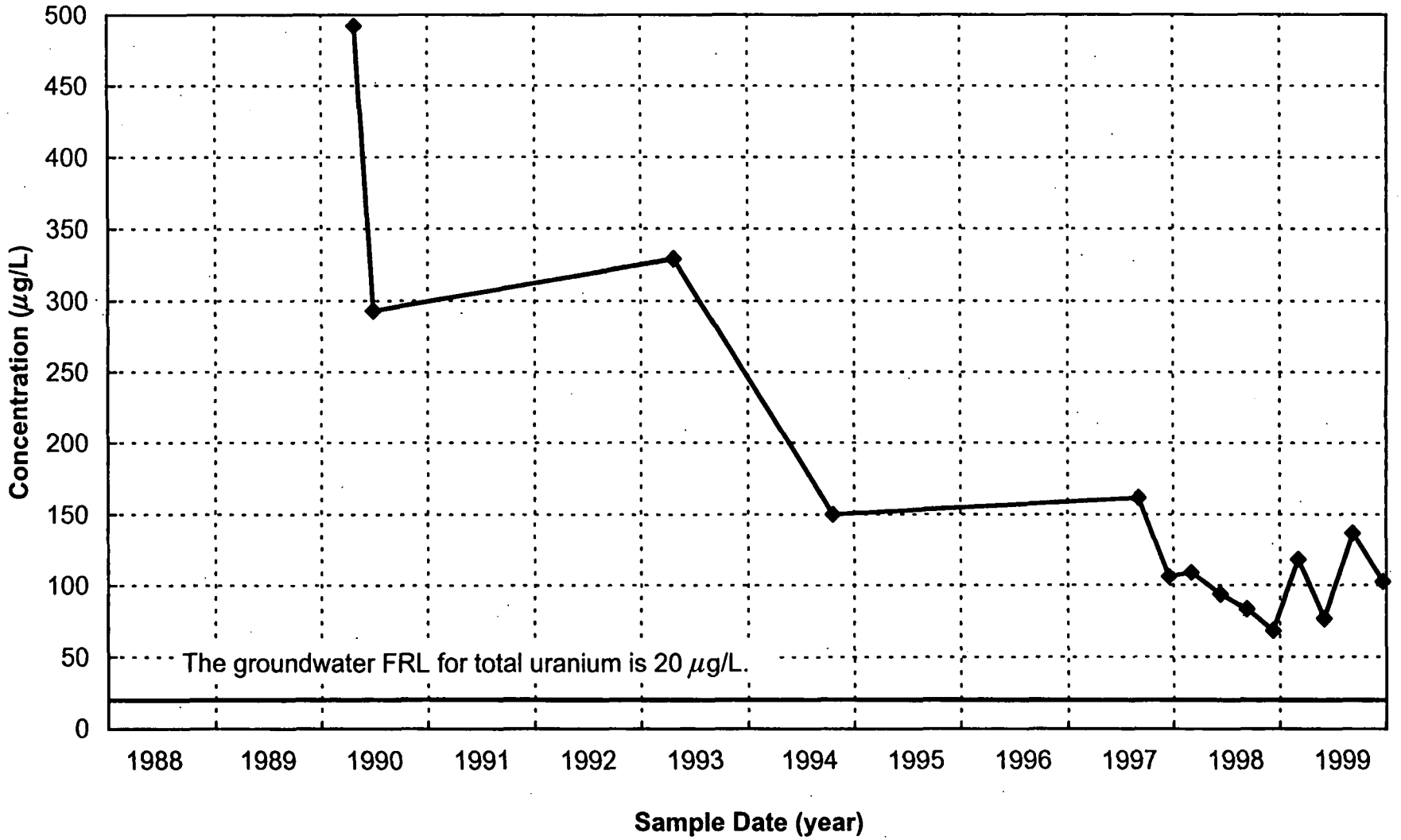


FIGURE A.2-45. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2387

000119

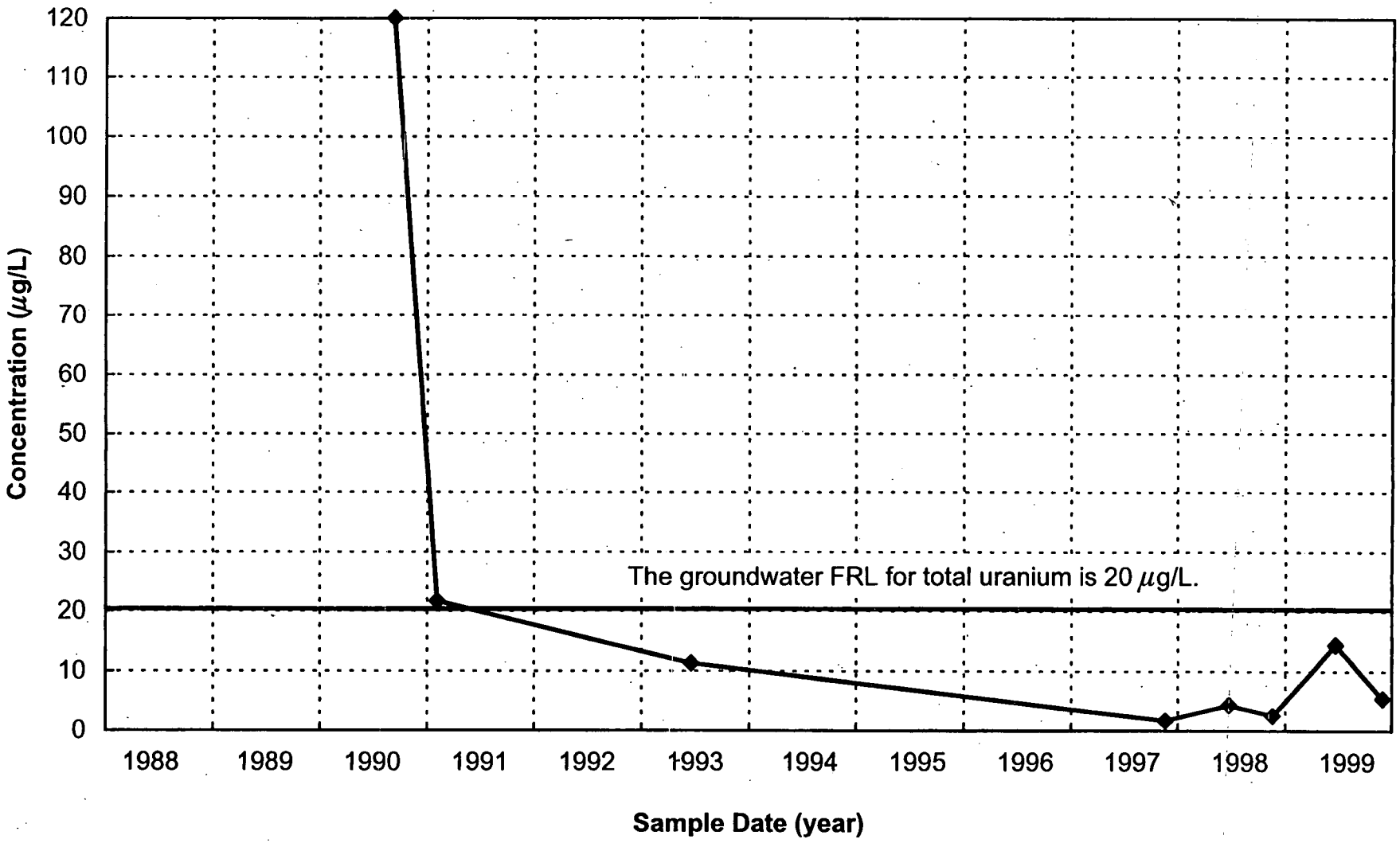


FIGURE A.2-46. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2389



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0001121

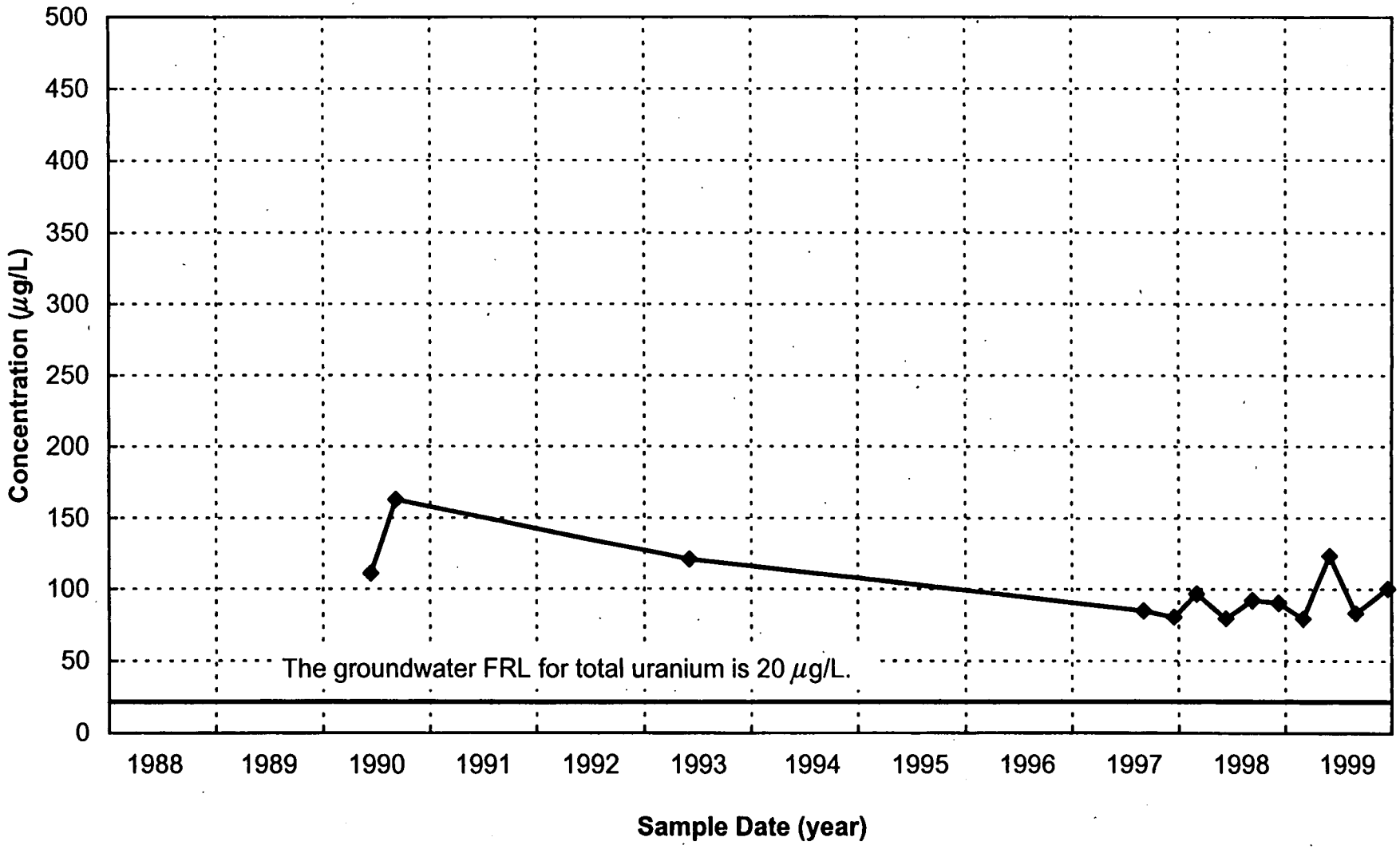


FIGURE A.2-47. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2390

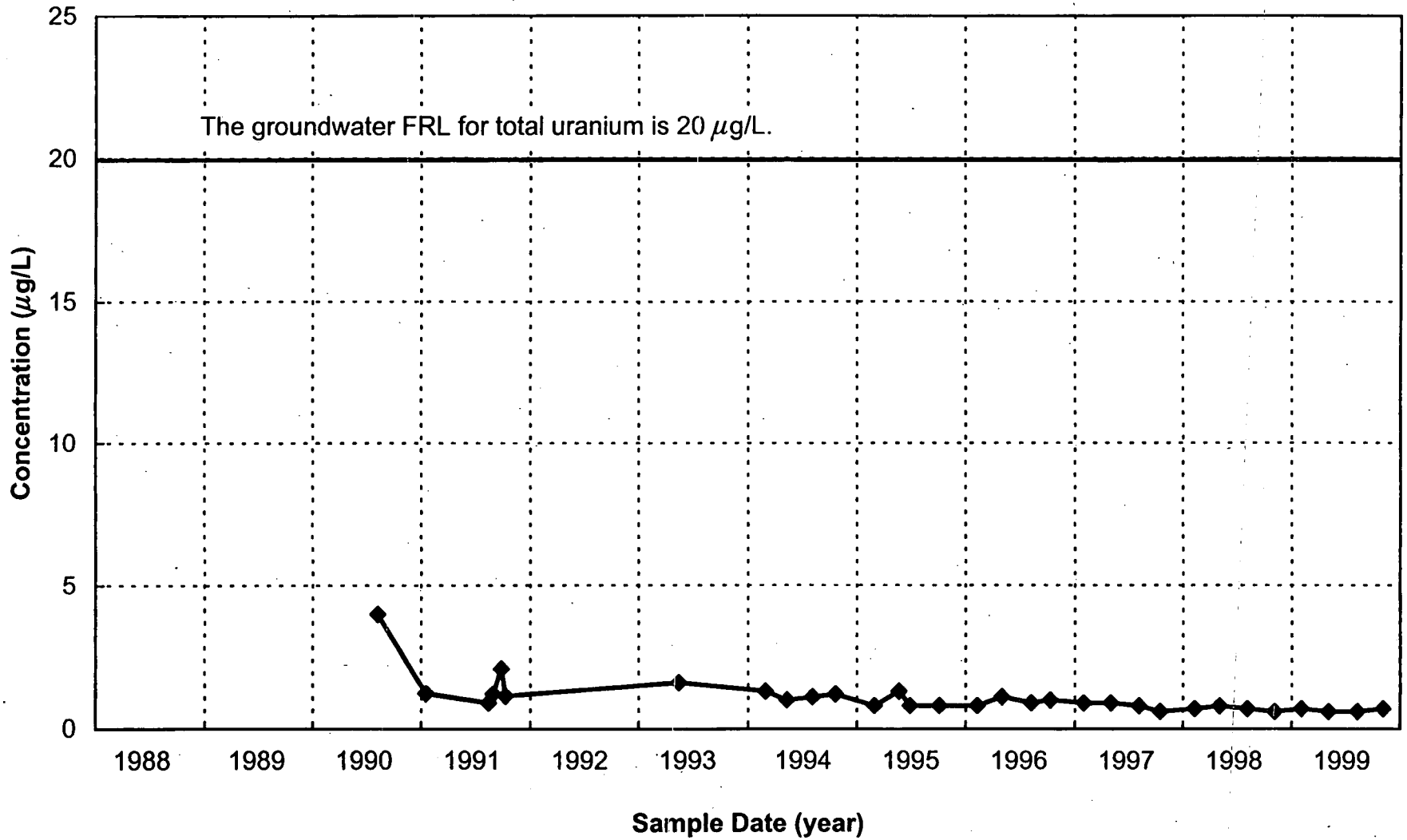


FIGURE A.2-48. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2396



0001122

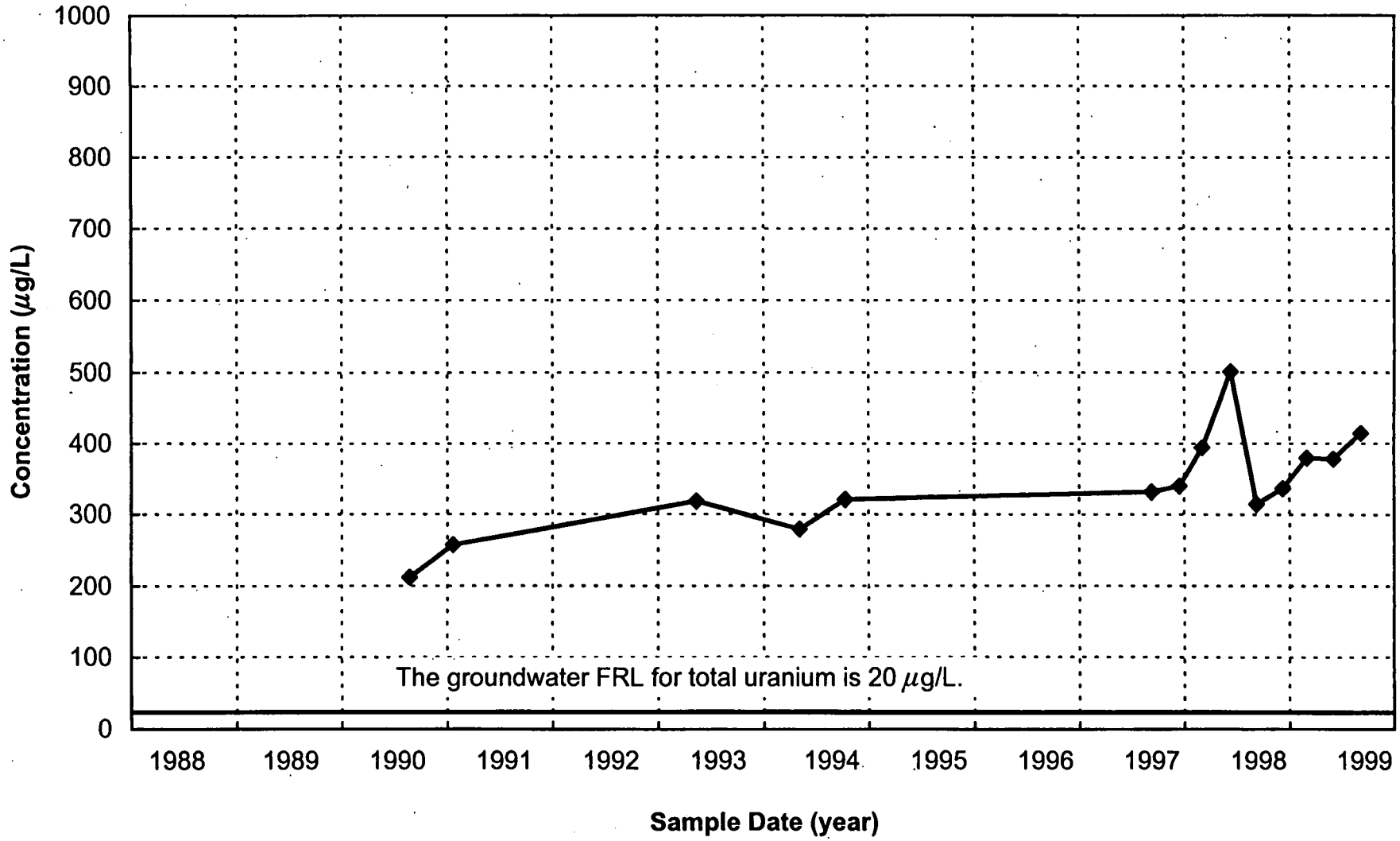


FIGURE A.2-49. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2397

000123

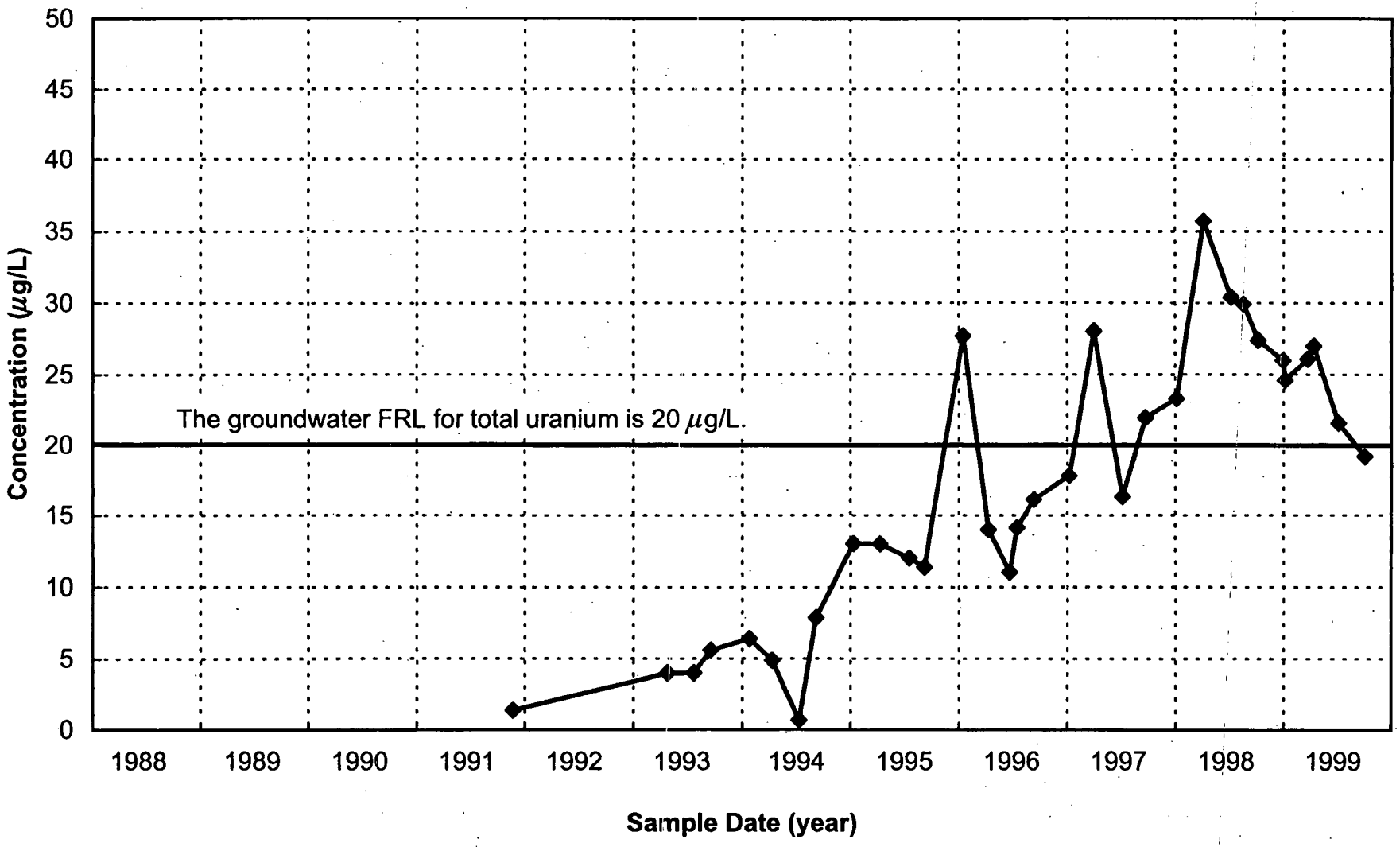


FIGURE A.2-50. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2398



000129

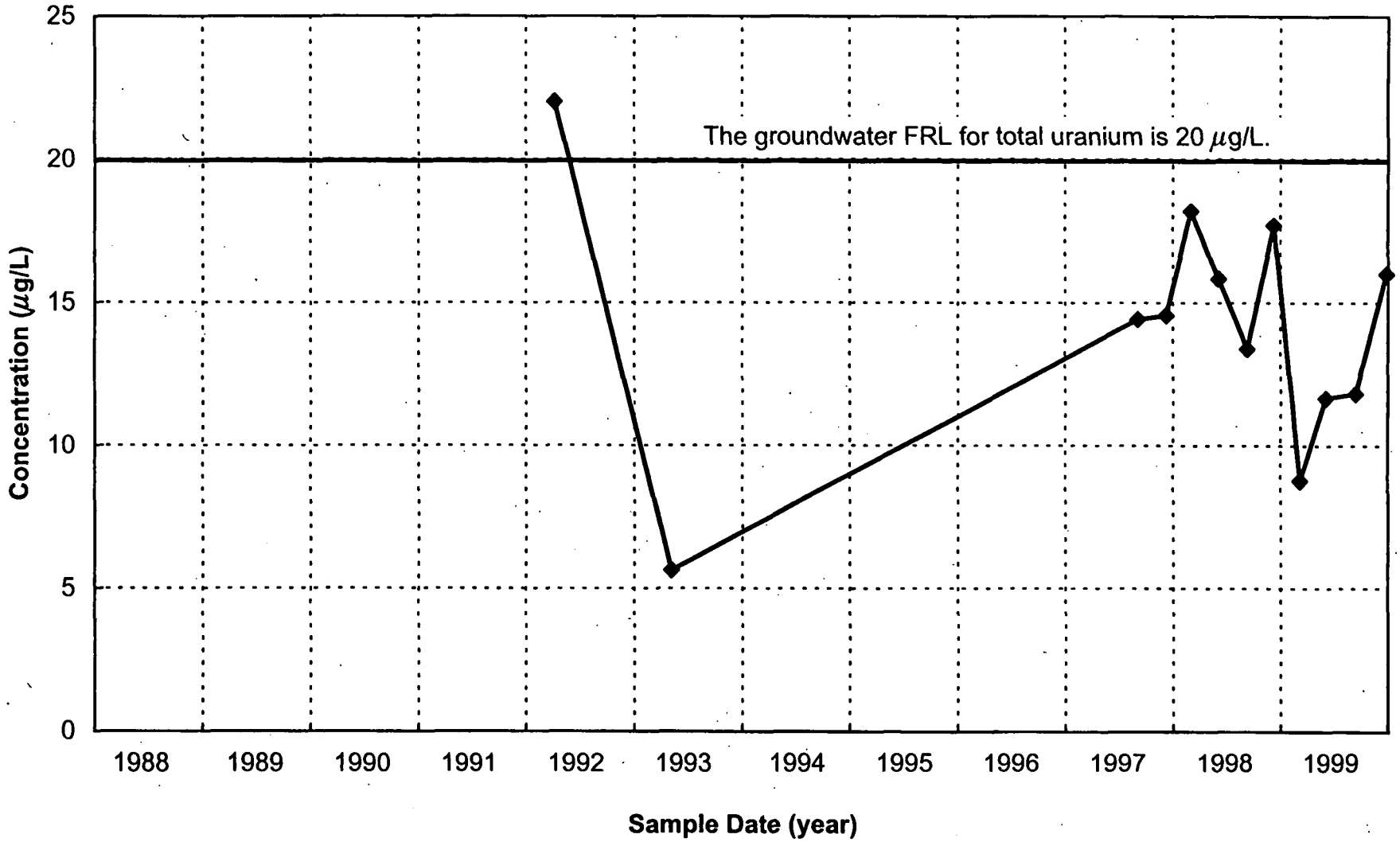


FIGURE A.2-51. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2402

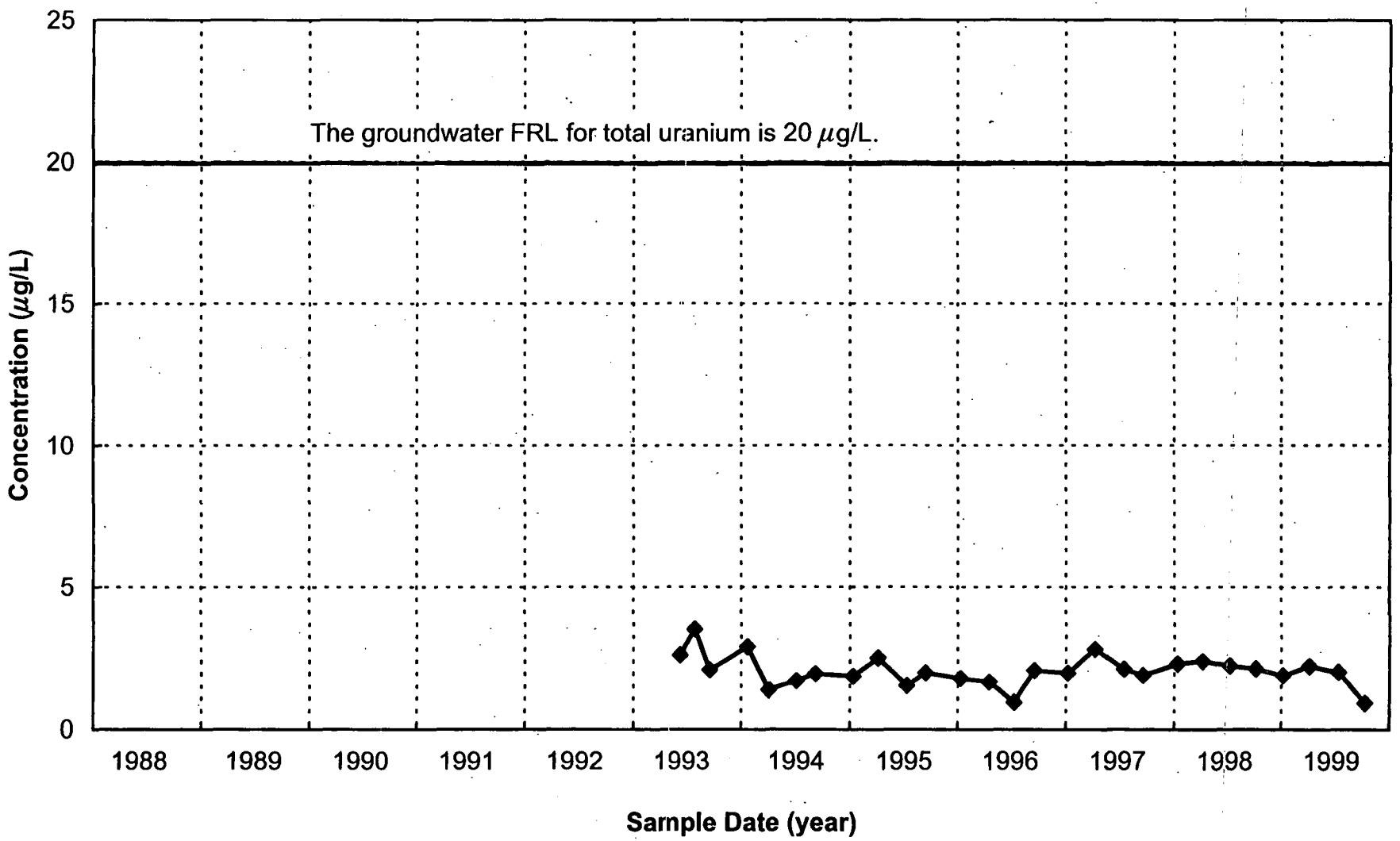


FIGURE A.2-52. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2417



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0001127

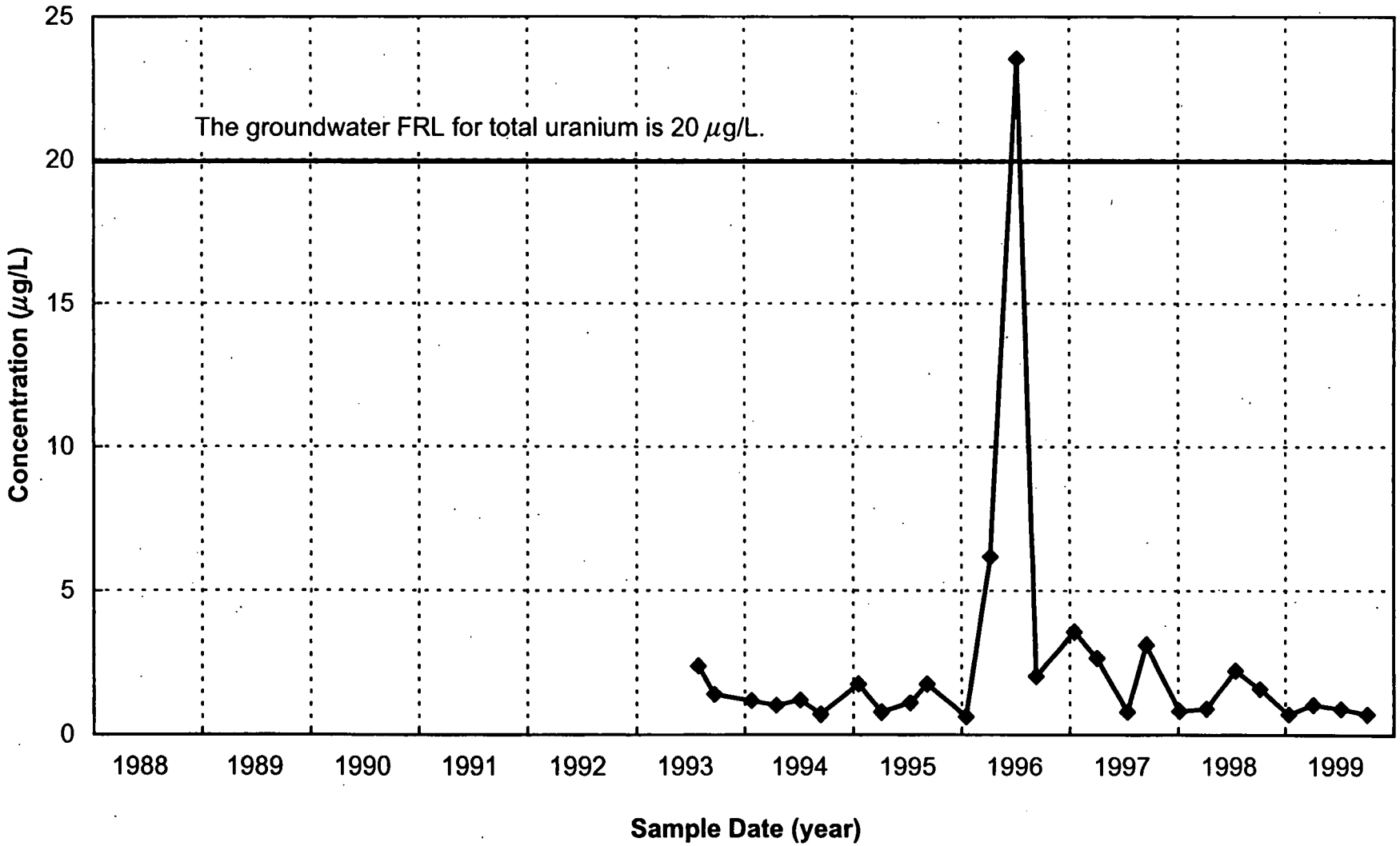


FIGURE A.2-53. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2424

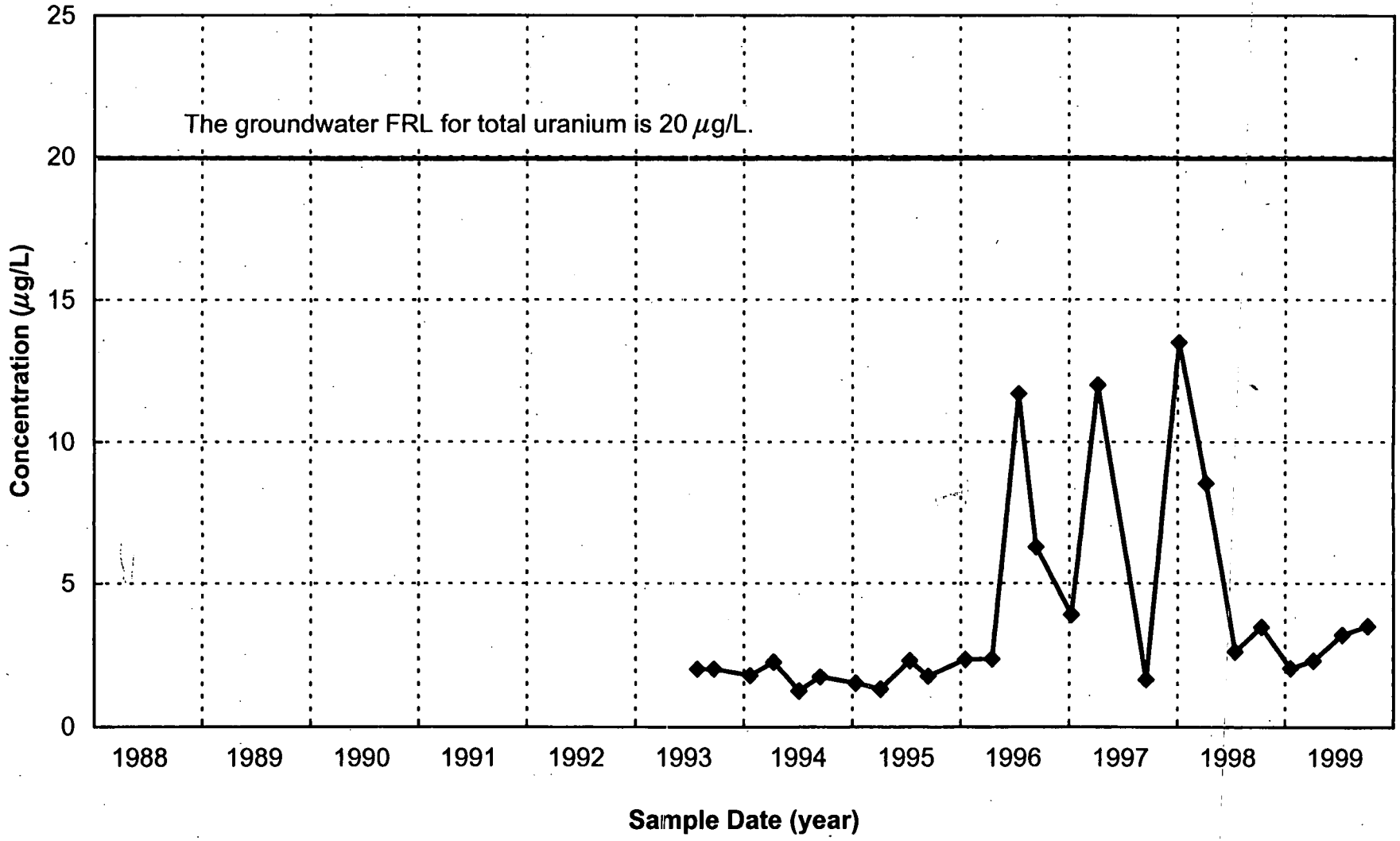


FIGURE A.2-54. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2426



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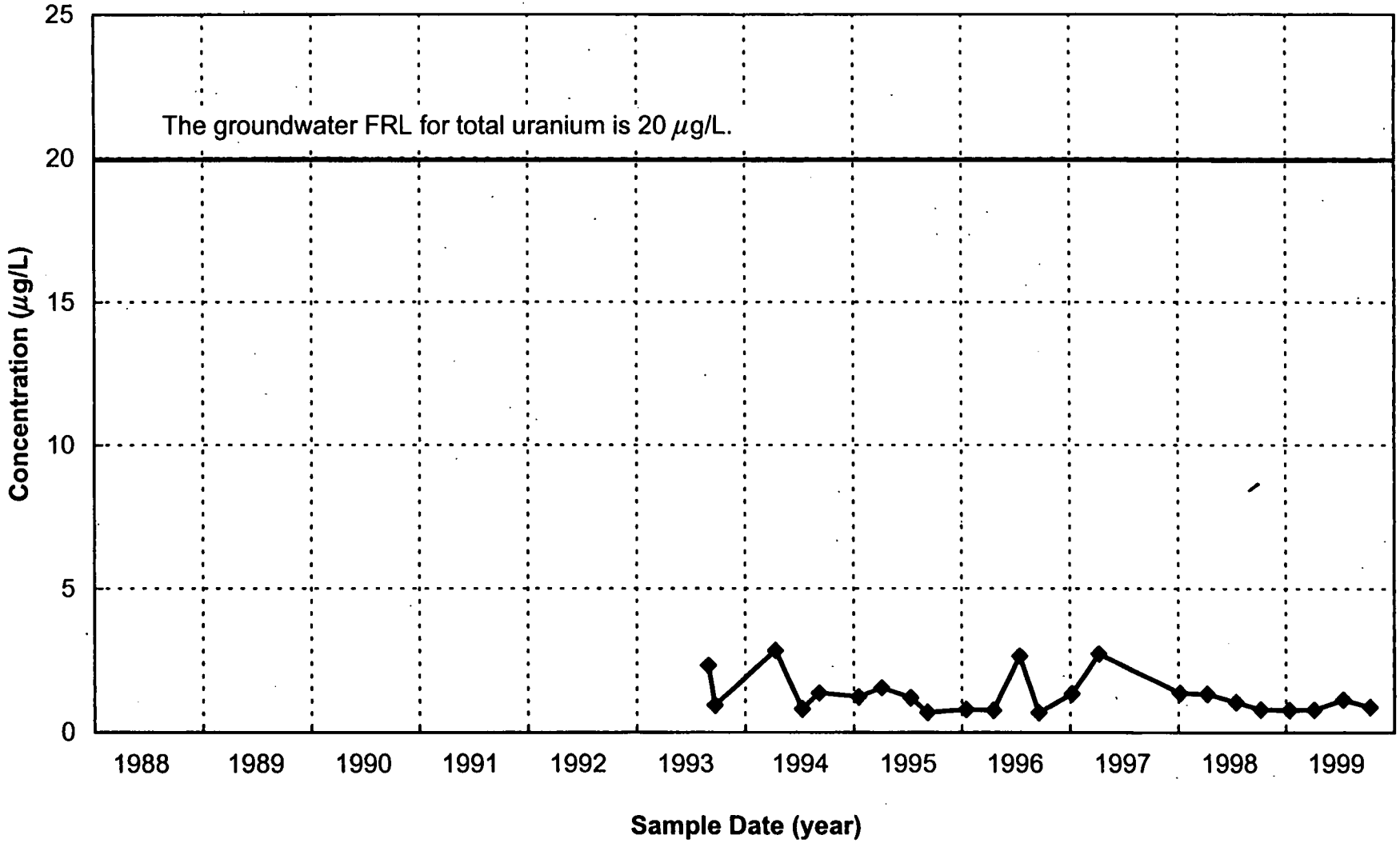


FIGURE A.2-55. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2429

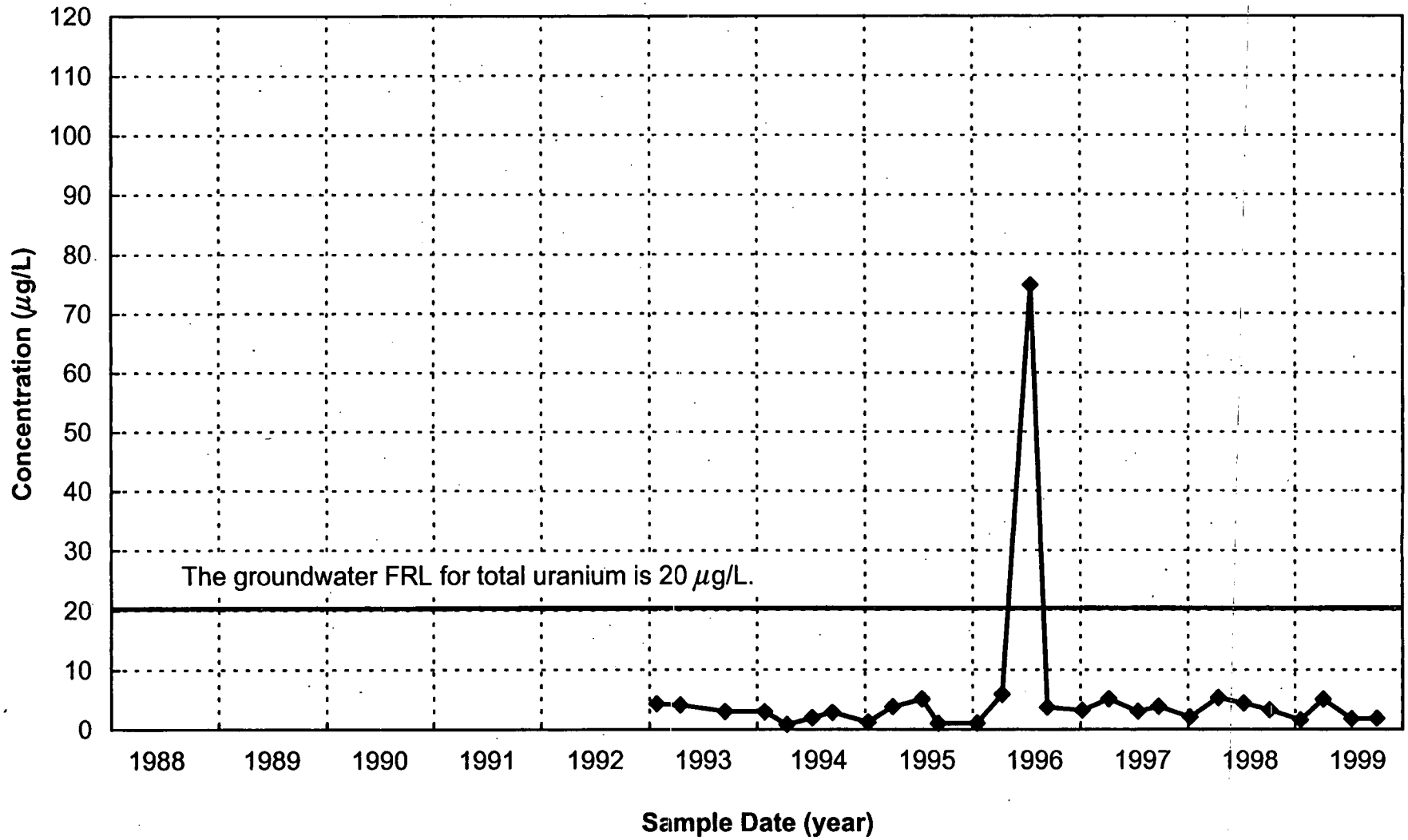


FIGURE A.2-56. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2430

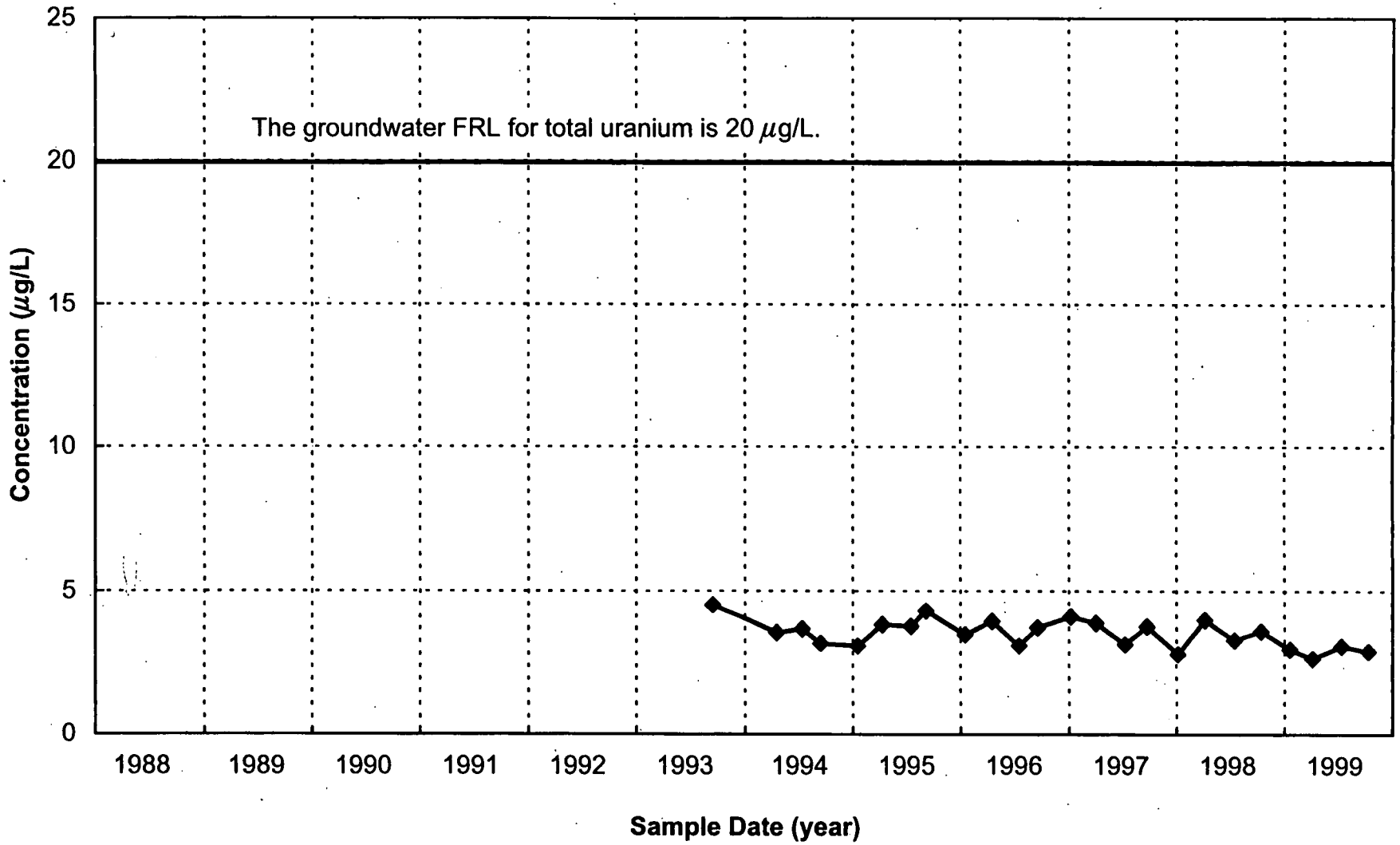


FIGURE A.2-57. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2431

000131

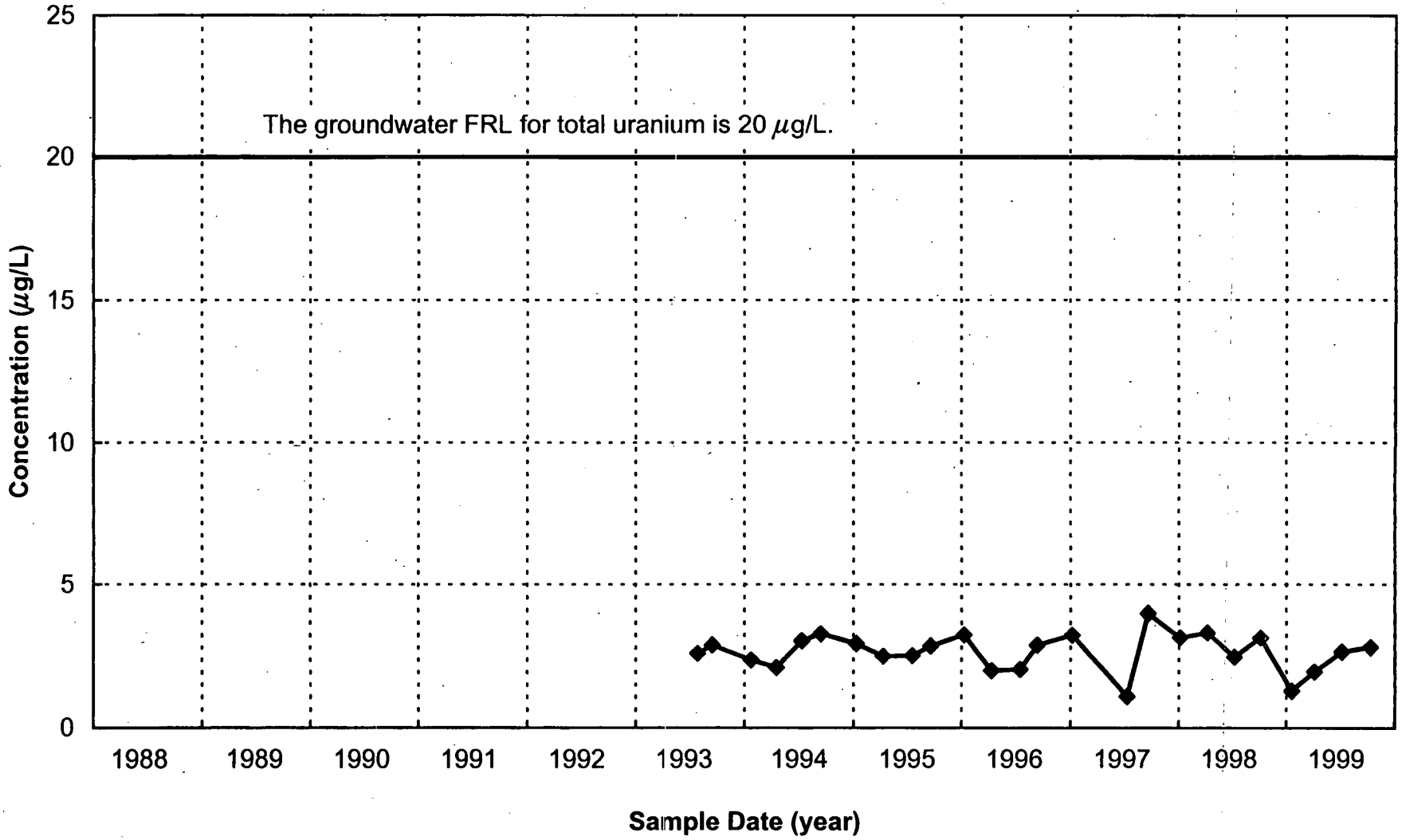


FIGURE A.2-58. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2432



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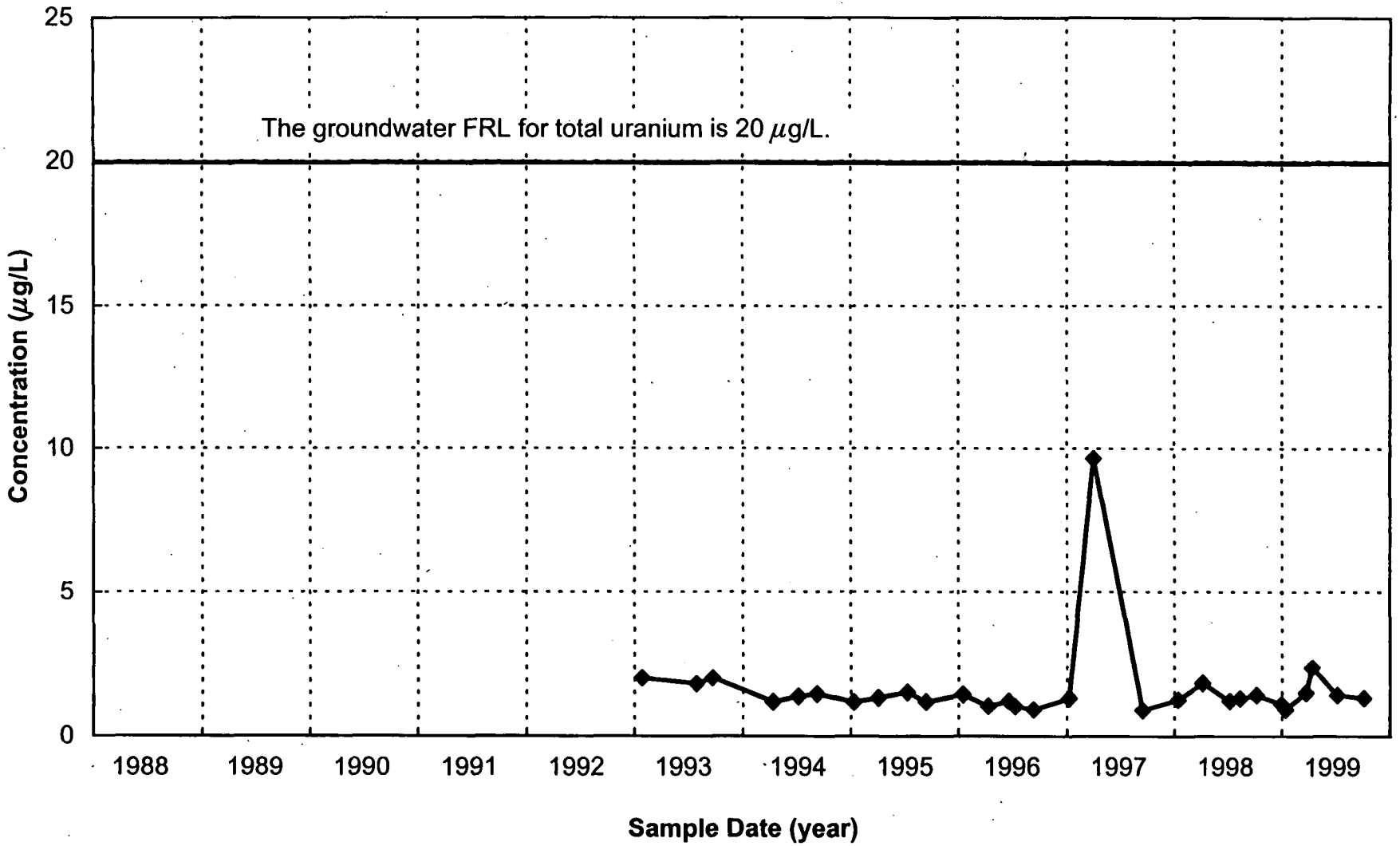


FIGURE A.2-59. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2434

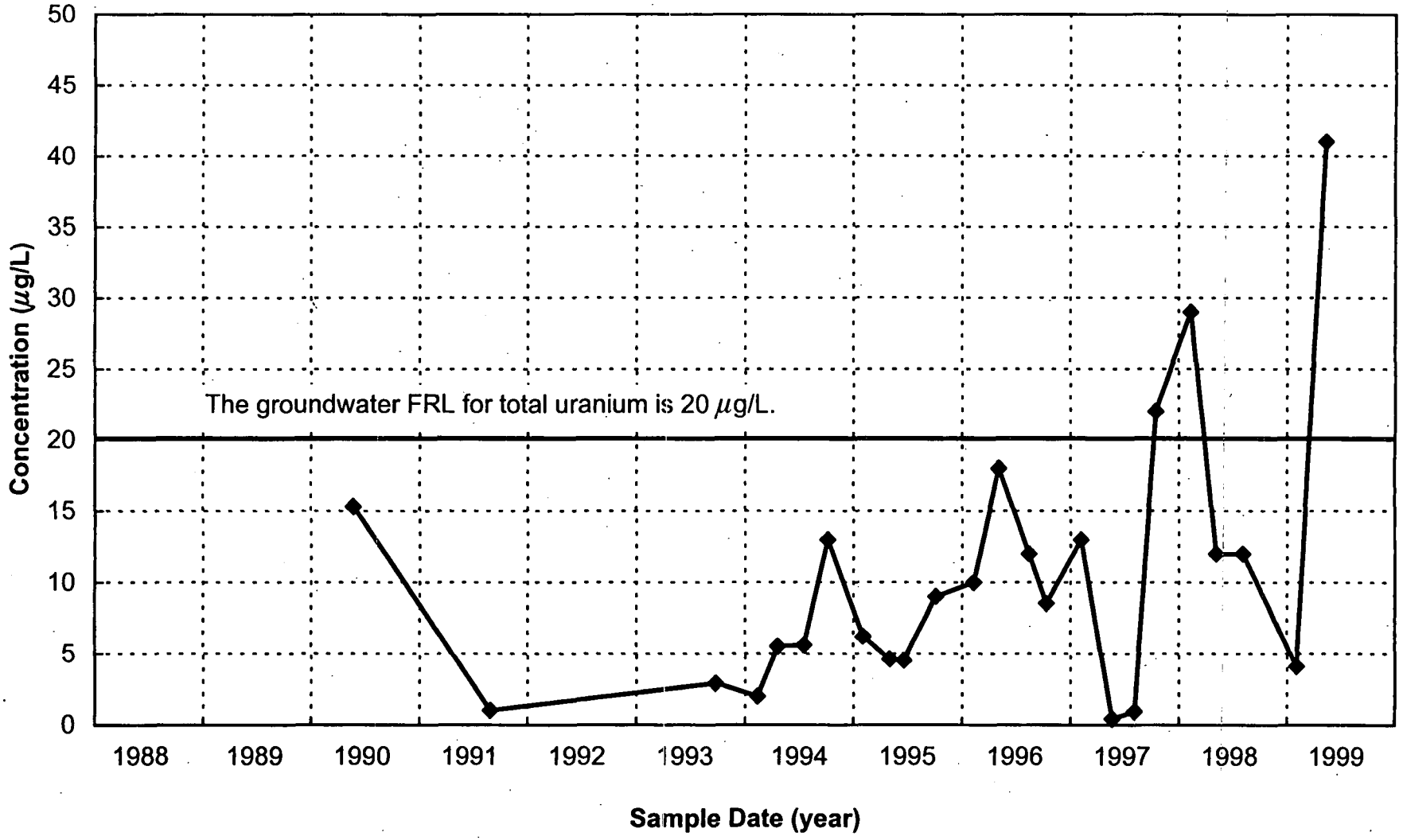


FIGURE A.2-60. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2544



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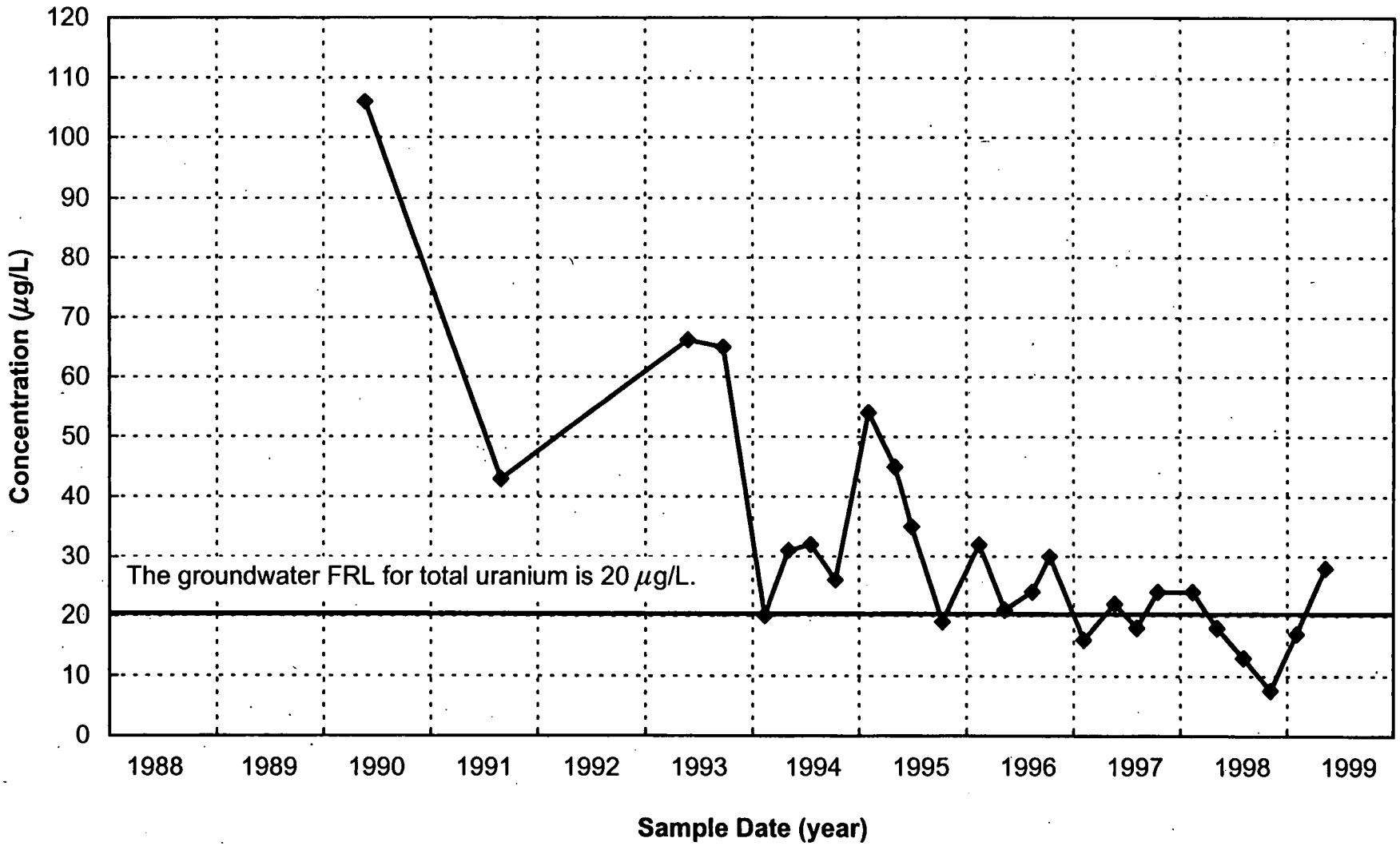


FIGURE A.2-61. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2545

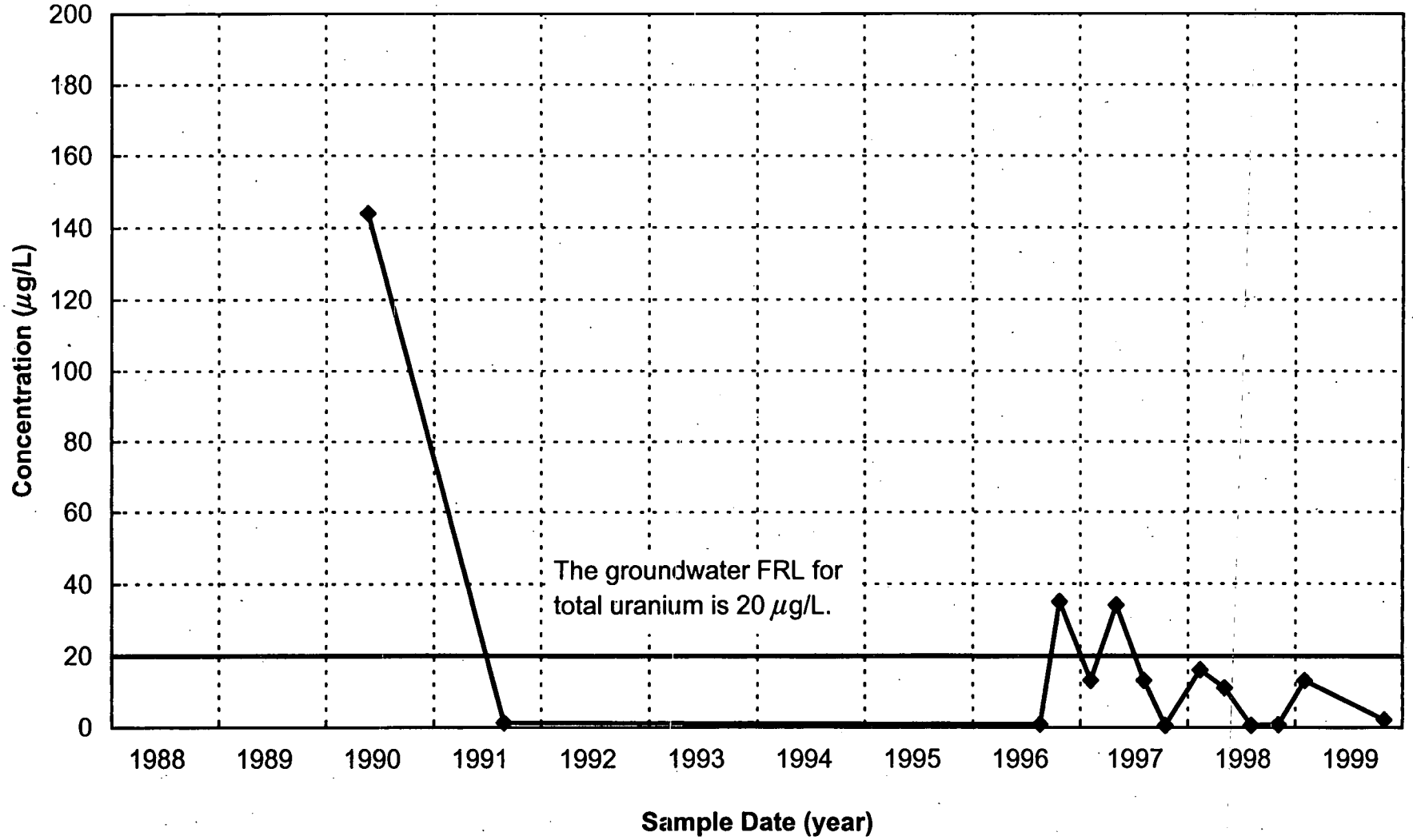


FIGURE A.2-62. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2546



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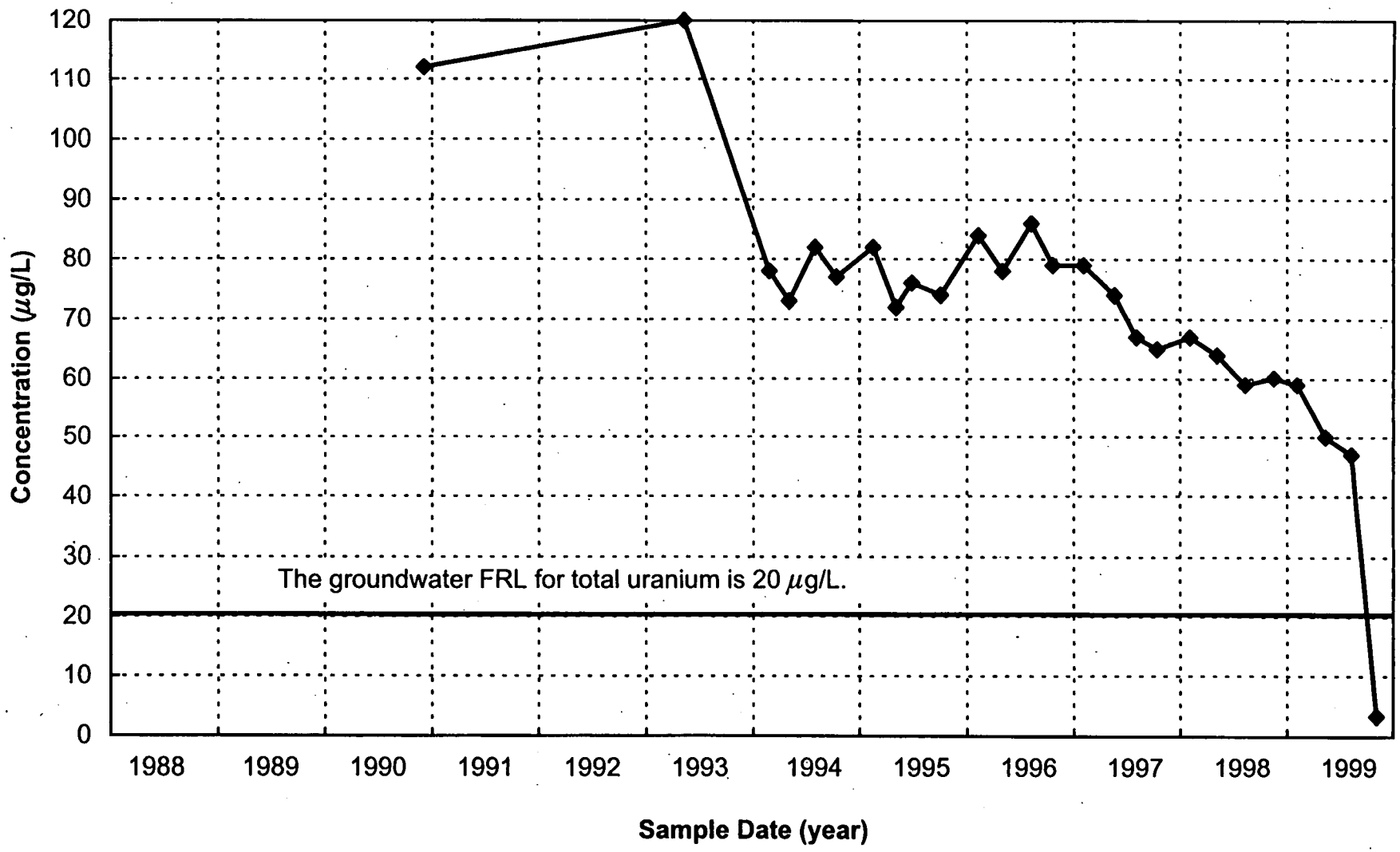


FIGURE A.2-63. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2550

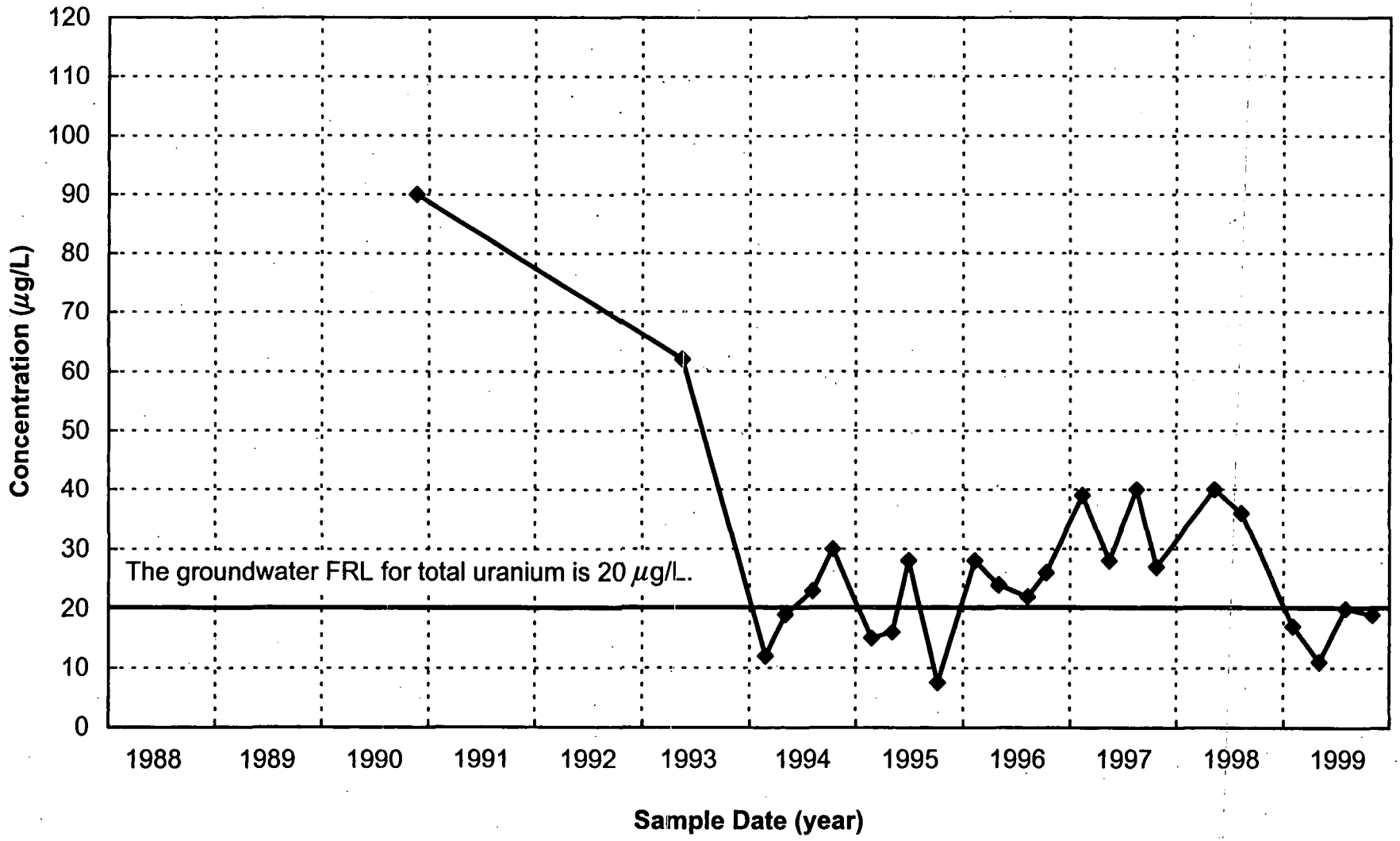


FIGURE A.2-64. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2551



0001138

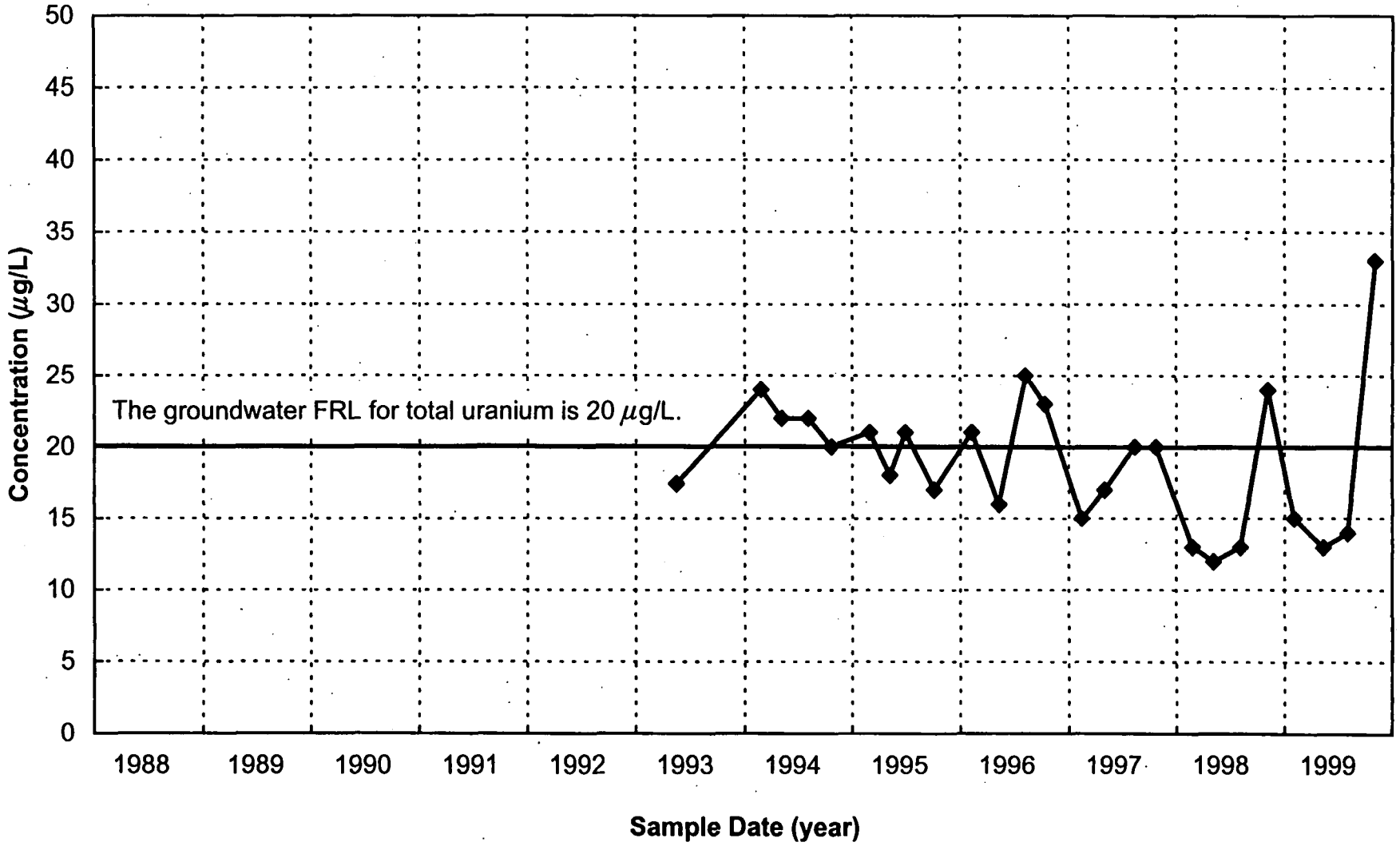


FIGURE A.2-65. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2552

000429

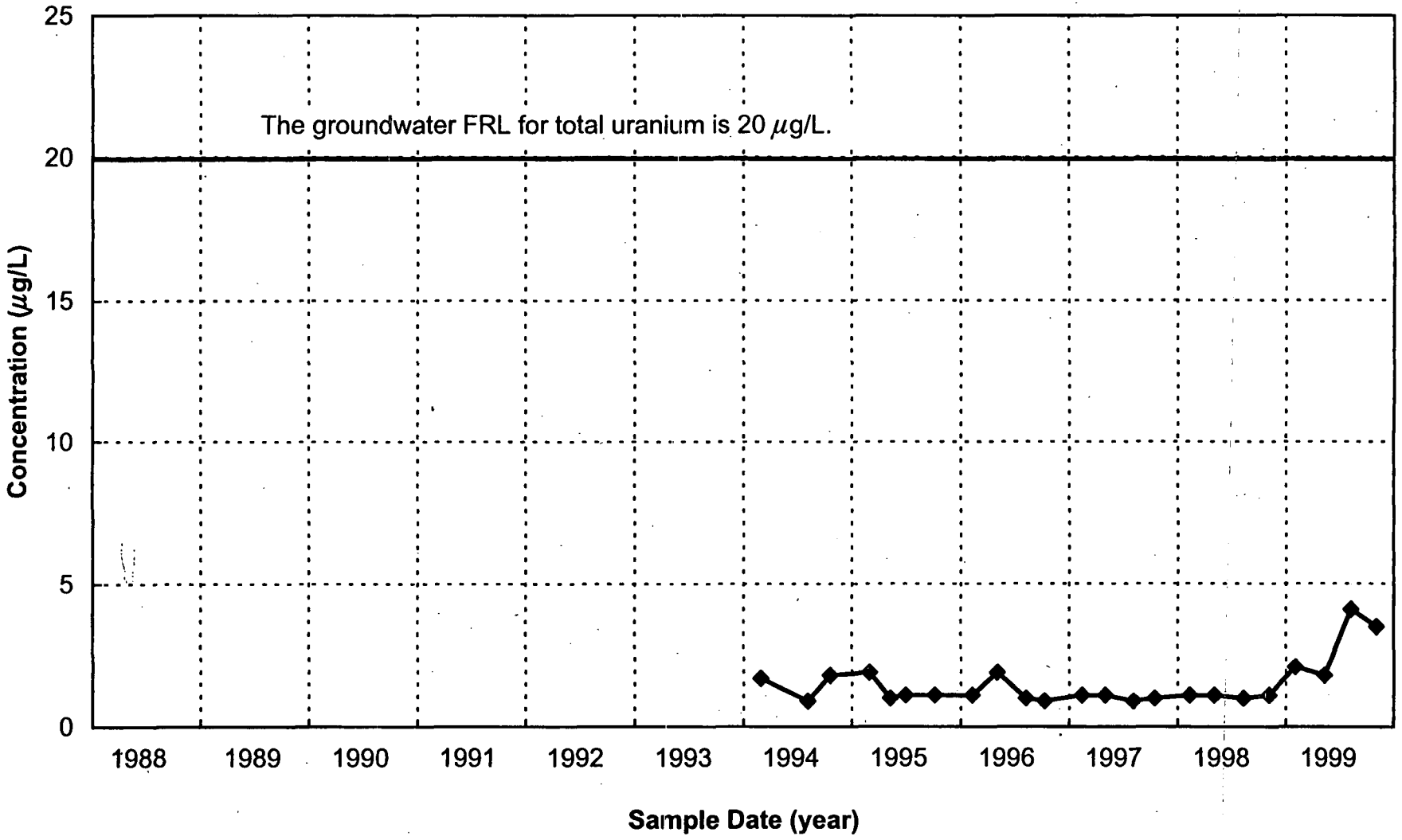


FIGURE A.2-66. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2553



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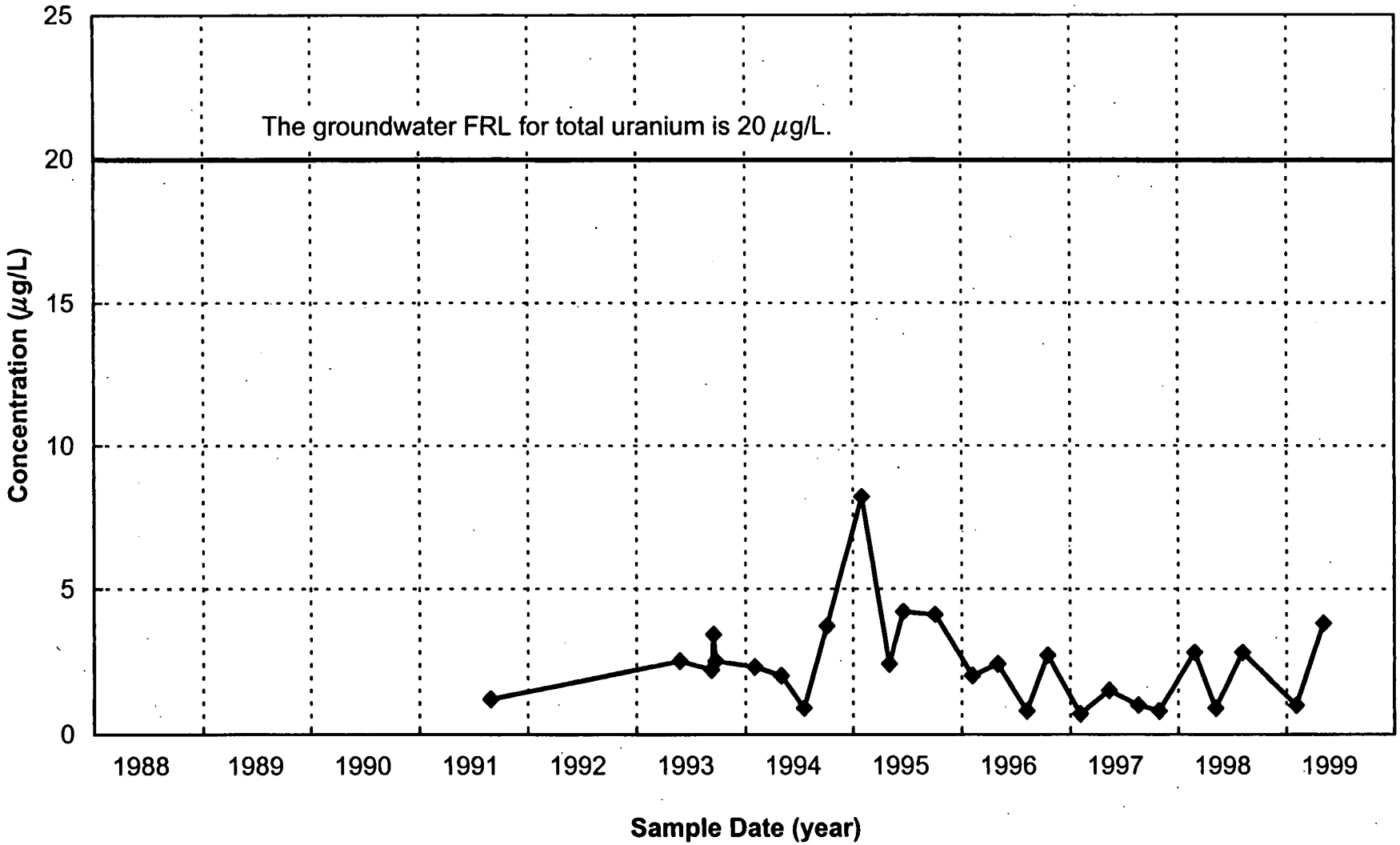


FIGURE A.2-67. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2625

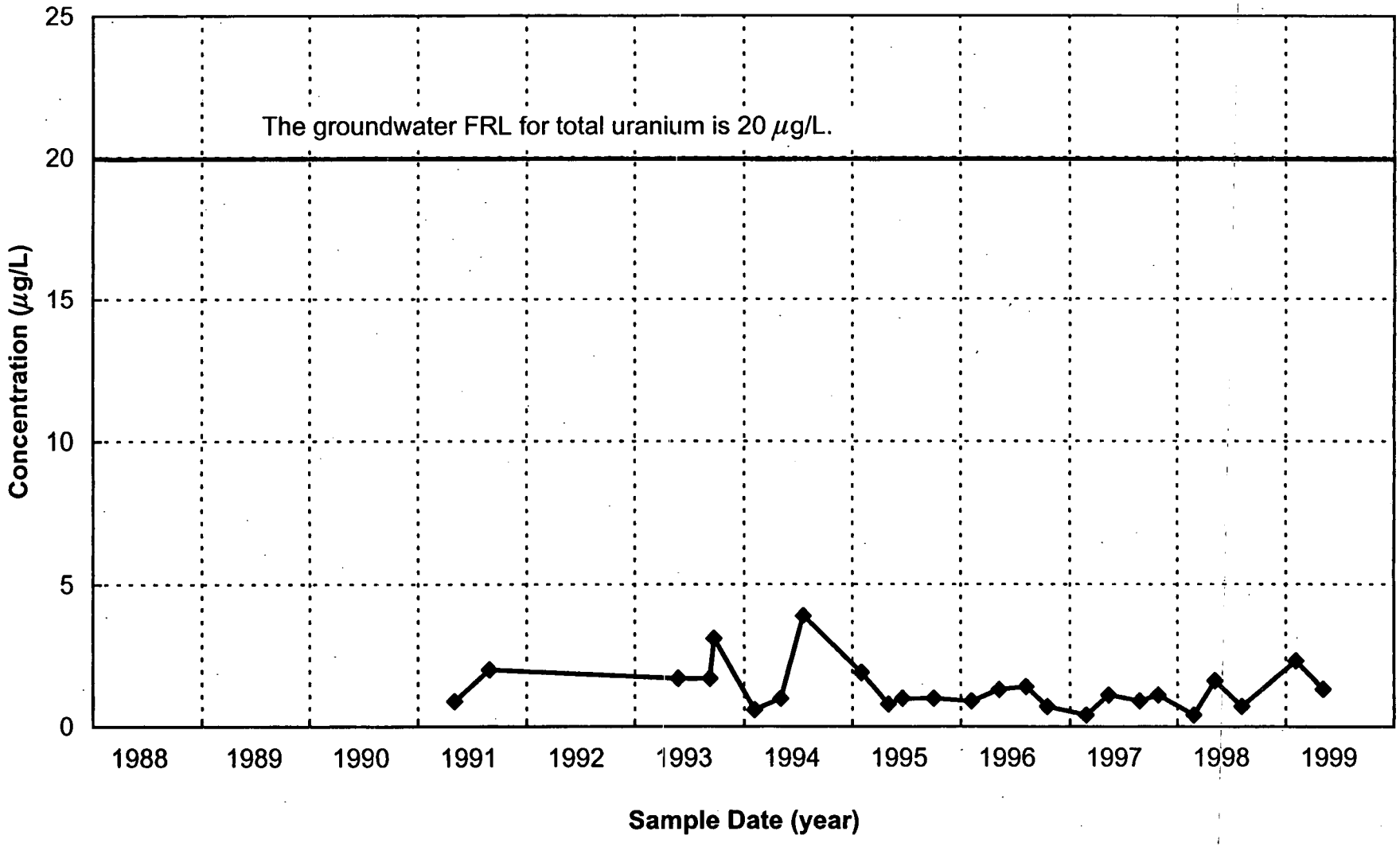


FIGURE A.2-68. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2636

000143

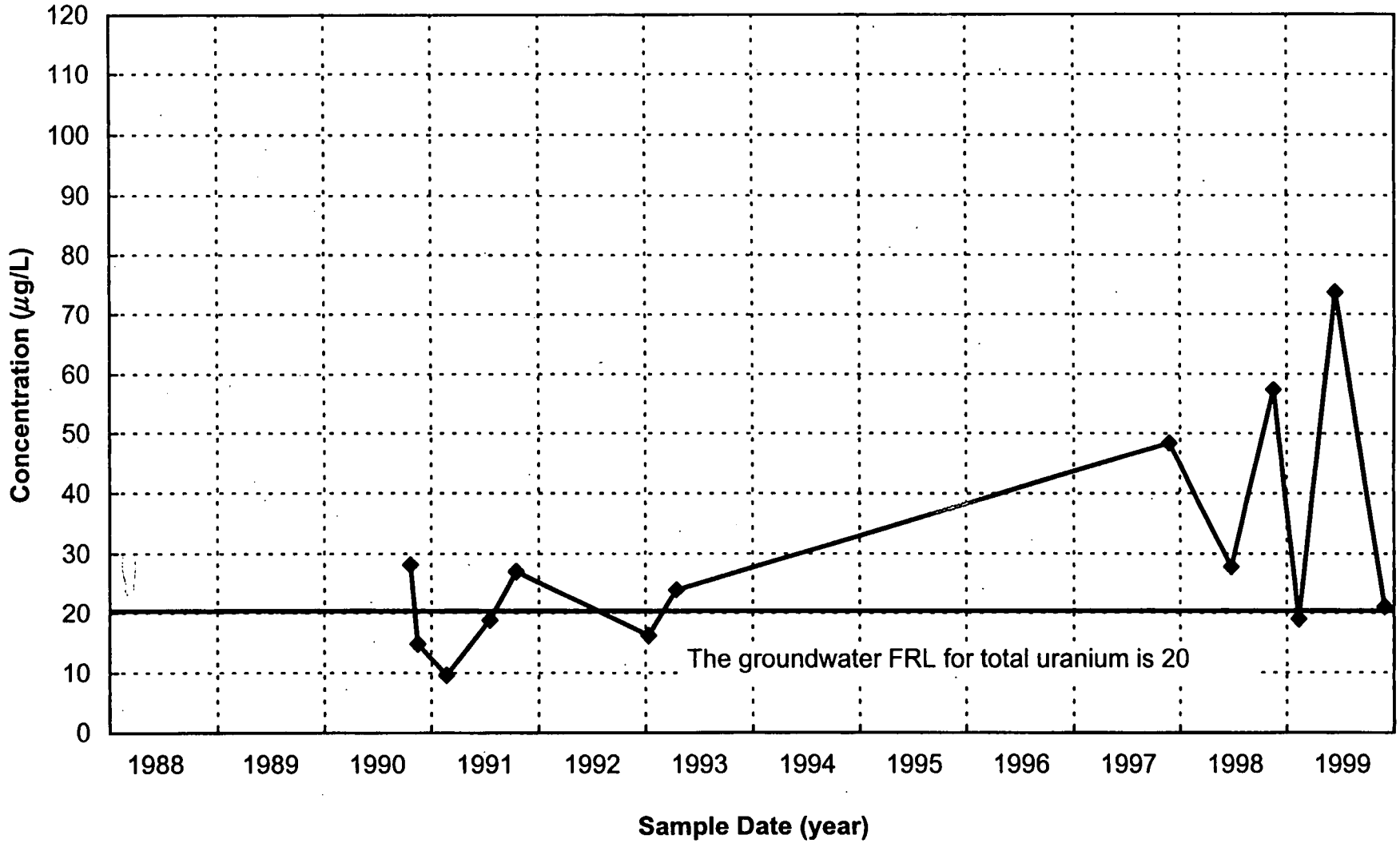


FIGURE A.2-69. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2648

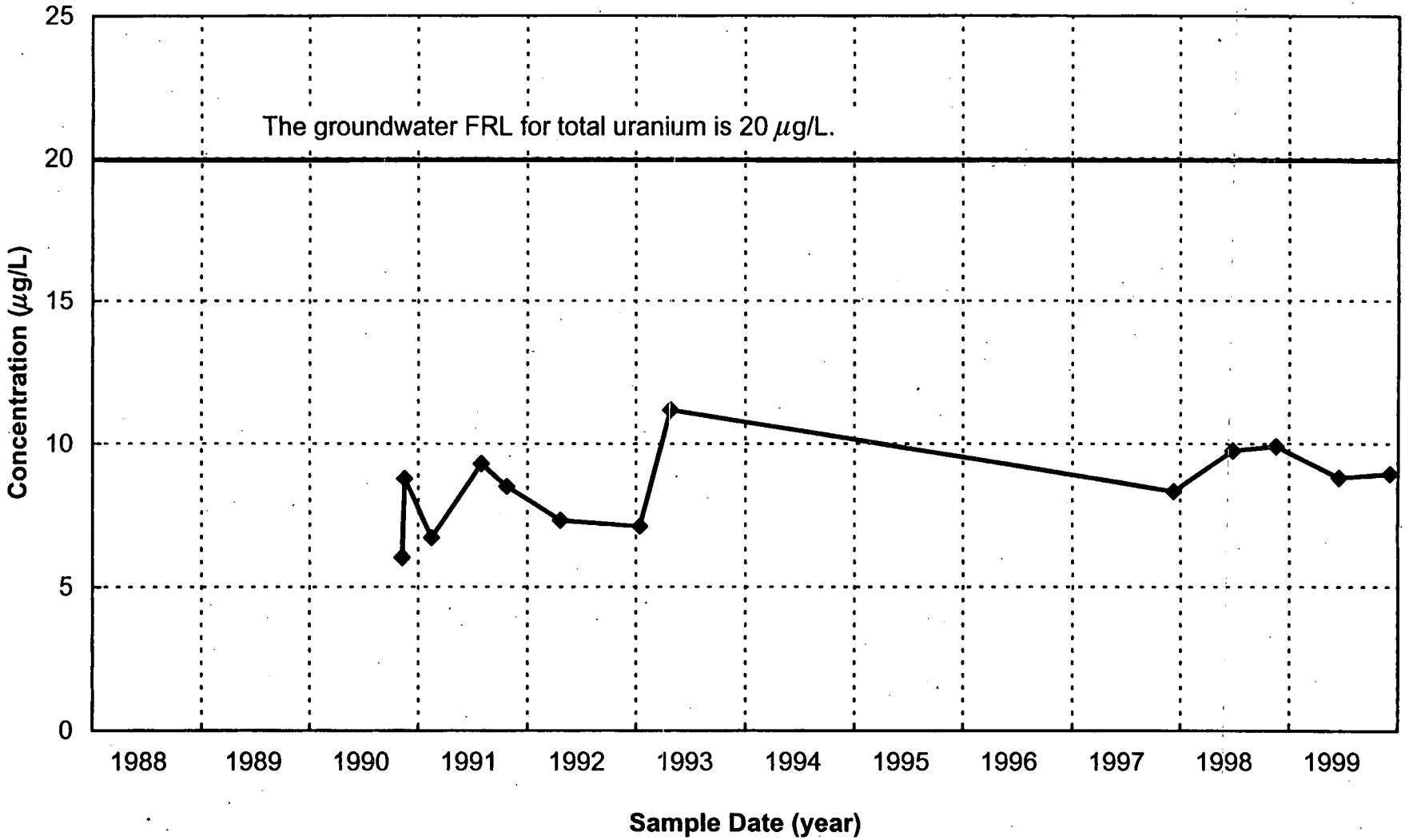


FIGURE A.2-70. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2649



000144

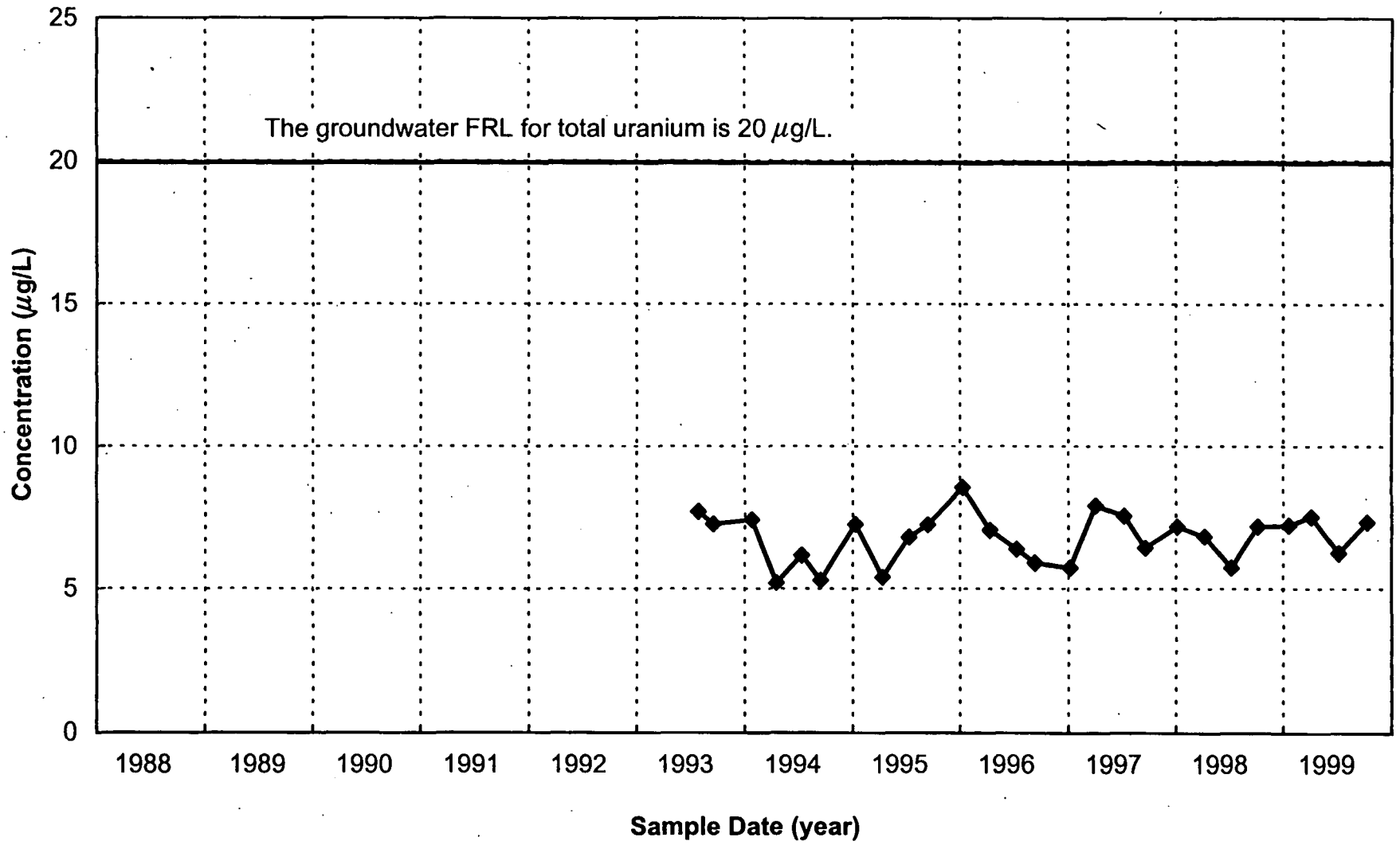


FIGURE A.2-71. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2733

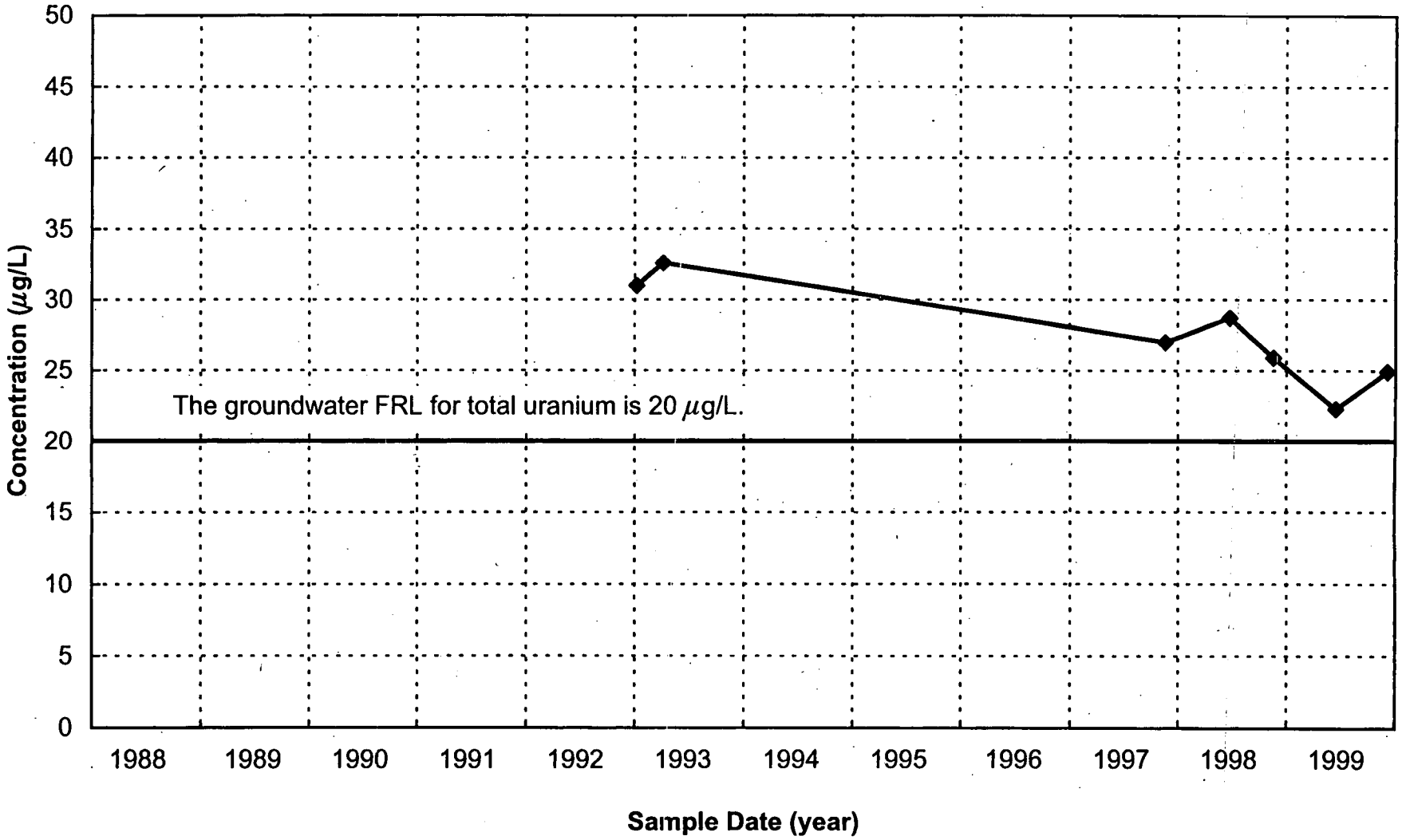


FIGURE A.2-72. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2821



000146

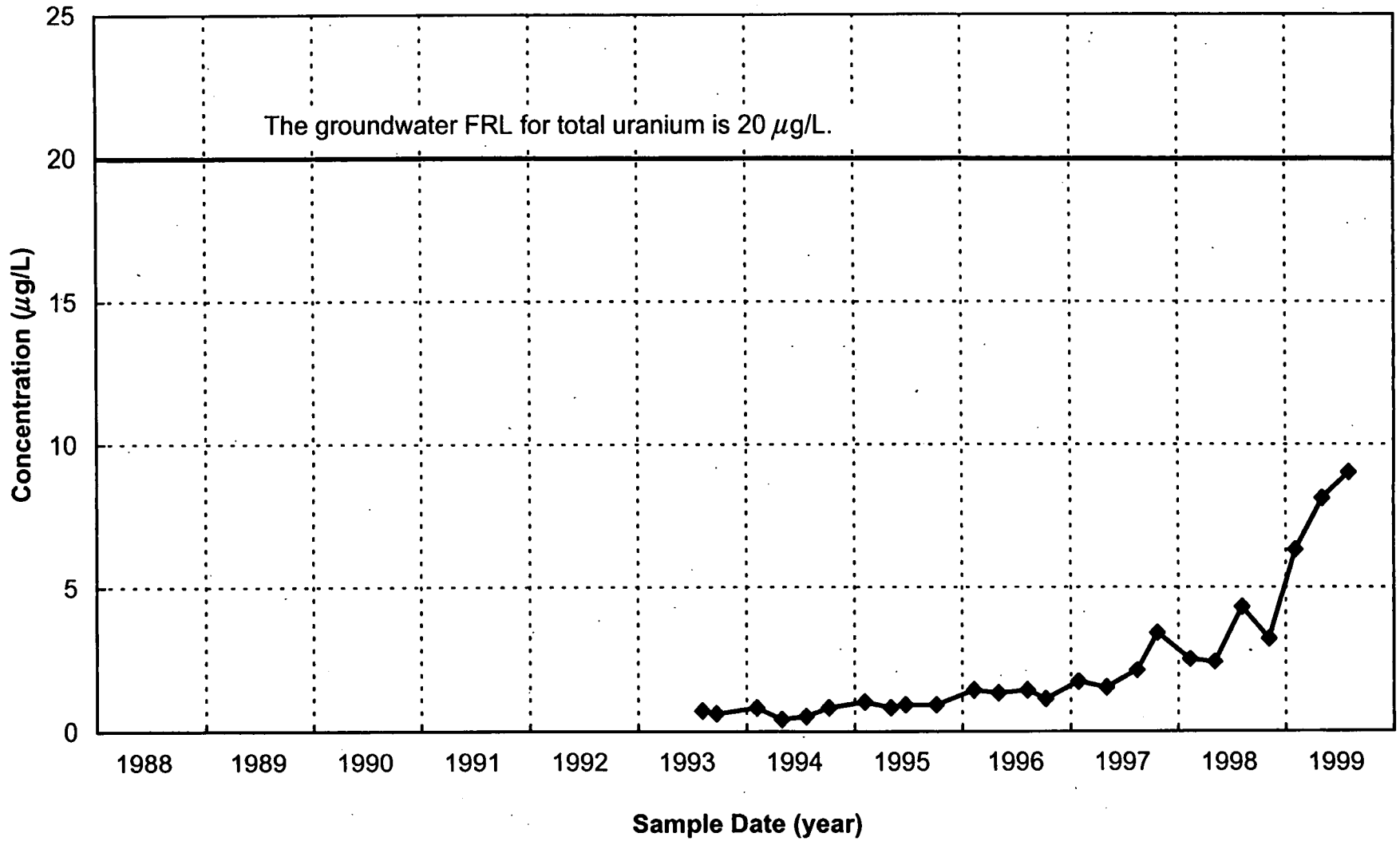


FIGURE A.2-73. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2880

000147

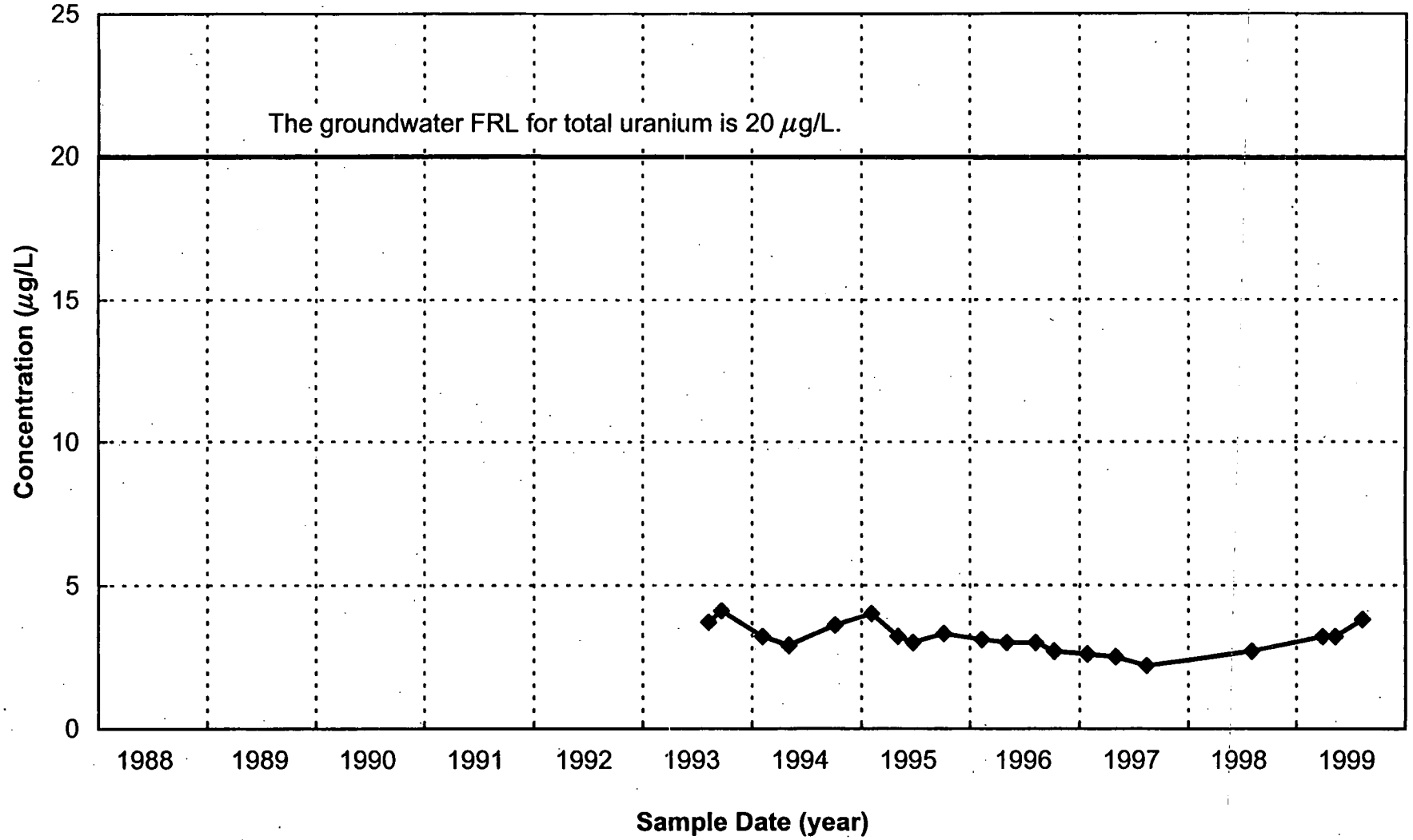


FIGURE A.2-74. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2881



000148

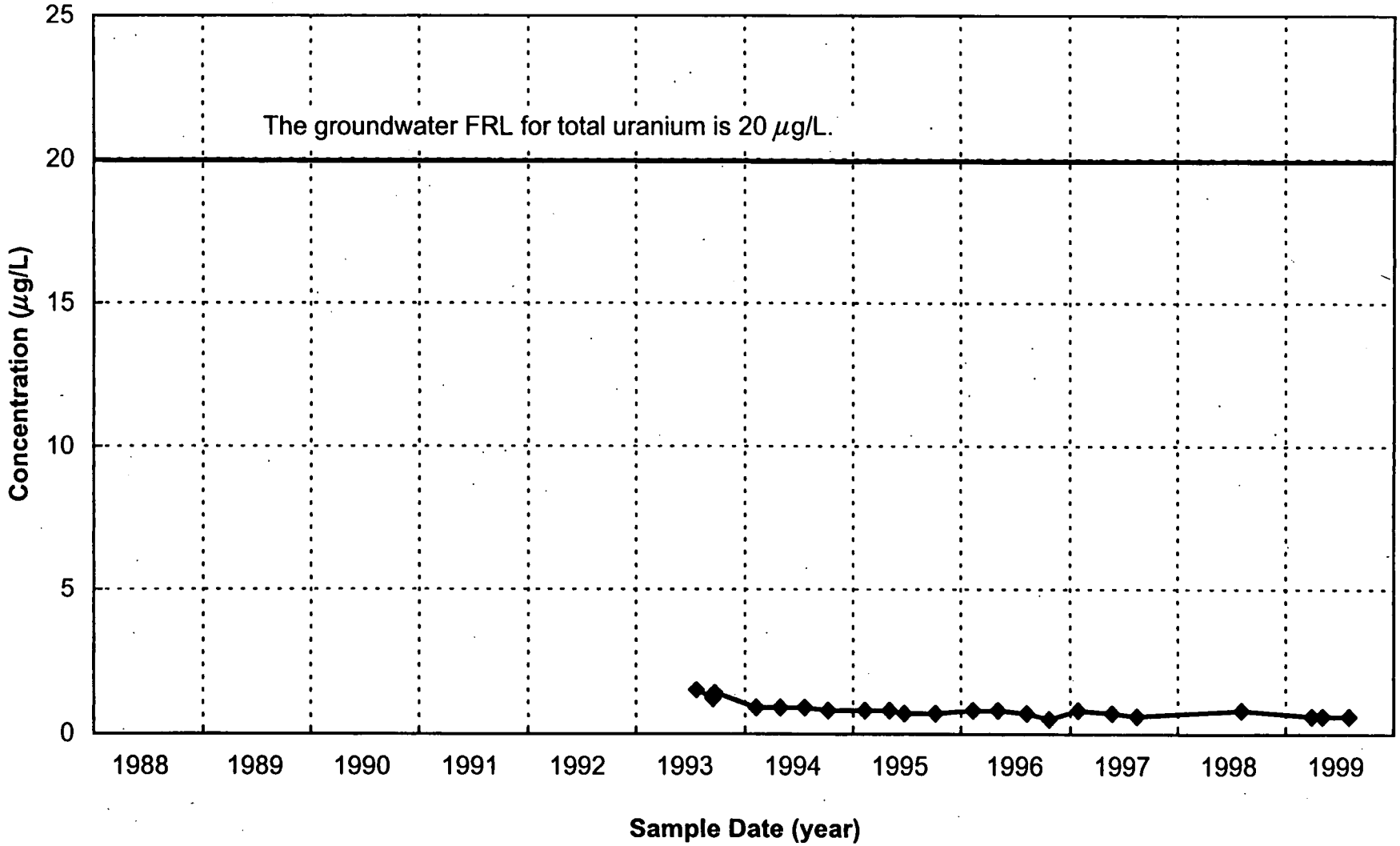


FIGURE A.2-75. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2897

000149

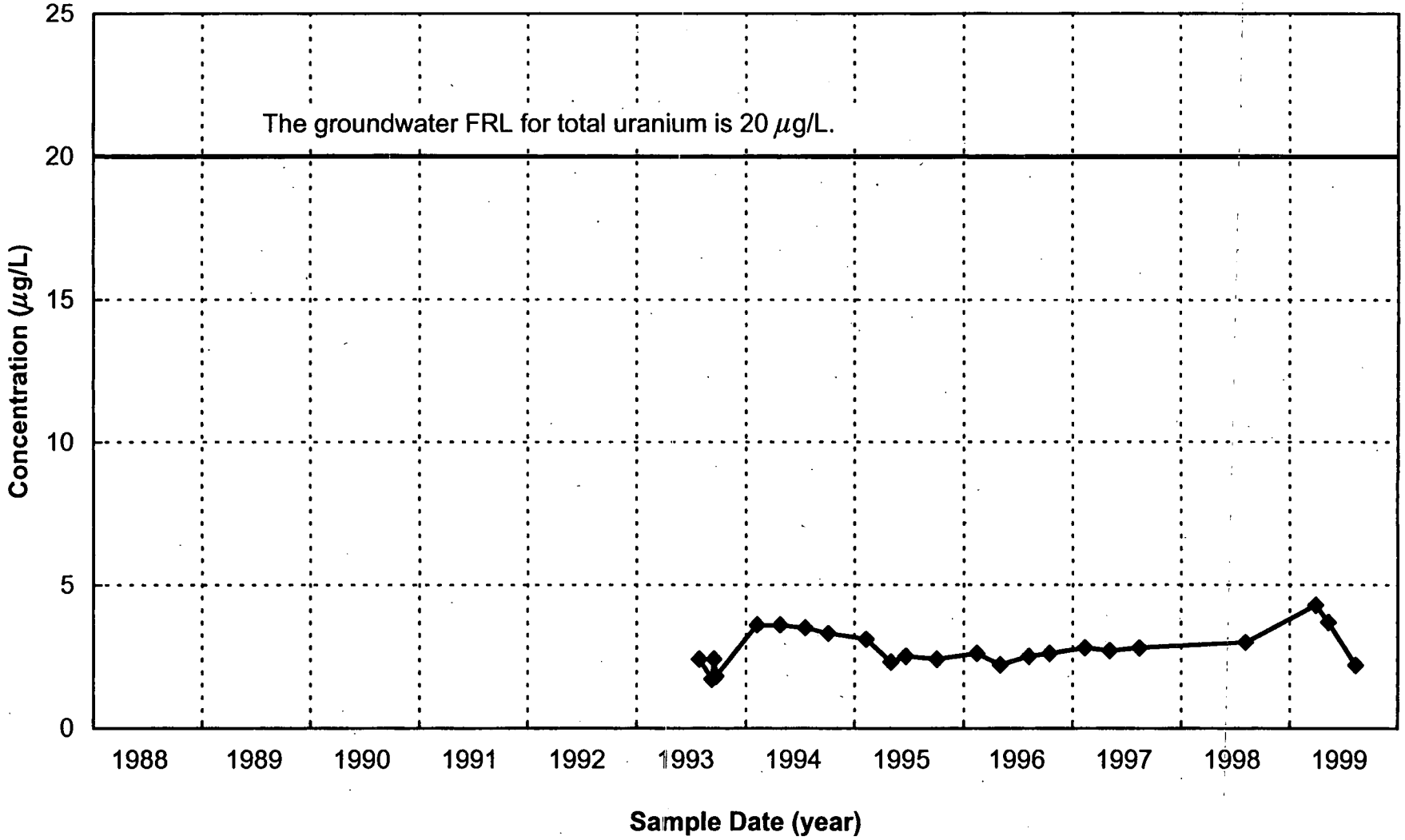


FIGURE A.2-76. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2898



000150

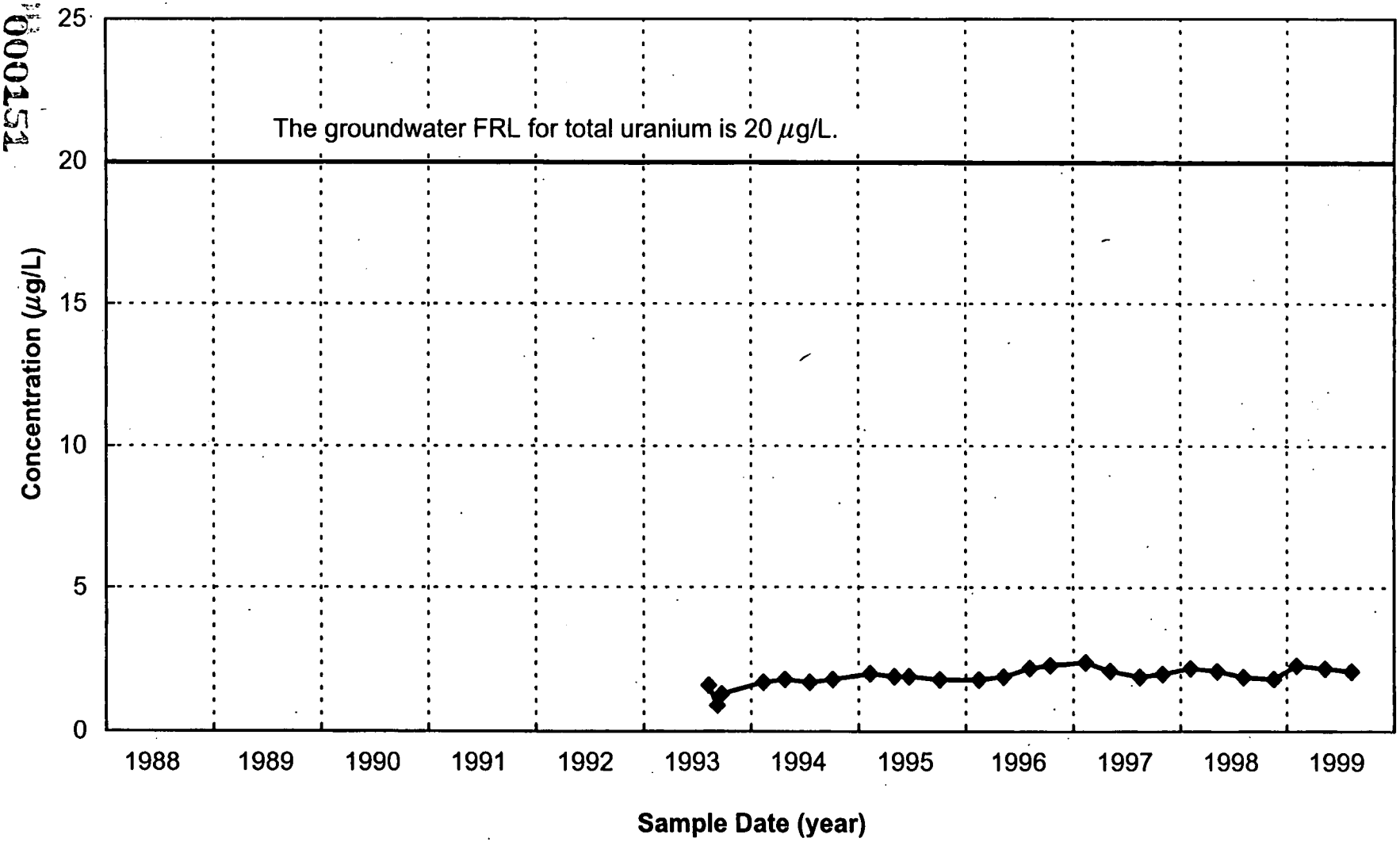


FIGURE A.2-77. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2899

0001154

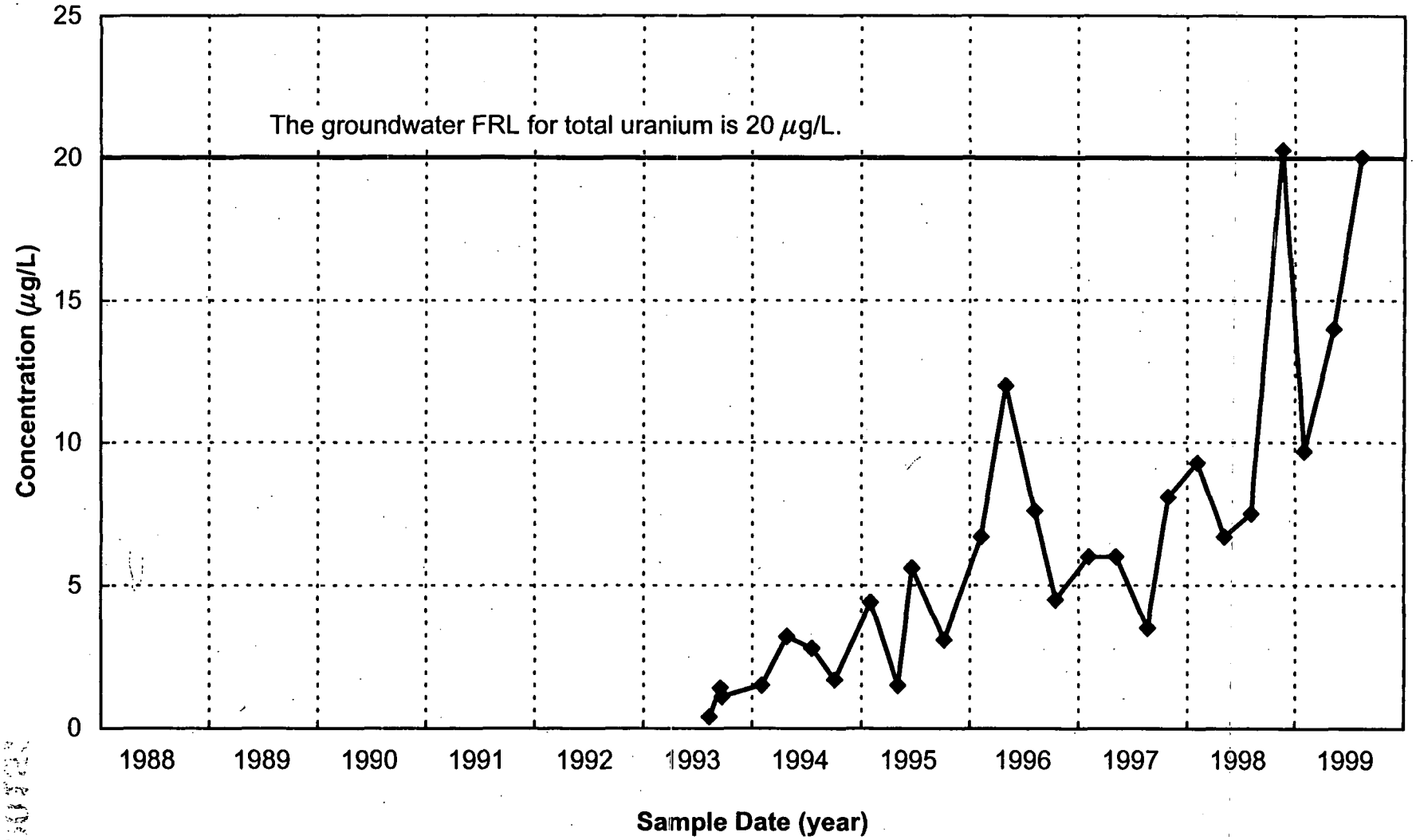


FIGURE A.2-78. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2900

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000153

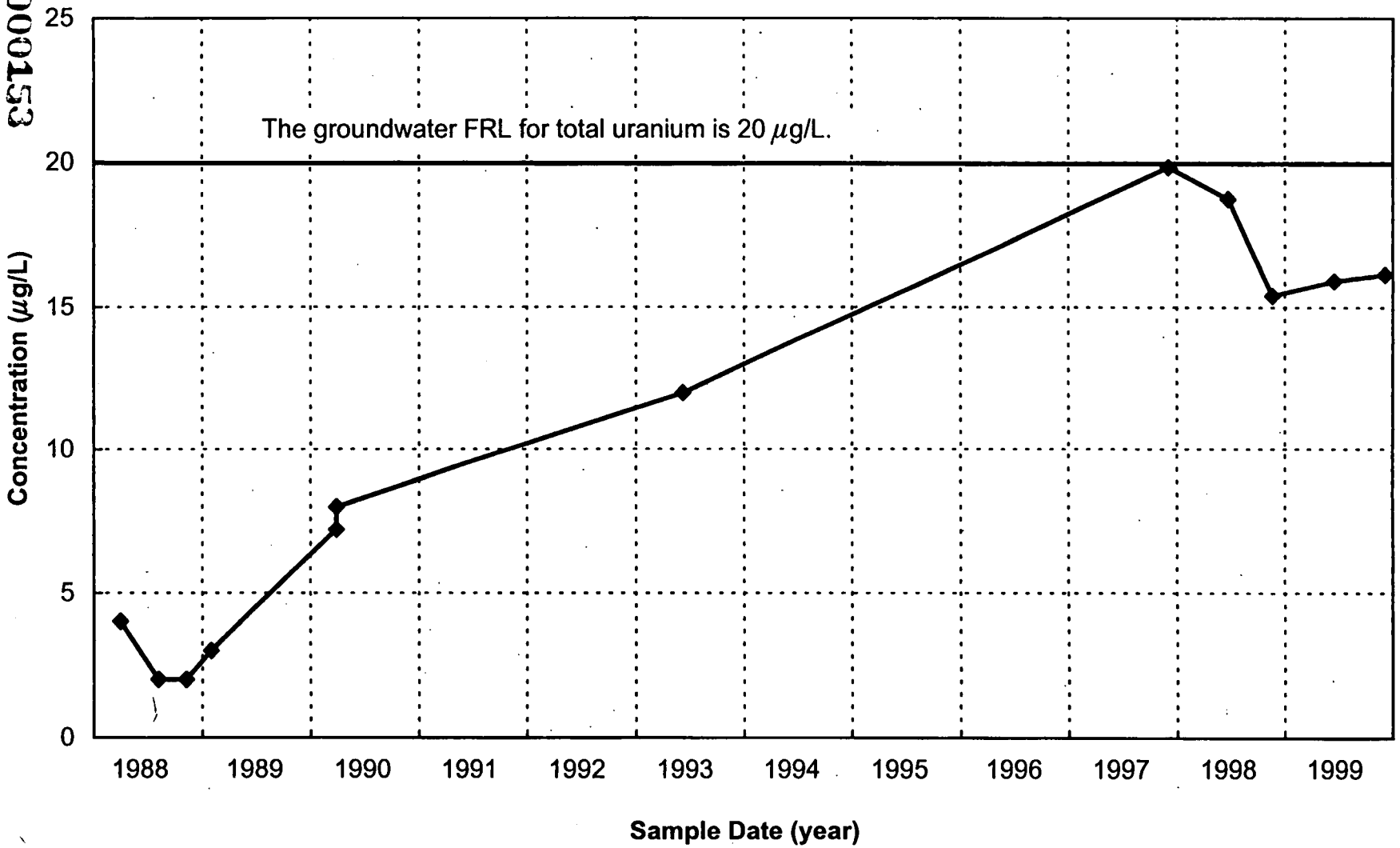



FIGURE A.2-79. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3009

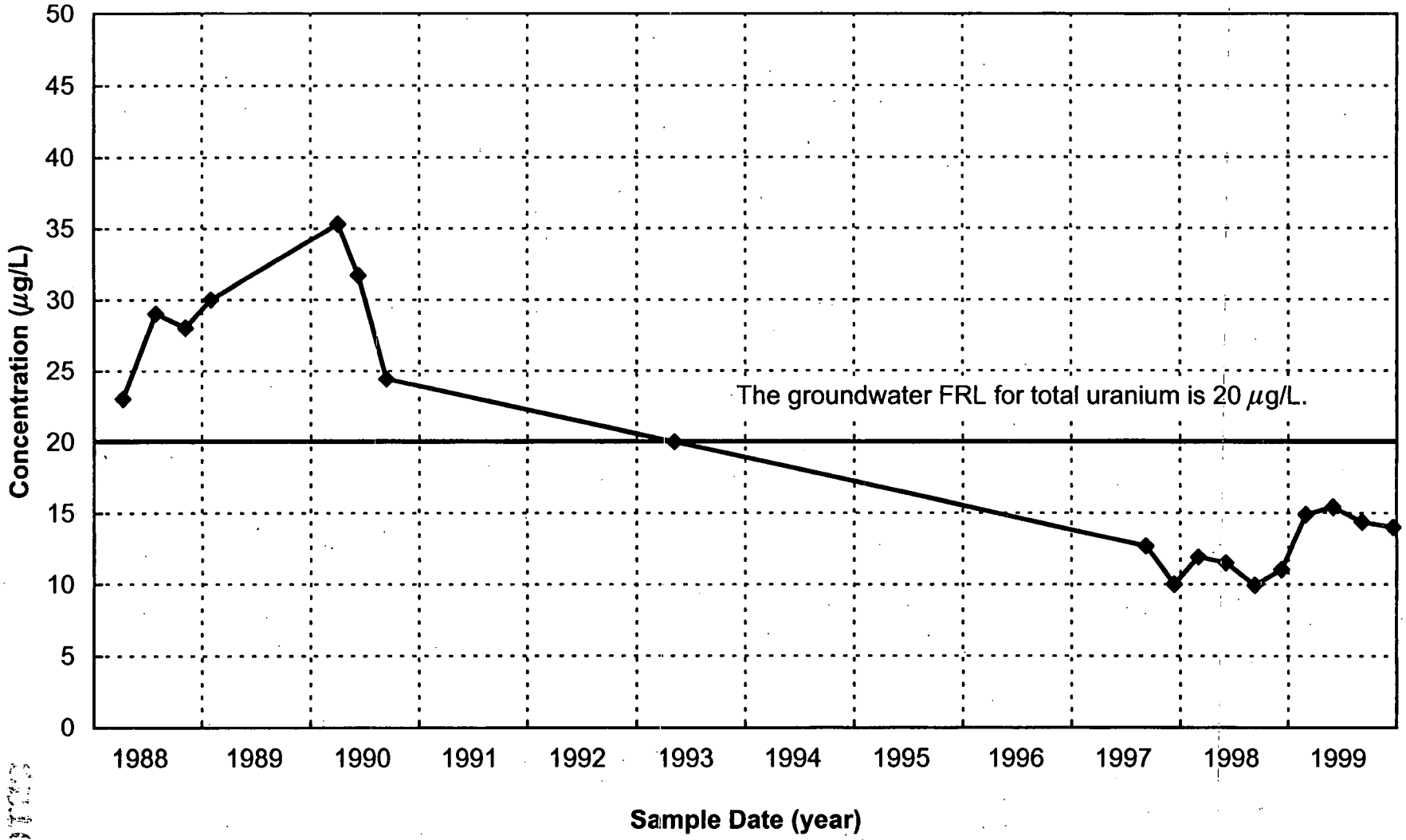



FIGURE A.2-80. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3014

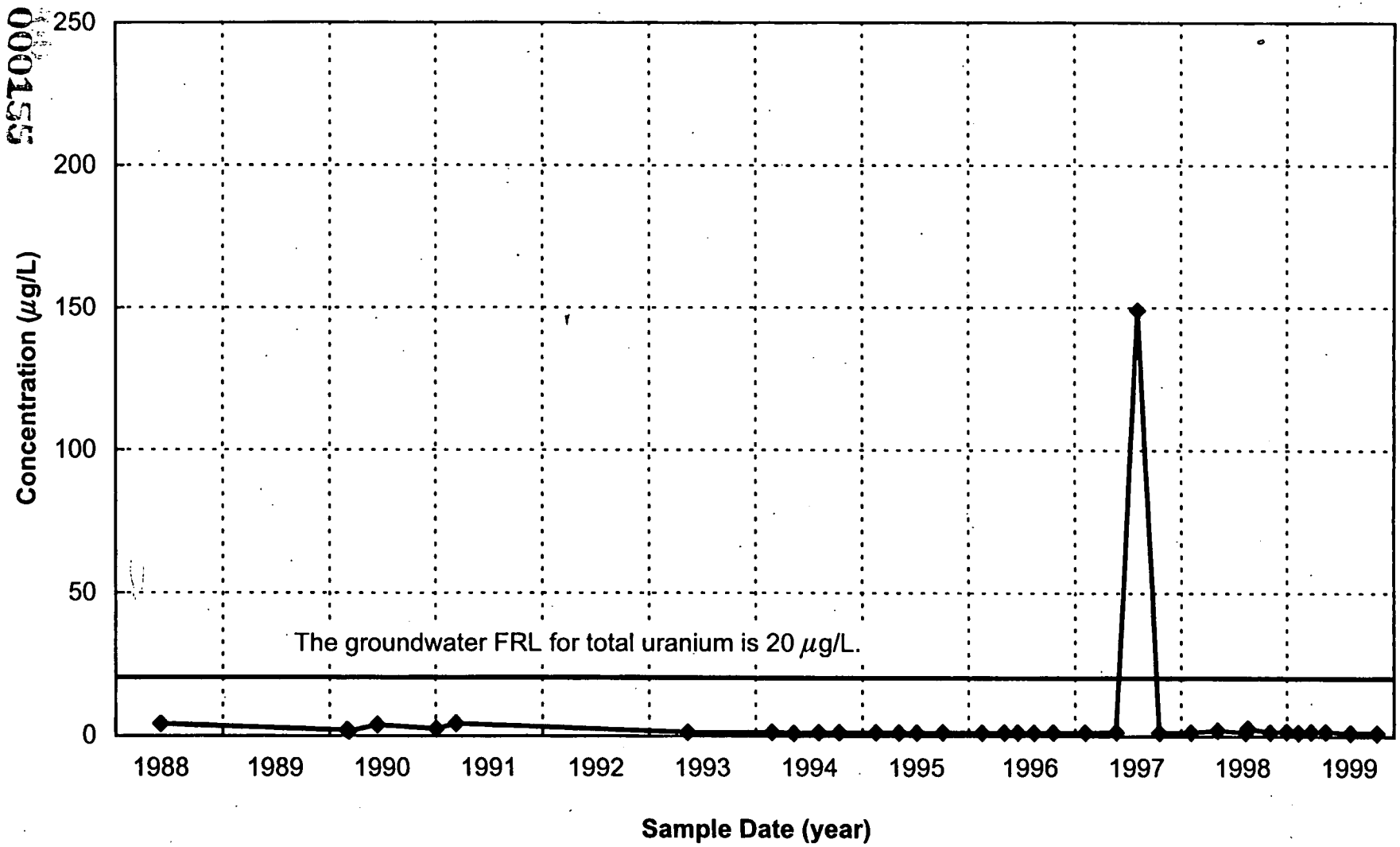



FIGURE A.2-81. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3015

000155

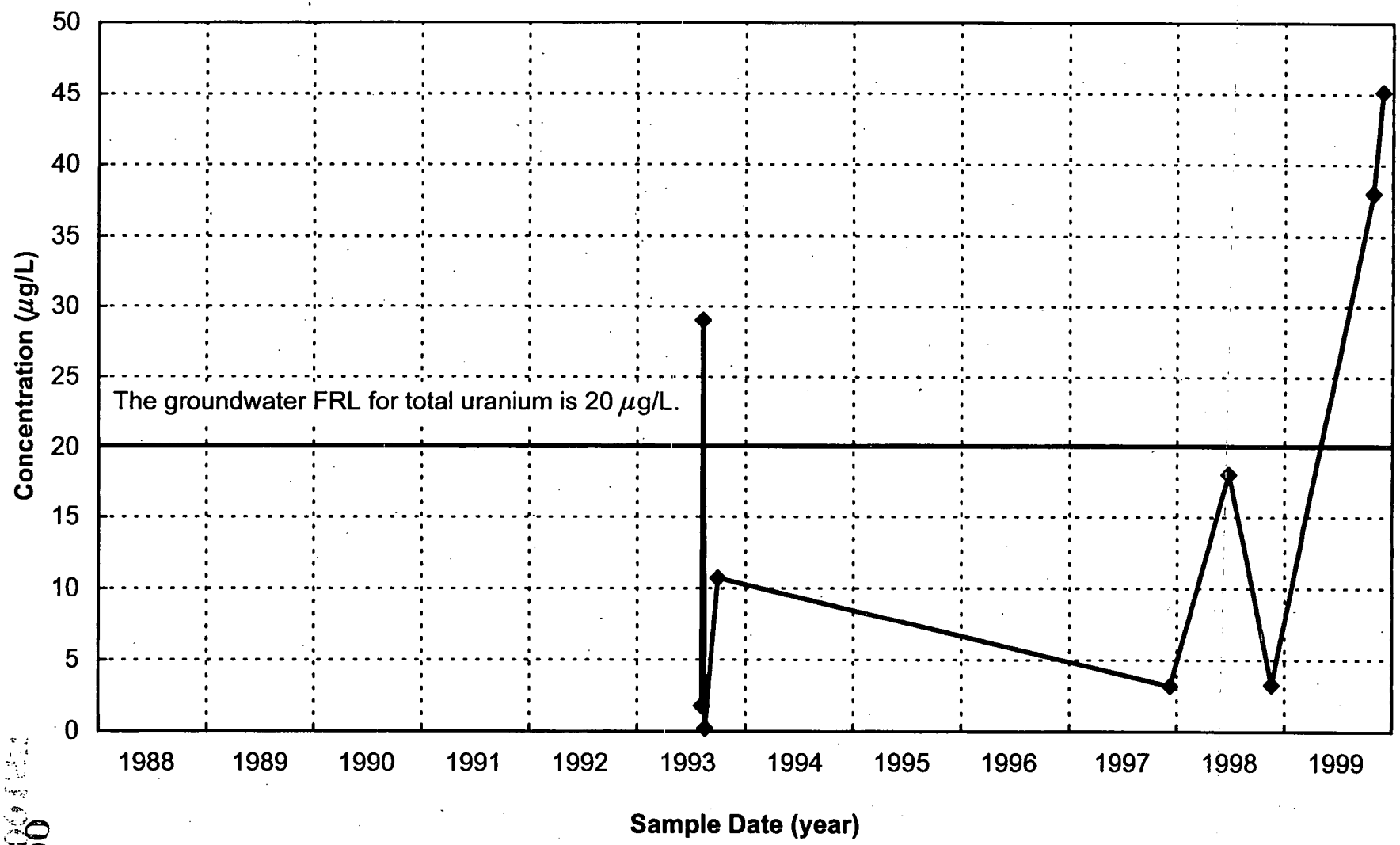



FIGURE A.2-82. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3027

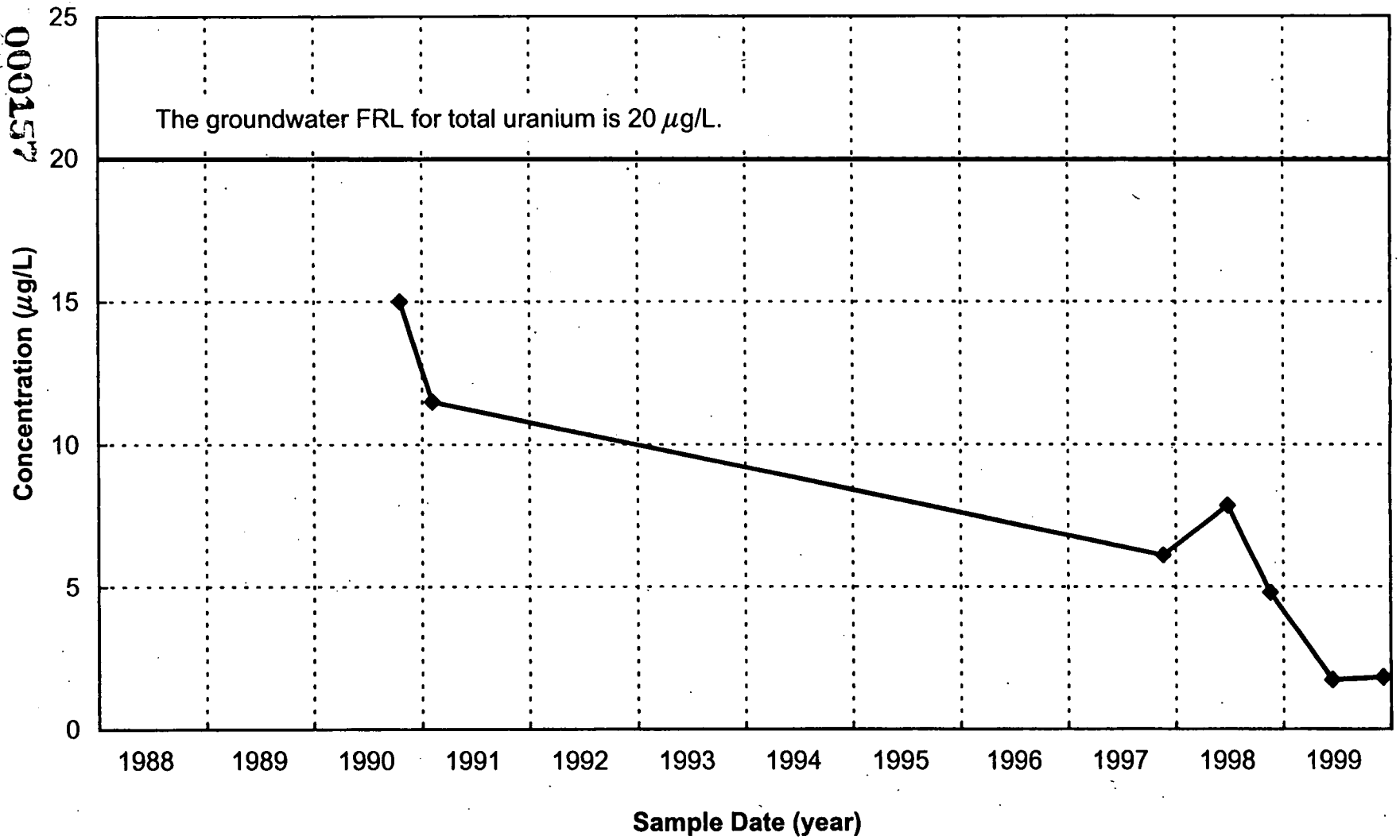



FIGURE A.2-83. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3032

000157

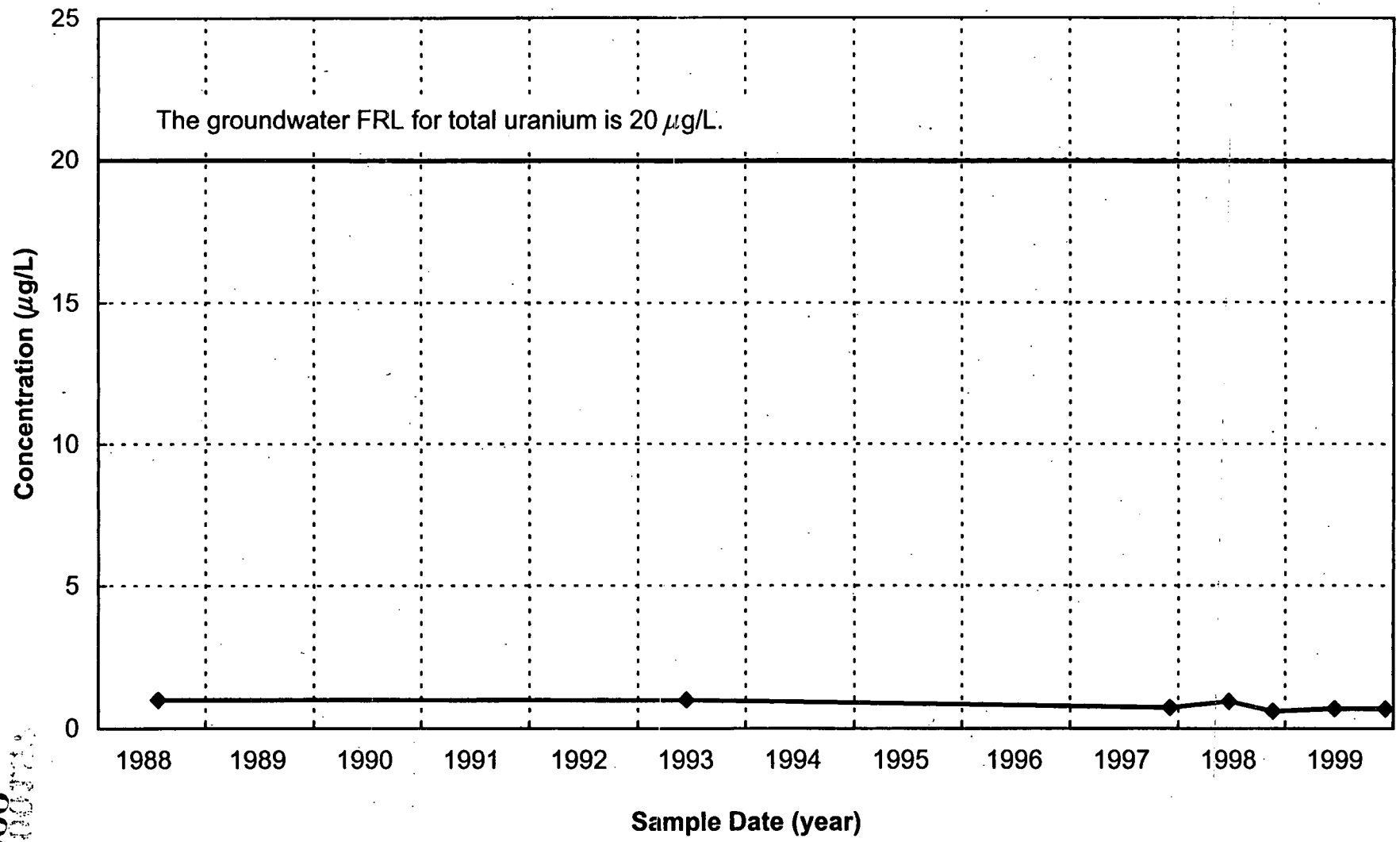



FIGURE A.2-84. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3034

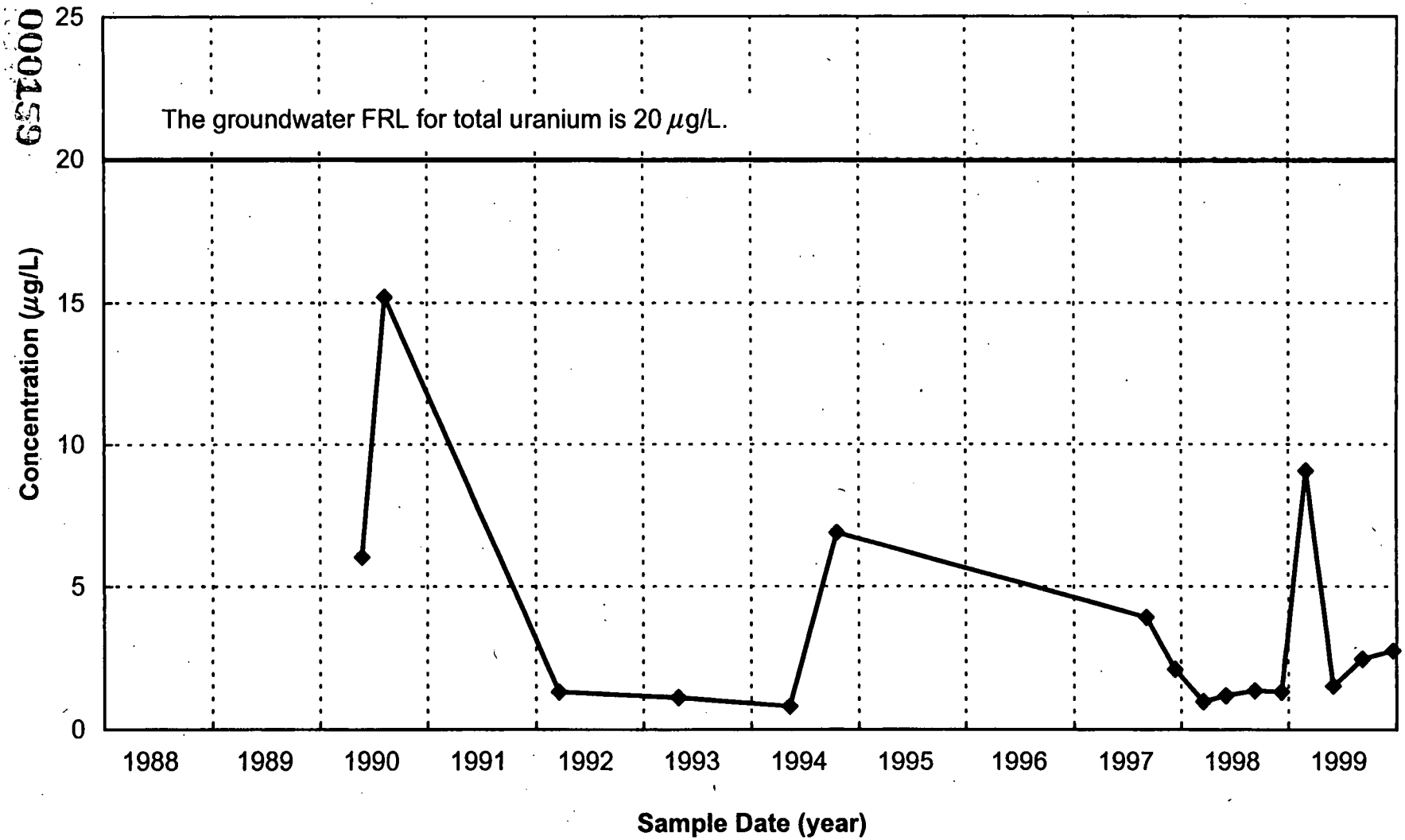



FIGURE A.2-85. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3045

000159

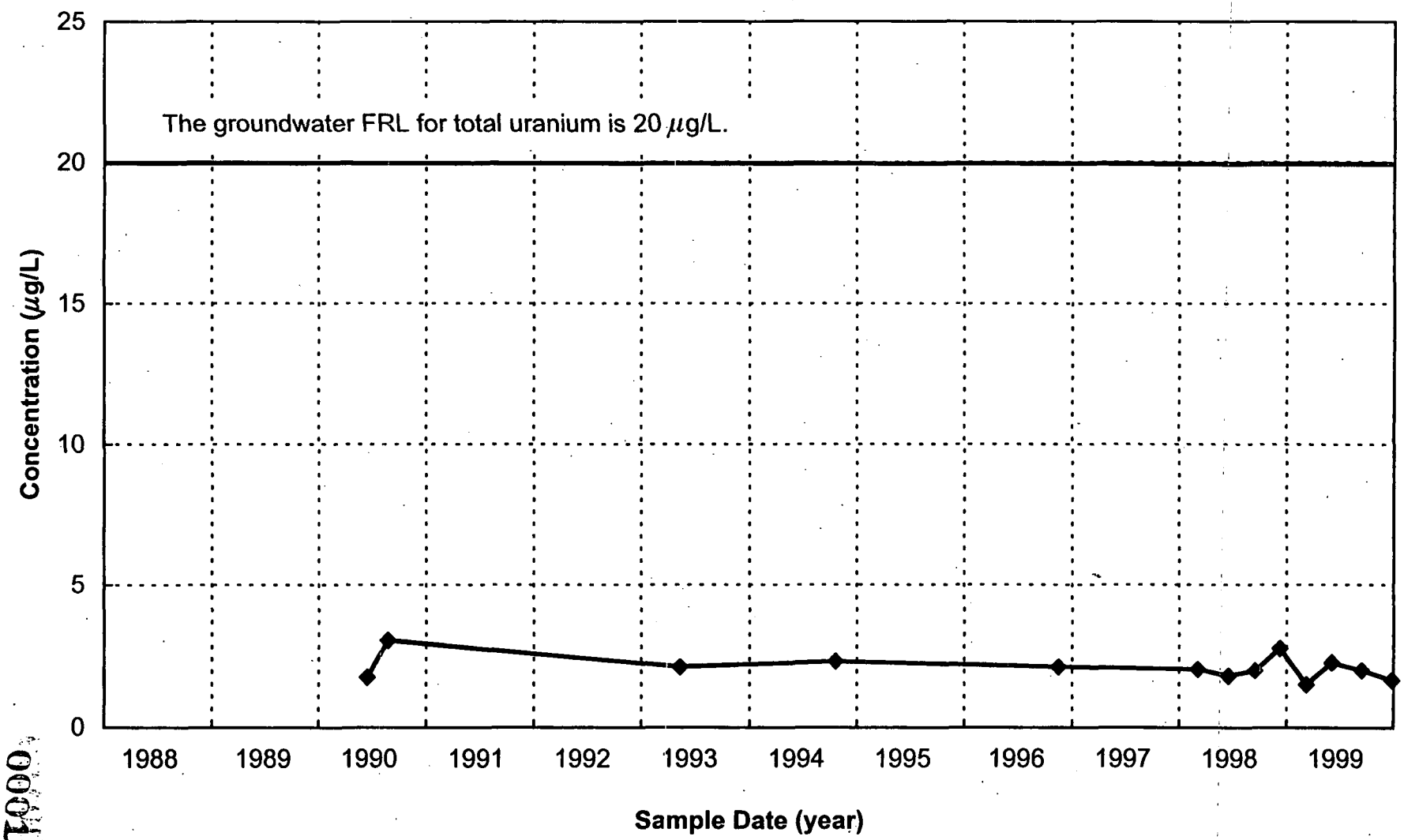



FIGURE A.2-86. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3046

0001130

- 3004

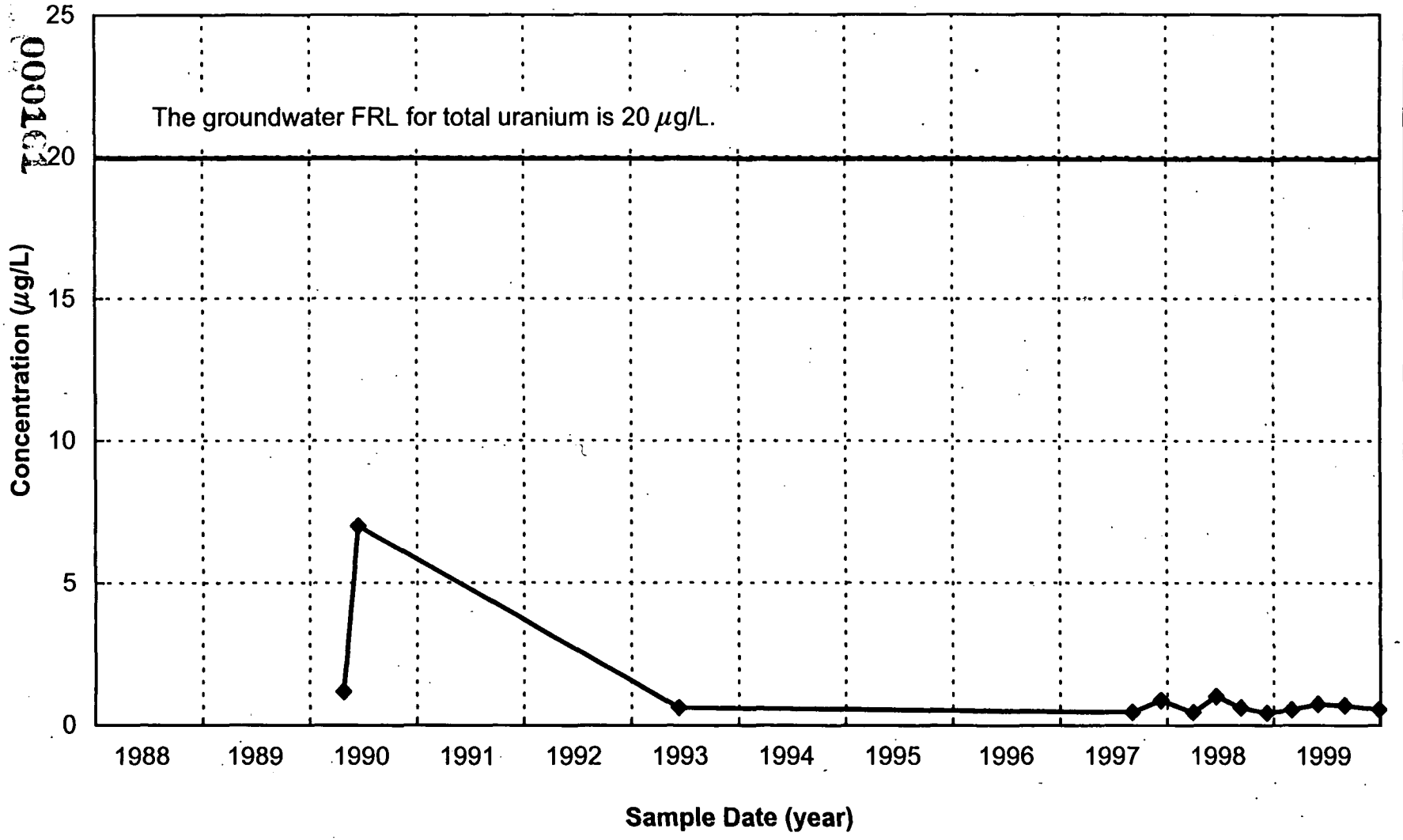



FIGURE A.2-87. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3049

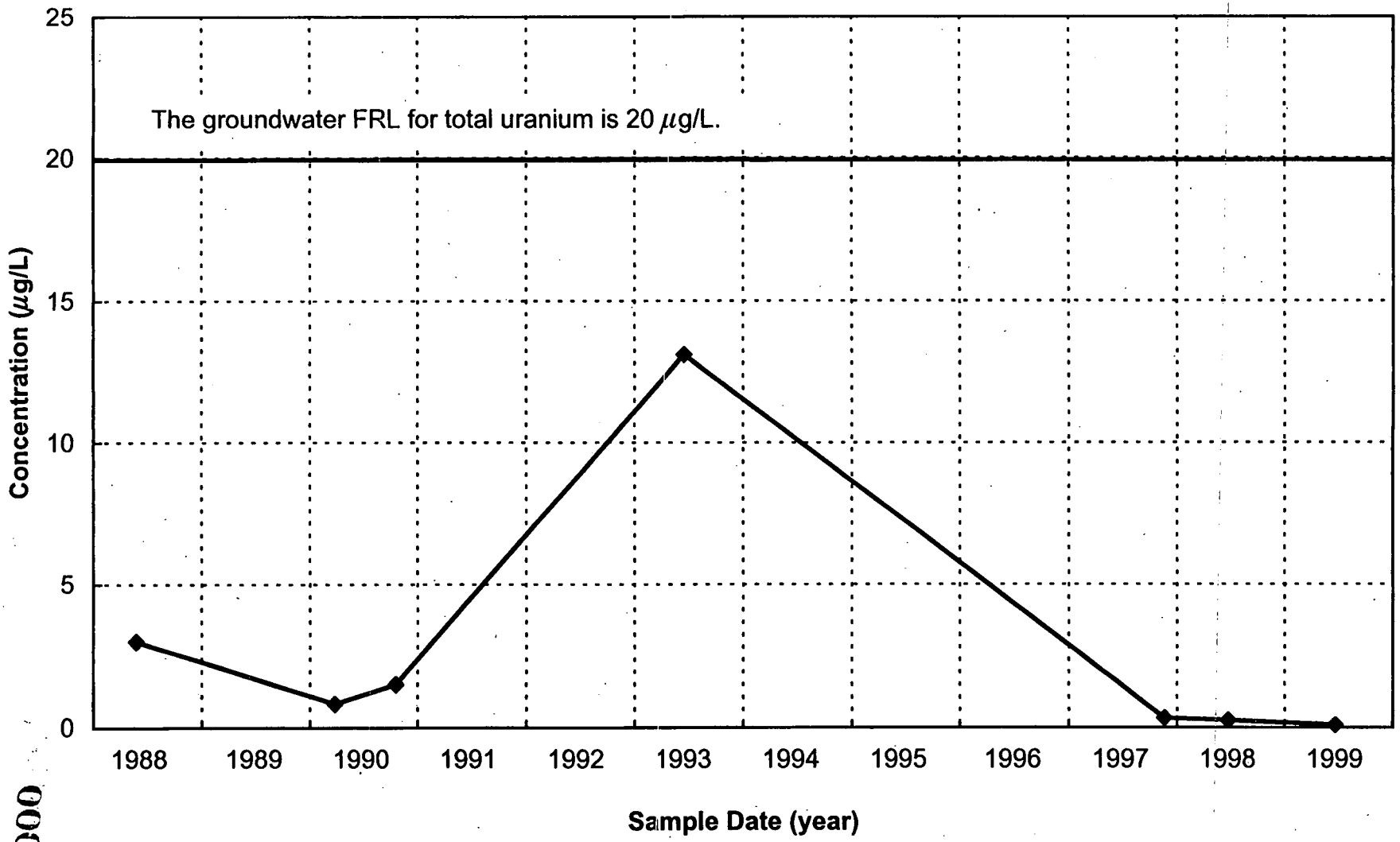



FIGURE A.2-88. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3054

000162

- 3004

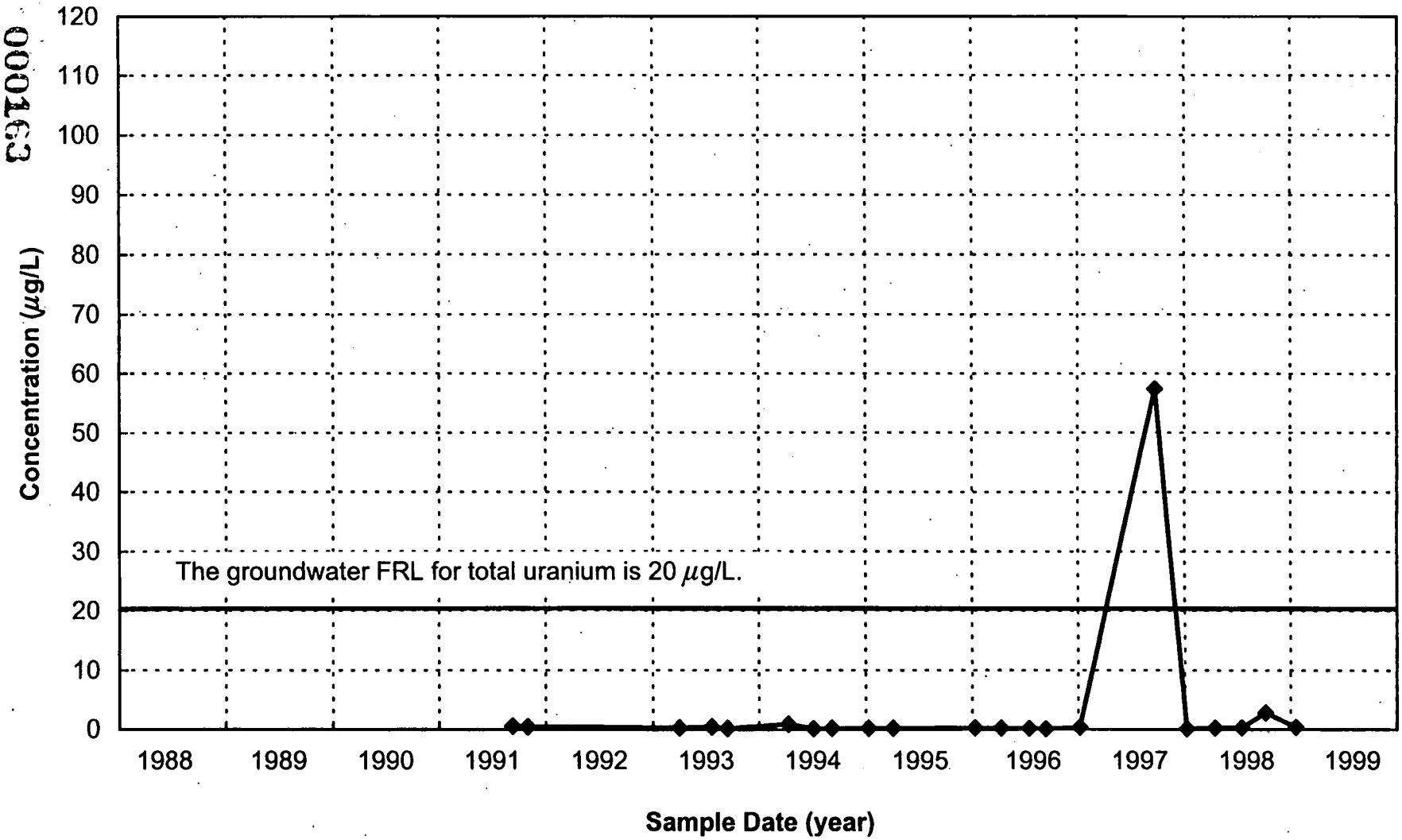



FIGURE A.2-89. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3067

000163

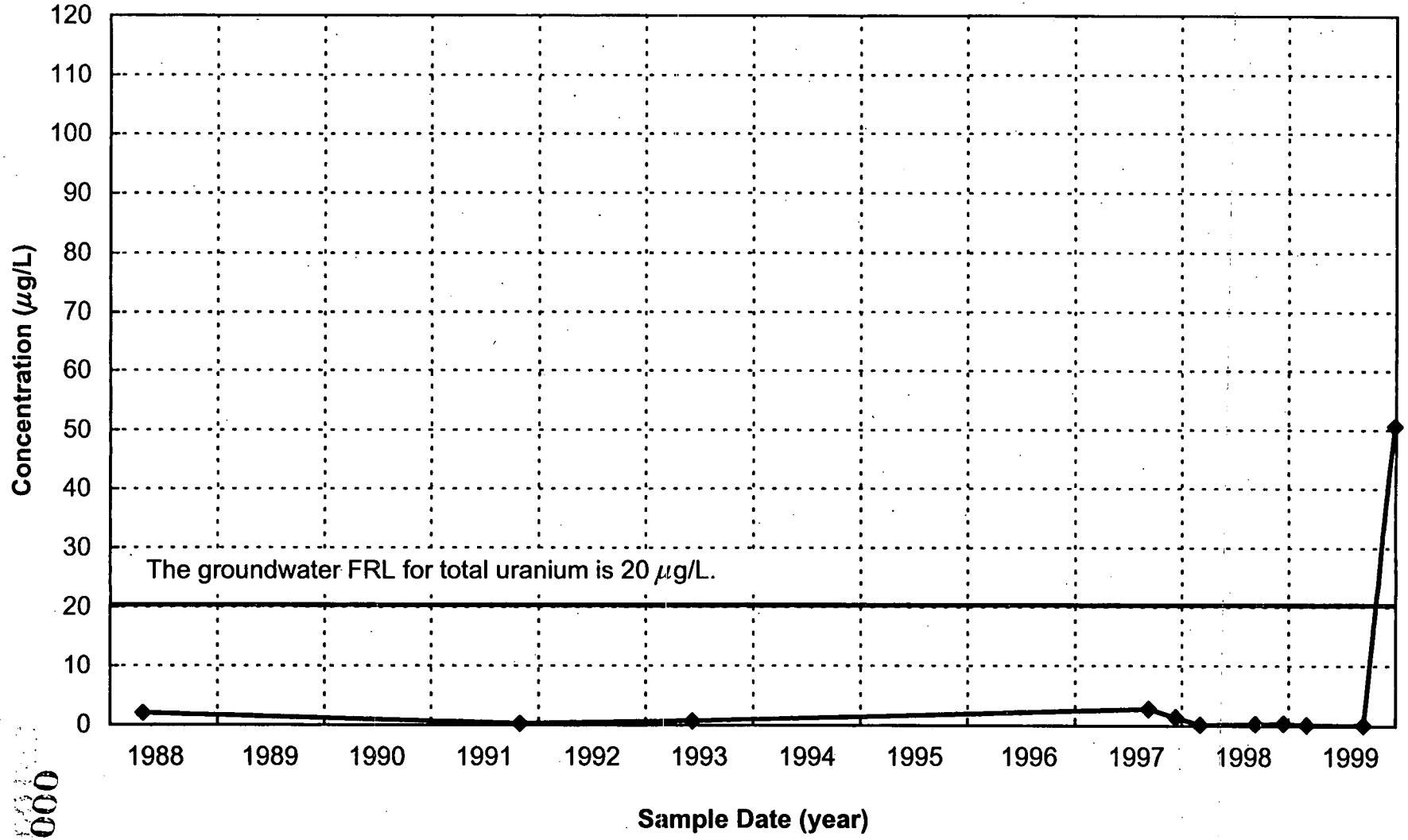



FIGURE A.2-90. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3068

0001664

30 04

0001165

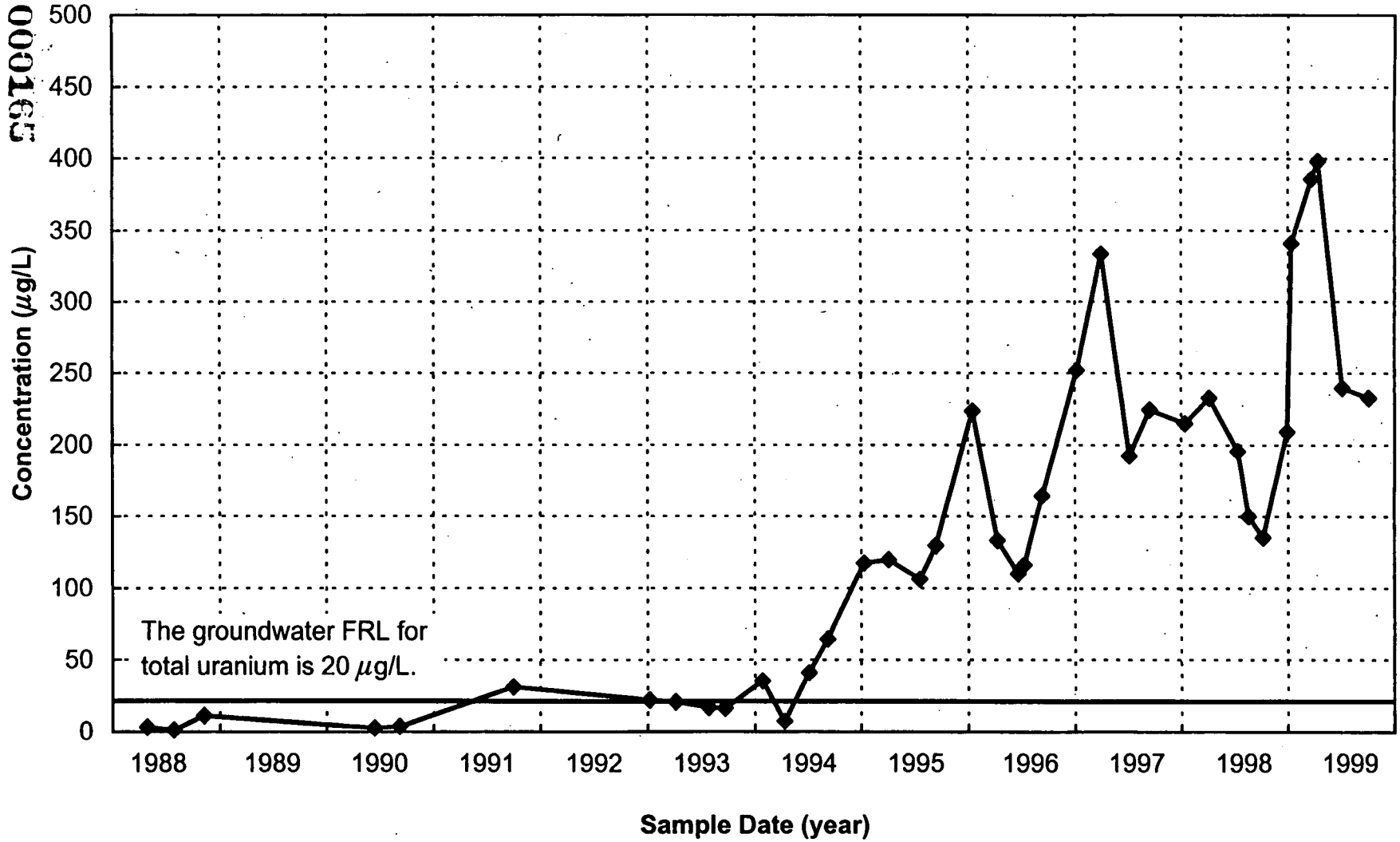



FIGURE A.2-91. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3069

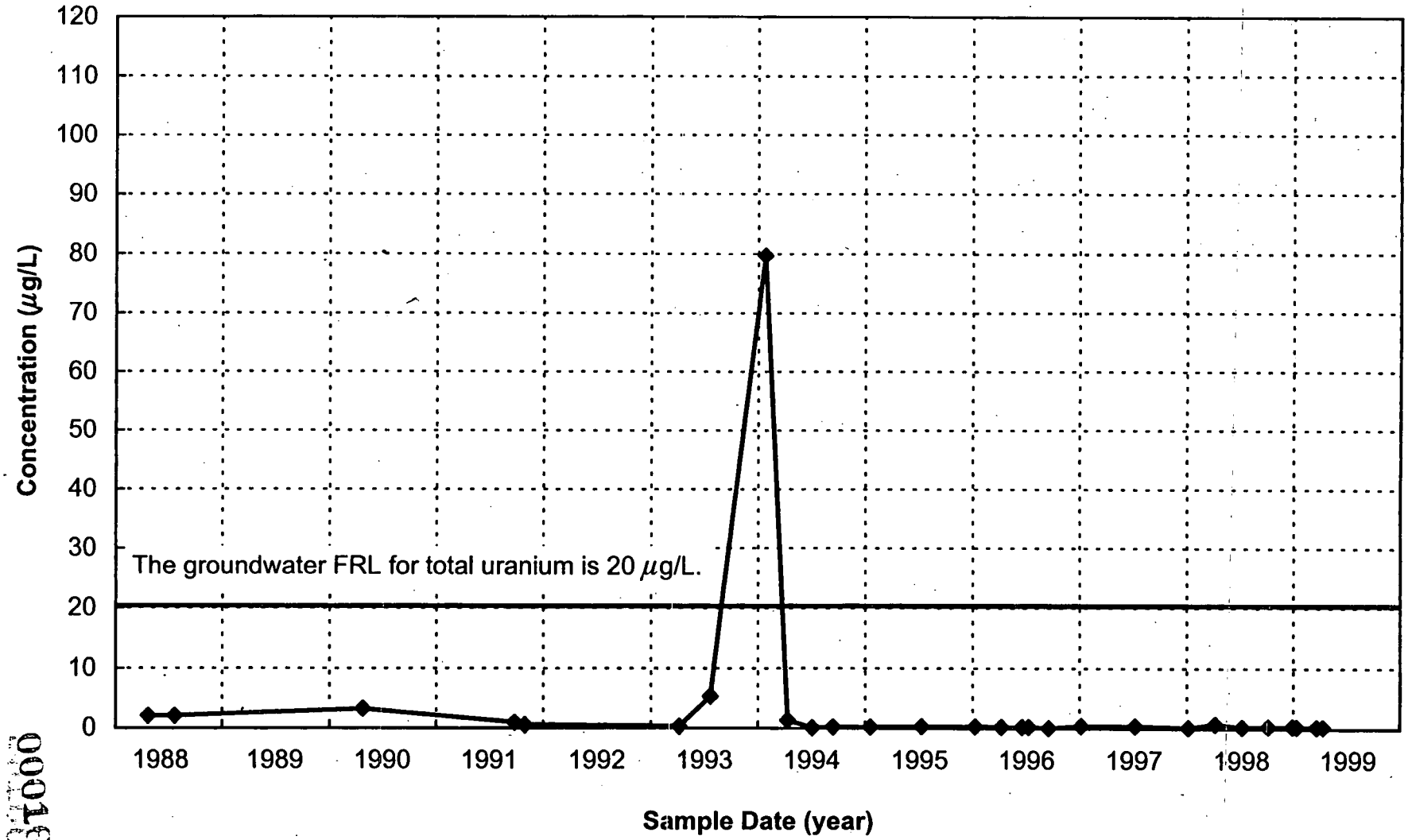



FIGURE A.2-92. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3070

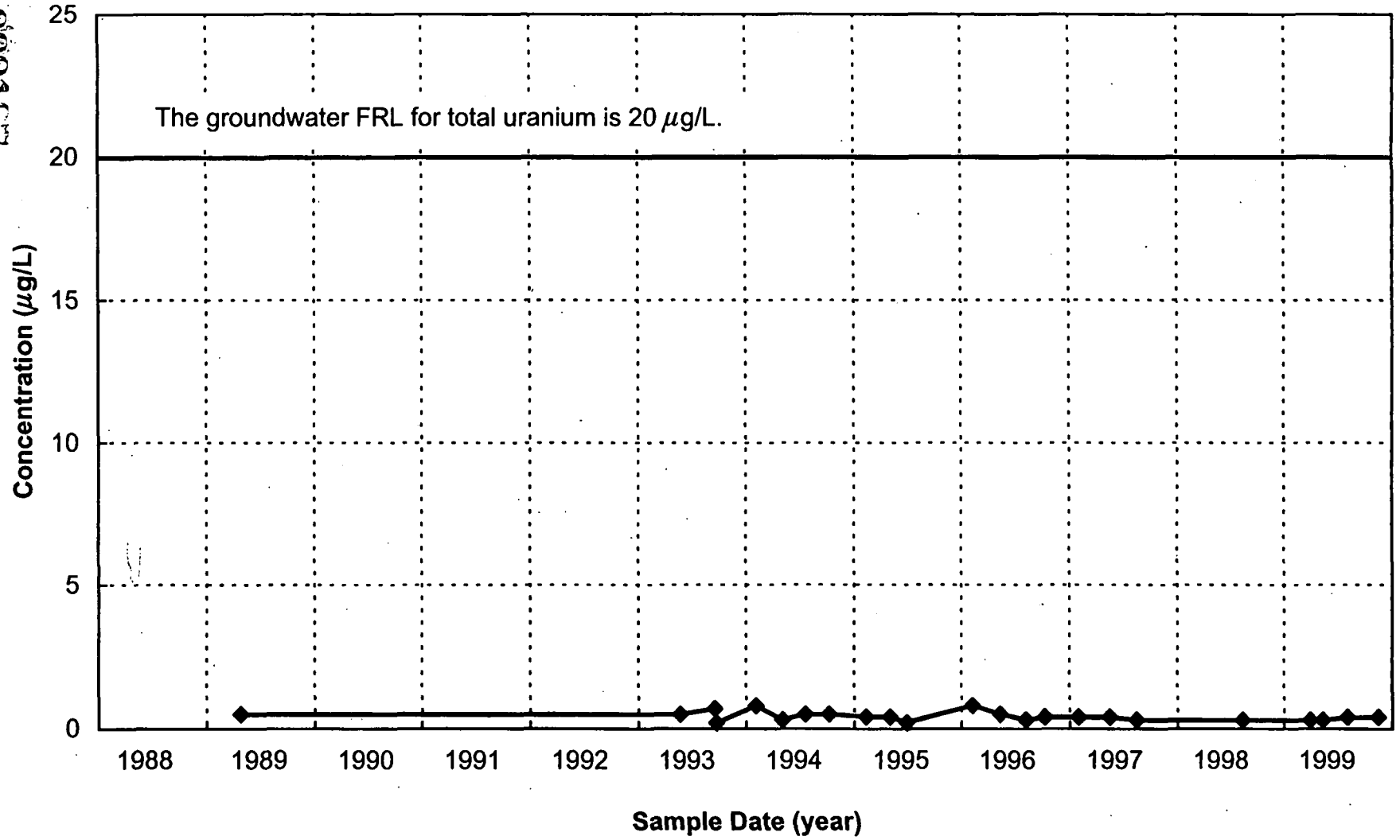



FIGURE A.2-93. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3093

000167

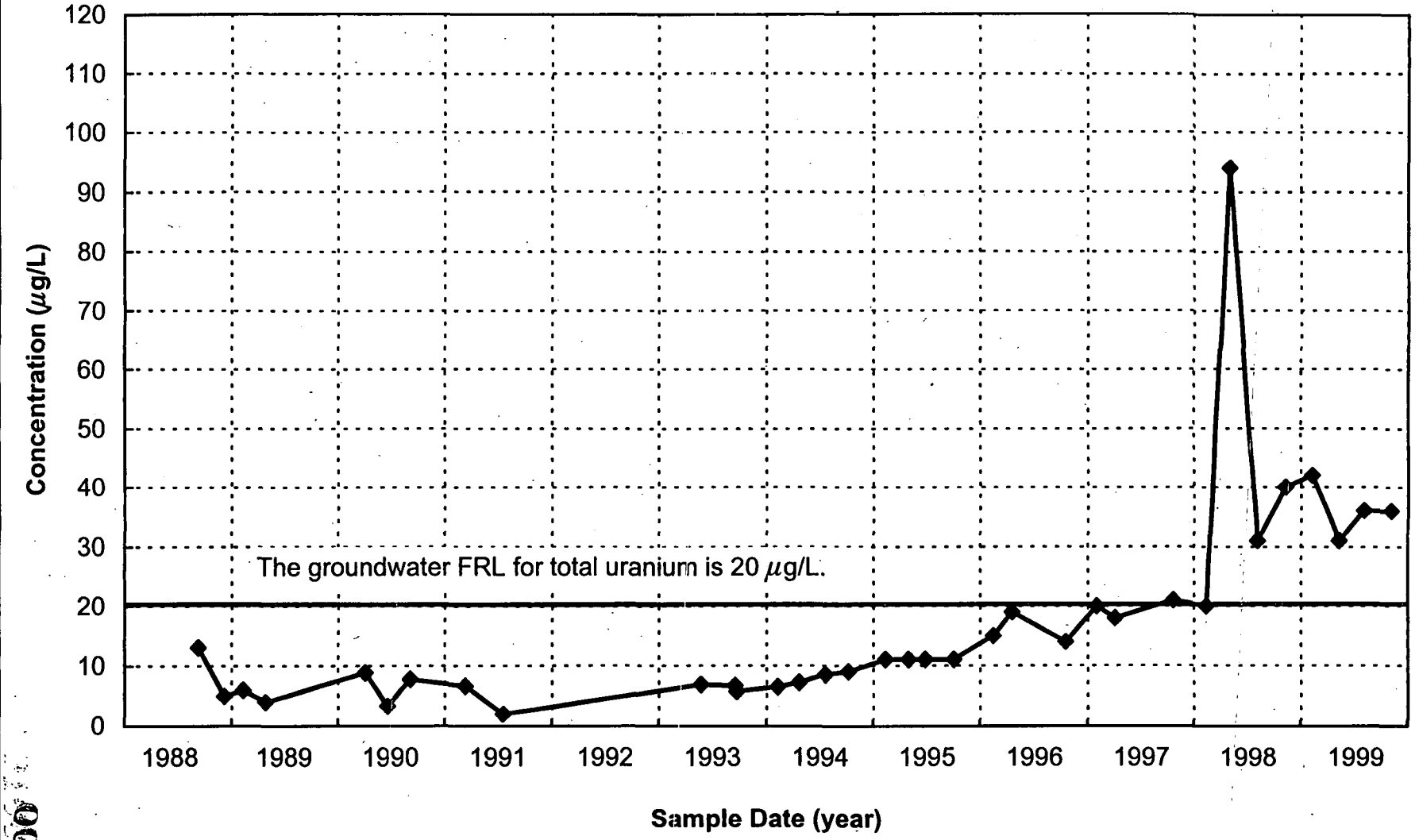



FIGURE A.2-94. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3095

000168

3004

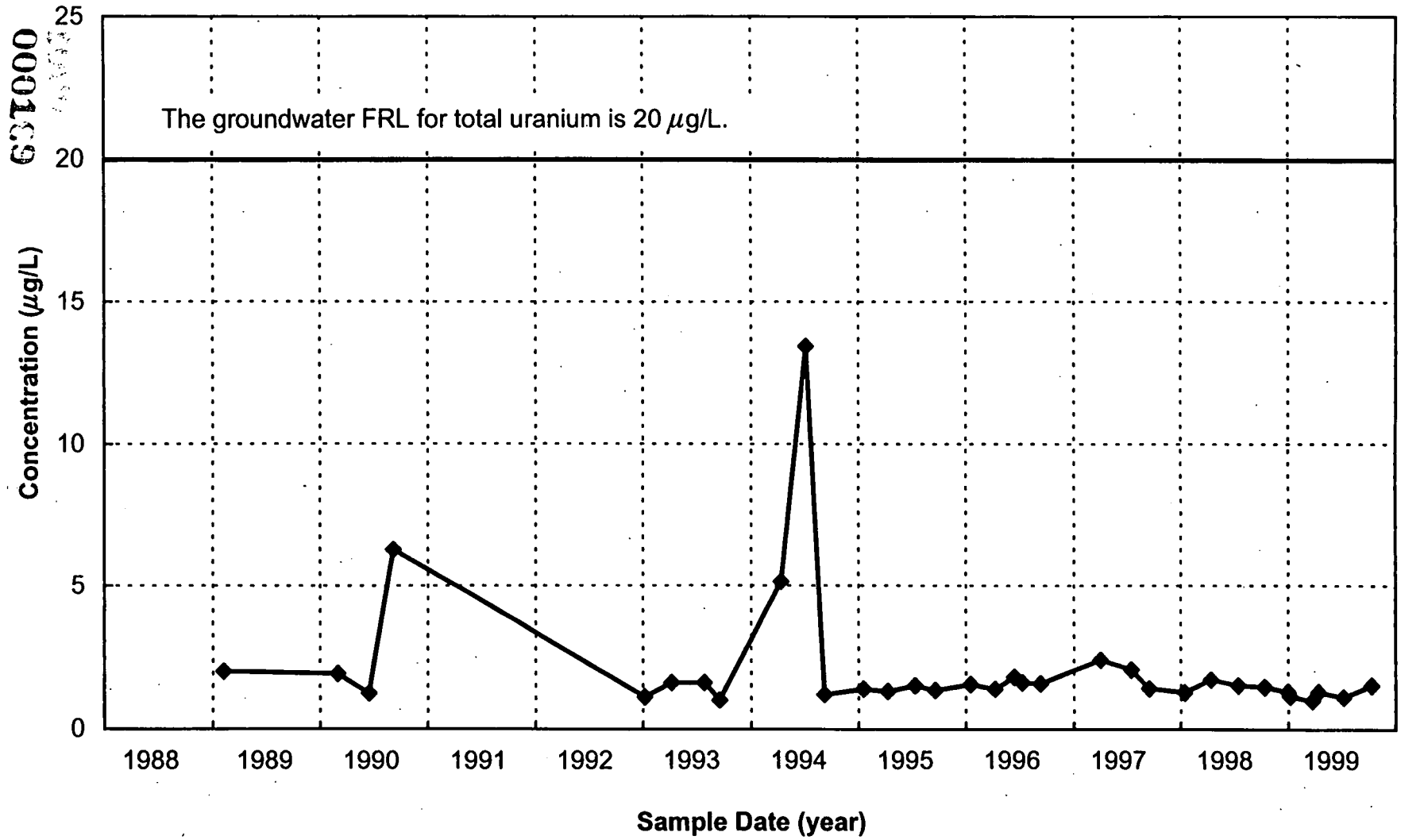



FIGURE A.2-95. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3106

000139

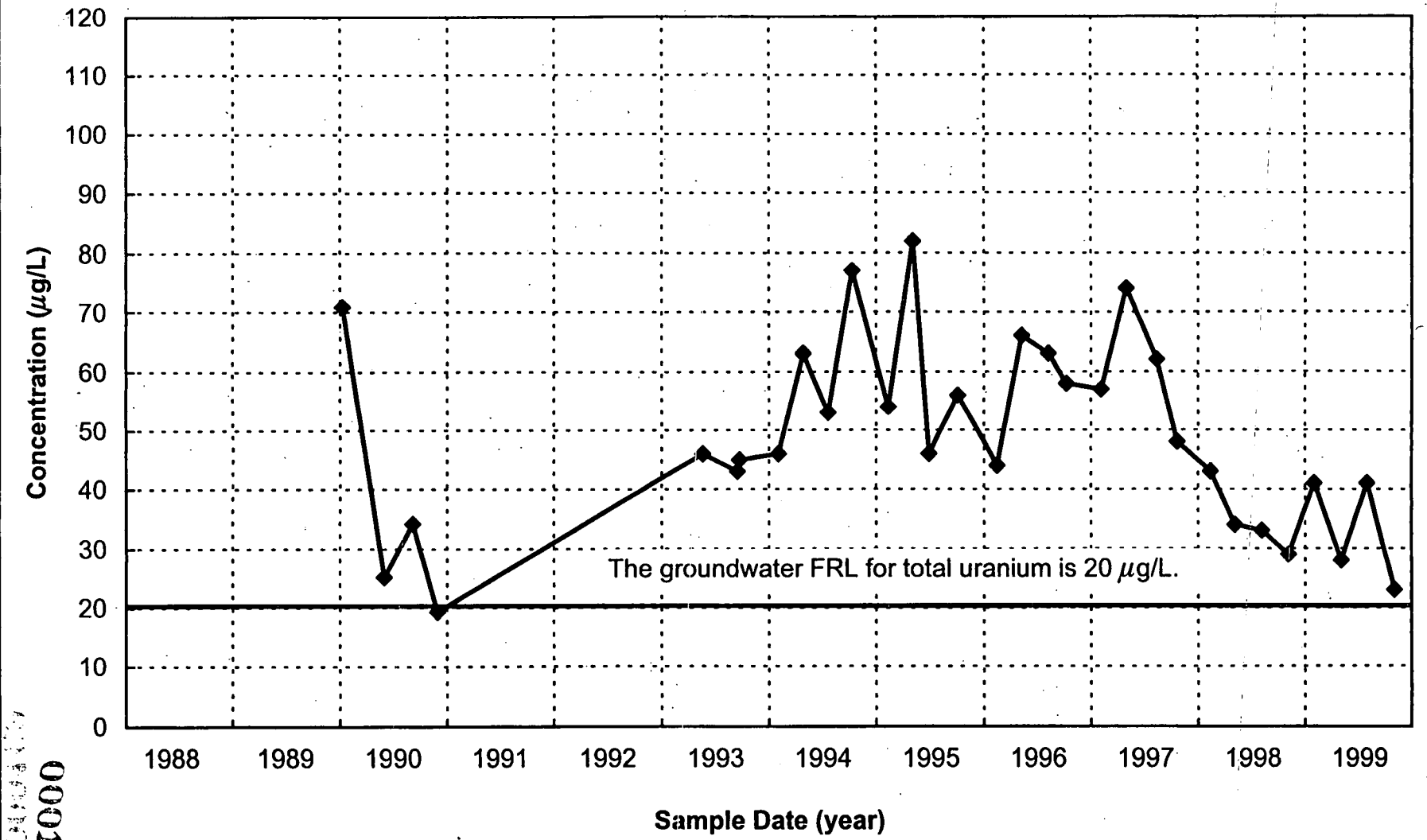



FIGURE A.2-96. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3125

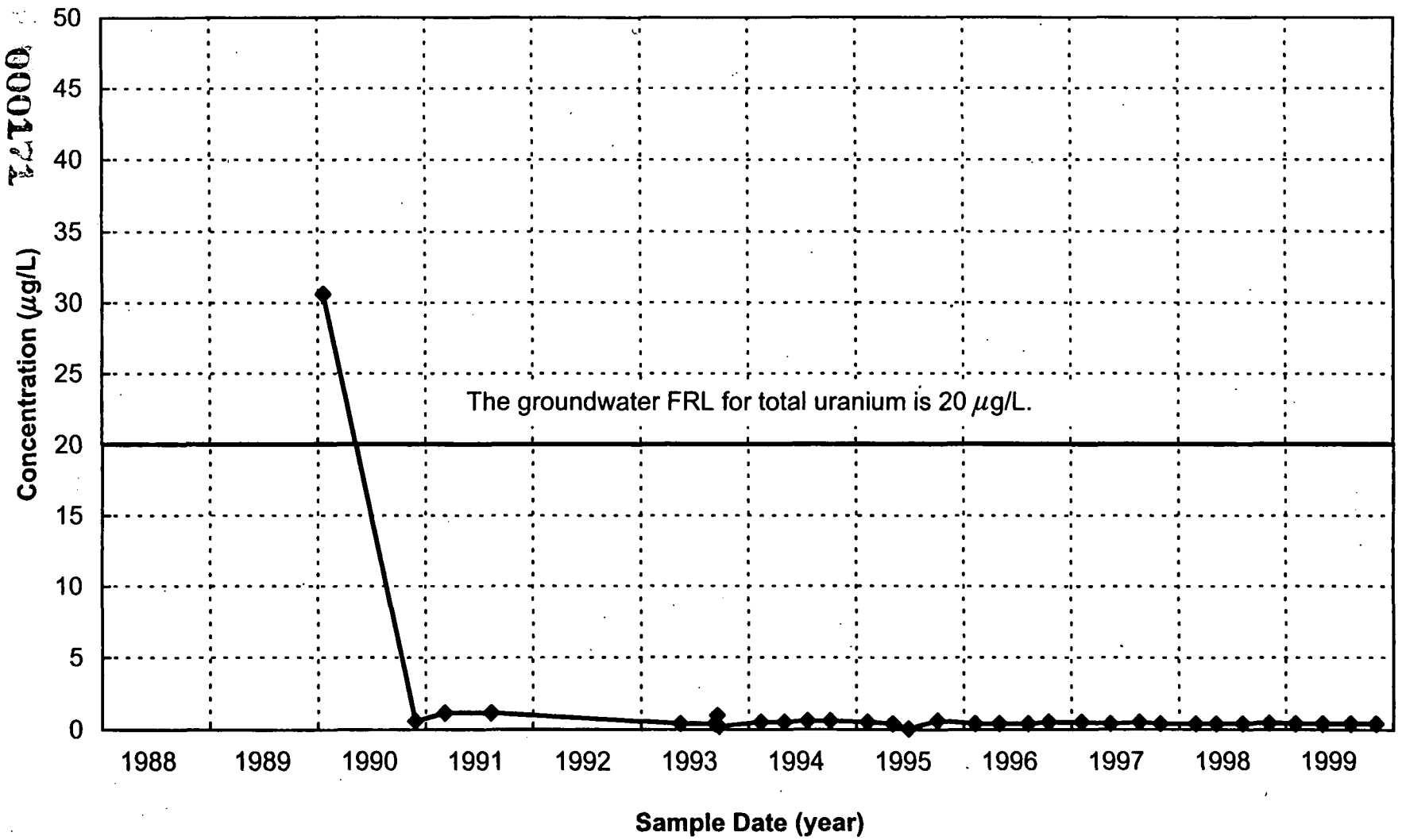



FIGURE A.2-97. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3128

000174

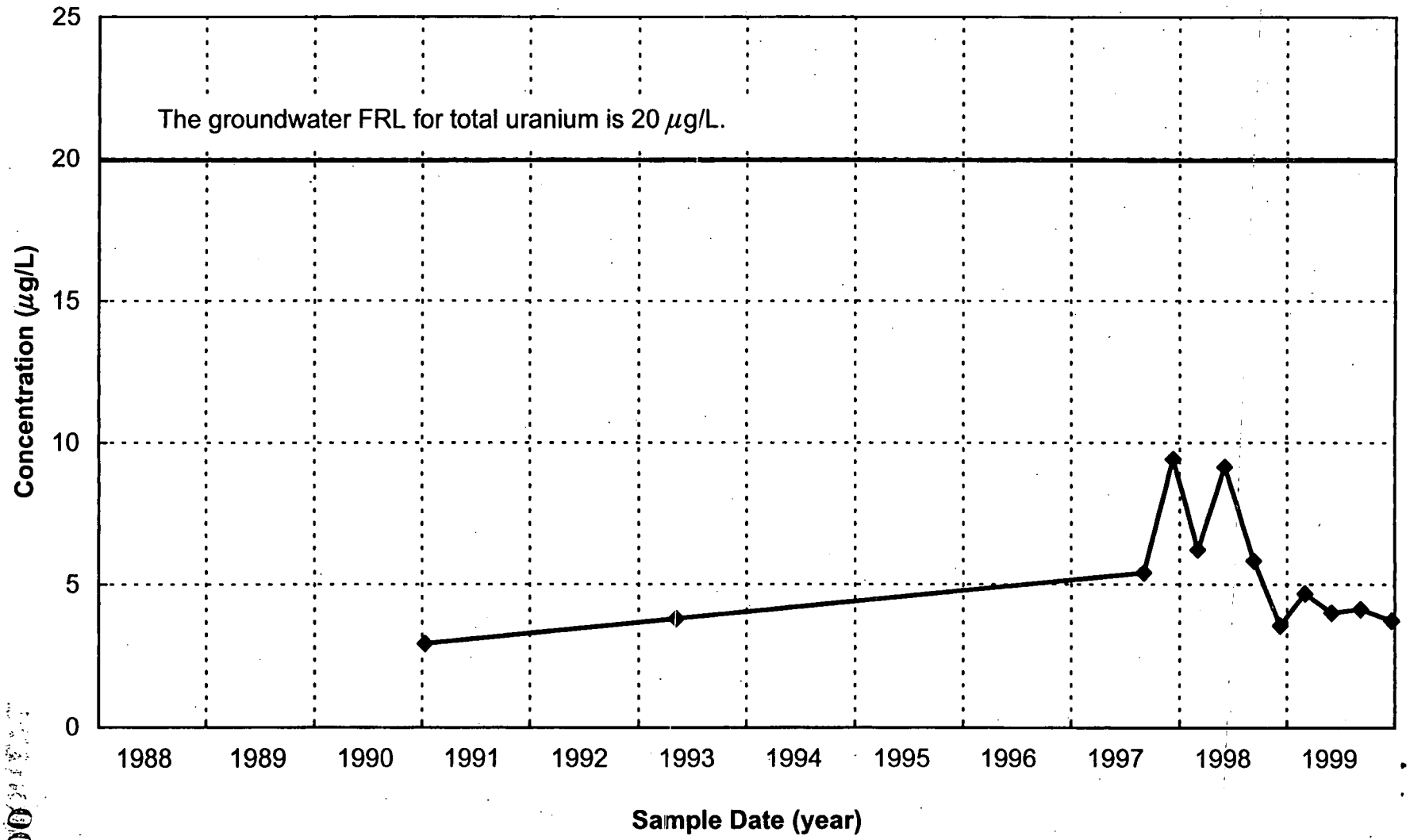



FIGURE A.2-98. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3385

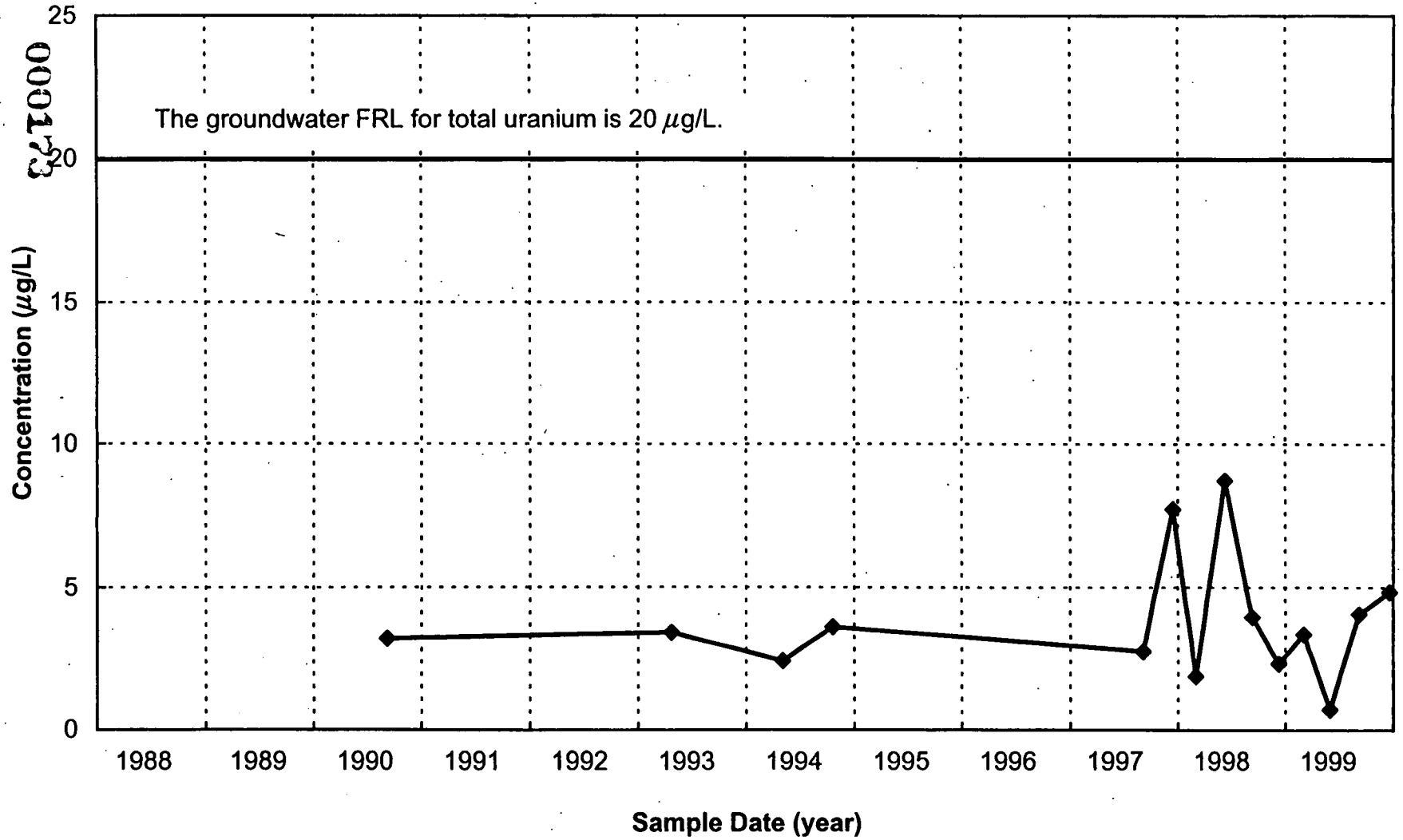



FIGURE A.2-99. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3387

000173

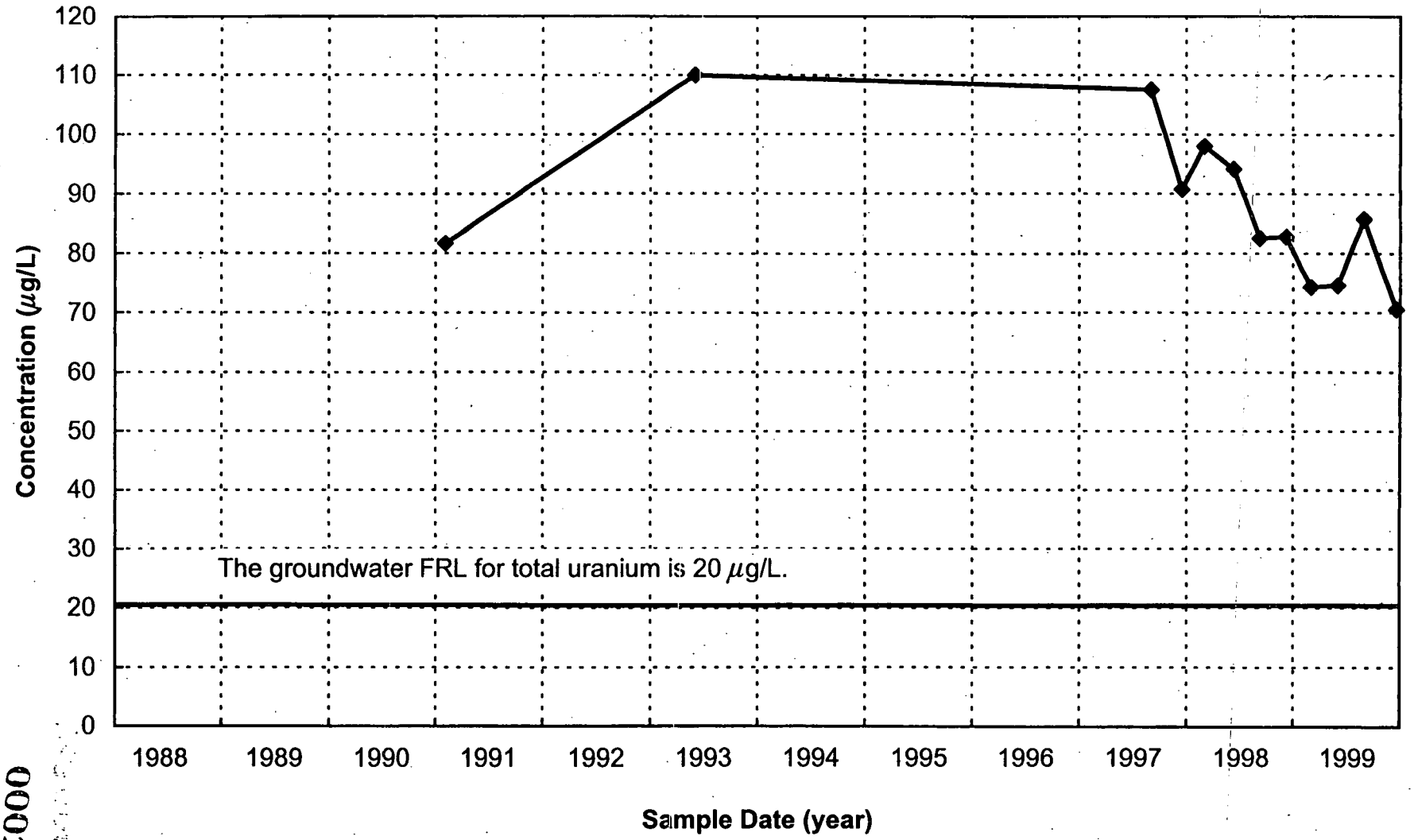



FIGURE A.2-100. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3390

0001274

30 04

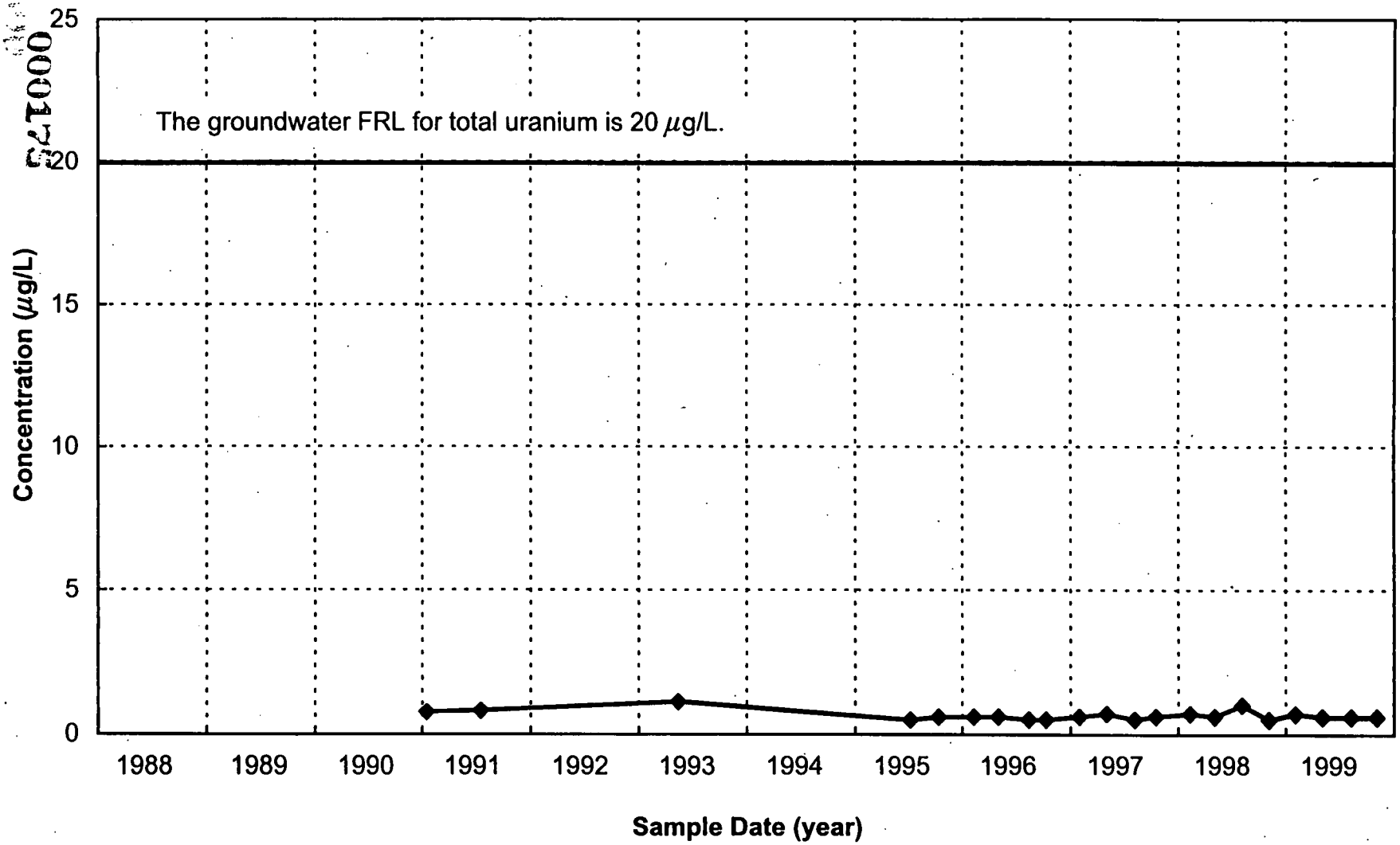



FIGURE A.2-101. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3396

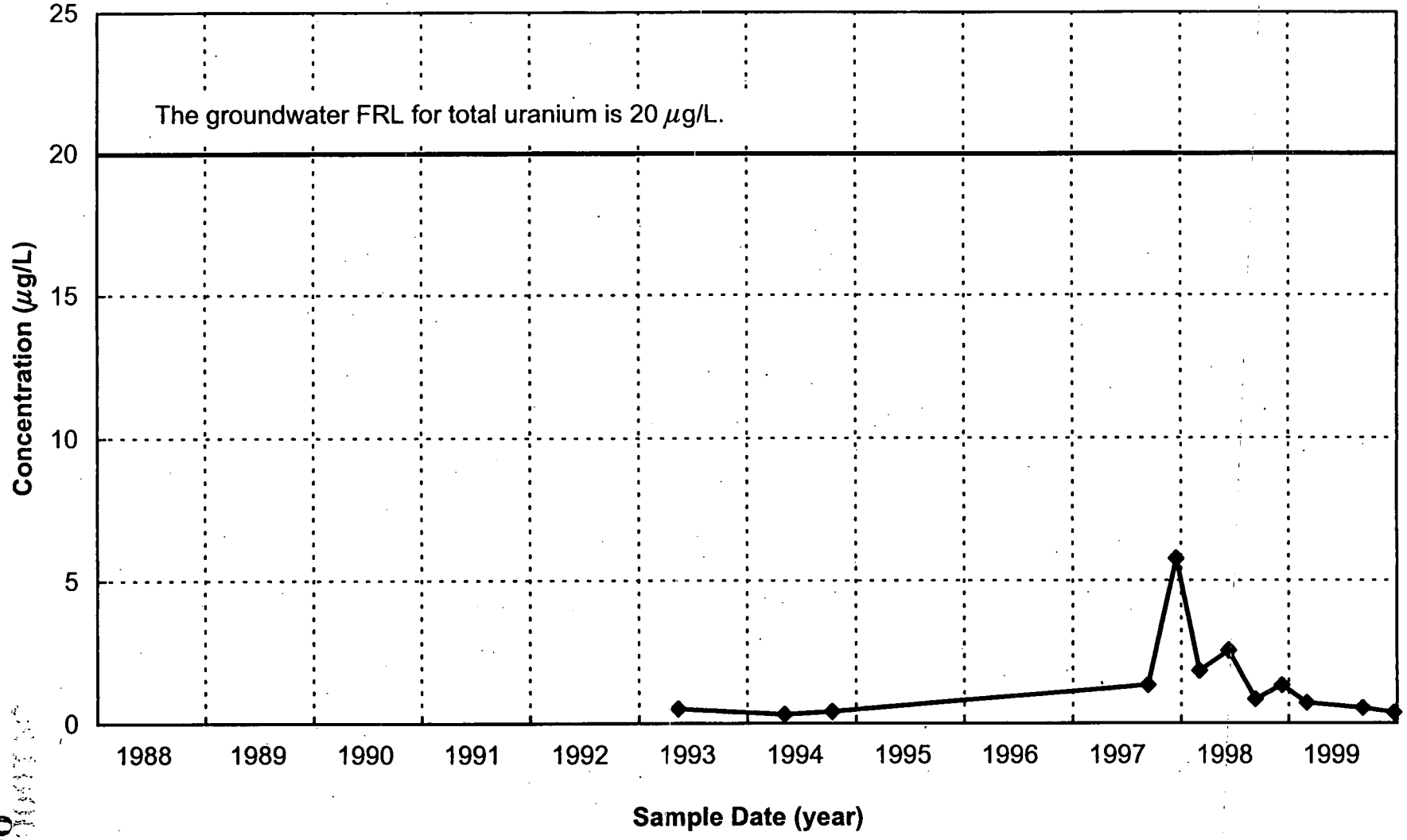



FIGURE A.2-102. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3397

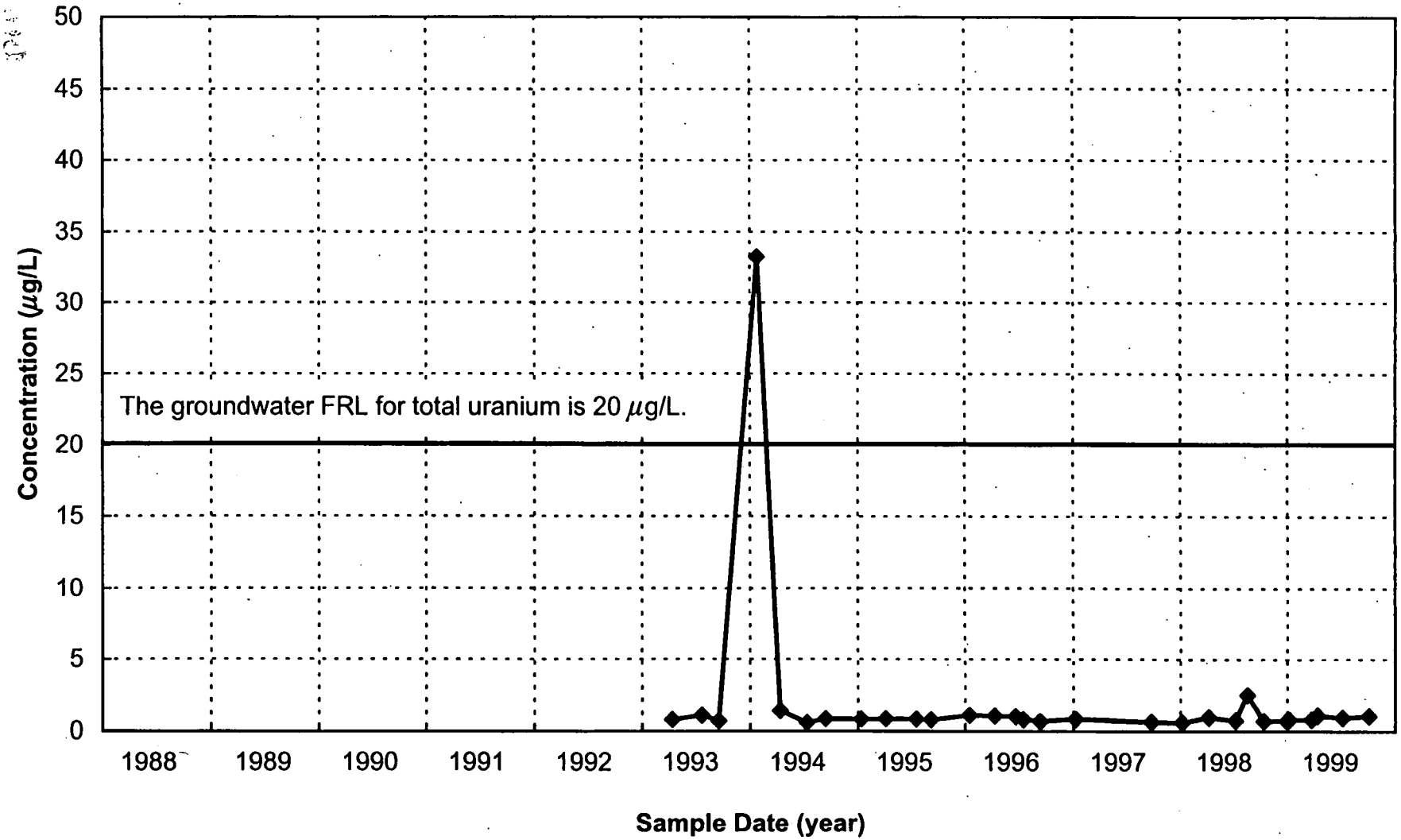



FIGURE A.2-103. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3398

000177

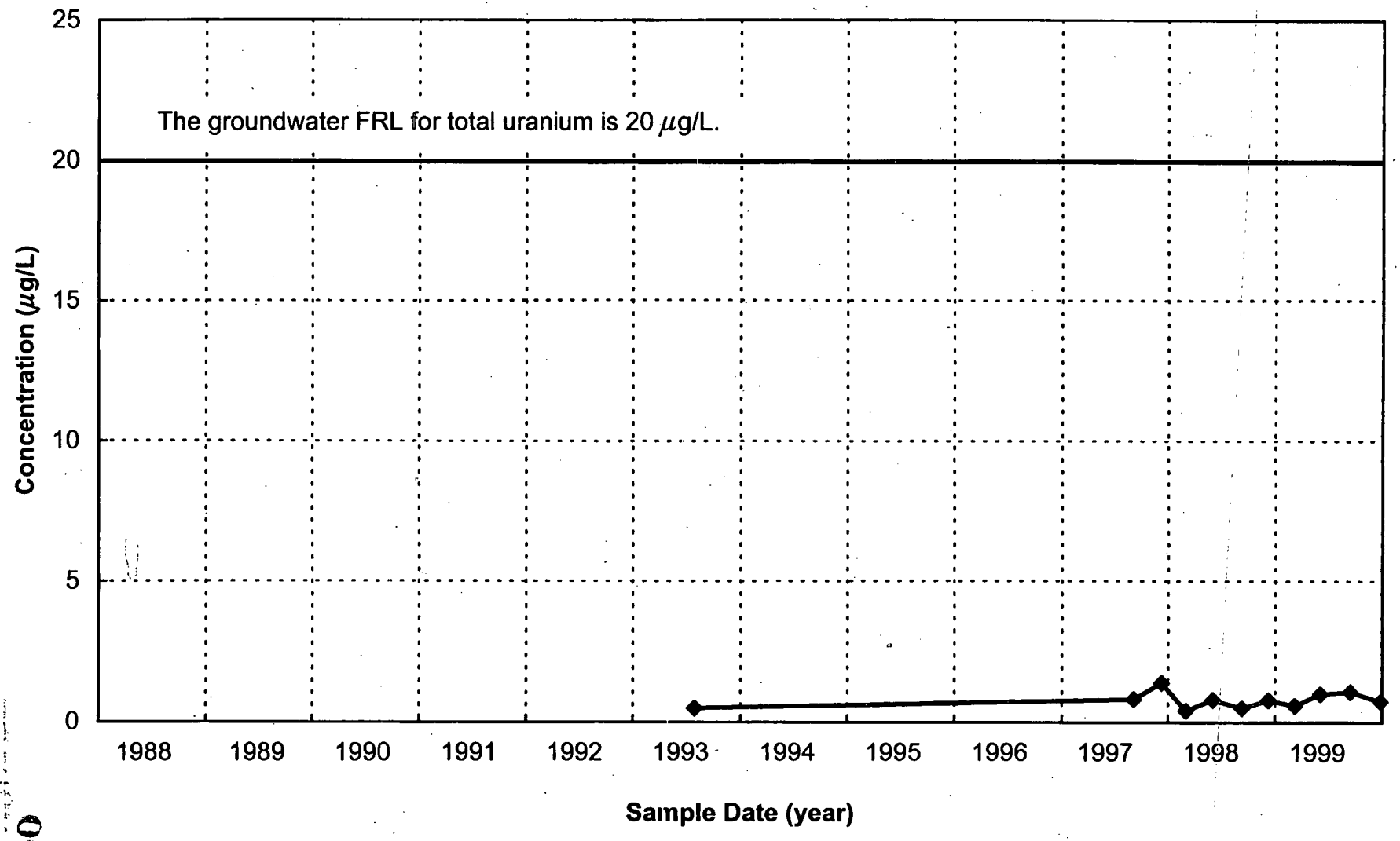



FIGURE A.2-104. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3402



000128

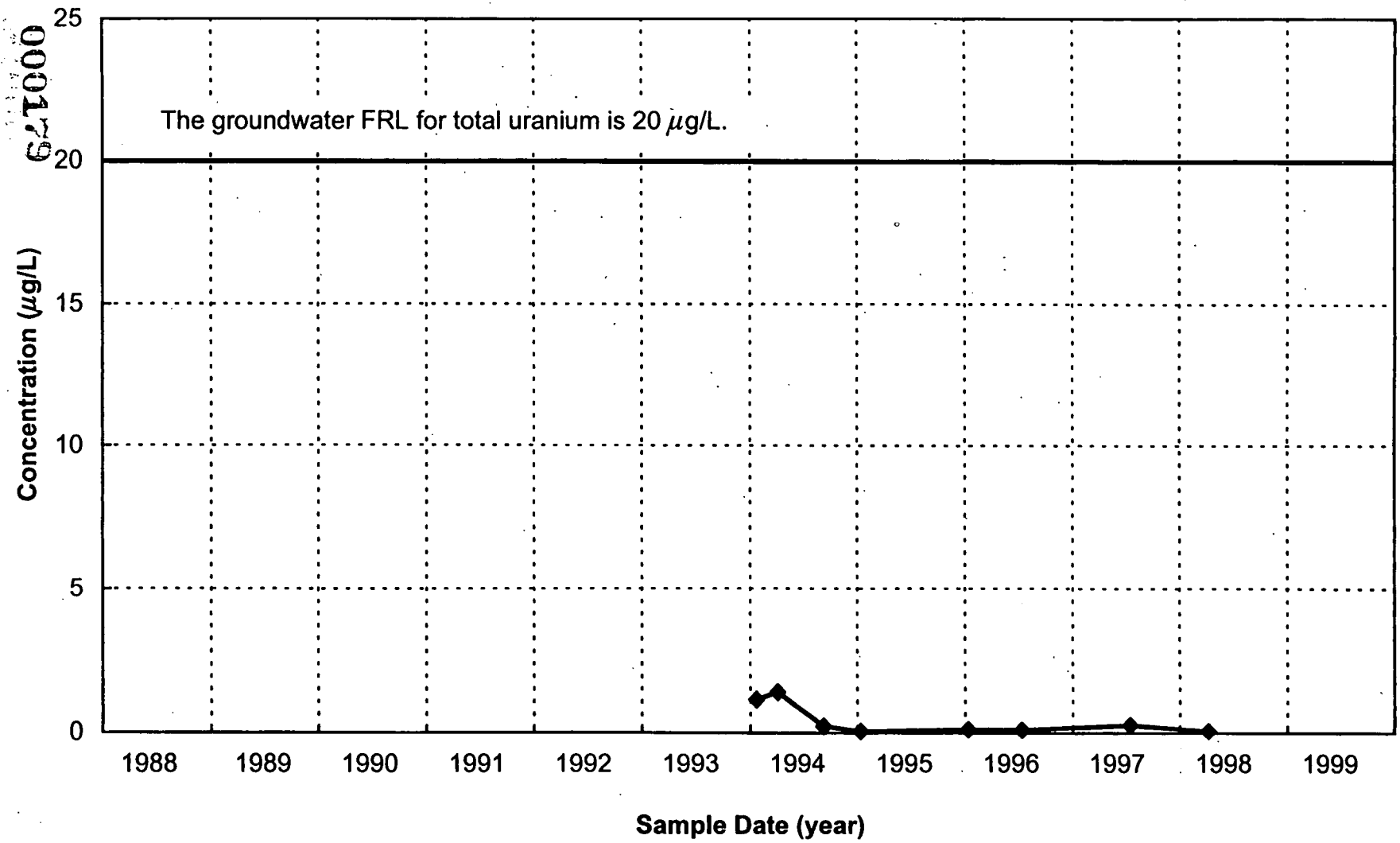



FIGURE A.2-105. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3417

000179

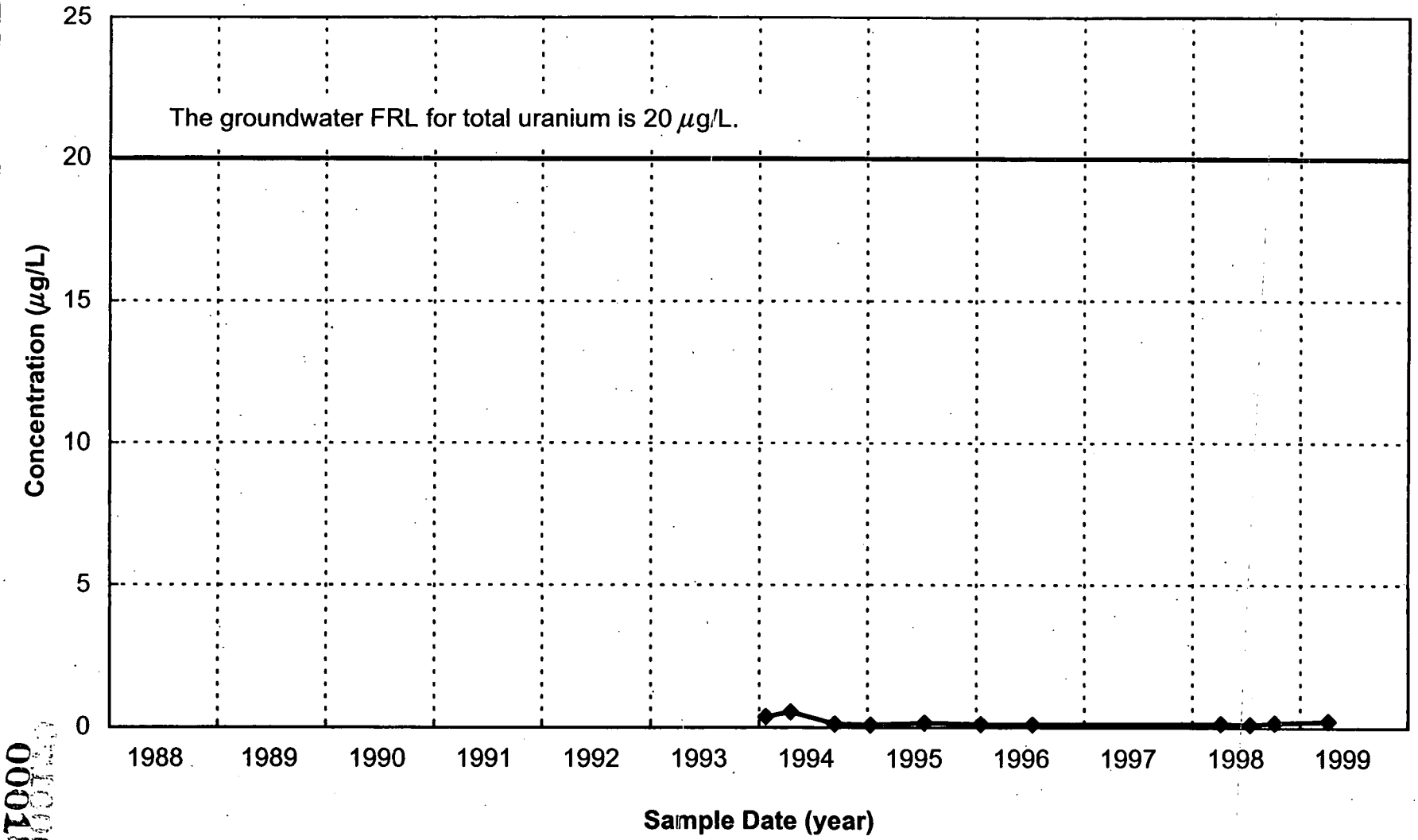



FIGURE A.2-106. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3424

000180

30 04

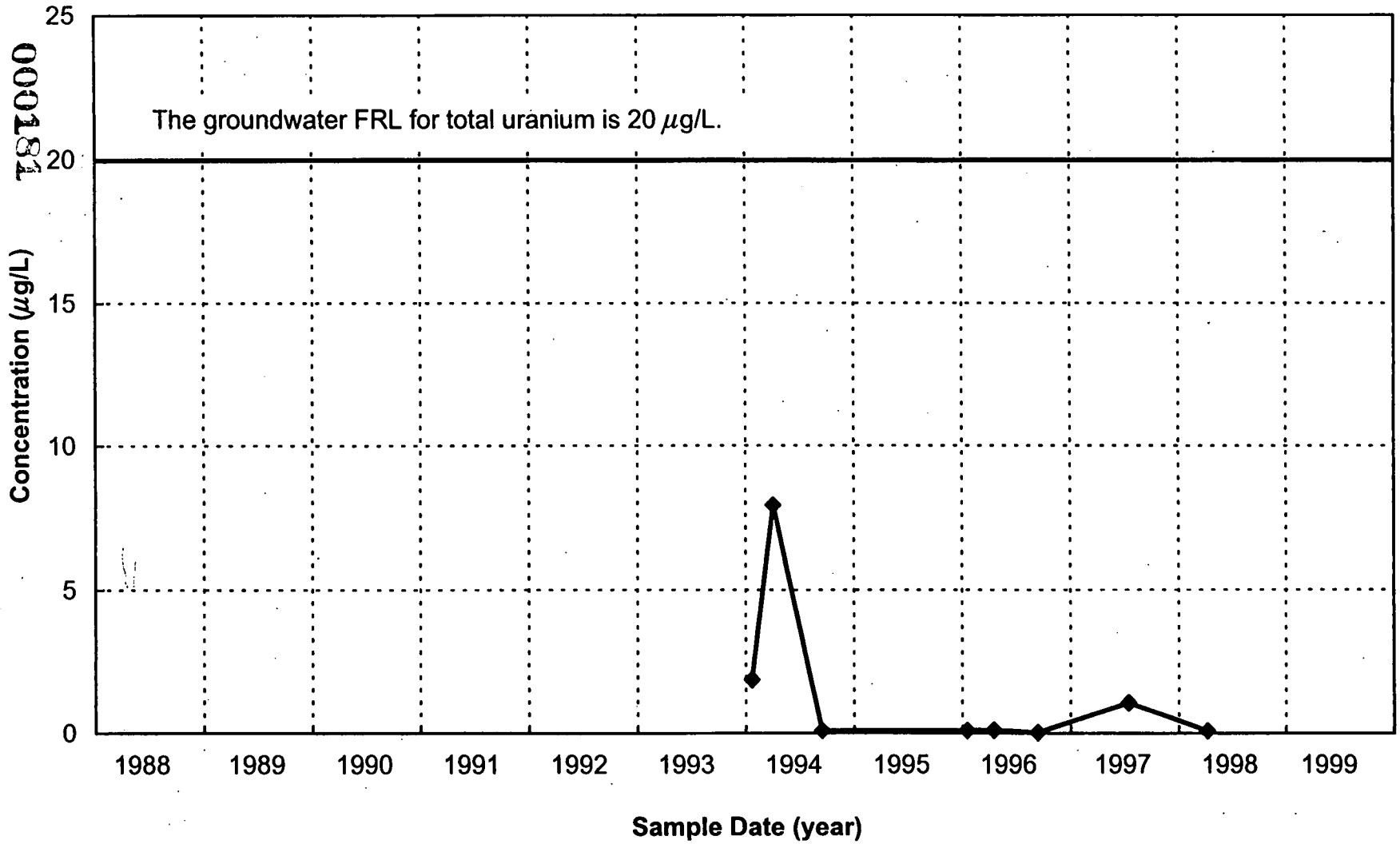



FIGURE A.2-107. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3426

000181

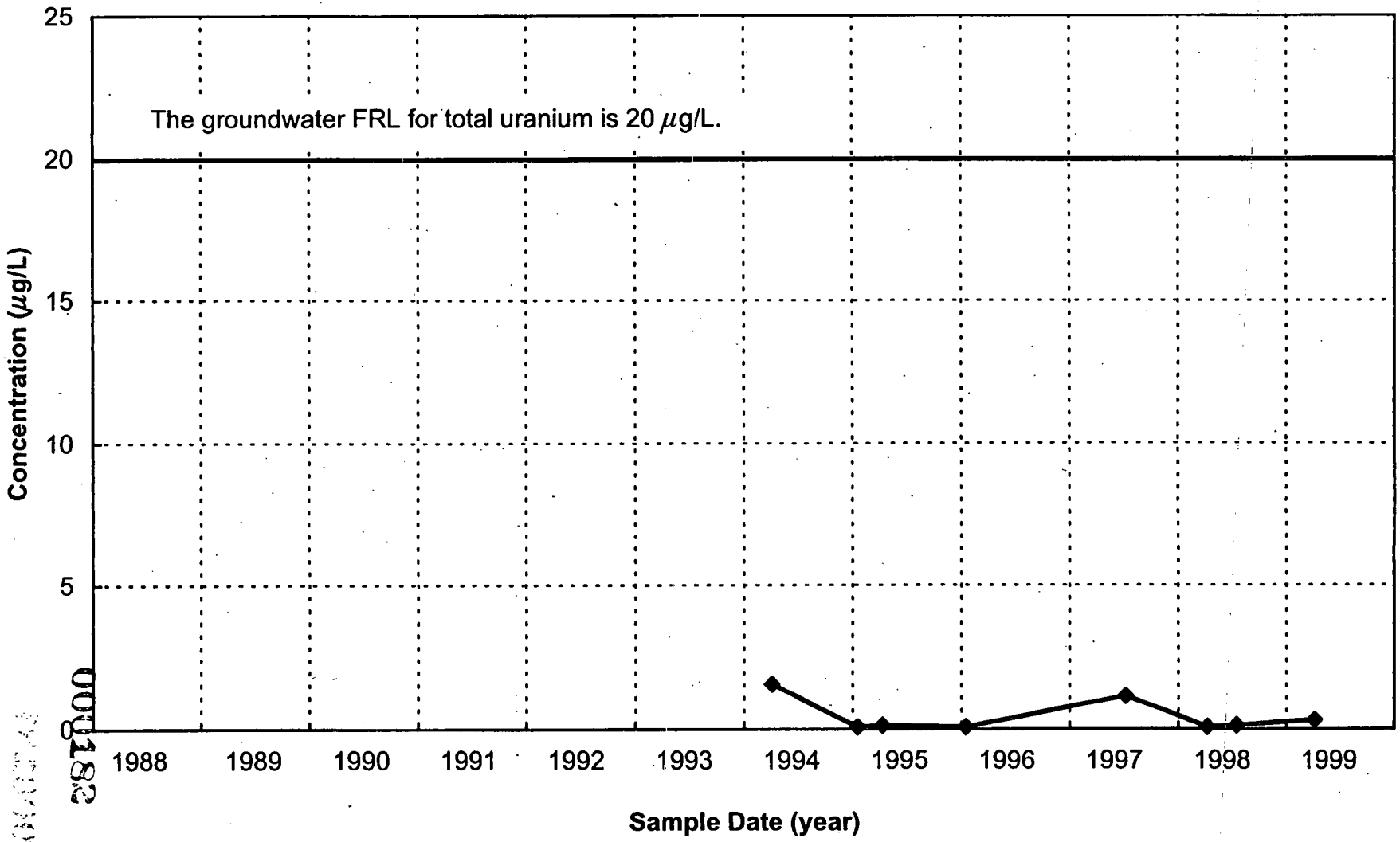



FIGURE A.2-108. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3429

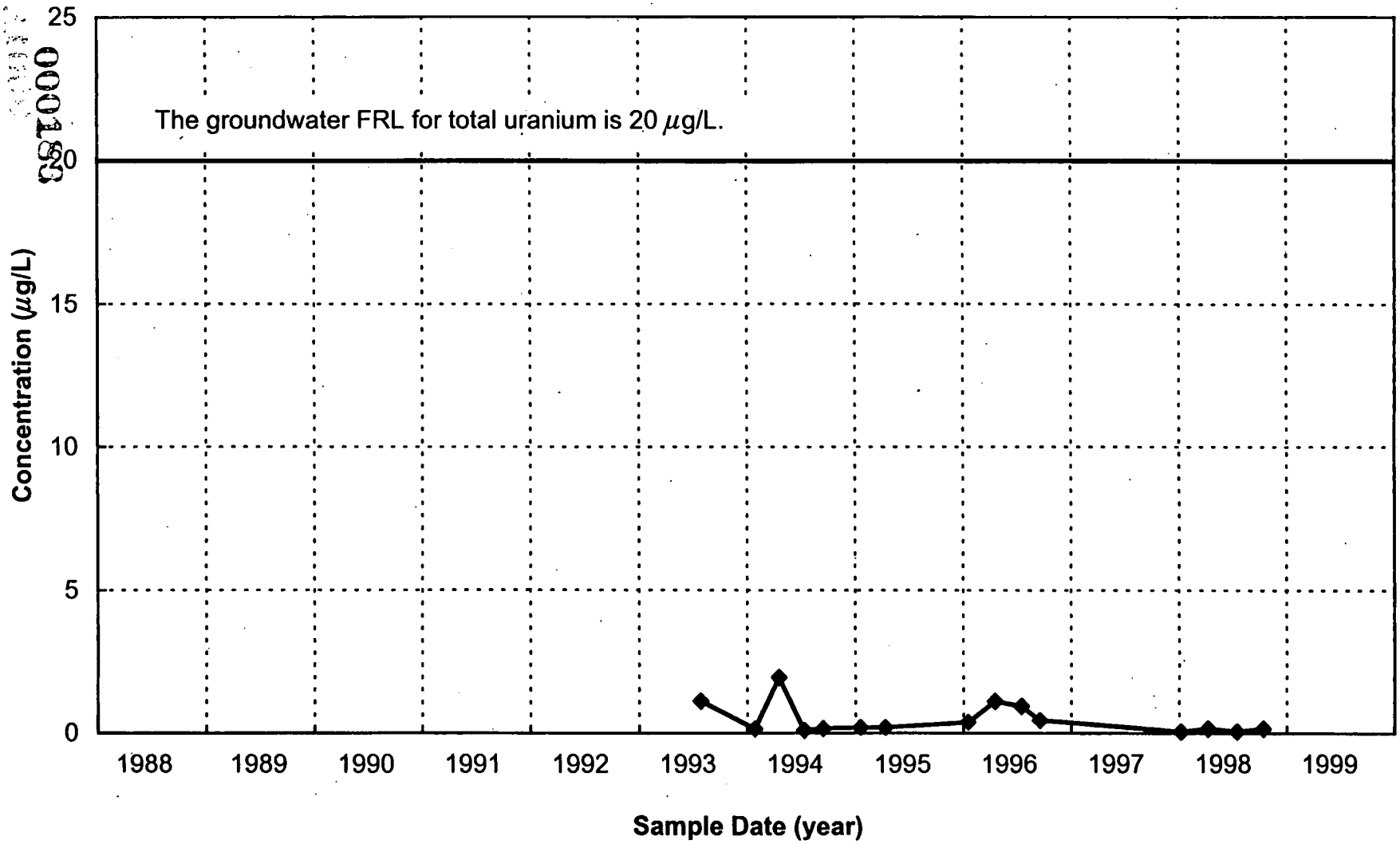



FIGURE A.2-109. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3431

000185

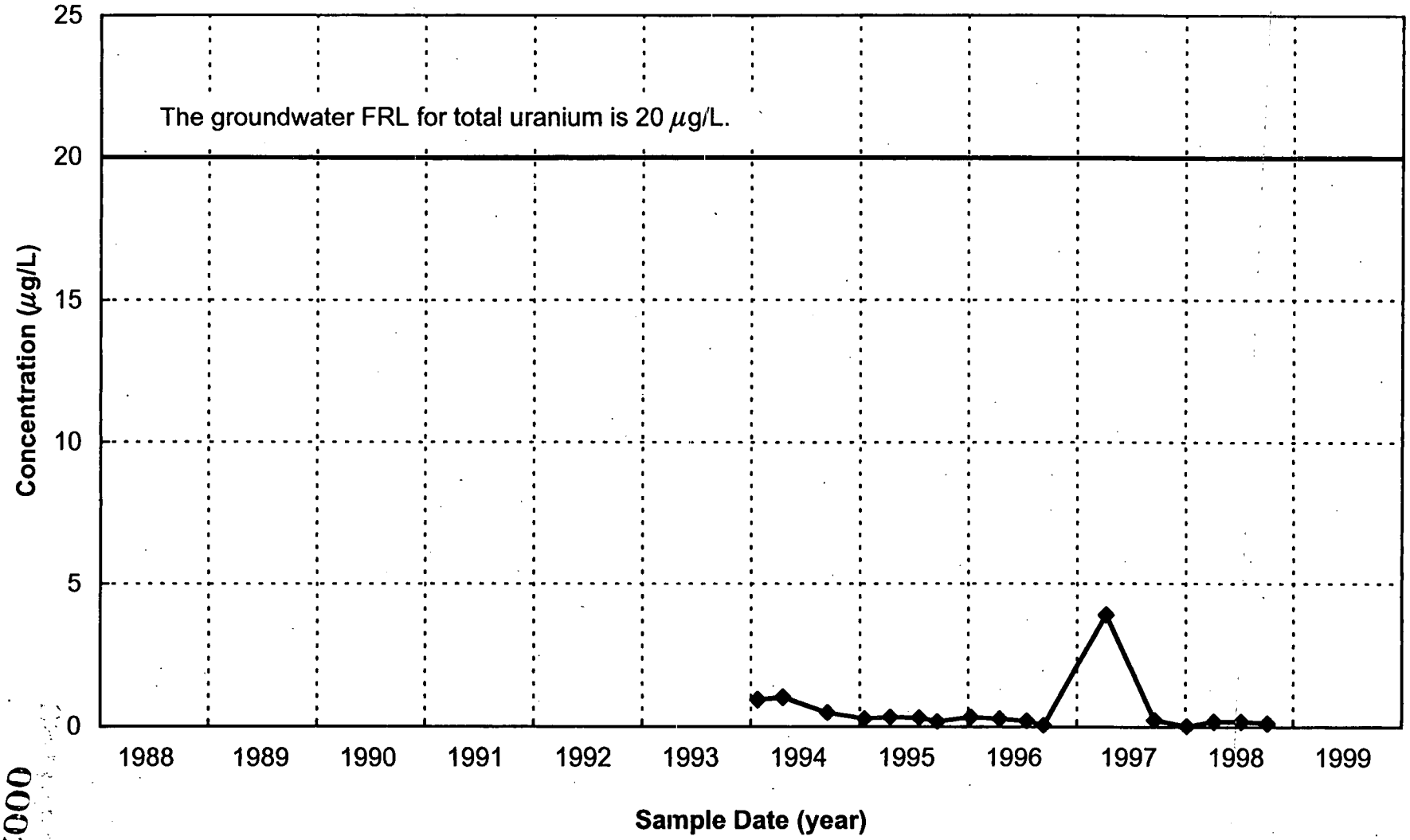



FIGURE A.2-110. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3432

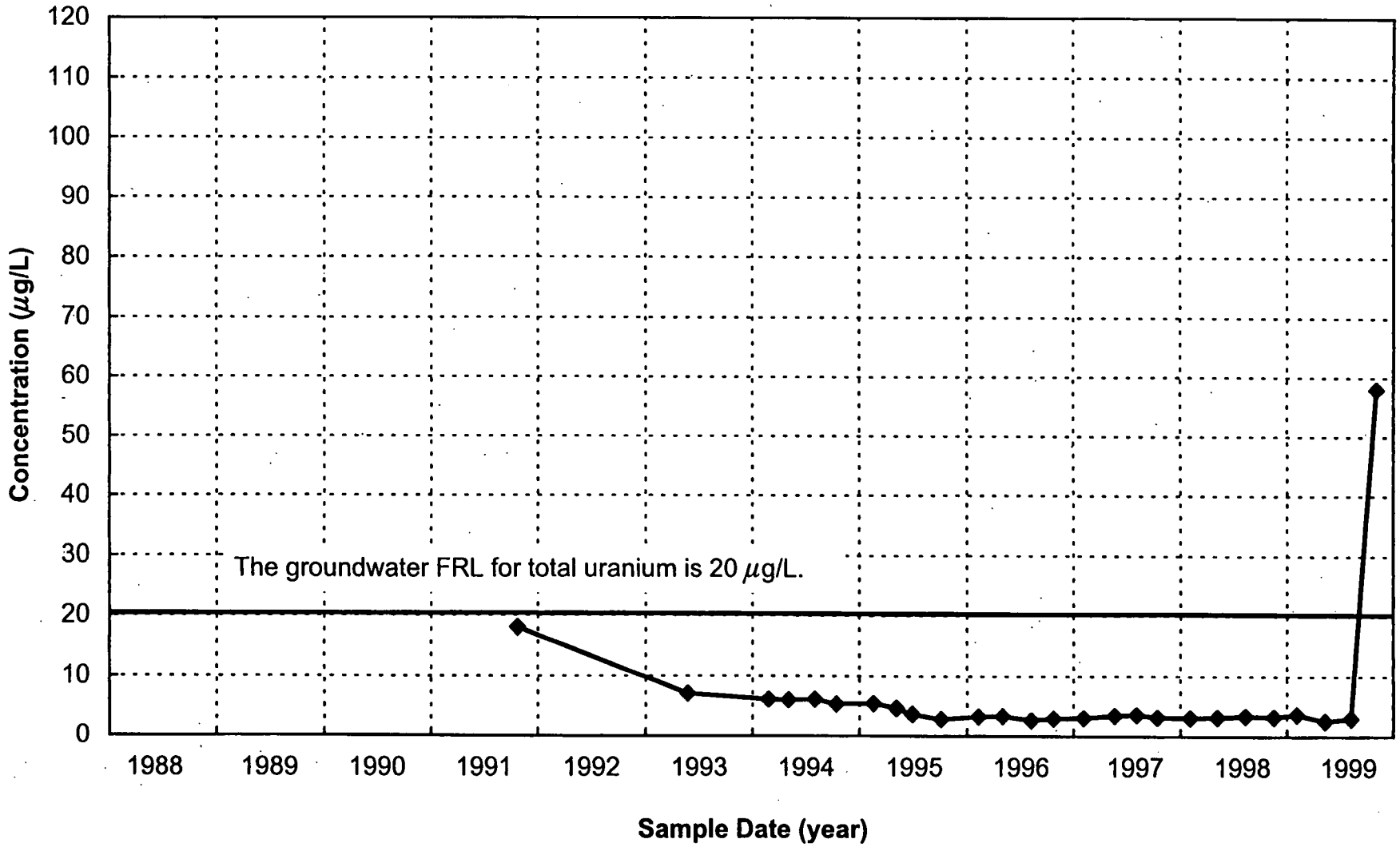



FIGURE A.2-111. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3550

001185

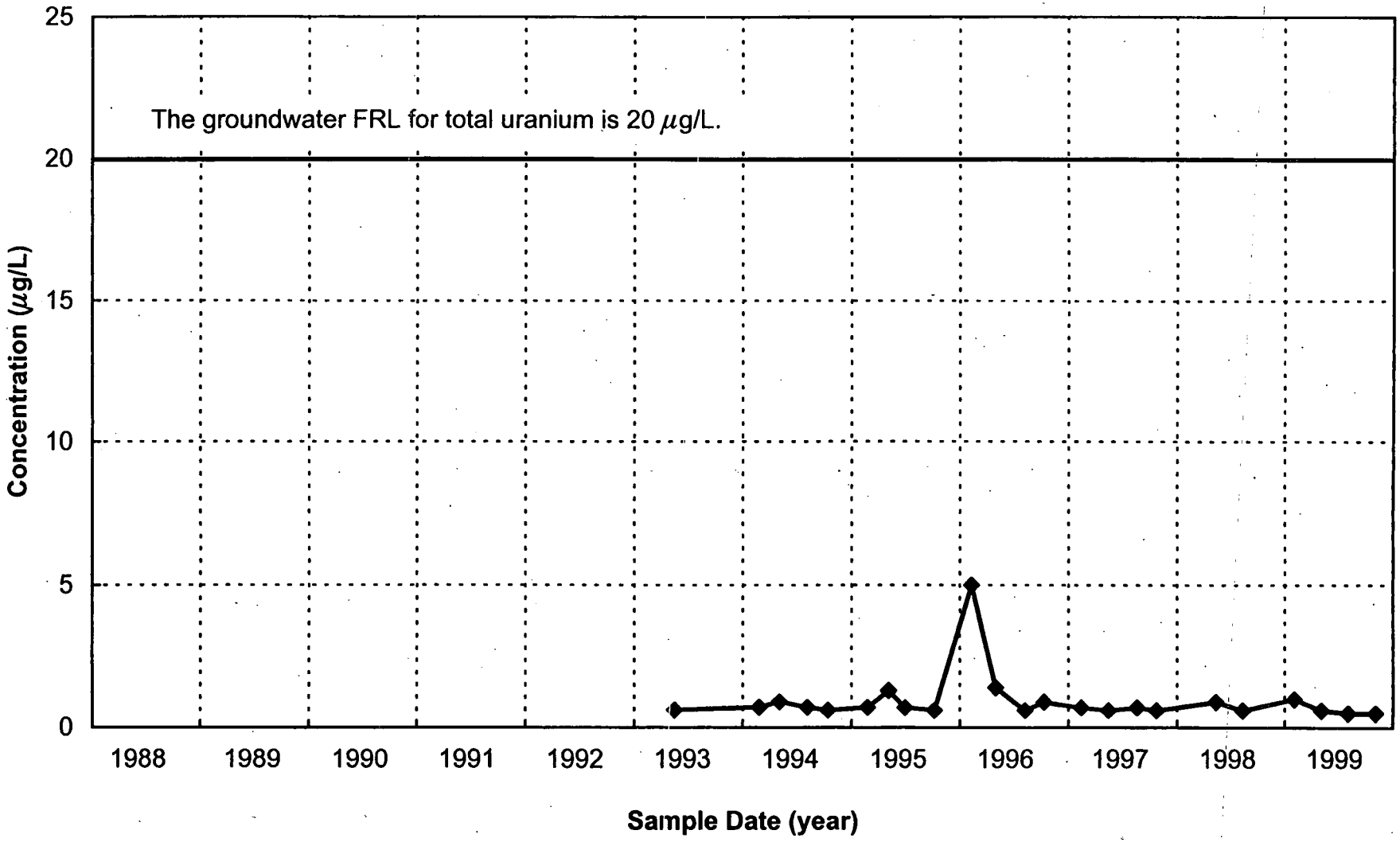



FIGURE A.2-112. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3551



000186

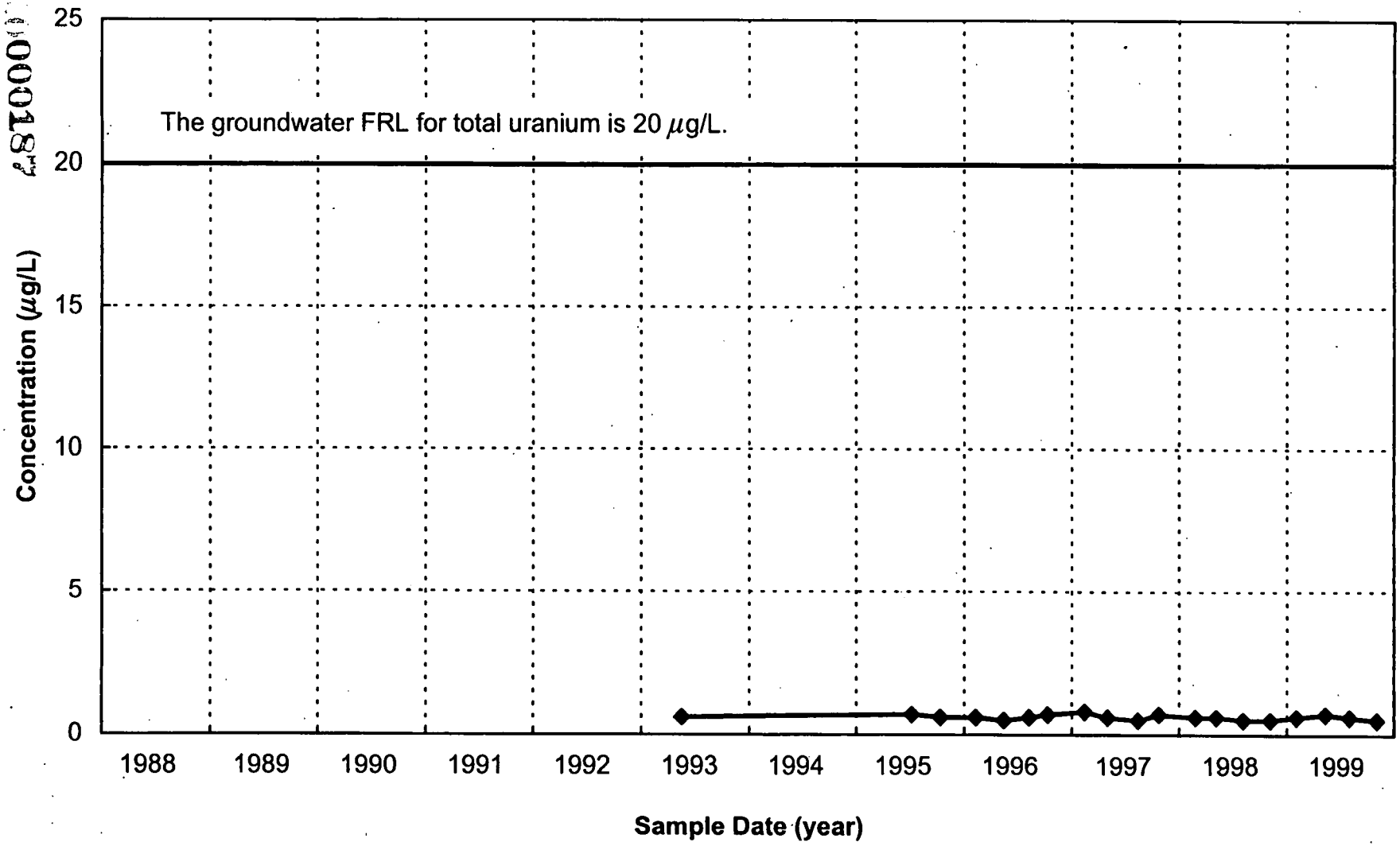



FIGURE A.2-113. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3552

000018?

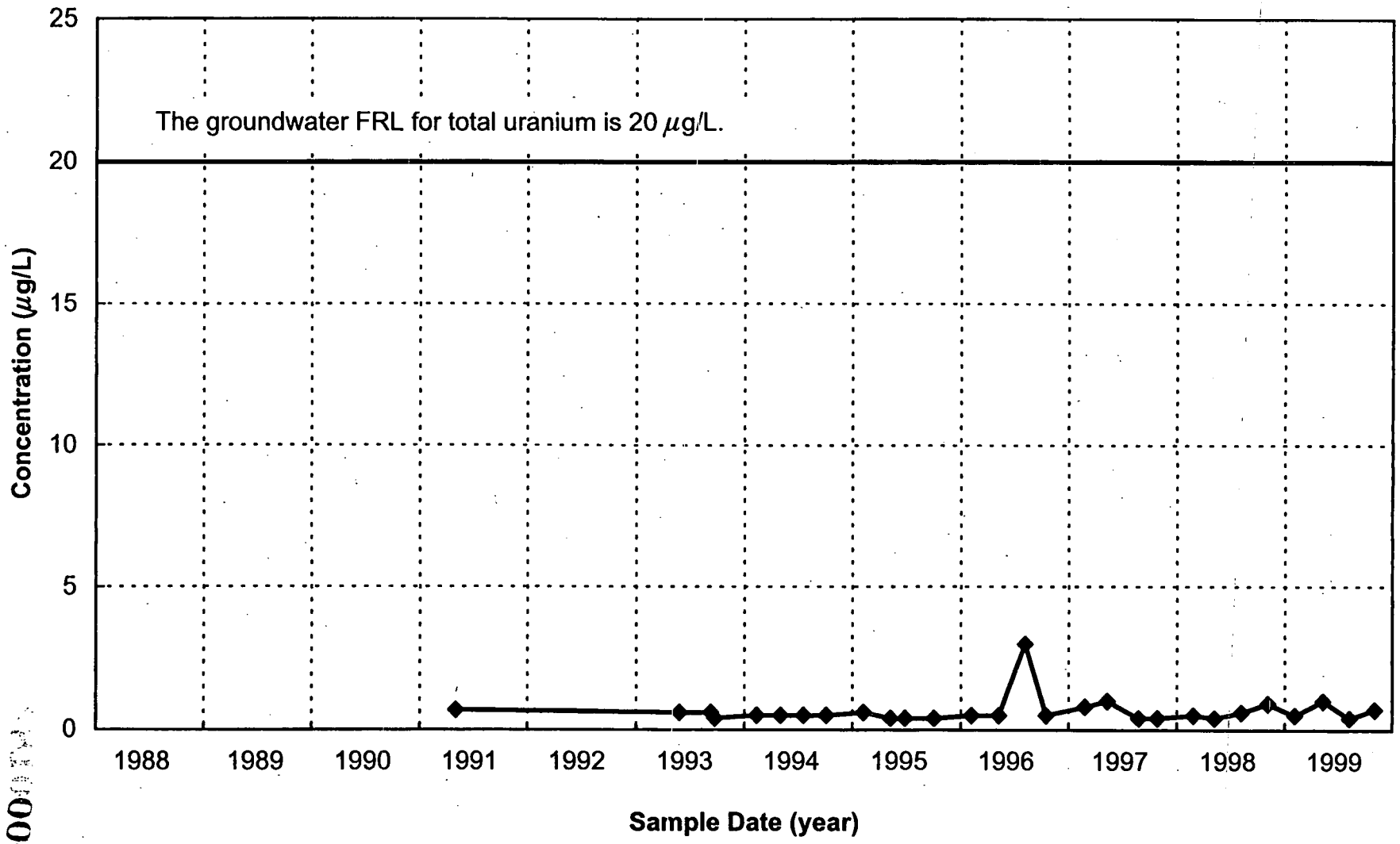



FIGURE A.2-114. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3636

0001188

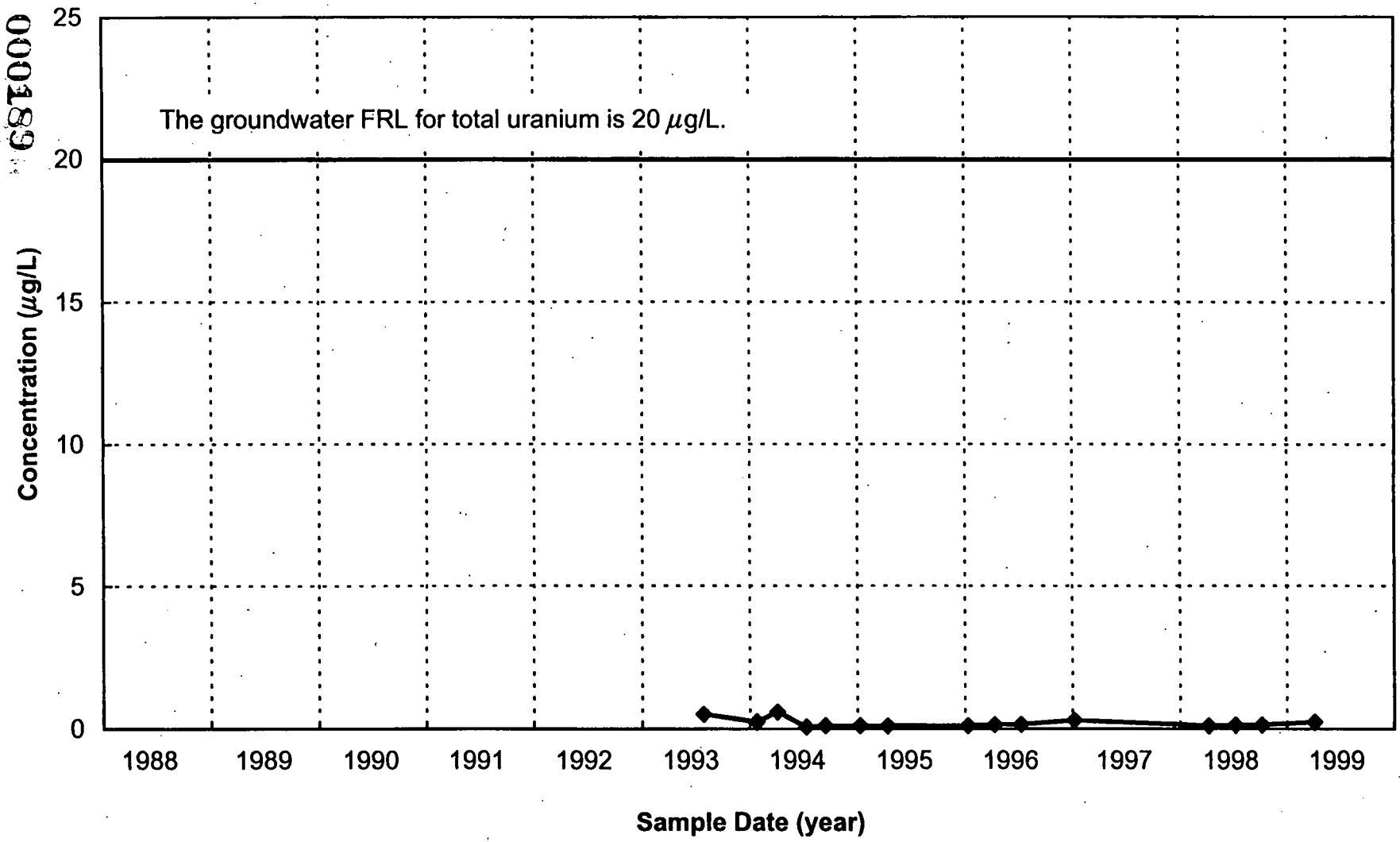



FIGURE A.2-115. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3733

000189

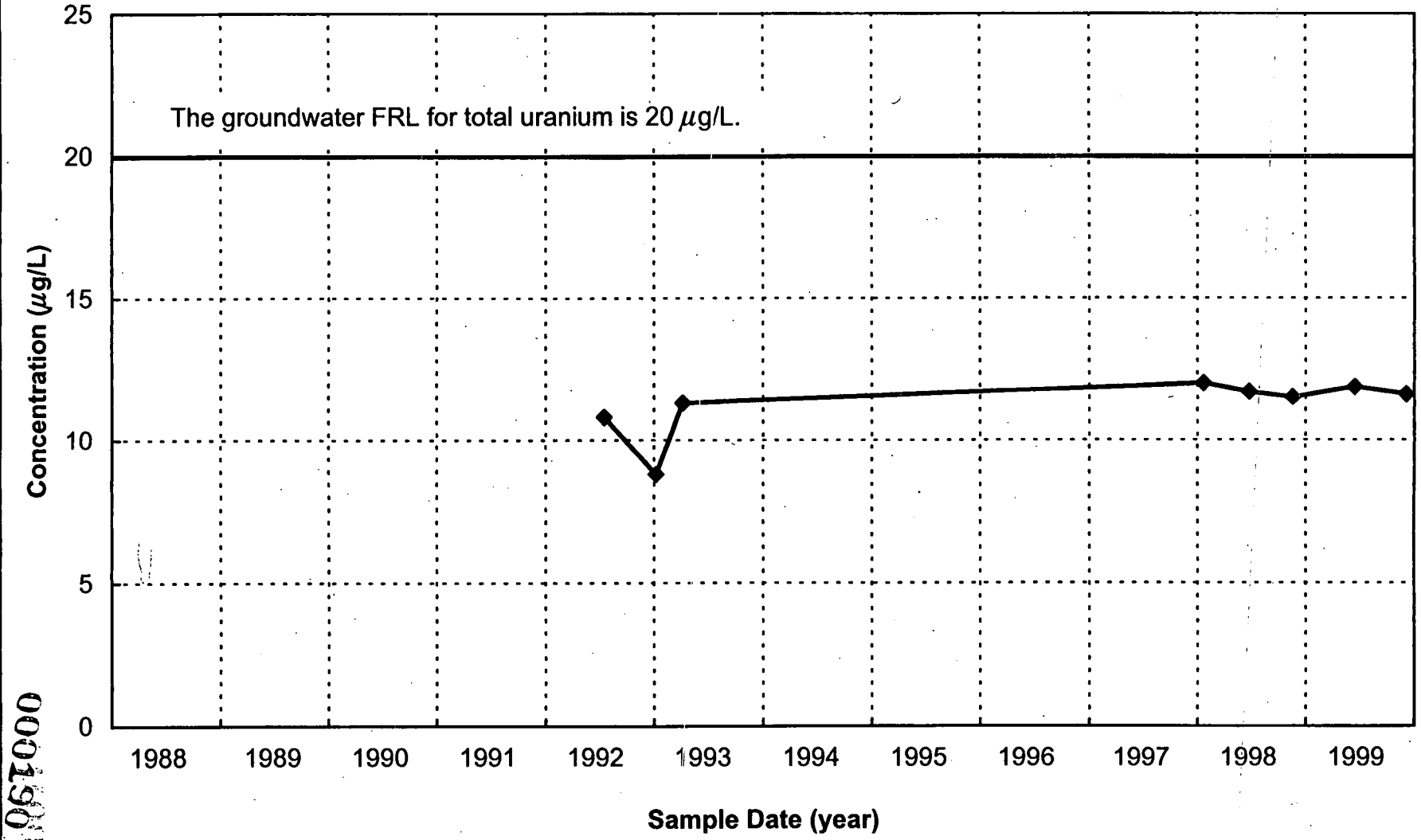



FIGURE A.2-116. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3821

000190

- 3004

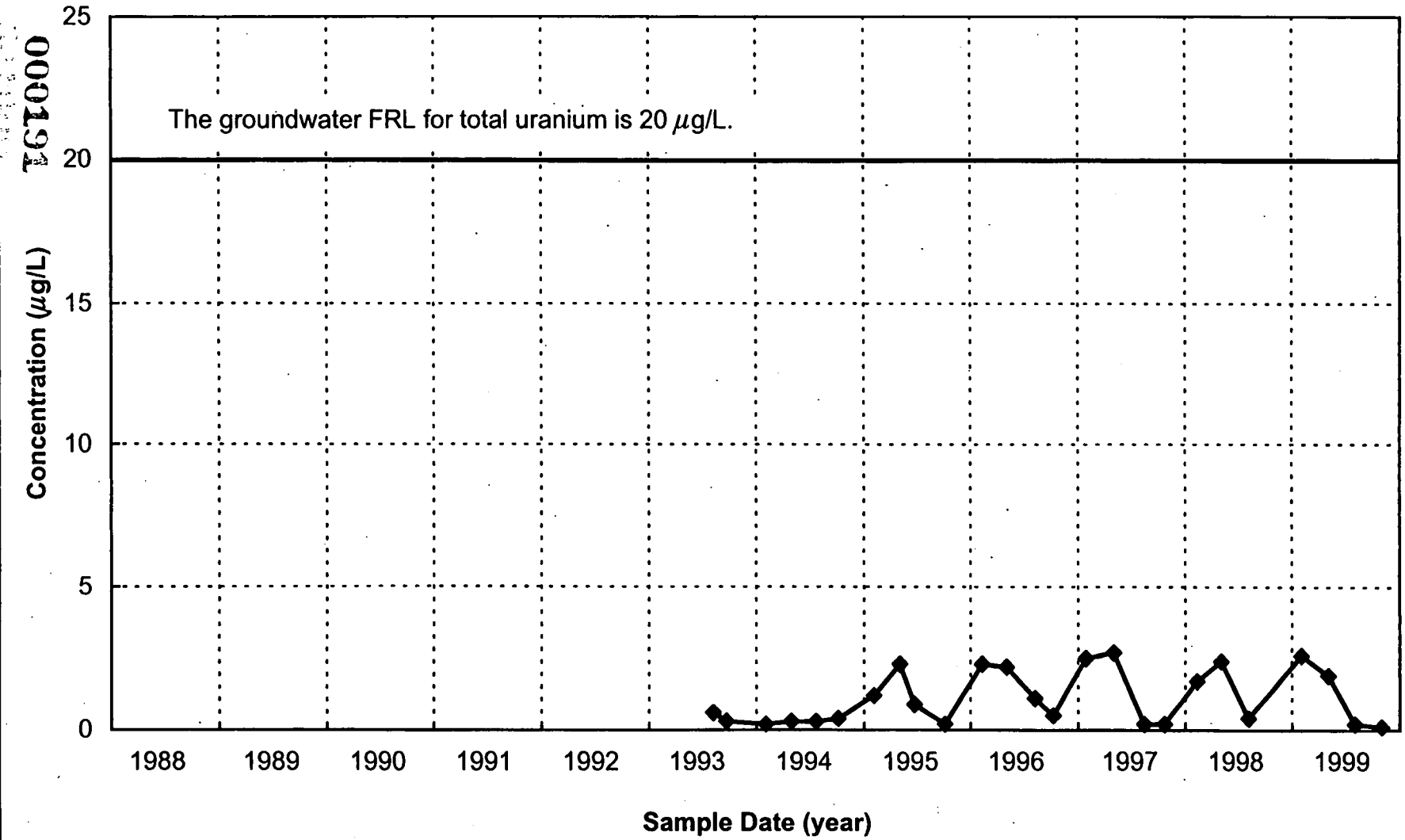



FIGURE A.2-117. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3880

000191

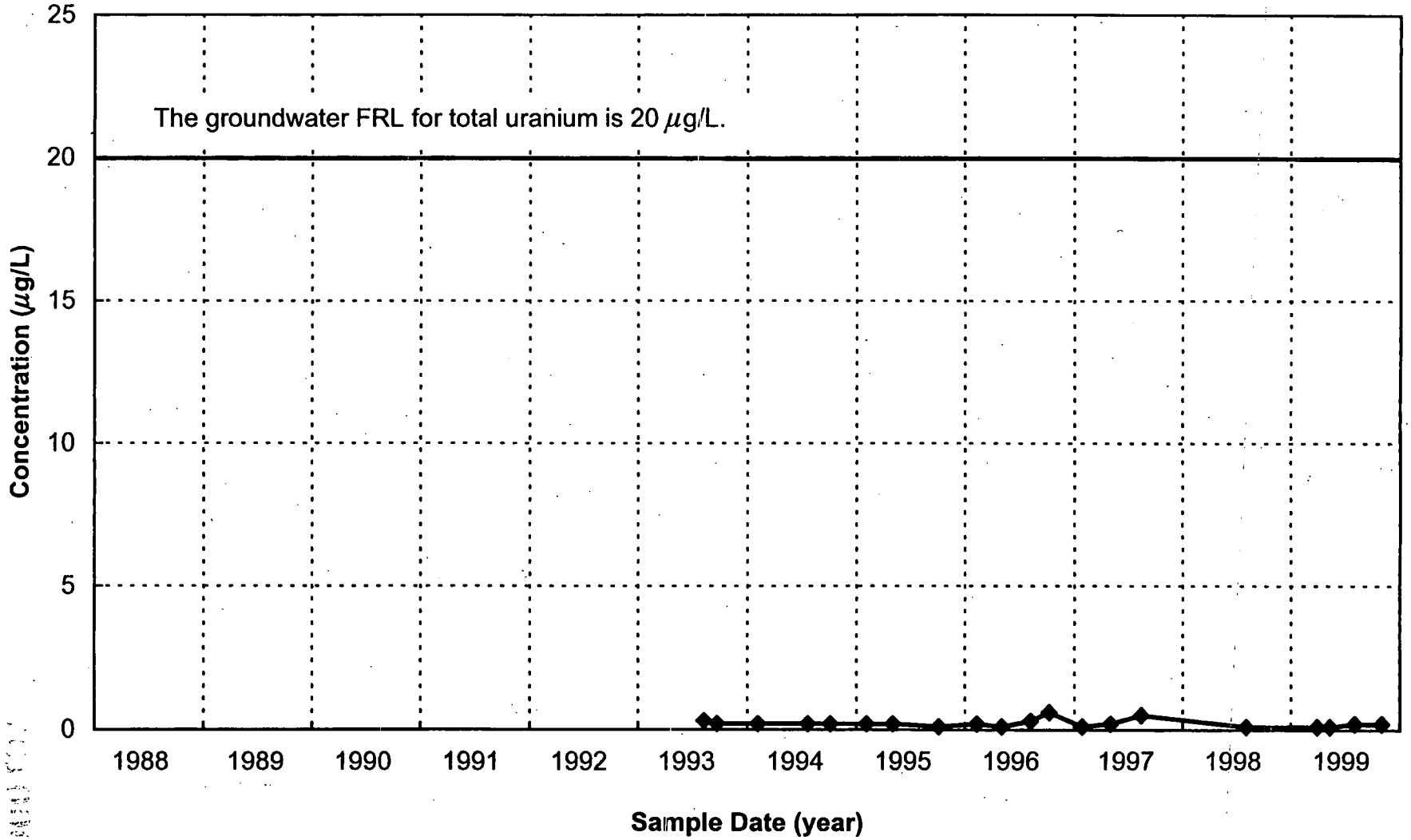



FIGURE A.2-118. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3881

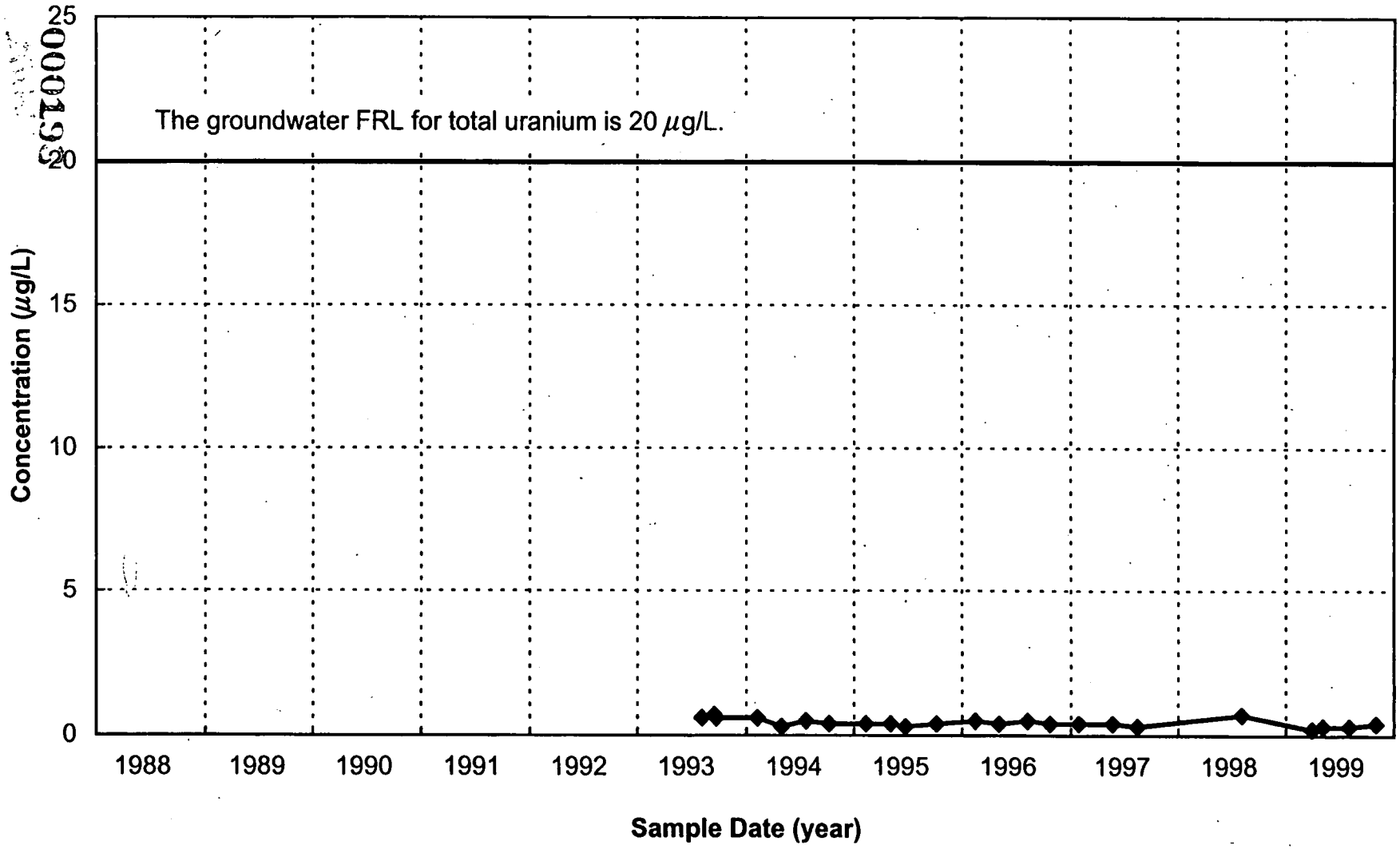



FIGURE A.2-119. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3897

000019

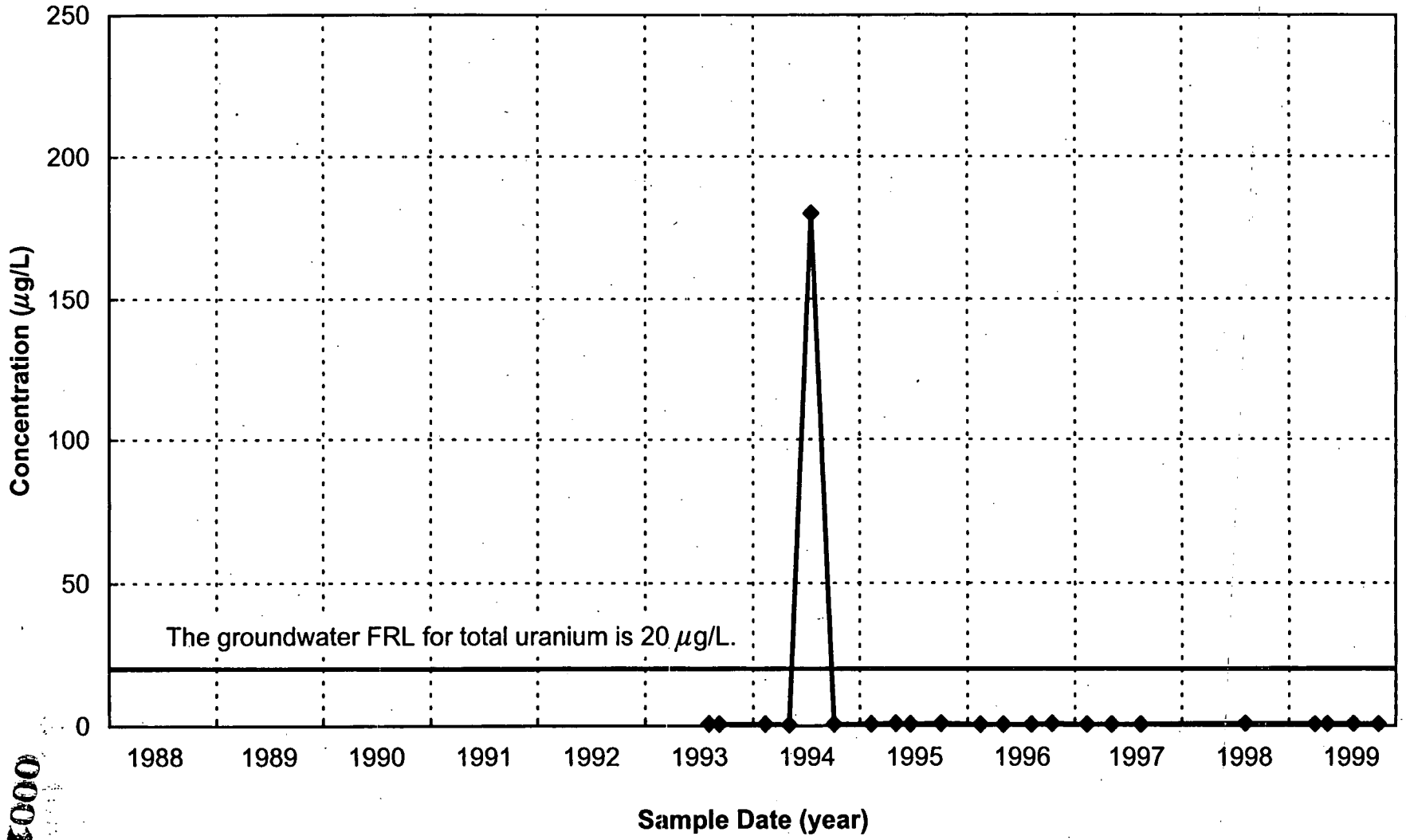



FIGURE A.2-120. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3898

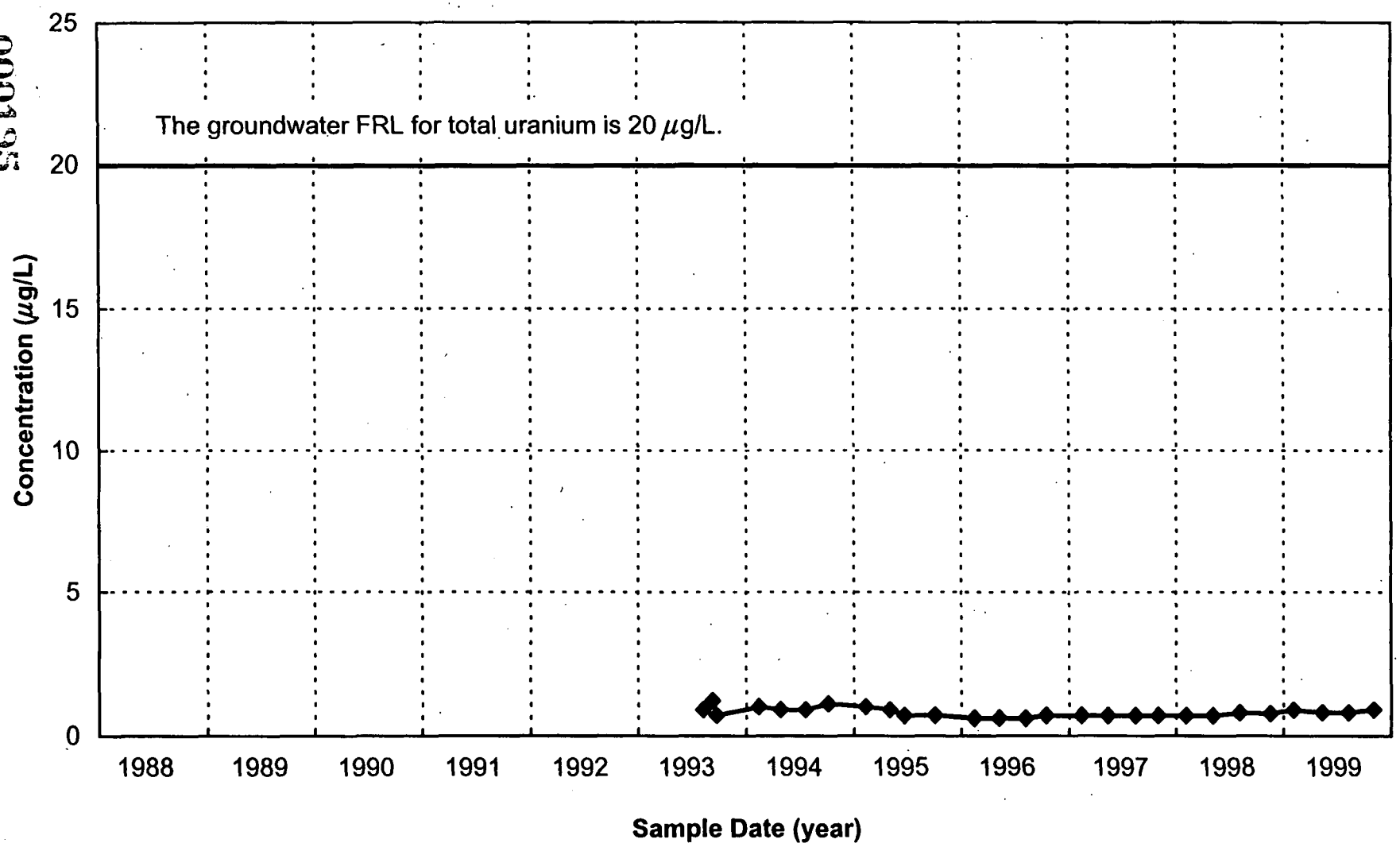



FIGURE A.2-121. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3899

000139

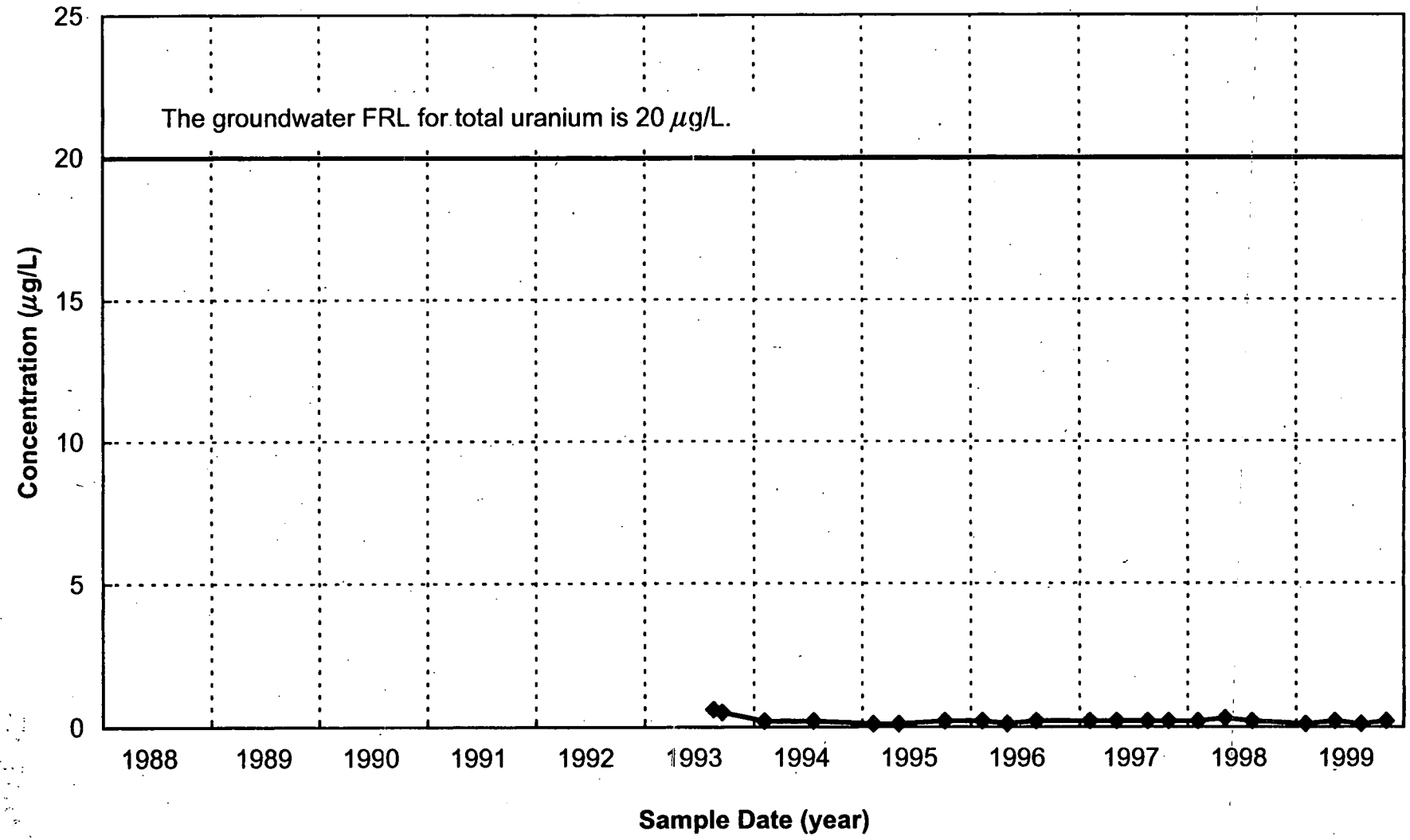



FIGURE A.2-122. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3900

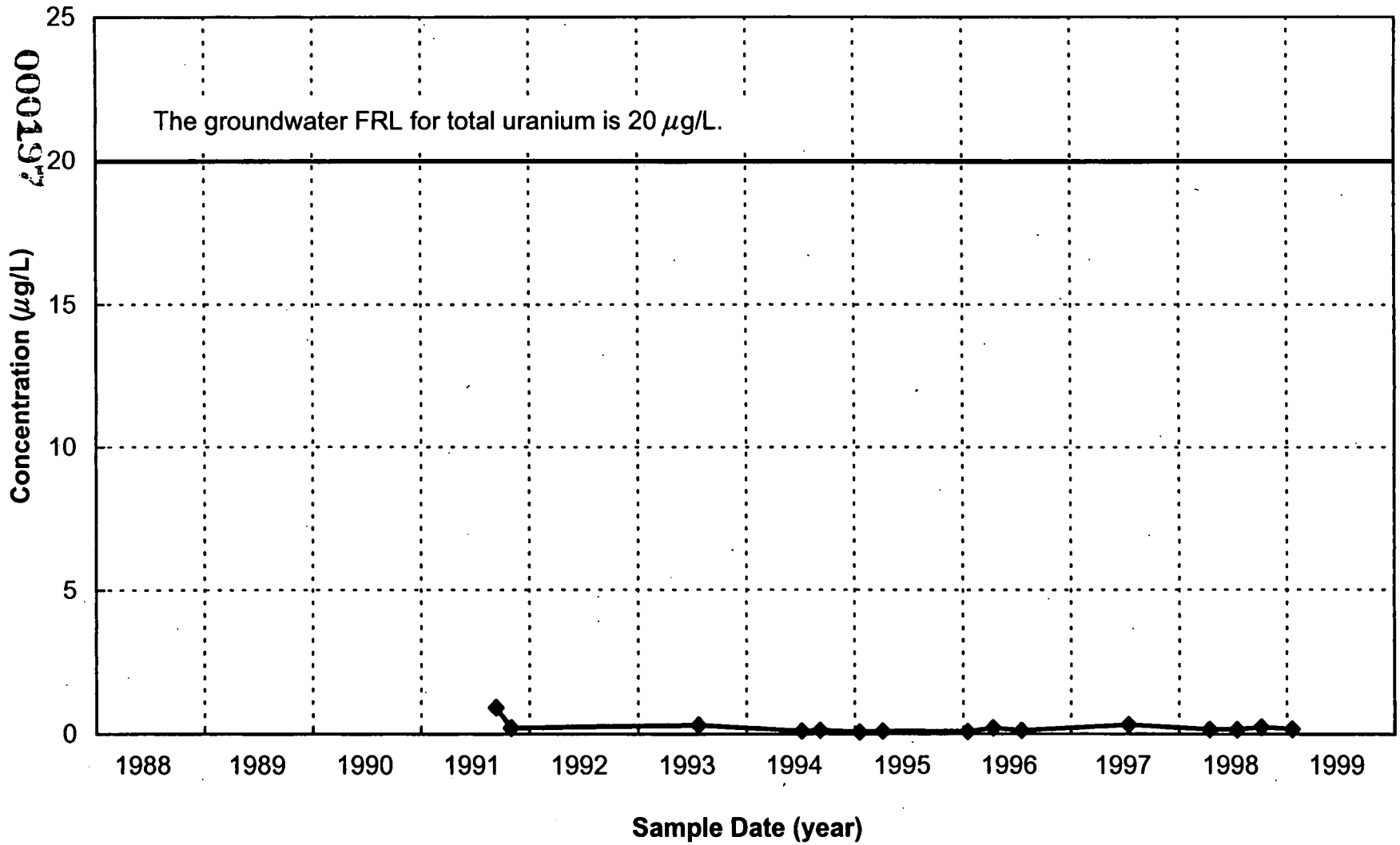



FIGURE A.2-123. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 4067

000197

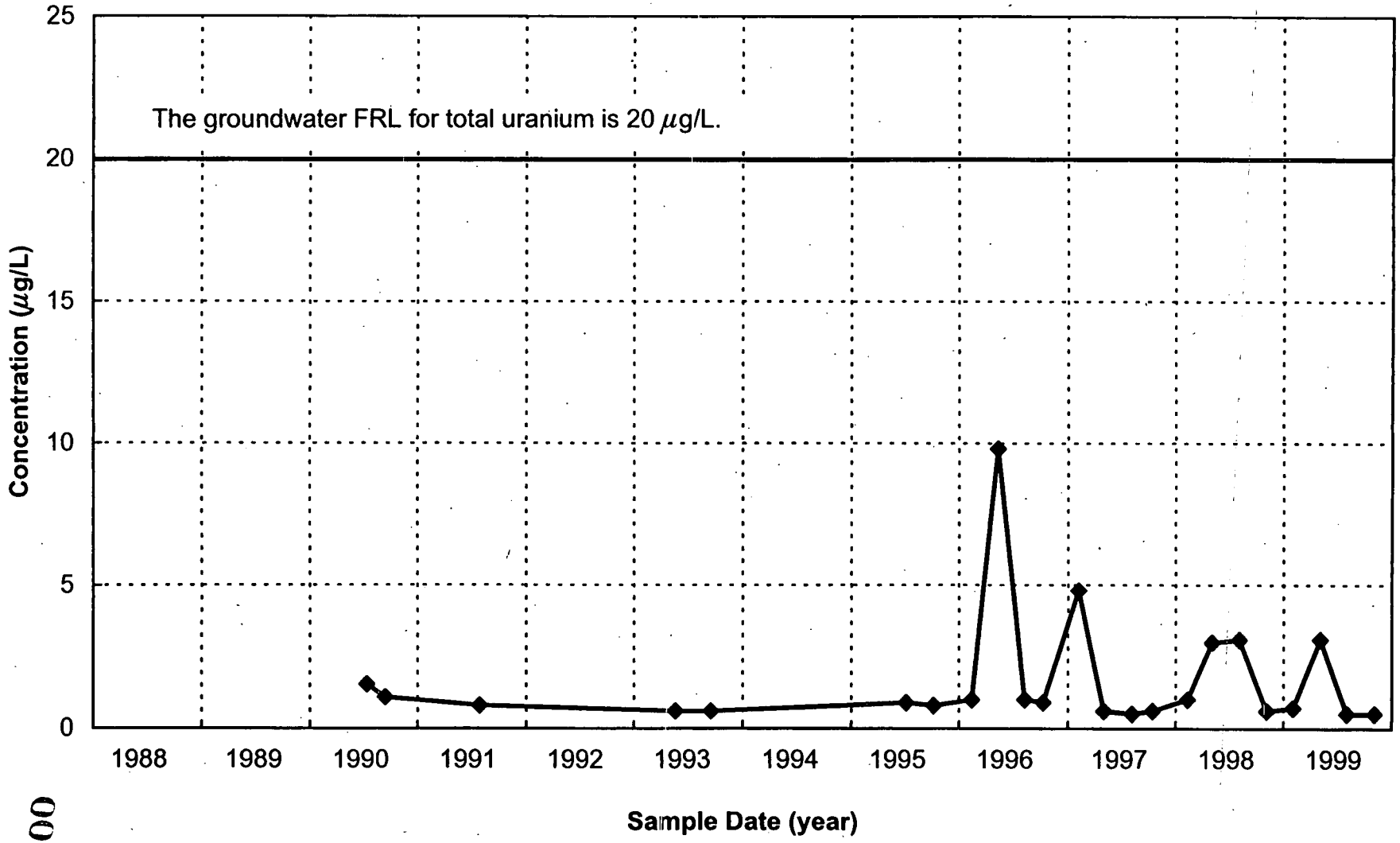



FIGURE A.2-124. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 4125

000199

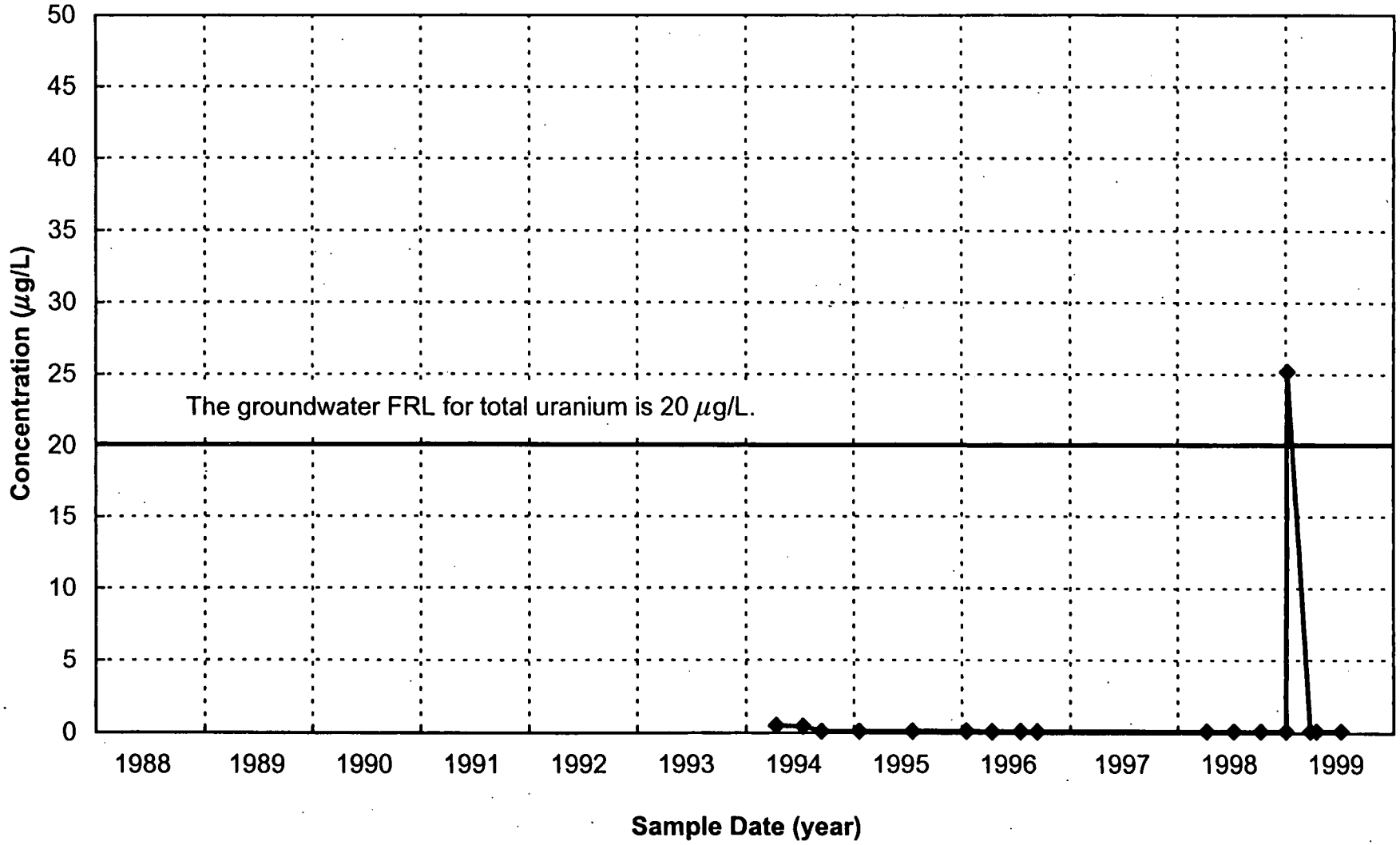



FIGURE A.2-125. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 4398

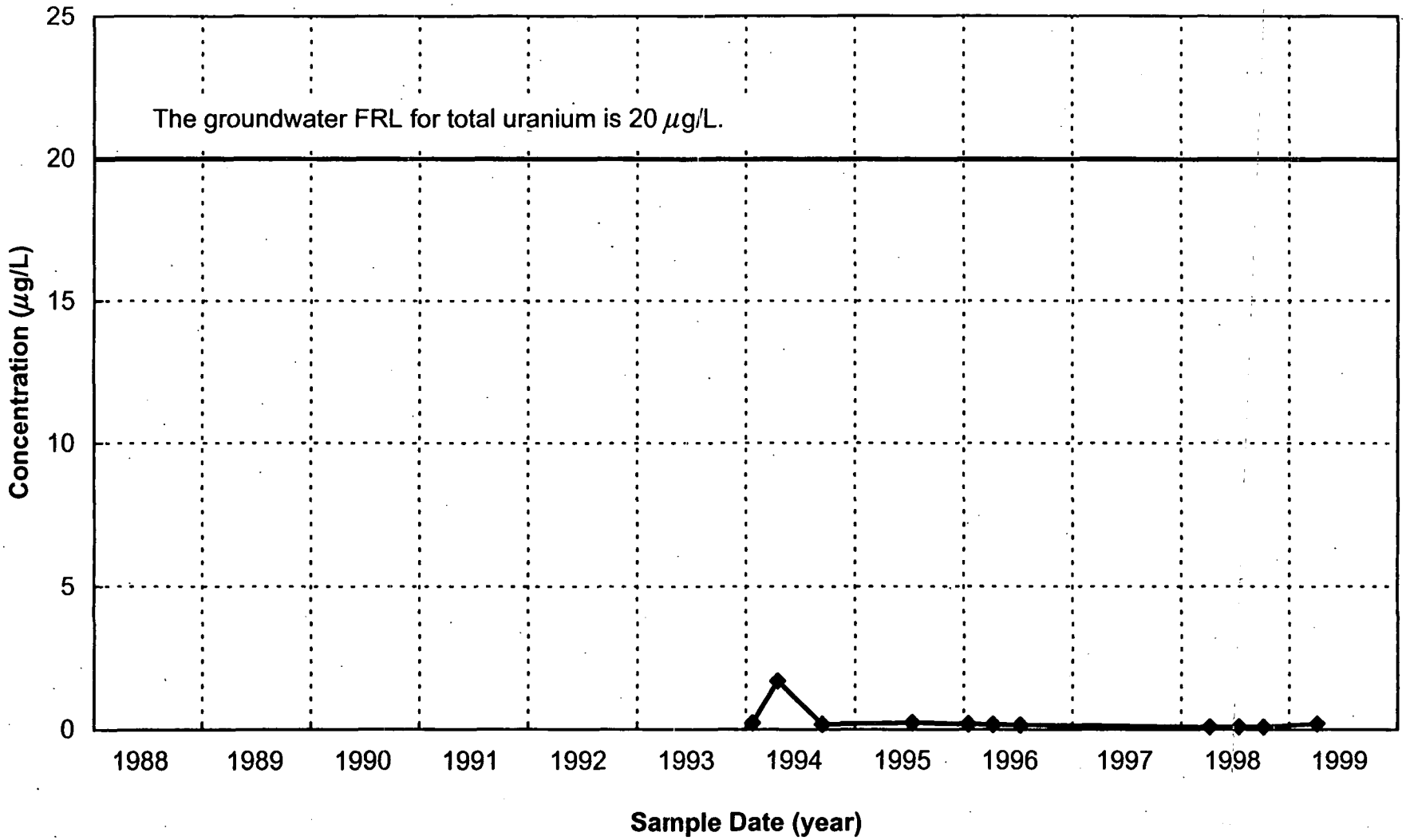



FIGURE A.2-126. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 4424

000201

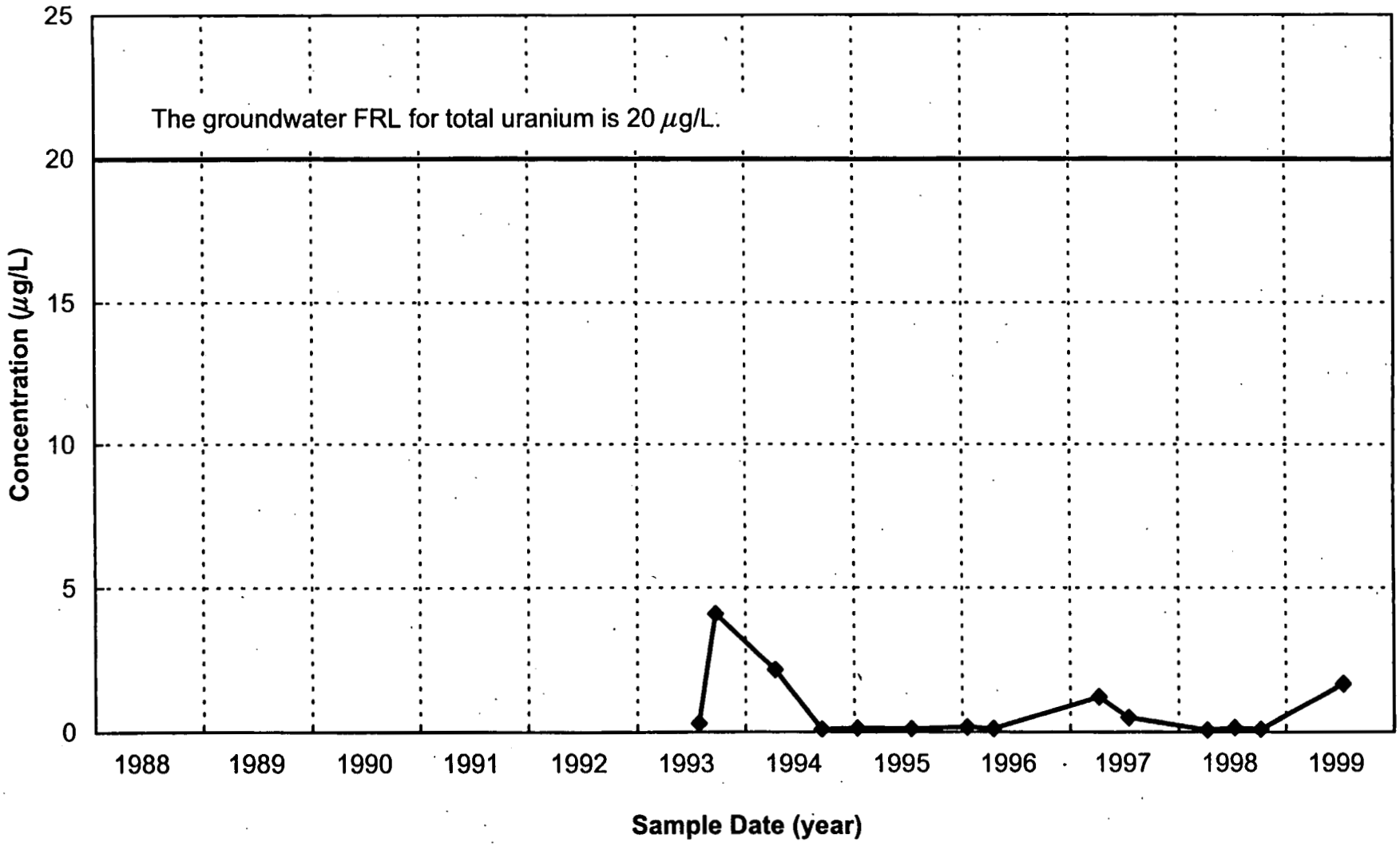



FIGURE A.2-127. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 4426

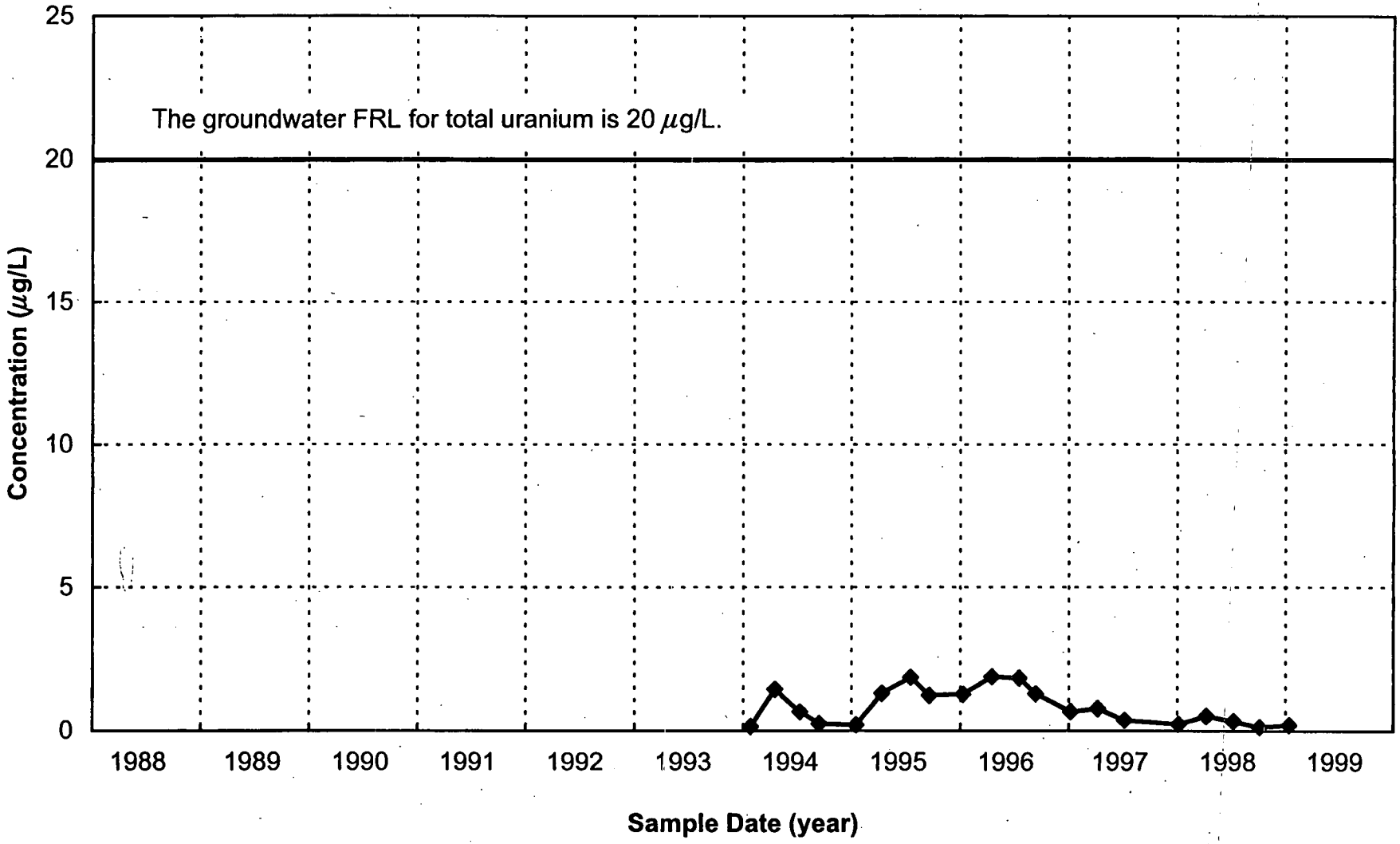



FIGURE A.2-128. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 4432



000202

000203

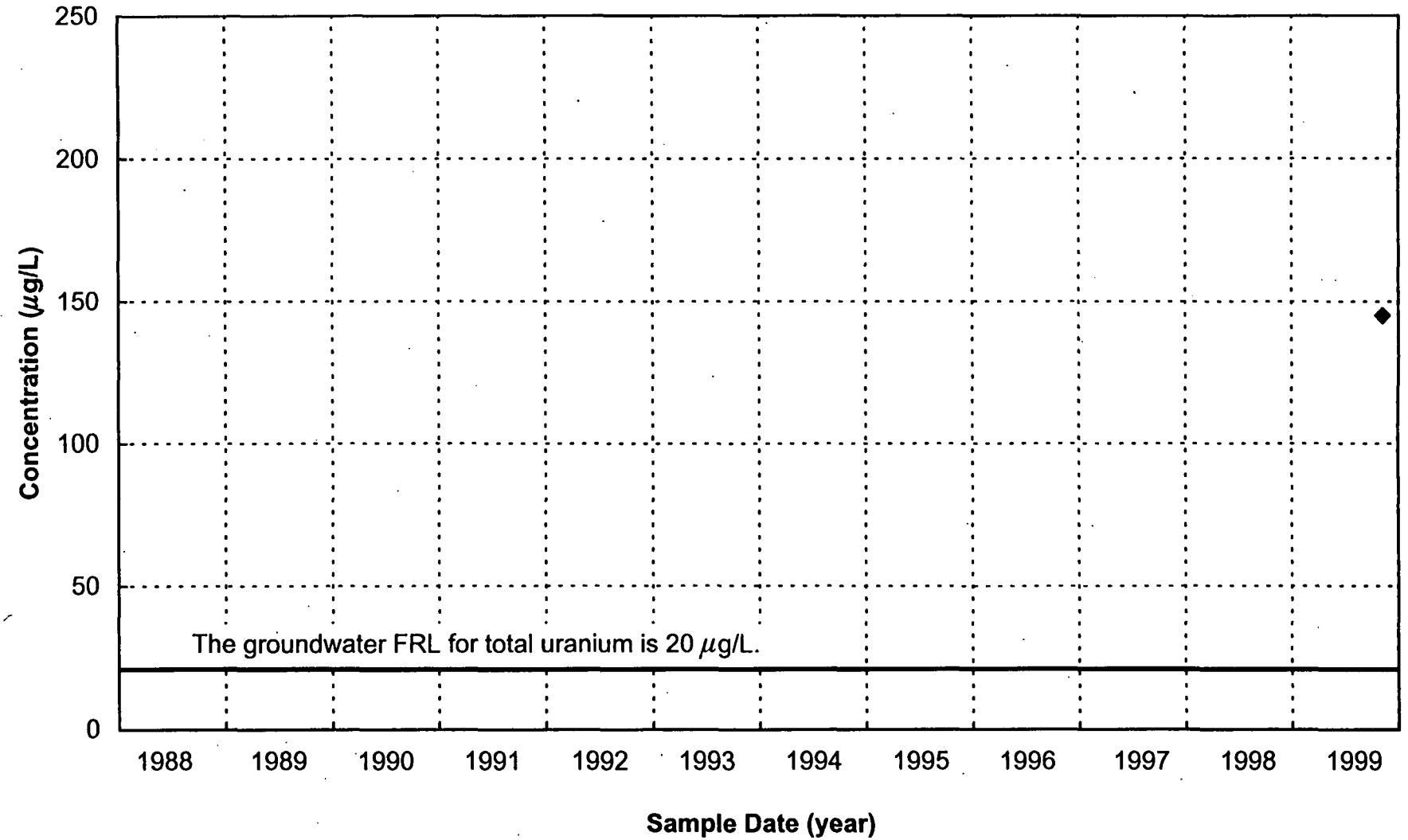



FIGURE A.2-129. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 6880

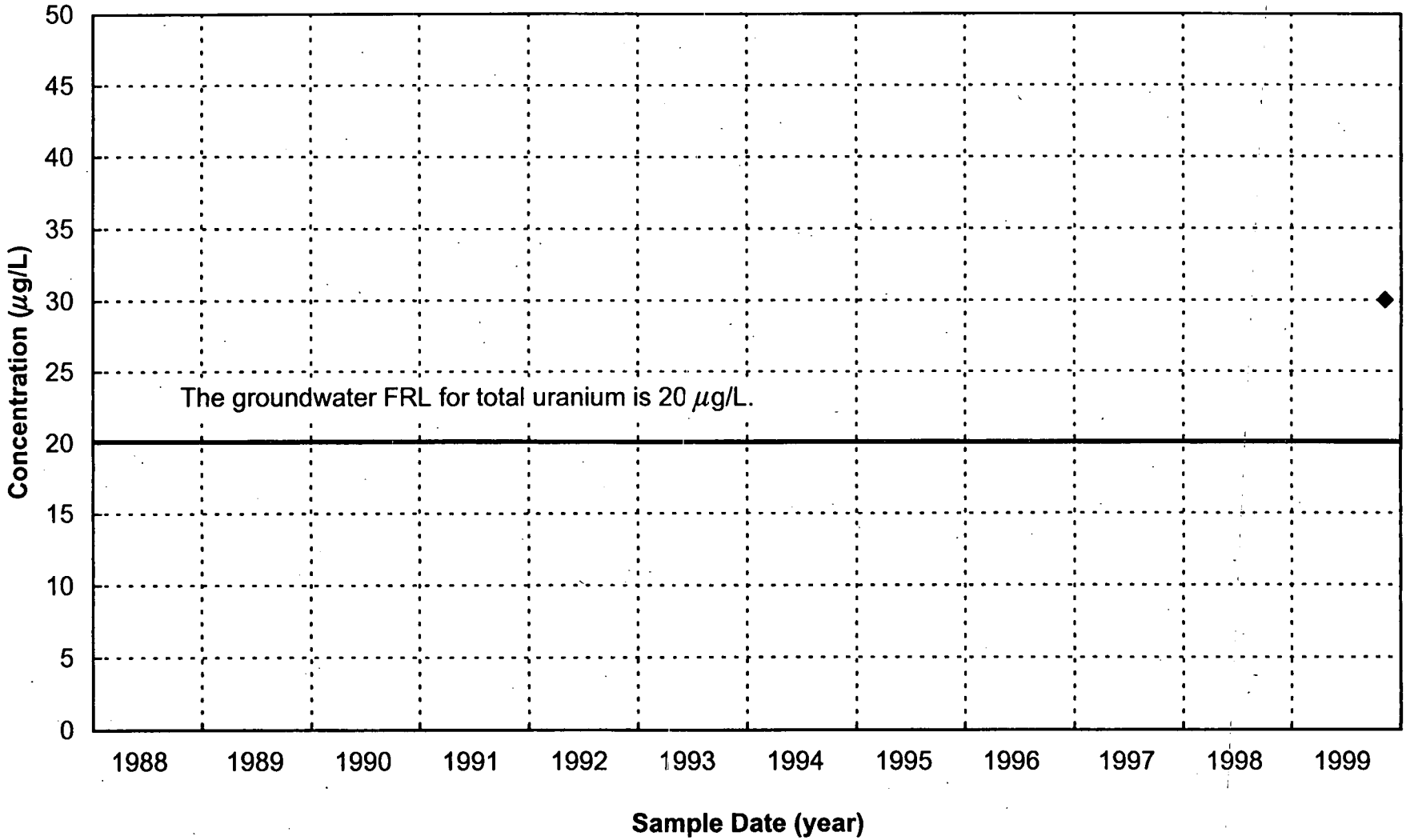



FIGURE A.2-130. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 6881



000204

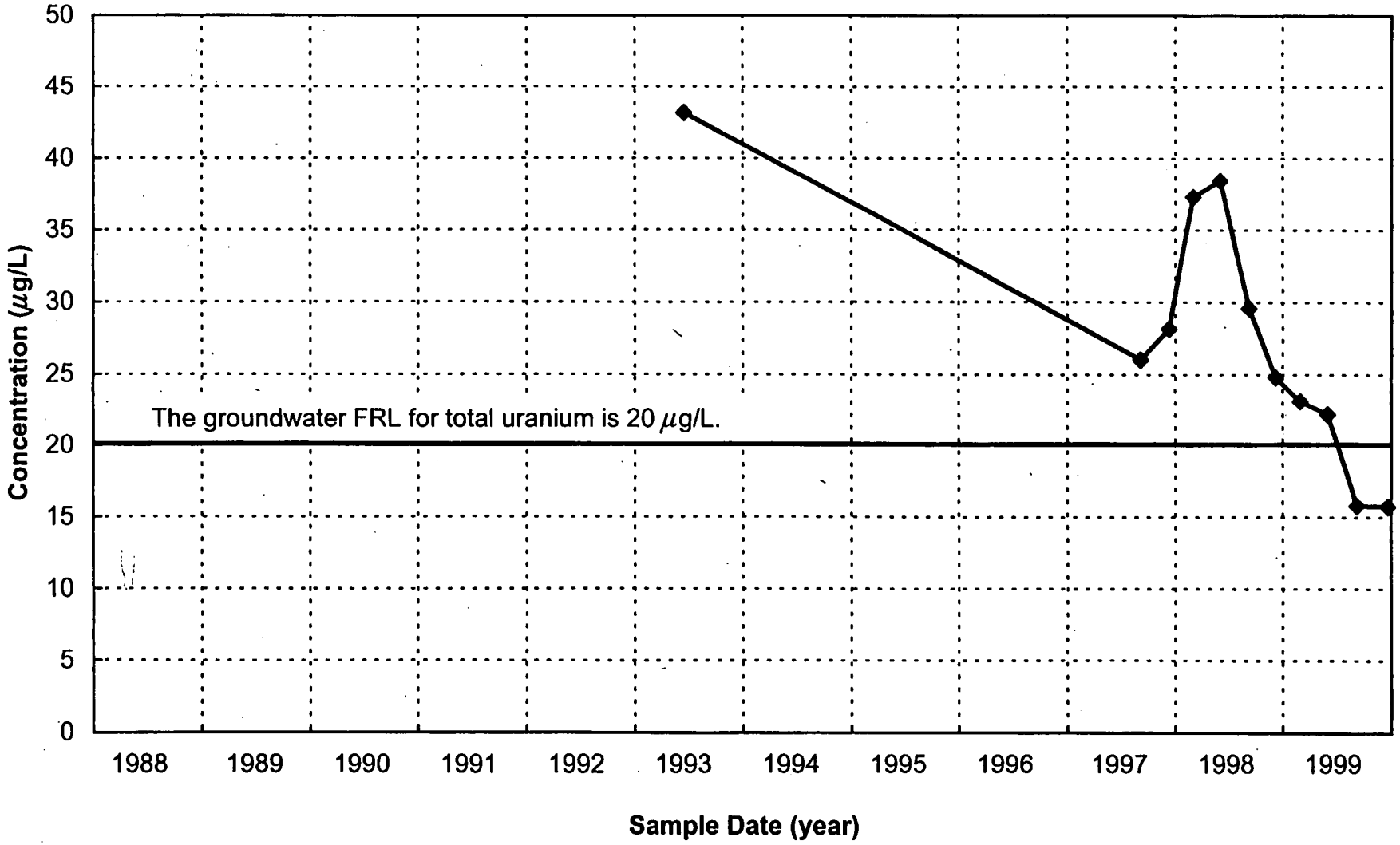



FIGURE A.2-131. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 21033

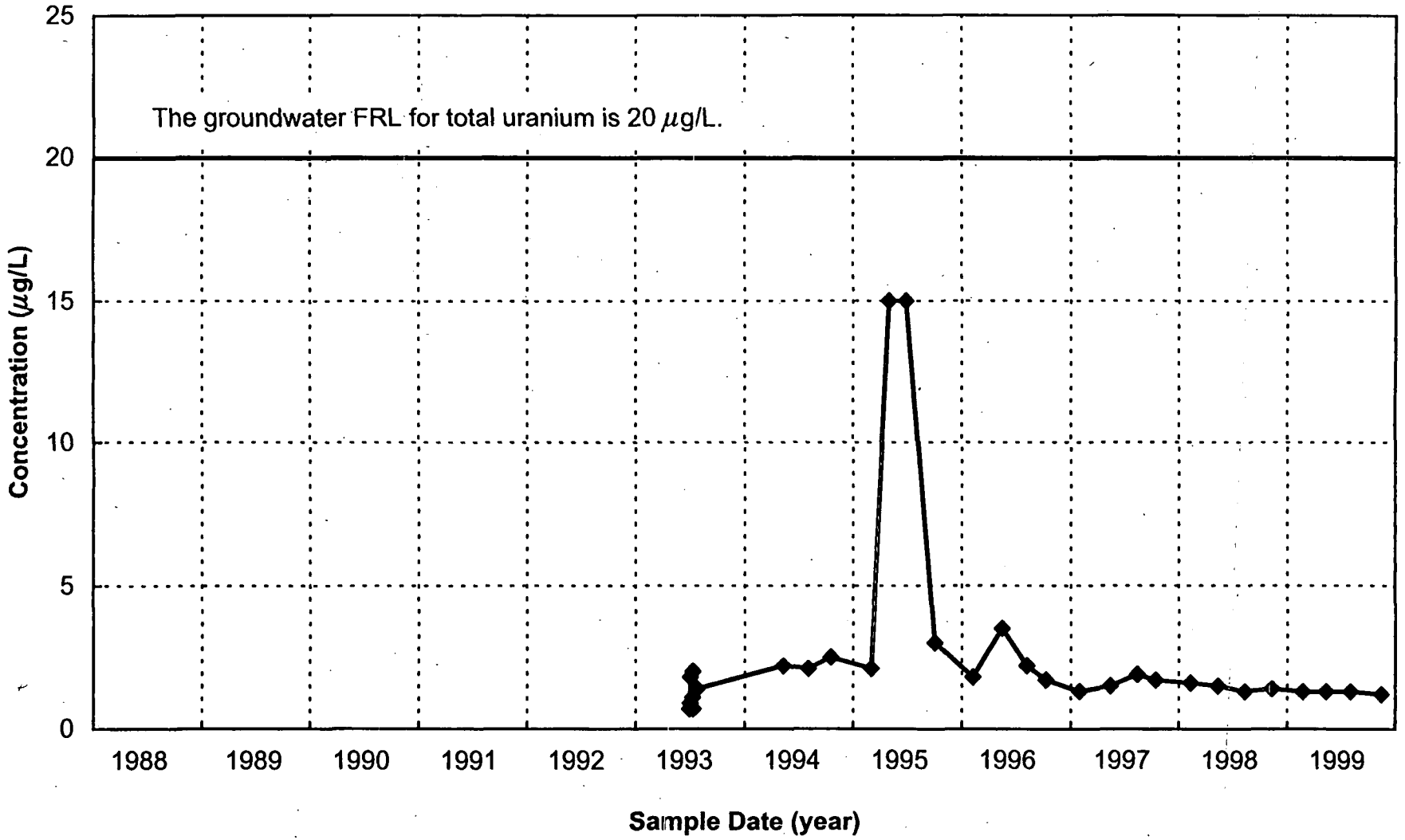



FIGURE A.2-132. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 21063



002006

000207

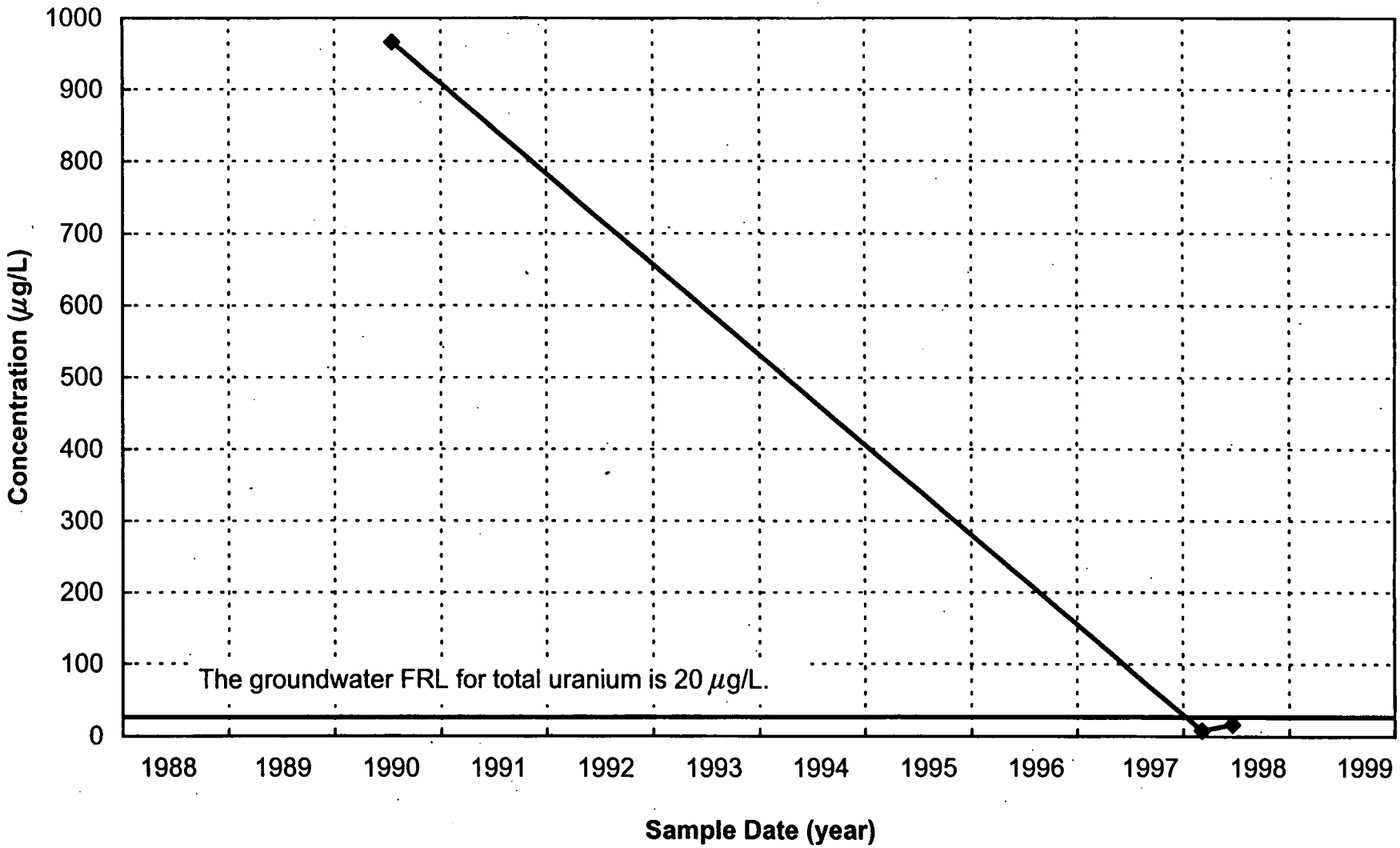



FIGURE A.2-133. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 21192

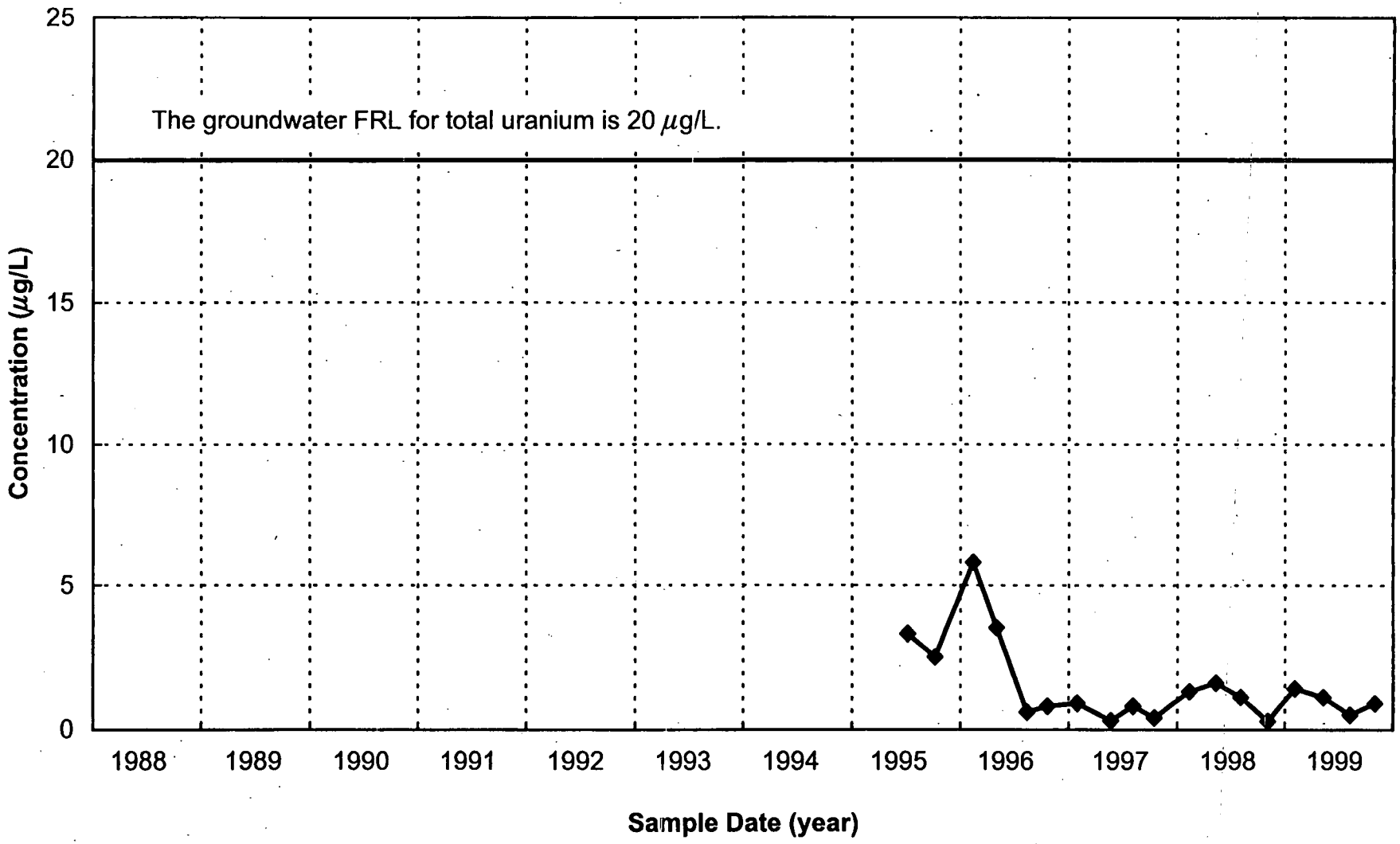



FIGURE A.2-134. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 21194



000208

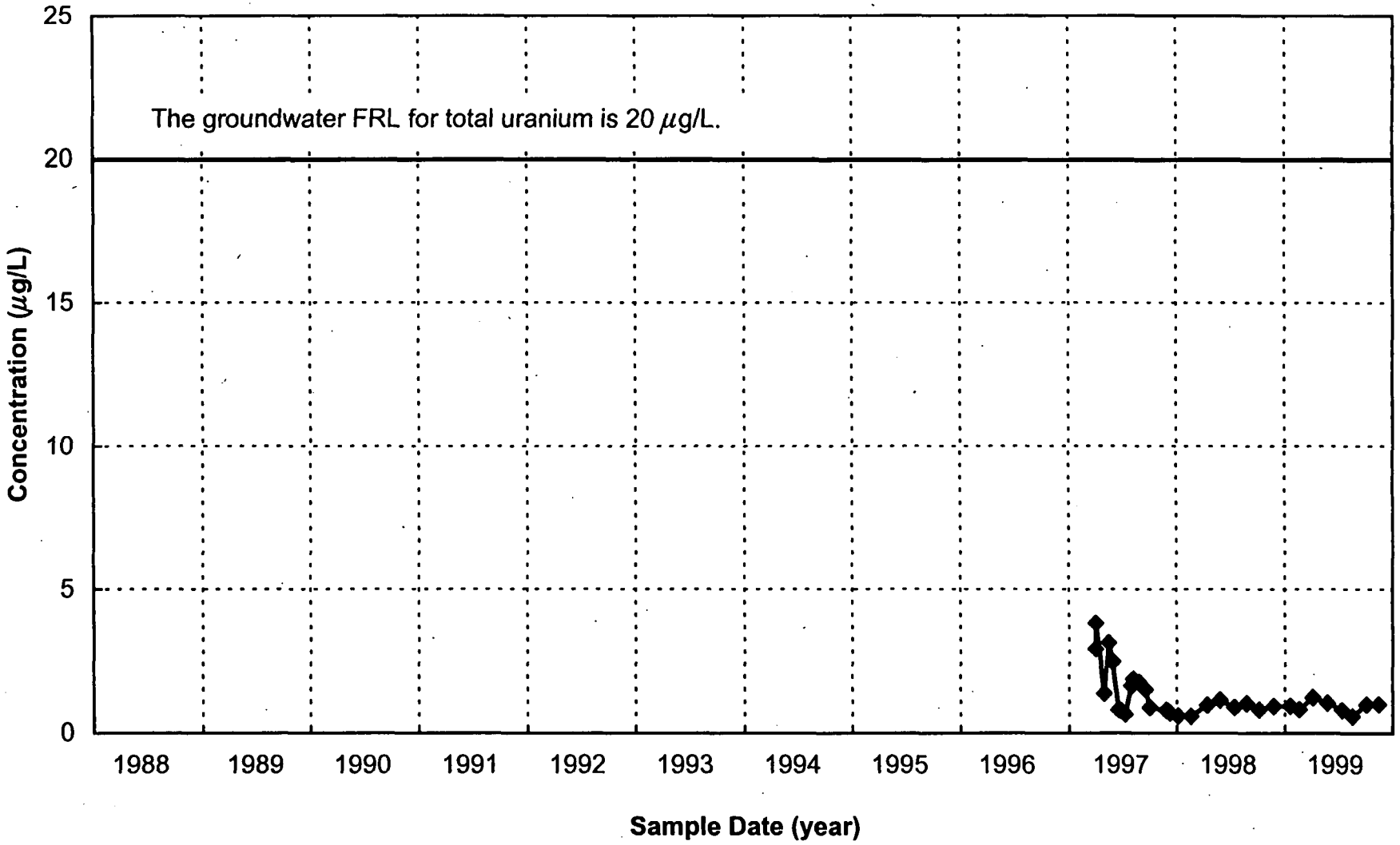



FIGURE A.2-135. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 22198

000209

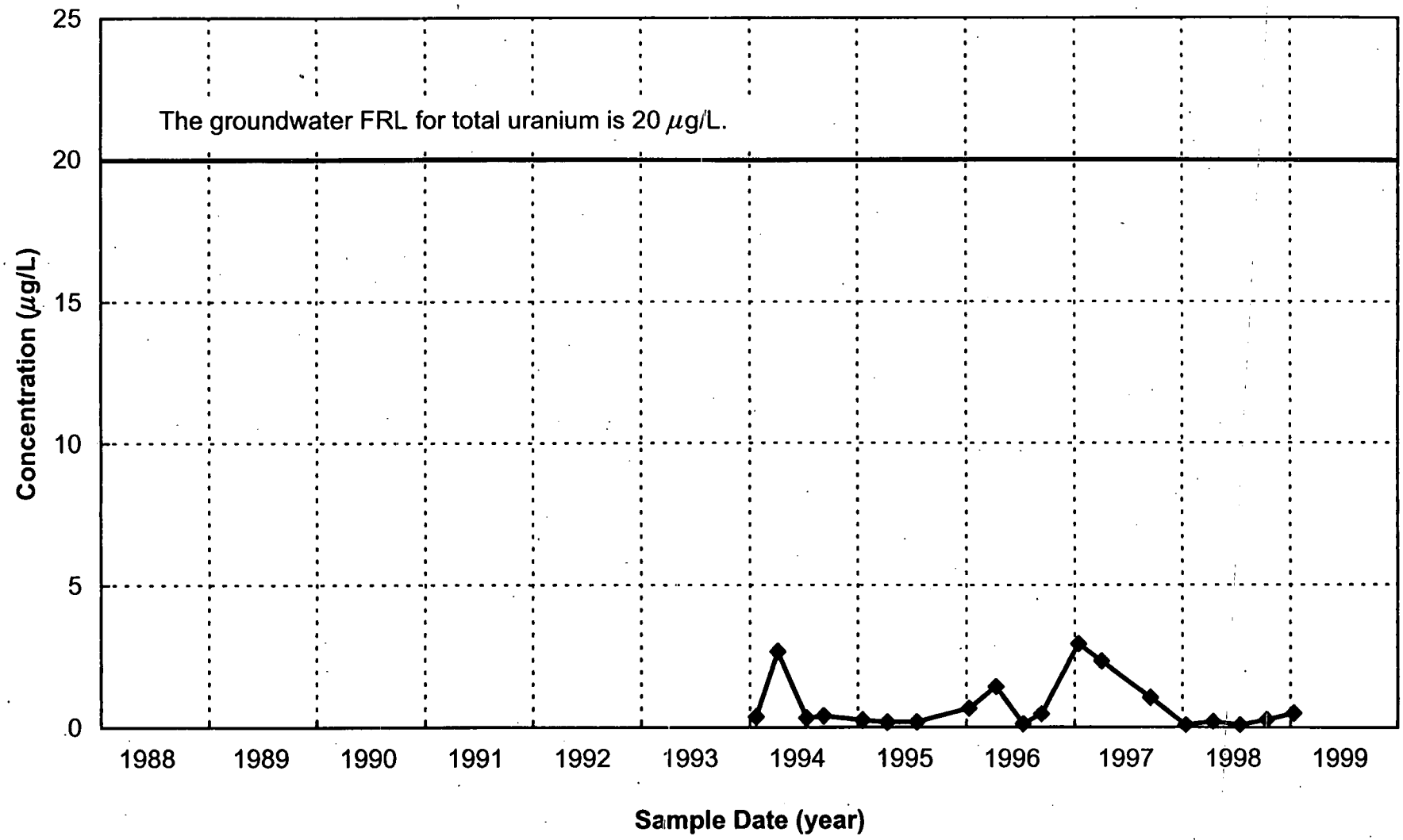



FIGURE A.2-136. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 31217

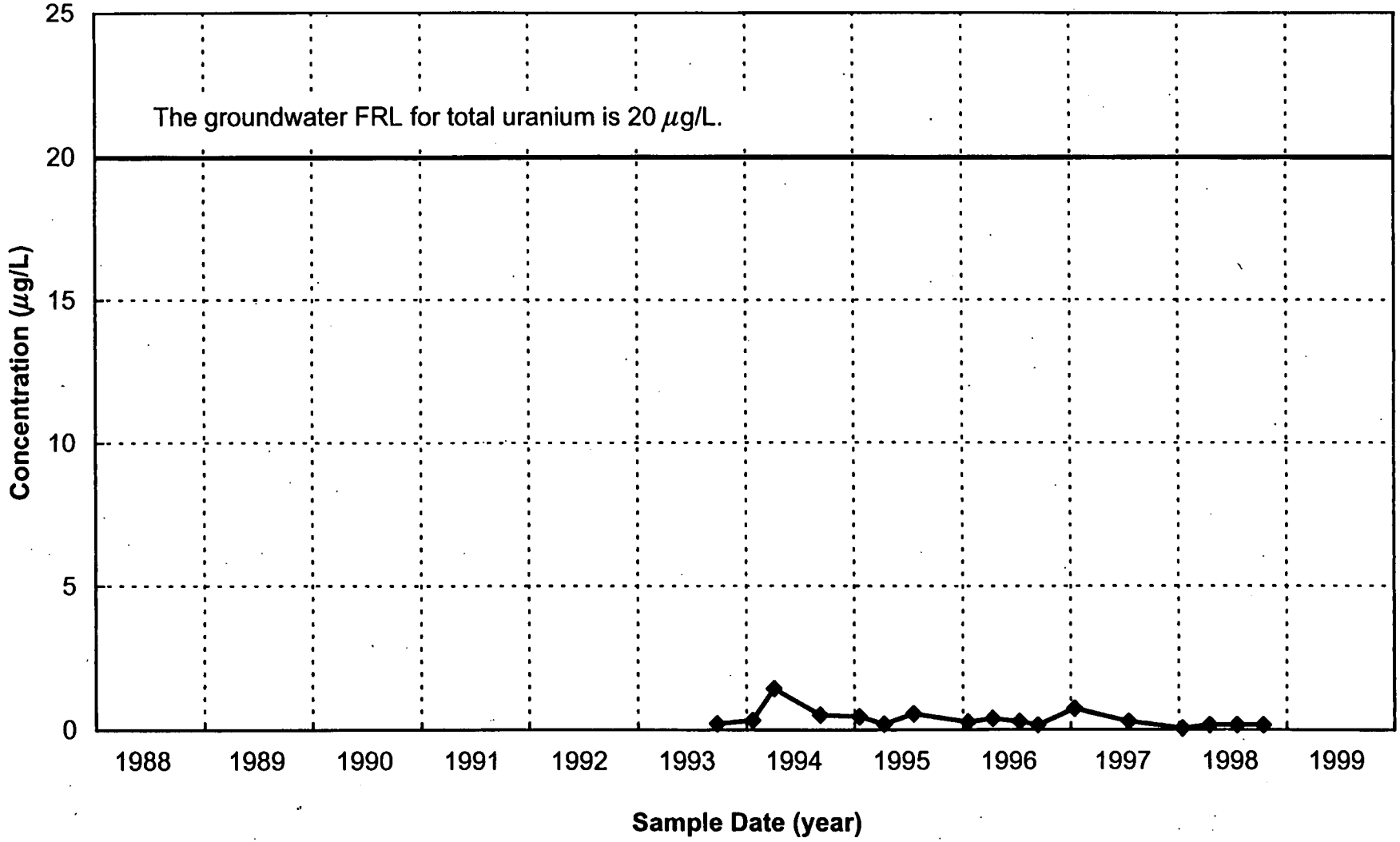



FIGURE A.2-137. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 41217

000244

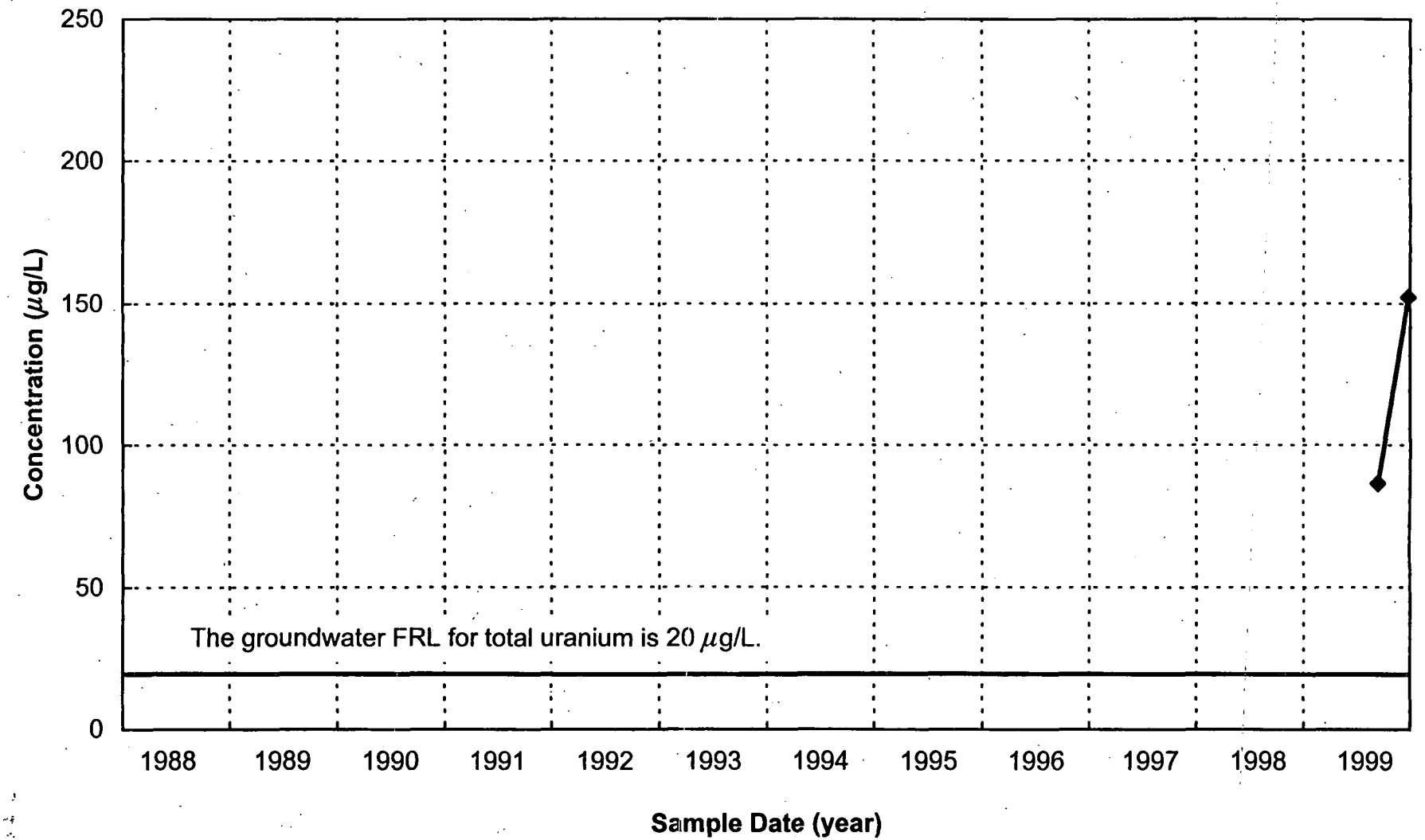



FIGURE A.2-138. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 62408

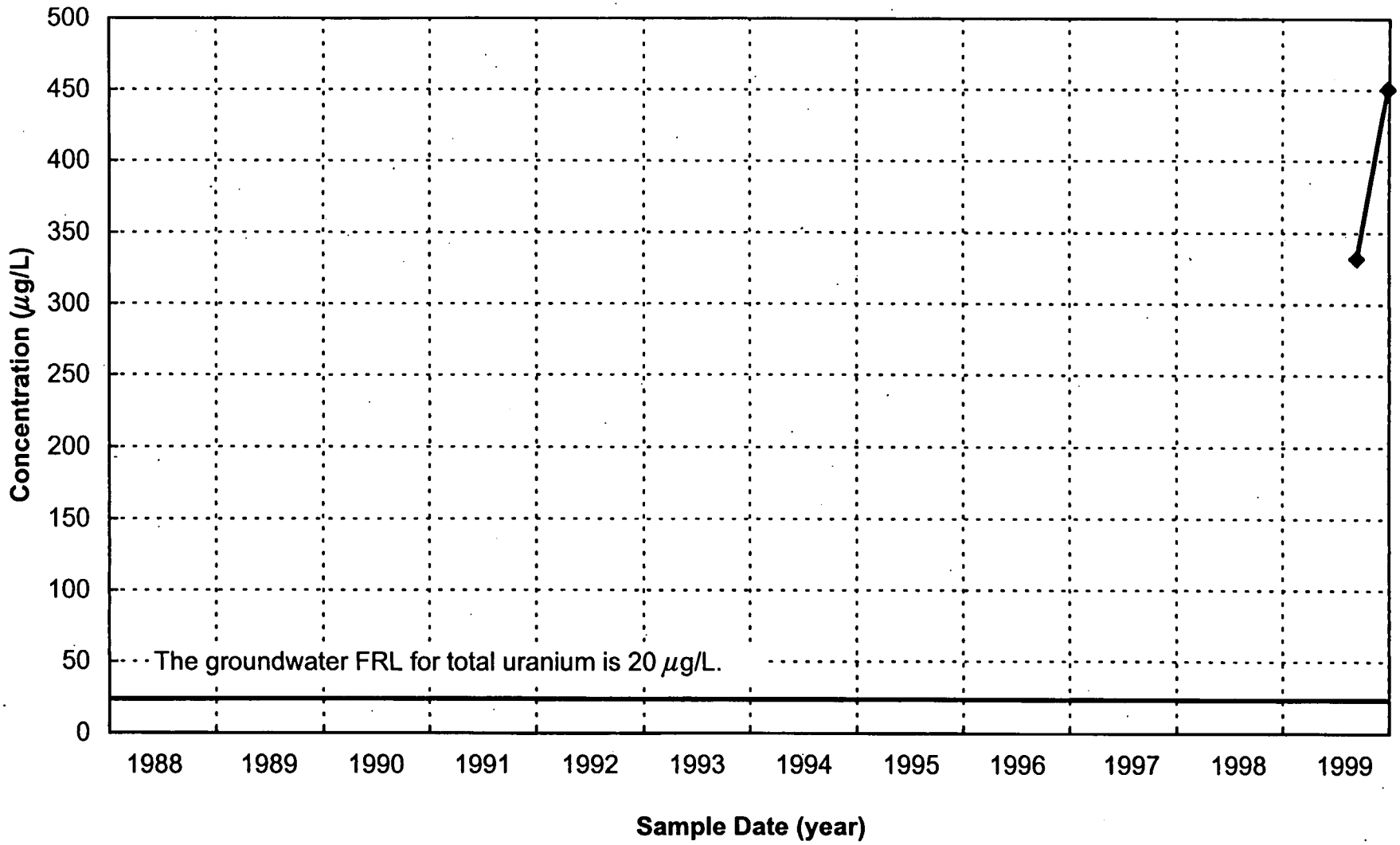



FIGURE A.2-139. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 62433

# ATTACHMENT A.3

# GROUNDWATER ELEVATIONS AND CAPTURE ASSESSMENT

# ATTACHMENT A.3



Groundwater elevation maps are shown in Figures A.3-1 through A.3-4 for Type 2 groundwater monitoring wells for the four quarters of 1999. The Type 3 maps are not provided, in accordance with EPA and OEPA (DOE 2000d-Comment #5). Each groundwater elevation map contains the following quarter-specific information:

- Groundwater elevation data and resultant water table contours
- Interpreted capture zones
- Bedrock highs
- 10-year, uranium-based restoration footprint
- Extent of the maximum total uranium plume 20 μg/L contour
- Model-specific pumping rates during the time that the groundwater elevation measurements were collected
- Major groundwater flow divide which separates groundwater exiting the New Haven Trough to the Great Miami River through the Paddys Run Outlet from groundwater exiting the New Haven Trough to the Great Miami River through the New Baltimore Outlet.

These elevation maps were also included in the 1999 IEMP quarterly status reports, but have been updated with the respective quarter's plume data.

Consistent with the 10-year, uranium-based restoration footprint, the capture zones/divides depicted in Figures A.3-1 through A.3-4 indicate (two exceptions noted below) that the southern portion of the uranium plume is being effectively captured by the extraction wells. In January 1999 (Figure A.3-1) the extreme southern tip of the northeast lobe is shown at or slightly outside the capture zone created by pumping from the South Plume extraction wells. All three other quarterly maps clearly indicate that capture of this area is being achieved. The fourth quarter map (Figure A.3-4) indicates that the extreme southern tip of the plume is outside of the fourth quarter capture zone but inside the 10-year, uranium-based restoration footprint. As discussed in Attachment A.2, this portion of the plume was extended slightly to the southwest based on the fourth quarter 1999 uranium concentration at Monitoring Well 2552. This fluctuation in uranium concentration at Monitoring Well 2552 has been observed in the past. In the past, it has been reported that Monitoring Well 2552 is sometimes within the capture zone of

the recovery system and sometimes outside of the capture zone as water levels in the aquifer fluctuate from seasonal drawdown and recharge (DOE 1997e). Quarterly monitoring of this key location will continue to determine if this situation persists.

Well cluster hydrographs, a means to assess vertical groundwater gradients, are provided in accordance with EPA and OEPA (DOE 2000c-Comment #1). Thus, hydrographs for the following monitoring well clusters (Type 2 and Type 3 wells) appear in Figures A.3-5 through A.3-34: 009, 014, 015, 017, 027, 032, 045, 046, 049, 054, 065, 068, 069 (434), 095, 106, 125,128, 385, 387, 390, 396, 398, 402, 550, 551, 552, 821, 880, 881, and 900. The last three digits of the monitoring wells identify the well clusters (e.g., cluster 552 consists of Monitoring Wells 2552 and 3552). Groundwater elevations available from 1993 through 1999 from Type 2 and Type 3 wells at the same cluster were plotted on the same graph. Figure A.1-1 identifies the well cluster locations.

Analysis of these hydrographs for 1999 indicates that elevations in the Type 2 and Type 3 monitoring wells within the majority of the clusters monitored are almost always identical for each measurement time. An occasional slight difference can be seen in the hydrographs for clusters 009, 049, 387, 398, 402, 550, 551, 552, and 900, but these differences display no systematic behavior and are attributed to measurement, transcription, or key-punch error when the data were processed.

A more substantial/consistent difference can be seen in the hydrographs for clusters 054, 065, and 390. At clusters 065 and 390, the Type 2 water level is slightly higher than the Type 3 water level implying a downward gradient. The Type 3 water level is slightly higher than the Type 2 water level in Cluster 054 implying an upward gradient. These differences are believed to be due to survey errors with respect to the well elevations, and not to aquifer conditions. The well elevation references will be checked during 2000.

It was reported in the 1998 Integrated Site Environmental Report that an apparent two-foot gradient was recorded in the wells at cluster 398 in the last two quarters of 1998. In 1999 it was discovered that this apparent gradient was due to a survey measurement error with respect to well elevations, and was not due to aquifer conditions. Well elevation data have been corrected and the corrected water level measurements are illustrated in Figure A.3-26.

In accordance with the IEMP, Revision 1 (DOE 1999b), the colloidal borescope was eliminated from routine use in monitoring wells around the South Plume Module and in the area of the northeast lobe of the total uranium plume during 1999. Therefore, no borescope data or discussions are included in this appendix.

In the fourth quarter of 1999, the groundwater flow model was successfully recalibrated to an October 1998 data set and was validated against three other quarterly elevation data sets (April 1998, June 1999, and October 1999). The Great Miami Aquifer VAM3D Flow Model Recalibration Report (DOE 2000e) was provided to EPA and OEPA in 2000. Phase II of the groundwater model upgrade project, which incorporates data fusion technology into the groundwater transport model, was completed in fourth quarter 1999. A draft of the report, issued in 1999 (HydroGeoLogic, Inc., 1999) is undergoing revisions, and will be submitted to EPA and OEPA in 2000.

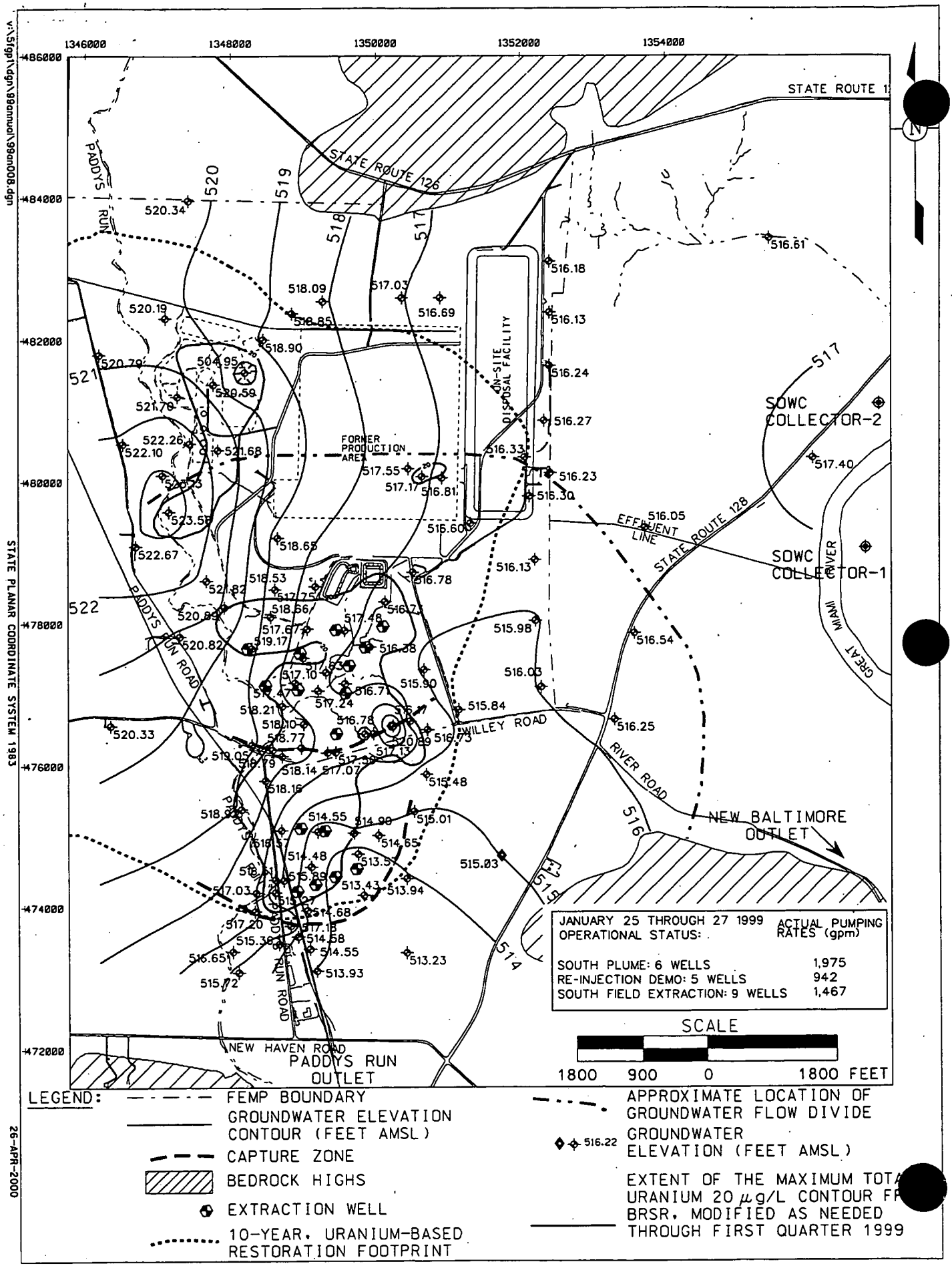



FIGURE A.3-1. ROUTINE GROUNDWATER ELEVATIONS FOR TYPE 2 WELLS, JANUARY 1999

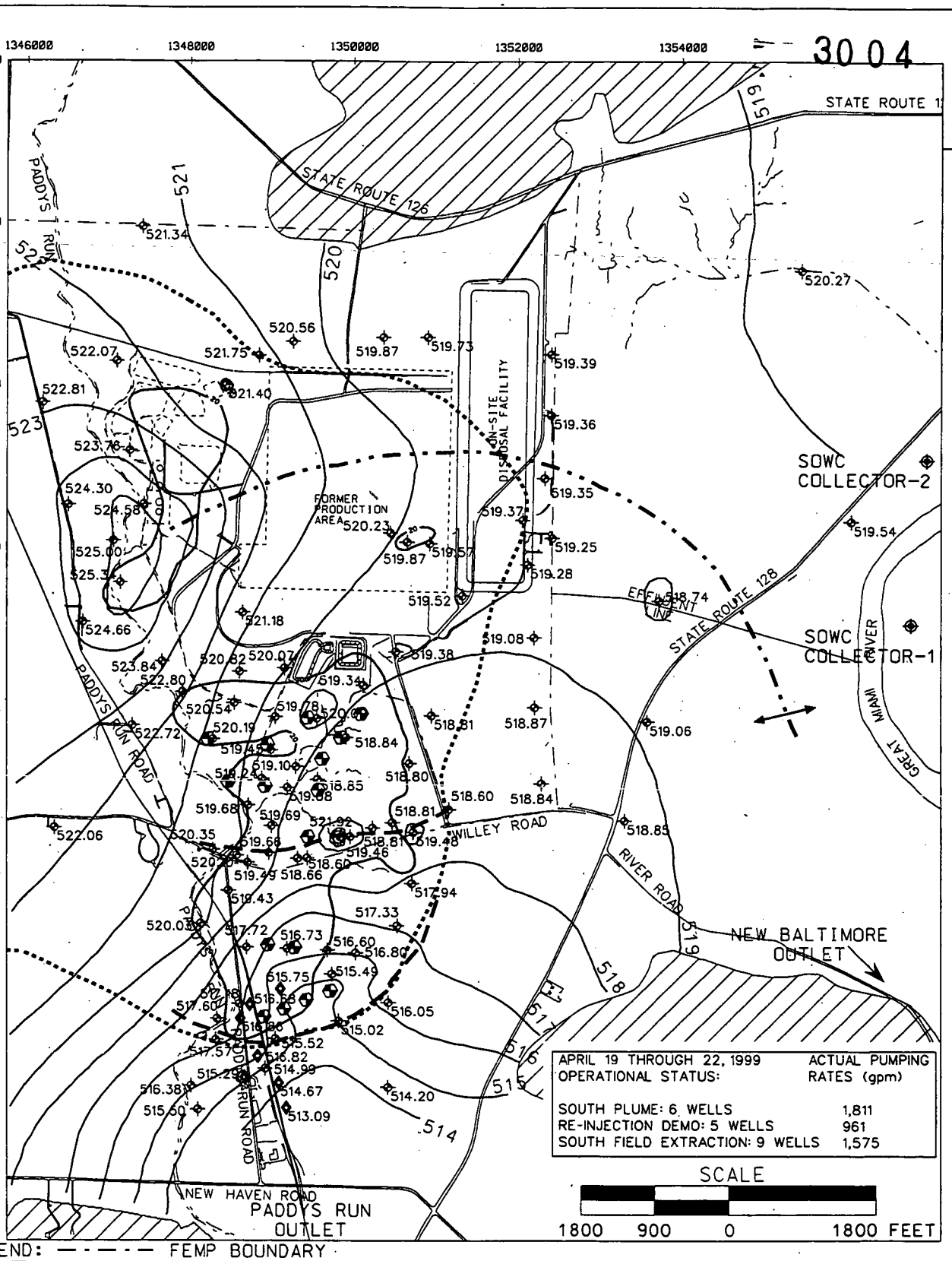



FIGURE A.3-2. ROUTINE GROUNDWATER ELEVATIONS FOR TYPE 2 WELLS, APRIL 1999

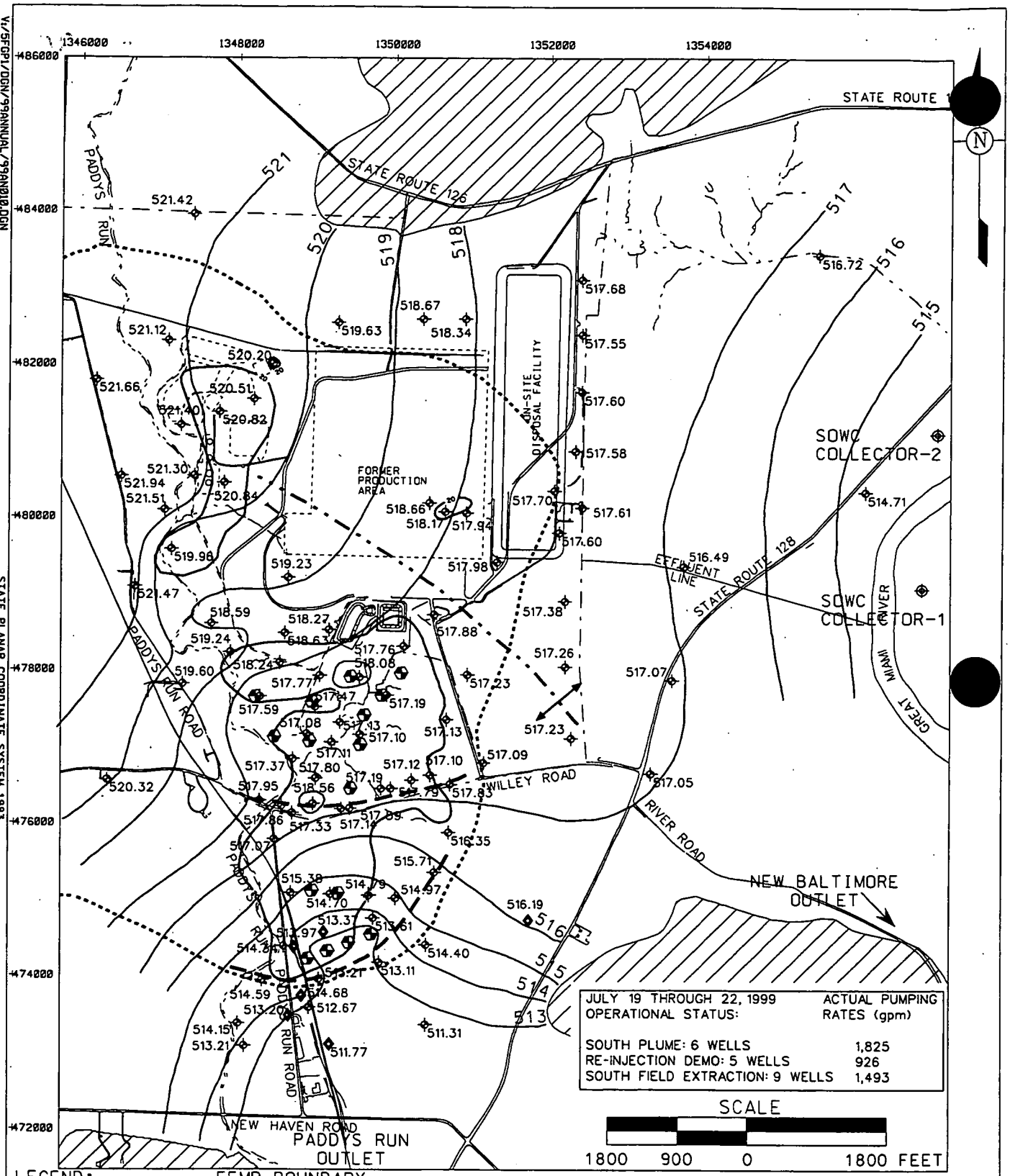
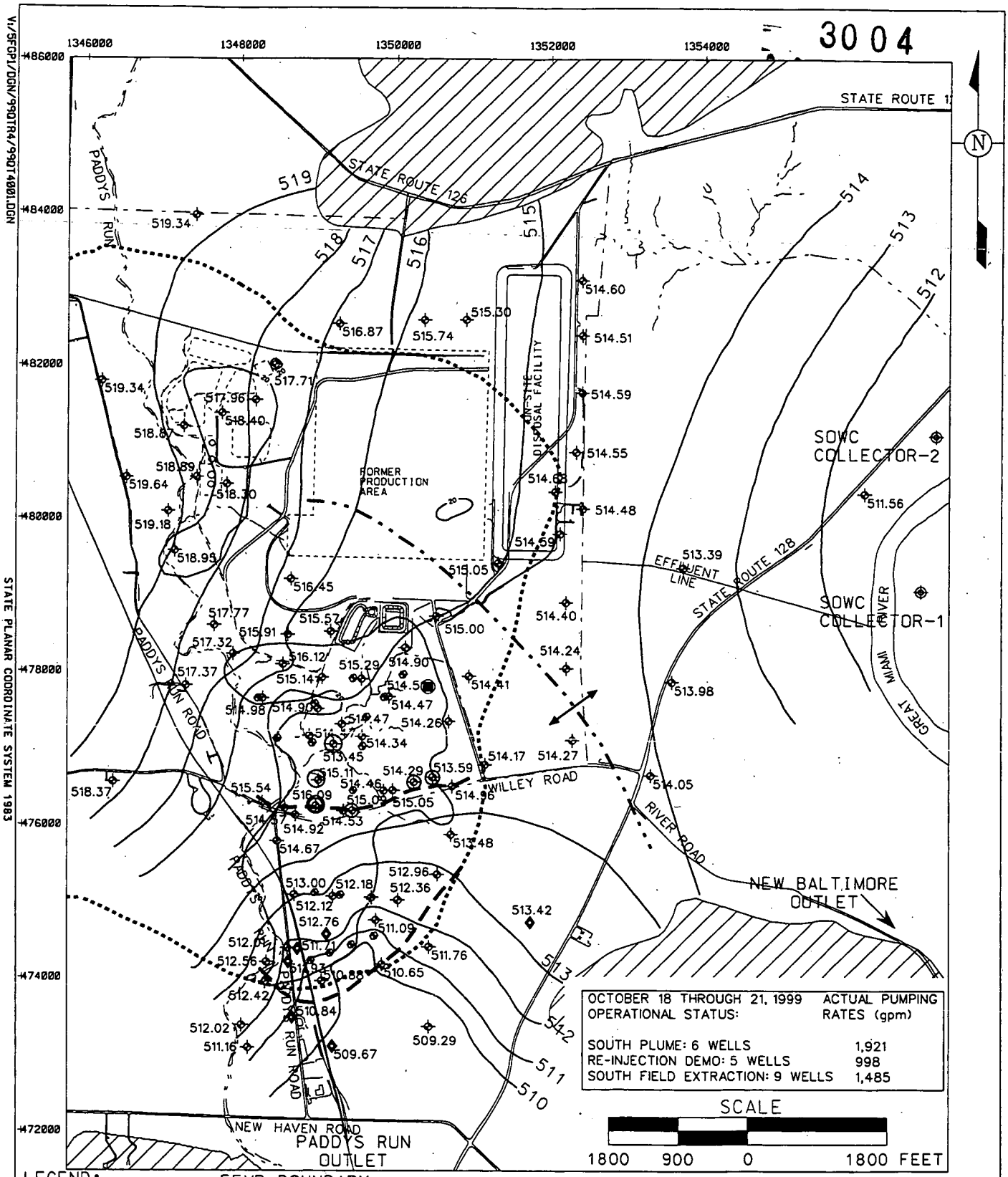



FIGURE A.3-3. ROUTINE GROUNDWATER ELEVATIONS FOR TYPE 2 WELLS, JULY 1999




V:/SFCP1/DGN/990TR4/990T4001.DGN

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FIGURE A.3-4. ROUTINE GROUNDWATER ELEVATIONS FOR TYPE 2 WELLS, OCTOBER 1999

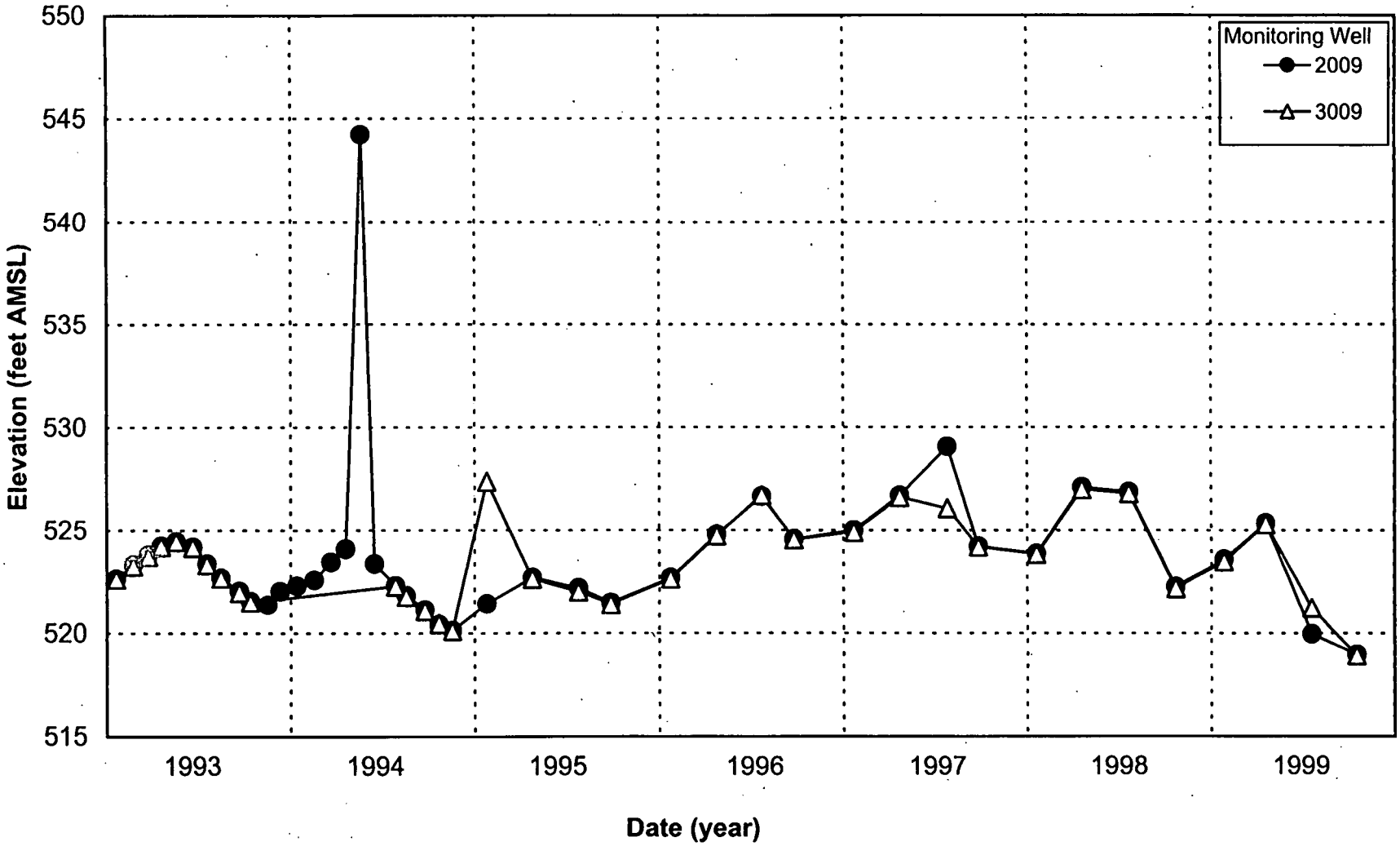



FIGURE A.3-5. HYDROGRAPH FOR WELL CLUSTER 009

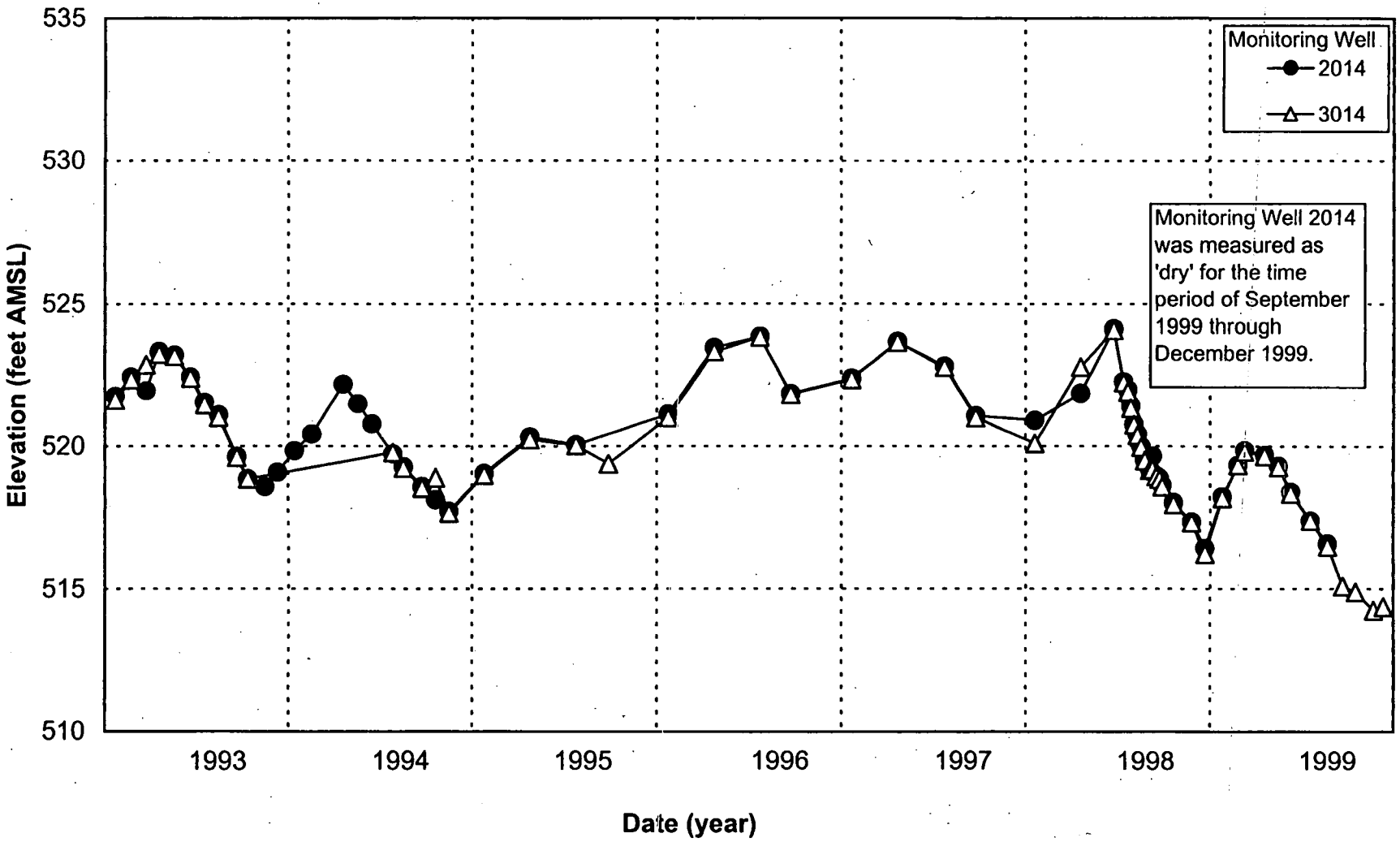



FIGURE A.3-6. HYDROGRAPH FOR WELL CLUSTER 014



000223

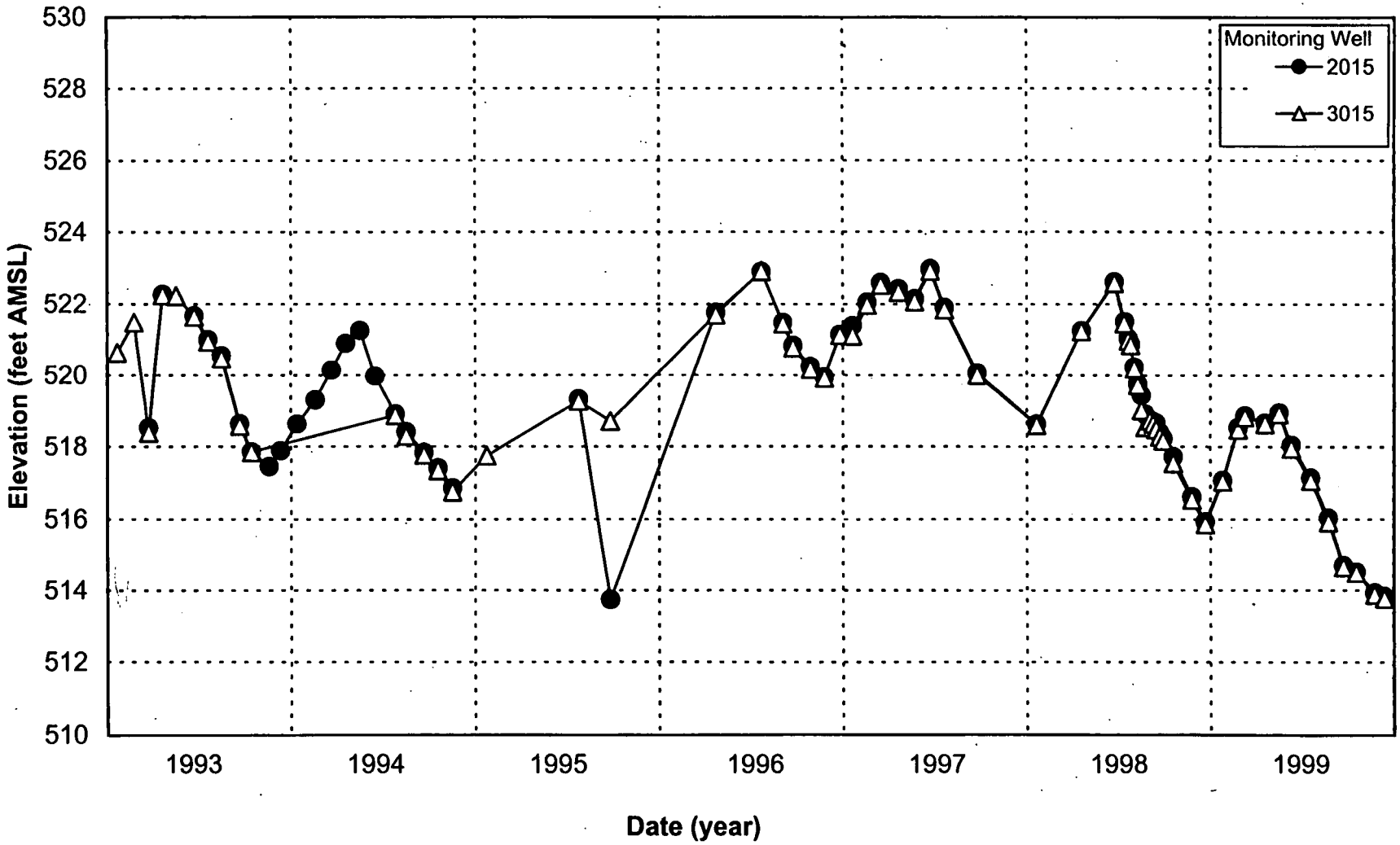



FIGURE A.3-7. HYDROGRAPH FOR WELL CLUSTER 015

000224

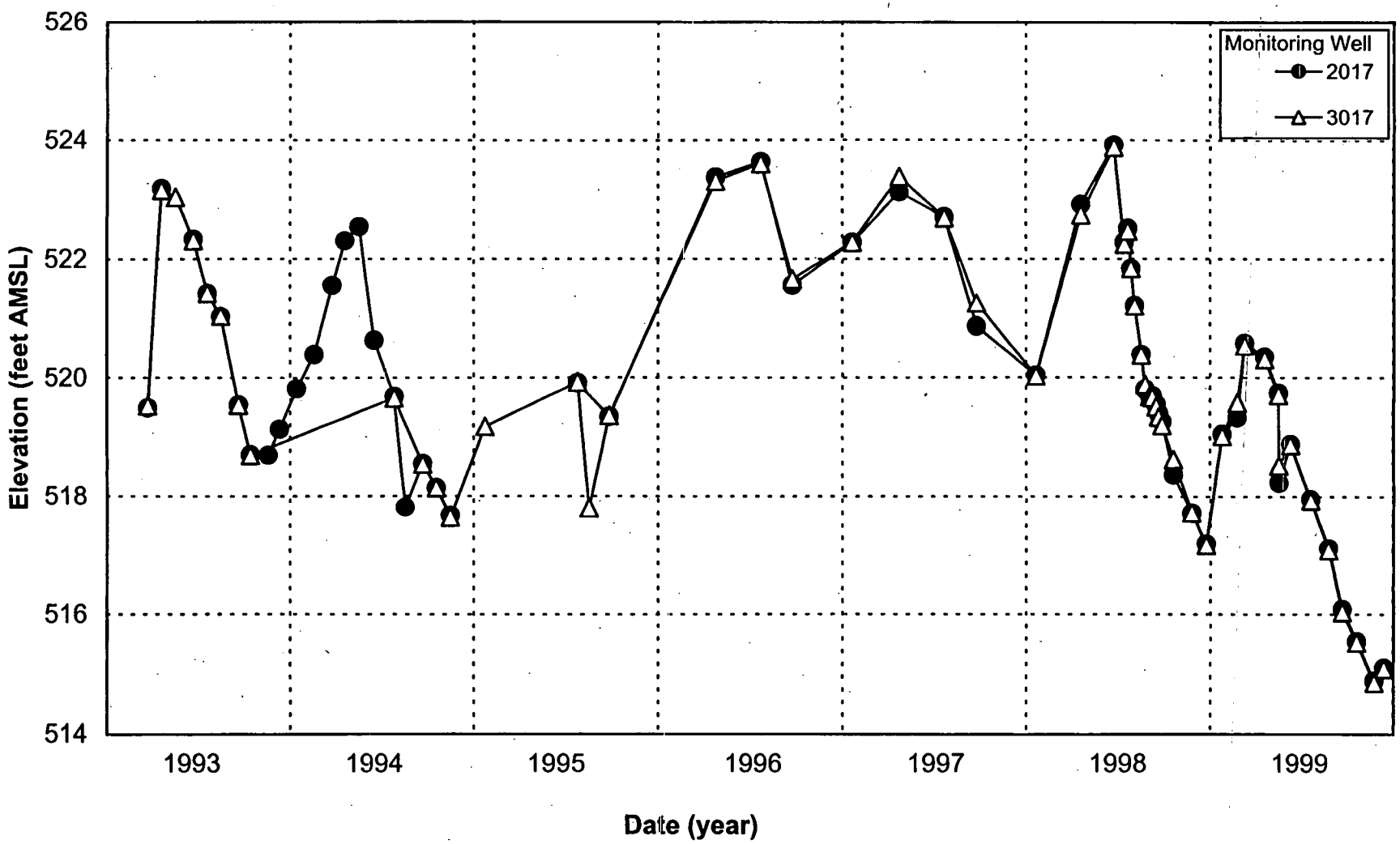



FIGURE A.3-8. HYDROGRAPH FOR WELL CLUSTER 017



0002225

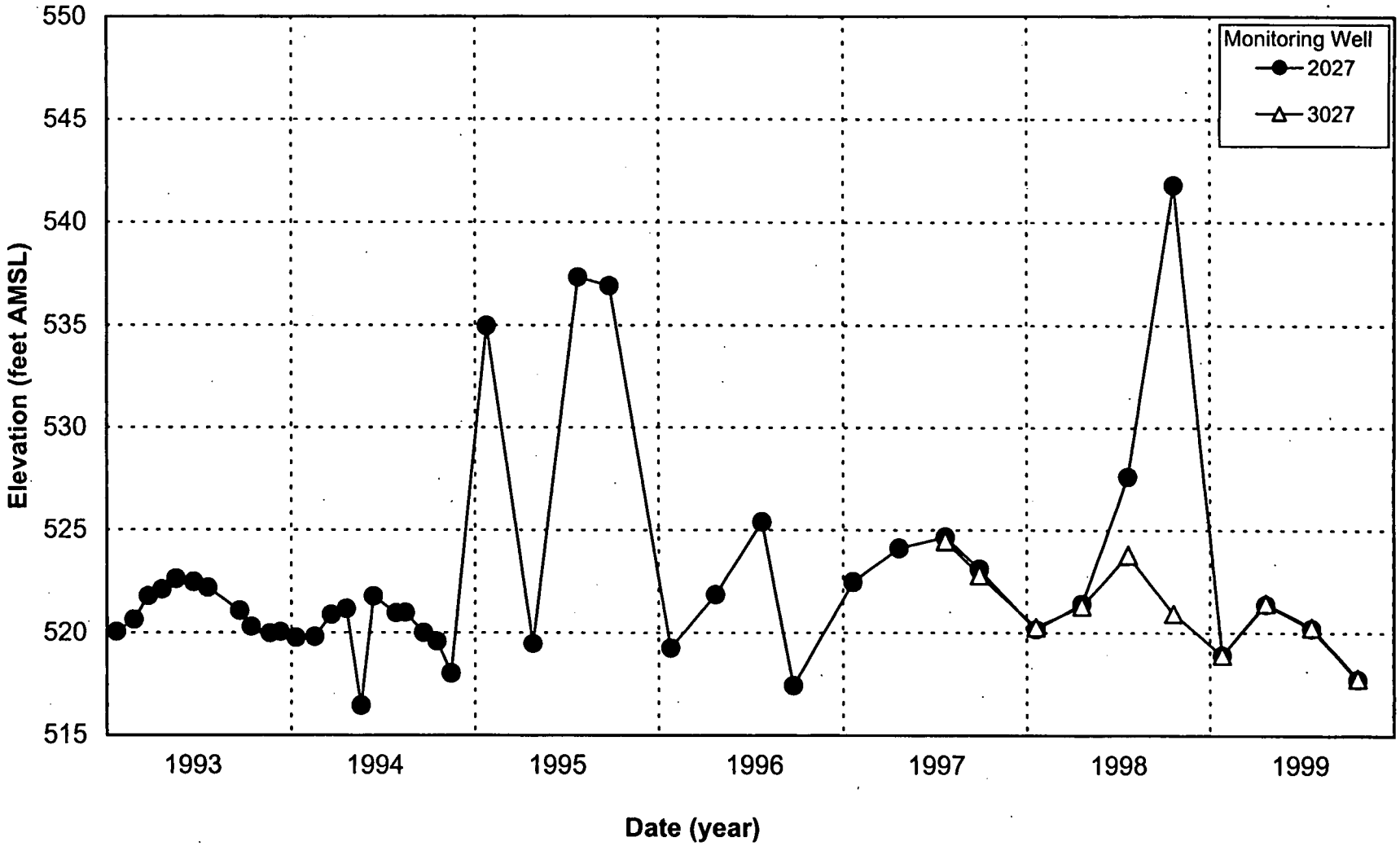



FIGURE A.3-9. HYDROGRAPH FOR WELL CLUSTER 027

000226

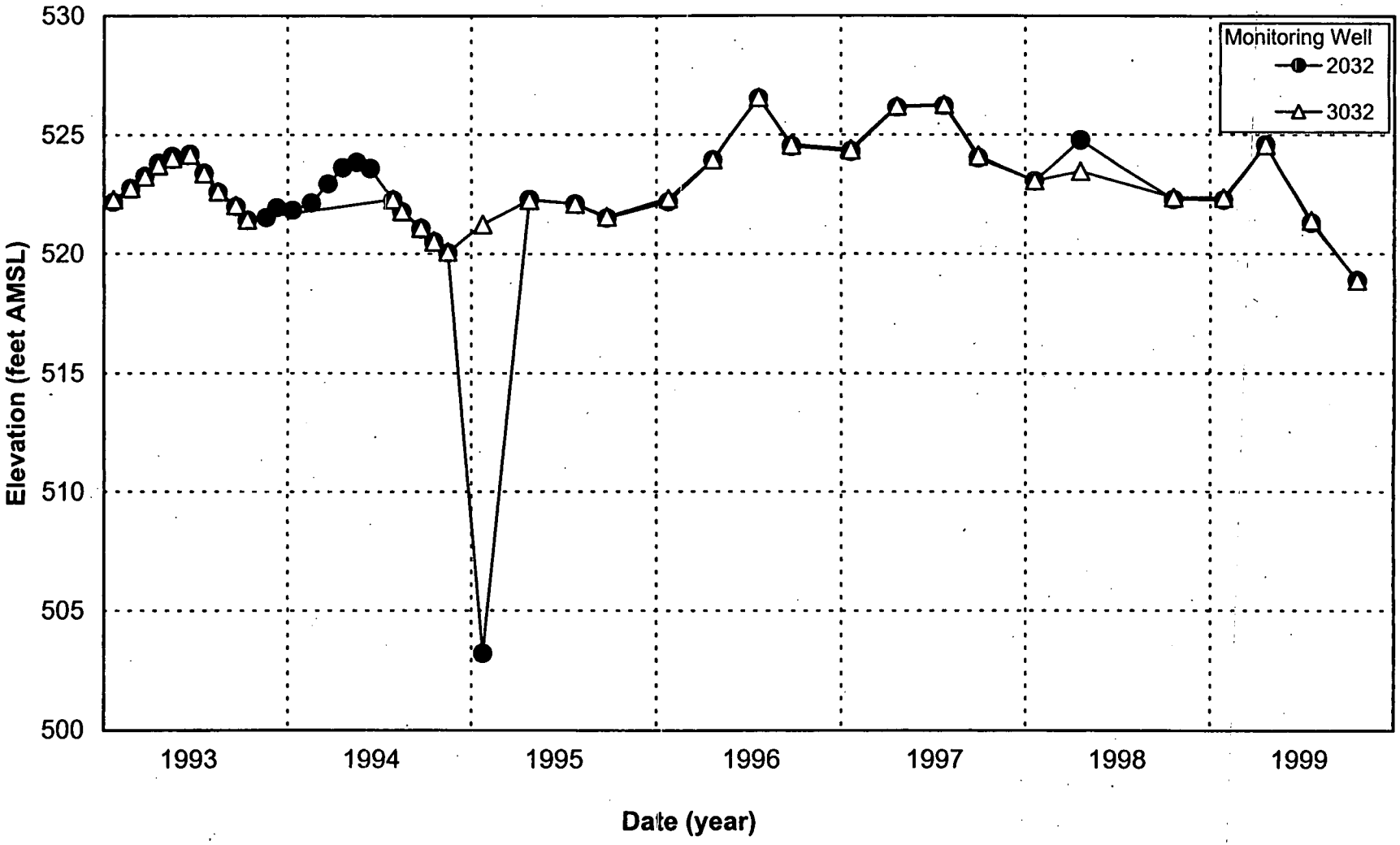



FIGURE A.3-10. HYDROGRAPH FOR WELL CLUSTER 032



000227

000228

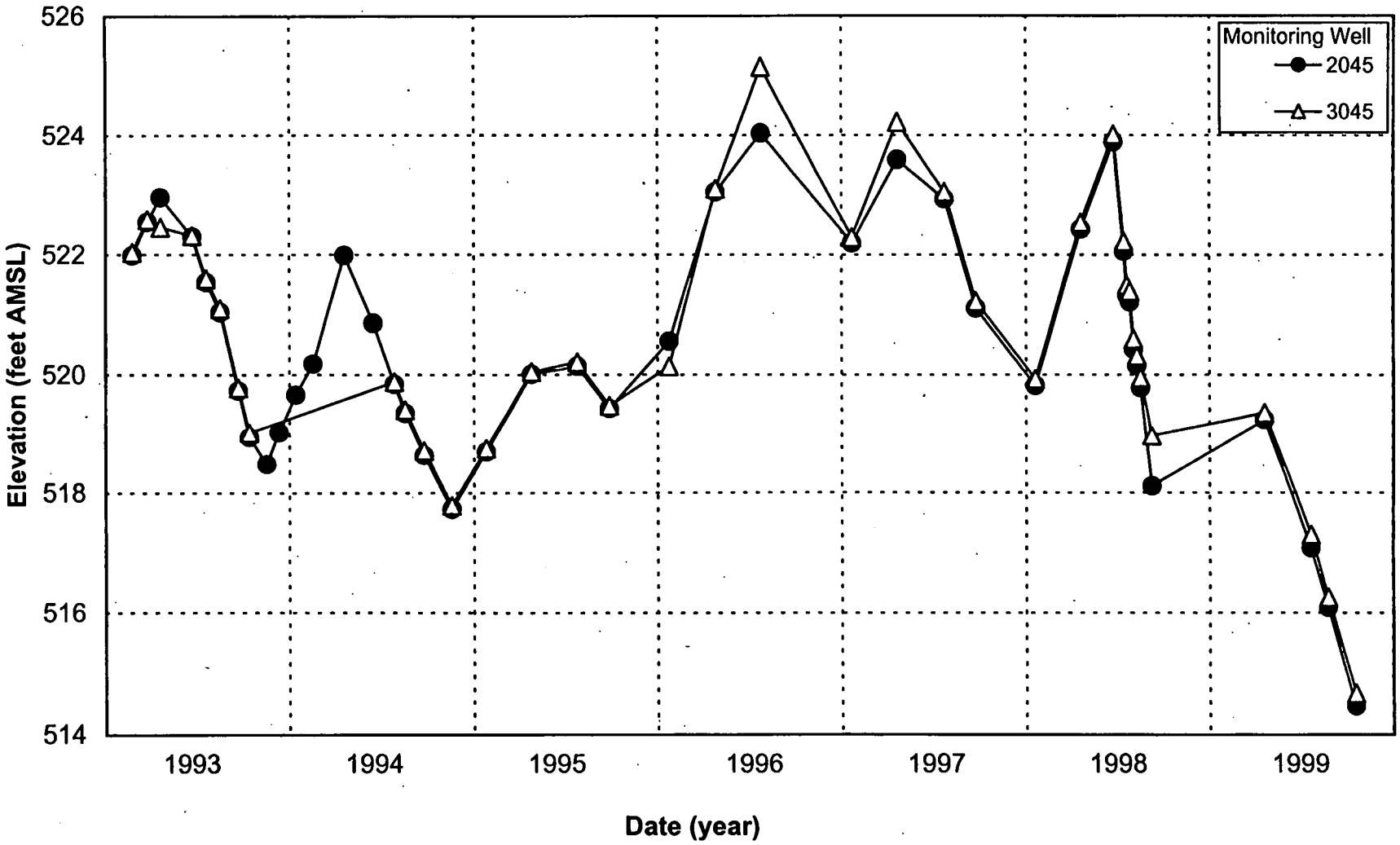



FIGURE A.3-11. HYDROGRAPH FOR WELL CLUSTER 045

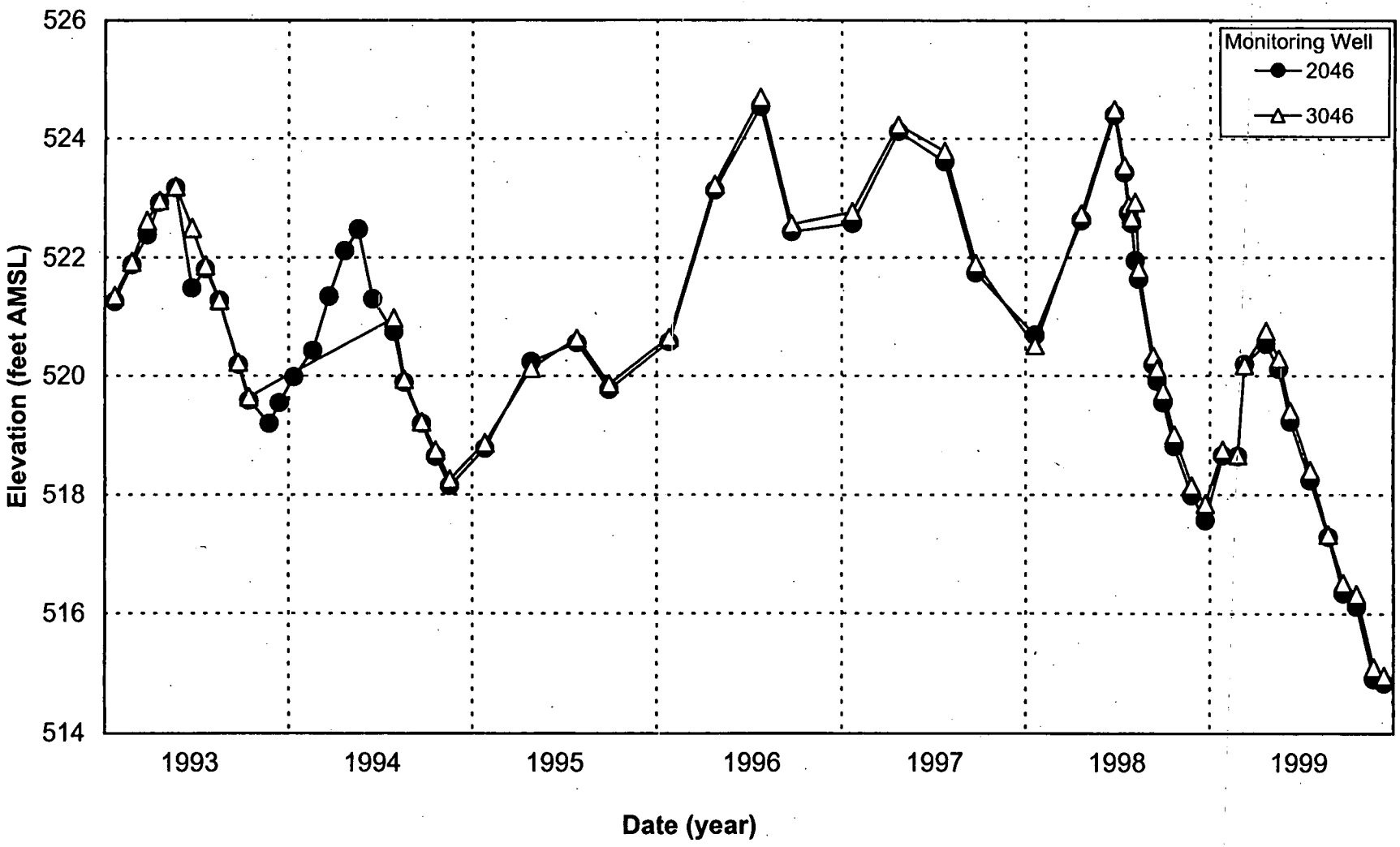



FIGURE A.3-12. HYDROGRAPH FOR WELL CLUSTER 046

000230

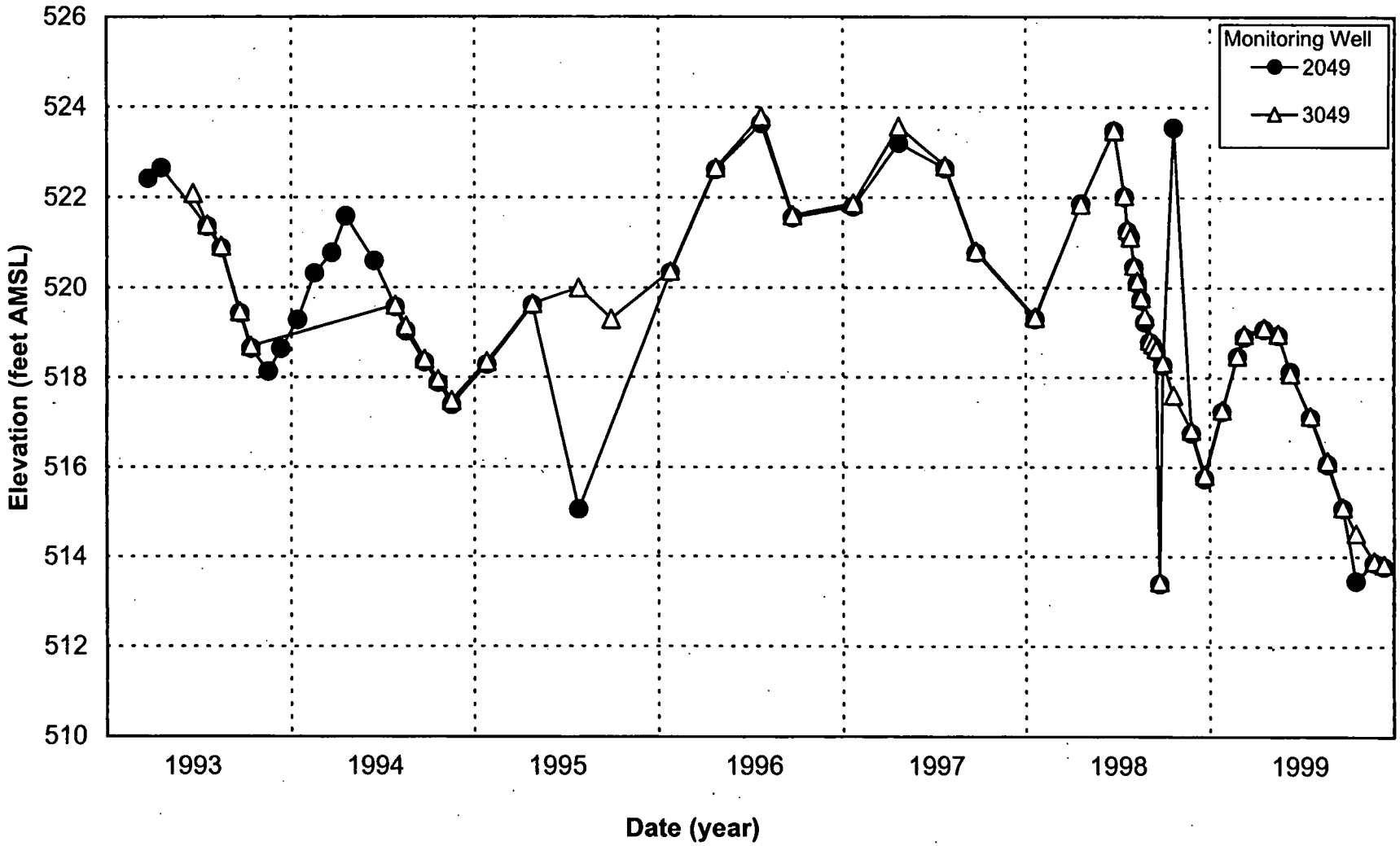



FIGURE A.3-13. HYDROGRAPH FOR WELL CLUSTER 049

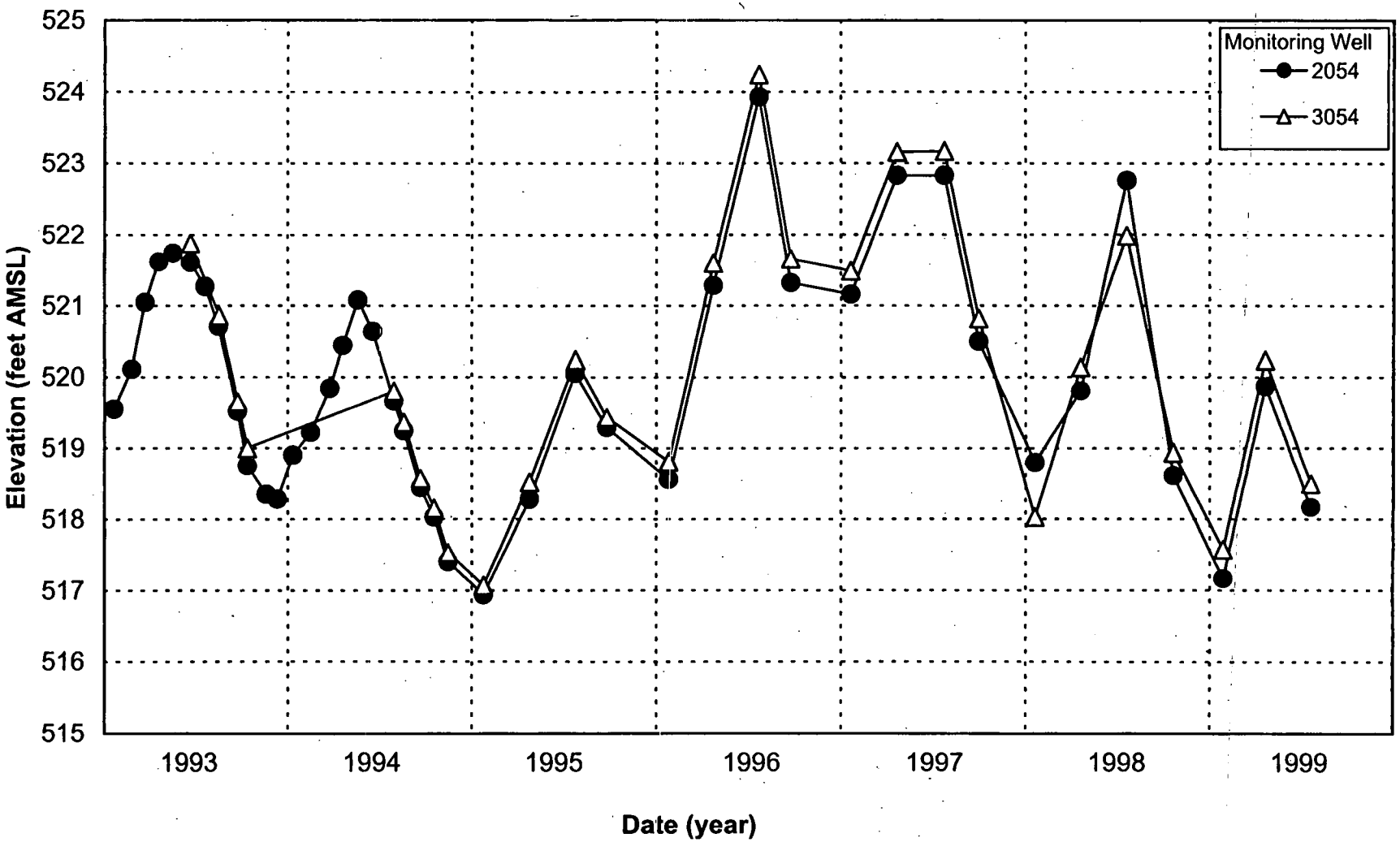



FIGURE A.3-14. HYDROGRAPH FOR WELL CLUSTER 054

000232

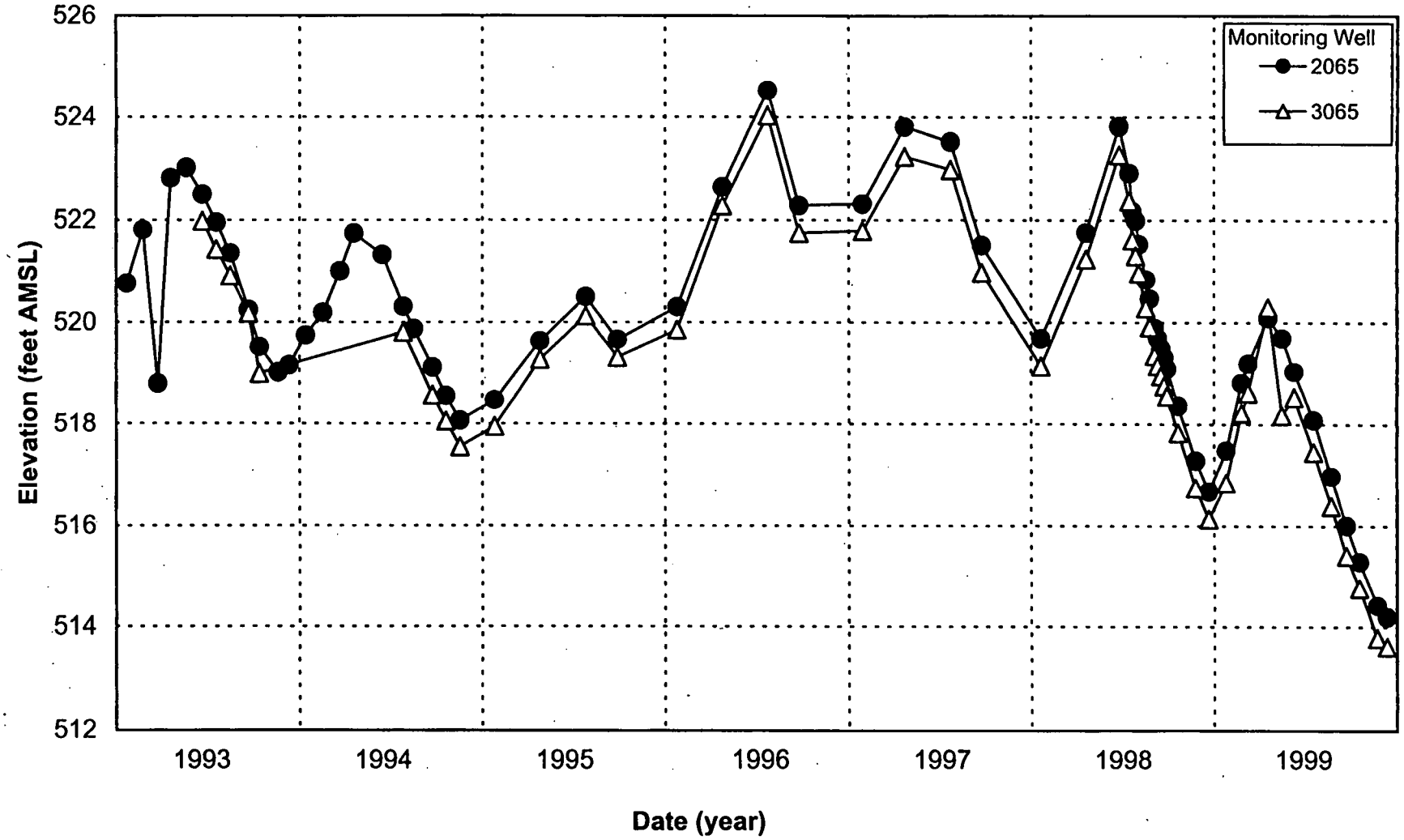



FIGURE A.3-15. HYDROGRAPH FOR WELL CLUSTER 065

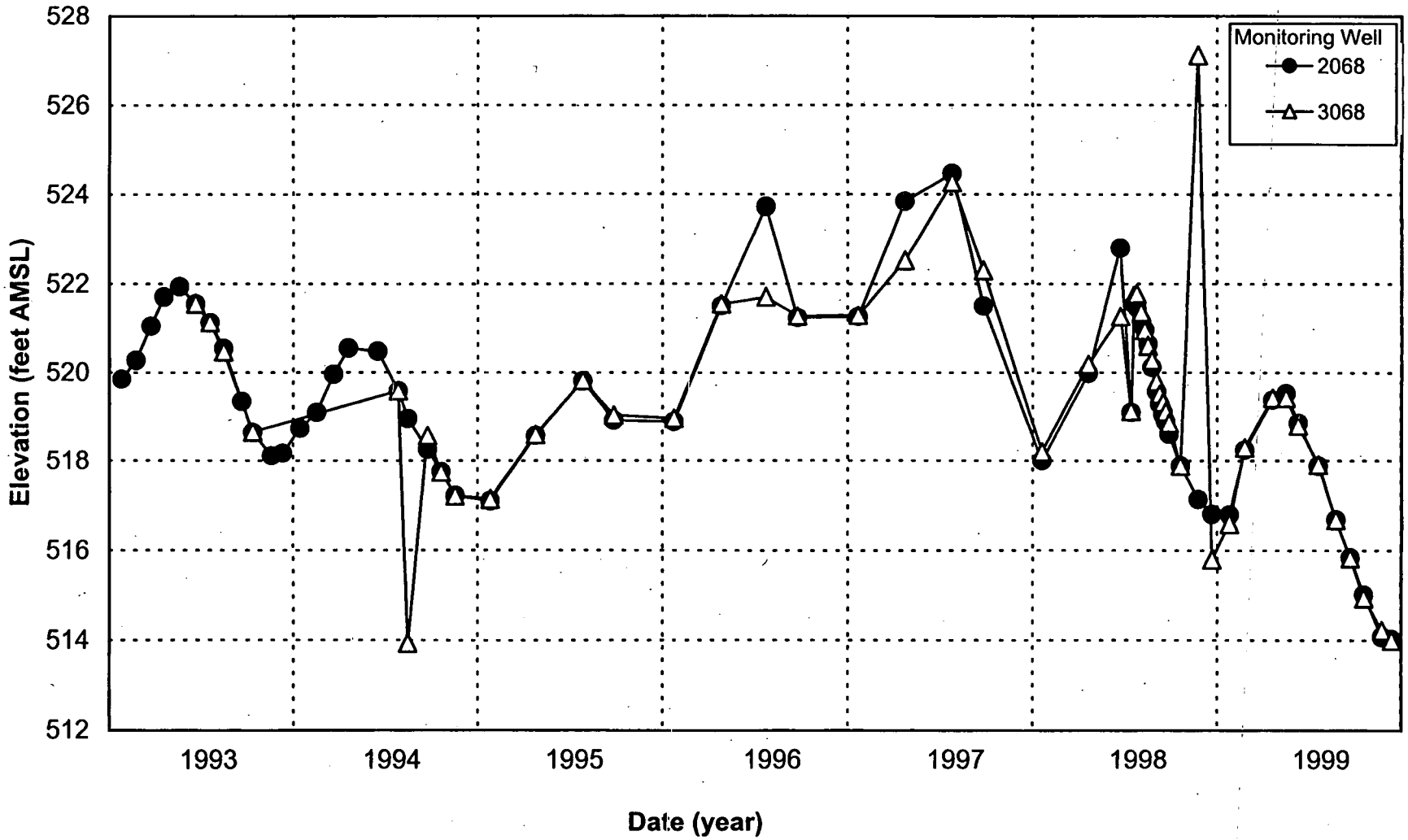



FIGURE A.3-16. HYDROGRAPH FOR WELL CLUSTER 068



000233

000234

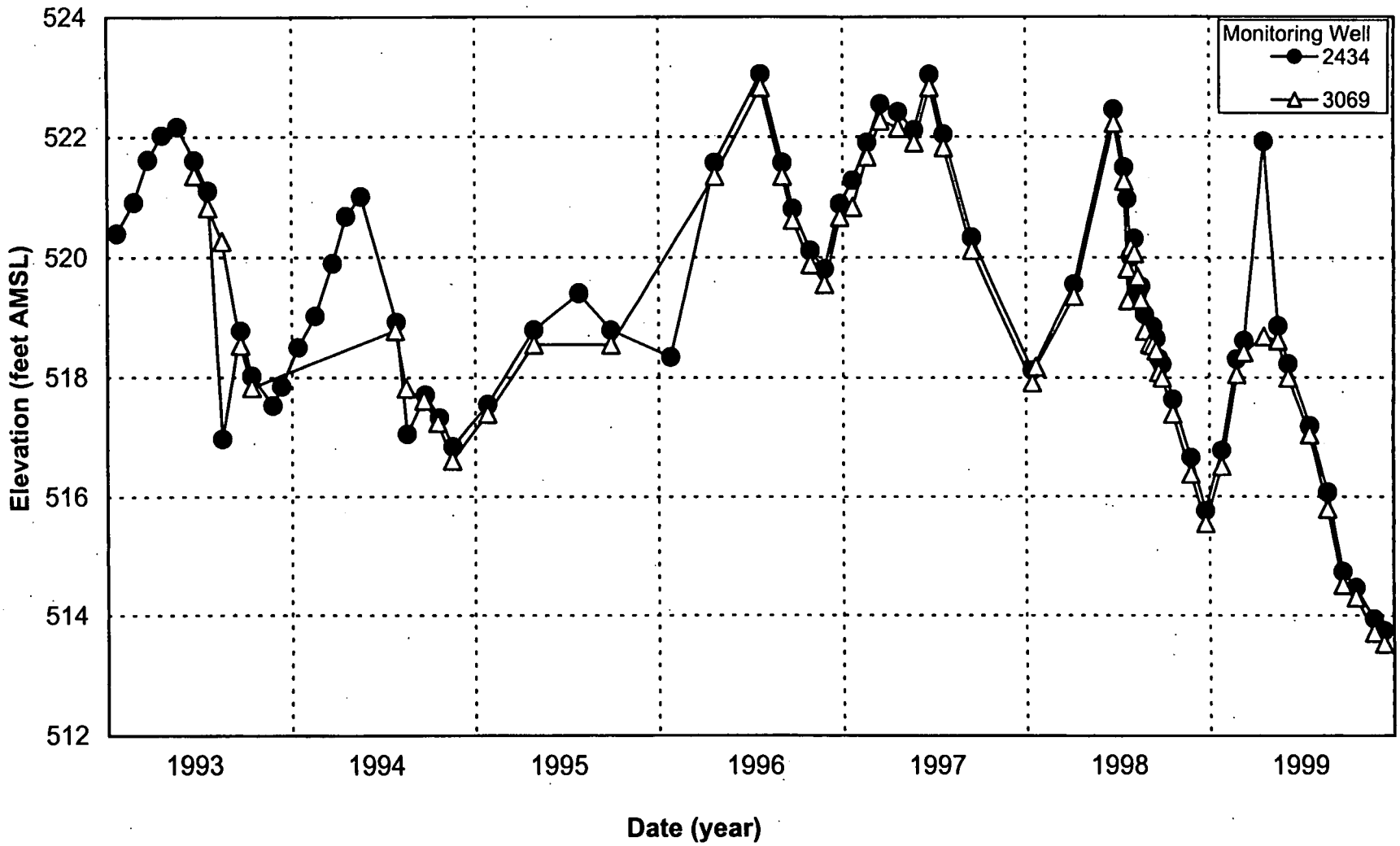



FIGURE A.3-17. HYDROGRAPH FOR WELLS 2434 AND 3069

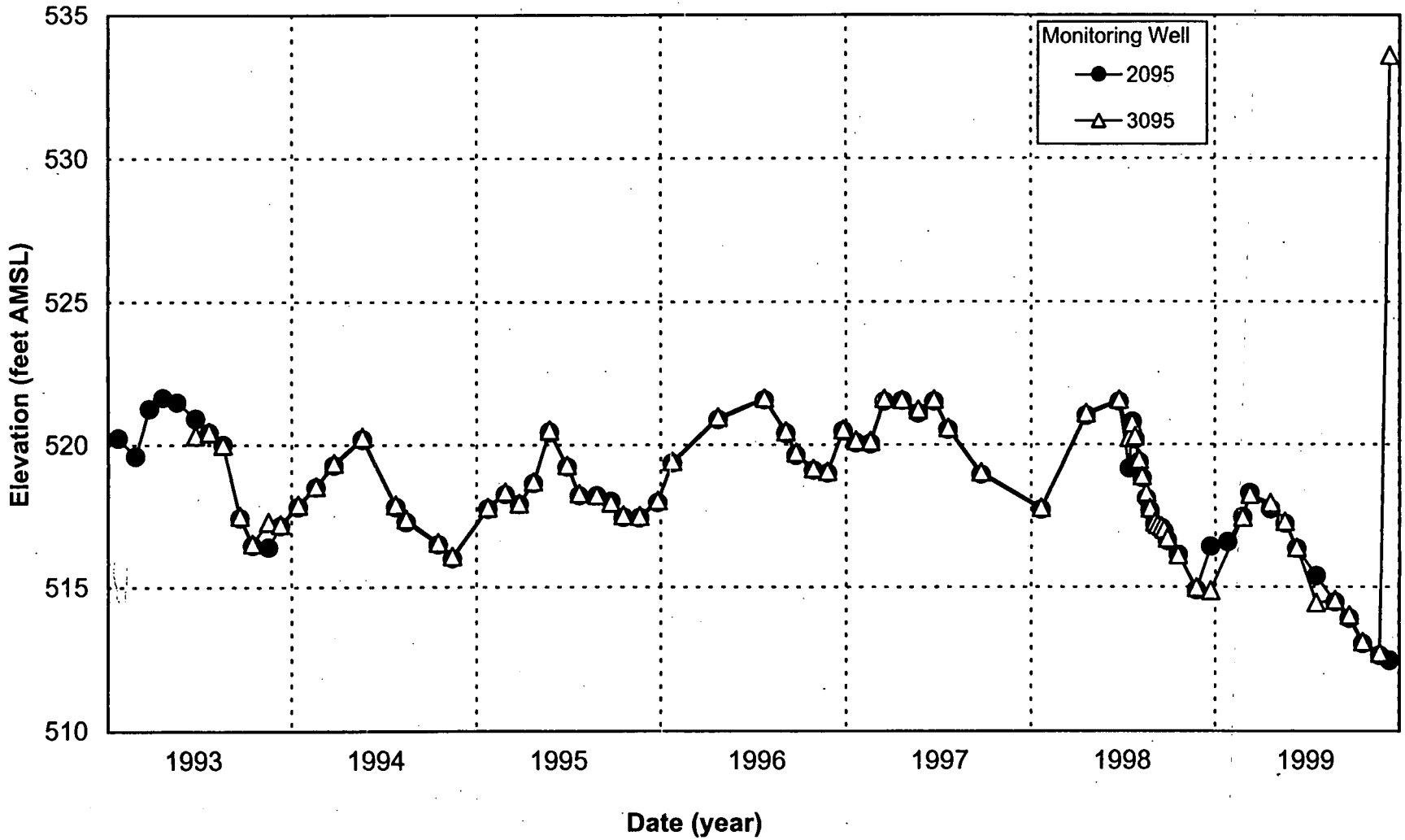



FIGURE A.3-18. HYDROGRAPH FOR WELL CLUSTER 095



000235

0002236

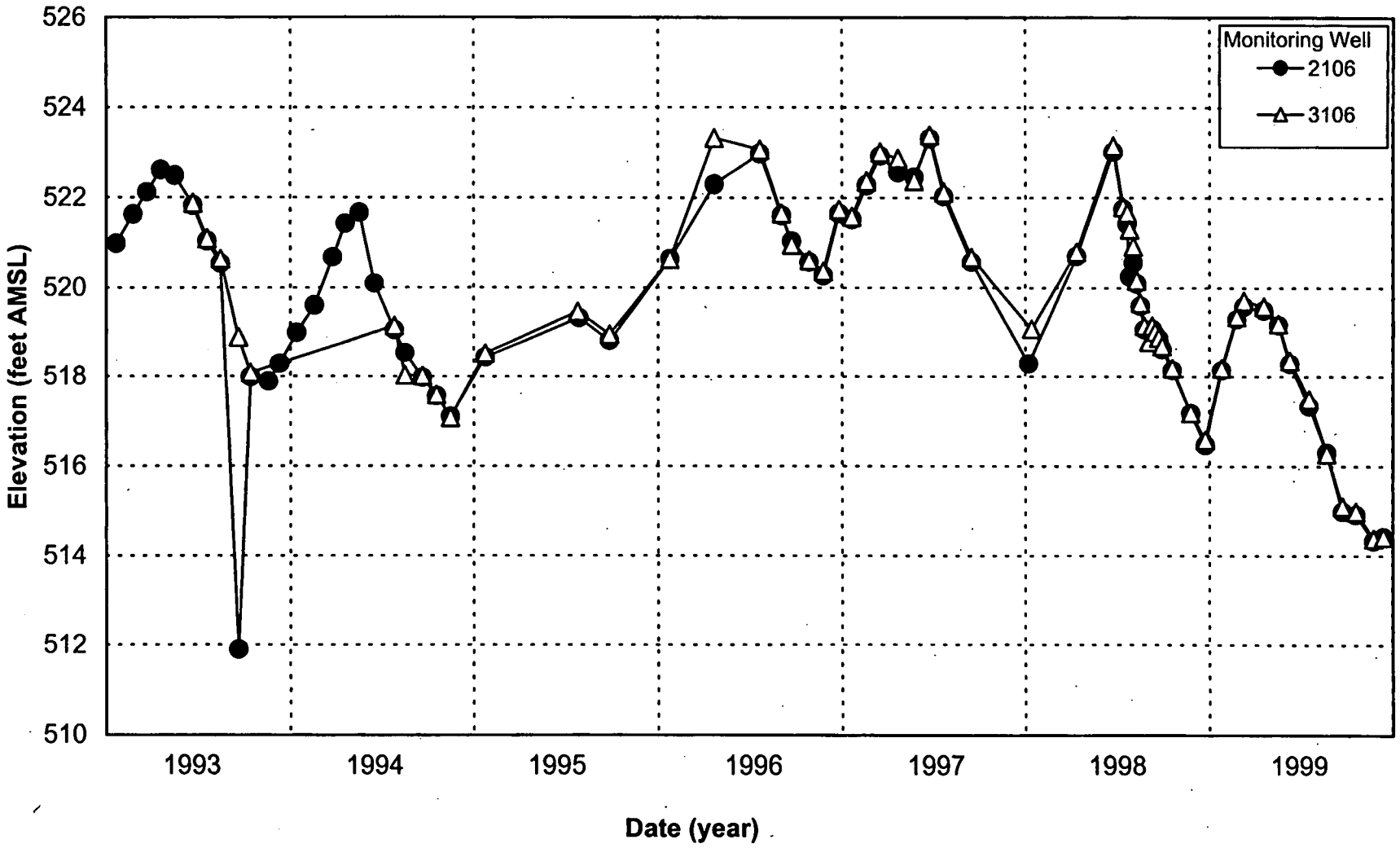



FIGURE A.3-19. HYDROGRAPH FOR WELL CLUSTER 106

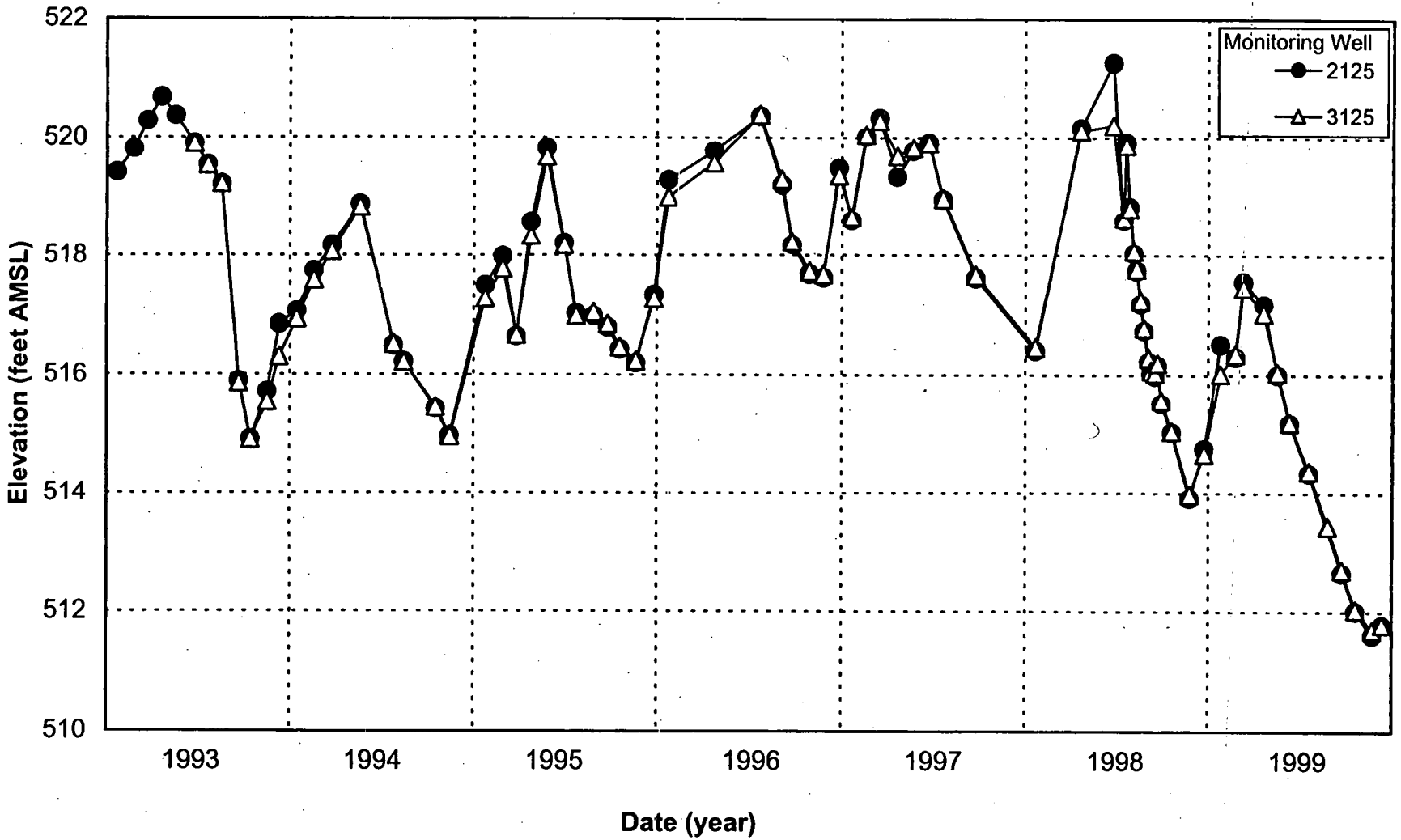



FIGURE A.3-20. HYDROGRAPH FOR WELL CLUSTER 125



000237

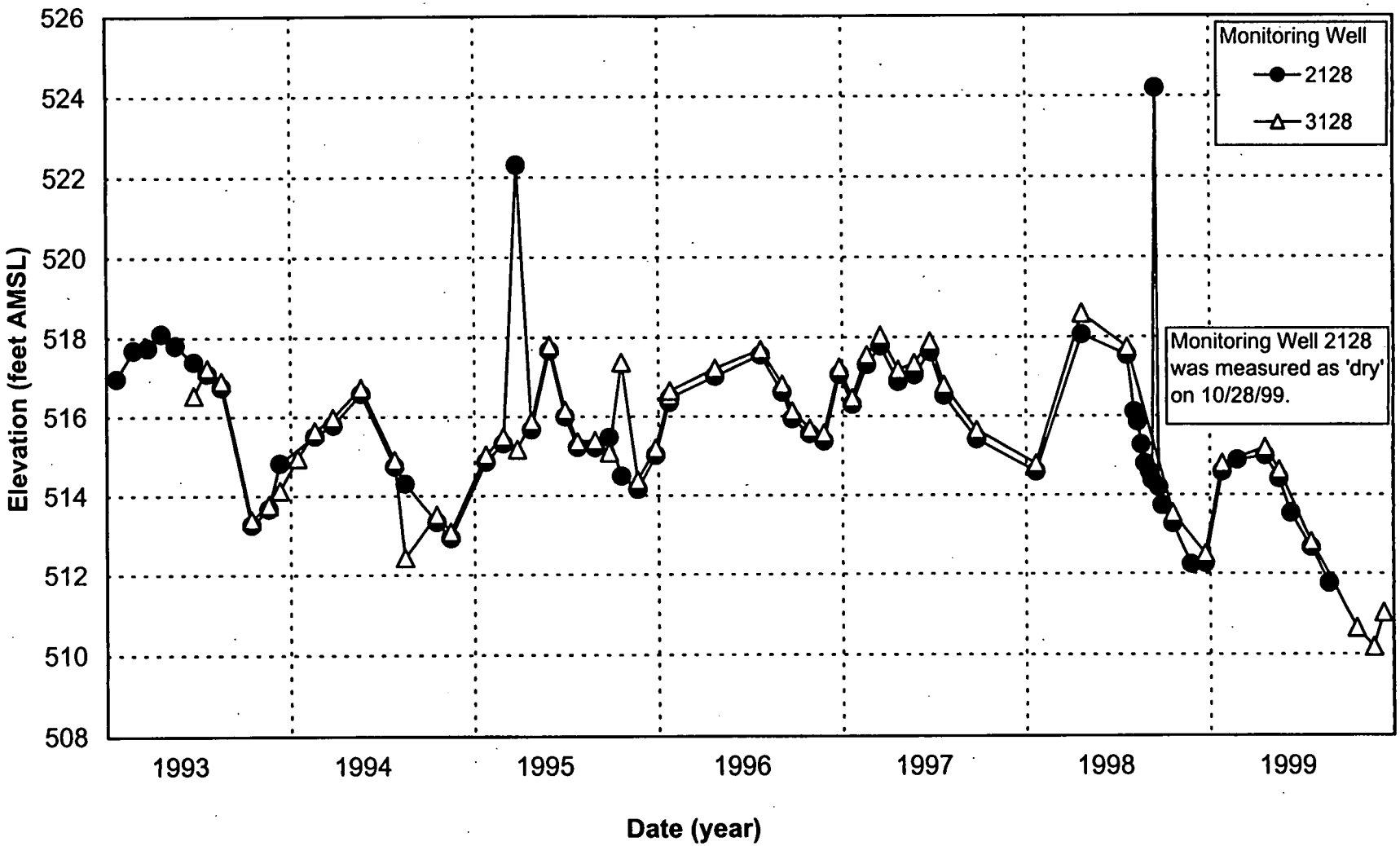



FIGURE A.3-21. HYDROGRAPH FOR WELL CLUSTER 128

000238

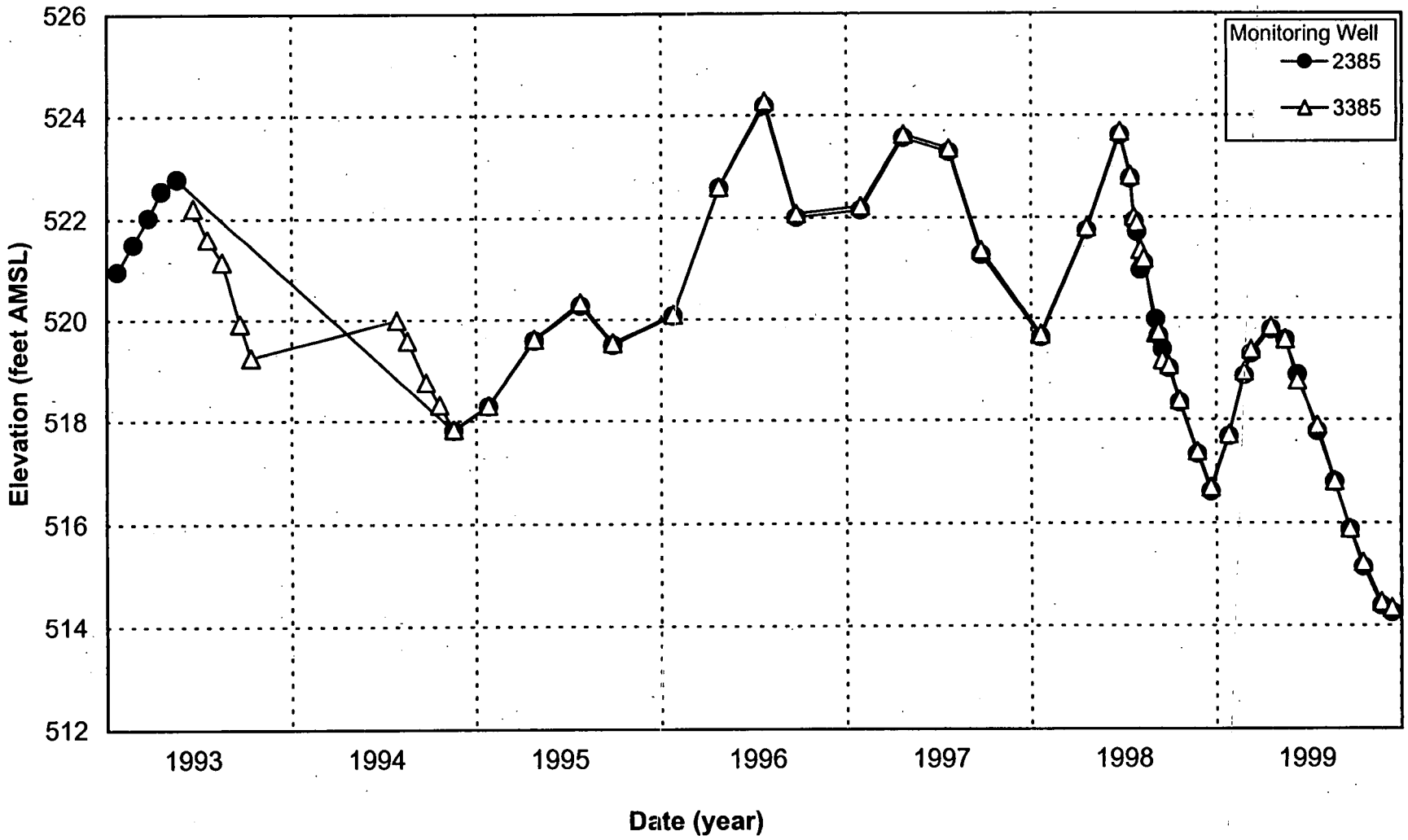



FIGURE A.3-22. HYDROGRAPH FOR WELL CLUSTER 385

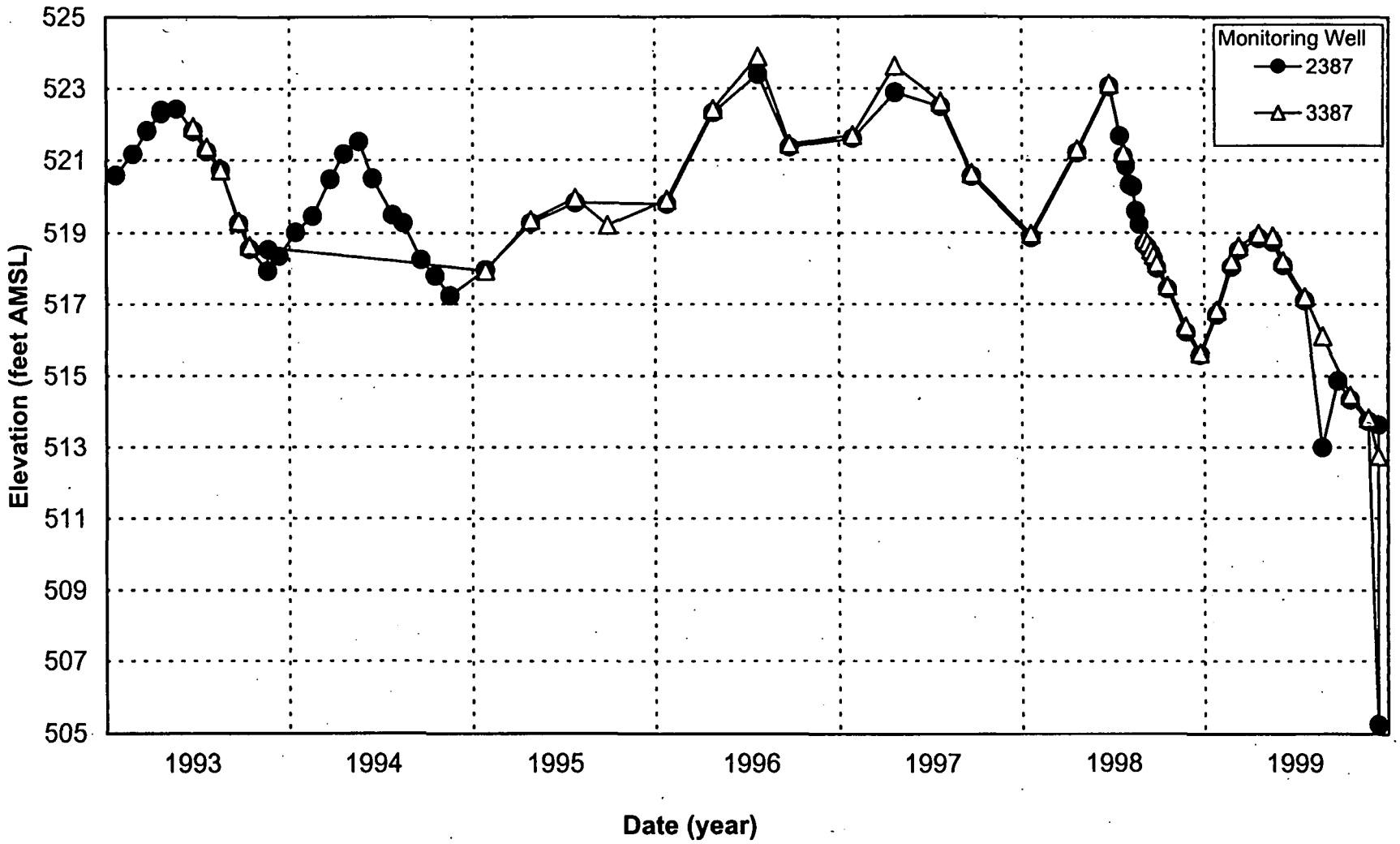



FIGURE A.3-23. HYDROGRAPH FOR WELL CLUSTER 387

000240

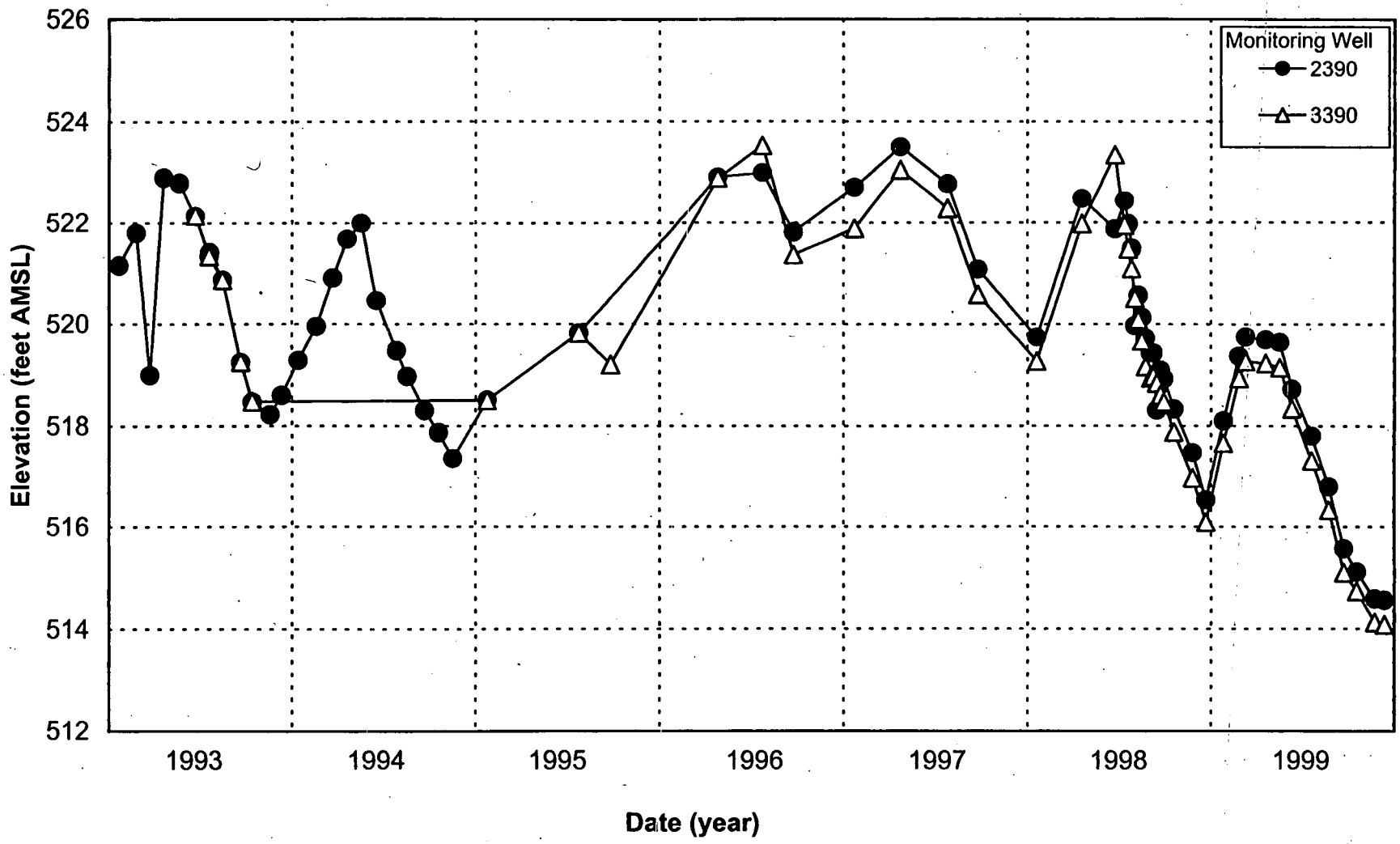



FIGURE A.3-24. HYDROGRAPH FOR WELL CLUSTER 390



000244

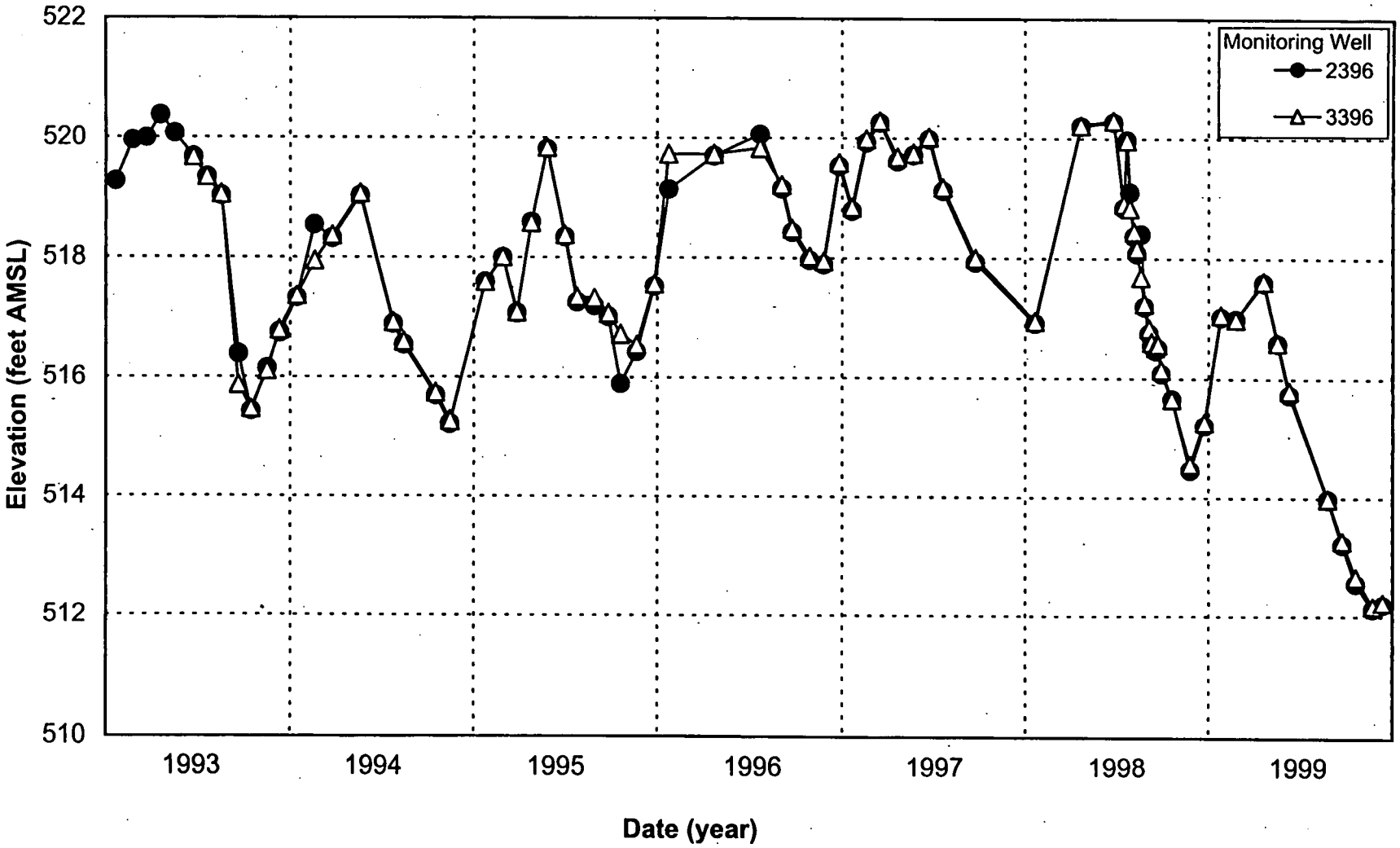



FIGURE A.3-25. HYDROGRAPH FOR WELL CLUSTER 396

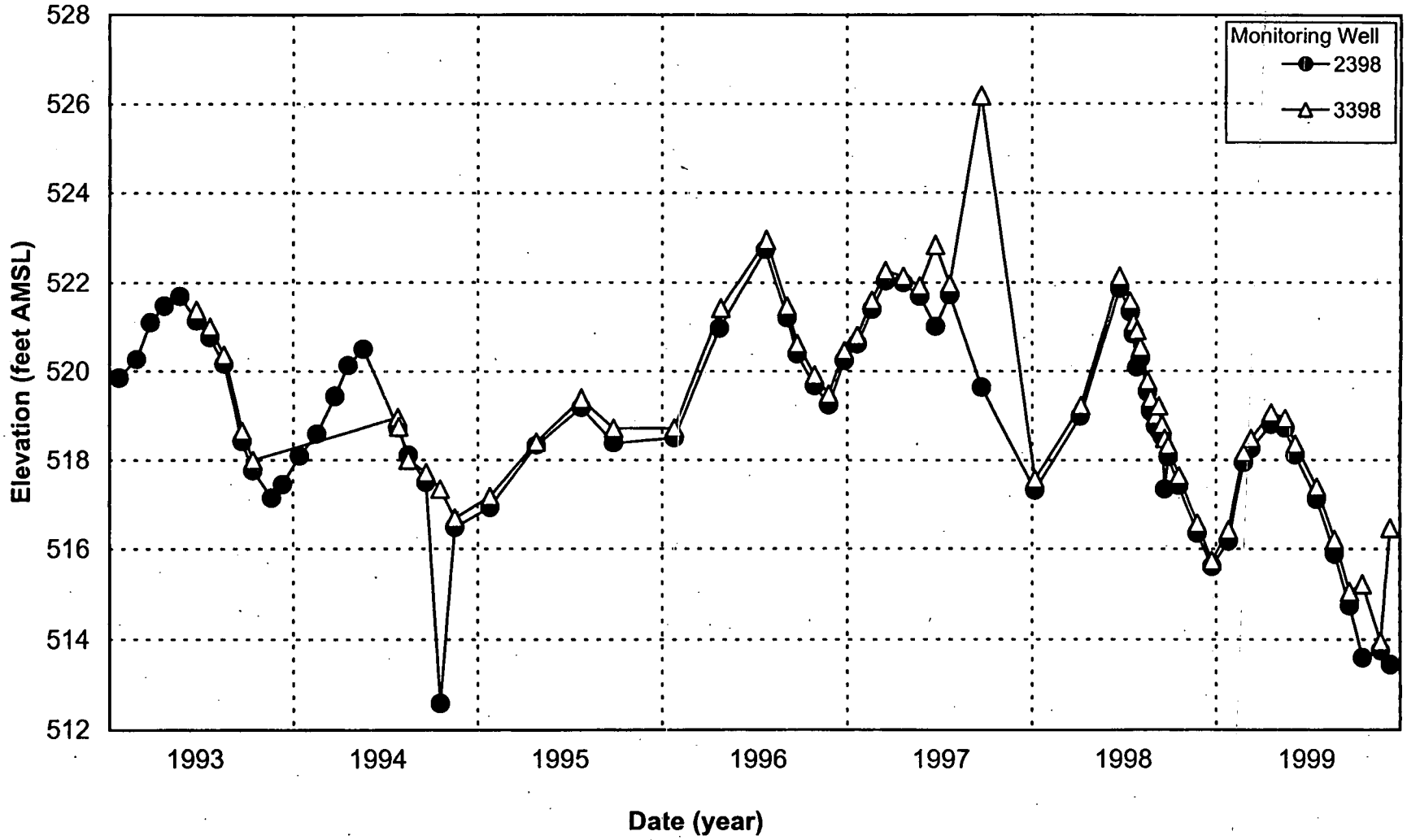



FIGURE A.3-26. HYDROGRAPH FOR WELL CLUSTER 398

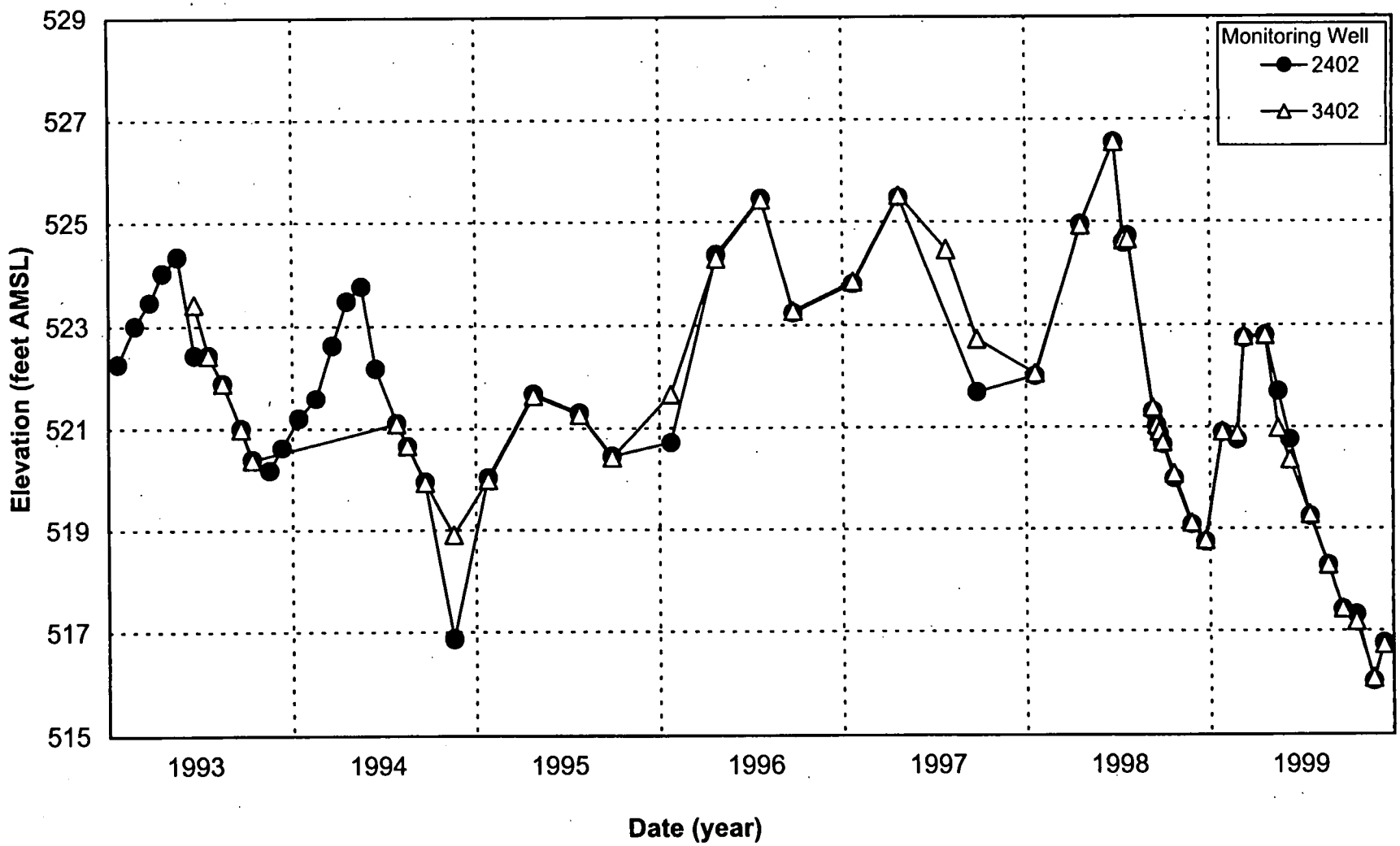



FIGURE A.3-27. HYDROGRAPH FOR WELL CLUSTER 402

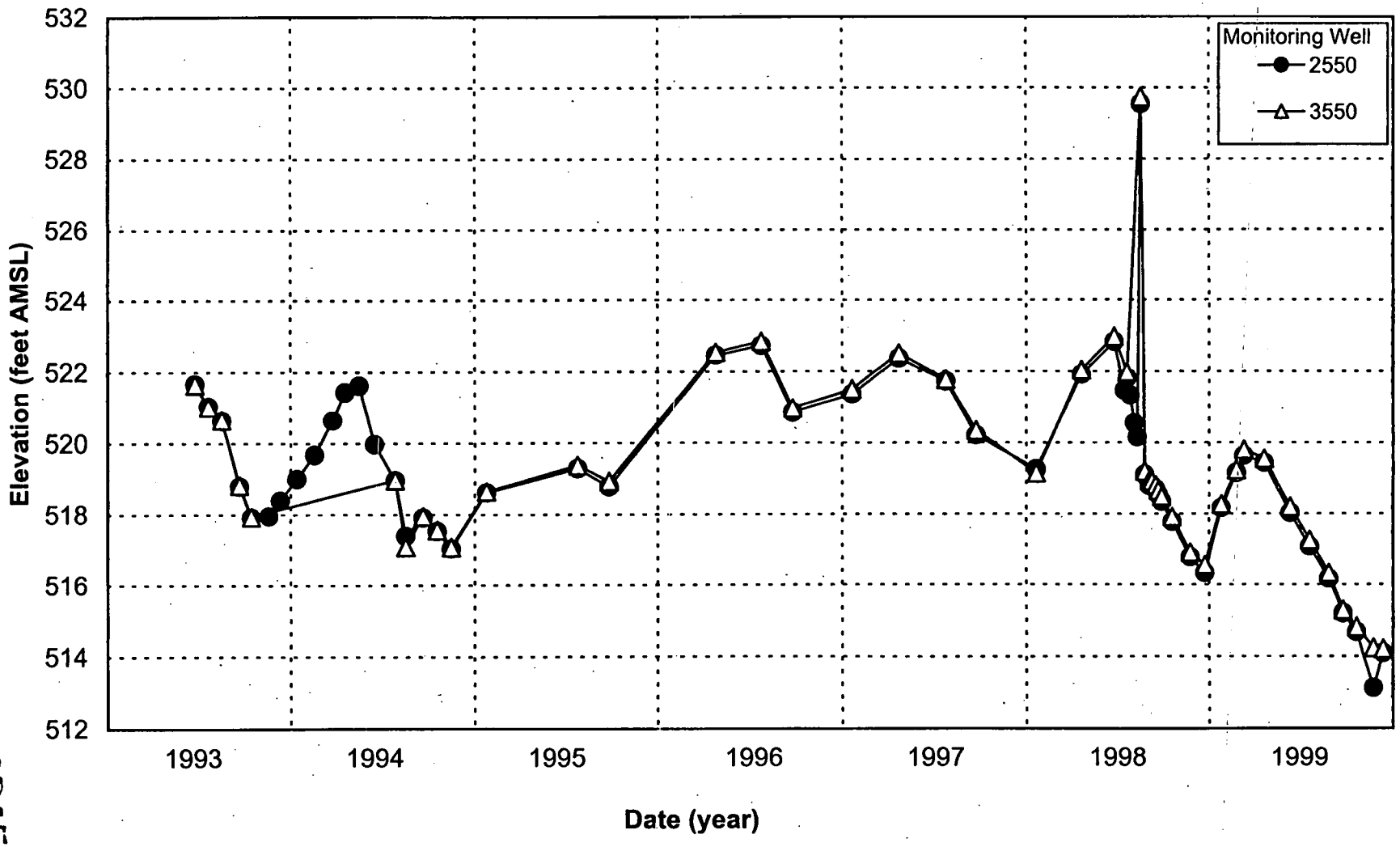



FIGURE A.3-28. HYDROGRAPH FOR WELL CLUSTER 550

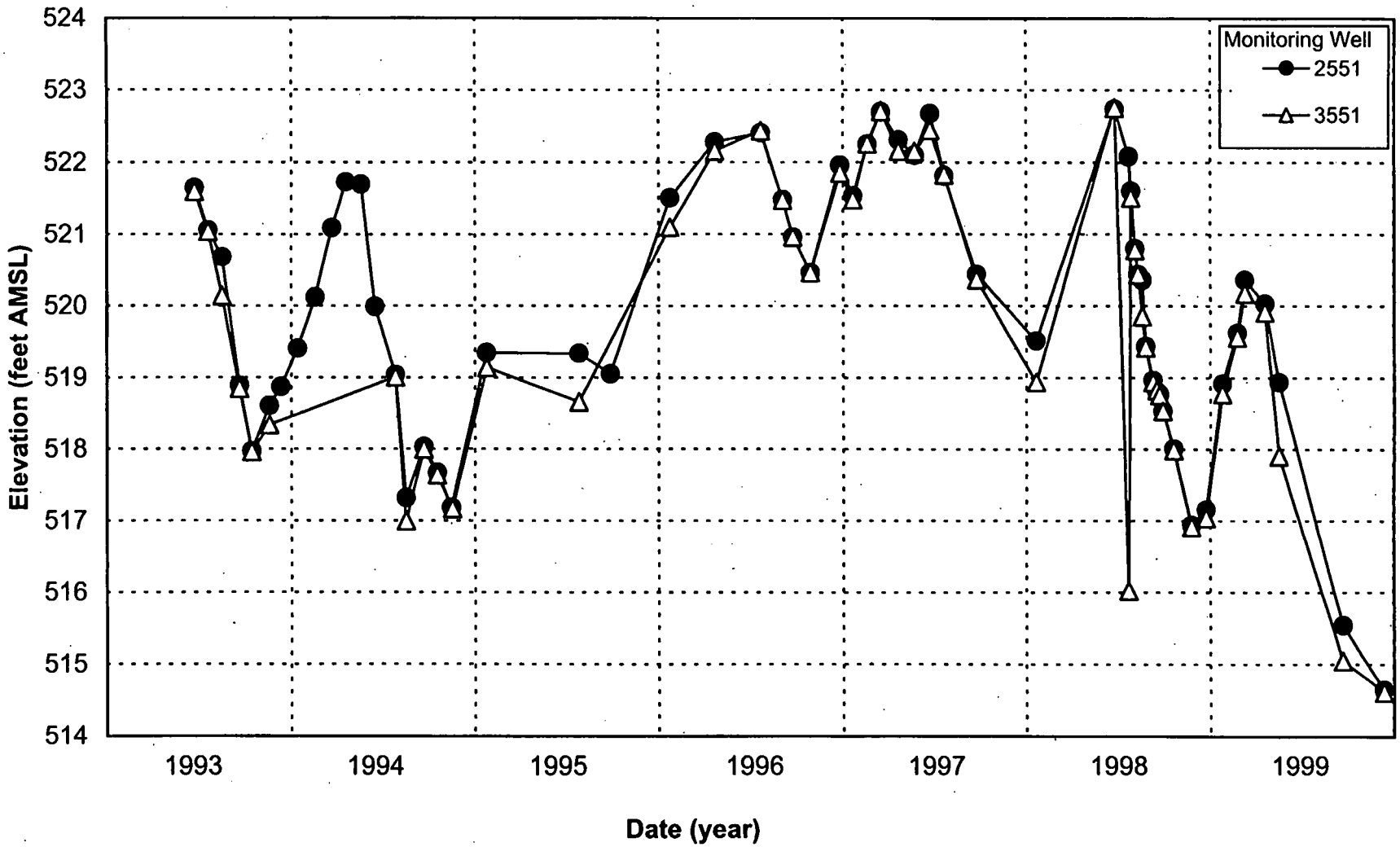



FIGURE A.3-29. HYDROGRAPH FOR WELL CLUSTER 551

000246

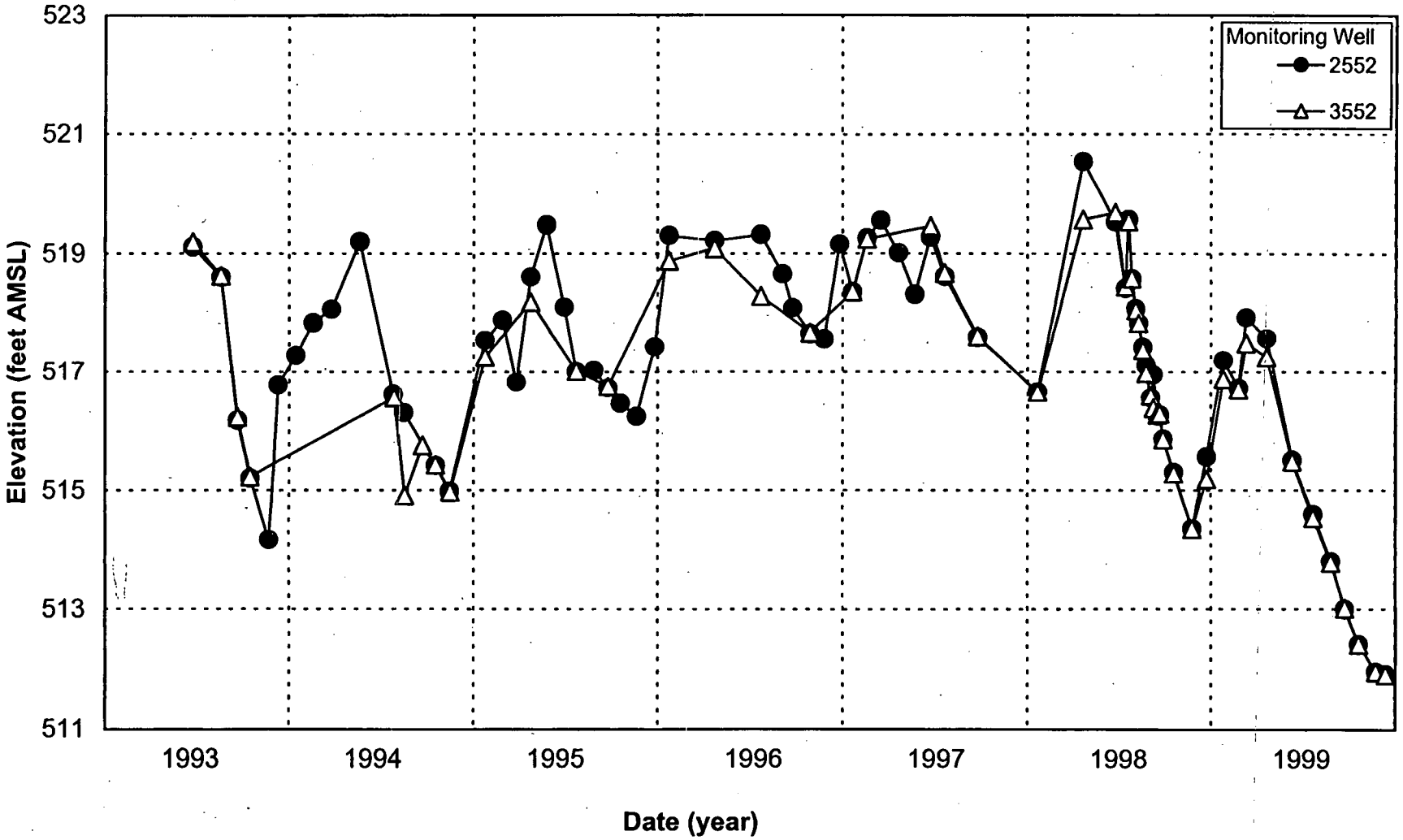



FIGURE A.3-30. HYDROGRAPH FOR WELL CLUSTER 552



000247

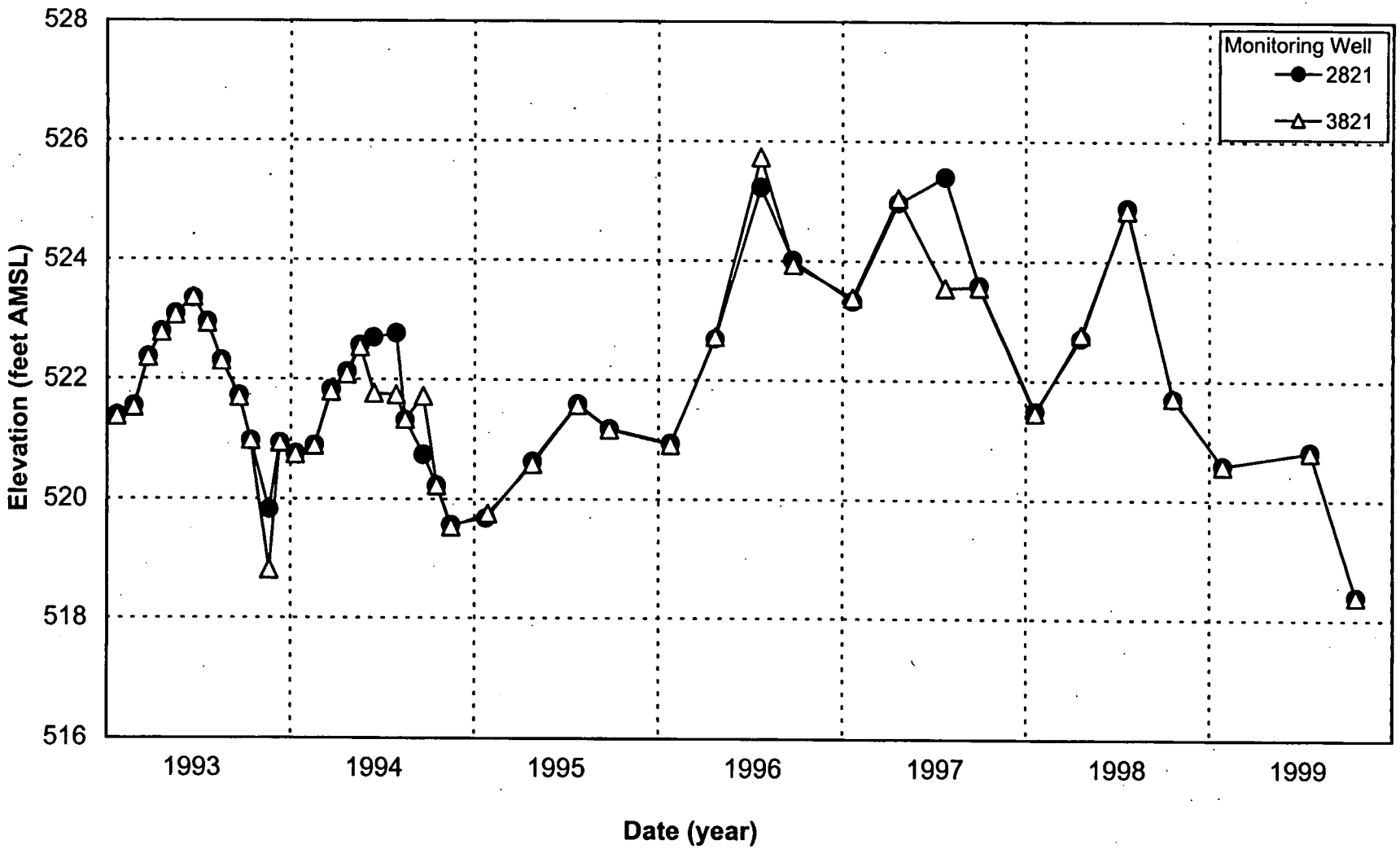



FIGURE A.3-31. HYDROGRAPH FOR WELL CLUSTER 821

000248

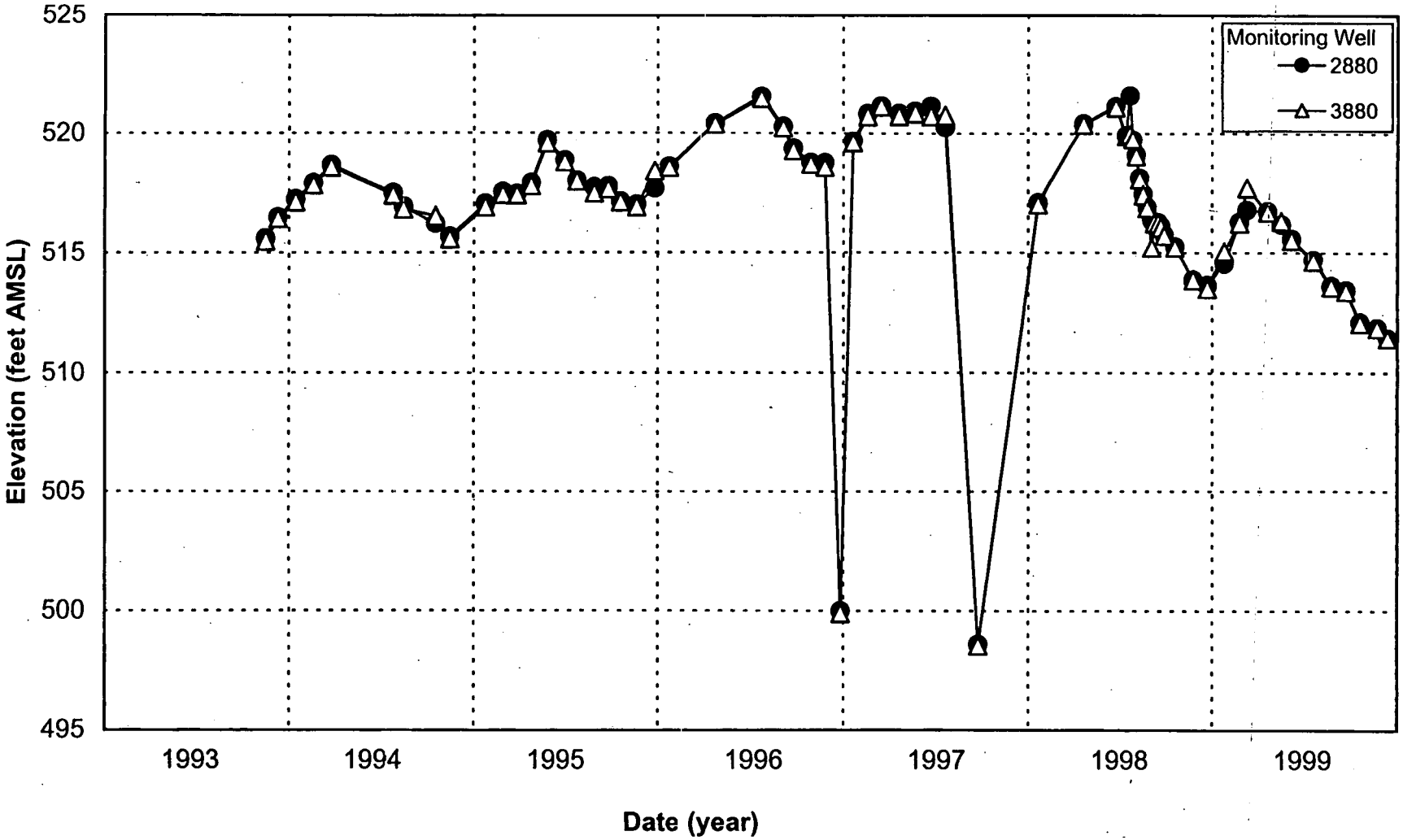



FIGURE A.3-32. HYDROGRAPH FOR WELL CLUSTER 880



0002249

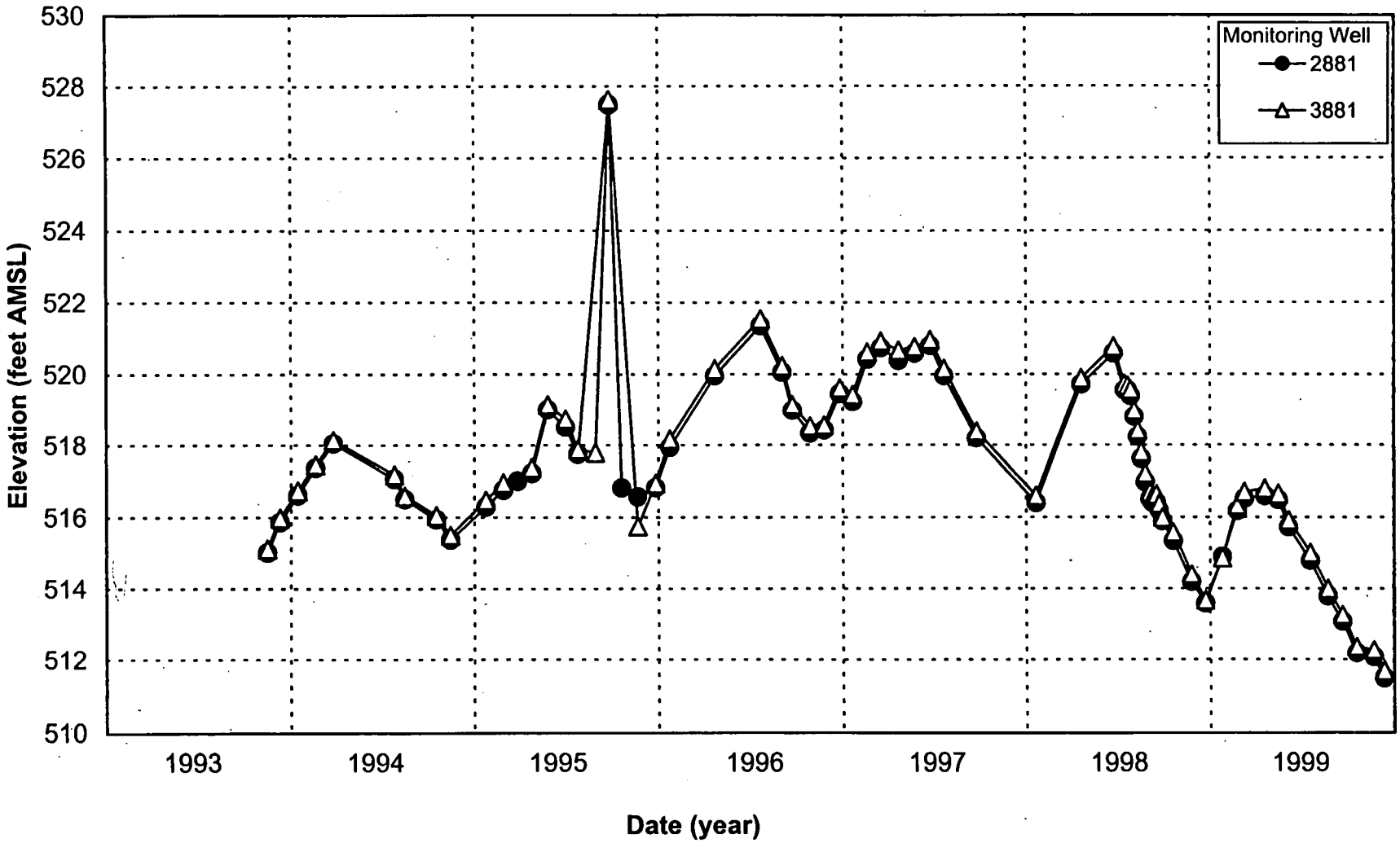



FIGURE A.3-33. HYDROGRAPH FOR WELL CLUSTER 881

002250

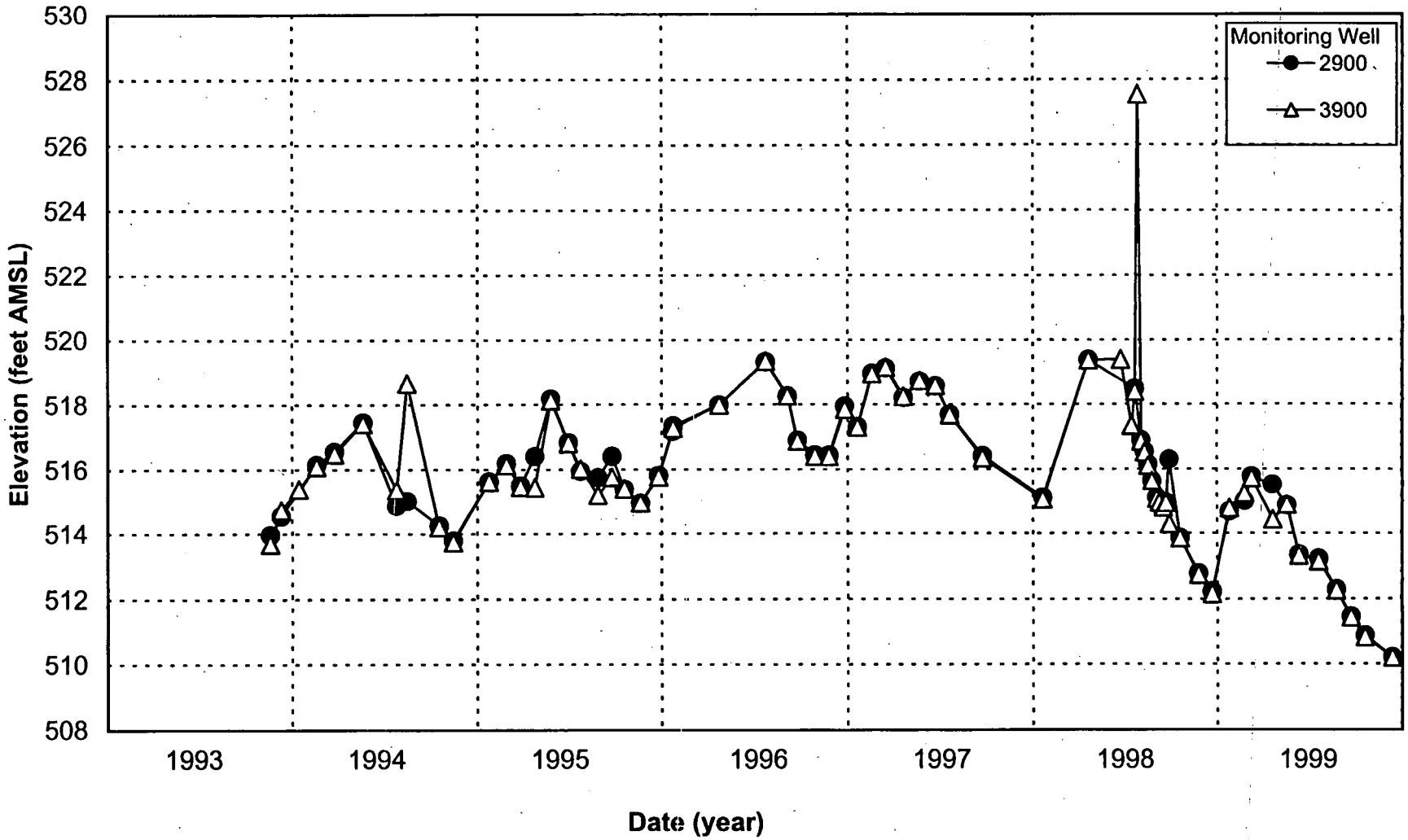



FIGURE A.3-34. HYDROGRAPH FOR WELL CLUSTER 900



000251

# ATTACHMENT A.4

# NON-URANIUM FRL EXCEEDANCES

# ATTACHMENT A.4

3004

This attachment to Appendix A evaluates non-uranium FRL exceedances that occurred in 1999. The purpose of the evaluation is to:

- Determine if 1999 non-uranium FRL exceedances result in the re-categorization of a constituent (Section A.4.1)
- Determine persistence of FRL exceedances outside the 10-year, uranium-based restoration footprint (Section A.4.2)
- Summarize additional studies conducted in 1999 (i.e., identify correlations between specific constituent concentrations) (Section A.4.3)
- Identify conclusions (Section A.4.4).

## A.4.1 RE-CATEGORIZATION OF NON-URANIUM FRL CONSTITUENTS BASED ON 1999 FRL EXCEEDANCES

Each year groundwater data are reviewed and monitoring constituent lists are evaluated to ensure that the sampling frequency for monitored constituents meets the criteria established for the program. The results of these evaluations are used to determine if the constituents should be re-categorized, which might change the monitoring frequency.

### A.4.1.1 Background

Groundwater monitoring under the IEMP focuses on the 50 groundwater FRL constituents listed in the Record of Decision for Remedial Actions at Operable Unit 5 (DOE 1996). A detailed selection process was used to develop lists of constituents for groundwater monitoring of the aquifer restoration remedy. This process is presented in Appendix A of the IEMP, Revision 1.

For the purpose of modeling and monitoring, the aquifer was divided into different zones. A unique monitoring constituent list was initially developed for each zone, based on data collected from the aquifer from 1988 through 1997 and criteria defined in Appendix A of the IEMP, Revision 1.

Constituents were categorized based on whether or not they were mobile and persistent, and whether or not they had been detected above the FRL in the aquifer zone in question. The categories are defined as follows:

- >MP The constituent has been detected in the aquifer at concentrations greater than its established FRL and is considered "Mobile and Persistent". It has been predicted to be able to migrate vertically from the glacial overburden to the aquifer and has already caused an FRL exceedance in the aquifer.

- >N The constituent has been detected in the aquifer at concentrations greater than its established FRL but is "Not considered mobile and persistent". This constituent is not predicted to be able to migrate vertically through the glacial overburden, reach the aquifer, and create an unacceptable risk. Background conditions and/or surface water infiltrations may be the cause of the isolated FRL exceedances noted in the historical record.

- <MP The constituent has not been detected in the aquifer at concentrations greater than its established FRL, but is considered both "Mobile and Persistent". This constituent is predicted to be able to migrate vertically through the glacial overburden to the aquifer (if no source removal/control actions are taken), but as yet has not caused exceedances of its established FRL.

- <N The constituent has not been detected in the aquifer at concentrations greater than its established FRL and is "Not considered mobile and persistent".

If a new exceedance occurs in an aquifer zone for an FRL constituent, then the following criteria would trigger the need to re-categorize the constituent and increase its sampling frequency:

- For a <MP constituent, two consecutive FRL exceedances will result in re-categorization to a >MP constituent for the affected aquifer zone. An evaluation of each specific exceedance will be conducted to determine if re-sampling ahead of schedule is warranted.

- For a <N constituent, two consecutive FRL exceedances will result in re-categorization to a >N constituent for the affected aquifer zone. An evaluation of each specific exceedance will be conducted to determine if re-sampling ahead of schedule is warranted.

A.4.1.2 Evaluation

The criteria presented above were used to evaluate the non-uranium FRL constituents with exceedances in 1999 for re-categorization. Table A.4-1 lists the 1999 non-uranium FRL exceedances both inside and outside the 10-year, uranium-based restoration footprint and Figure A.4-1 identifies the location of these FRL exceedances. In 1999, 10 non-uranium FRL constituents had one or more FRL exceedances (Table A.4-1). As reported in Table A-2 of the IEMP, of the 10 constituents identified in Table A.4-1, six (boron, carbon disulfide, molybdenum, nitrate/nitrite as nitrogen, technetium-99, and trichloroethene)

have a "<" categorization in one or more aquifer zones. Correlation of the locations where the six constituents had exceedances in 1999 with the aquifer zones defined in the IEMP indicate that only one constituent, carbon disulfide, had an FRL exceedance in an aquifer zone where it is currently categorized as "<".

An FRL exceedance for carbon disulfide was detected in 1999 in Monitoring Well 2432. Monitoring Well 2432 is located in Aquifer Zone 0. Carbon disulfide is currently categorized as <N in Aquifer Zone 0. Figure A.4-2 presents the carbon disulfide concentration versus time graph for Monitoring Well 2432. As shown in Figure A.4-2, the exceedance occurred in the first quarter of 1999. Data collected in the second, third, and fourth quarters of 1999 indicate that the carbon disulfide concentration is not above the FRL value of 5.5 μg/L. Therefore, a re-categorization change from <N to >N in Aquifer Zone 0 is not required.

### A.4.2 THE PERSISTENCE OF 1999 NON-URANIUM FRL EXCEEDANCES OUTSIDE THE 10-YEAR, URANIUM-BASED RESTORATION FOOTPRINT

The Restoration Area Verification Sampling Program Summary Report (DOE 1998b) states that any FRL exceedance outside the 10-year, uranium-based restoration footprint at the property boundary during routine monitoring would also be evaluated for persistence. This evaluation is to be performed using the same conservative data evaluation method approved for the Restoration Area Verification Sampling Program, Project-Specific Plan (DOE 1997d) to determine if a change in the aquifer restoration remedy is required. This section presents an evaluation of the persistence of non-uranium FRL exceedances.

#### A.4.2.1 Background

Analytical data from samples collected immediately following an FRL exceedance are evaluated to determine if the detected exceedance is persistent. In accordance with the approved Restoration Area Verification Sampling method, if two or more sampling events following an FRL exceedance indicate that the concentration in question has decreased below the groundwater FRL, then the exceedance is not considered persistent.

If an FRL exceedance detected outside the 10-year, uranium-based restoration footprint is determined to be not persistent, then no additional action is required above and beyond the routine groundwater monitoring specified in the IEMP. If an FRL exceedance is determined to be persistent, then the cause of the persistent exceedance needs to be identified, and its impact on the aquifer remedy design assessed. Ultimately, the cause needs to be addressed either through a modification of the aquifer remedy or by other means as applicable.

Results reported in Appendix A of the Restoration Area Verification Sampling Project-Specific Plan and the Restoration Area Verification Sampling Program Summary Report indicate that no persistent FRL exceedance was identified outside the 10-year, uranium-based restoration footprint. Evaluations for the IEMP began in 1997. In 1997 a persistent FRL exceedance for manganese was identified in Monitoring Wells 2426, 2430, and 2431 and reported in the 1997 Integrated Site Environmental Report (DOE 1998a). For 1998 no persistent FRL exceedances were reported; however, several possible persistent FRL exceedances were identified, but they required additional data to be collected in 1999. The possible persistent FRL exceedances identified in the 1998 Integrated Site Environmental Report are listed below:

- Chromium at Monitoring Wells 2431 and 4067
- Fluoride at Monitoring Wells 2424, 2431, and 4067
- Zinc at Monitoring Wells 2424, 2431, 2434, 4067, and 41217.

The non-uranium FRL exceedances for 1999 along with the possible persistent exceedances for 1998 are addressed below.

A.4.2.2 Evaluation

Figure A.4-1 and Table A.4-1 identify the 1999 FRL exceedances. In 1999, four FRL constituents had one or more FRL exceedances at nine property boundary wells located outside the 10-year, uranium-based restoration footprint, as noted below:

- Carbon disulfide at Monitoring Well 2432
- Manganese at Monitoring Well 2426
- Nickel at Monitoring Well 22198
- Zinc at Monitoring Wells 2424, 2432, 2733, 3426, 3429, 4067, and 4426.

Table A.4-2 provides a summary of the 1999 FRL exceedances that occurred in the property boundary wells outside the 10-year uranium-based restoration footprint. Table A.4-2 also addresses the possible persistent FRL exceedances identified for 1998 in the 1998 Integrated Site Environmental Report. If two or more sampling events immediately following an FRL exceedance indicate that the concentration decreased below the FRL, then the exceedance is identified as not persistent in Table A.4-2. Referring to Table A.4-2, one persistent FRL exceedance was identified (zinc in Monitoring Well 4067 [Figure A.4-19]) outside the 10-year, uranium-based restoration footprint using groundwater data collected in 1999.

The following is a summary of results presented in Table A.4.2:

- The following FRL exceedances detected in 1998 are not persistent, based on 1999 monitoring data:
  - Chromium at Monitoring Wells 2431 and 4067
  - Fluoride at Monitoring Wells 2424, 2431, and 4067
  - Zinc at Monitoring Wells 2424, 2431, 2434, and 41217.
- The following FRL exceedances detected in 1999 are not persistent:
  - Carbon disulfide at Monitoring Well 2432
  - Zinc at Monitoring Wells 2424, 2432, 2733, 3429, and 4426.
- Data collected in 2000 are needed to determine the persistence of the following exceedances detected in 1999:
  - Manganese at Monitoring Well 2426
  - Nickel at Monitoring Well 22198
  - Zinc at Monitoring Well 3426.

Figures A.4-2 (also used for the Section A.4.1 discussion – carbon disulfide in Monitoring Well 2432) and A.4-3 through A.4-18 present individual concentration versus time graphs for all monitoring wells and constituents identified above.

A.4.2.3 Discussion

1999 marks the third year that an evaluation of the persistence of non-uranium FRL exceedances detected in property boundary wells located outside the 10-year, uranium-based restoration footprint has been conducted as part of the IEMP. Evaluating the data for persistence appears to be valuable in tracking changing conditions outside the 10-year, uranium-based restoration footprint. So far the evaluation has resulted in:

- The identification of three persistent manganese FRL exceedances in 1997 at Monitoring Wells 2426, 2430, and 2431. However, the manganese concentration at all three of these wells in 1998 and 1999 was below the manganese FRL concentration of 0.90 mg/L, such that no persistent manganese FRL exceedances were identified for them in either 1998 or 1999.
- The identification of one persistent zinc FRL exceedance in 1999 at Monitoring Well 4067. The zinc concentration at this well increased above the zinc FRL concentration of 0.021 mg/L during the third quarter of 1998, and has remained above the FRL for six consecutive sampling quarters.

As shown in Figure A.4-19, the zinc concentration at Monitoring Well 4067 dramatically increased in July of 1998 to a reported concentration of 13.6 mg/L. Since July of 1998, the concentration has decreased. During the fourth quarter of 1999, the concentration of zinc was estimated (validated with a J qualifier) to be approximately 0.03 mg/L, which is only slightly above the FRL.

Nonetheless, the cause of the elevated zinc concentration at Monitoring Well 4067 is not understood, in light of three possible explanations that have been suggested. Zinc is primarily used to make corrosion-resistant coatings (i.e., galvanizing), it is also a constituent of brass and bronze and used as a white pigment in paint or rubber. Given the depth in the aquifer at which the screen is set in Monitoring Well 4067, and the abrupt appearance of the elevated zinc concentration in samples collected in July of 1998, it is not very probable that the zinc FRL exceedance is due to past production operations at the FEMP. The iron and manganese concentrations at the well appear to be stable, and are not fluctuating with the zinc concentration. If bioaccumulation was taking place, then it is expected that all three metals would be trending similarly. The well itself is composed of stainless steel, and zinc is not a component of stainless steel. Further discussion concerning the persistent zinc exceedance is provided below.

### A.4.3 ADDITIONAL STUDIES

The following subsection provides a discussion on the correlation of iron, manganese, and zinc concentrations in property boundary wells. The commitment to begin this study was identified in the 1997 Integrated Site Environmental Report.

As presented in the previous section, in 1997 a persistent FRL exceedance for manganese was identified in Monitoring Wells 2426, 2430, and 2431. Data collected in 1998 no longer indicated a persistent FRL exceedance at these wells. In 1998 as well as 1999, several monitoring wells had FRL exceedances for zinc, although only one of the exceedances (Monitoring Well 4067) met the criteria for being persistent.

It is theorized that the changes in zinc concentrations could be due to biofouling around well screens, which can lead to bioaccumulation of iron, manganese, and zinc (Cullimore 1993). For this reason, groundwater samples were collected during 1998 and 1999 at the property boundary wells to determine if there is a correlation between iron, manganese, and zinc concentrations.

Figures A.4-20 through A.4-52 are concentration versus sample date plots for iron, manganese, and zinc for each property boundary well. Six wells showed simultaneous (within each well) increases in iron, zinc, and manganese concentrations (Monitoring Wells 2398 [Figure A.4-24], 2431 [Figure A.4-30], 2432 [Figure A.4-31], 2733 [Figure A.4-33], 3069 [Figure A.4-35] and 3106 [Figure A.4-37]) during either

1998 or 1999. The increases were short-lived, with concentrations usually decreasing by the time that the next sample was collected. The simultaneous short-lived increases in these metals support that bioaccumulation could be the cause of these transient FRL exceedances. Sampling for iron, manganese, and zinc will continue to better document the nature of the transient concentration increases.

Four wells (Monitoring Wells 2424 [Figure A.4-26], 3429 [Figure A.4-43], 4067 [Figure A.4-47], and 4426 [Figure A.4-51]) had an increase in zinc during either 1998 or 1999 but no increase in iron or manganese. Additionally, the zinc increases were not one time detects. The pattern is one of a sudden increase (as much as several orders of magnitude) followed by a gradual decrease. All four wells are located along the eastern property boundary, just east of the on-site disposal facility construction site.

Determining the cause of the elevated zinc concentrations in the wells is ongoing. Specifically, sampling results, field readings, and sampling protocols are being re-evaluated. Specifications for dedicated field equipment (QED dedicated equipment) have been checked and the equipment does not contain any brass, bronze, or galvanized steel that might provide a source for zinc; however, sampling procedures are being reviewed to determine if a source for the zinc can be identified. Findings will be reported to EPA and OEPA, as they develop, through the regularly scheduled weekly teleconferences, and will be summarized in the 2000 Integrated Site Environmental Report.

### A.4.4 CONCLUSIONS

From the above sections, the following conclusions can be made from review of the 1999 non-uranium FRL exceedance data:

- Re-categorization of FRL constituents is not required, and the sampling frequency used in 1999 to sample FRL constituents do not need to be changed.
- There is one new persistent FRL exceedance outside the 10-year, uranium-based restoration footprint (zinc in Monitoring Well 4067). A change in the design of the aquifer remedy to address the exceedance is not required at this time
- Work will continue on the issue of why zinc concentrations are fluctuating in the property boundary wells. Groundwater samples will continue to be collected from the property boundary wells and analyzed for iron, manganese, and zinc. Findings will be reported to EPA and OEPA as they develop through the regularly scheduled weekly teleconferences, and will be summarized in the 2000 Integrated Site Environmental Report.

# TABLE A.4-1

## SUMMARY STATISTICS AND TREND ANALYSIS FOR NON-URANIUM CONSTITUENTS WITH 1999 RESULTS ABOVE FINAL REMEDIATION LEVELS

| Constituent (FRL)[a] | Monitoring Well | No. of Samples[b,c,d] | No. of Samples Above FRL[b,c,d] | No. of Samples Above FRL for 1999[c,d] | Minimum[b,c,d,e,f] | Maximum[b,c,d,e,f] | Average[b,c,d,e,f] | Standard Deviation[b,c,d,e,f] | Trend[b,c,d,e,f] |
|---|---|---|---|---|---|---|---|---|---|
| Boron (0.33 mg/L) | | | | | (mg/L) | (mg/L) | (mg/L) | (mg/L) | |
| | 2045 | 10 | 2 | 2 | 0.0434 | 0.666 | 0.199 | 0.198 | **Up, Significant** |
| | 2049 | 10 | 8 | 4 | 0.154 | 1.16 | 0.663 | 0.348 | No Significant Trend |
| Carbon disulfide (5.5 µg/L) | | | | | (µg/L) | (µg/L) | (µg/L) | (µg/L) | |
| | 2027 | 6 | 2 | 1 | 0.3 | 10 | 5 | 4 | No Significant Trend |
| | 2432 | 26 | 1 | 1 | 0.5 | 6 | 1.7 | 1.7 | No Significant Trend |
| | 3821 | 7 | 1 | 1 | 0.3 | 14 | 5 | 4.5 | No Significant Trend |
| Lead (0.015 mg/L) | | | | | (mg/L) | (mg/L) | (mg/L) | (mg/L) | |
| | 3045 | 4 | 2 | 1 | 0.00021 | 0.0268 | 0.013 | 0.014 | No Significant Trend |
| | 3387 | 4 | 2 | 1 | 0.002 | 0.0437 | 0.02 | 0.018 | No Significant Trend |
| Manganese (0.90 mg/L) | 2118 | 4 | 1 | 1 | 0.209 | 1.15 | 0.741 | 0.391 | **Up, Significant** |
| | 2385 | 4 | 3 | 1 | 0.384 | 9.15 | 2.92 | 4.17 | No Significant Trend |
| | 2389 | 4 | 1 | 1 | 0.241 | 0.973 | 0.471 | 0.337 | No Significant Trend |
| | 2426 | 26 | 7 | 1 | 0.326 | 4.55 | 1.03 | 0.991 | **Up, Significant** |
| | 2648 | 6 | 4 | 1 | 0.566 | 2.93 | 1.63 | 0.949 | No Significant Trend |
| | 3027 | 4 | 4 | 1 | 1.29 | 1.69 | 1.49 | 0.228 | No Significant Trend |
| | 3045 | 5 | 2 | 1 | 0.0257 | 5.23 | 1.33 | 2.23 | No Significant Trend |
| | 3387 | 4 | 2 | 1 | 0.406 | 3.41 | 1.63 | 1.35 | No Significant Trend |
| | 3821 | 4 | 1 | 1 | 0.706 | 2.85 | 1.27 | 1.05 | No Significant Trend |
| Molybdenum (0.10 mg/L) | 2649 | 5 | 5 | 1 | 0.359 | 0.69 | 0.52 | 0.13 | No Significant Trend |
| Nickel (0.10 mg/L) | 22198 | 11 | 1 | 1 | 0.00025 | 0.13 | 0.015 | 0.038 | No Significant Trend |
| | 2386 | 5 | 2 | 1 | 0.0095 | 1.42 | 0.35 | 0.60 | **Up, Significant** |
| | 2387 | 4 | 2 | 1 | 0.0095 | 0.972 | 0.30 | 0.46 | **Up, Significant** |
| | 2398 | 27 | 11 | 2 | 0.003 | 0.791 | 0.11 | 0.16 | **Up, Significant** |
| | 4398 | 26 | 1 | 1 | 0.00016 | 0.101[g] | 0.0086 | 0.019 | Down, Significant |
| Nitrate/Nitrite (11 mg/L)[h] | | | | | | | | | |
| | 2648 | 6 | 3 | 1 | 0.15 | 20 | 9.4 | 9.2 | No Significant Trend |
| | 2649 | 6 | 6 | 2 | 29.1 | 73.6 | 44.3 | 15.7 | Down, Marginal |
| | 2821 | 6 | 1 | 1 | 1.9 | 13.6 | 6.1 | 4.3 | No Significant Trend |
| Technetium-99 (94 pCi/L) | | | | | (pCi/L) | (pCi/L) | (pCi/L) | (pCi/L) | |
| | 2648 | 6 | 1 | 1 | 1.9535 | 369.726 | 80.0464 | 142.341 | No Significant Trend |
| | 2649 | 5 | 5 | 2 | 130.587 | 1352.27 | 844.770 | 545.318 | No Significant Trend |
| | 2821 | 5 | 1 | 1 | 10.132 | 166.342 | 56.3500 | 62.4315 | No Significant Trend |
| Trichloroethene (5.0 µg/L) | | | | | (µg/L) | (µg/L) | (µg/L) | (µg/L) | |
| | 2649 | 6 | 5 | 1 | 0.5 | 150 | 100 | 50 | No Significant Trend |
| | 3009 | 4 | 1 | 1 | 0.5 | 20.7 | 7 | 10 | No Significant Trend |
| Zinc (0.021 mg/L) | | | | | (mg/L) | (mg/L) | (mg/L) | (mg/L) | |
| | 2424 | 27 | 8 | 1 | 0.00065 | 0.239 | 0.025 | 0.048 | No Significant Trend |
| | 2432 | 26 | 2 | 1 | 0.0008 | 0.114 | 0.01 | 0.02 | Down, Significant |
| | 2733 | 25 | 3 | 1 | 0.00135 | 0.152 | 0.0148 | 0.0306 | Down, Significant |



000250

## Table A.4-1
## (Continued)

| Constituent (FRL)[a] | Monitoring Well | No. of Samples[b,c,d] | No. of Samples Above FRL[b,c,d] | No. of Samples Above FRL for 1999[c,d] | Minimum[b,c,d,e,f] | Maximum[b,c,d,e,f] | Average[b,c,d,e,f] | Standard Deviation[b,c,d,e,f] | Trend[b,c,d,e,f] |
|---|---|---|---|---|---|---|---|---|---|
| Zinc (Continued) | 3045 | 4 | 2 | 1 | 0.0052 | 0.367 | 0.12 | 0.17 | No Significant Trend |
| | 3069 | 26 | 1 | 1 | 0.00055 | 0.0265 | 0.0050 | 0.0059 | Down, Significant |
| | 3385 | 4 | 3 | 1 | 0.014 | 0.0656 | 0.0389 | 0.0249 | No Significant Trend |
| | 3387 | 4 | 3 | 1 | 0.0121 | 0.162 | 0.0676 | 0.0658 | No Significant Trend |
| | 3426 | 24 | 4 | 2 | 0.0013 | 0.0699 | 0.011 | 0.015 | No Significant Trend |
| | 3429 | 25 | 2 | 2 | 0.00065 | 1.11 | 0.050 | 0.22 | No Significant Trend |
| | 4067 | 27 | 6 | 4 | 0.00085 | 13.6 | 0.53 | 2.6 | **Up, Significant** |
| | 4426 | 26 | 2 | 1 | 0.00029 | 0.0389 | 0.0066 | 0.0085 | No Significant Trend |

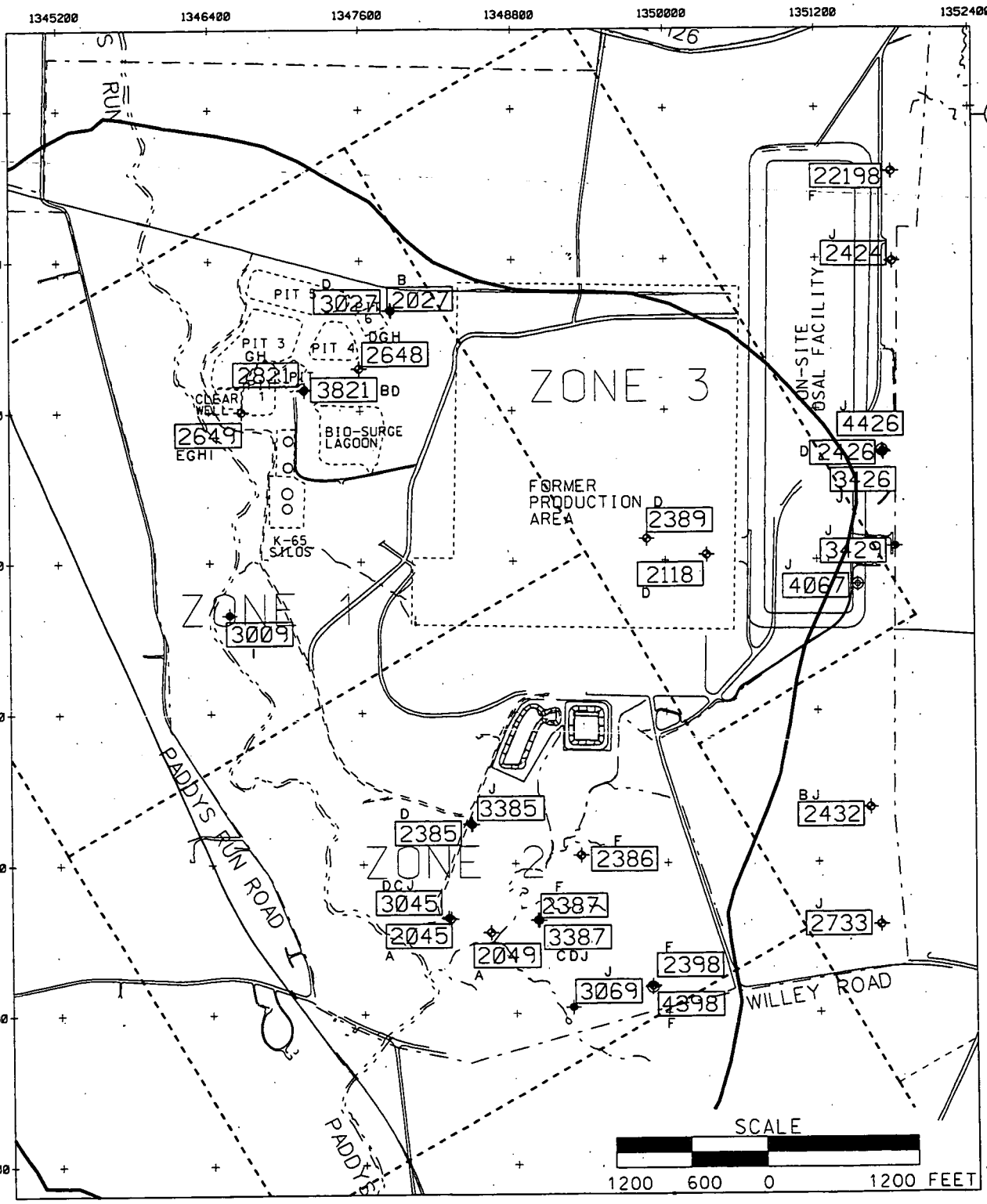
Note: Highlighting indicates well is outside the 10-year, uranium-based restoration footprint.

[a]From Operable Unit 5 Record of Decision, Table 9-4
[b]Based on unfiltered samples from the Operable Unit 5 remedial investigation/feasibility study data set (1988 through 1993) and 1994 through 1999
[c]If more than one sample is collected per well per day (e.g., duplicate), then only one sample is counted for the total number of samples, and the sample with the maximum concentration is used for determining the summary statistics (minimum, maximum, average, and standard deviation [SD]) and Mann-Kendall test for trend.
[d]Rejected data qualified with either a R or Z were not included in the count, the summary statistics, or Mann-Kendall test for trend.
[e]If the number of samples is greater than or equal to four, then the Mann-Kendall test for trend and all of the summary statistics are reported. If the total number of samples is equal to three, then the minimum, maximum, and average are reported. If the total number of samples is equal to two, then the minimum and maximum are reported. If the total number of samples is equal to one, then the data point is reported as the minimum.
[f]For results where the concentrations are below the detection limit, the results used in the summary statistics and Mann-Kendall test for trend are each set at half the detection limit.
[g]This report (sampled 1/6/99) appears to be an outlier. It is suspected that the sample for this well was switched with the duplicate sample for Monitoring Well 2398.
[h]FRL based on nitrate, from Operable Unit 5 Record of Decision, Table 9-4

## TABLE A.4-2

## SUMMARY OF PERSISTENCE EVALUATION OF NON-URANIUM FRL EXCEEDANCES OUTSIDE THE 10-YEAR, URANIUM-BASED RESTORATION FOOTPRINT

| Constituent | Monitoring Well | Pertinent 1998 Results | 1999 FRL Exceedance First Qtr | Second Qtr | Third Qtr | Fourth Qtr | Evaluation Results for 1999 | Figure No. |
|---|---|---|---|---|---|---|---|---|
| Carbon Disulfide | 2432 | | Y | N | N | N | Not Persistent | A.4-2 |
| Chromium | 2431 | Fourth Quarter FRL Exceedance | N | N | N | N | Not Persistent | A.4-3 |
| | 4067 | Third Quarter FRL Exceedance | N | N | N | N | Not Persistent | A.4-4 |
| Fluoride | 2424 | Fourth Quarter FRL Exceedance | N | N | N | N | Not Persistent | A.4-5 |
| | 2431 | Fourth Quarter FRL Exceedance | N | N | N | N | Not Persistent | A.4-6 |
| | 4067 | Fourth Quarter FRL Exceedance | N | N | N | N | Not Persistent | A.4-7 |
| Manganese | 2426 | | N | N | Y | N | Additional Data Required | A.4-16 |
| Nickel | 22198 | | N | N | N | Y | Additional Data Required | A.4-17 |
| Zinc | 2424 | Third and Fourth Quarter FRL Exceedance | Y | Y | N | N | Not Persistent | A.4-8 |
| | 2431 | Third and Fourth Quarter FRL Exceedance | N | N | N | N | Not Persistent | A.4-9 |
| | 2432 | | Y | N | N | N | Not Persistent | A.4-12 |
| | 2434 | Fourth Quarter FRL Exceedance | N | N | N | N | Not Persistent | A.4-10 |
| | 2733 | | N | Y | N | N | Not Persistent | A.4-13 |
| | 3426 | | N | Y | N | Y | Additional Data Required | A.4-18 |
| | 3429 | | Y | N | N | N | Not Persistent | A.4-14 |
| | 4067 | Third and Fourth Quarter FRL Exceedance | Y | Y | Y | Y | Persistent | A.4-19 |
| | 4426 | | N | Y | N | N | Not Persistent | A.4-15 |
| | 41217 | Third Quarter FRL Exceedance | N | N | N | N | Not Persistent | A.4-11 |




LEGEND:

- FEMP BOUNDARY
- MONITORING WELL LOCATIONS WITH FRL EXCEEDANCE
- 10-YEAR, URANIUM-BASED RESTORATION FOOTPRINT
- AQUIFER ZONE BOUNDARY

FRL EXCEEDANCE KEY:

- A BORON
- B CARBON DISULFIDE
- C LEAD
- D MANGANESE
- E MOLYBDENUM
- F NICKEL
- G NITRATE/NITRITE
- H TECHNETIUM-99
- I TRICHLOROETHENE
- J ZINC

STATE PLANAR COORDINATE SYSTEM 1983

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FIGURE A.4-1. NON-URANIUM CONSTITUENTS WITH 1999 RESULTS ABOVE FINAL REMEDIATION LEVELS

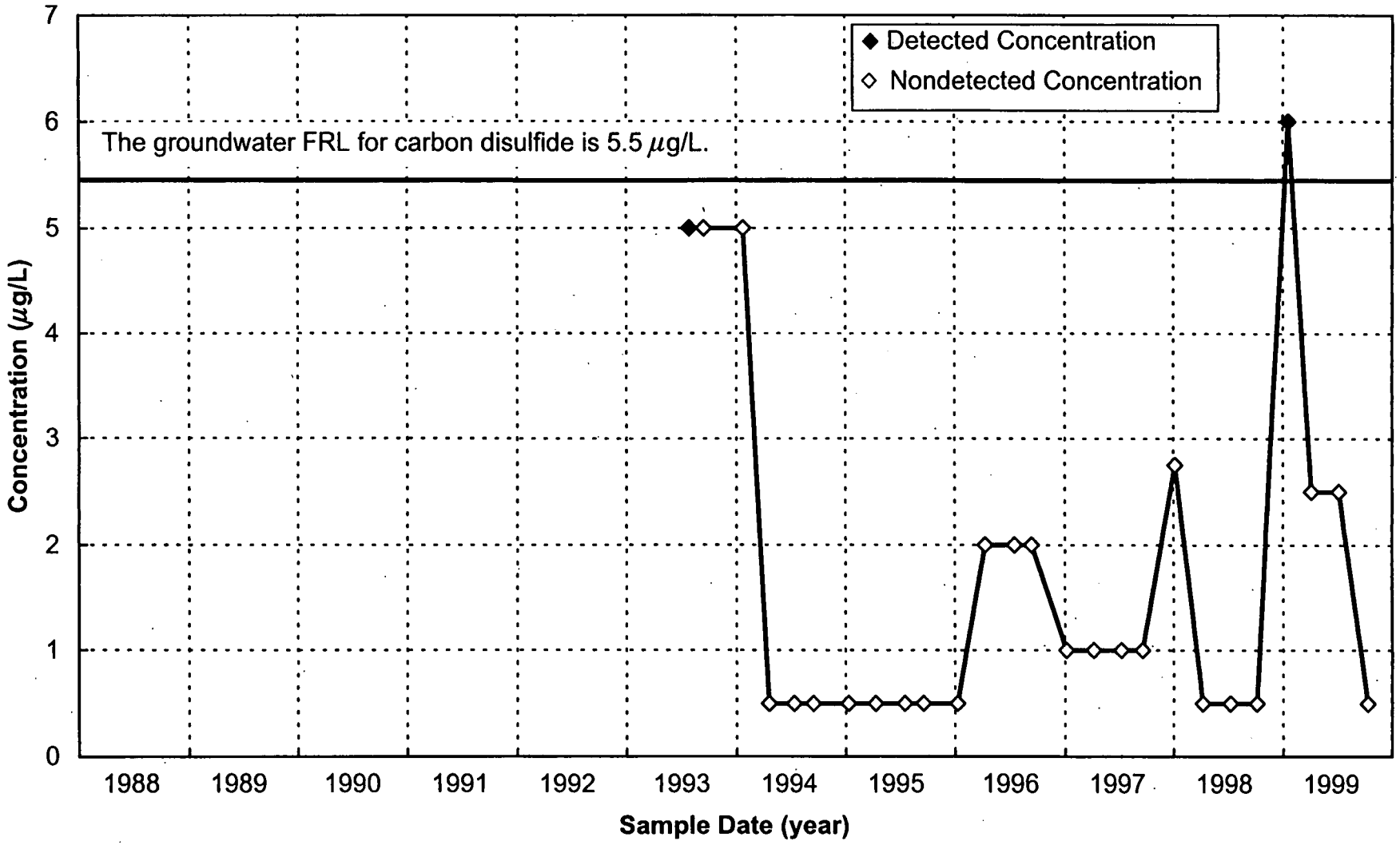


FIGURE A.4-2. CARBON DISULFIDE CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2432

000264

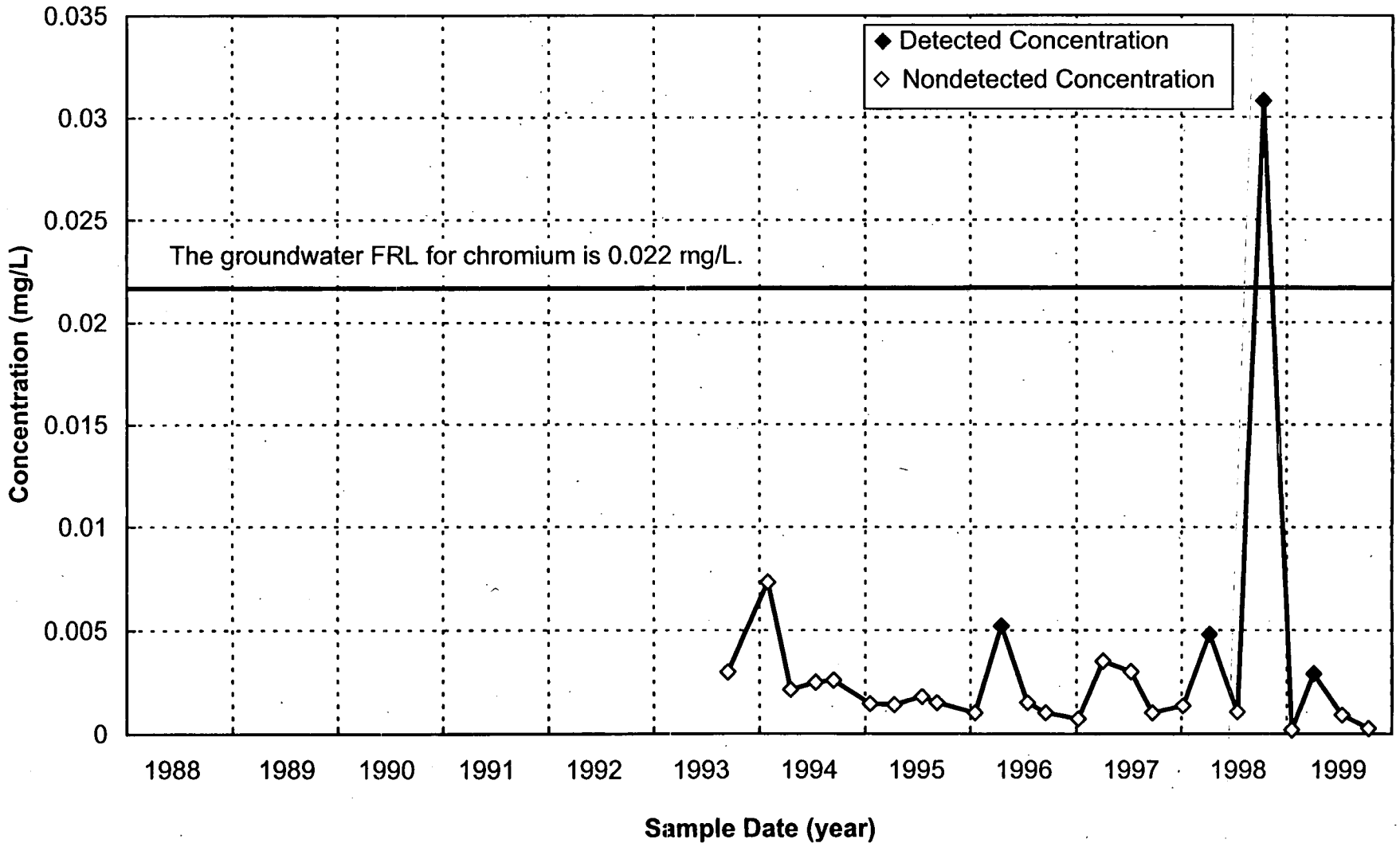


FIGURE A.4-3. CHROMIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2431



0002655

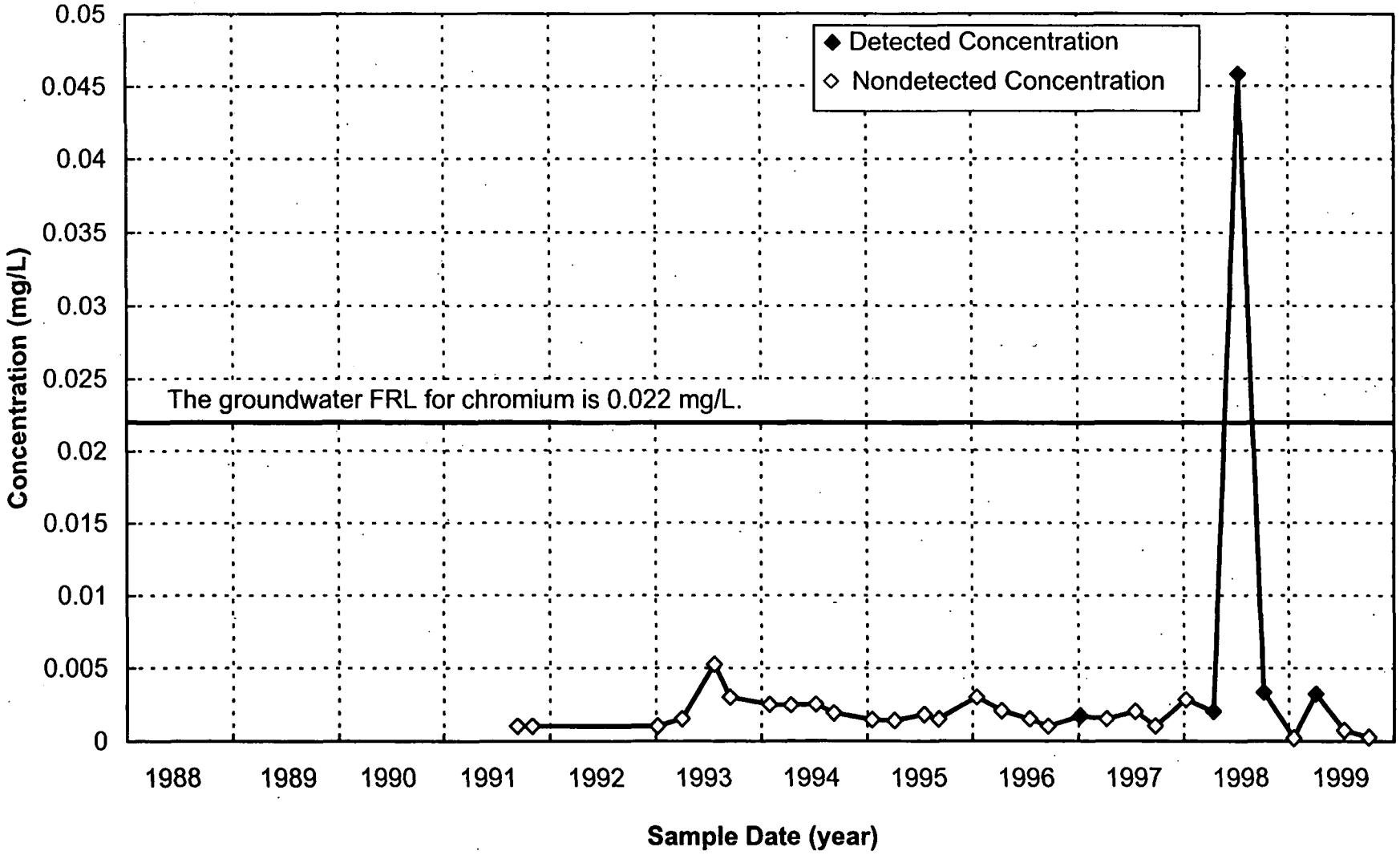


FIGURE A.4-4. CHROMIUM CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 4067

000236

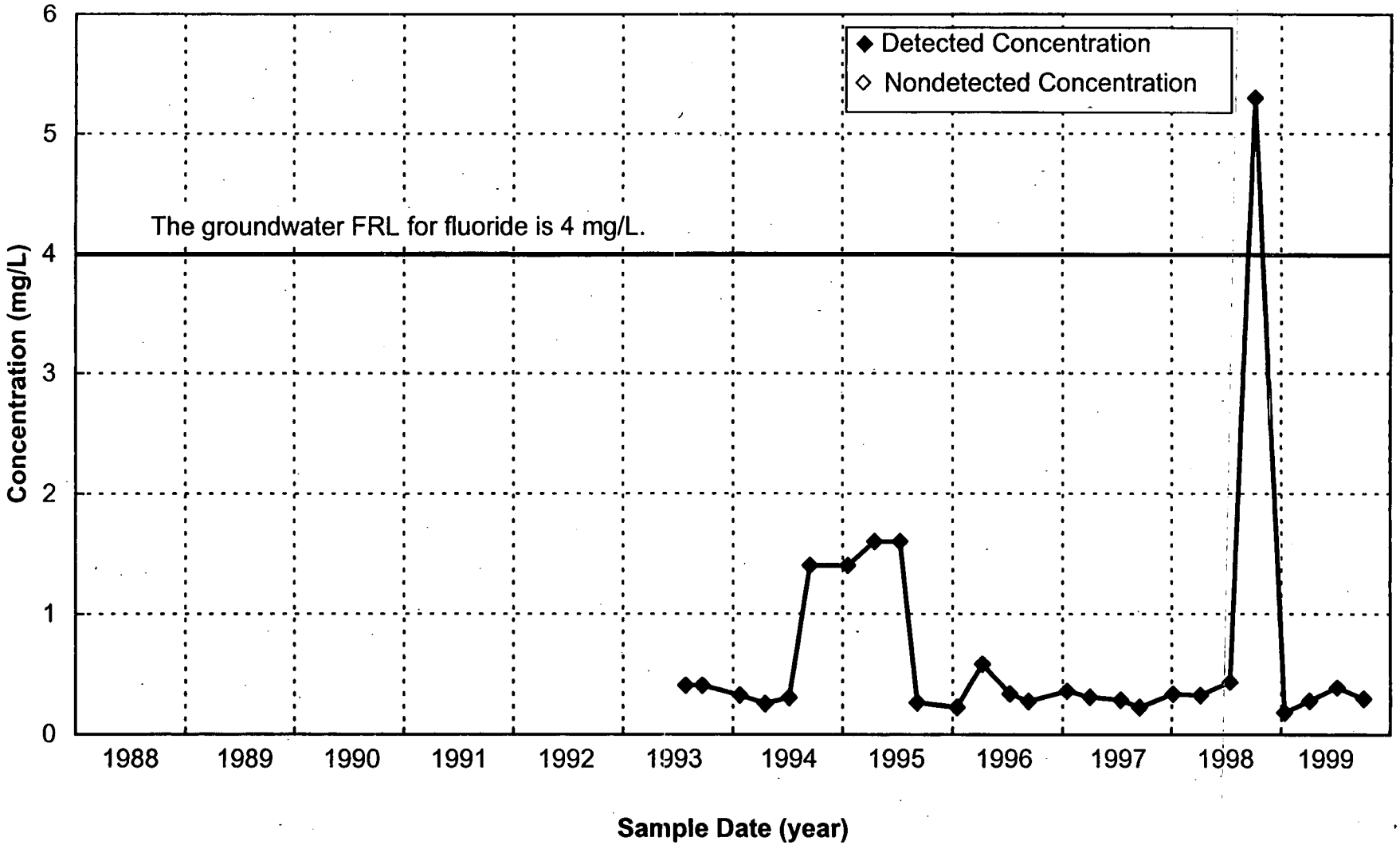


FIGURE A.4-5. FLUORIDE CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2424



000262

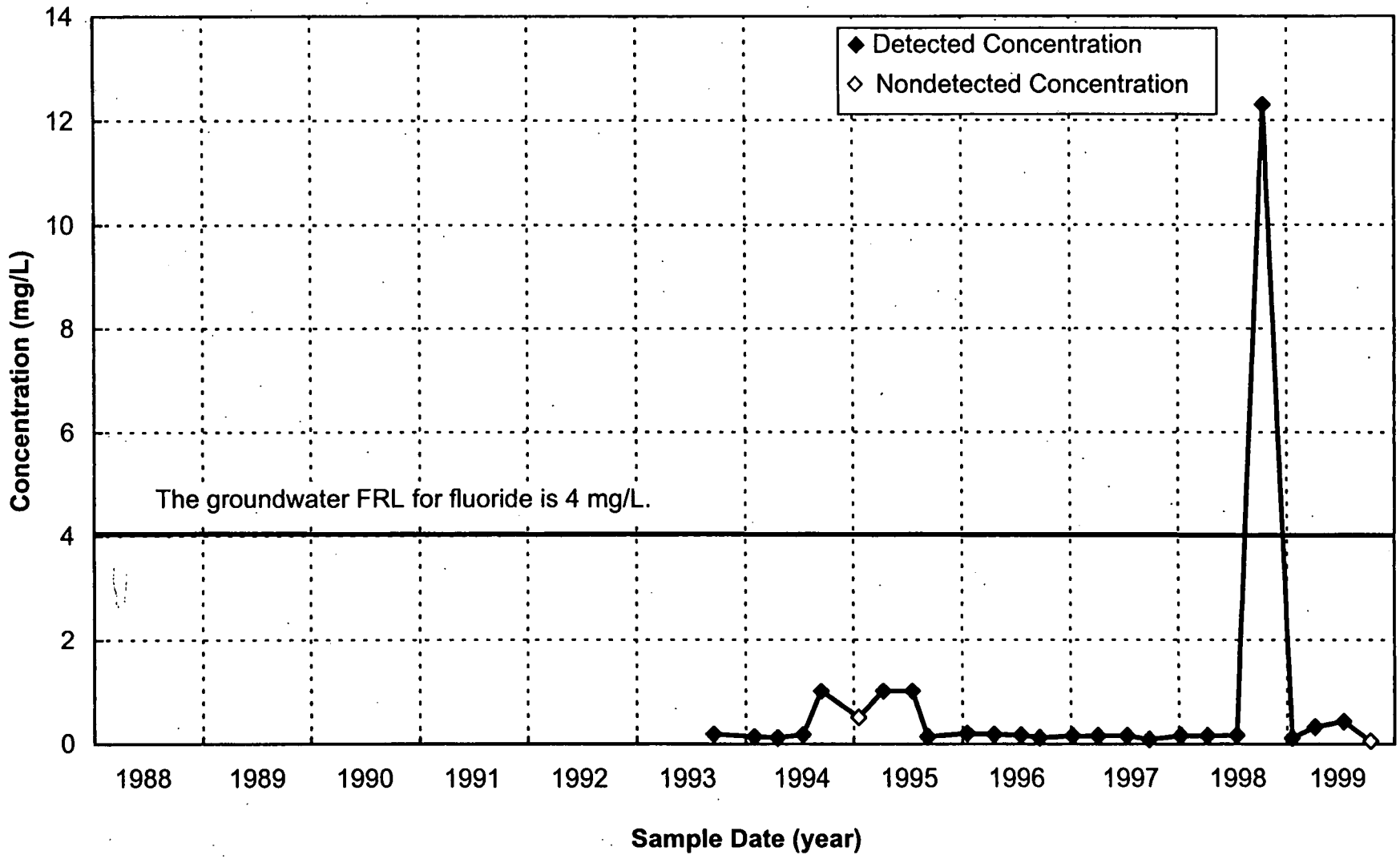


FIGURE A.4-6. FLUORIDE CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2431

002208

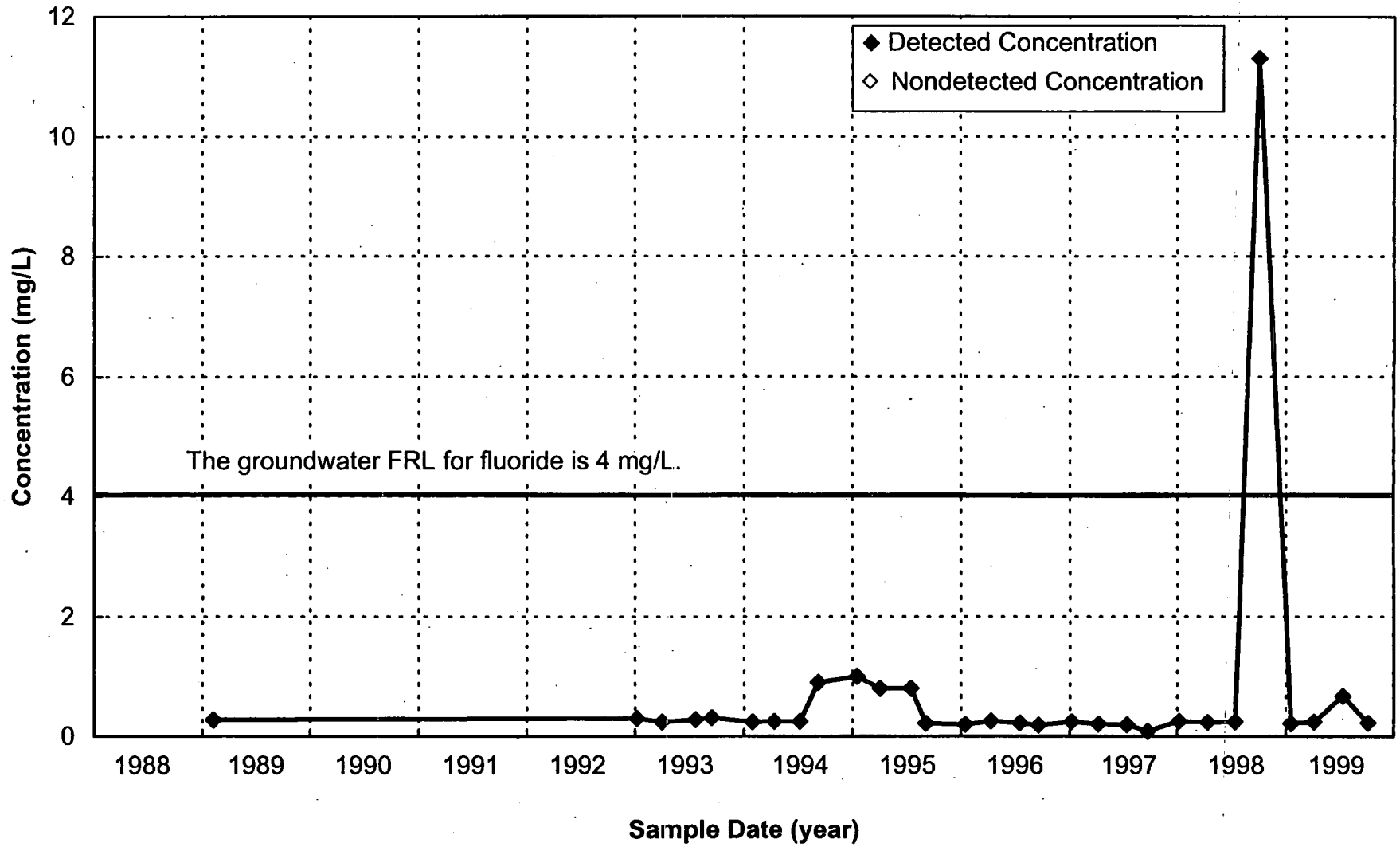


FIGURE A.4-7. FLUORIDE CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 4067

632000

30 04

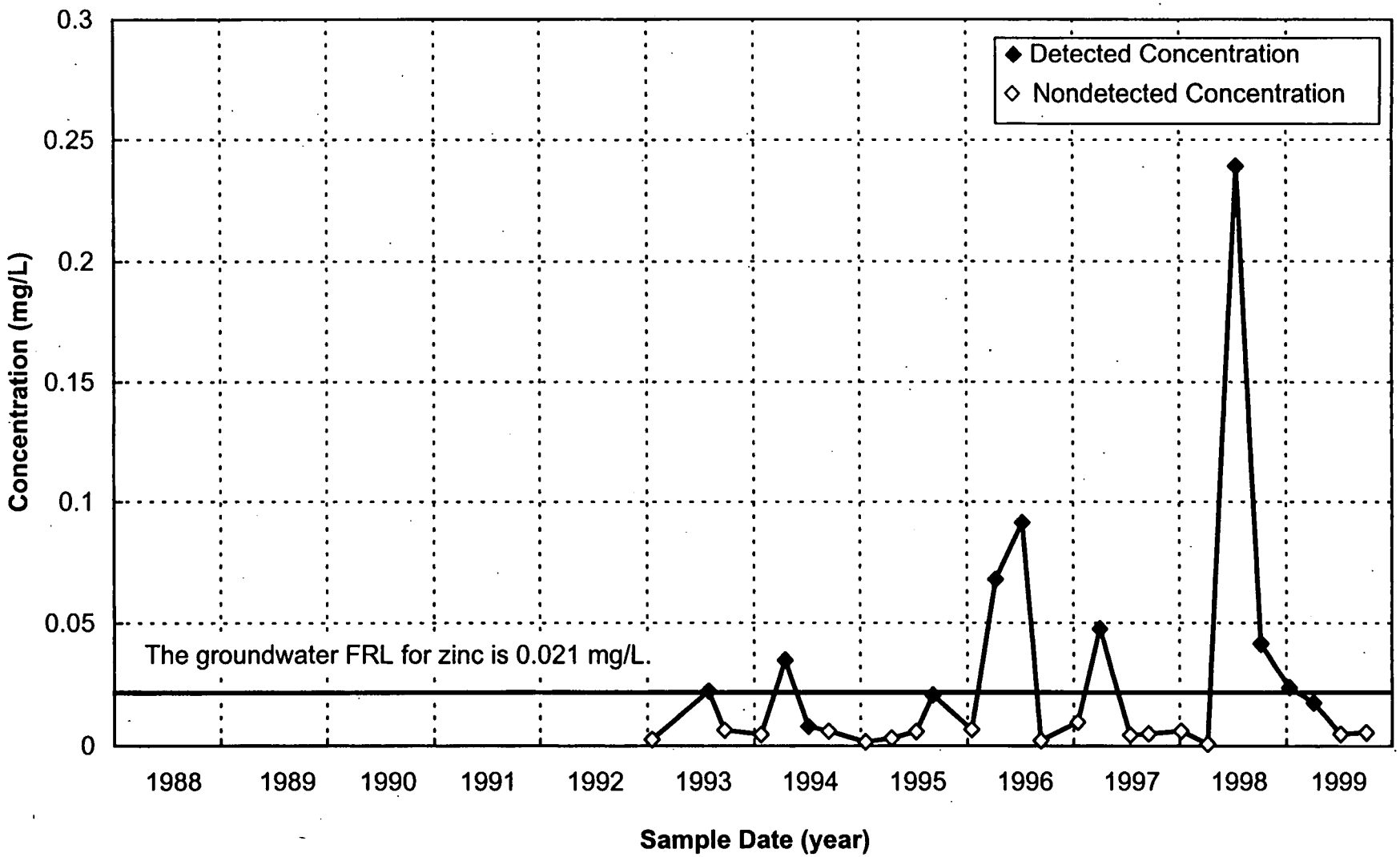


FIGURE A.4-8. ZINC CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2424

022000

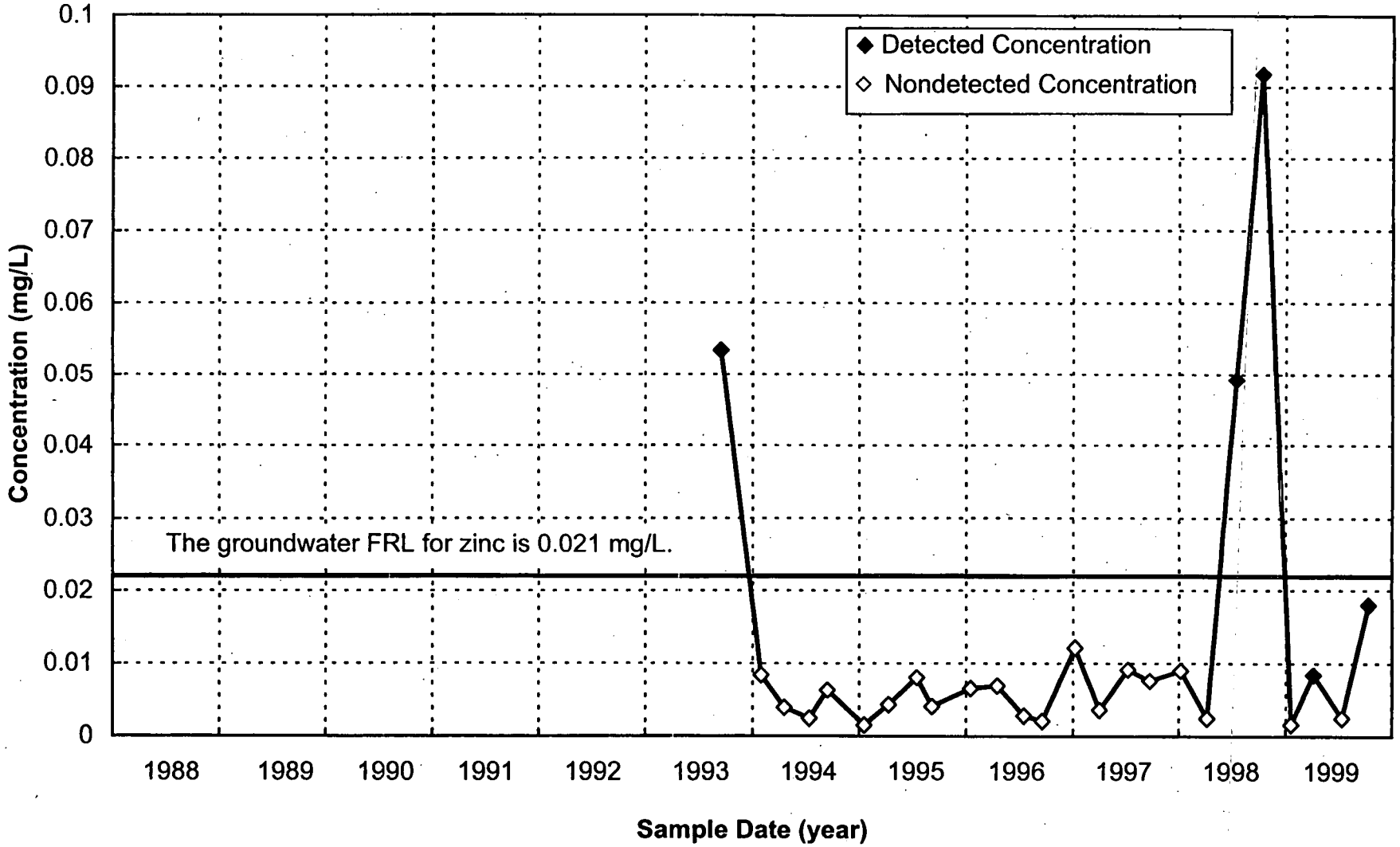


FIGURE A.4-9. ZINC CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2431



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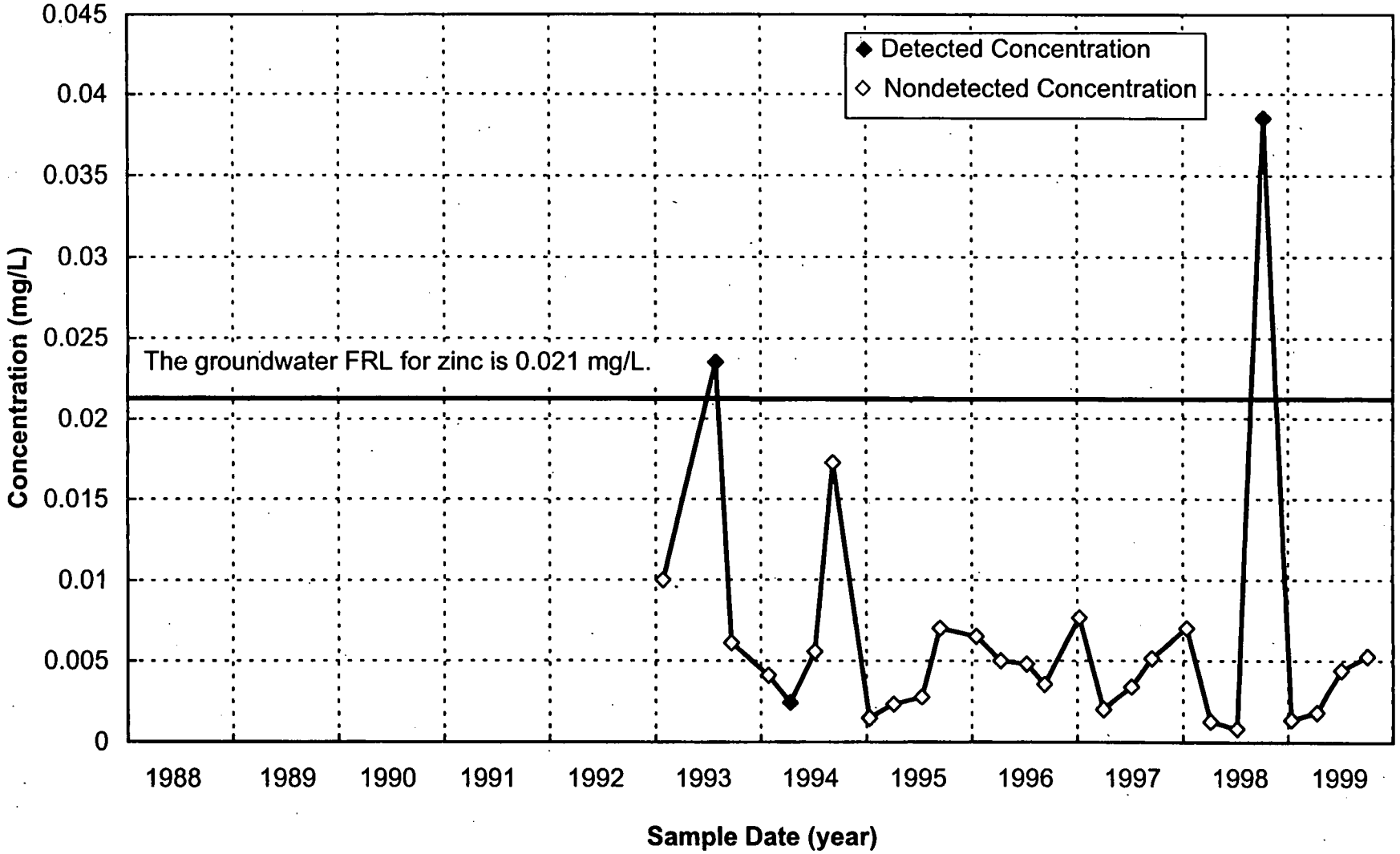


FIGURE A.4-10. ZINC CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2434

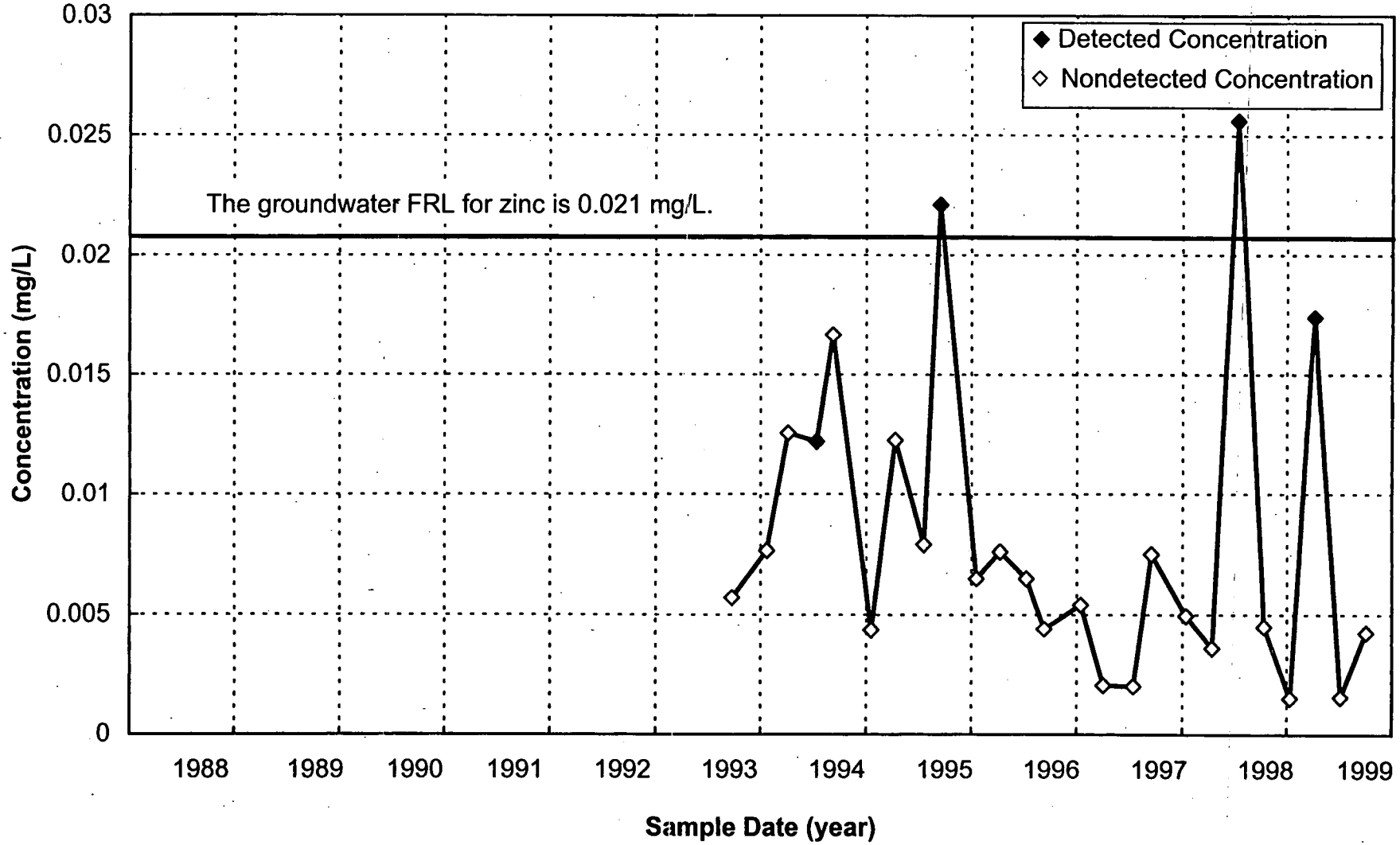


FIGURE A.4-11. ZINC CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 41217



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000274

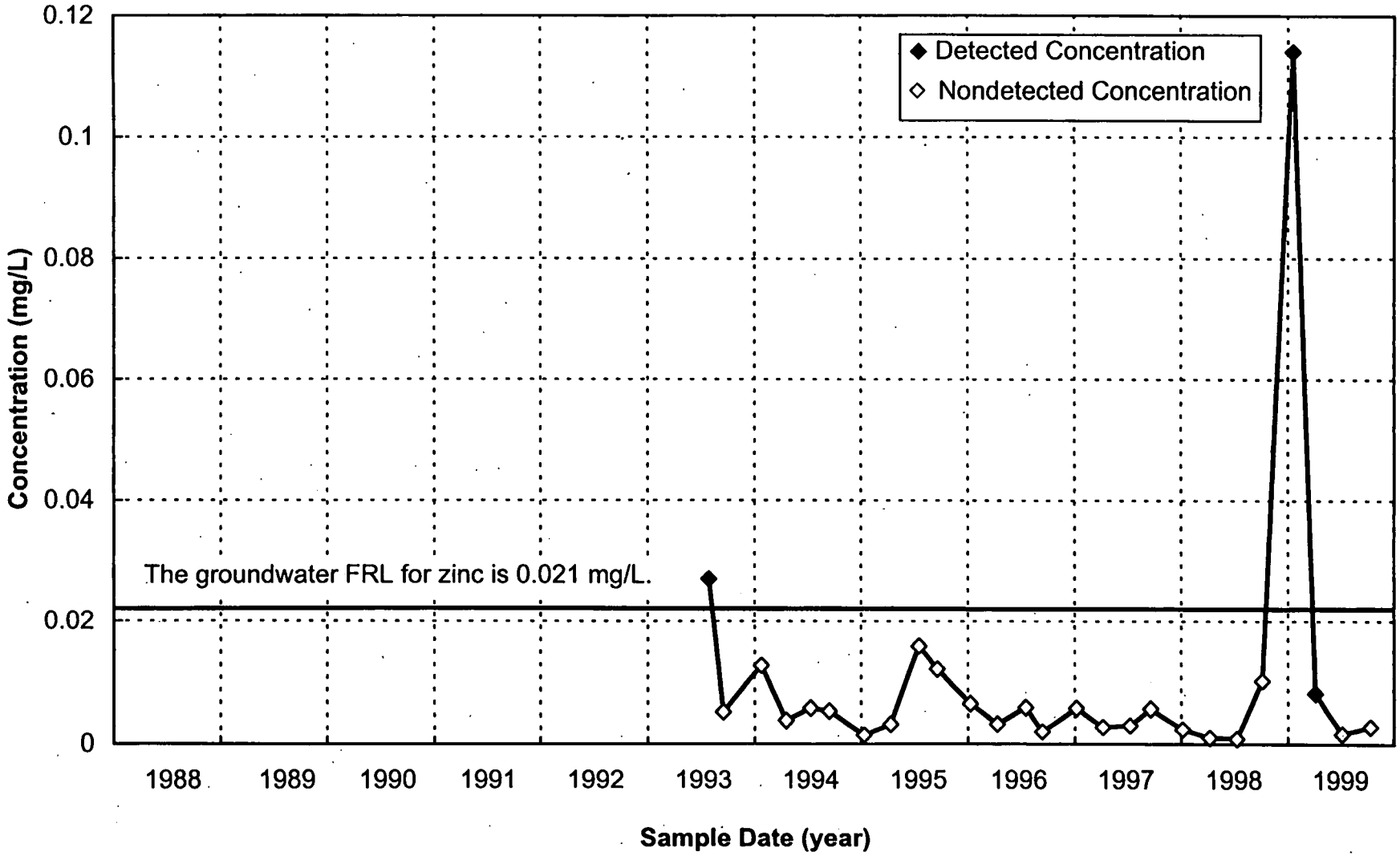


FIGURE A.4-12. ZINC CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2432

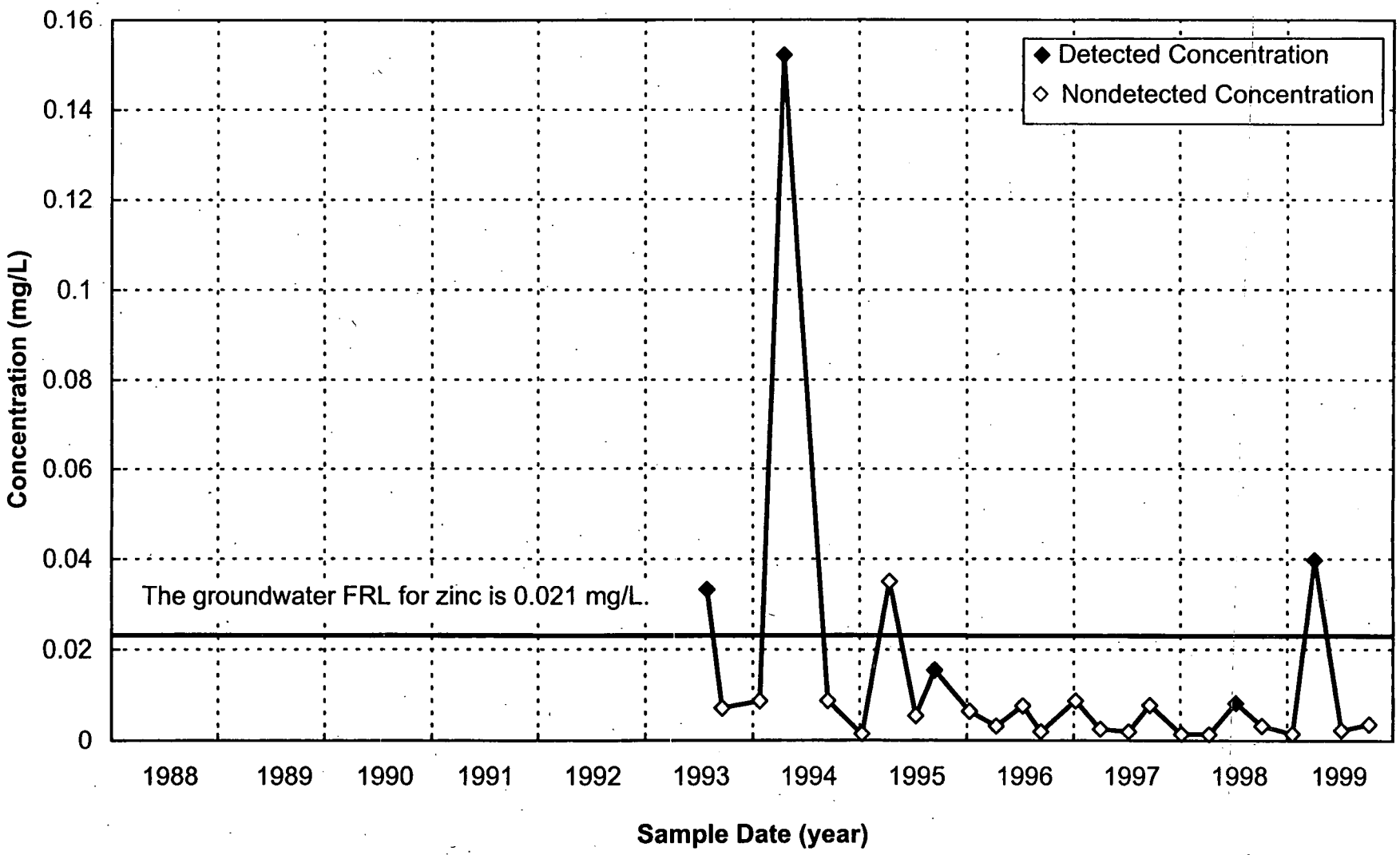


FIGURE A.4-13. ZINC CONCENTRATION VS. TIME PLOT
FOR MONITORING WELL 2733



000275

000276

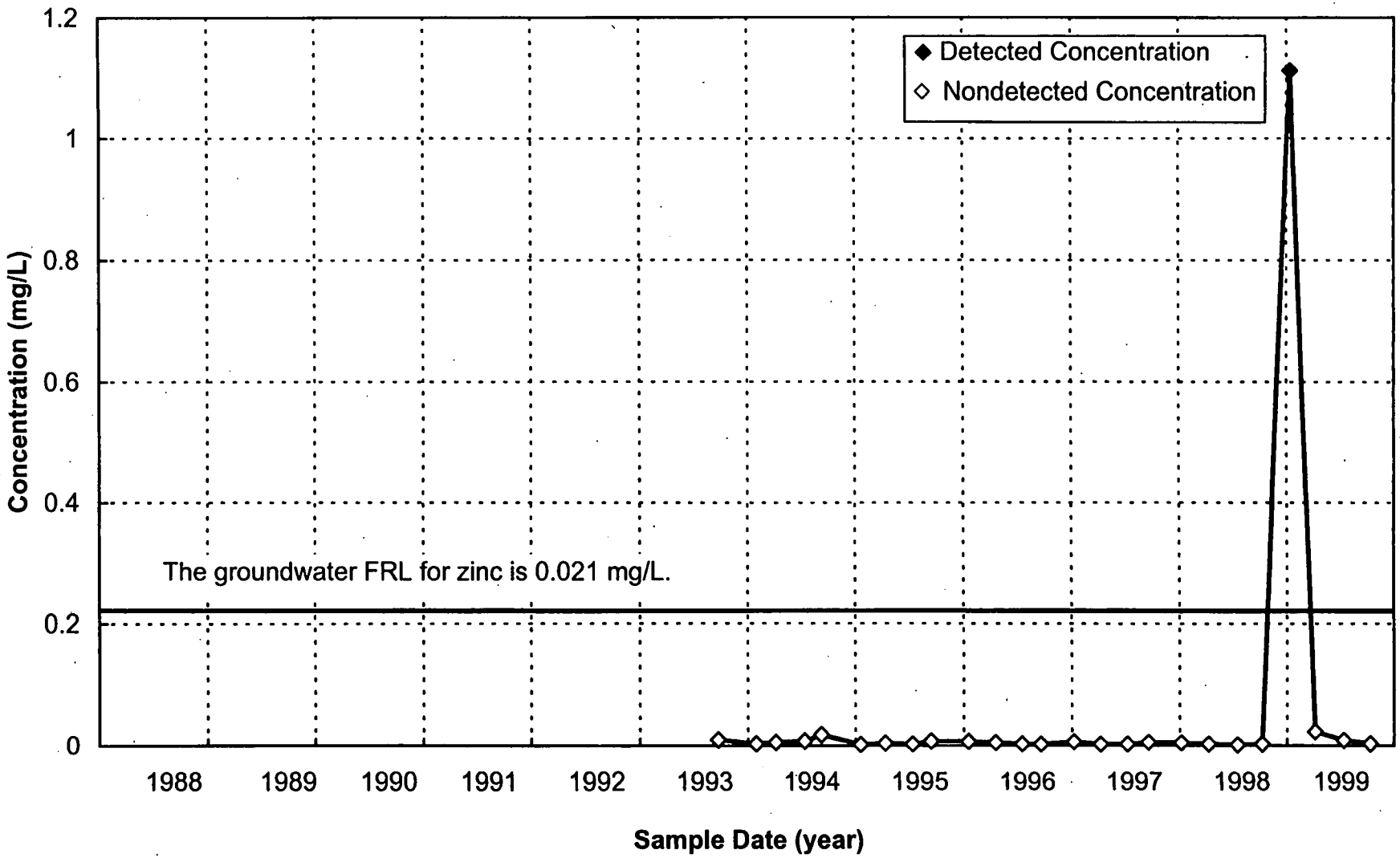


FIGURE A.4-14. ZINC CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3429

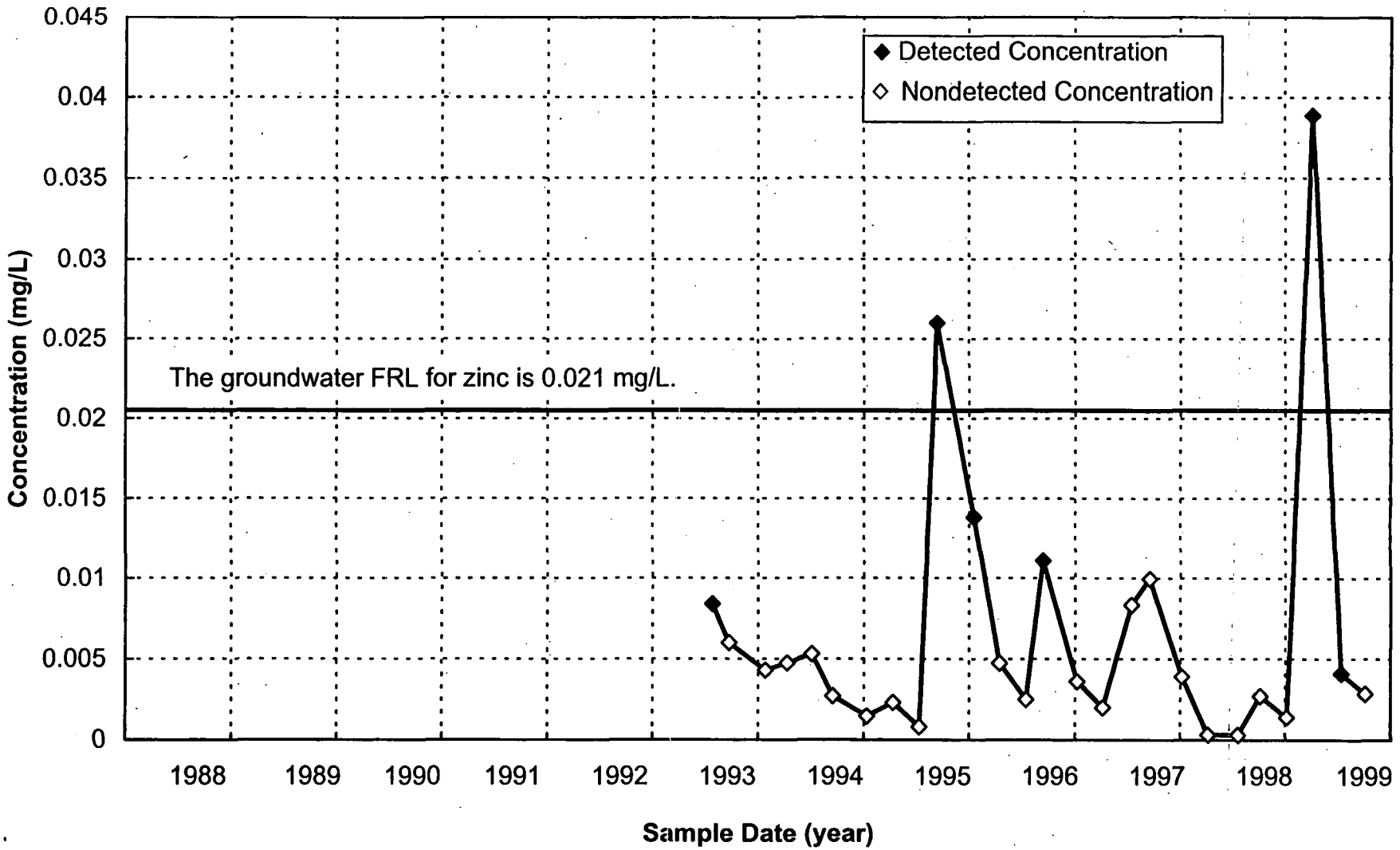


FIGURE A.4-15. ZINC CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 4426



000277

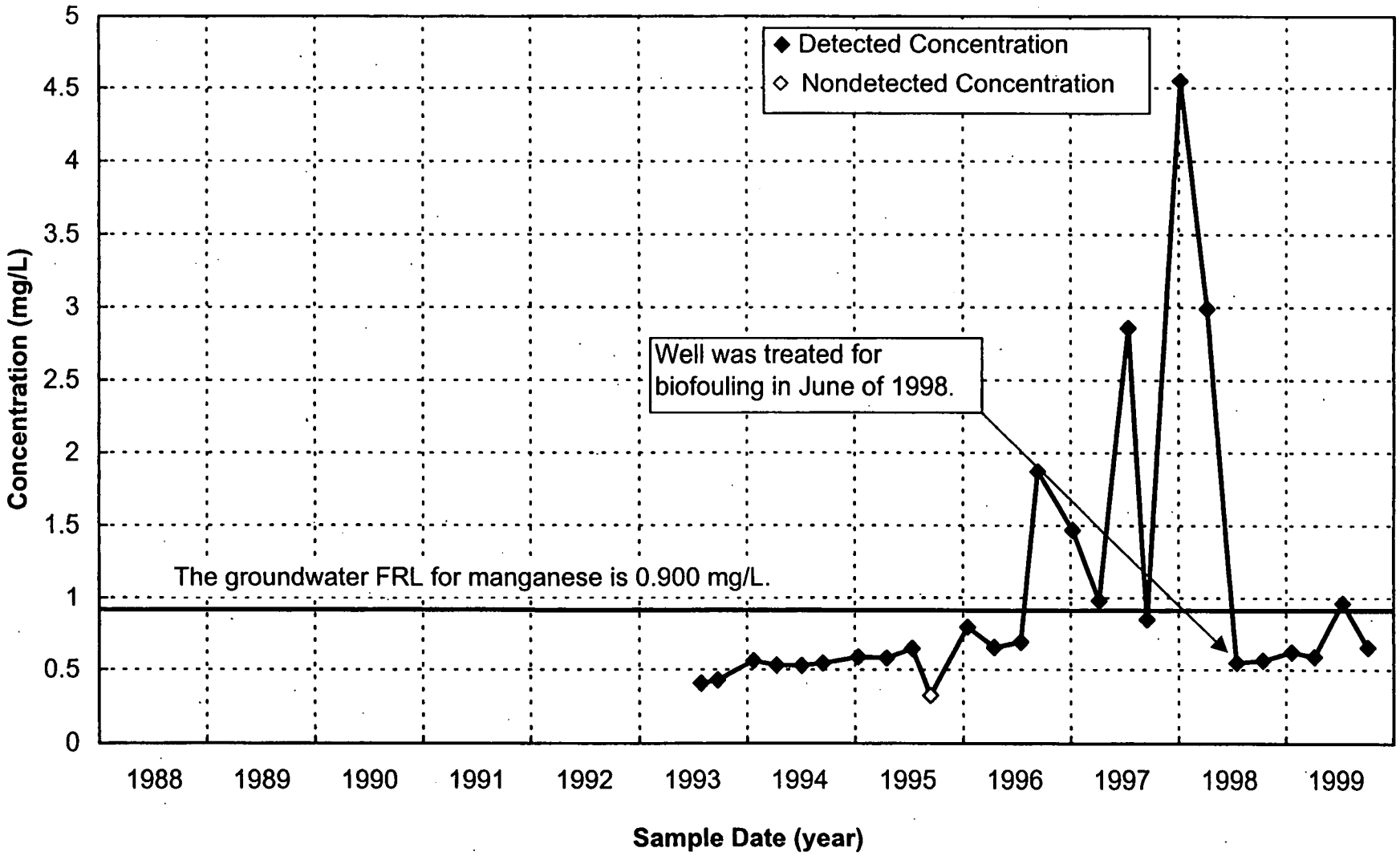


FIGURE A.4-16. MANGANESE CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 2426

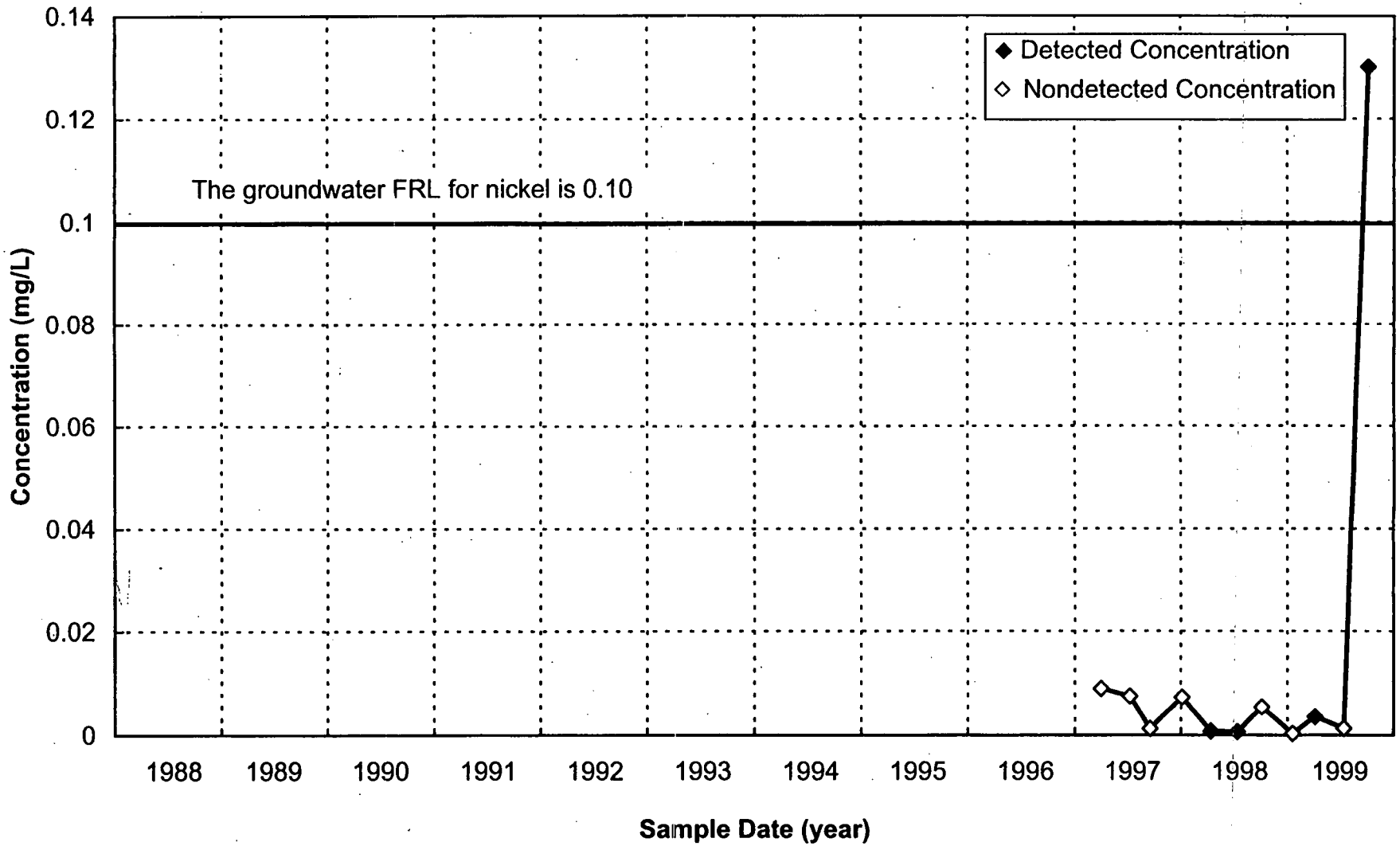


FIGURE A.4-17. NICKEL CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 22198



000279

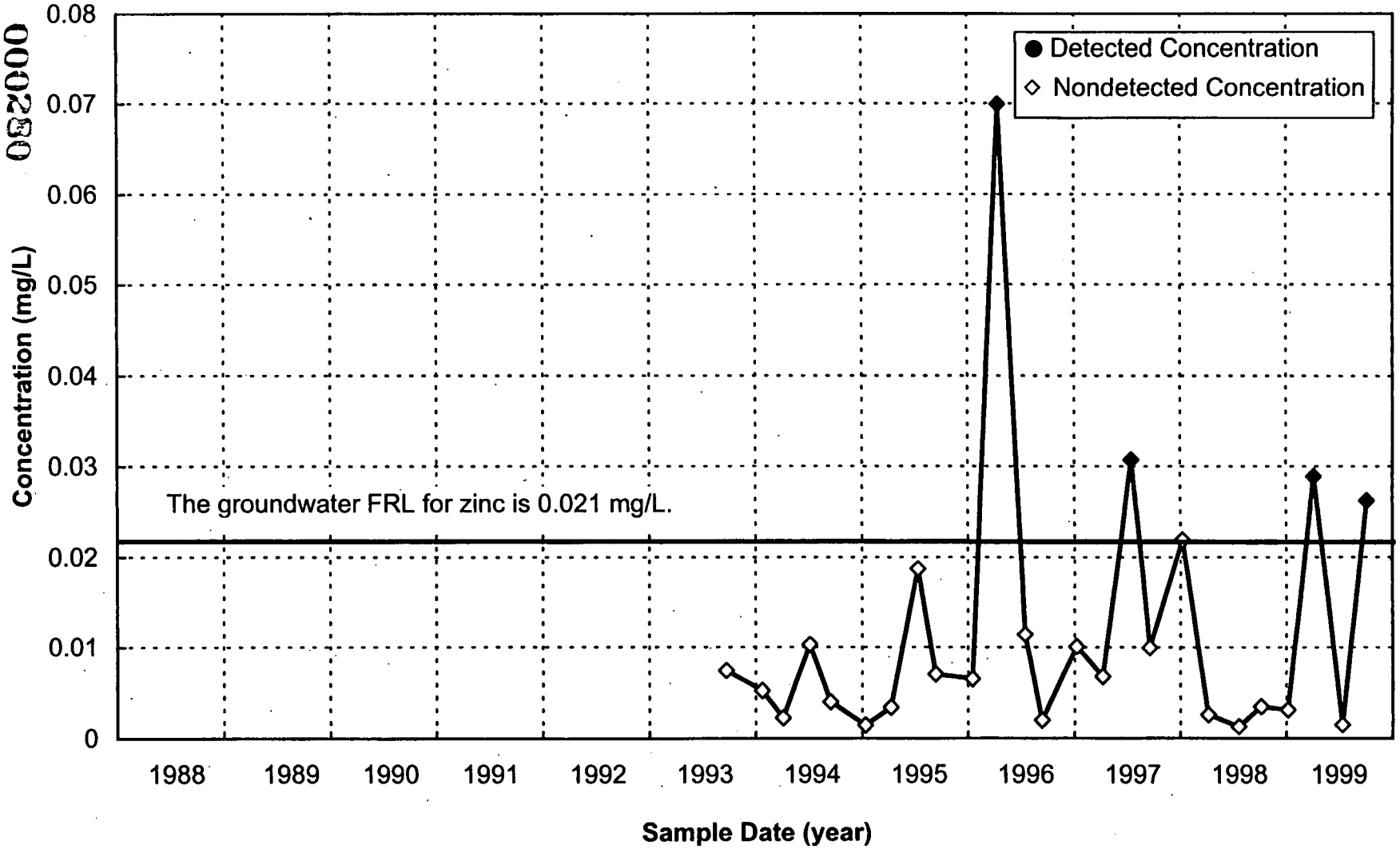


FIGURE A.4-18. ZINC CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 3426

082000

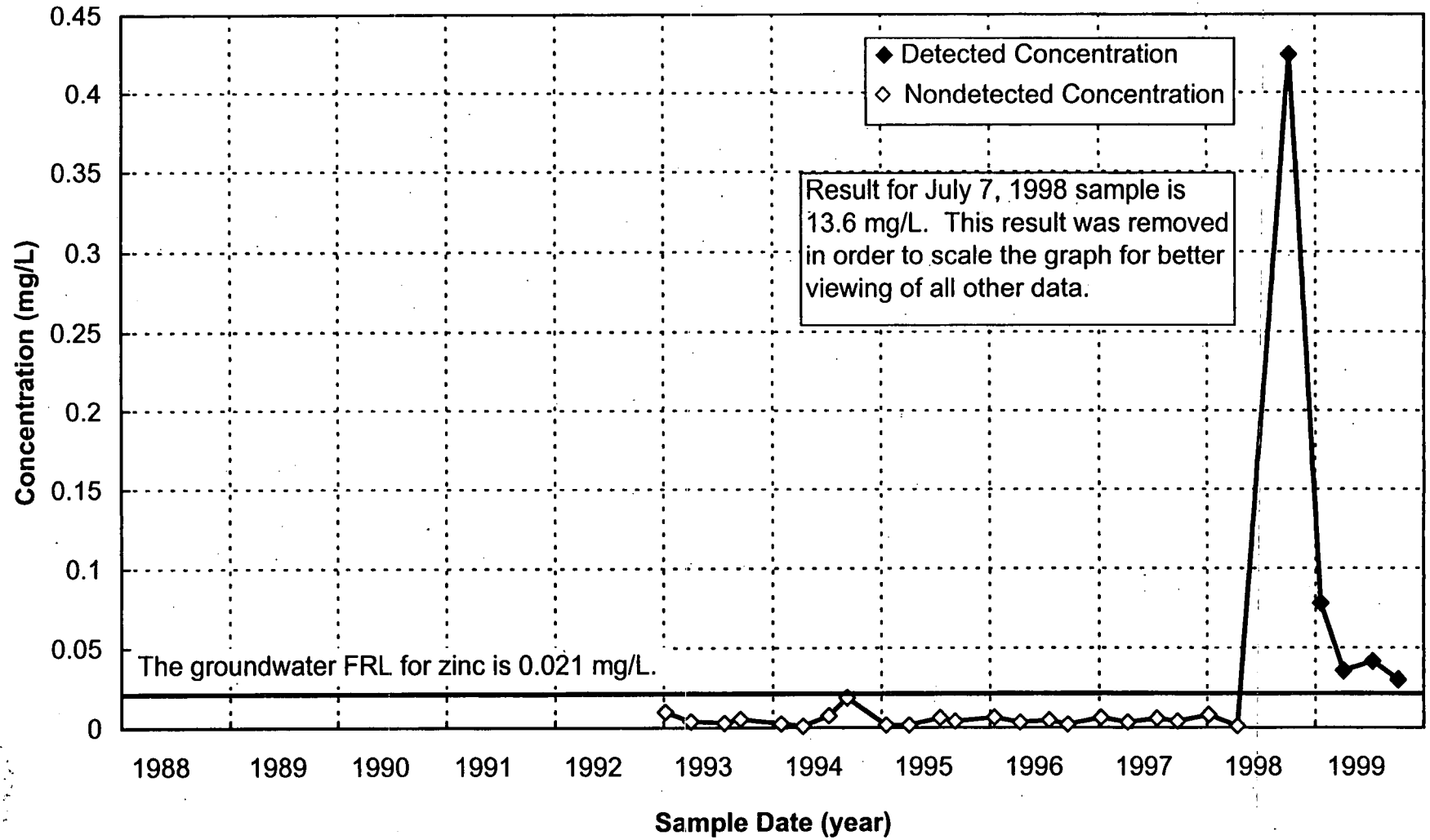


FIGURE A.4-19. ZINC CONCENTRATION VS. TIME PLOT FOR MONITORING WELL 4067

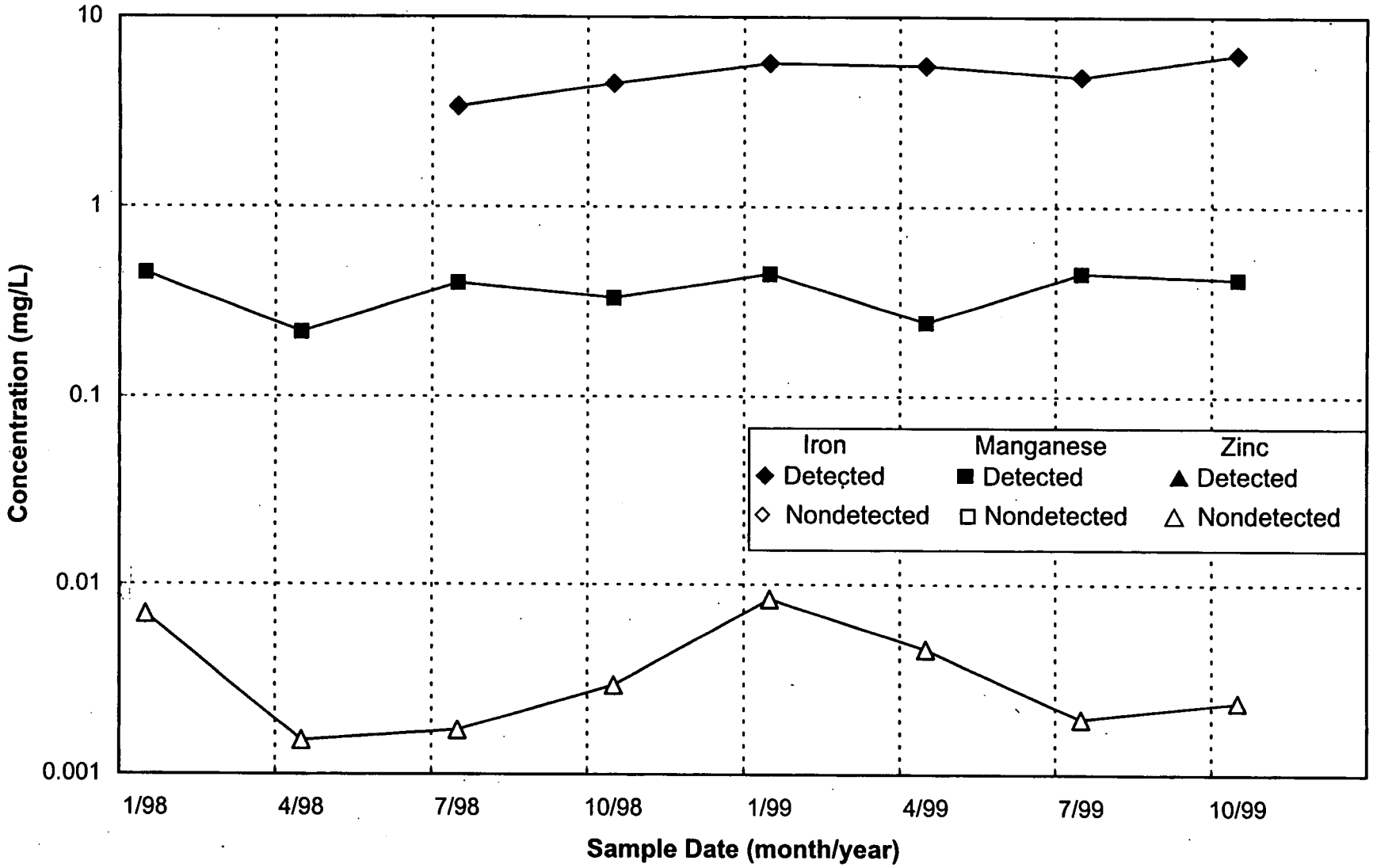


FIGURE A.4-20. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 2051

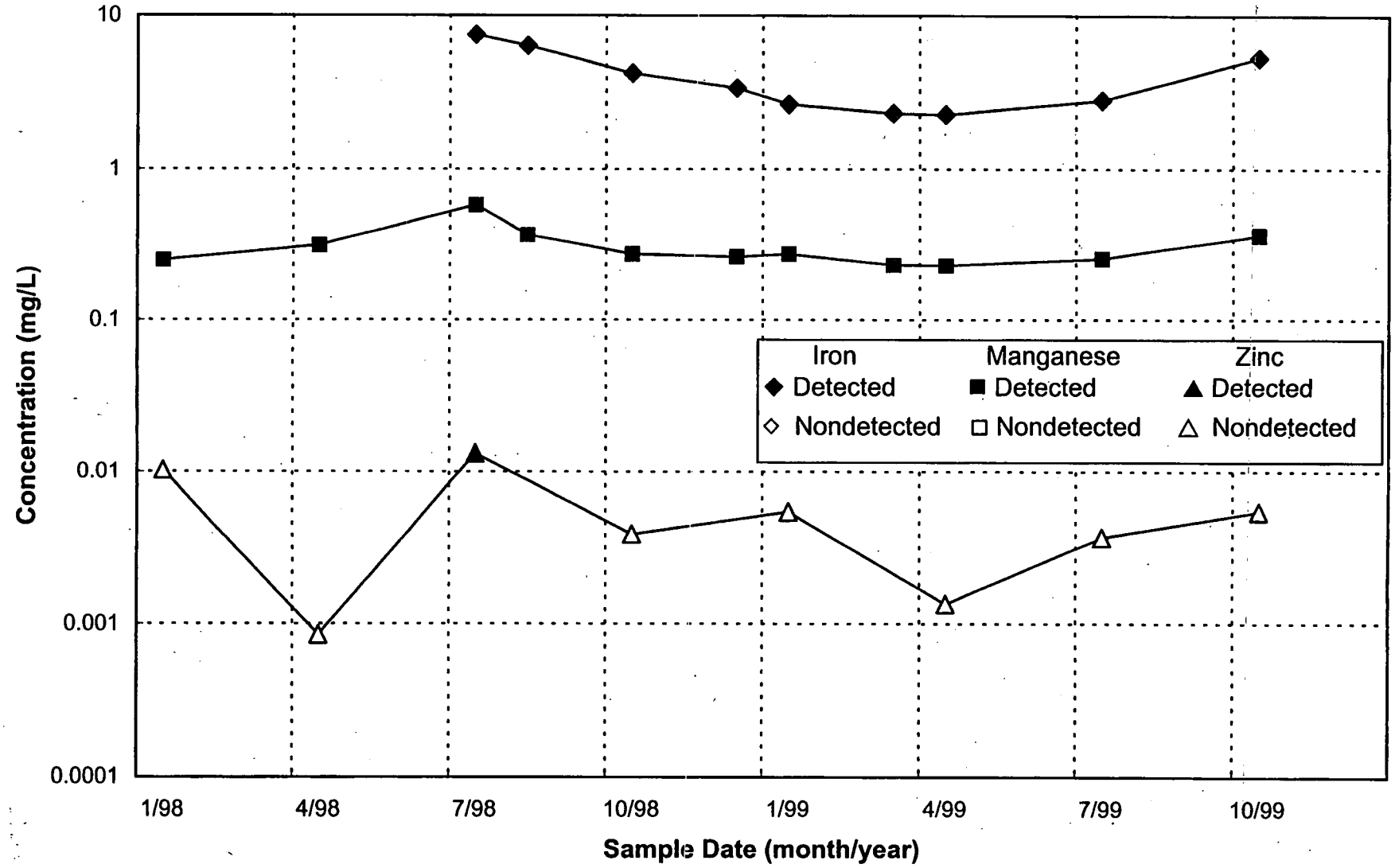


FIGURE A.4-21. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 2070

000284

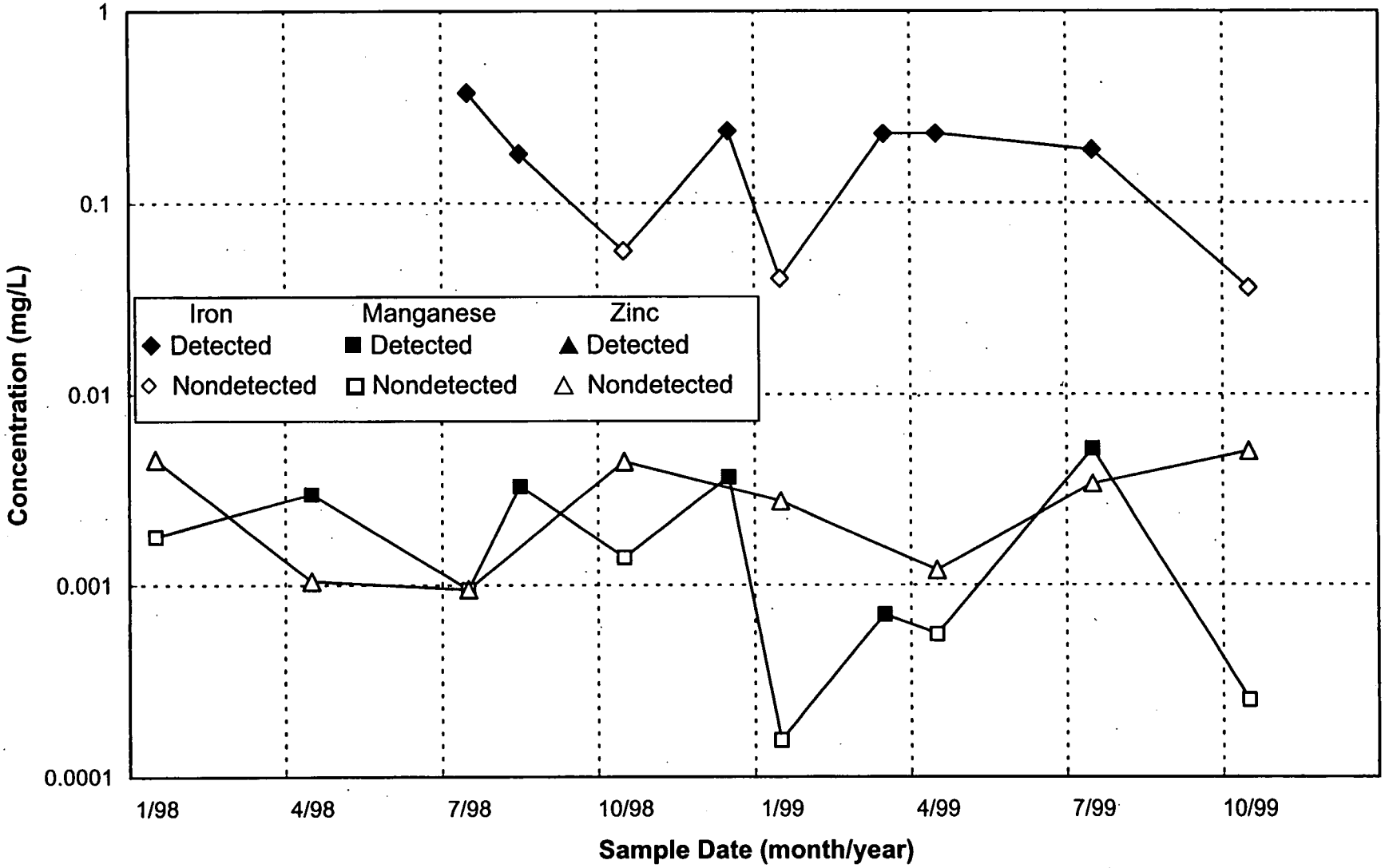


FIGURE A.4-22. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 2106

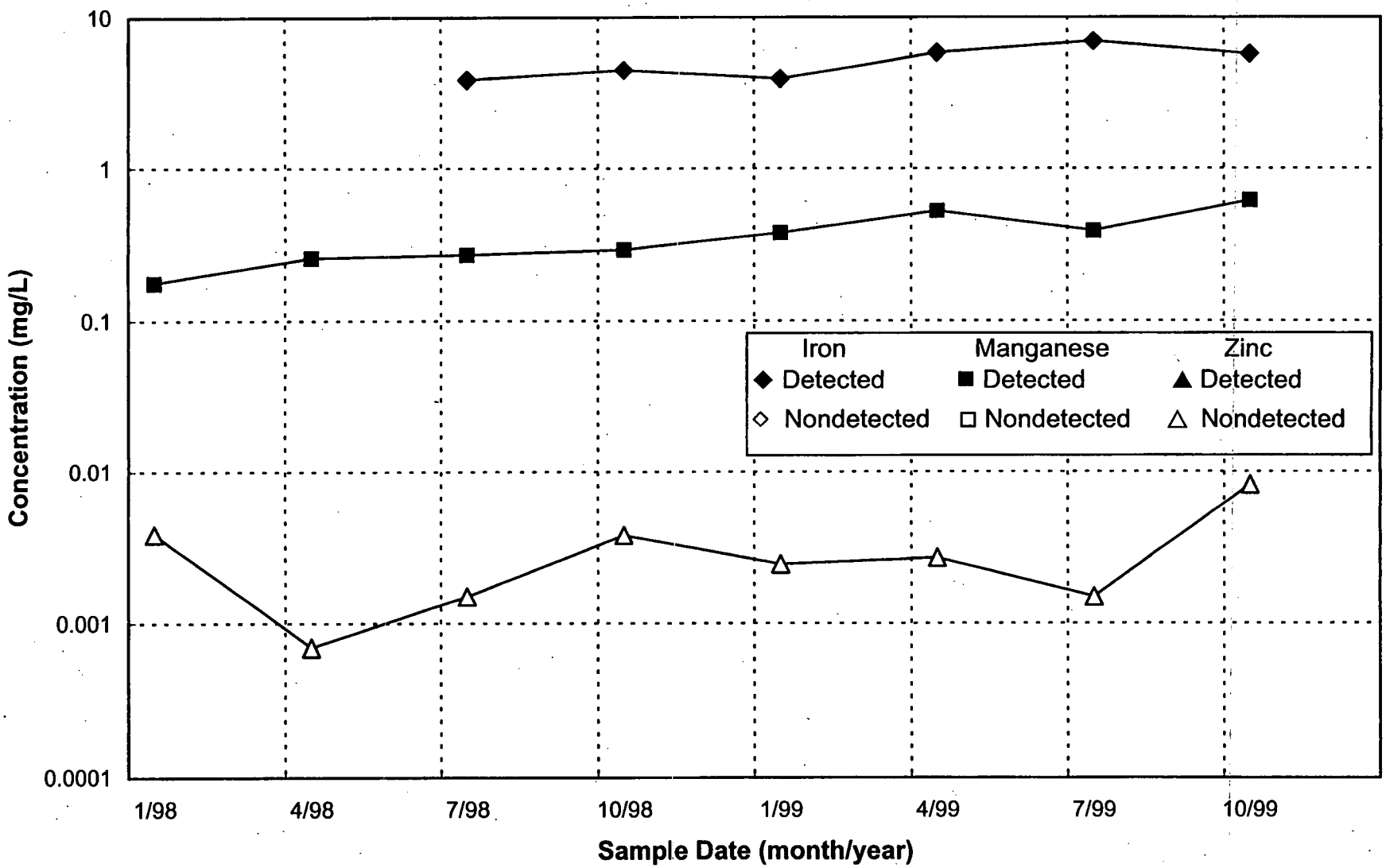


FIGURE A.4-23. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 22198

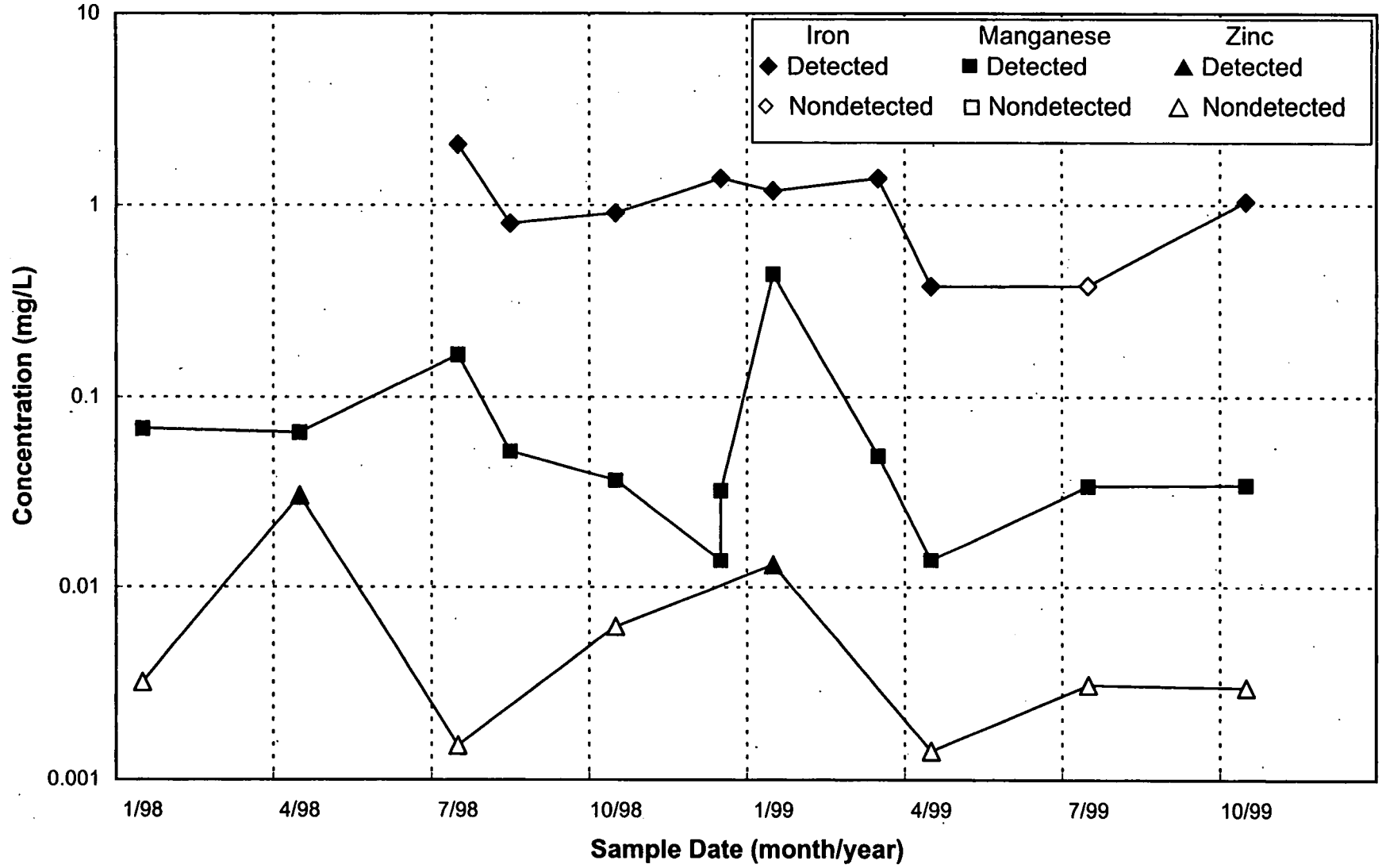


FIGURE A.4-24. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 2398

000286

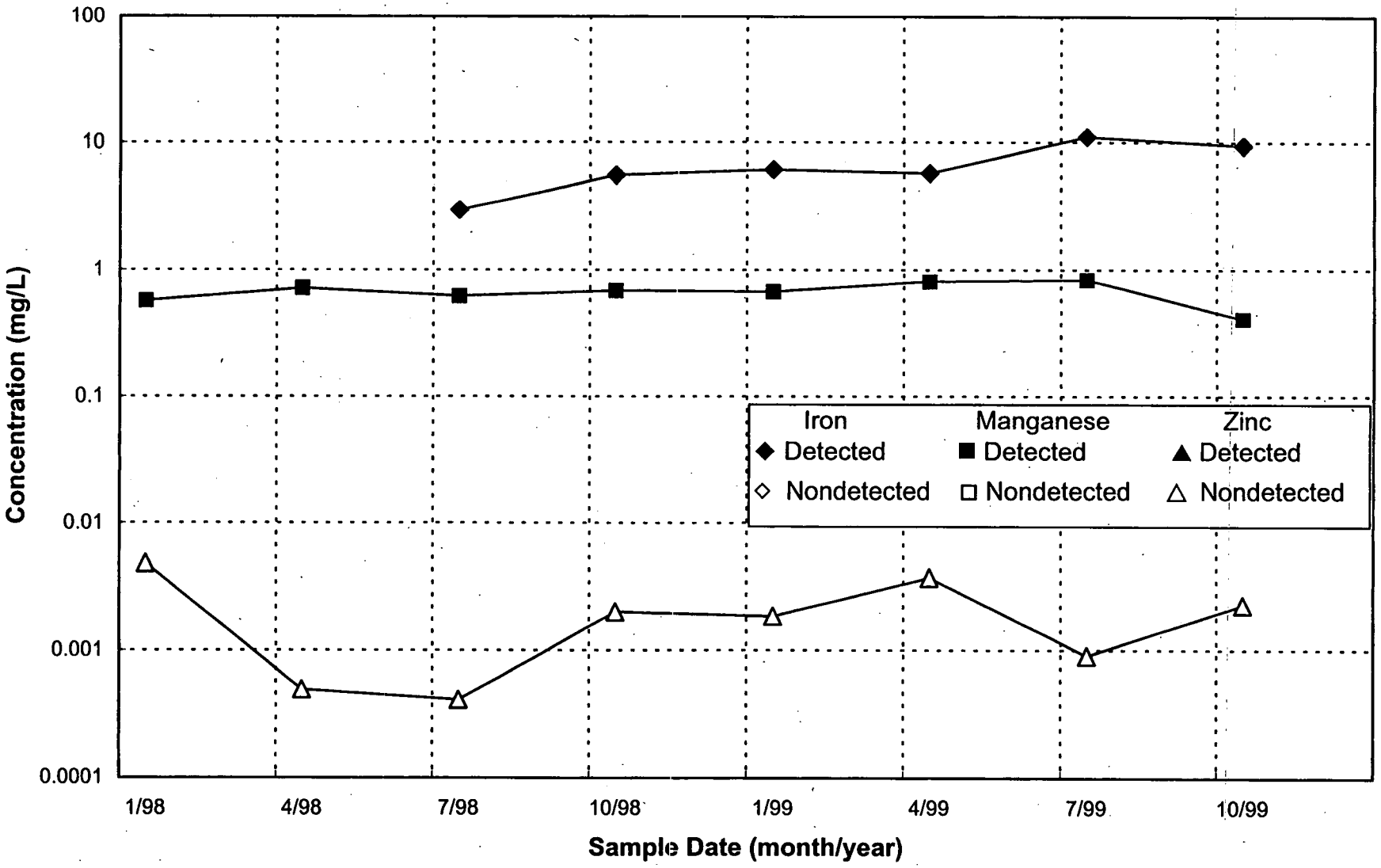


FIGURE A.4-25. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 2417



000287

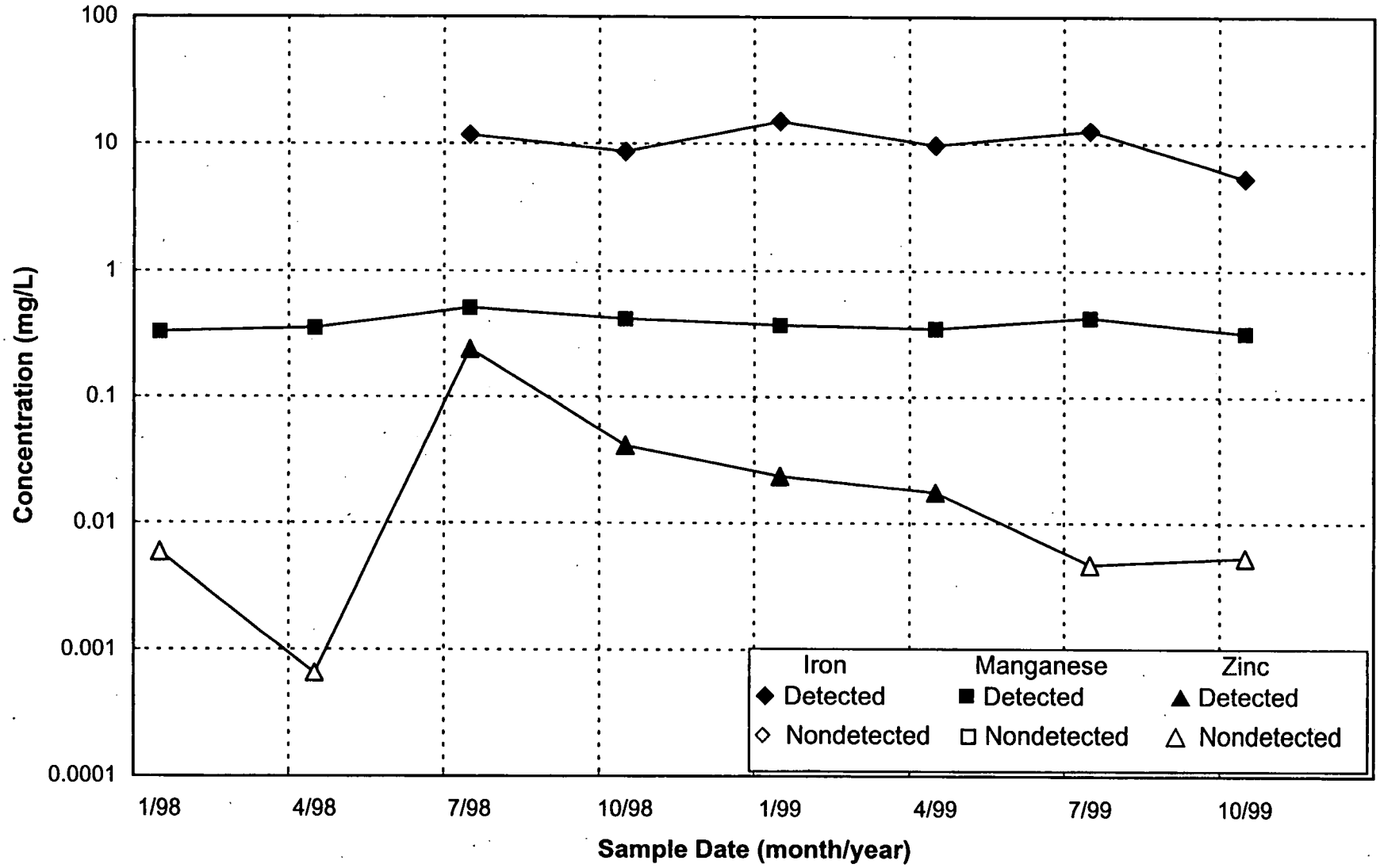


FIGURE A.4-26. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 2424

000288

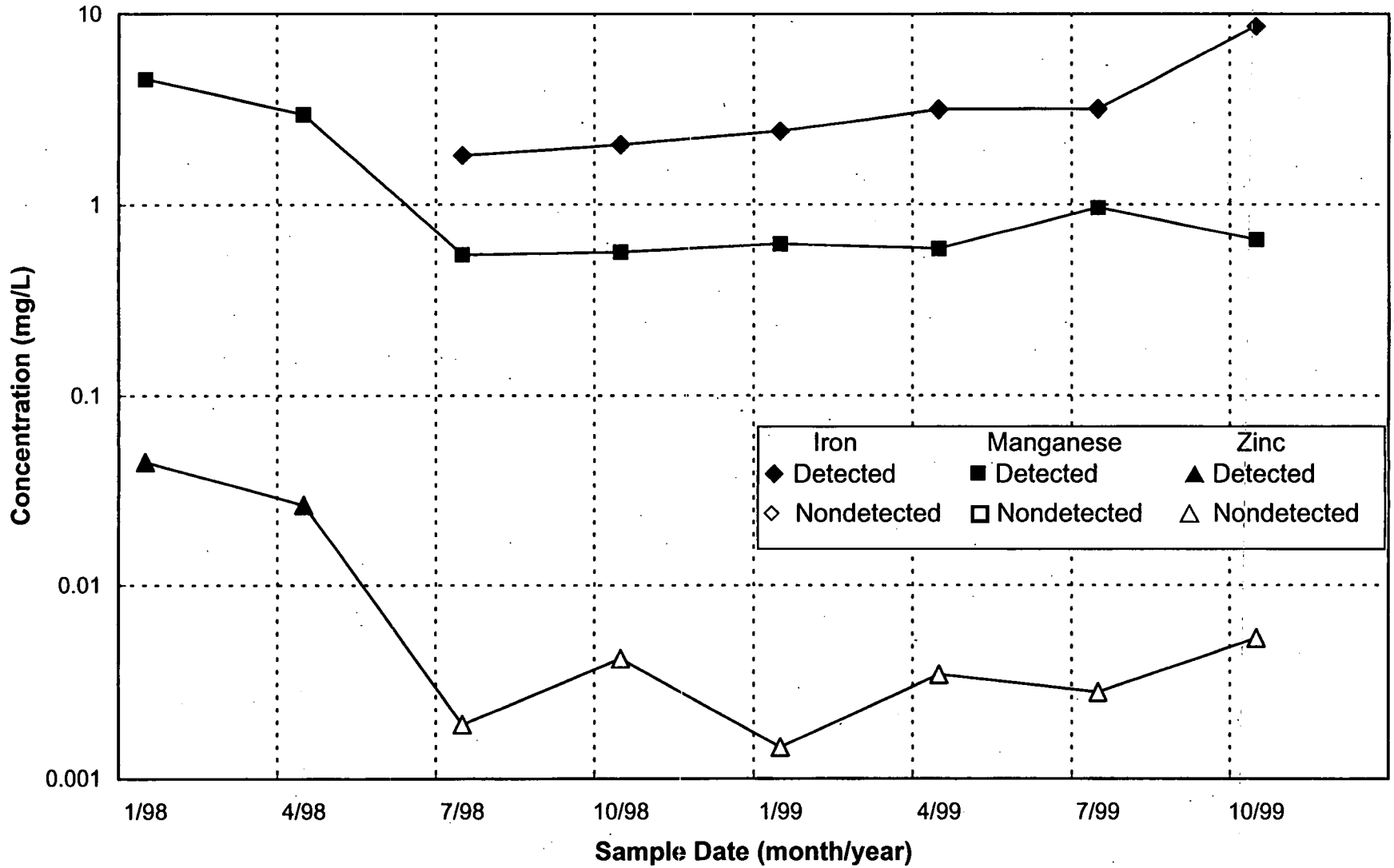


FIGURE A.4-27. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 2426



000289

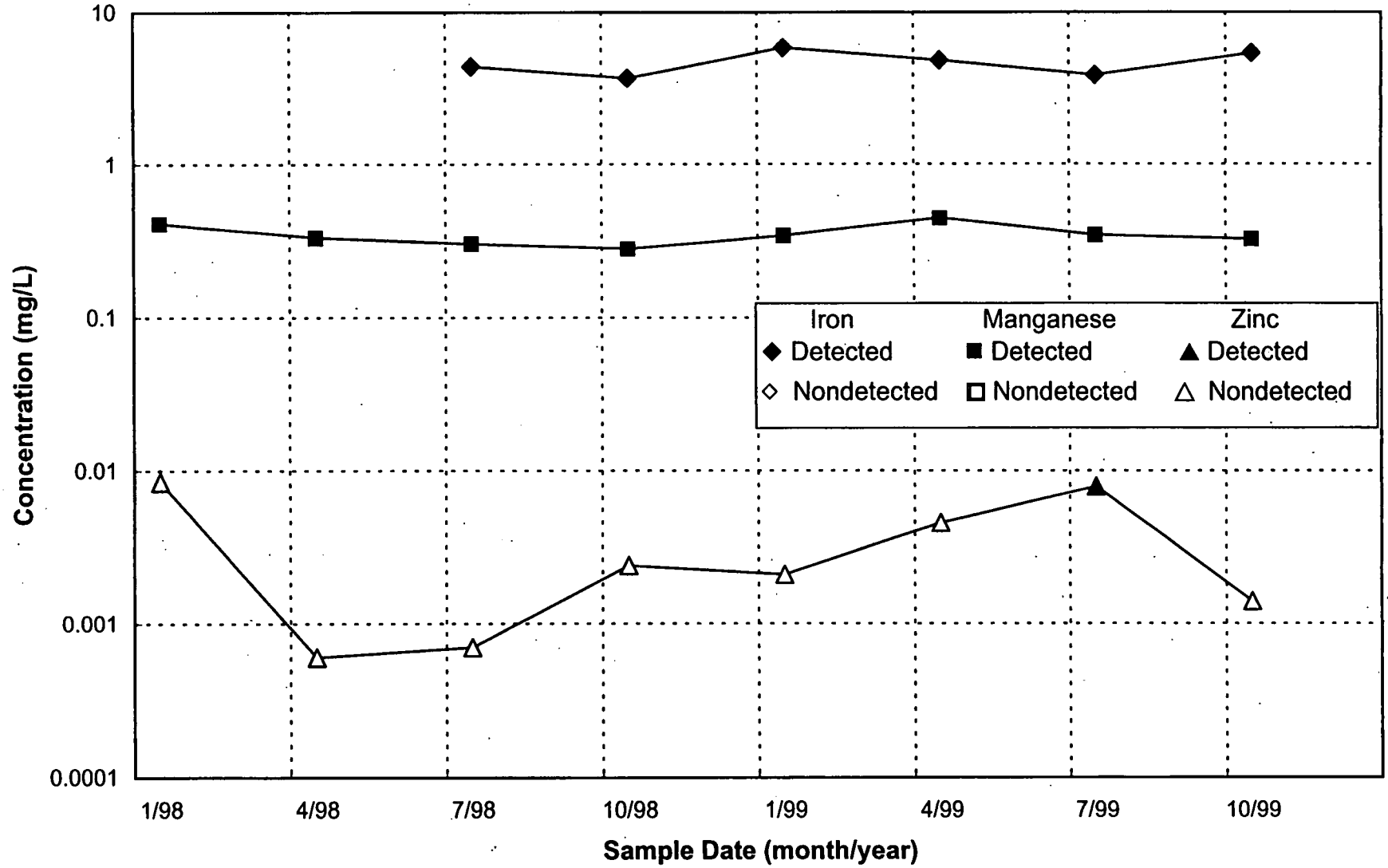


FIGURE A.4-28. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 2429

000290

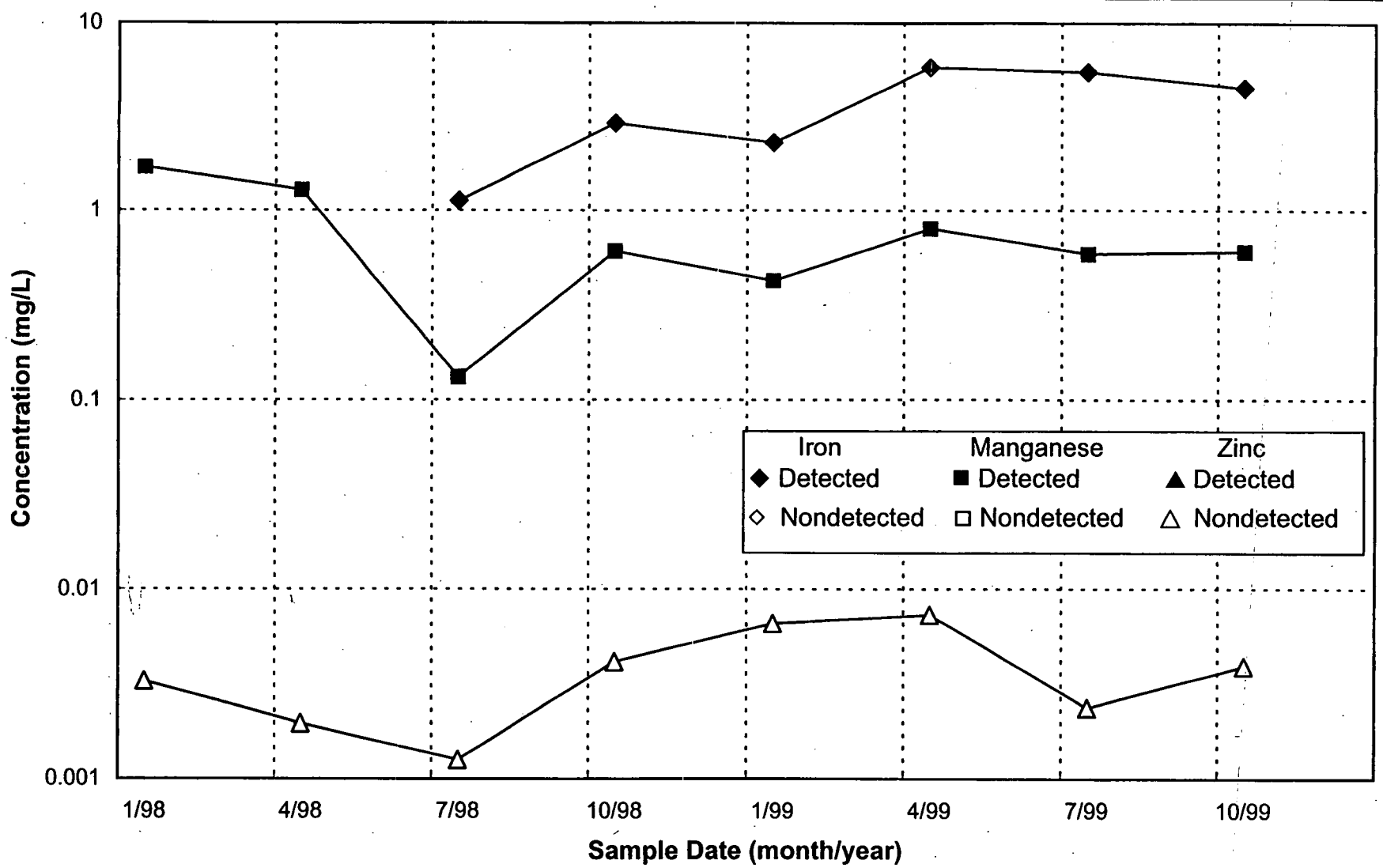


FIGURE A.4-29. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 2430

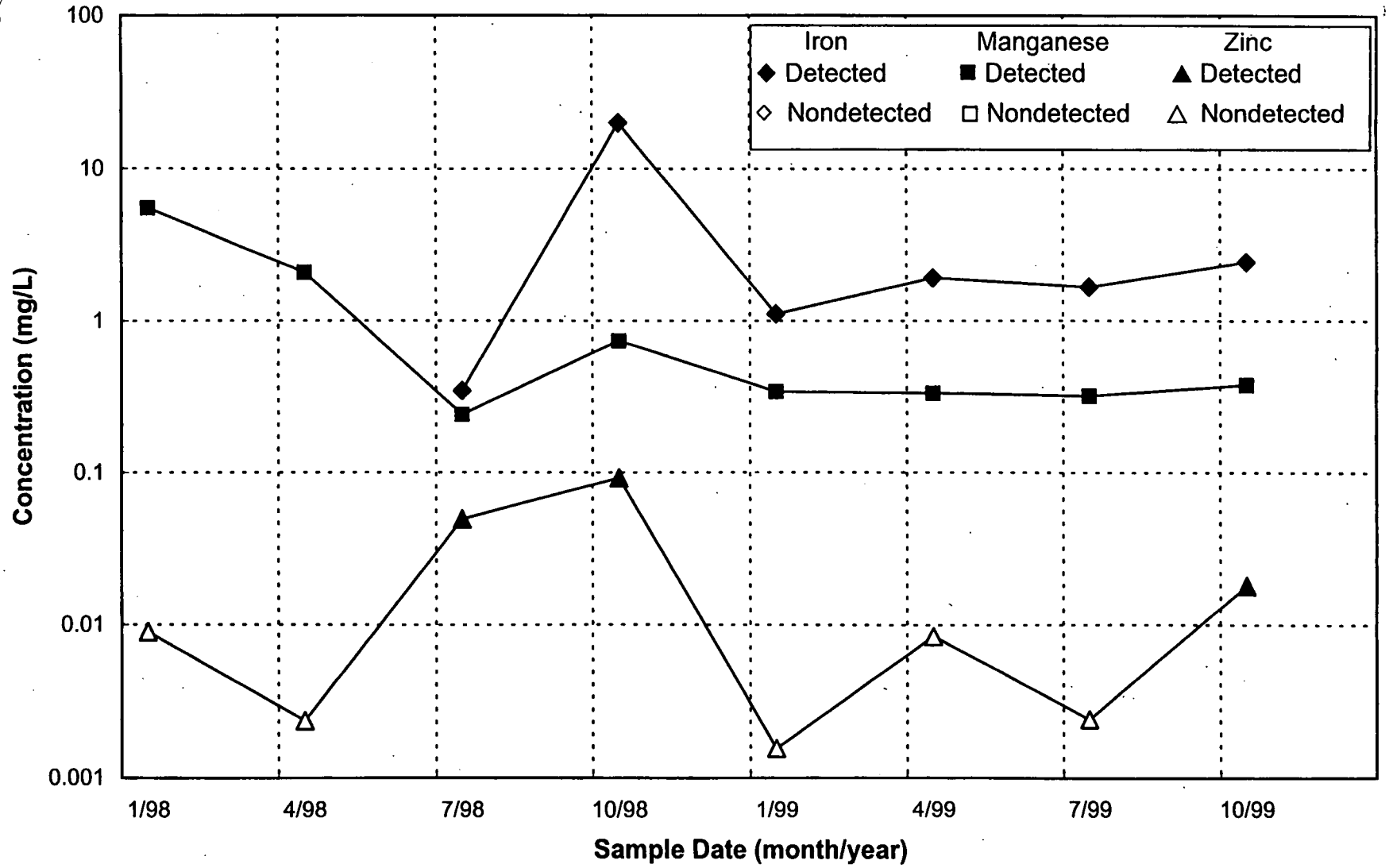


FIGURE A.4-30. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 2431

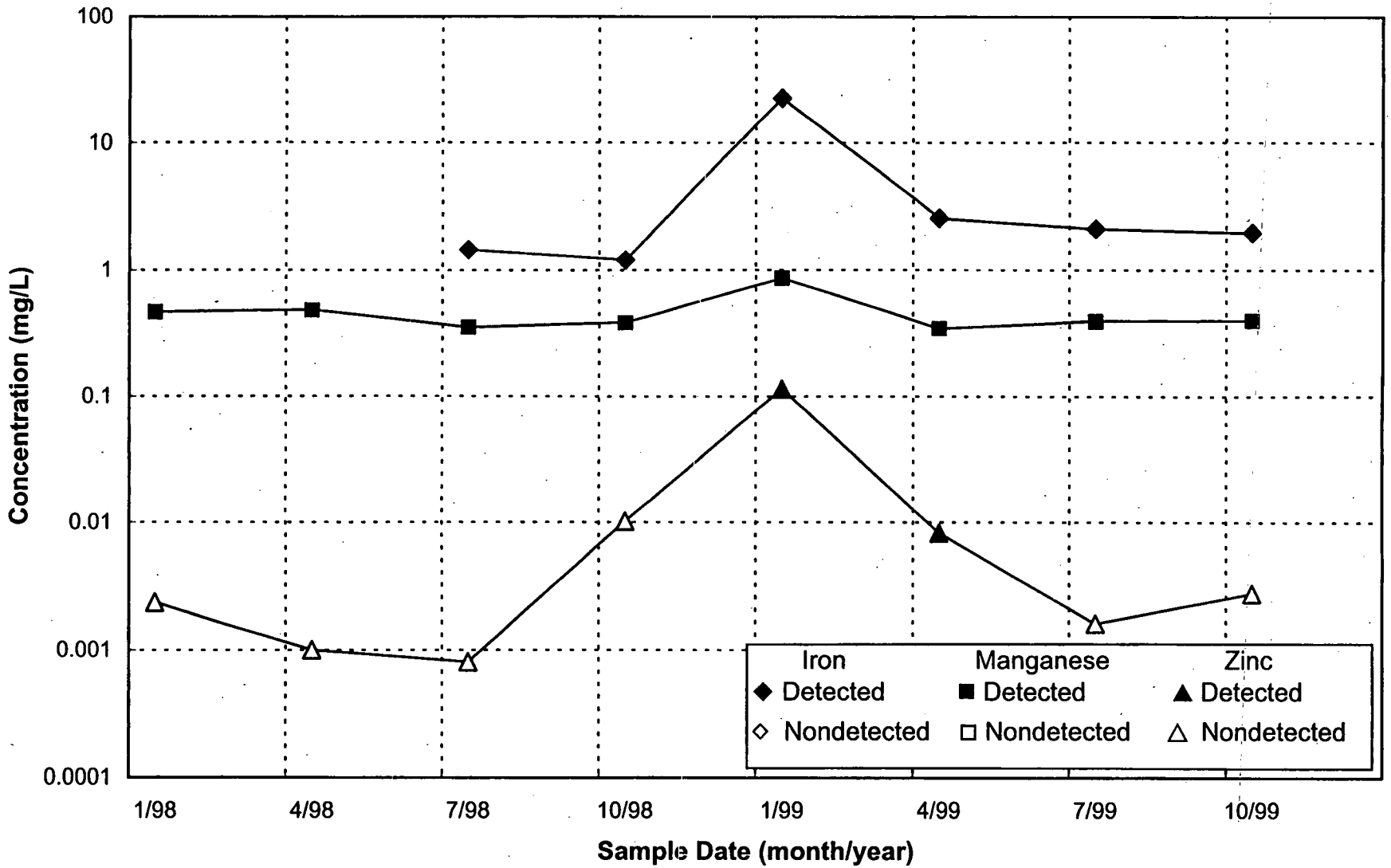


FIGURE A.4-31. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 2432

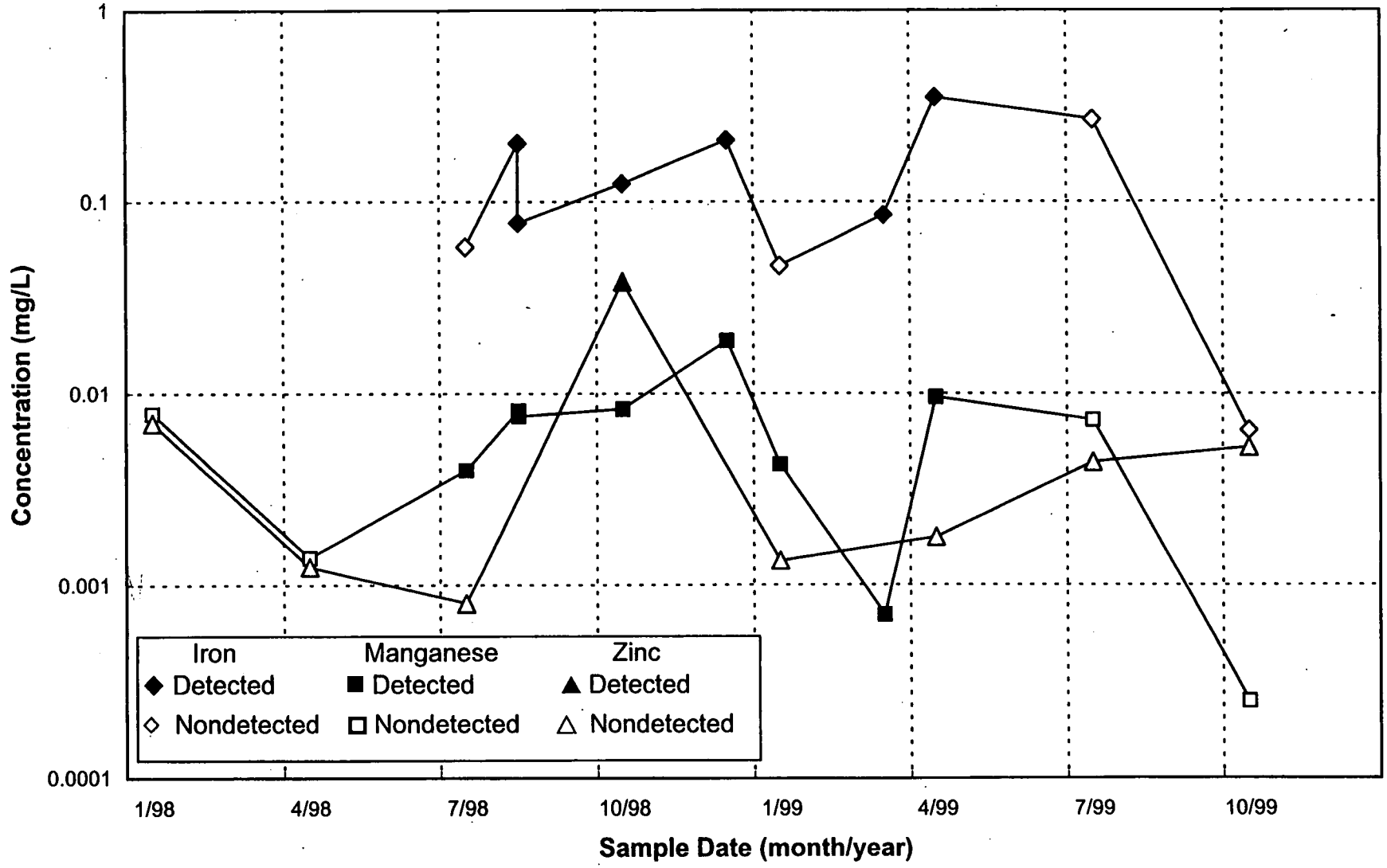


FIGURE A.4-32. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 2434

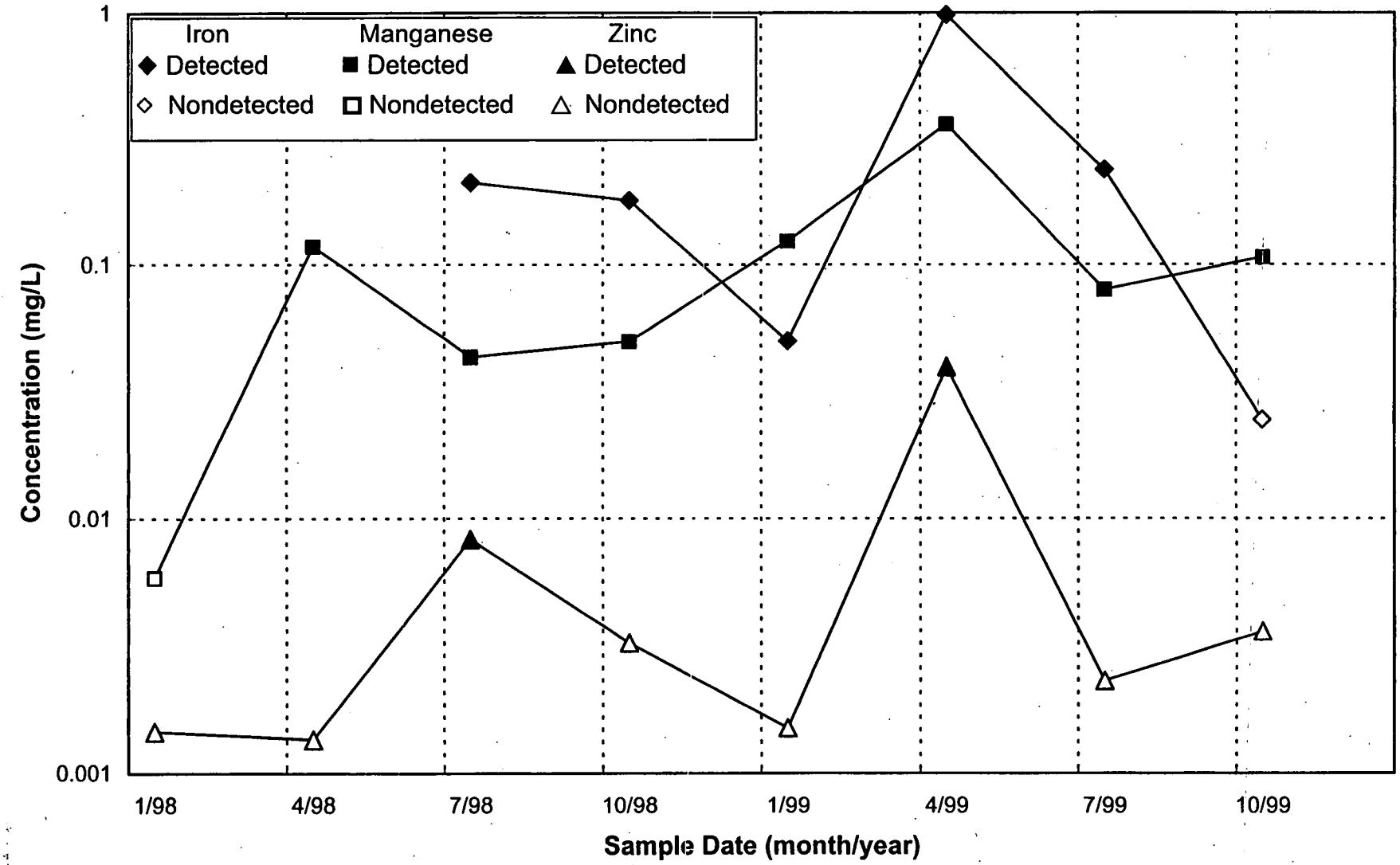


FIGURE A.4-33. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 2733

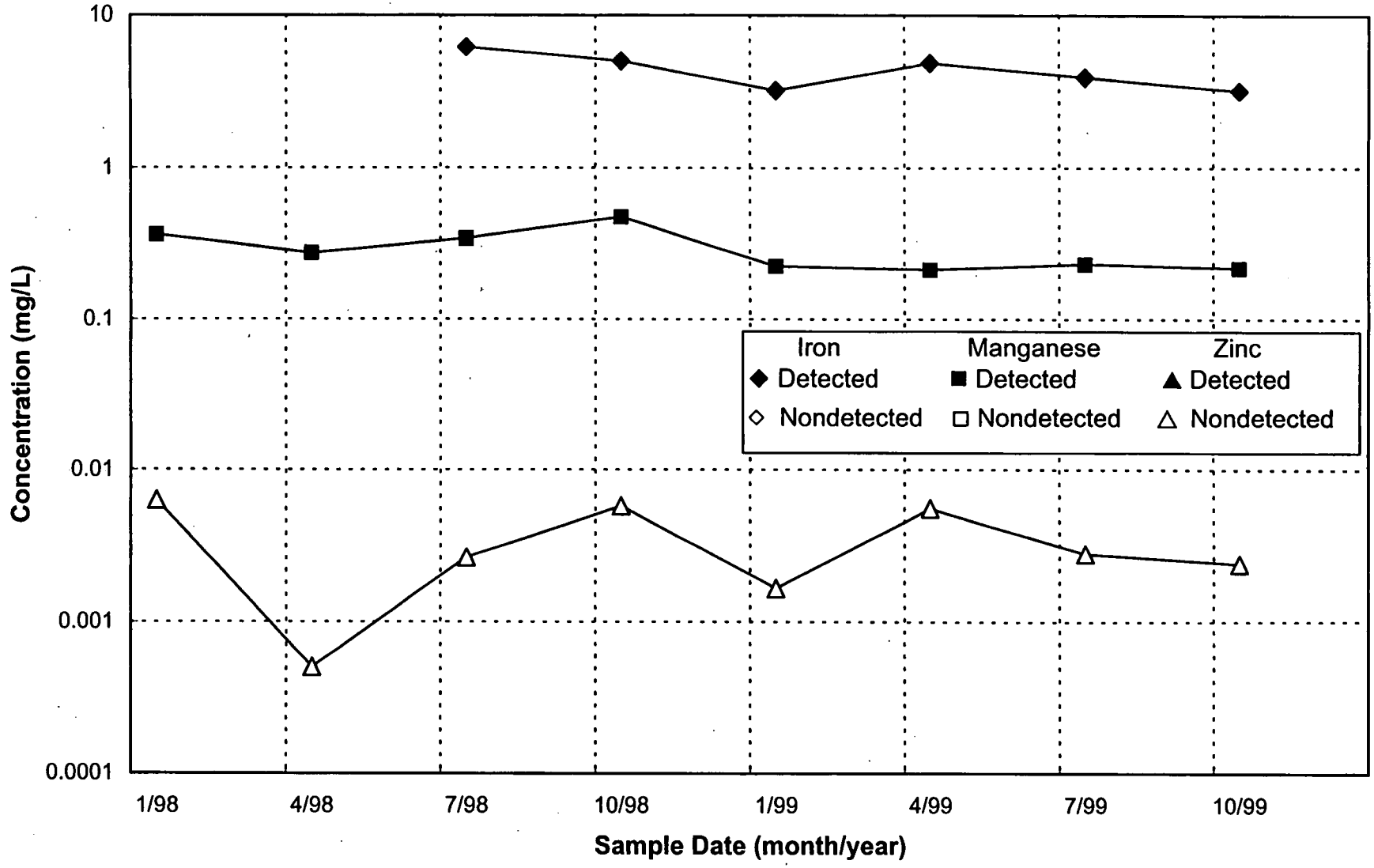


FIGURE A.4-34. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 3067

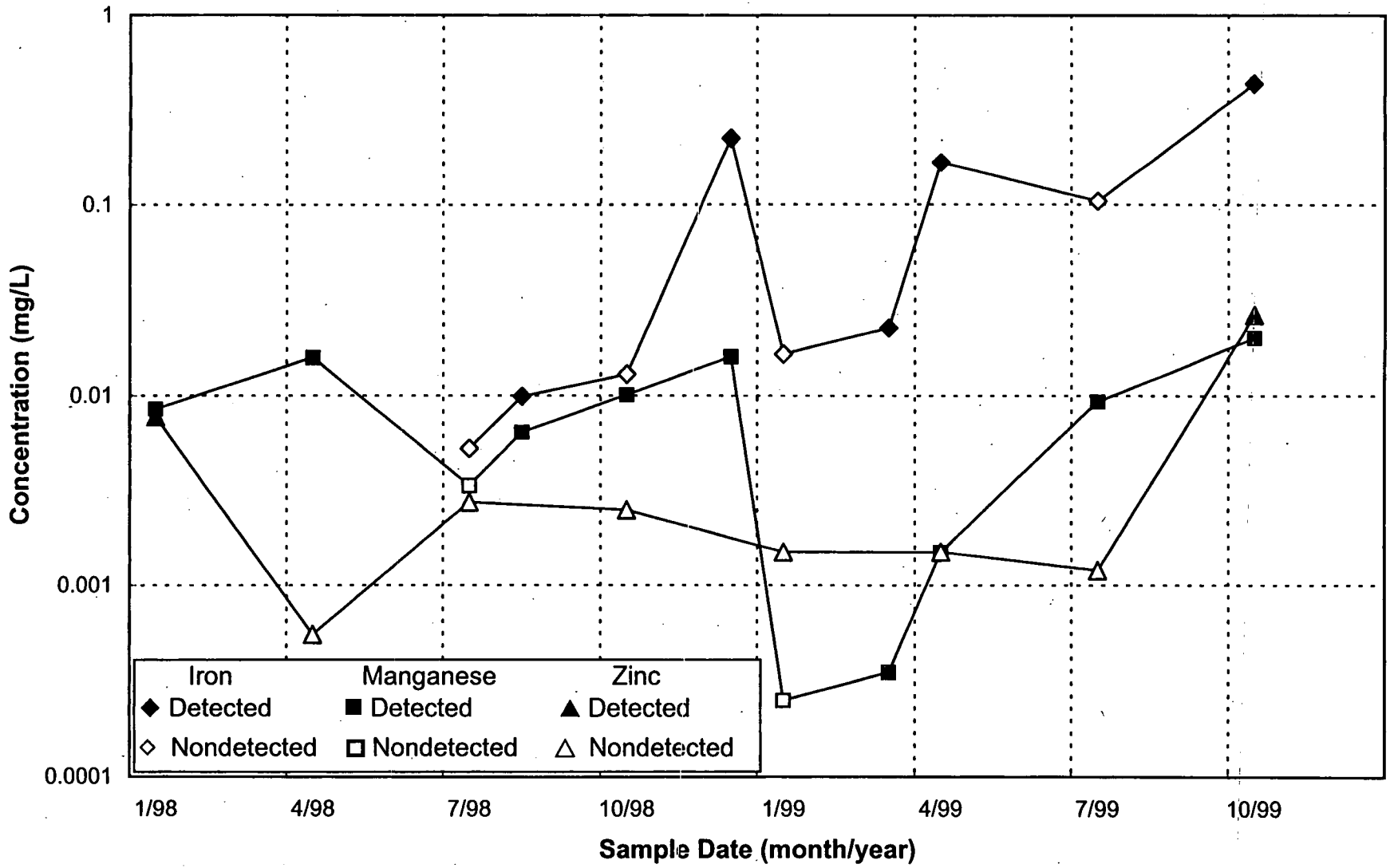


FIGURE A.4-35. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 3069



000297

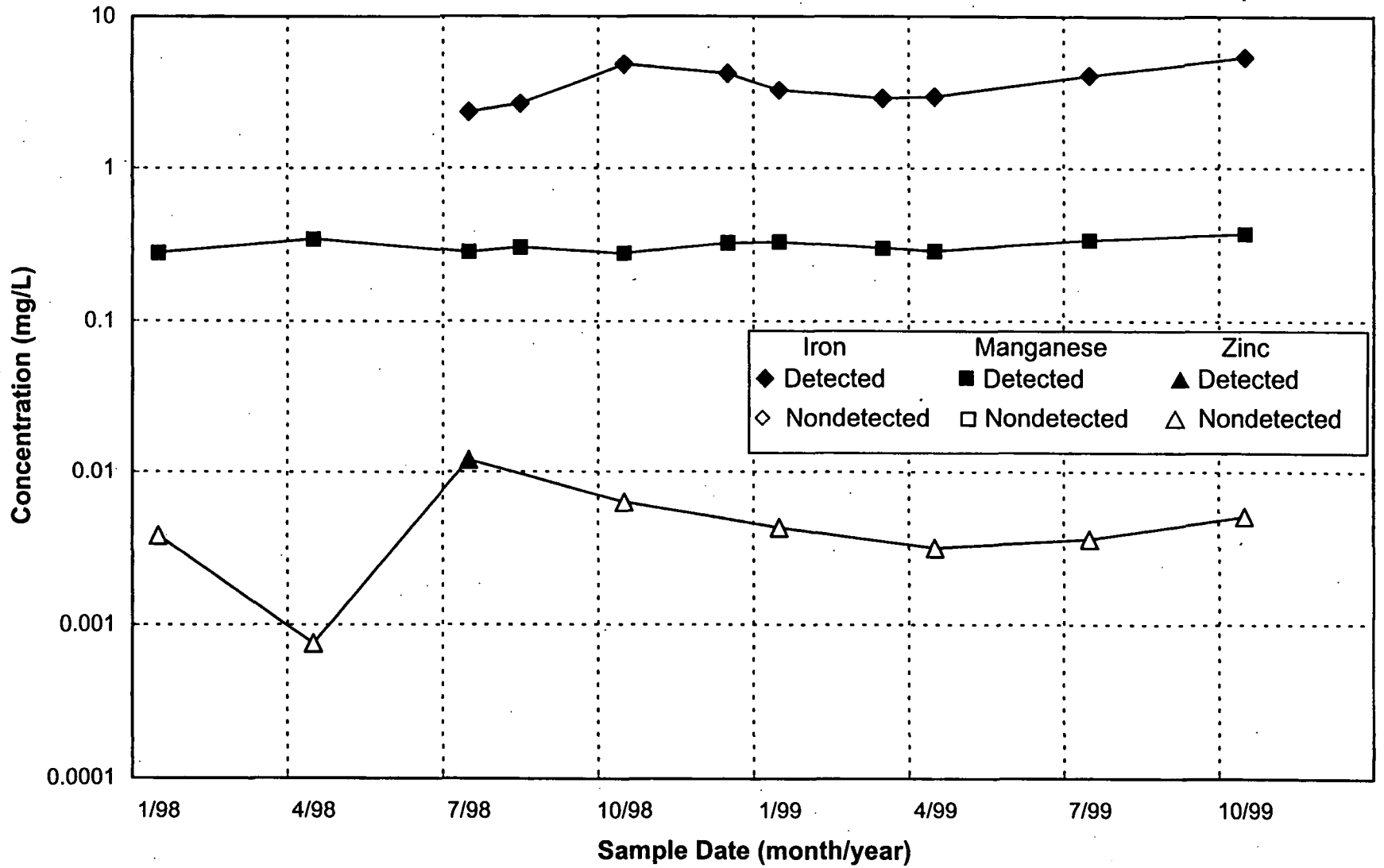


FIGURE A.4-36. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 3070

000298

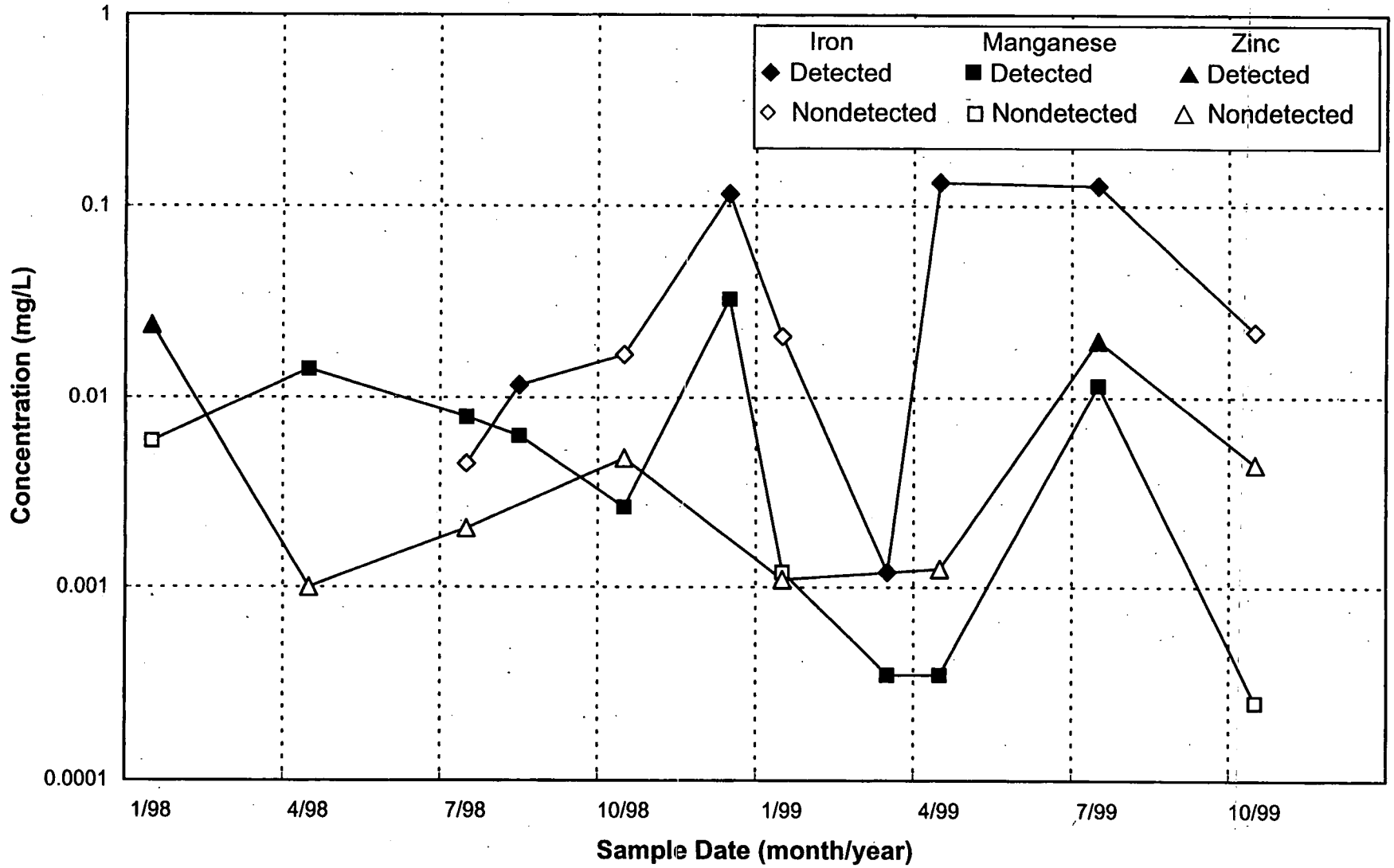


FIGURE A.4-37. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 3106



000299

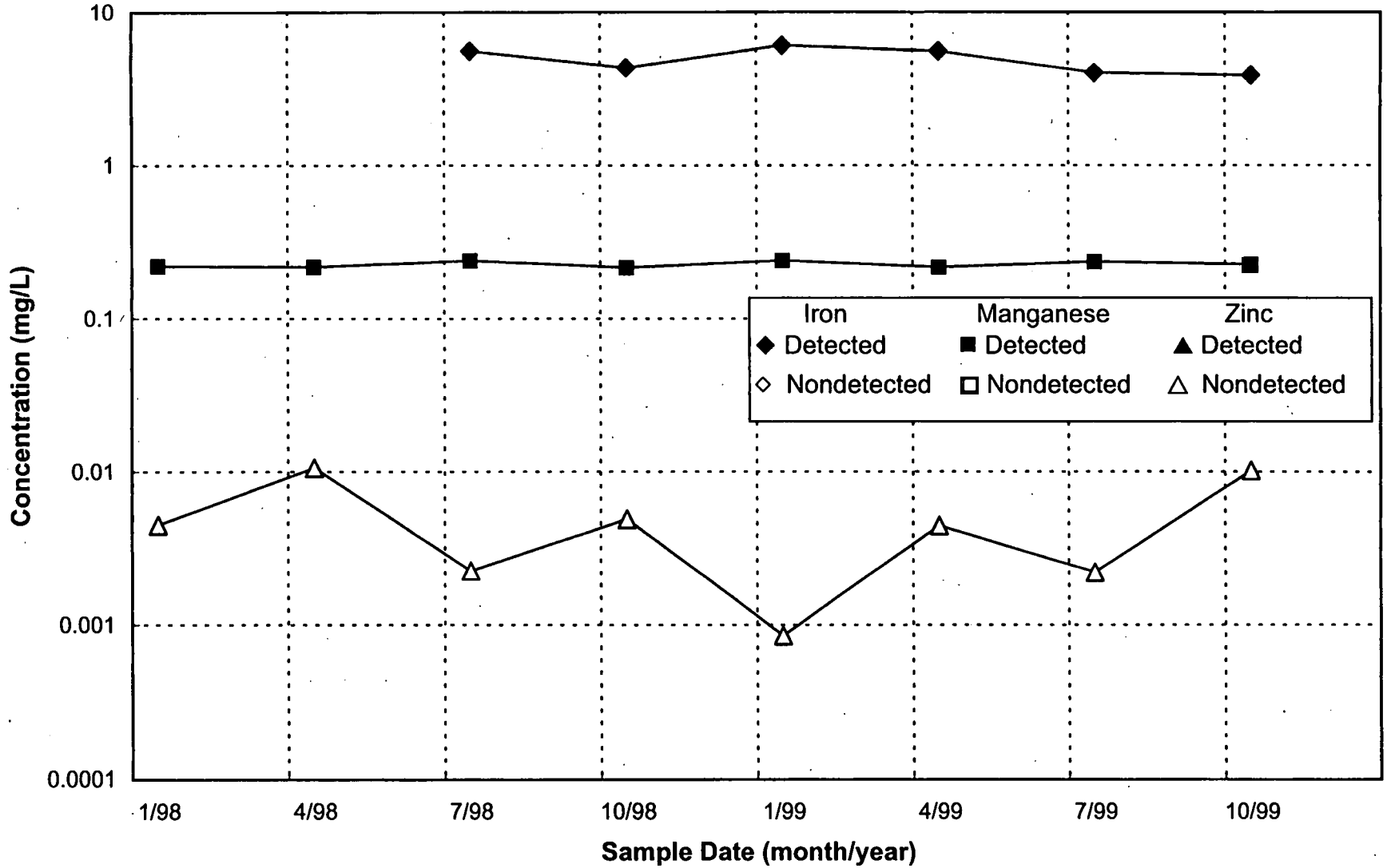


FIGURE A.4-38. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 31217

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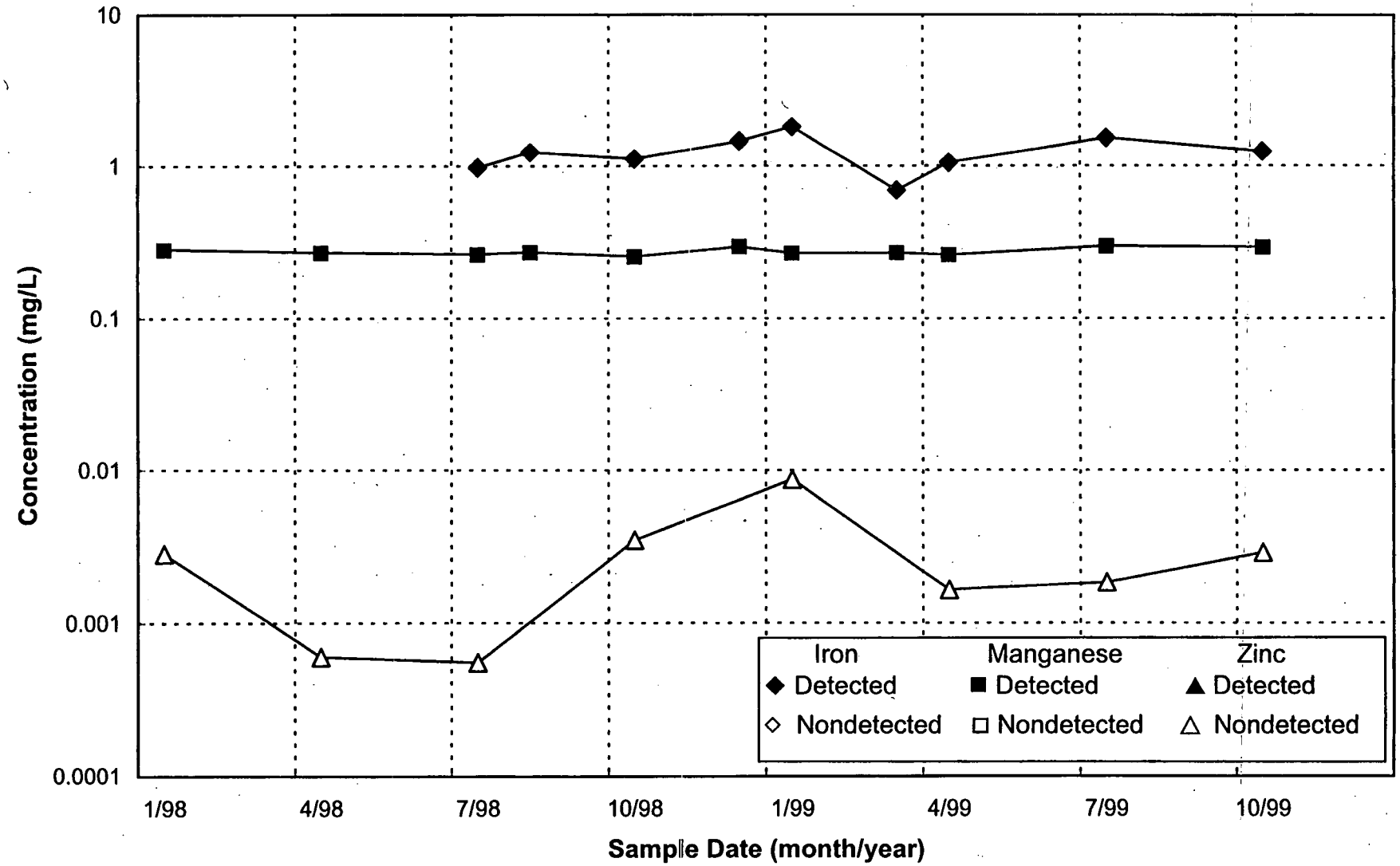


FIGURE A.4-39. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 3398

000302

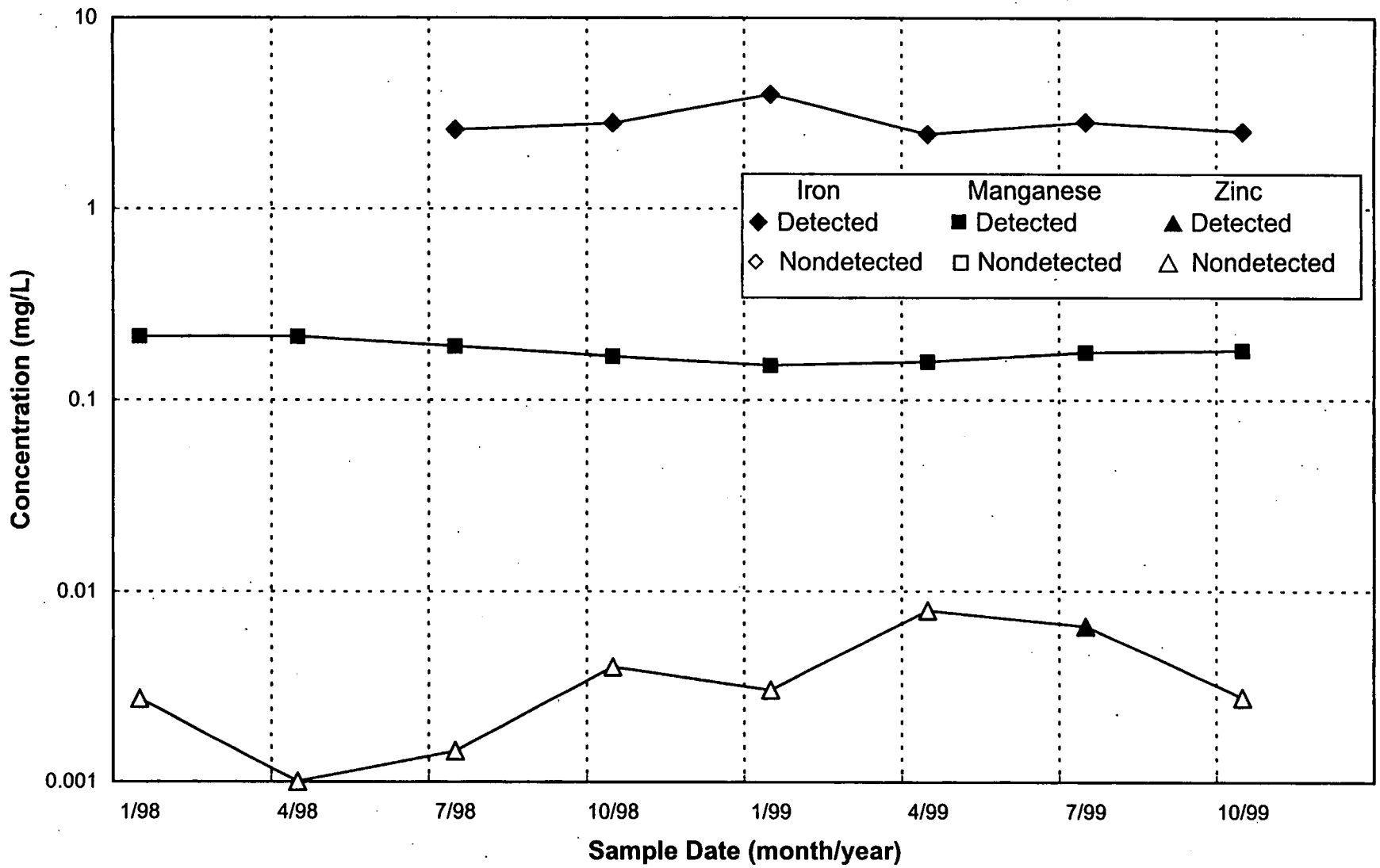


FIGURE A.4-40. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 3417

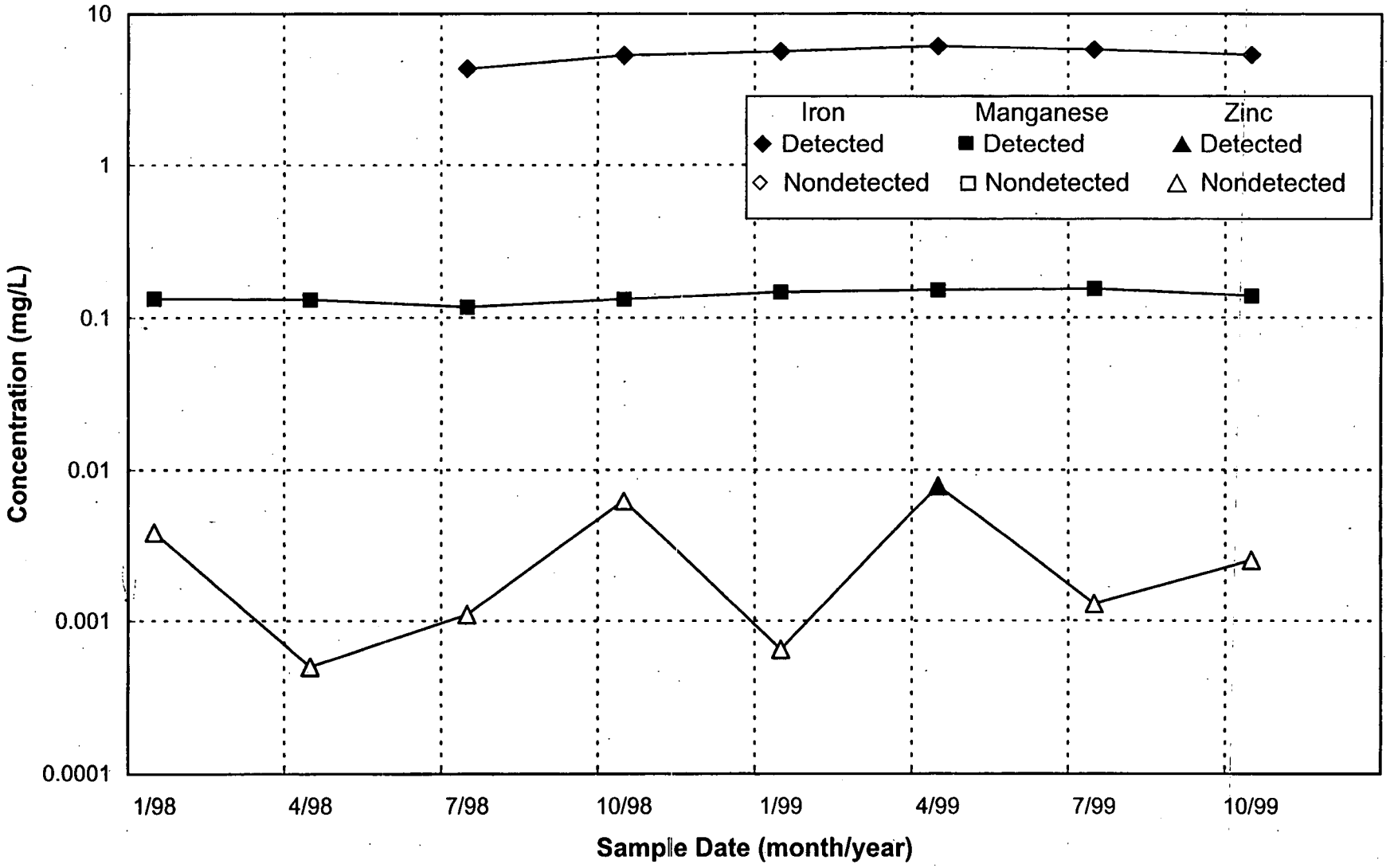


FIGURE A.4-41. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 3424

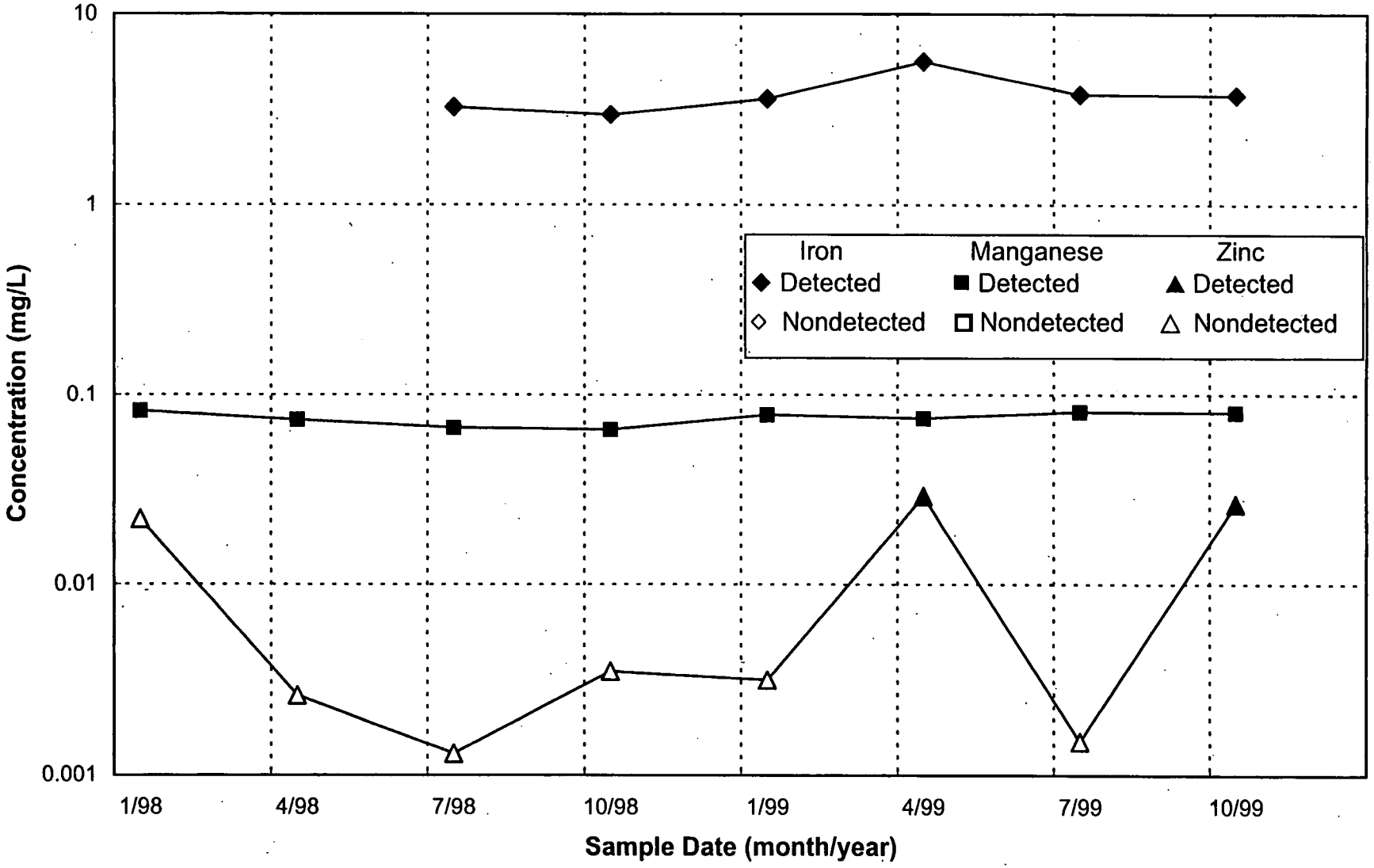


FIGURE A.4-42. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 3426

000304

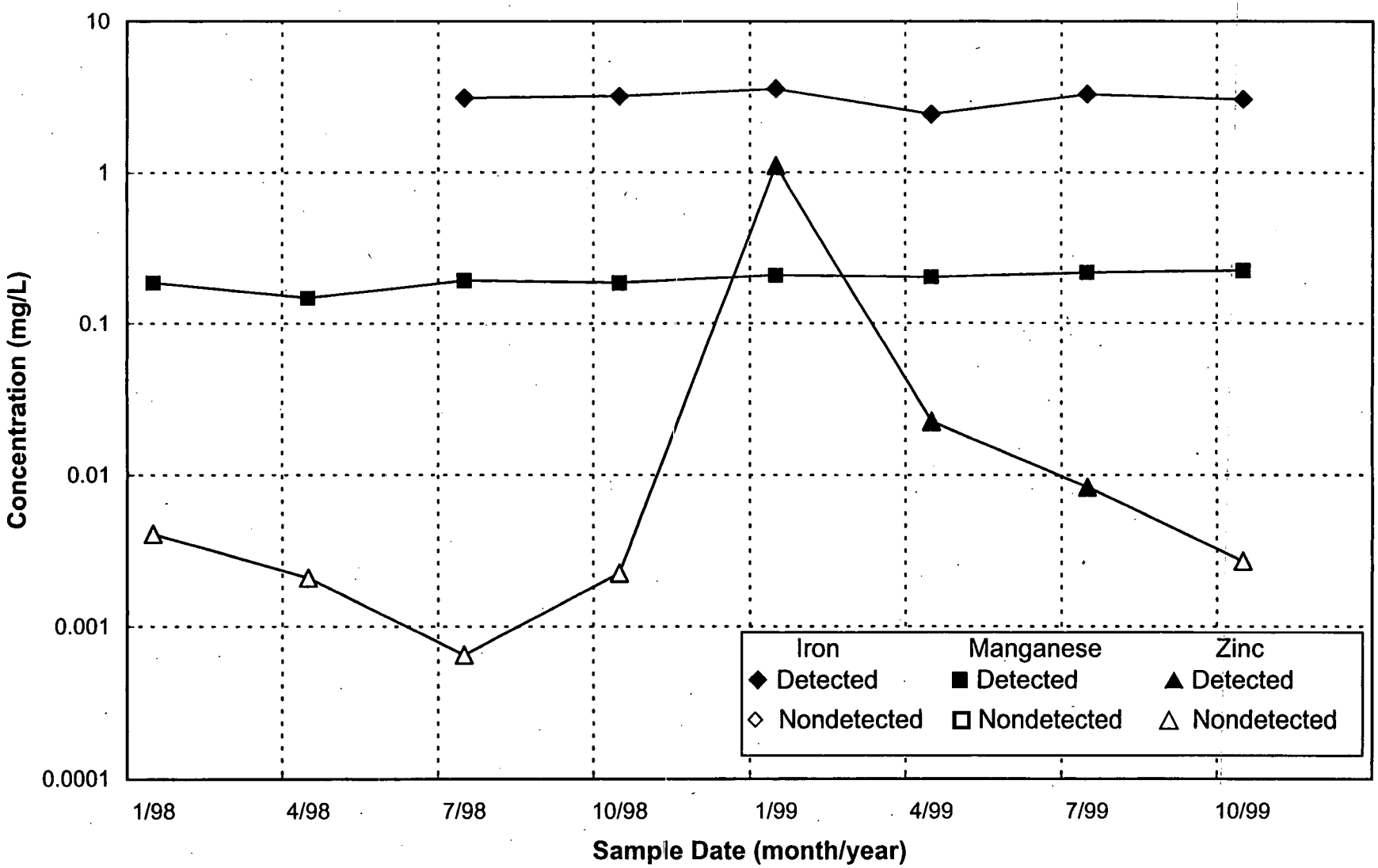


FIGURE A.4-43. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 3429

000306

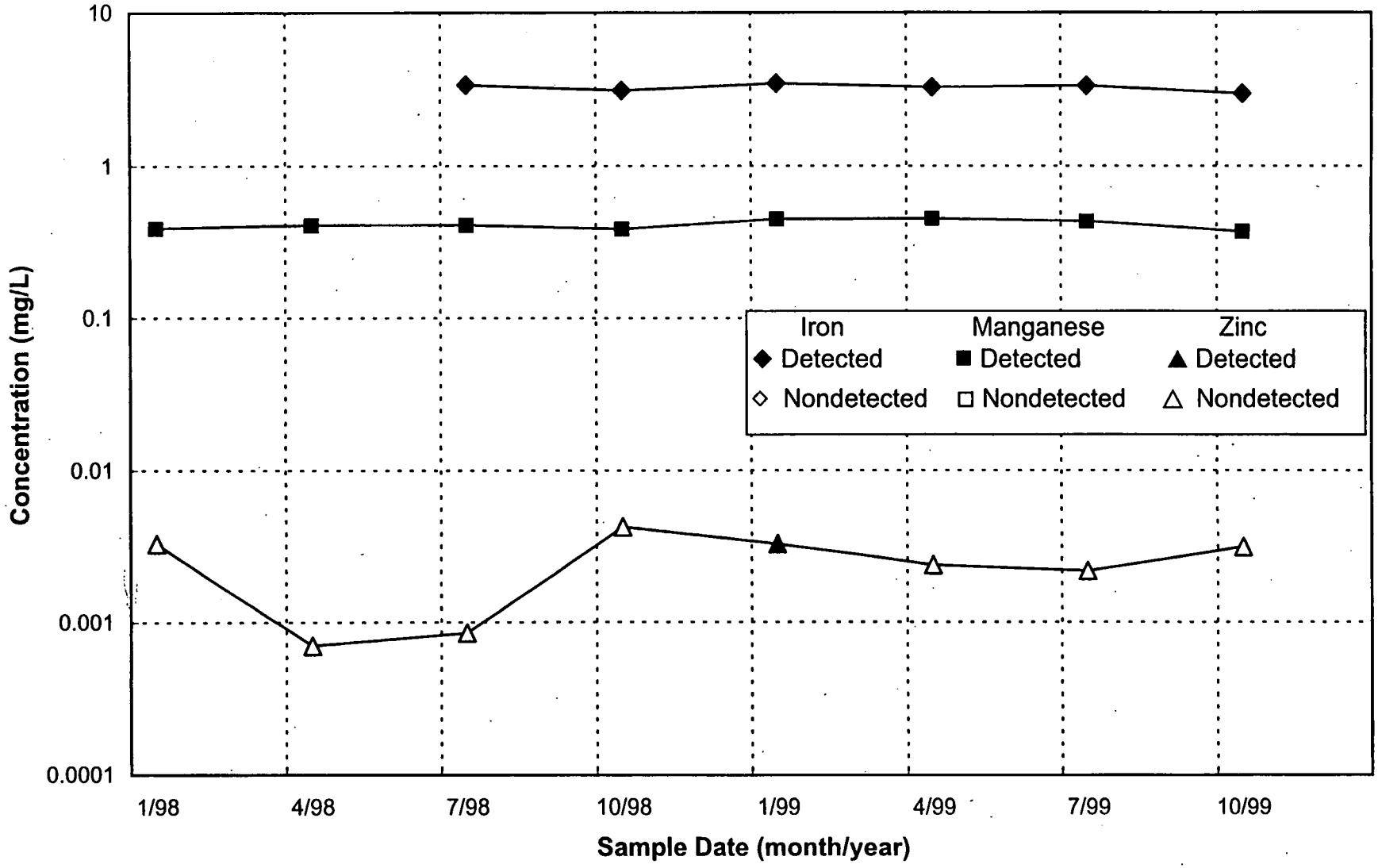


FIGURE A.4-44. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 3431

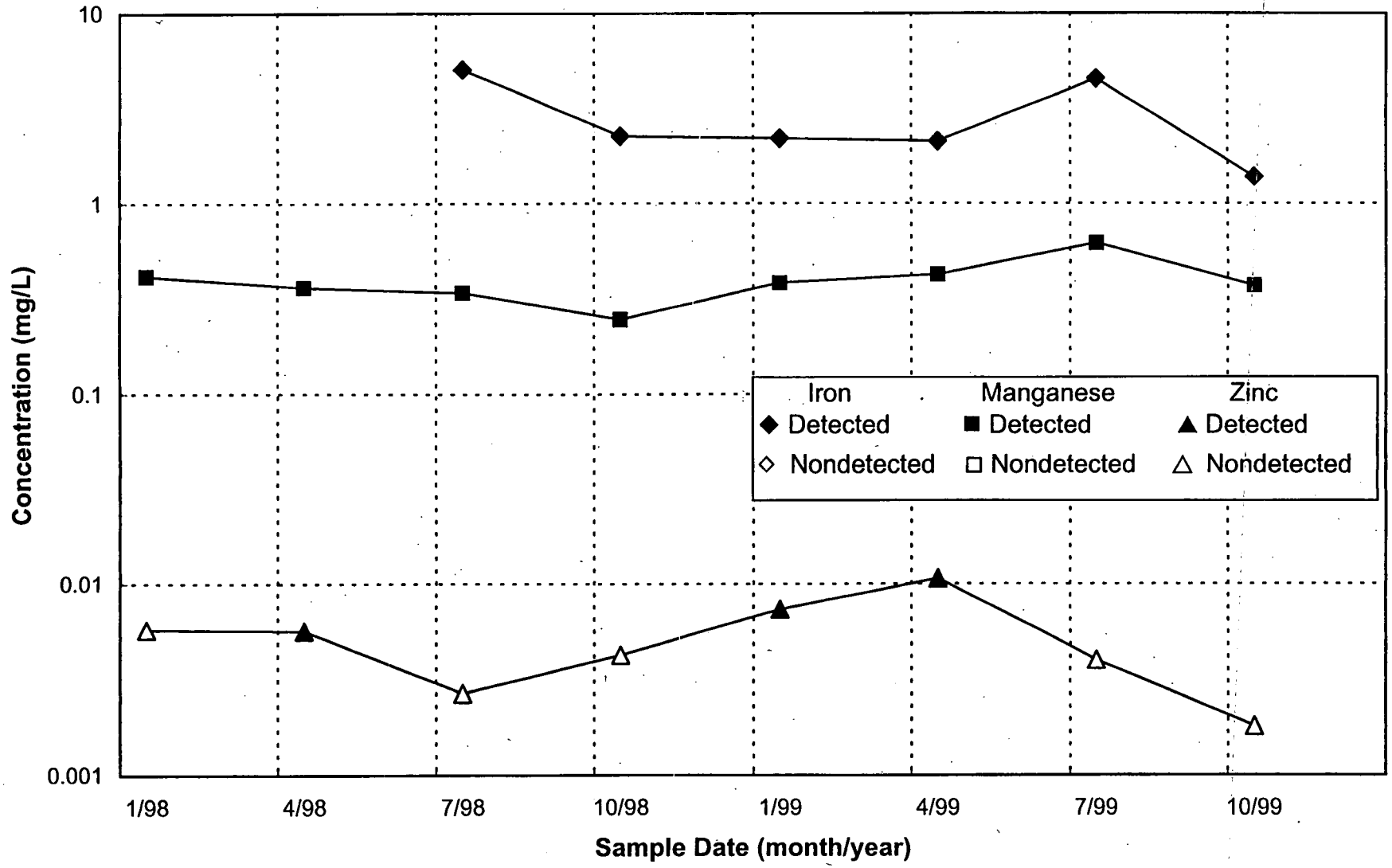


FIGURE A.4-45. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 3432



000307

000308

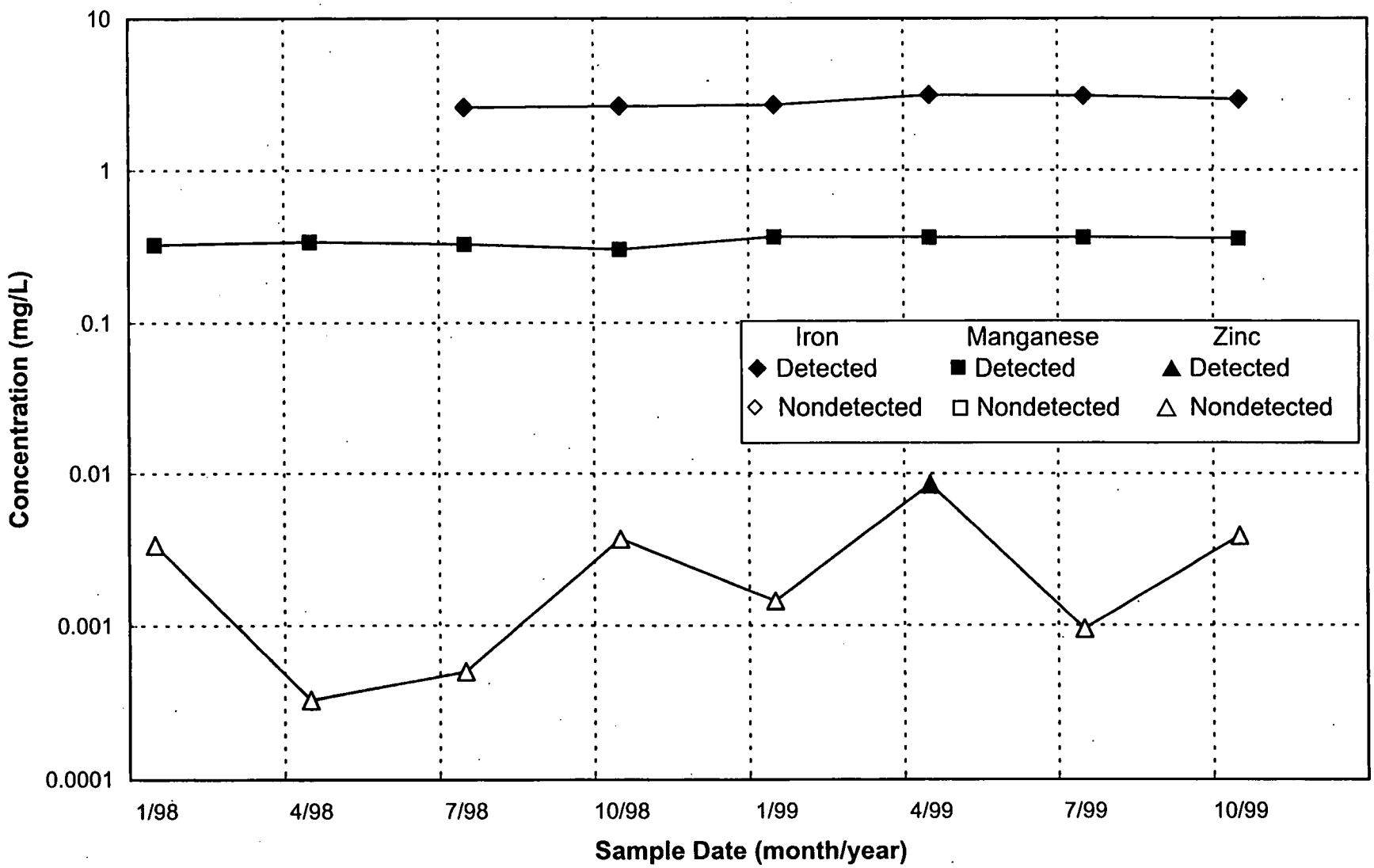


FIGURE A.4-46. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 3733

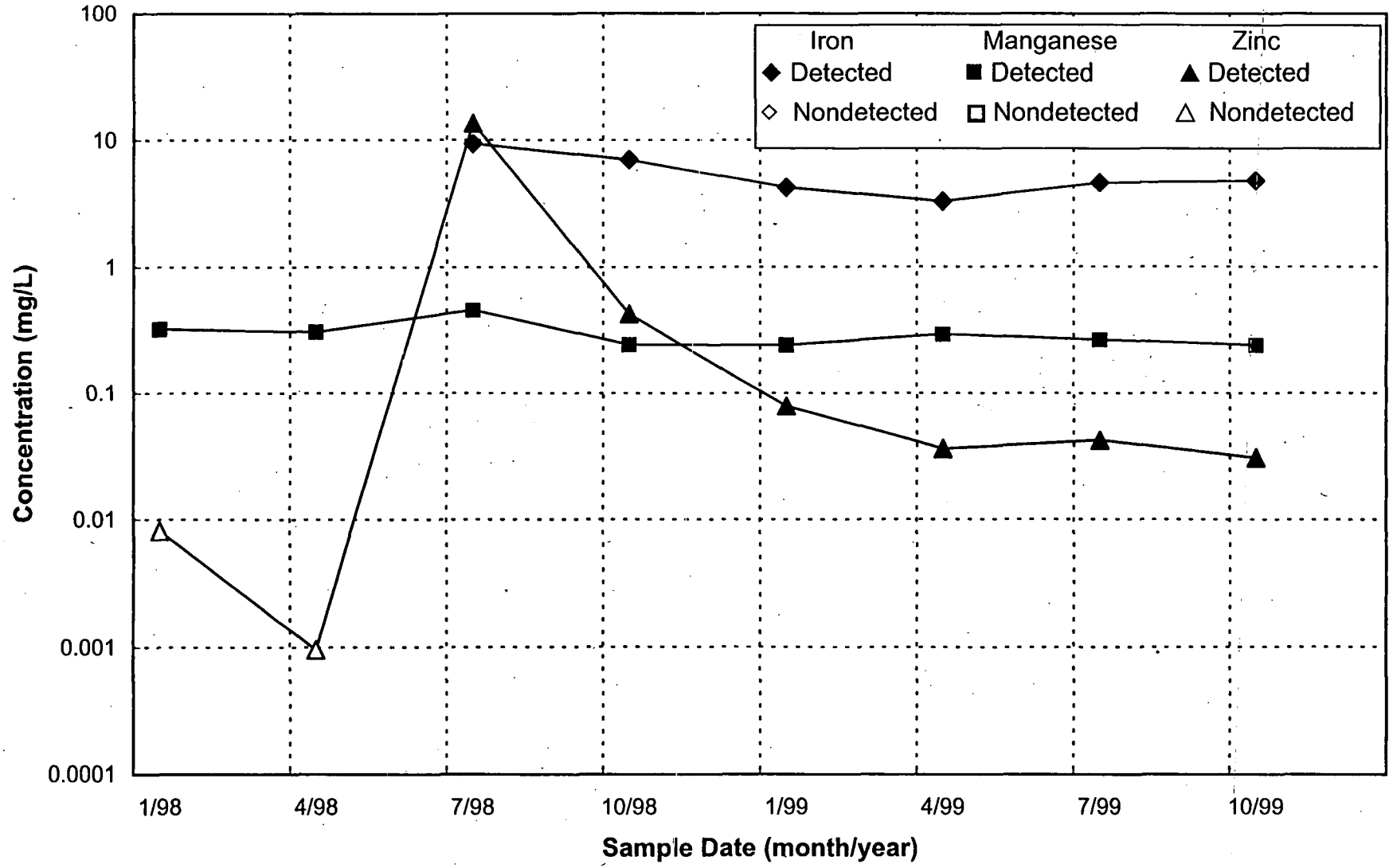


FIGURE A.4-47. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 4067

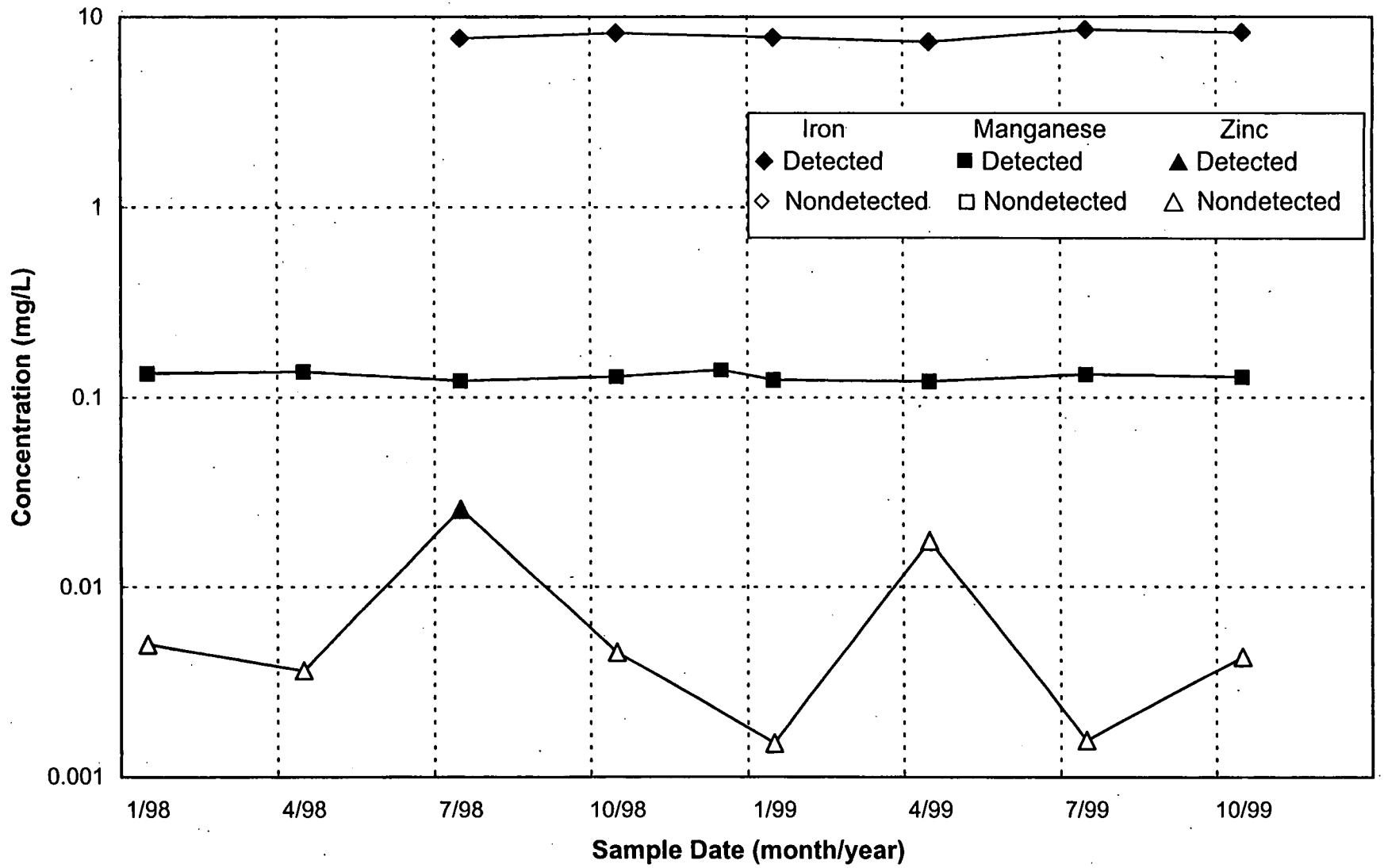


FIGURE A.4-48. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 41217

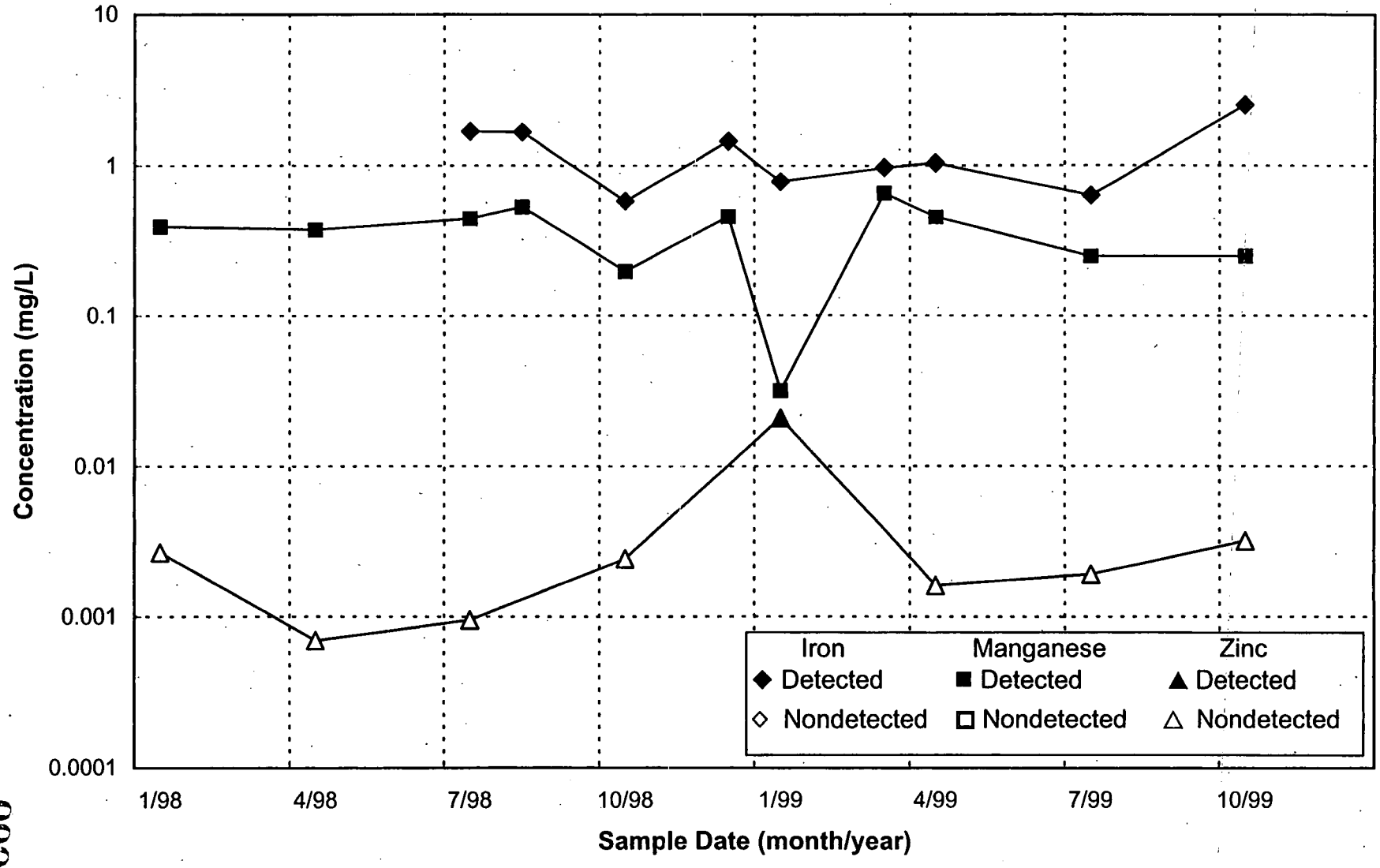


FIGURE A.4-49. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 4398

000312

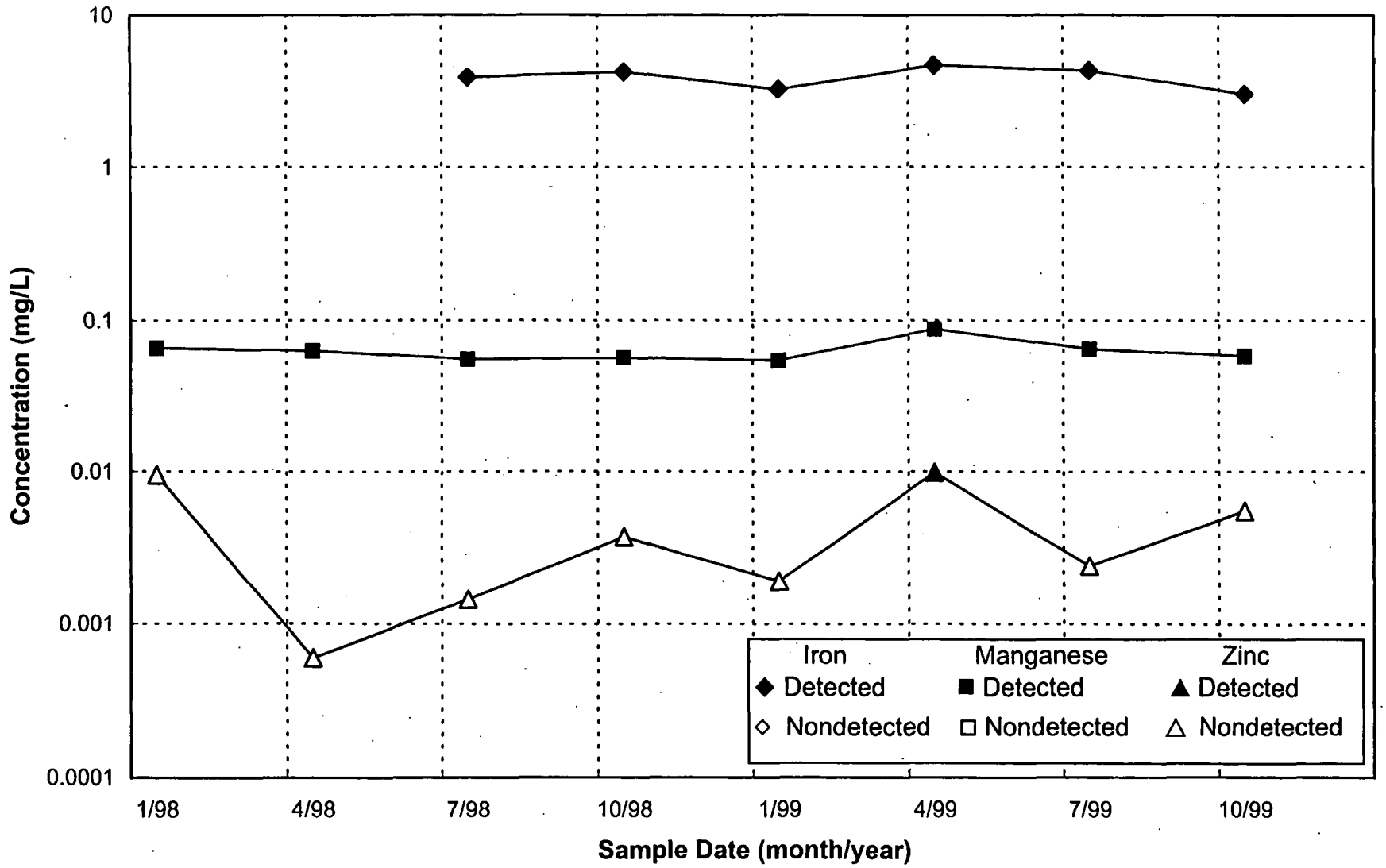


FIGURE A.4-50. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 4424

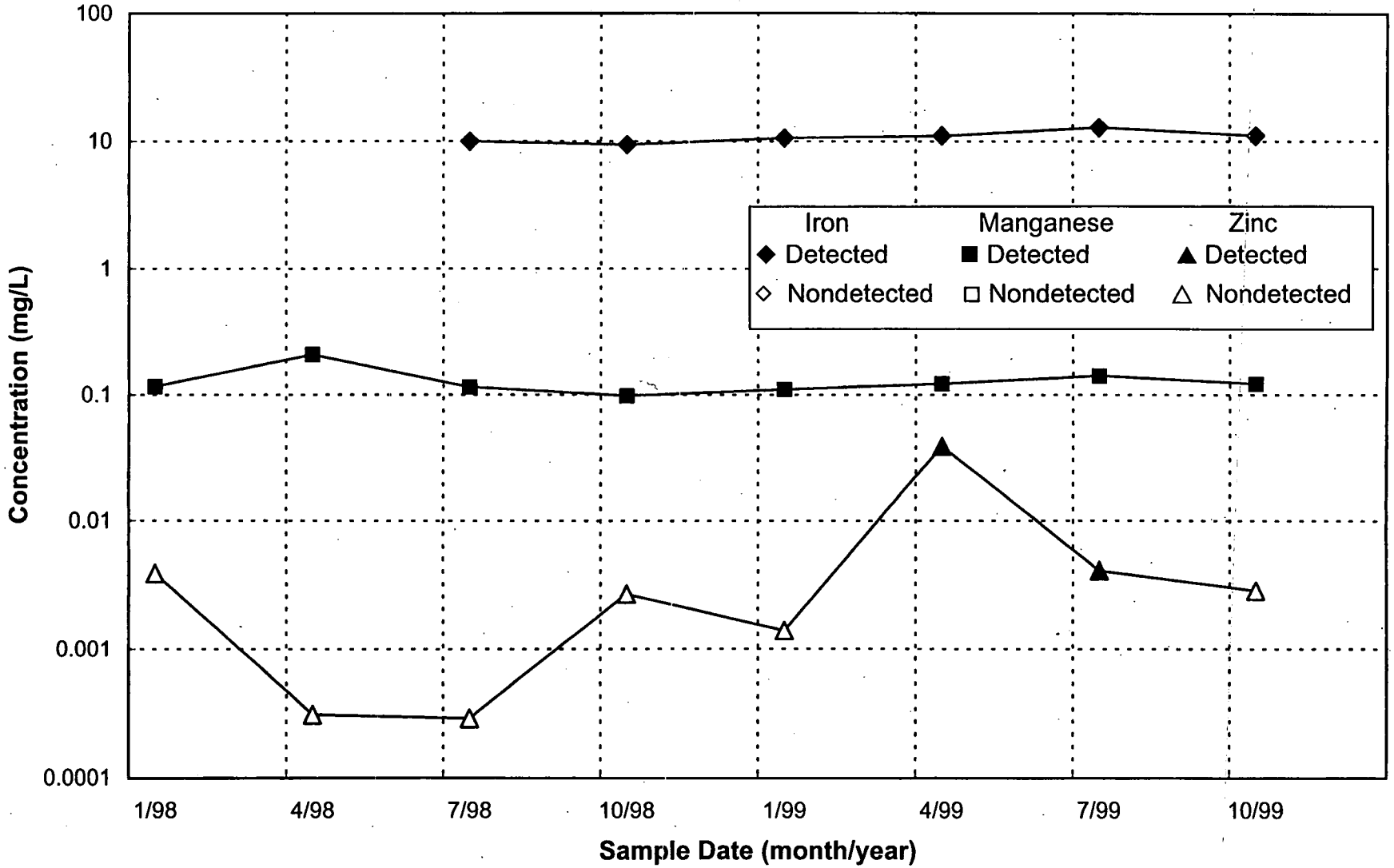


FIGURE A.4-51. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 4426



000313

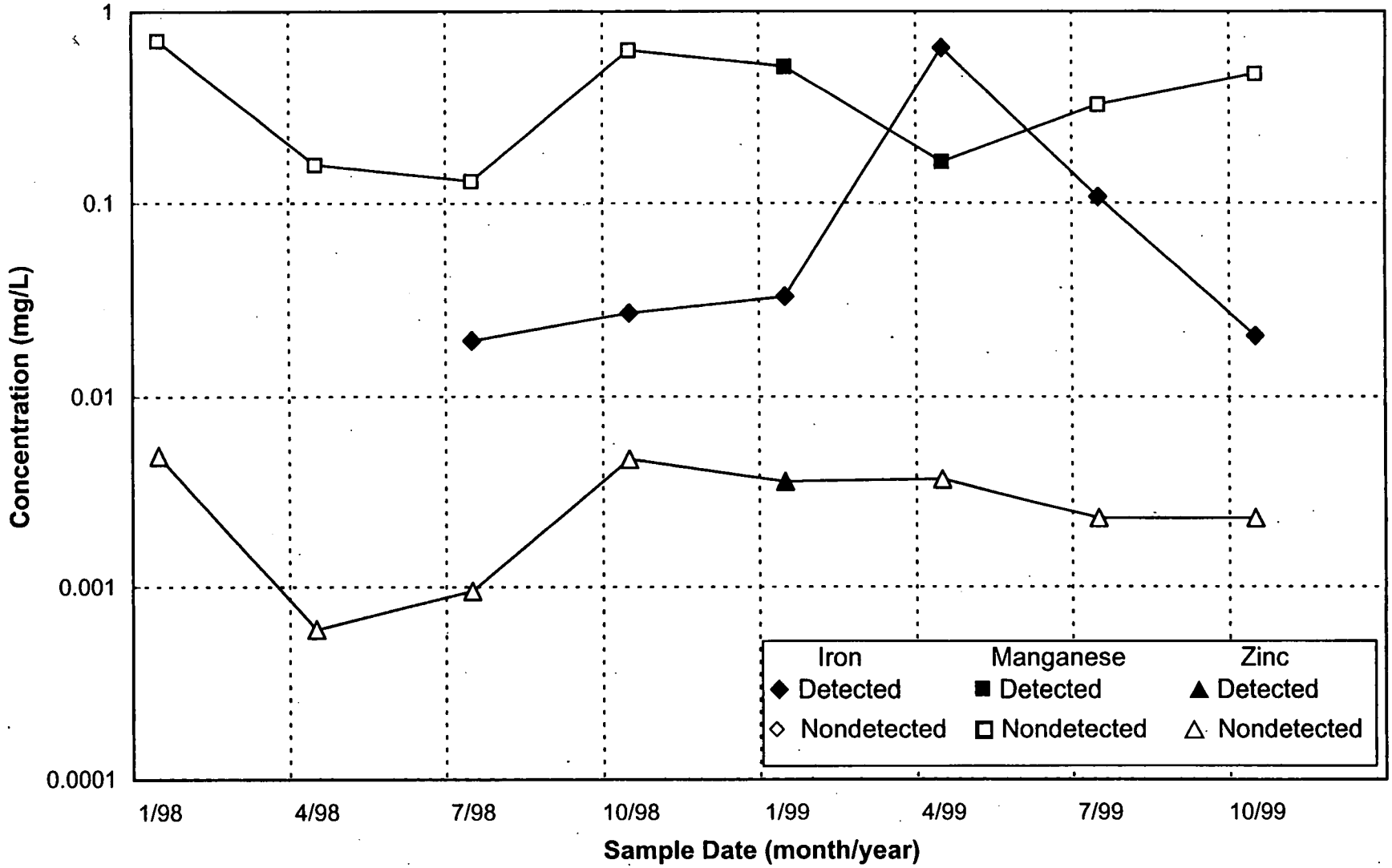


FIGURE A.4-52. IRON, MANGANESE, AND ZINC CONCENTRATIONS VS. TIME PLOT FOR MONITORING WELL 4432

000314

# ATTACHMENT A.5

# MISCELLANEOUS MONITORING ACTIVITIES

# ATTACHMENT A.5

KC-2 Warehouse Well Monitoring Activity

The KC-2 Warehouse well monitoring has also been included as part of the IEMP. Monitoring of this well (Well 67 in Figure A.5-1) is conducted on an annual basis. As identified to EPA and OEPA in October 1999, the KC-2 Warehouse well will be removed from the IEMP sampling program as it is scheduled to be plugged and abandoned in spring of 2000 (refer to Letter No. C:OOTP:99-0391, dated October 29, 1999, from DOE to EPA and OEPA).

Although all results were below the groundwater FRLs, the August 1999 sampling event for the KC-2 Warehouse well (Table A.5-1) revealed some constituents with higher concentrations of hazardous substance list metals than the sampling results for 1998. The detected results that exceeded last year's results included magnesium, nickel, potassium, silver, sodium, and thallium. Of these, the only exceedance above the historical average (20.4 mg/L) was sodium at 20.8 mg/L. The well will be sampled prior to plugging and abandonment in 2000.

# TABLE A.5-1

## KC-2 WAREHOUSE GROUNDWATER SUMMARY STATISTICS (January 1993 through Third Quarter [August] 1999)

| Constituent | Number of Samples[a,b] | FRL[c] (mg/L) | Min.[a,b,d,e] (mg/L) | Max.[a,b,d,e] (mg/L) | Avg.[a,b,d,e] (mg/L) | SD[a,b,d,e] (mg/L) | 1999 Data Sample Result (mg/L); Validation Qualifier[f] |
|---|---|---|---|---|---|---|---|
| Aluminum | 13 | NA | 0.0104 | 80 | 13 | 24 | 0.0104 - |
| Antimony | 13 | 0.0060 | 0.000065 | 0.22 | 0.048 | 0.069 | 0.00062 U |
| Arsenic | 13 | 0.050 | 0.00041 | 0.0873 | 0.015 | 0.029 | 0.00082 U |
| Barium | 13 | 2.0 | 0.103 | 0.867 | 0.350 | 0.251 | 0.208 - |
| Beryllium | 13 | 0.0040 | 0.00001 | 0.005 | 0.0013 | 0.0016 | 0.00002 U |
| Cadmium | 13 | 0.014 | 0.00003 | 0.0671 | 0.01 | 0.02 | 0.00008 U |
| Calcium | 13 | NA | 45.3 | 1310 | 318 | 434 | 45.3 - |
| Chromium | 13 | 0.022[g] | 0.000415 | 2.35 | 0.40 | 0.74 | 0.00083 U |
| Cobalt | 13 | 0.17 | 0.000065 | 0.102 | 0.024 | 0.037 | 0.00013 U |
| Copper | 13 | 1.3 | 0.000335 | 0.373 | 0.089 | 0.14 | 0.00077 U |
| Cyanide | 5 | NA | 0.000985 | 0.005 | 0.0024 | 0.0016 | 0.01 U |
| Iron | 13 | NA | 1.65 | 620 | 140 | 220 | 1.65 - |
| Lead | 13 | 0.015 | 0.00026 | 3.8 | 0.74 | 1.3 | 0.00052 U |
| Magnesium | 13 | NA | 33.9 | 322 | 98.4 | 102 | 36.5 - |
| Manganese | 13 | 0.900 | 0.0363 | 8.52 | 1.89 | 3.03 | 0.0363 - |
| Mercury | 13 | 0.0020 | 0.00005 | 0.0022 | 0.0003 | 0.0006 | 0.0001 U |
| Nickel | 13 | 0.10 | 0.00039 | 1.21 | 0.23 | 0.39 | 0.00039 - |
| Potassium | 12 | NA | 0.922 | 14.6 | 3.09 | 3.99 | 1.33 - |
| Selenium | 13 | 0.050 | 0.00039 | 0.0099 | 0.0027 | 0.0028 | 0.00092 U |
| Silver | 13 | 0.050 | 0.00025 | 0.0312 | 0.005 | 0.009 | 0.0008 - |
| Sodium | 12 | NA | 17.5 | 23.9 | 20.4 | 1.83 | 20.8 - |
| Thallium | 13 | NA | 0.000025 | 1.8 | 0.14 | 0.50 | 0.0013 - |
| Vanadium | 13 | 0.038 | 0.000075 | 0.19 | 0.035 | 0.055 | 0.00015 U |
| Zinc | 13 | 0.021 | 0.0061 | 1.79 | 0.36 | 0.57 | 0.0138 UJ |
| | | (µg/L) | (µg/L) | (µg/L) | (µg/L) | (µg/L) | (µg/L) |
| Uranium, Total | 13 | 20 | 0.04 | 2400 | 200 | 700 | 0.08 U |

[a]If more than one sample is collected per well per day (e.g., duplicate), then only one sample is counted for the total number of samples, and the sample with the maximum concentration is used to determine the summary statistics (minimum, maximum, average, and standard deviation [SD]).
[b]Rejected data qualified with either a R or Z were not included in this count or the summary statistics.
[c]NA = not applicable
[d]Where concentrations are below the detection limit, each result used in the summary statistics is set at half the detection limit.
[e]If the total number of samples is greater than or equal to four, then all of the summary statistics are reported. If the total number of samples is equal to three, then the minimum, maximum, and average are reported. If the total number of samples is equal to two, then the minimum and maximum are reported. If the total number of samples is equal to one, then the data point is reported as the minimum.
[f]Validation qualifier codes are provided in Appendix D of the Sitewide CERCLA Quality Assurance Project Plan.
[g]The FRL is based on chromium VI, from Operable Unit 5 Record of Decision, Table 9 -4; however, the sampling results are for total chromium.

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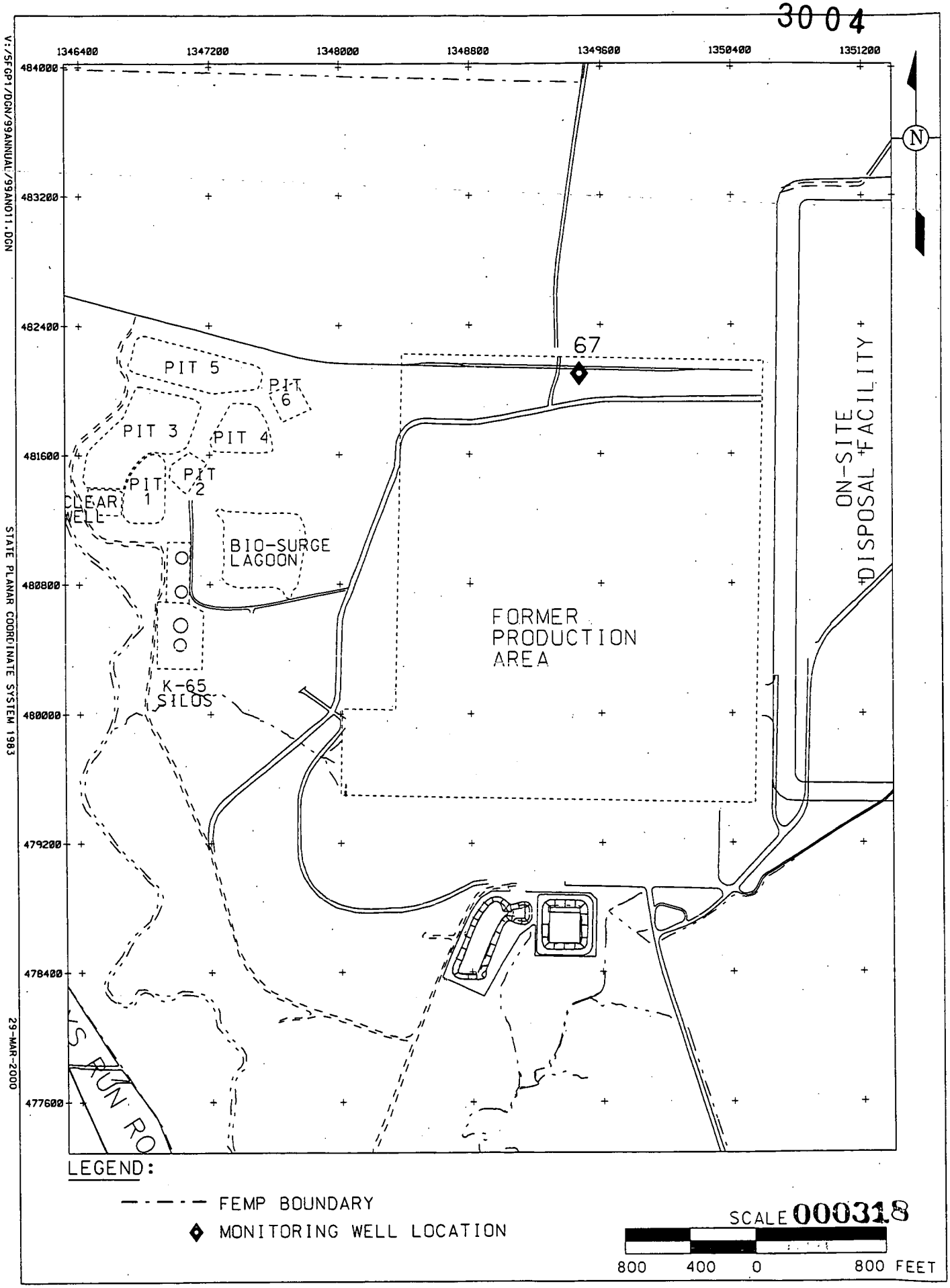


FIGURE A.5-1. KC-2 WAREHOUSE WELL MONITORING LOCATION

# ATTACHMENT A.6

## ON-SITE DISPOSAL FACILITY MONITORING RESULTS

# ATTACHMENT A.6



The on-site disposal facility monitoring program fulfills two purposes: leak detection and leachate monitoring. It also meets the regulatory requirements for groundwater detection monitoring in the Great Miami Aquifer and perched groundwater system at the FEMP. The On-Site Disposal Facility Groundwater/Leak Detection and Leachate Monitoring Plan (DOE 1997c) presents the specific on-site disposal facility monitoring strategy for construction, closure, and post closure. The plan represents the first part of a three-tiered detection, assessment, and corrective action monitoring strategy required by EPA.

The final anticipated facility dimensions are: capacity of 2.5 million cubic yards, maximum height of approximately 65 feet, and an estimated areal coverage of 70 acres of the northeastern area of the FEMP. Protection of the Great Miami Aquifer and the overlying perched groundwater system includes the following measures for each of the eight anticipated cells:

- Leachate collection system
- Leak detection system
- Multi-layer composite liner system
- Multi-layer composite cap system.

The leachate collection system consists of a gravel layer installed beneath the waste to collect rainwater that comes in contact with the waste during cell construction, and additional moisture that drains from the waste following capping. The leak detection system is located beneath both the leachate collection system and the primary geosynthetic liner system and provides a mechanism for collecting and monitoring leakage from the on-site disposal facility prior to any releases to the environment. Both systems drain to the west and extend beyond the synthetic liner systems where they become accessible for monitoring through manholes. Figure A.6-1 depicts a cross section of the liner system. Horizontal till wells are set beneath the compacted clay liner of each cell and provide monitoring of the perched groundwater quality beneath the point where the leachate collection and leak detection system pipes exit the liner system. The Great Miami Aquifer is monitored via both an upgradient and a downgradient monitoring well for each cell.

The following subsections provide information for Cells 1, 2, and 3 where monitoring was conducted during 1999. There is also a subsection on Cell 4 where well installation occurred during 1999. Figure A.6-2 identifies the well locations associated with the on-site disposal facility.

## A.6.1 CELL 1

### A.6.1.1 Construction and Leak Detection System Flow Data

Placement of waste (contaminated soil and debris) in Cell 1, which began in December 1997, continued during 1999. At the end of December 1999, Cell 1 was approximately 80 percent full. Figure A.6-3 shows the volumes of water (monthly totals) pumped from the Cell 1 leak detection monitoring system for 1999.

Beginning in May 1999 quantitative measurement of the volumes accumulating and pumped from the Cell 1 leak detection monitoring system was initiated. This was accomplished by installing a water level probe (data logger) in the primary containment vessel, which recorded water levels on an hourly basis. On a weekly basis, the water level data collected are downloaded then converted into a volume based on volumetric calibration of the containment vessel. This tracking of the accumulating volume in the primary containment vessel provided the data to determine the monthly volume pumped (refer to Figure A.6-3). Figure A.6-4 provides the May through December 1999 Cell 1 leak detection system accumulation rates which were calculated each time the primary containment vessel was pumped out. The accumulation rate increased just after beginning waste placement in June 1999, peaked for the year at a rate of 0.87 gallons per acre per day (gpad) based on the July 14 pump out, then steadily declined. The peaking and subsequent decline is consistent with what is expected, if the primary source of the accumulating water was construction water (water introduced during lead detection system construction) being squeezed out of the leak detection system by the weight of waste placement activities occurring in the above cell.

Table A.6-1 provides precipitation volumes that fell on Cells 1, 2, and 3 during construction of their secondary and primary liners. The calculated volume that fell on Cell 1 during construction of its primary liner was 604,780 gallons. A portion of this water became trapped, as construction water, in the geosynthetic clay liner on top of the Cell 1 leak detection system and in the geotextile cushion within the leak detection system. The total water yield recorded for the Cell 1 leak detection system for 1999 was 7,827 gallons or about 1.3 percent of the volume that fell on Cell 1 during construction of its primary liner.

In the On-site Disposal Facility Final Design Calculation Package (DOE 1997b), it was concluded that an initial response leakage rate for individual cells would be 20 gpad. The above noted maximum accumulation rate for Cell 1 (0.87 gpad) is about four percent of the initial response leakage rate. This indicates that the liner system is performing well within the specifications outlined in the approved cell design. Over time, with the capping and closure of the cell, the volume of water removed from the leak

detection system is expected to continue to diminish. The volume of water removed from the leak detection system will continue to be closely tracked to determine if the primary liner system continues to perform as expected.

A.6.1.2 Analytical Data

Sampling of groundwater, the leachate collection system, and the leak detection system for Cell 1 continued in 1999. Groundwater sampling was initiated for Cell 1 in 1997 in an effort to establish a baseline for the horizontal till well and Great Miami Aquifer wells prior to the initiation of waste placement in December 1997. During 1998 a draft technical memorandum was issued to discuss the baseline results. The regulatory agencies issued comments on this technical memorandum identifying that it would be necessary to extend the baseline sampling period for the existing horizontal till wells in order to better establish baseline conditions. Accordingly, a strategy to extend the baseline sampling period for the horizontal till wells associated with Cells 1, 2, and 3 was approved by the regulatory agencies in 1999.

Table A.6-2 presents the constituents detected in 1999 from the monitoring locations (leachate collection system, leak detection system, horizontal till well, and Great Miami Aquifer) associated with Cell 1. Of the 16 constituents sampled, five (total organic carbon, total organic halogens, boron, technetium-99, and total uranium) were detected in at least one location. Consistent with the Final On-Site Disposal Facility Groundwater/Leak Detection and Leachate Monitoring Plan, the table also provides the results of the Mann-Kendall statistical trend analysis on data from leachate collection and leak detection systems. Monitoring results by location are discussed below.

A.6.1.2.1 Leachate Collection System

Four of the five constituents identified in Table A.6-2 were detected in the leachate collection system. Technetium-99 was not detected. Trend analysis indicates that there was no significant trend for total organic carbon, total organic halogens, and total uranium; an Up, Marginal trend for boron; and a Down, Significant trend for technetium-99.

A sample is collected annually and analyzed for 67 additional constituents (general chemistry, inorganic, and organic) from Ohio Administrative Code 3745-27-10, Appendix I, to determine if the constituents analyzed quarterly are sufficient for leak detection purposes. This monitoring is identified in the On-Site Disposal Facility Groundwater/Leak Detection and Leachate Monitoring Plan. As noted in the plan, new indicator constituents are to be added to the quarterly monitoring list if 1) concentrations observed in the

annual sample are much higher than the perched water concentrations at the FEMP and 2) routine analysis of the constituent can significantly enhance the early detection capability.

The annual sample for 1999 was collected in November. All detected constituent concentrations found in the annual leachate sample were within the range of FEMP perched water constituent concentrations as defined in the Operable Unit 5 Remedial Investigation Report, except for chemical oxygen demand, which was not sampled for during the remedial investigation. The chemical oxygen demand concentration in the annual sample was 65 mg/L, which was higher than the 1998 result of 13.8 mg/L. Routine analysis of chemical oxygen demand is not believed to be a significant enhancement to early detection capability therefore, based on the results of the 1999 annual sample, no changes to the quarterly monitoring list are required.

The volume of water pumped from the leachate collection system is discussed in Section A.6.4.

A.6.1.2.2 Leak Detection System

All five of the constituents identified in Table A.6-2 were detected in the leak detection system. The 1999 maximum concentrations of the constituents detected in the Cell 1 leak detection system are, as expected, less than the overall maximum concentrations detected in the leachate collection system. Trend analysis indicates no significant trend in any of the detected constituents.

A.6.1.2.3 Horizontal Till Well

Four of the five constituents identified in Table A.6-2 were detected at the horizontal till well. Technetium-99 was not detected. Three constituents (total organic halogens, boron, and technetium-99) showed an overall higher maximum concentration than those found in the overlying leak detection system. One constituent (total organic halogen) showed a higher 1999 maximum than the overlying leak detection system. Therefore, these concentrations are interpreted as being within the range of baseline concentrations in the perched water and do not represent a release from the cell.

A.6.1.2.4 Great Miami Aquifer

Four of the five constituents identified in Table A.6-2 were detected in the Great Miami Aquifer wells. Total organic halogens were not detected in upgradient Monitoring Well 22201, and technetium-99 was not detected in either well. None of the constituents sampled and analyzed from the aquifer exceeded groundwater FRLs. The maximum overall concentrations for total organic carbon and total organic halogens are greater in both Great Miami Aquifer wells than in the horizontal till well. It should also be

noted that the 1999 maximum boron concentration in upgradient Monitoring Well 22201 was greater than the 1999 maximum in the horizontal till well. These concentrations are interpreted as being within the range of baseline concentrations in the Great Miami Aquifer and therefore do not represent a release from the cell.

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A.6.2 CELL 2

A.6.2.1 Construction and Leak Detection System Flow Data

Placement of waste (contaminated soil and debris) in Cell 2, which began in November 1998, continued during 1999. At the end of December 1999, Cell 2 was approximately 40 percent full. Figure A.6-5 shows the monthly volume of water pumped from the Cell 2 leak detection system for 1999. The volume of water removed from the system in January reflects a mixture of water that came from the Cell 2 leak detection system and water from the leachate pipeline, as discussed in Section A.6.2.2.2. Therefore, an accurate determination of the volume of water associated solely with the Cell 2 leak detection system for January can not be made; however, flows for the remaining months of 1999 are considered representative.

As with Cell 1, in May 1999, quantitative measurement of the volumes accumulating and pumped from the Cell 2 leak detection monitoring system was initiated. Figure A.6-6 provides the May through September 1999 Cell 2 leak detection system accumulation rates, which were calculated each time the primary containment vessel was pumped out. In June, the rate of accumulation peaked at a maximum of 6.8 gpad based on the June 16 pump out, then declined to a rate of 0.9 gpad based on the last pump out of the year which occurred on September 11. The accumulation rate increase in June, just after waste placement began, and the subsequent decline are consistent with what is expected if the primary source of the accumulating water was construction water (water introduced during leak detection system construction) being squeezed out of the leak detection system by waste placement activities occurring in the above cell.

Table A.6-1 provides precipitation volumes that fell on Cells 1, 2, and 3 during construction of their secondary and primary liners. The calculated volume that fell on Cell 2 during construction of its primary liner was 140,768 gallons. A portion of this water became trapped, as construction water, in the geosynthetic clay liner on top of the Cell 2 leak detection system and in the geotextile cushion within the leak detection system. The total water yield recorded for the Cell 2 leak detection system for 1999 was 12,320 gallons or about nine percent of the volume that fell on Cell 2 during construction of its primary liner. The total volume yielded from the Cell 2 leak detection system is significantly more than the Cell 1 leak detection system even though Cell 2 has not been open nearly as long as Cell 1. This higher yield

from Cell 2 is being attributed to malfunctions in the leachate transmission pipeline that allowed mixing of flows as described below in Section A.6.2.2.2.

Cell 2 leak detection system accumulation rates based on pump outs were not available after September 11 when the vessel was pumped for the last time in 1999. The rates declined to the degree that it was not necessary to pump the primary containment vessel for the remainder of the year. However, as with Cell 1, the accumulation rates were evaluated weekly based on the hourly water level measurements collected by the data logger. These weekly evaluations indicated that accumulation rates remained below 1 gpad for the remainder of the year.

As noted for Cell 1, the On-site Disposal Facility Final Design Calculation Package specified an initial response leakage rate for individual cells of 20 gpad. The above noted maximum accumulation rate for Cell 2 (6.8 gpad) is 34 percent of the initial response leakage rate and the rate calculated from the last pump out of the year (0.9 gpad) on September 11 is 4.5 percent of the initial response leakage rate. These rates indicate that the liner system for Cell 2 is performing well within the specifications outlined in the approved cell design. Over time, with the capping and closure of the cell, the volume of water removed from the leak detection system is expected to continue to diminish. The volume of water removed from the leak detection system will continue to be closely tracked to determine if the primary liner system continues to perform as expected.

A.6.2.2 Analytical Data

Groundwater sampling was initiated in 1997 for Cell 2 and continued in 1999. Leachate collection and leak detection system monitoring began after waste placement was initiated in November 1998. Table A.6-3 presents the constituents detected in 1999 from the monitoring locations (leachate collection system, leak detection system, horizontal till well, and Great Miami Aquifer) associated with Cell 2. Of the 16 constituents sampled, six constituents were detected in at least one location (total organic carbon, total organic halogens, boron, mercury, technetium-99, and total uranium). Consistent with the Final On-Site Disposal Facility Groundwater/Leak Detection and Leachate Monitoring Plan, the table also provides the results of Mann-Kendall statistical trend analysis on data from leachate collection and leak detection systems. Monitoring results by location are discussed below.

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A.6.2.2.1 Leachate Collection System

Five of the six constituents identified in Table A.6-3 were detected in the leachate collection system. Mercury was not detected. Trend analysis indicates that there was no significant trend for any of the six constituents at this monitoring location.

A sample is collected annually and analyzed for 67 additional constituents (general chemistry, inorganic, and organic) at the leachate collection system. Like the annual sample for Cell 1, the Cell 2 annual sample had no constituent concentrations that would require a change to the quarterly monitoring list.

The volume of water pumped from the leachate collection system is discussed in Section A.6.4.

A.6.2.2.2 Leak Detection System

As reported in the 1998 Integrated Site Envirionmental Report, the leachate transmission pipeline for the on-site disposal facility was found to be malfunctioning during 1998 and was shut down (from the leachate collection system manholes to the permanent lift station) through the spring of 1999 to accommodate repairs. This pipeline is part of a system that connects the on-site disposal facility to the FEMP's advanced wastewater treatment facility for the subsequent treatment and discharge of collected leachate and storm water runoff (contact storm water) from cells where waste placement has begun. During the period that the above noted pipeline was not in service, a contingency plan for leachate collection was used to manually truck collected leachate/stormwater from Cells 1 and 2 for delivery to the advanced wastewater treatment facility.

The malfunctions associated with the pipeline interrupted the FEMP's ability to obtain accurate water volume measurements and water quality monitoring data for the on-site disposal facility, most notably from the Cell 2 leak detection system. During this period, it became difficult to keep the various waters originating from the on-site disposal facility separate from one another during storm events so that representative monitoring of each individual water source could be conducted. Water originating from the Cell 1 leachate collection system periodically became mixed with water collected from the Cell 2 leak detection system, resulting in non-representative water quality data for the Cell 2 leak detection system. Data continued to be collected throughout the time that the pipeline was not functioning properly and under repair to comply with existing monitoring plan requirements. Repairs to the line were completed in May 1999.

Table A.6-3 summarizes all of the water quality results collected from the Cell 2 leak detection system during the IEMP reporting period. Due to the mixing of flows noted above, the leak detection system results noted in Table A.6-3 are not considered representative of the Cell 2 leak detection system. Review of the data identified in Table A.6-3 indicates that five of the six constituents were detected in the Cell 2 leak detection system samples (mercury was not detected). Three of the five detected constituents (total organic carbon, boron, and total uranium) were detected in 1999 at concentrations much higher than those found in the Cell 2 leachate collection system samples. These elevated concentrations attributed to the mixing of flows. The elevated concentrations are expected to decline over time so that the analytical results become representative of the Cell 2 leak detection system again. Trend analysis for total uranium indicates a Down, Significant trend for this ubiquitous site contaminant. However, no significant trend was observed for the remaining five constituents at this monitoring location.

A.6.2.2.3 Horizontal Till Well

Five of the six constituents identified in Table A.6-3 were detected in the horizontal till well. Technetium-99 was not detected. Two constituents (total organic halogens and mercury) showed 1999 maximum concentrations higher than the overall maximum concentration found in the overlying leak detection system. Therefore, these concentrations are interpreted as being within the range of baseline concentrations in the perched water and do not represent a release from the cell. As indicated in Table A.6-3, the maximum total uranium result for 1999 was 3.19 μg/L which is less than the previous maximum of 3.6 μg/L. These concentrations are far below the groundwater FRL of 20 μg/L.

A.6.2.2.4 Great Miami Aquifer

Four of the six constituents identified in Table A.6-3 were detected in the Great Miami Aquifer wells. Mercury and technetium-99 were not detected in either well. The 1999 maximum total organic halogen concentrations in both wells were less than the 1999 maximum in the horizontal till well and previous maxima for both wells. There is no FRL for total organic halogens. The total uranium concentration in Monitoring Well 22199 indicates elevated baseline uranium concentrations at this well. Baseline control charts are scheduled for completion in 2000 for the Cell 2 Great Miami Aquifer monitoring. These charts may provide for a better understanding of the significance of these apparently elevated concentrations. None of the constituents sampled and analyzed from the aquifer exceeded groundwater FRLs.

## A.6.3 CELL 3

### A.6.3.1 Construction and Leak Detection Flow Data

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Placement of waste (contaminated soil and debris) in Cell 3 began during the fourth quarter of 1999. At the end of December 1999, Cell 3 was approximately 10 percent full. Quantitative measurement of the volumes accumulating and pumped from the Cell 3 leak detection system began in October 1999. This monitoring is consistent with the Cells 1 and 2 monitoring which began in May 1999, as described above. From October 11, 1999, through the end of the year, no water had accumulated in the primary containment vessel for the Cell 3 leak detection system. This indicates that the liner system for Cell 3 is performing well within design specifications. However, given the behavior of Cells 1 and 2, it was deemed unusual that no water came out of the Cell 3 leak detection system once waste placement had been initiated. For this reason, a camera survey was conducted in November 1999 to ensure that the leak detection system piping was not obstructed. The results of the survey indicated that the leak detection system piping was not obstructed.

As shown in Table A.6-1, precipitation for the period when the Cell 3 liner system was installed indicates that the conditions were much drier than those when the liners for Cells 1 and 2 were installed. These drier conditions may have led to a condition where, unlike Cells 1 and 2, very little construction water accumulated in the Cell 3 leak detection layer. As noted in earlier sections, when waste placement and associated compaction began in Cells 1 and 2 this year, a clear response (initial increase then decline) was seen in their leak detection systems. This lack of construction water in Cell 3 may be the reason that the leak detection layer did not yield water when waste placement began in the fourth quarter of 1999.

### A.6.3.2 Analytical Data

Sampling for Cell 3 was initiated in July 1998, and continued throughout 1999, to establish baseline groundwater conditions. Sampling of the leachate collection system and leak detection system was initiated in the fourth quarter of 1999. Table A.6-4 presents the constituents detected in 1999 from the monitoring locations associated with Cell 3. Of the 16 constituents sampled, six constituents (total organic carbon, total organic halogens, boron, mercury, technetium-99, and total uranium) were detected at least at one location. Consistent with the On-Site Disposal Facility Groundwater/Leak Detection and Leachate Monitoring Plan, the table also provides the results of Mann-Kendall statistical trend analysis for leachate collection and leak detection data. Monitoring results by location (leachate collection system, leak detection system, horizontal till well, and Great Miami Aquifer) are discussed below.

A.6.3.2.1 Leachate Collection System

The leachate collection system for Cell 3 was sampled twice in 1999, once just prior to waste placement (protective layer) in October and a second time in November after waste placement was initiated. Four of the six constituents identified in Table A.6-4 were detected in the leachate collection system samples (mercury and technetium-99 were not detected). The four detected constituent concentrations in the pre-waste placement water sample were all greater than the concentrations in the water sample collected after waste placement began in November. This was unexpected. However, boron and total uranium concentrations may be higher due to high turbidity samples. The October sample had a higher turbidity (320 NTU) than the November sample (155 NTU). Because the samples are unfiltered, the October result could be biased high due to dissolution of sediment in the sample by the preservative or by the sample preparation techniques in the laboratory.

A sample is collected annually at the leachate collection system and analyzed for 67 additional constituents (general chemistry, inorganic, and organic). Like Cells 1 and 2, the Cell 3 annual sample had no constituent concentrations that would require a change to the quarterly monitoring list.

A.6.3.2.2 Leak Detection System

Due to lack of water accumulation/yield, leak detection system for Cell 3 was not sampled during 1999.

A.6.3.2.3 Horizontal Till Well

All six of the constituents identified in Table A.6-4 were detected in the horizontal till well. The 1999 data from the horizontal till well will be added to the data set to be used for calculating baseline conditions.

A.6.3.2.4 Great Miami Aquifer

Five of the six constituents identified in Table A.6-4 were detected in the Great Miami Aquifer monitoring wells. Technetium-99 was not detected. None of the constituents sampled and analyzed from the aquifer exceeded groundwater FRLs. All five of the 1999 detected constituents were found at higher concentrations in downgradient Monitoring Well 22204 than in the upgradient Monitoring Well 22203, indicating higher baseline conditions at the downgradient well. The 1999 data from the Great Miami Aquifer monitoring wells will be added to the data set to be used for calculating baseline conditions.

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## A.6.4 CELL 4 ANALYTICAL STATUS

The downgradient Great Miami Aquifer Monitoring Well 22205 for Cell 4 was installed in August. Development of this well has been postponed till this spring due to unusually low water levels. DOE chose not to develop the well last fall for the following reasons:

- Due to the low water level in the well, it was estimated that it would take much more time (and therefore be more costly) to develop the well than waiting until the water levels came back up in the spring.
- The viability of the development process (which includes airlifting) was determined to be questionable when the water levels were low.
- Sufficient time was available to delay the development of the well and still collect a year's worth of pre-waste placement baseline data, given that the schedule for waste placement in Cell 4 indicated that the cell would not become operational until at least late 2001.

Installation of a new well, to serve as the upgradient well for Cell 4, will not be required because Monitoring Well 2421 will be used. Baseline sampling of these two wells is scheduled to begin the summer of 2000.

## A.6.5 LEACHATE COLLECTION SYSTEM VOLUMES

Leachate volumes are measured at a meter located within the on-site disposal facility leachate conveyance system at a manhole near the Bio-Surge Lagoon. In addition to leachate from active cells, the volumes measured include water from the following sources: 1) on-site disposal facility heavy equipment wash, 2) water pumped from excavations at the former sewage treatment plant, and 3) water pumped from the leak detection system of each active cell. These three flows are subtracted from the total meter reading at the Bio-Surge Lagoon to obtain a leachate volume measurement representative of the collective leachate volume from all on-site disposal facility cells that contain waste materials.

Leachate from Cells 1, 2, and 3 contributed to the leachate volumes measured during 1999. Leachate was collected from Cells 1 and 2 for the entire year (since waste placement began prior to 1999) and from Cell 3 from October 19, 1999 through December 31, 1999 (since placement of material in Cell 3 began in October). A total of approximately 5.25 million gallons of leachate were collected and pumped to the Bio-Surge Lagoon for subsequent treatment at Phase II of the advanced wastewater treatment facility. This leachate volume indicates that about 40 percent of the precipitation that fell on the controlled areas of Cells 1, 2, and 3 (13,016,788 gallons) became leachate that was collected. The remaining 60 percent of the precipitation likely evaporated or was retained in the waste material. The 5.25 million gallons

collected is somewhat higher than what was expected based on design calculations (4.9 million gallons), given that the design calculations assumed average precipitation (approximately 40 inches/year) and the actual precipitation at the FEMP was approximately 34 inches for 1999. The design calculations used were:

- For Cell 1 (considered to be in the intermediate stage based on 1999 volume in cell), average annual for the intermediate stage (696 gpad) x (6.45 acres/cell) x (365 days) = 1,638,558 gallons
- For Cell 2 (considered to be in the initial stage based on 1999 volume in cell), average annual for the initial stage (1145 gpad) x (6.45 acres/cell) x (365 days) = 2,695,616 gallons
- For Cell 3, average annual for the initial stage (1145 gpad) x (6.45 acres/cell) x (74 days) = 546,509 gallons
- Total for Cells 1, 2, and 3 = 4.9 million gallons.

As presented in Figure A.6-7, leachate volumes fluctuated throughout the year but generally correlate to precipitation. These fluctuations are expected during the active waste placement period of the on-site disposal facility (prior to final capping) because the leachate volumes during this period primarily reflect the amount of precipitation that falls on the active cells and is subsequently collected in the leachate collection systems. As the cells are capped, the leachate volumes from the capped cells are expected to stabilize and diminish over time.

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## TABLE A.6-1

## PRECIPITATION DURING CONSTRUCTION OF CELLS 1, 2, AND 3 SECONDARY AND PRIMARY LINERS

| Activity/Item | | Cell 1 | Cell 2 | Cell 3 |
|---|---|---|---|---|
| Secondary liner construction | Start: | October 21, 1997 | September 8, 1998 | August 18, 1999 |
| | Finish: | November 12, 1997 | October 7, 1998 | September 2, 1999 |
| Precipitation during construction (inches) | | 1.9 | 4.12 | 1.77 |
| Cell area (acres) | | 6.45 | 6.45 | 6.45 |
| Precipitation volume on cell during construction (gallons) | | 330,196 | 716,004 | 307,604 |
| Primary liner construction | Start: | November 1997 | October 20, 1998 | September 13, 1999 |
| | Finish: | December 18, 1997 | November 2, 1998 | September 28, 1999 |
| Precipitation during construction (inches) | | 3.48 | 0.81 | 0.07 |
| Cell area (acres) | | 6.45 | 6.45 | 6.45 |
| Precipitation volume on cell during construction (gallons) | | 604,780 | 140,768 | 12,165 |
| Total precipitation volume on cell during secondary and primary liner construction periods (gallons) | | 934,976 | 856,772 | 319,769 |

# TABLE A.6-2

## ON-SITE DISPOSAL FACILITY CELL 1 DATA SUMMARY FOR CONSTITUENTS DETECTED DURING 1999

Note: Non-italicized pertains to total number of samples (including 1999 samples).
*Italicized pertains to 1999 samples only.*

| Constituent (FRL)[a] | LCS[b,c,d,e] (12338C) | | LDS[b,c,d,e] (12338D) | | HTW[b,c,d,e,f] (12338) | | Great Miami Aquifer: Upgradient[b,c,d,f] (22201) | | Great Miami Aquifer: Downgradient[b,c,d,f] (22198) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. of Samples with Detections / No. of Samples | Range | No. of Samples with Detections / No. of Samples | Range | No. of Samples with Detections / No. of Samples | Range | No. of Samples with Detections / No. of Samples | Range | No. of Samples with Detections / No. of Samples | Range |
| Total Organic Carbon (NA[f] mg/L) | 6/8 | ND to 123 | 5/7 | ND to 80.9 | 24/26 | ND to 12.2 | 20/23 | ND to 59.7 | 19/23 | ND to 52.5 |
| | *2/4* | **ND to 25.8** | *2/4* | **ND to 11** | *5/7* | **ND to 5.23** | *1/4* | **ND to 2.22** | *2/4* | **ND to 3.56** |
| Trend | No Significant Trend | | No Significant Trend | | NA | | NA | | NA | |
| Total Organic Halogens (NA[f] mg/L) | 7/8 | ND to 0.204 | 6/7 | ND to 0.0426 | 15/25 | ND to 0.077 | 12/23 | ND to 0.078 | 8/23 | ND to 0.0526 |
| | *4/4* | ***0.00716 to 0.204*** | *4/4* | ***0.0164 to 0.0202*** | *6/7* | **ND to 0.0703** | *0/4* | **ND** | *1/4* | **ND to 0.0147** |
| Trend | No Significant Trend | | No Significant Trend | | NA | | NA | | NA | |
| Boron (0.33 mg/L) | 9/9 | 0.0642 to 2.8 | 7/7 | 0.0296 to 0.321 | 20/26 | ND to 0.685 | 18/23 | ND to 0.142 | 24/32 | ND to 0.116 |
| | *4/4* | ***0.536 to 2.8*** | *4/4* | ***0.253 to 0.276*** | *5/7* | **ND to 0.0674** | *4/4* | ***0.0983 to 0.125*** | *6/8* | **ND to 0.0541** |
| Trend | Up, Marginal | | No Significant Trend | | NA | | NA | | NA | |
| Technetium-99 (94.0 pCi/L) | 2/8 | ND to 18.28 | 1/7 | ND to 8.92 | 7/26 | ND to 21.1 | 1/23 | ND to 13.41 | 2/32 | ND to 14.8 |
| | *0/4* | **ND** | *1/4* | **ND to 8.92** | *0/7* | **ND** | *0/4* | **ND** | *0/8* | **ND** |
| Trend | Down, Significant | | No Significant Trend | | NA | | NA | | NA | |
| Total Uranium (20 µg/L) | 7/8 | ND to 119 | 7/7 | 1.5 to 20.17 | 25/26 | ND to 19 | 20/23 | ND to 5.196 | 32/32 | 0.557 to 3.814 |
| | *3/4* | **ND to 102.14** | *4/4* | ***11.4 to 20.17*** | *6/7* | **ND to 2.37** | *3/4* | **ND to 0.592** | *8/8* | ***0.557 to 1.221*** |
| Trend | No Significant Trend | | No Significant Trend | | NA | | NA | | NA | |

[a]From Operable Unit 5 Record of Decision, Table 9-4
[b]If there was more than one sample result per day (e.g., a duplicate sample), then only the maximum sample concentration was counted and compared to the FRL.
[c]Rejected data qualified with either a R or Z were not used in this comparison.
[d]ND = not detected
[e]LCS = leachate collection system
LDS = leak detection system
HTW = horizontal till well
[f]NA = not applicable



000330

# TABLE A.6-3

## ON-SITE DISPOSAL FACILITY CELL 2 DATA SUMMARY FOR CONSTITUENTS DETECTED DURING 1999

Note: Non-italicized pertains to total number of samples (including 1999 samples).
*Italicized pertains to 1999 samples only.*

| Constituent (FRL)[a] | LCS[b,c,d,e] (12339C) | | LDS[b,c,d,e,f] (12339D) | | HTW[b,c,d,e,g] (12339) | | Great Miami Aquifer: Upgradient[b,c,d,g] (22200) | | Great Miami Aquifer: Downgradient[b,c,d,g] (22199) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. of Samples with Detections / No. of Samples | Range | No. of Samples with Detections / No. of Samples | Range | No. of Samples with Detections / No. of Samples | Range | No. of Samples with Detections / No. of Samples | Range | No. of Samples with Detections / No. of Samples | Range |
| Total Organic Carbon (NA[f] mg/L) | 3/5 | ND to 3.51 | 5/6 | ND to 26.1 | 20/24 | ND to 4.22 | 16/18 | ND to 47.6 | 14/18 | ND to 51.8 |
| | *2/4* | **ND to 3.51** | *4/5* | **ND to 26.1** | *3/7* | **ND to 3.04** | *3/4* | **ND to 16.2** | *2/4* | **ND to 2.57** |
| Trend | No Significant Trend | | No Significant Trend | | NA | | NA | | NA | |
| Total Organic Halogens (NA[f] mg/L) | 3/5 | ND to 0.0299 | 4/6 | ND to 0.0205 | 16/24 | ND to 0.101 | 9/18 | ND to 0.124 | 9/18 | ND to 0.0386 |
| | *2/4* | **ND to 0.0299** | *3/5* | **ND to 0.015** | *4/7* | **ND to 0.101** | *2/4* | **ND to 0.0138** | *3/4* | **ND to 0.0272** |
| Trend | No Significant Trend | | No Significant Trend | | NA | | NA | | NA | |
| Boron (0.33 mg/L) | 5/6 | ND to 0.915 | 5/5 | 0.408 to 2.22 | 14/24 | ND to 0.0829 | 12/18 | ND to 0.158 | 12/18 | ND to 0.0569 |
| | *4/4* | ***0.207 to 0.915*** | *4/4* | ***0.408 to 2.22*** | *5/7* | **ND to 0.0432** | *4/4* | ***0.0465 to 0.0536*** | *4/4* | ***0.0404 to 0.0458*** |
| Trend | No Significant Trend | | No Significant Trend | | NA | | NA | | NA | |
| Mercury (0.0020 mg/L) | 0/5 | ND | 0/5 | ND | 2/23 | ND to 0.00025 | 0/18 | ND | 0/18 | ND |
| | *0/4* | **ND** | *0/4* | **ND** | *1/7* | **ND to 0.00025** | *0/4* | **ND** | *0/4* | **ND** |
| Trend | No Significant Trend | | No Significant Trend | | NA | | NA | | NA | |
| Technetium-99 (94.0 pCi/L) | 1/5 | ND to 21.25 | 1/5 | ND to 15.99 | 5/25 | ND to 12 | 0/17 | ND | 0/18 | ND |
| | *1/4* | **ND to 21.25** | *1/4* | **ND to 15.99** | *0/7* | **ND** | *0/4* | **ND** | *0/4* | **ND** |
| Trend | No Significant Trend | | No Significant Trend | | NA | | NA | | NA | |
| Total Uranium (20 g/L) | 5/5 | 4.51 to 22.7 | 5/5 | 12 to 71 | 24/25 | ND to 3.607 | 12/18 | ND to 1.11 | 18/18 | 0.259 to 12.1 |
| | *4/4* | ***4.51 to 22.7*** | *4/4* | ***12 to 50.37*** | *6/7* | **ND to 3.19** | *1/4* | **ND to 0.13** | *4/4* | ***0.544 to 12.1*** |
| Trend | No Significant Ttrend | | Down, Significant | | NA | | NA | | NA | |

[a]From Operable Unit 5 Record of Decision, Table 9-4
[b]If there was more than one sample result per day (e.g, a duplicate sample), then only the maximum sample concentration was counted and compared to the FRL.
[c]Rejected data qualified with either a R or Z were not used in this comparison.
[d]ND = not detected
[e]LCS = leachate collection system
LDS = leak detection system
HTW = horizontal till well
[f]Data from the Cell 2 LDS is considered suspect due to mixing of flows (refer to Section A.6.2.2.2).
[g]NA = not applicable

# TABLE A.6-4

## ON-SITE DISPOSAL FACILITY CELL 3 DATA SUMMARY FOR CONSTITUENTS DETECTED DURING 1999

Note: Non-italicized pertains to total number of samples (including 1999 samples).
*Italicized pertains to 1999 samples only.*

| Constituent (FRL)[a] | LCS[b,c,d,e,f] (12340C) | | LDS[b,c,d,e,f,g] (12340D) | | HTW[b,c,d,e,f,h] (12340) | | Great Miami Aquifer: Upgradient[b,c,d,f,h] (22203) | | Great Miami Aquifer: Downgradient[b,c,d,f,h] (22204) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. of Samples with Detections / No. of Samples | Range | No. of Samples with Detections / No. of Samples | Range | No. of Samples with Detections / No. of Samples | Range | No. of Samples with Detections / No. of Samples | Range | No. of Samples with Detections / No. of Samples | Range |
| Total Organic Carbon (NA[f] mg/L) | 1/2 | ND to 34.2 | NA | NA | 10/20 | ND to 4.21 | 5/16 | ND to 3.51 | 6/16 | ND to 5 |
| | *1/2* | **ND to 34.2** | **NA** | **NA** | *5/14* | **ND to 4.21** | *2/11* | **ND to 2.52** | *3/11* | **ND to 2.82** |
| Trend | NA | | NA | | NA | | NA | | NA | |
| Total Organic Halogens (NA[f] mg/L) | 2/2 | 0.104 to 0.178 | NA | NA | 16/20 | ND to 0.158 | 8/16 | ND to 0.019 | 7/16 | ND to 0.03 |
| | *2/2* | ***0.104 to 0.178*** | **NA** | **NA** | *12/14* | **ND to 0.158** | *5/11* | **ND to 0.019** | *5/11* | **ND to 0.03** |
| Trend | NA | | NA | | NA | | NA | | NA | |
| Boron (0.33 mg/L) | 2/2 | 0.268 to 0.496 | NA | NA | 16/19 | ND to 0.24 | 10/16 | ND to 0.0776 | 9/16 | ND to 0.179 |
| | *2/2* | ***0.268 to 0.496*** | **NA** | **NA** | *13/13* | ***0.0433 to 0.24*** | *8/11* | ***ND to 0.0454*** | *8/11* | ***ND to 0.179*** |
| Trend | NA | | NA | | NA | | NA | | NA | |
| Mercury (0.0020 mg/L) | 0/2 | ND | NA | NA | 1/19 | ND to 0.00026 | 0/16 | ND | 1/16 | ND to 0.00028 |
| | *0/2* | ***ND*** | ***NA*** | ***NA*** | *1/13* | ***ND to 0.00026*** | *0/11* | ***ND*** | *1/11* | ***ND to 0.00028*** |
| Trend | NA | | NA | | NA | | NA | | NA | |
| Technetium-99 (94.0 pCi/L) | **0/2** | ND | NA | NA | 2/19 | ND to 38.35 | 0/16 | ND | 0/16 | ND |
| | *0/2* | ***ND*** | ***NA*** | ***NA*** | *2/13* | ***ND to 38.35*** | *0/11* | ***ND*** | *0/11* | ***ND*** |
| Trend | NA | | NA | | NA | | NA | | NA | |
| Total Uranium (20 µg/L) | **2/2** | 9.27 To 11.5 | NA | NA | 17/19 | ND to 9.14 | 11/16 | ND to 0.907 | 15/16 | ND to 2.995 |
| | *2/2* | ***9.27 To 11.5*** | ***NA*** | ***NA*** | *12/13* | ***ND to 8.64*** | *6/11* | ***ND to 0.907*** | *10/11* | ***ND to 1.67*** |
| Trend | NA | | NA | | NA | | NA | | NA | |

[a]From Operable Unit 5 Record of Decision, Table 9-4
[b]If there was more than one sample result per day (e.g., a duplicate sample), then only the maximum sample concentration was counted and compared to the FRL. [c]Rejected data qualified with either a R or Z were not used in this comparison.
[d]ND = not detected
[e]HTW = horizontal till well
[f]The Mann-kendall test for trend is reported unless the number of samples is less than four.
[g]No samples were taken from the LDS because it was dry.
[h]NA = not applicable



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0003335

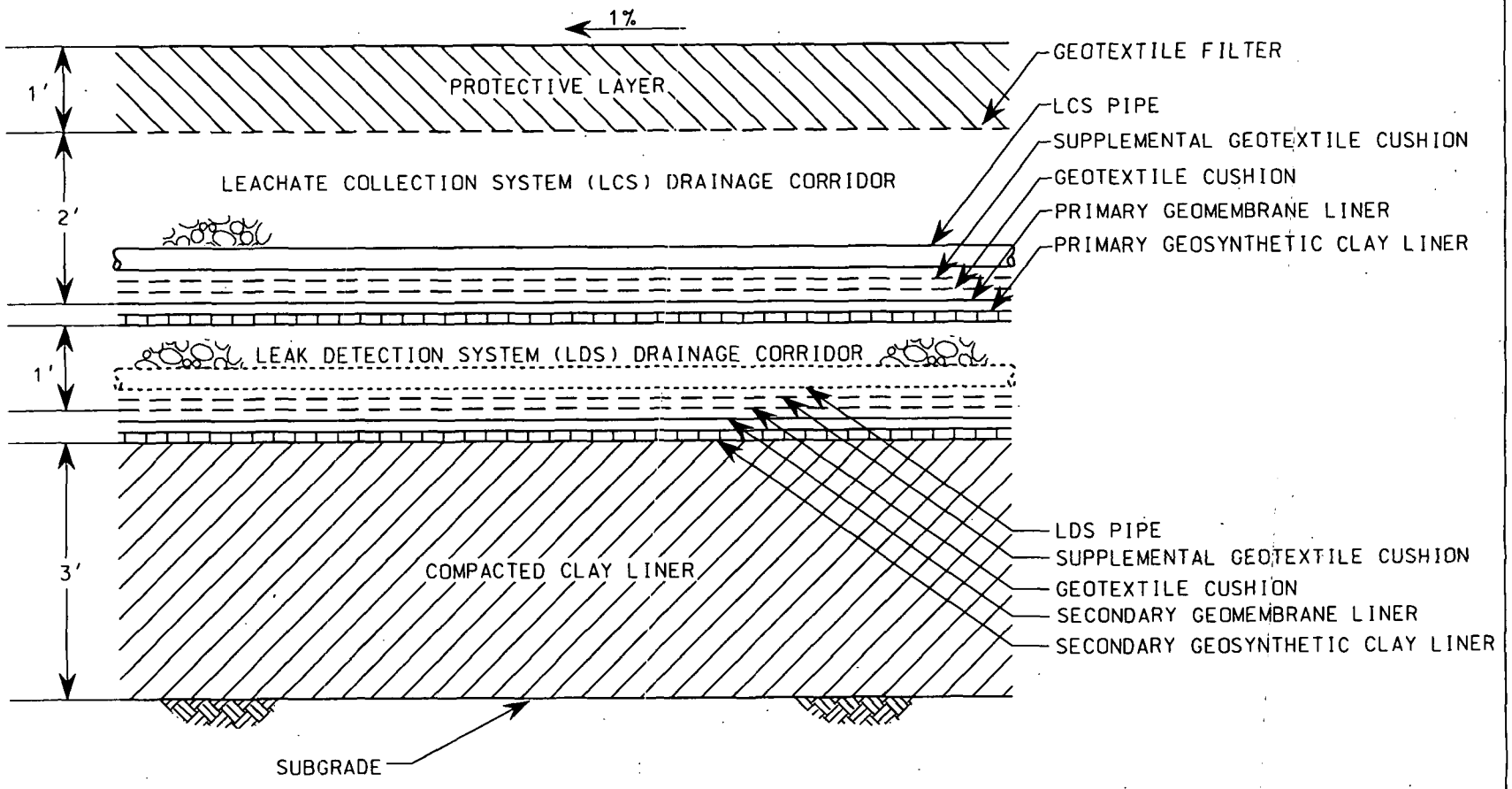


FIGURE A.6-1. ON-SITE DISPOSAL FACILITY LINER SYSTEM AT THE DRAINAGE CORRIDOR

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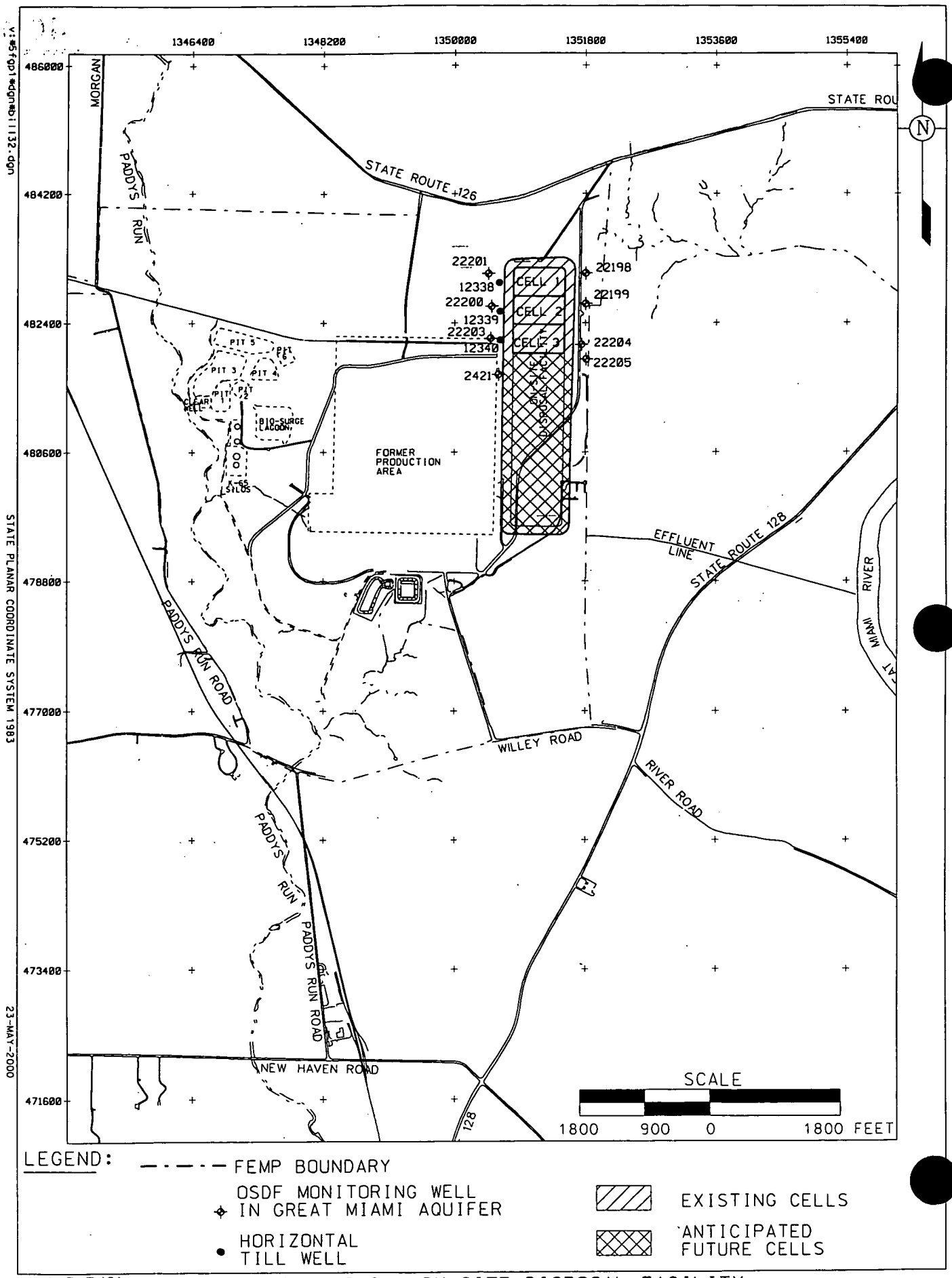
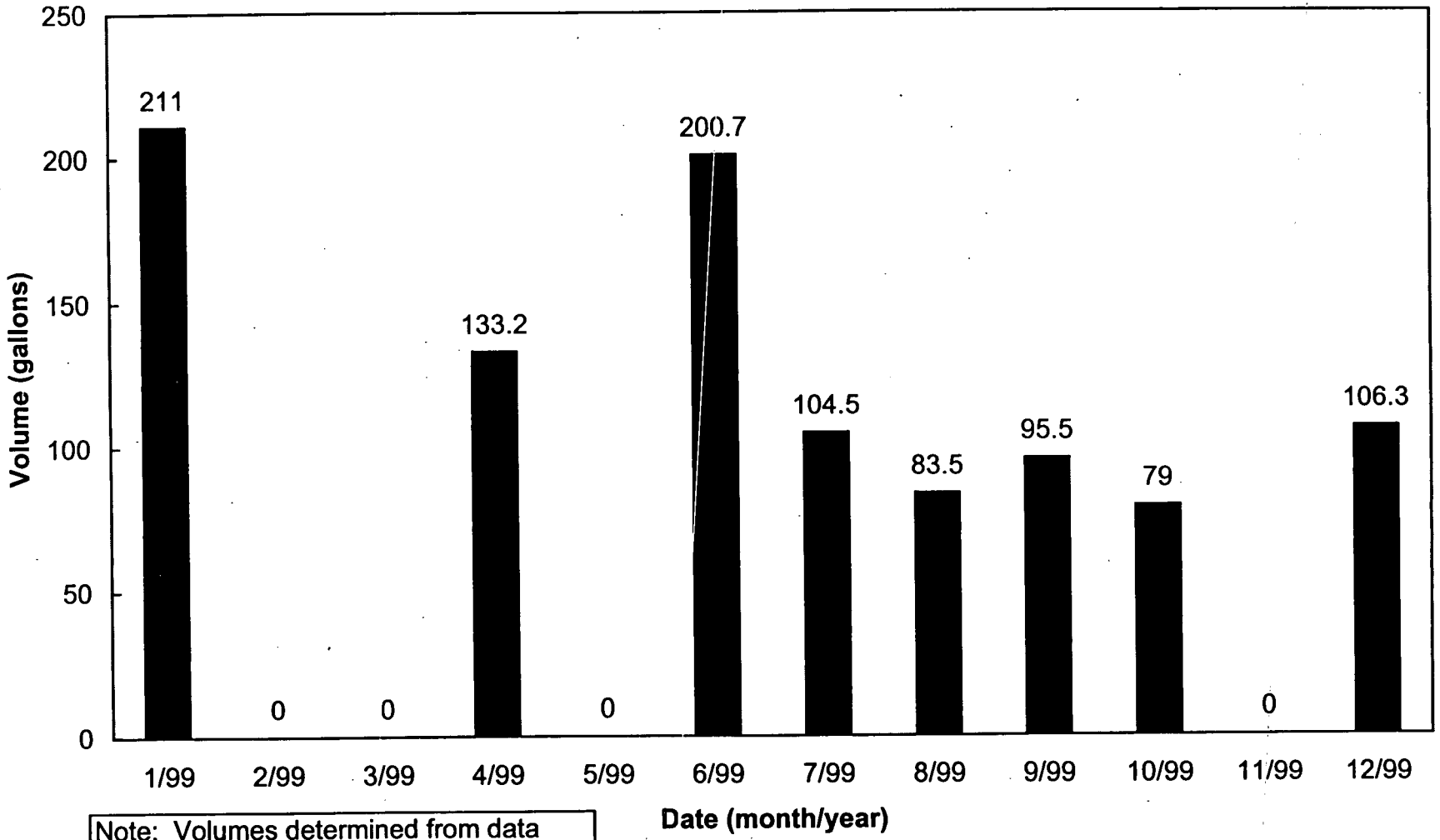
24-MAY-2000




000337

FIGURE A.6-2. ON-SITE DISPOSAL FACILITY FOOTPRINT AND MONITORING WELL LOCATIONS




Note: Volumes determined from data logger measurements beginning in May.

FIGURE A.6-3. 1999 VOLUMES PUMPED FROM THE LEAK DETECTION SYSTEM FOR CELL 1 OF THE ON-SITE DISPOSAL FACILITY



000338

000339

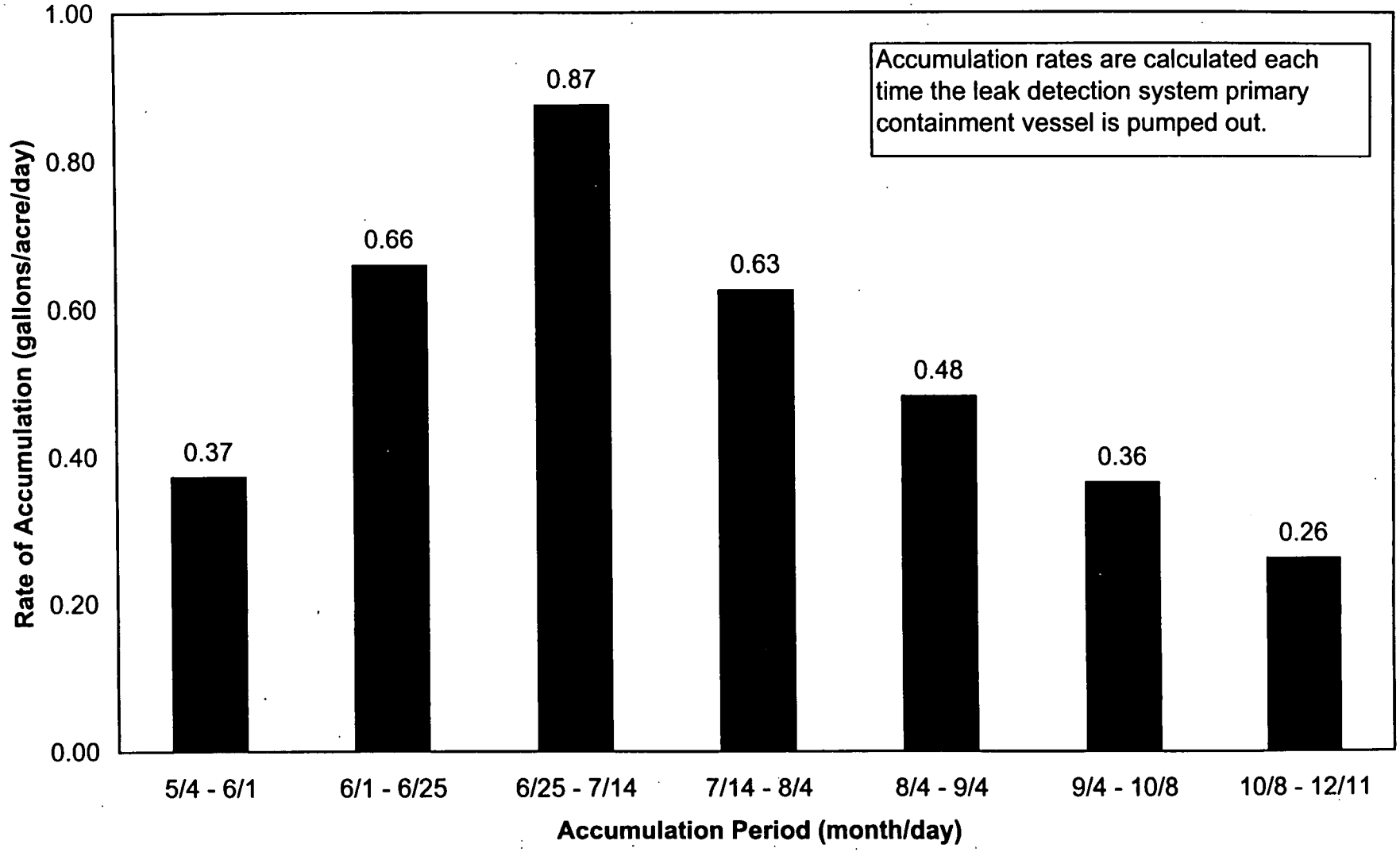



FIGURE A.6-4. ON-SITE DISPOSAL FACILITY CELL 1 LEAK DETECTION SYSTEM RATE OF ACCUMULATION, MAY 4, 1999 THROUGH DECEMBER 11, 1999

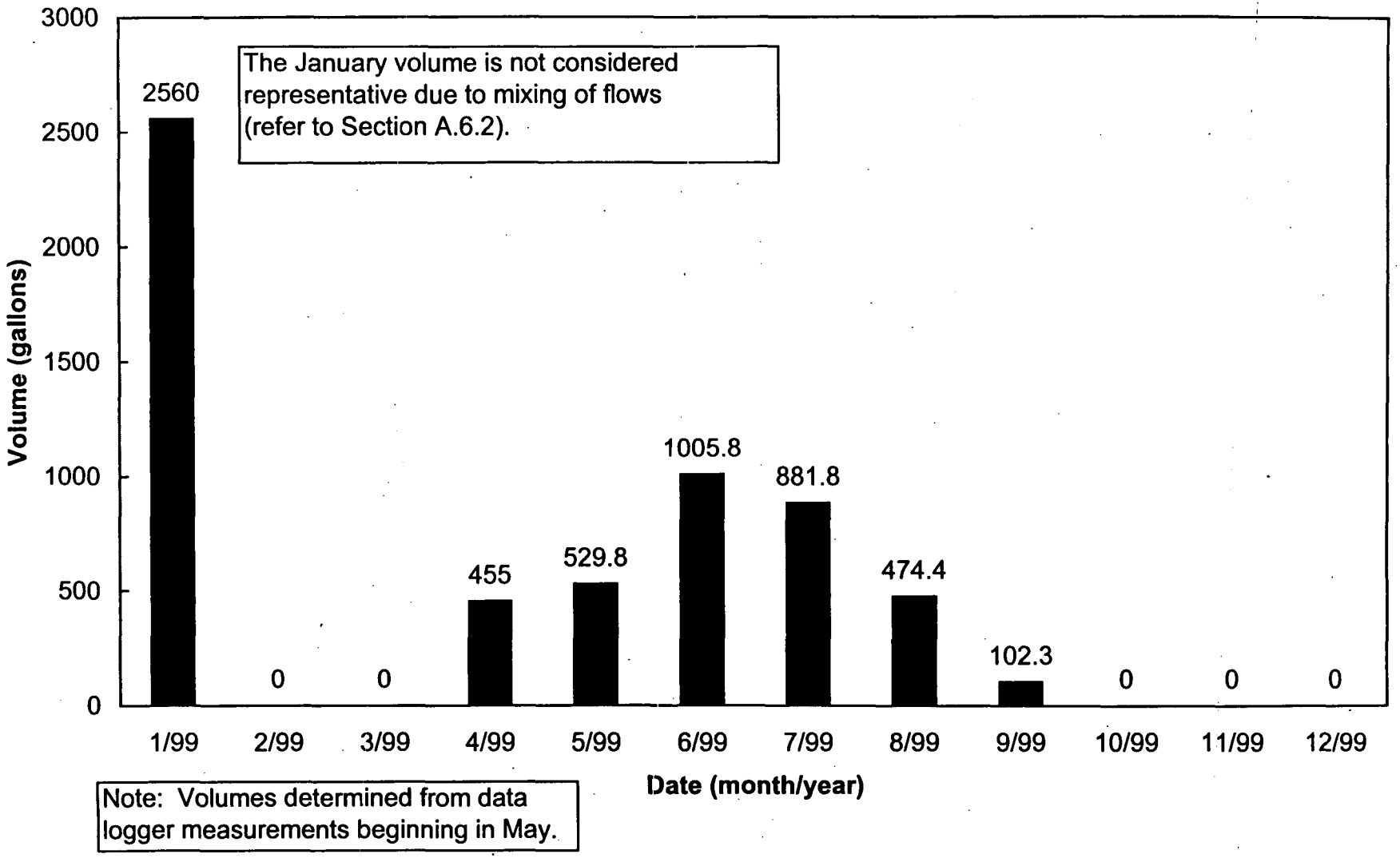



FIGURE A.6-5. 1999 VOLUMES PUMPED FROM THE LEAK DETECTION SYSTEM FOR CELL 2 OF THE ON-SITE DISPOSAL FACILITY

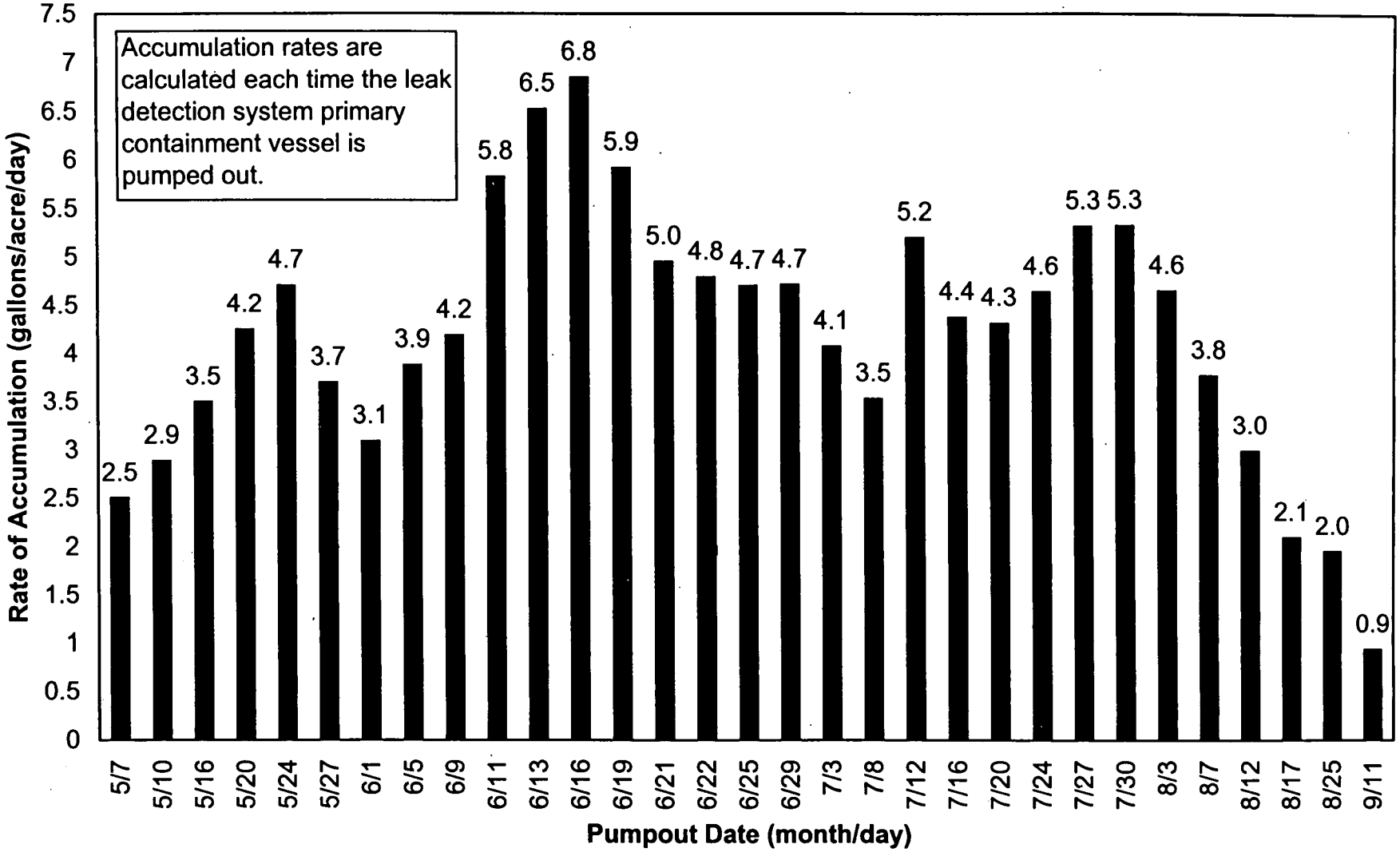



FIGURE A.6-6. ON-SITE DISPOSAL FACILITY CELL 2 LEAK DETECTION SYSTEM RATE OF ACCUMULATION, MAY 6, 1999 THROUGH SEPTEMBER 11, 1999

000377

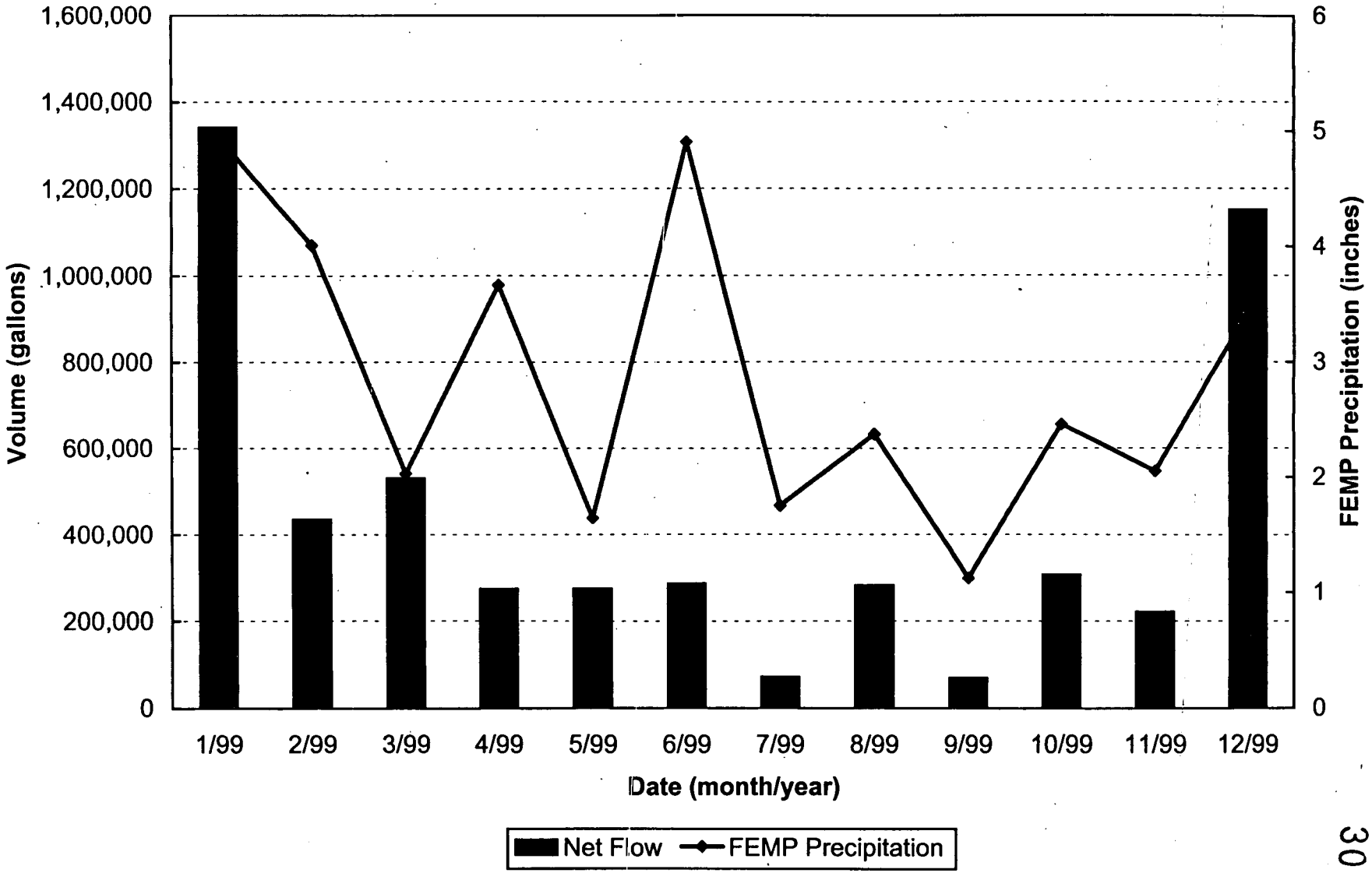



FIGURE A.6-7. 1999 LEACHATE COLLECTION SYSTEM VOLUMES



000342

# APPENDIX B

# SUPPLEMENTAL SURFACE WATER AND TREATED EFFLUENT INFORMATION

# TABLE OF CONTENTS

Appendix B Supplemental Surface Water And Treated Effluent Information ..... B-1

Attachment B.1 Surface Water and Treated Effluent ..... B.1-1

Attachment B.2 Sediment ..... B.2-1

# LIST OF ACRONYMS

| | |
|---|---|
| BTV | benchmark toxicity value |
| cfs | cubic feet per second |
| EPA | U.S. Environmental Protection Agency |
| FEMP | Fernald Environmental Management Project |
| FFCA | Federal Facilities Compliance Agreement |
| FRL | final remediation level |
| IEMP | Integrated Environmental Monitoring Plan |
| mg/kg | milligrams per kilogram |
| mg/L | milligrams per liter |
| NPDES | National Pollutant Discharge Elimination System |
| OEPA | Ohio Environmental Protection Agency |
| pCi/g | picoCuries per gram |
| pCi/L | picoCuries per liter |
| µg/L | micrograms per liter |
| WPRAP | Waste Pits Remedial Action Project |

# APPENDIX B

3004

Appendix B presents additional surface water, treated effluent, and sediment data in support of Chapter 4 of this 1999 Integrated Site Environmental Report. This appendix consists of two attachments as follows:

- Attachment B.1 provides further evaluation of the final remediation levels (FRLs) and benchmark toxicity values (BTVs) exceedances for surface water and treated effluent including an assessment of potential cross-media impacts to the groundwater pathway. This attachment also provides detail on storm water-related bypasses pertaining to compliance with the Record of Decision for Remedial Actions at Operable Unit 5 (DOE 1996) total uranium treated effluent discharge limits.

- Attachment B.2 provides additional details pertaining to the 1999 sediment analytical results and historical results for comparison purposes.

# REFERENCES



U.S. Dept. of Energy, 2000, "Integrated Environmental Monitoring Status Report for Fourth Quarter 1999," Final, Fernald Environmental Management Project, U.S. Dept. of Energy, Cincinnati, OH.

U.S. Dept. of Energy, 1999a, "Integrated Environmental Monitoring Plan, Revision 1" Final, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1999b, "Operations and Maintenance Master Plan for Aquifer Restoration and Wastewater Treatment Projects," Final, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1998, "Sitewide Excavation Plan," Draft Final, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1996, "Record of Decision for Remedial Actions at Operable Unit 5," Final, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1995, "Remedial Investigation Report for Operable Unit 5," Final, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

# ATTACHMENT B.1

## SURFACE WATER AND TREATED EFFLUENT

# ATTACHMENT B.1

3004

During 1999 surface water and treated effluent samples were collected under the Integrated Environmental Monitoring Plan (IEMP), Revision 1 (DOE 1999a) and locations are presented in Figures B.1-1 and B.1-2. The following information is discussed in this attachment:

- Surveillance monitoring (Section B.1.1)
- Federal Facilities Compliance Agreement (FFCA)/Operable Unit 5 Record of Decision compliance (Section B.1.2)
- Controlled and uncontrolled areas (Section B.1.3).

National Pollutant Discharge Elimination System (NPDES) is not discussed in this attachment as it is discussed in sufficient detail in Chapter 4 of this report.

## B.1.1 SURVEILLANCE MONITORING

Surveillance monitoring is the comparison of surface water and treated effluent analytical results to the surface water FRLs and BTVs in order to determine effects of Fernald Environmental Management Project (FEMP) remediation activities on the surface water pathway. Surveillance monitoring also includes an assessment of the effects surface water may have on the groundwater pathway (referred to as cross-media impacts).

All 1999 data with the exception of the data collected from the new sewage treatment plant (STP 4601) were compared to FRLs and BTVs. Results of treated effluent samples collected from the sewage treatment plant (STP 4601) are not used for surveillance monitoring, because these samples are collected at an internal point prior to the sewage treatment plant treated effluent being discharged to the Parshall Flume (PF 4001). (Note: During 1999 the sewage treatment plant effluent comprised less than two percent of the combined effluent discharged to the Great Miami River.) Samples collected at the Parshall Flume (PF 4001) are used in the surveillance evaluation because this is the last point treated effluent is sampled prior to discharge to the Great Miami River.

Water discharges to the Great Miami River are required to be below the FRLs at the point where discharged water is completely mixed with water in the Great Miami River (i.e., outside the mixing zone). To make a determination of the concentration of each constituent at this point in the Great Miami River for comparison to the FRLs, the following calculation was applied to data from the Parshall Flume (PF 4001):

$$C_{PF4001} = \frac{[Q_{10}][C_{GMR}] + [Q_{PF}][C_{PF}]}{[Q_{10}] + [Q_{PF}]}$$

where:

| | | |
|---|---|---|
| $C_{PF4001}$ | = | Flow-weighted average concentration outside the mixing zone in the Great Miami River, picoCuries per liter (pCi/L) or milligrams per liter (mg/L) |
| $Q_{10}$ | = | 7-day, 10-year low flow, 583 cubic feet per second (cfs) |
| $C_{GMR}$ | = | Background concentration in Great Miami River from the Remedial Investigation Report for Operable Unit 5 (DOE 1995), pCi/L or mg/L (0 was used when no background concentration was available) |
| $Q_{PF}$ | = | Daily flow at Parshall Flume (PF 4001), cfs |
| $C_{PF}$ | = | Daily concentration at Parshall Flume (PF 4001), pCi/L or mg/L |

Note: In addition, flow conditions at the Hamilton Dam gauge are periodically reviewed to determine if there is a lower flow than the 7-day, 10-year low flow of 583 cfs. The lowest daily flow measured at the Hamilton Dam gauge (if lower than 583 cfs) is used in the equation to see if an exceedance could potentially occur.

It is also important to note that several surface water sample locations were dry or not sampled during 1999, and therefore there are no analytical data available during these periods. The locations that were dry or not sampled are as follows: first quarter (STRM 4003 and STRM 4004); second quarter (STRM 4004 and SWD-03 in April); third quarter (STRM 4004, SWD-01, SWP-01, SWP-02, SWP-03, and SWD-03 in July and September); and fourth quarter (STRM 4004, SWD-02 in October, and SWD-03 in October).

As identified in the Integrated Environmental Monitoring Status Report for Fourth Quarter 1999 (DOE 2000), 1999 was exceptionally dry and precipitation was below the 50-year average, as shown in Figure B.1-3. Even though precipitation was low for the year, it became apparent through review of the field paperwork that sampling crews did not attempt to collect samples during some months of the year. Meetings were held with the sampling crew managers, and a strategy was developed to ensure that the necessary samples would be taken in the future. The strategy includes the following actions:

- Due to the intermittent nature of the flow at the surface water sample locations, the sampling crews must be ready to sample at the beginning of a quarter so that the crews have the maximum number of opportunities to collect samples during drier quarters.

- The surface water sampling procedure governing these activities is being revised to require the sampling crews be ready to sample at the beginning of the quarter.

This process will continue to be monitored closely to ensure that the strategy is implemented as planned. It should also be noted that although some samples were not collected, there is no reason to believe that any unmonitored discharges were significantly different in character from previous discharges based on the site activities occurring during the year.

B.1.1.1 Evaluation of Constituents Above FRLs for 1999

Table B.1-1 lists surface water FRL exceedances at corresponding sample locations and Figure B.1-4 shows the locations of these exceedances. The FRL exceedances that occurred in 1999 were generally sporadic. The following are general observations:

- No exceedances occurred in the Great Miami River (using the mixing equation and Parshall Flume [PF 4001] concentrations). The lowest daily flow at the Hamilton Dam gauge during 1999 was 267 cfs. There were also no exceedances identified using this low flow value in the mixing equation.

- No exceedances occurred at the point where Paddys Run flows off property (SWP-03), with the exception of one chromium exceedance.

- No exceedances of the surface water FRL for total uranium occurred at any surface water sample location. Figure B.1-5 shows the total uranium concentrations at SWP-03 (Paddys Run at downstream property boundary).

- There were only two FRL exceedances; the above mentioned chromium exceedance at SWP-03 and an exceedance for manganese at background location SWP-01. No BTV exceedances were experienced during 1999.

The exceedance for manganese was at the Paddys Run background location SWP-01. This location is not under the influence of FEMP discharges. The background data are used to distinguish impacts from FEMP activities against upstream water quality conditions.

The FRL (0.010 mg/L) for chromium was exceeded at only one location. The FRL for chromium is actually associated with hexavalent chromium; however, due to the short laboratory holding times for hexavalent chromium, in most cases total chromium is analyzed instead. Comparing total chromium concentrations against the hexavalent chromium FRL is conservative, because hexavalent chromium is a component of total chromium. Given the field activities that occurred in 1999, no specific circumstances can be discerned that would explain the chromium exceedance nor can the validity of the chromium exceedance be discerned due to the lack of site specific chromium speciation data. There is no significant trend associated with the chromium exceedance.

B.1.1.2 Evaluation of Cross-Media Impacts for 1999

Another objective of the IEMP surveillance monitoring program is to provide an ongoing assessment of the potential for cross-media impacts from surface water to the underlying Great Miami Aquifer. To conduct this assessment, sample locations were selected to evaluate contaminant concentrations in surface water just upstream from those areas where site drainages have eroded through the protective glacial overburden (i.e., the Storm Sewer Outfall Ditch and certain reaches of Paddys Run). In areas where the overburden is absent, a direct pathway exists for contaminants to reach the aquifer.

Total uranium is used as an indicator to evaluate the impact of surface water on the Great Miami Aquifer, because it is the primary contaminant at the site. A conservative assumption is used in this assessment, which considers the total uranium concentration (and all other constituent concentrations) in the surface water to be at the same concentration when the water reaches the Great Miami Aquifer through infiltration. However, the most likely scenario is that the total uranium concentration (and all other constituent concentrations) would decrease, because dilution and adsorption occur as the water infiltrates through the ground and is mixed with the groundwater in the Great Miami Aquifer.

As shown in Table B.1-2, the results of the cross-media impact assessment for 1999 indicate occasional exceedances of the groundwater total uranium FRL (20 micrograms per liter [μg/L]) in the areas where surface water is directly infiltrating into the Great Miami Aquifer. Key sample locations associated with these areas of direct infiltration are SWP-02, SWD-02, and the Storm Water Retention Basin overflow (SWRB 4002O). Figures B.1-6 through B.1-8 present the total uranium concentrations along with the

results from trend analysis (from Mann-Kendall test for trend) for these locations. Only one of these locations (SWD-02) had total uranium groundwater FRL exceedances. However, based on the exceedances at this location, it is not likely that there were any significant cross-media impacts to the underlying Great Miami Aquifer. Moreover, trend analysis indicates that there was a "down, significant" trend at SWD-02. In addition, the design of the groundwater restoration systems has accounted for this potential contaminant pathway by installing extraction wells downgradient of these areas where direct infiltration can occur. No other surface water constituent concentrations at the three locations exceeded any groundwater FRLs.

It should be noted that in early 2000, pre-design groundwater characterization activities in the waste storage and Plant 6 areas confirmed that an area in the Pilot Plant Drainage Ditch adjacent to Paddys Run should be considered as a primary source of infiltration, and therefore a cross-media impact to the underlying aquifer. Therefore, STRM 4005 (the IEMP and NPDES monitoring point immediately usptream of this point of confluence) and SWD-03 will also be evaluated and discussed in future IEMP reports with respect to cross-media impacts to the groundwater pathway.

B.1.1.3 Evaluation of Constituents Above BTVs for 1999

Based on the results of the BTV screening process presented in the approved Sitewide Excavation Plan (DOE 1998), three constituents (barium, cadmium, and silver) are evaluated against surface water BTVs. No BTV exceedances occurred during 1999.

B.1.1.4 Conclusions

Based on the sporadic nature of these FRL and BTV exceedances, continued monitoring is recommended to determine their significance. The data will continue to be used to document exceedances, provide statistical analysis, assess the cross-media impacts, and determine if additional administrative or engineered controls are required to protect the surface water pathway. At this time no additional controls are warranted.

### B.1.2 FFCA/OPERABLE UNIT 5 RECORD OF DECISION COMPLIANCE

The Operable Unit 5 Record of Decision stipulates compliance with a monthly flow-weighted average total uranium concentration of 20 µg/L at the Great Miami River via the Parshall Flume (PF 4001) beginning on January 1, 1998. Additionally, the Operable Unit 5 Record of Decision stipulates that the total mass discharged during a year is limited to 600 pounds. During 1999 the FEMP monitored total uranium concentrations at the Parshall Flume (PF 4001) daily to demonstrate compliance with these limitations.

The FEMP was in compliance with the total mass limitation as uranium discharges totaled 233 pounds, which is well below the 600 pound limitation. The FEMP was in compliance with the 20 µg/L limitation every month except January. The January 1999 exceedance is explained in Subsection B.1.2.3.

#### B.1.2.1 Storm Water-Related Bypasses

The Operable Unit 5 Record of Decision allows the FEMP to directly discharge water collected in the Storm Water Retention Basin to the Great Miami River during periods of "significant precipitation." These are referred to as bypass events (storm water bypassing treatment directly to the Great Miami River). The Operable Unit 5 Record of Decision allows the FEMP to eliminate the flow-weighted concentration for these bypass days due to "significant precipitation" (up to 10 days each year) in order to comply with the 20 µg/L total uranium limit. The definition of significant precipitation and the manner in which these days are accounted for in the calculation demonstrating compliance with the 20 µg/L limitation is in the Operations and Maintenance Master Plan for Aquifer Restoration and Wastewater Treatment Project (Section 3.6.2) (DOE 1999b). The Operations and Maintenance Master Plan was revised in 1999 and approved by the U.S. Environmental Protection Agency (EPA) and the Ohio Environmental Protection Agency (OEPA) in December 1999. In summary, "significant precipitation" bypass days are to be accounted for as follows:

- Each day the system is bypassed for less than 12 hours is to be counted only as necessary to achieve the 20 µg/L monthly average total uranium limit.
- Each day the system is bypassed for 12 or more hours is to be counted as a full bypass day.

The flow-weighted concentration and flow rate for each bypass day are eliminated from the calculation for the month.

Based on the approved definition, no significant precipitation bypass days occurred during 1999.

B.1.2.2 Maintenance Related Bypasses

Bypassing during scheduled treatment plant maintenance is permissible under the Operable Unit 5 Record of Decision provided prior notice is given to EPA and OEPA. The uranium concentration, for those days when a maintenance activity was performed, can be eliminated from the uranium concentration calculation. The FEMP had three such days in March 1999 as identified in Table B.1-3. The FEMP was in compliance with the 20 µg/L limitation for that month as identified on Figure B.1-9.

B.1.2.3 1999 Exceedances of the 20 µg/L Total Uranium Limitation

The average concentration for January was 26.1 µg/L. The January exceedance was partially due to eluate (with elevated total uranium concentrations) from frozen valves on the ion exchange resin regeneration system leaking into the advance wastewater treatment facility (Phase II) discharge header. The leaking valves were identified on January 6, 1999, and the situation controlled by January 11, 1999. However, the total uranium concentrations during this time (January 6 through 11) were well above normal at the Parshall Flume. Additionally, the total uranium concentrations at the sewage treatment plant were well above normal during January. Once discovered, the new sewage treatment plant effluent was temporarily redirected during a portion of January to the advanced wastewater treatment facility (Phase II). In addition, some extraction and re-injection wells were shut down during a portion of January to mitigate the higher total uranium concentrations occurring at the Parshall Flume.

B.1.3 CONTROLLED AND UNCONTROLLED AREAS

There were a few acres, previously uncontrolled, that were added to the FEMP controlled storm water system in 1999 (Figure B.1-10). This includes Cell 3 of the on-site disposal facility. This change added approximately seven acres of previously uncontrolled area to the controlled system. The following identifies for each specific area where storm water runoff is collected, how it is controlled, the reason why the area is now controlled, and the amount of area controlled:

- On-Site Disposal Facility: Storm water runoff associated with Cells 1, 2, and, beginning in October 1999, storm water runoff associated with Cell 3 is collected by the leachate collection system. This storm water runoff is pumped to the Bio-Surge Lagoon and then to the advanced wastewater treatment facility. This area is controlled because waste placement is occurring within all three cells. Each individual cell is approximately seven acres; therefore, the total controlled area associated with the on-site disposal facility was raised from 14 acres at the end of 1998 (waste placement was occurring in Cells 1 and 2) to 21 acres by the end of 1999.

- Southern Waste Units: Storm water runoff associated with the southern waste units is collected by three engineered basins which became operational in July 1998. They continued to be operated in 1999. The water from these basins is transferred to the Storm Water Retention Basin and then to the advanced wastewater treatment facility.

This area is controlled due to the excavation of contaminated soil and waste material. The area controlled is 26 acres.

- Waste Pits Remedial Action Project area: The Waste Pits Remedial Action Project facility area is designed so that storm water runoff associated with this project is collected in the Storm Water Management Pond. Collected storm water requiring treatment is pumped to the Bio-Surge Lagoon and then to the advanced wastewater treatment facility. Runoff from this area (10.5 acres) is controlled due to past construction and current excavation activities in the Operable Unit 1 area.

The U.S. Department of Energy has received approval to discharge storm water from this Storm Water Management Pond, which is determined to be uncontaminated, directly to Paddys Run upon the following conditions:

- Prior to discharging water to Paddys Run, a sample is collected from the Storm Water Management Pond and analyzed for total uranium. If the total uranium result is below 20 μg/L, then the water is discharged to Paddys Run.

- As the water is being discharged to Paddys Run, a total suspended solids sample is collected.

The water from the Storm Water Management Pond is not discharged to Paddys Run if the total uranium result is above 20 μg/L.

The areas from which run-off must be controlled will continue to change throughout remediation. Potentially contaminated areas will be added to the controlled system and areas that have been remediated will be removed from the system. This information will continue to be provided in IEMP quarterly status reports.

## TABLE B.1-1

## SUMMARY STATISTICS AND TREND ANALYSIS FOR CONSTITUENTS WITH 1999 RESULTS ABOVE FINAL REMEDIATION LEVELS

| Location[a] | Constituent | No. of Samples[b,c,d] | No. of Samples Above FRL[b,c,d] | No. of Samples Above FRL for 1999[c,d] | FRL[e] (mg/L) | Min.[b,c,d,f] (mg/L) | Max.[b,c,d,f] (mg/L) | Avg.[b,c,d,f] (mg/L) | SD[b,c,d,f] (mg/L) | Trend[b,c,d,f] |
|---|---|---|---|---|---|---|---|---|---|---|
| SWP-01 (Paddys Run Background) | Manganese | 10 | 1 | 1 | 1.5 | 0.0133 | 1.71 | 0.211 | 0.528 | Up, Marginal |
| SWP-03 (Paddys Run at Downstream Property Boundary) | Chromium | 14 | 1 | 1 | 0.01[g] | 0.00024 | 0.0131 | 0.0024 | 0.0033 | No Significant Trend |

[a]Refer to Figure B.1-4
[b]Based on samples collected from 1997 through 1999
[c]If more than one sample is collected per surface water location per day (e.g., duplicate, grab, composite), then only one sample is counted for the number of samples, and the sample with the maximum concentration is used for determining the summary statistics (minimum, maximum, average, and standard deviation [SD]), Mann-Kendall test for trend, and in determining FRL exceedances.
[d]Rejected data qualified with either a R or Z were not included in the count, the summary statistics, or Mann-Kendall test for trend.
[e]From Operable Unit 5 Record of Decision, Table 9-5
[f]For results where the concentrations are below the detection limit, the results used in the summary statistics and Mann-Kendall test for trend are each set at half the detection limit.
[g]FRL based on hexavalent chromium, from Operable Unit 5 Record of Decision, Table 9-5; however, the sampling results are for total chromium.



000357

# TABLE B.1-2

## SUMMARY STATISTICS AND TREND ANALYSIS OF 1999 TOTAL URANIUM GROUNDWATER FINAL REMEDIATION LEVELS EXCEEDANCE FOR CROSS-MEDIA IMPACTS[a]

| Location[b] | No. of Samples[c,d,e] | No. of Samples Above FRL[c,d,e] | No. of Samples Above FRL for 1999[d,e] | Min.[c,d,e,f] (µg/L) | Max.[c,d,e,f] (µg/L) | Avg.[c,d,e,f] (µg/L) | SD[c,d,e,f] (µg/L) | Trend[c,d,e,f] |
|---|---|---|---|---|---|---|---|---|
| SWD-02 (Storm Sewer Outfall Ditch) | 27 | 9 | 2 | 0.599 | 73 | 21 | 15 | No Significant Trend |

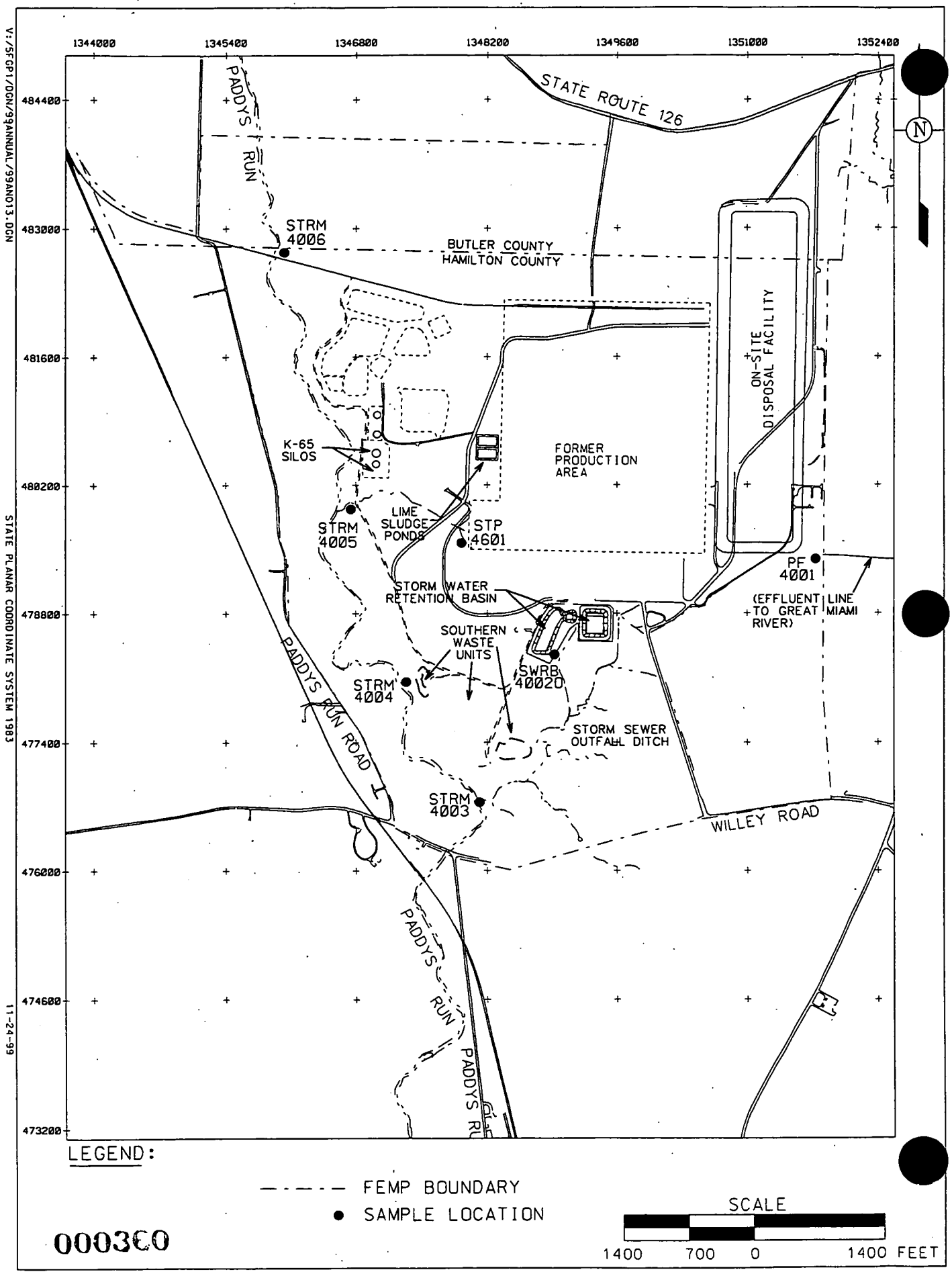
[a]Groundwater total uranium FRL is 20 µg/L.
[b]Refer to Figure B.1-1 for sample locations
[c]Based on samples collected from 1997 through 1999
[d]If more than one sample is collected per surface water location per day (e.g., duplicate, grab, composite), then only one sample is counted for the number of samples, and the sample with the maximum concentration is used for determining the summary statistics (minimum, maximum, average, and standard deviation [SD]) and in determining FRL exceedances.
[e]Rejected data qualified with either a R or Z were not included in the count, the summary statistics, or Mann-Kendall test for trend.
[f]For results where the concentrations are below the detection limit, the results used in the summary statistics and Mann-Kendall test for trend are each set at half the detection limit.

## TABLE B.1-3

## 1999 TREATMENT BYPASS EVENTS

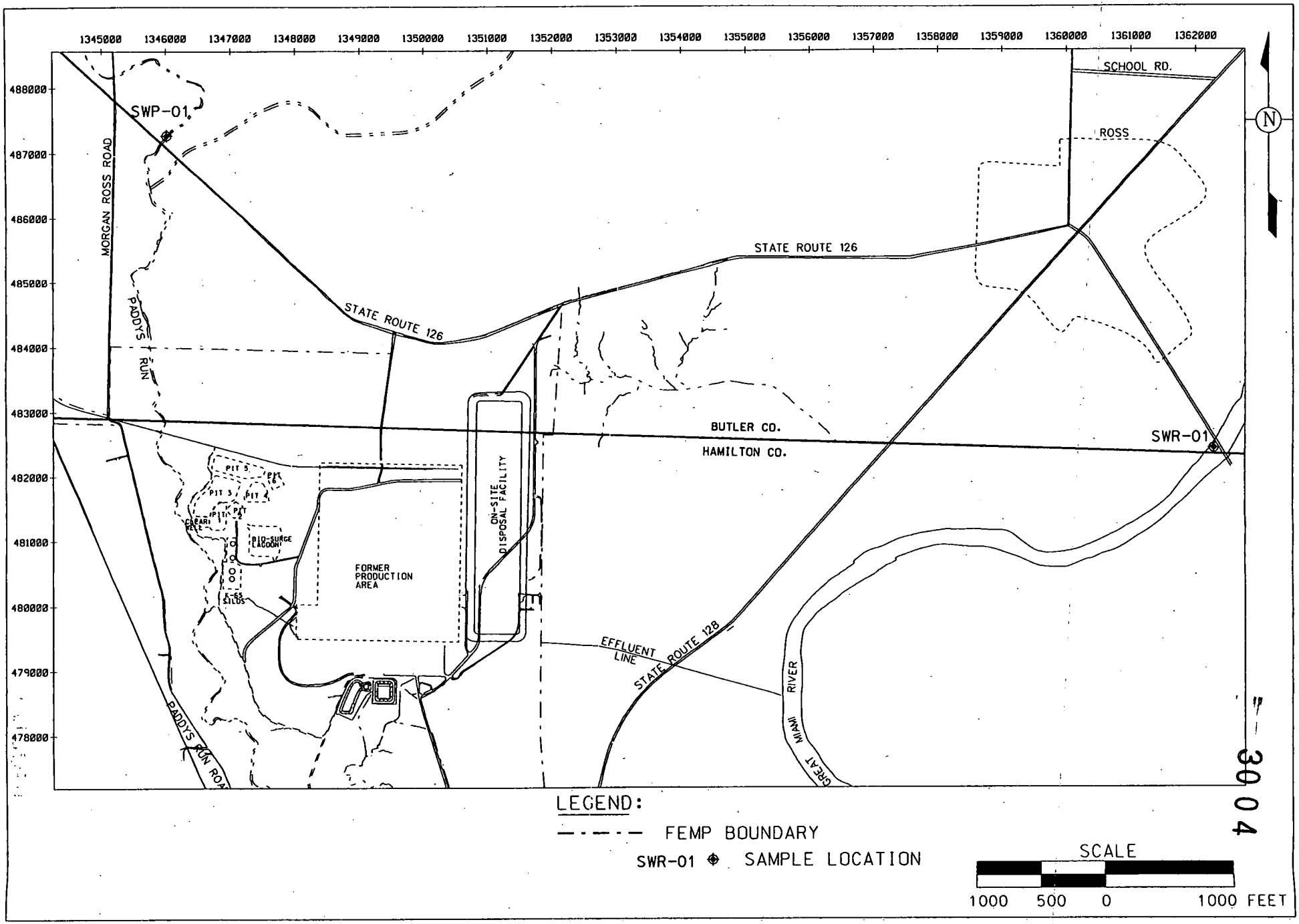
| Event | Duration (hours) | Number of Bypass Days[a] | Cumulative Number of Bypass Days | Total Uranium Discharged (pounds) (to Great Miami River) | Total Water Discharged (millions of gallons) (to Great Miami River) |
|---|---|---|---|---|---|
| **Treatment Plant Maintenance Bypasses** | | | | | |
| March 15 through March 17 | 72 | 3 | 3 | 3.29 | 13.767 |

[a]Days are counted according to the definition provided in the Operations and Maintenance Master Plan for the Aquifer Restoration and Wastewater Treatment Project.




000360

FIGURE B.1-1. IEMP SURFACE WATER AND TREATED EFFLUENT SAMPLE LOCATIONS




V:/5FGP1/DGN/99ANNUAL/99AN012.DGN 29-MAR-2000
STATE PLANAR COORDINATE SYSTEM 1983

FIGURE B.1-2. IEMP BACKGROUND SURFACE WATER SAMPLE LOCATIONS

000362

1999 FEMP Precipitation Total: 34.39 inches
Average Precipitation Total: 40.86 inches [a]

[a] Average precipitation is based on data collected at the Greater Cincinnati/Northern Kentucky International Airport.

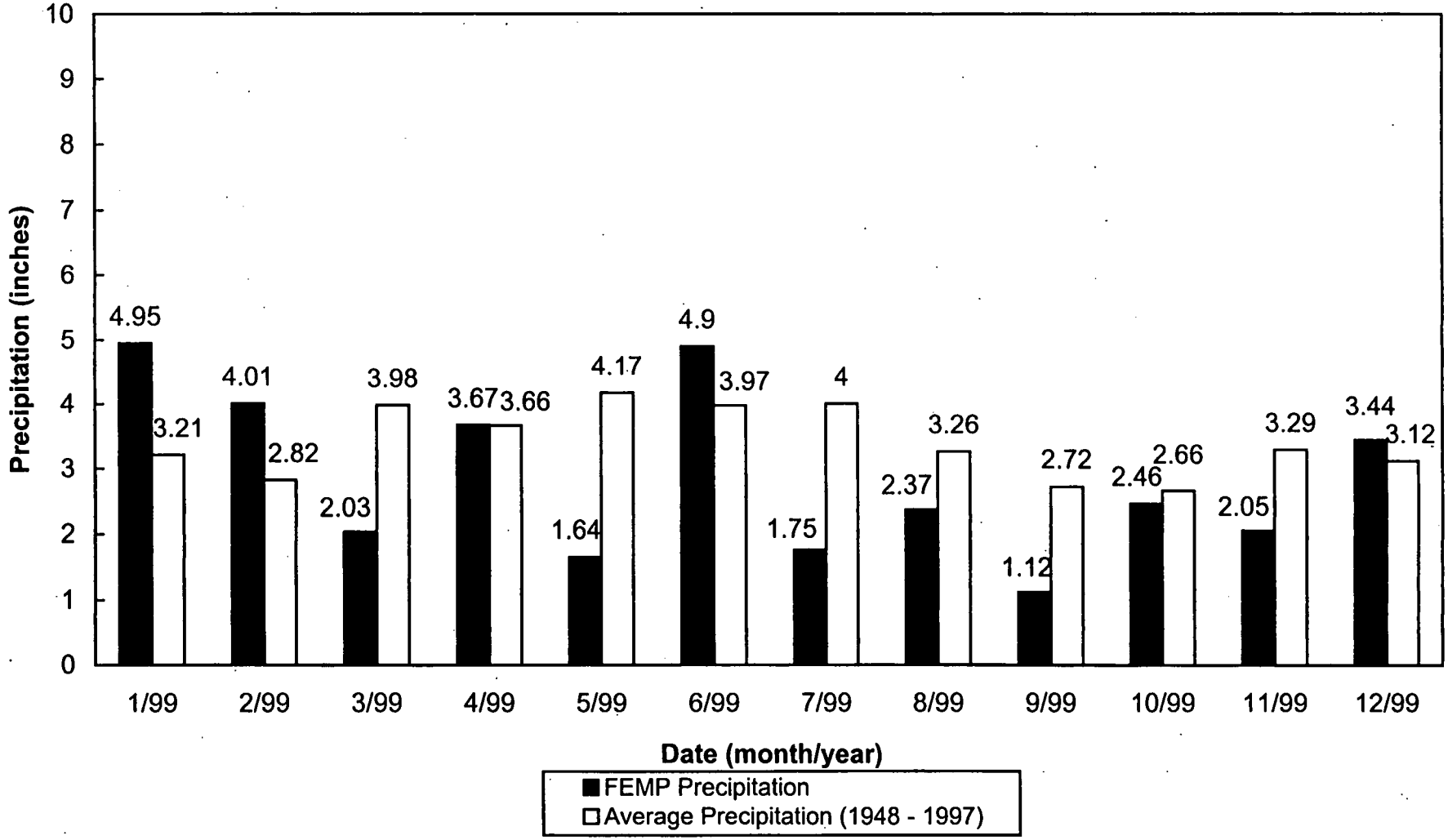



FIGURE B.1-3. 1999 FEMP MONTHLY PRECIPITATION DATA

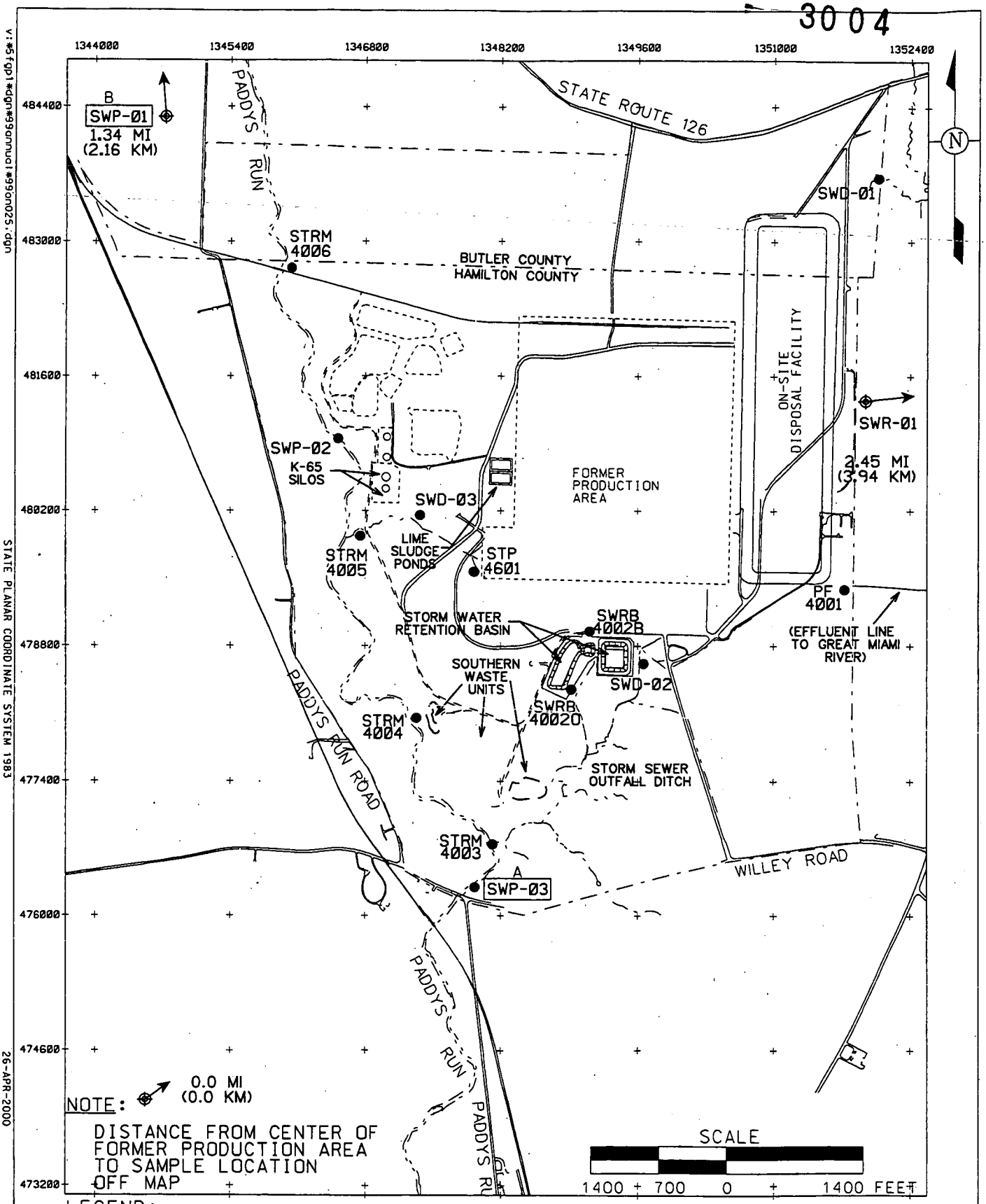





FIGURE B.1-4. CONSTITUENTS WITH 1999 RESULTS ABOVE FINAL REMEDIATION LEVELS AND/OR BENCHMARK TOXICITY VALUES

000336

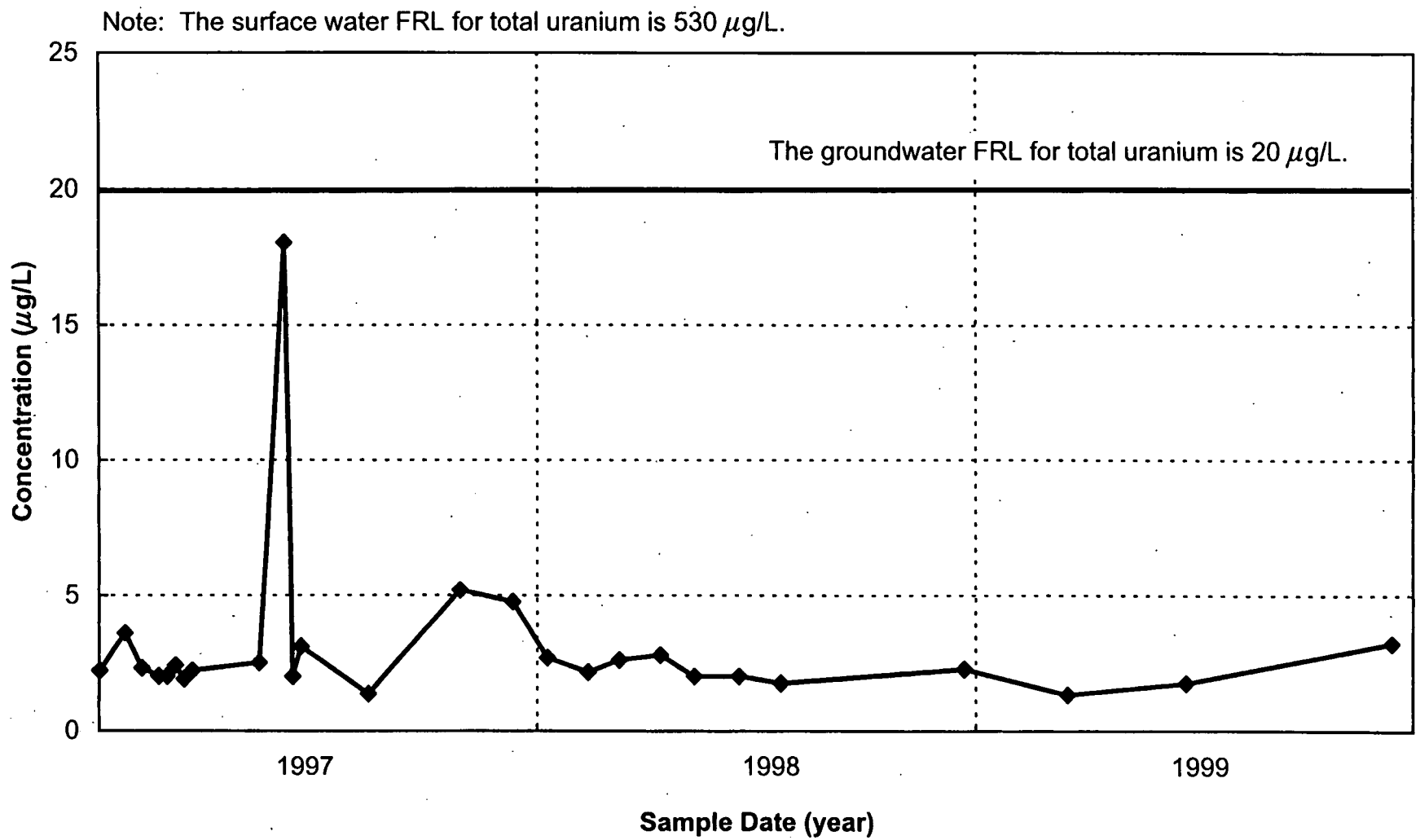



FIGURE B.1-5. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR LOCATION SWP-03 (PADDYS RUN AT DOWNSTREAM PROPERTY BOUNDARY)

Down Significant

Note: The surface water FRL for total uranium is 530 $\mu$g/L.

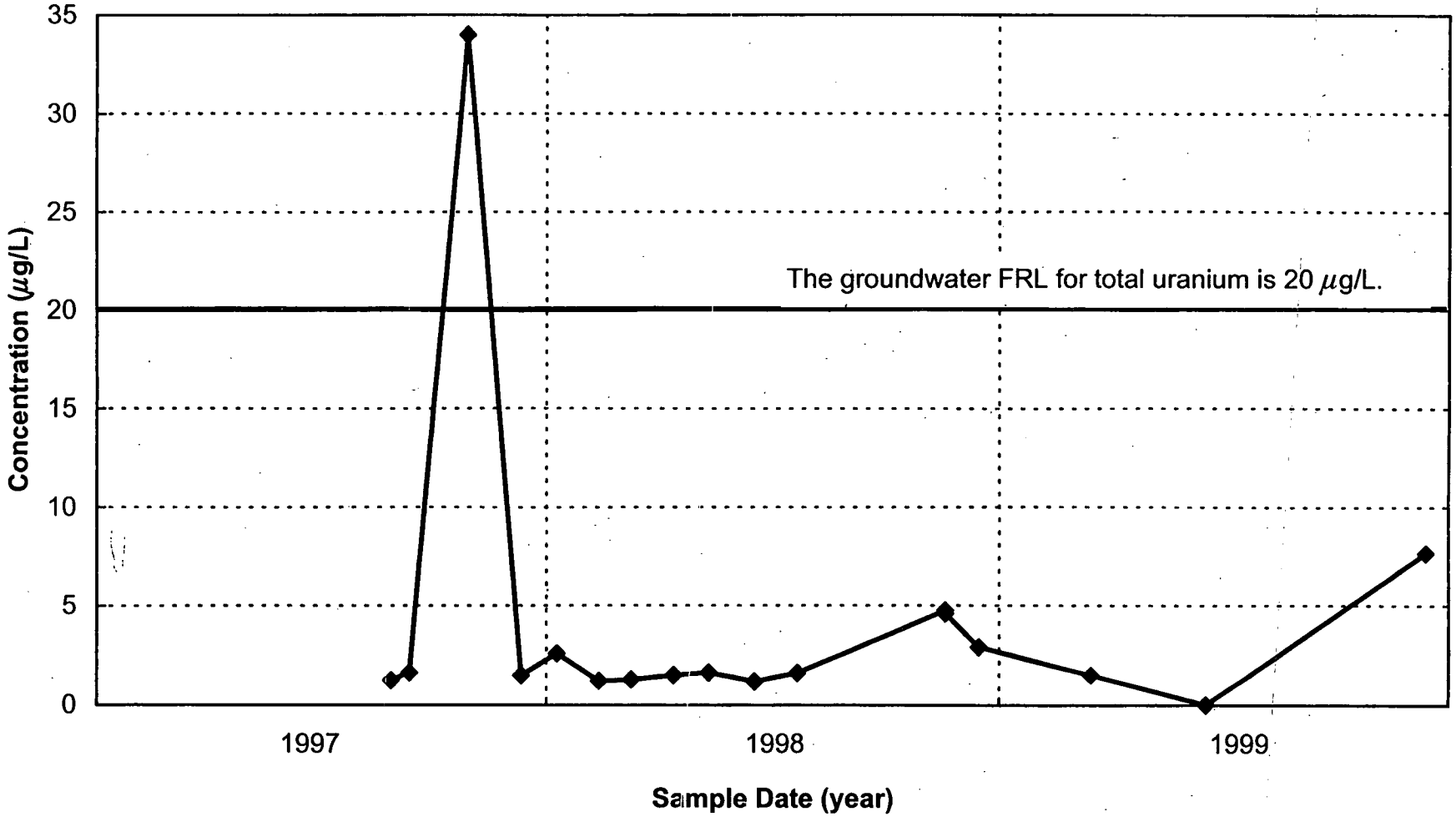



FIGURE B.1-6. TOTAL URANIUM CONCENTRATION VS. TIME PLOT
FOR LOCATION SWP-02 (PADDYS RUN)
FOR CROSS-MEDIA IMPACT EVALUATION

Down Marginal

000366

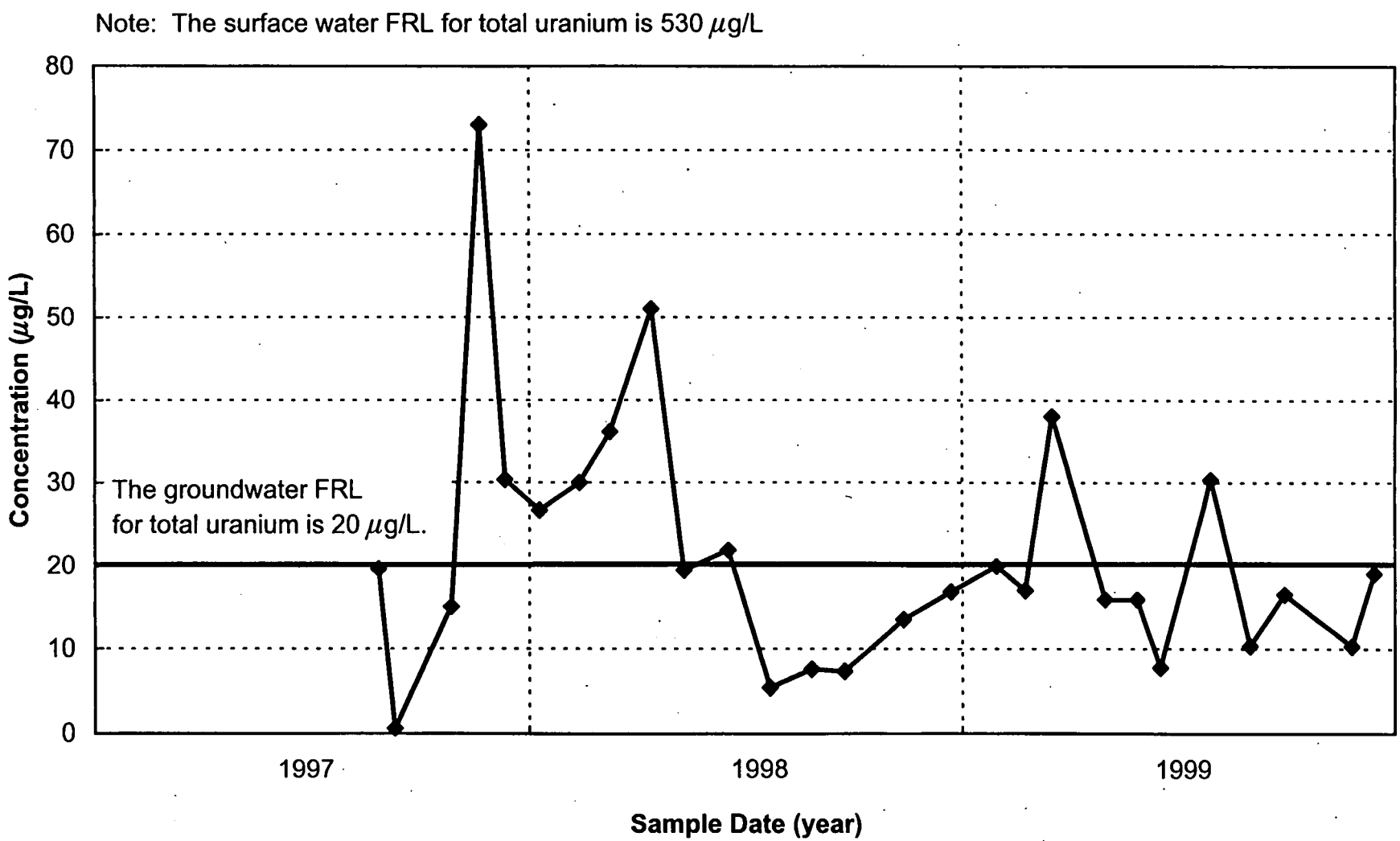
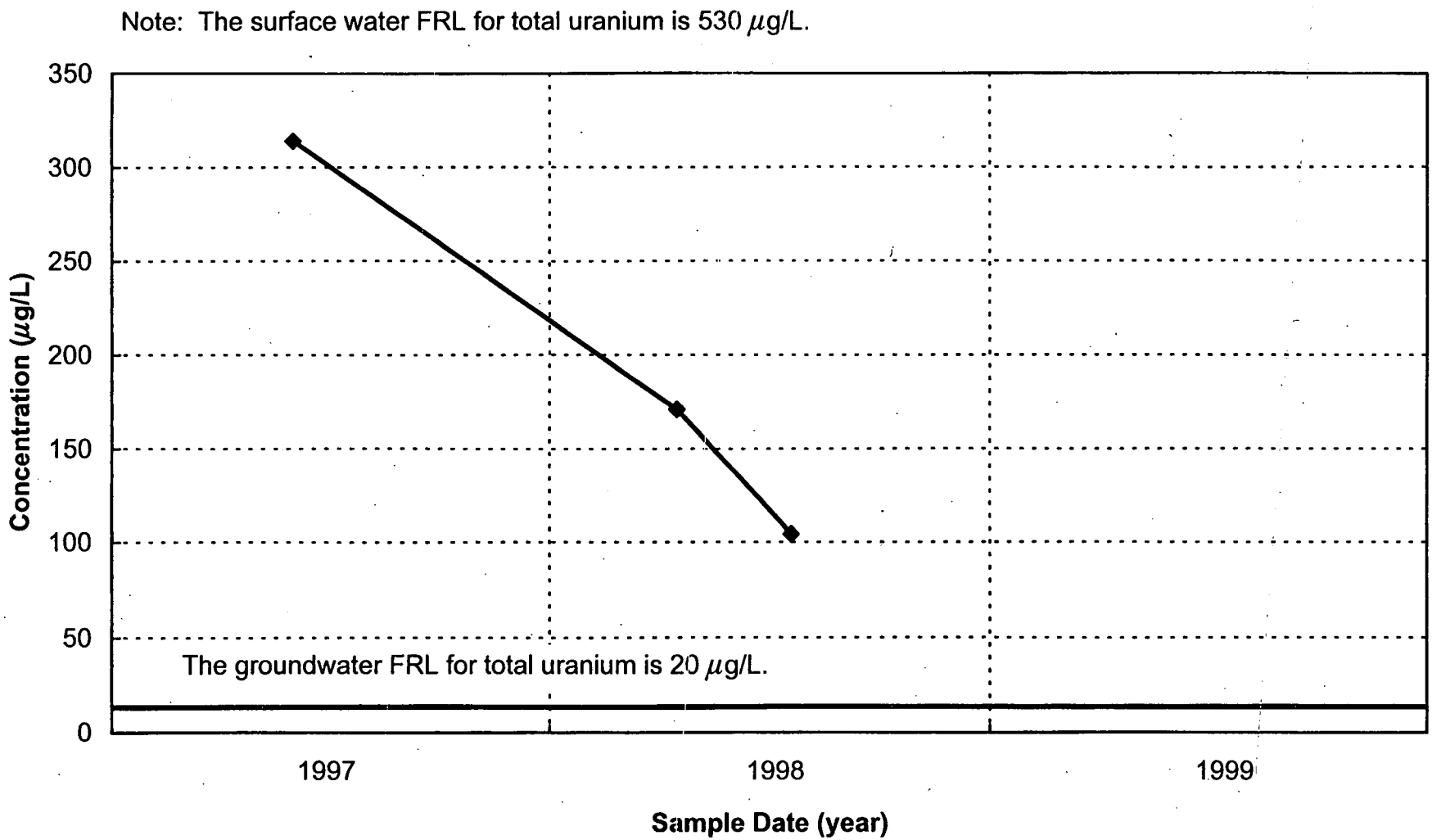


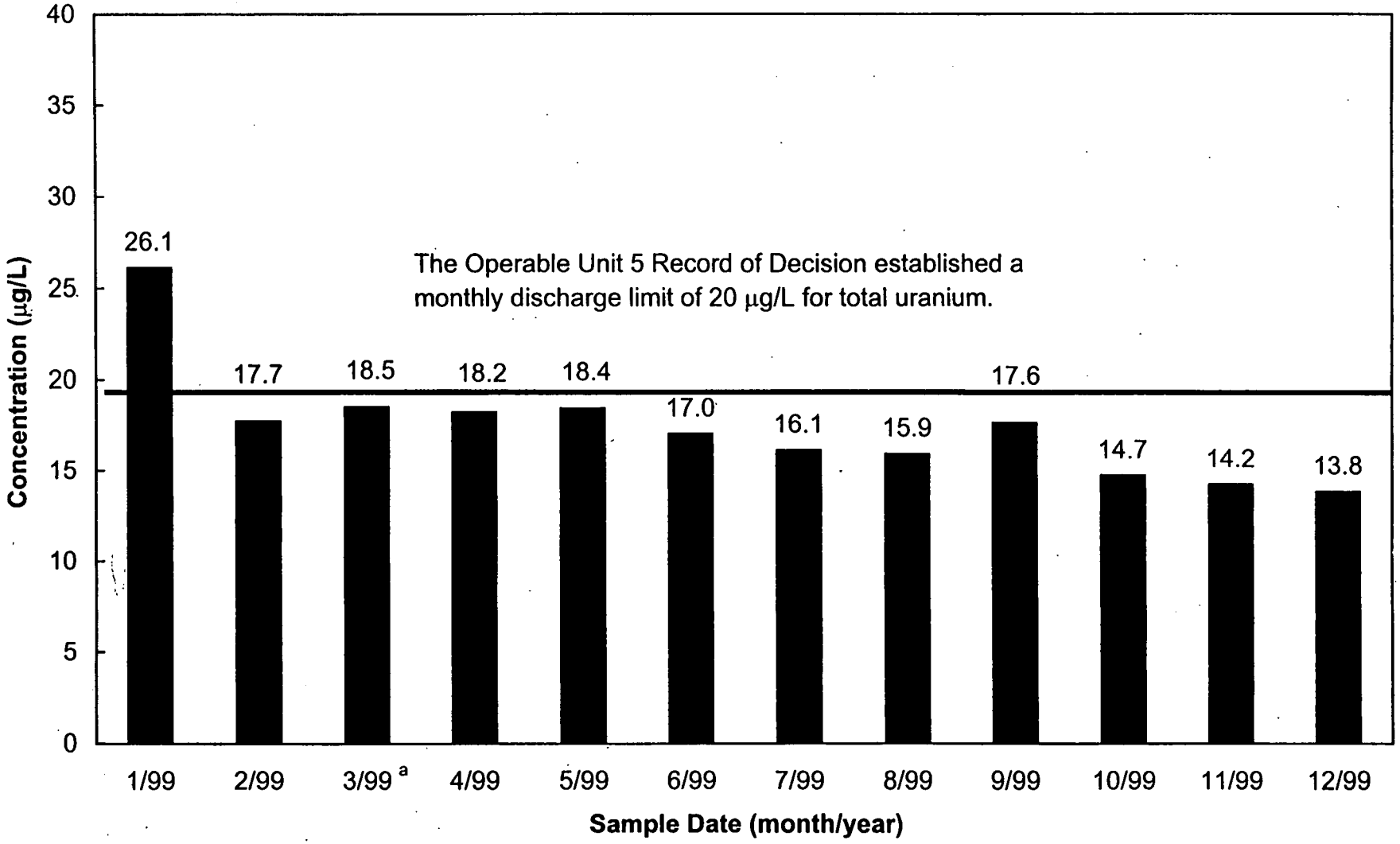

FIGURE B.1-7. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR LOCATION SWD-02 (STORM SEWER OUTFALL DITCH) FOR CROSS-MEDIA IMPACT EVALUATION

Down Significant




Not enough samples to perform trend analysis.

FIGURE B.1-8. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR LOCATION SWRB 4002O (STORMWATER RETENTION BASIN OVERFLOW) FOR CROSS-MEDIA IMPACT EVALUATION




[a] Actual concentration was 19.4 µg/L. Eliminating the three "treatment plant maintenance" bypass days reduces average to 18.5 µg/L.

FIGURE B.1-9. 1999 MONTHLY AVERAGE TOTAL URANIUM CONCENTRATION IN WATER DISCHARGED FROM THE PARSHALL FLUME (PF 4001) TO THE GREAT MIAMI RIVER

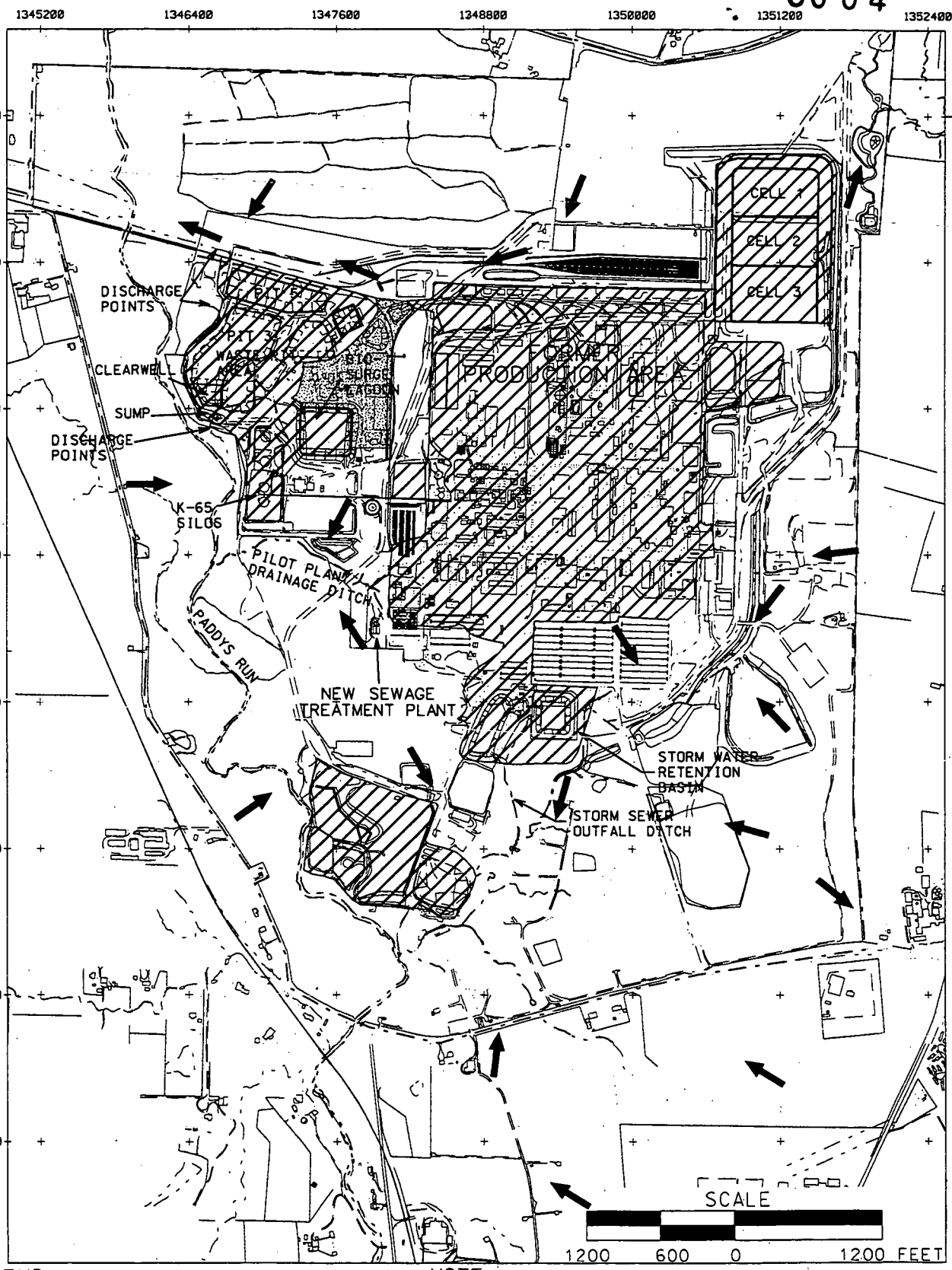
FINAL

000368

V:/5FGP1/DGN/99ANNUAL/99ANO14.DGN

STATE PLANAR COORDINATE SYSTEM 1983

11-24-99




LEGEND:

- FEMP BOUNDARY
- CONTROLLED AREA
- UNCONTROLLED RUNOFF FLOW DIRECTION

NOTE:

CONTROLLED MEANS WATER IS COLLECTED AND SENT FOR TREATMENT AT THE AWWT.

- WATER TREATED IF TOTAL URANIUM RESULT IS >20 μg/L

FIGURE B.1-10. CONTROLLED SURFACE WATER AREAS AND UNCONTROLLED FLOW DIRECTIONS FOR FOURTH QUARTER 1999

# ATTACHMENT B.2

# SEDIMENT

# ATTACHMENT B.2



Sediment is a secondary exposure pathway and is monitored annually to assess the impact of remediation activities on sediments deposited along surface water drainages. Sediment is collected at strategic locations to ensure that the most recently deposited sediment is collected. Sediment collected in 1999 marked the second year for implementing the sediment-monitoring program contained in the IEMP.

Sediment samples were collected in August of 1999 at 16 locations along Paddys Run, the Storm Sewer Outfall Ditch, and the Great Miami River (refer to Figure B.2-1). Samples collected at each location were analyzed for total uranium. All samples collected from the Storm Sewer Outfall Ditch, Paddys Run north and south of the outfall ditch, and from the Paddys Run background location were also analyzed for radium-226, radium-228, and isotopic thorium. Per the IEMP, Revision 1, the monitoring program was revised to eliminate four of the 20 monitoring locations based on a nine-year trend of sediment data that are near or equivalent to background concentrations for the contaminants.

Table B.2-1 summarizes the results of the 1999 sediment monitoring program. Analytical results of samples collected from the Storm Sewer Outfall Ditch, Paddys Run, and the Great Miami River from 1999 were below the FRL for all of the constituents (total uranium, isotopic thorium, radium-226, and radium-228). On average, there was a slight increase in all constituents at the Paddys Run North and Storm Sewer Outfall Ditch locations, while average total uranium concentrations increased at all of the monitored locations. However, all results are within the range of historical background levels. Figures B.2-2 through B.2-6 present sediment data trends. Monitoring of sediment will continue with the IEMP to determine the effectiveness of the engineered controls designed to reduce erosion from the FEMP and sedimentation of Paddys Run and its tributaries.

# TABLE B.2-1

## SUMMARY STATISTICS FOR SEDIMENT MONITORING PROGRAM

| | 1999 Results – Concentration (dry weight) | | | | | | | 1998 Results | | | | | | | 1990 - 1997 Results | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. of | Minimum[a,b,c] | | Maximum[a,b,c] | | Average[a,b,c] | | No. of | Minimum[a,b,c] | | Maximum[a,b,c] | | Average[a,b,c] | | Minimum[a,b,c] | | Maximum[a,b,c] | |
| Radionuclide | Samples[a] | pCi/g | (mg/kg) | pCi/g | (mg/kg) | pCi/g | (mg/kg) | Samples[a] | pCi/g | (mg/kg) | pCi/g | (mg/kg) | pCi/g | (mg/kg) | pCi/g | (mg/kg) | pCi/g | (mg/kg) |
| **Great Miami River, North of the Effluent Line** | | | | | | | | | | | | | | | | | | |
| Uranium, Total | 1 | 1.30 | (1.92) | NA | NA | NA | NA | 1 | 0.70 | (1.04) | NA | NA | NA | NA | 0.50 | (0.74) | 1.8 | (2.7) |
| **Great Miami River, South of the Effluent Line** | | | | | | | | | | | | | | | | | | |
| Uranium, Total | 1 | 2.51 | (3.72) | NA | NA | NA | NA | 3 | 0.46 | (0.65) | 1.13 | (1.7) | 0.83 | (1.2) | 0.30 | (0.44) | 2.6 | (3.8) |
| **Paddys Run Background, North of S.R. 126** | | | | | | | | | | | | | | | | | | |
| Radium-226 | 1 | 0.494 | NA | NA | NA | NA | NA | 1 | 0.57 | NA | NA | NA | NA | NA | 0.00 | NA | 1.4 | NA |
| Radium-228 | 1 | 0.416 | NA | NA | NA | NA | NA | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Thorium-228 | 1 | 0.426 | NA | NA | NA | NA | NA | 1 | 0.36 | NA | NA | NA | NA | NA | 0.15 | NA | 1.2 | NA |
| Thorium-230 | 1 | 0.461 | NA | NA | NA | NA | NA | 1 | 0.48 | NA | NA | NA | NA | NA | 0.22 | NA | 1.9 | NA |
| Thorium-232 | 1 | 0.364 | NA | NA | NA | NA | NA | 1 | 0.42 | NA | NA | NA | NA | NA | 0.15 | NA | 1.1 | NA |
| Uranium, Total | 1 | 0.824 | (1.22) | NA | NA | NA | NA | 1 | 0.78 | (1.2) | NA | NA | NA | NA | 0.41 | (0.61) | 2.8 | (4.1) |
| **Paddys Run, North of the Storm Sewer Outfall Ditch** | | | | | | | | | | | | | | | | | | |
| Radium-226 | 5 | 0.612 | NA | 0.889 | NA | 0.745 | NA | 5 | 0.40 | NA | 0.52 | NA | 0.47 | NA | 0.00 | NA | 3.7 | NA |
| Radium-228 | 5 | 0.478 | NA | 0.655 | NA | 0.602 | NA | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Thorium-228 | 5 | 0.295 | NA | 0.704 | NA | 0.511 | NA | 5 | 0.33 | NA | 0.37 | NA | 0.34 | NA | 0.25 | NA | 5.1 | NA |
| Thorium-230 | 5 | 0.548 | NA | 1.22 | NA | 0.842 | NA | 5 | 0.28 | NA | 0.67 | NA | 0.54 | NA | 0.08 | NA | 9.8 | NA |
| Thorium-232 | 5 | 0.277 | NA | 0.604 | NA | 0.458 | NA | 5 | 0.24 | NA | 0.45 | NA | 0.35 | NA | 0.19 | NA | 5.4 | NA |
| Uranium, Total | 5 | 0.939 | (1.39) | 2.01 | (2.98) | 1.48 | (2.19) | 5 | 0.66 | (0.97) | 1.26 | (1.9) | 0.89 | (1.3) | 0.55 | (0.81) | 8.7 | (13) |
| **Storm Sewer Outfall Ditch** | | | | | | | | | | | | | | | | | | |
| Radium-226 | 5 | 0.538 | NA | 0.932 | NA | 0.7548 | NA | 5 | 0.46 | NA | 0.52 | NA | 0.48 | NA | 0.00 | NA | 1.4 | NA |
| Radium-228 | 5 | 0.339 | NA | 0.813 | NA | 0.614 | NA | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Thorium-228 | 5 | 0.426 | NA | 0.773 | NA | 0.615 | NA | 5 | 0.24 | NA | 0.39 | NA | 0.30 | NA | 0.05 | NA | 1.9 | NA |
| Thorium-230 | 5 | 0.595 | NA | 0.959 | NA | 0.929 | NA | 5 | 0.49 | NA | 0.85 | NA | 0.64 | NA | 0.02 | NA | 4.0 | NA |
| Thorium-232 | 5 | 0.294 | NA | 0.674 | NA | 0.479 | NA | 5 | 0.22 | NA | 0.41 | NA | 0.29 | NA | 0.01 | NA | 2.1 | NA |
| Uranium, Total | 5 | 1.51 | (2.24) | 4.49 | (6.65) | 2.75 | (4.07) | 5 | 1.04 | (1.5) | 1.71 | (2.5) | 1.33 | (2.0) | 0.41 | (0.61) | 16 | (23) |
| **Paddys Run, South of the Storm Sewer Outfall Ditch** | | | | | | | | | | | | | | | | | | |
| Radium-226 | 1 | 0.645 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Radium-228 | 1 | 0.582 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Thorium-228 | 1 | 0.347 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Thorium-230 | 1 | 0.675 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Thorium-232 | 1 | 0.352 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Uranium, Total | 3 | 1.03 | (1.53) | 1.45 | (2.15) | 1.26 | (1.87) | 5 | 0.67 | (0.99) | 1.16 | (1.7) | 0.88 | (1.3) | 0.55 | (0.81) | 30 | (44) |

| FRLs | mg/kg | pCi/g |
|---|---|---|
| Radium-226 | - | 2.9 |
| Radium-228 | - | 4.8 |
| Thorium-228 | - | 3.2 |
| Thorium-230 | - | 18,000 |
| Thorium-232 | - | 1.6 |
| Uranium, Total | 210 | - |

[a]If more than one sample is collected per sample location (e.g., split or duplicate), then only one sample is counted for the number of samples, and the sample with the maximum concentration is used for determining the summary statistics (minimum, maximum, and average).
[b]If the number of samples is greater than or equal to three, then the minimum, maximum, and average are reported. If the number of samples is equal to two, then the minimum and maximum are reported. If the number of samples is equal to one, then the result is reported as the minimum.
[c]NA = not ap

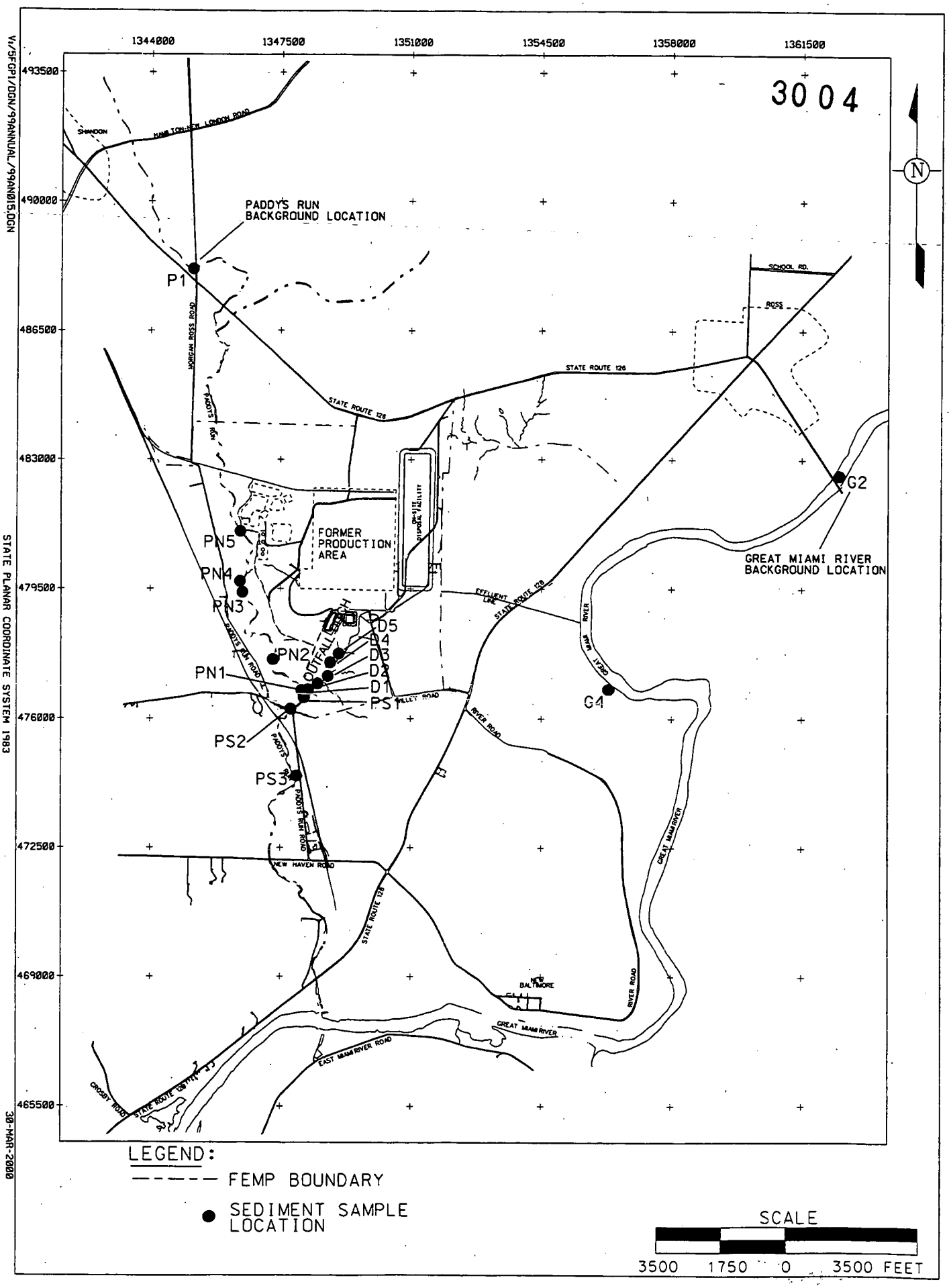



FIGURE B.2-1. 1999 SEDIMENT SAMPLE LOCATIONS

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Note: The sediment BTV for radium-226 is 580,000 pCi/g.

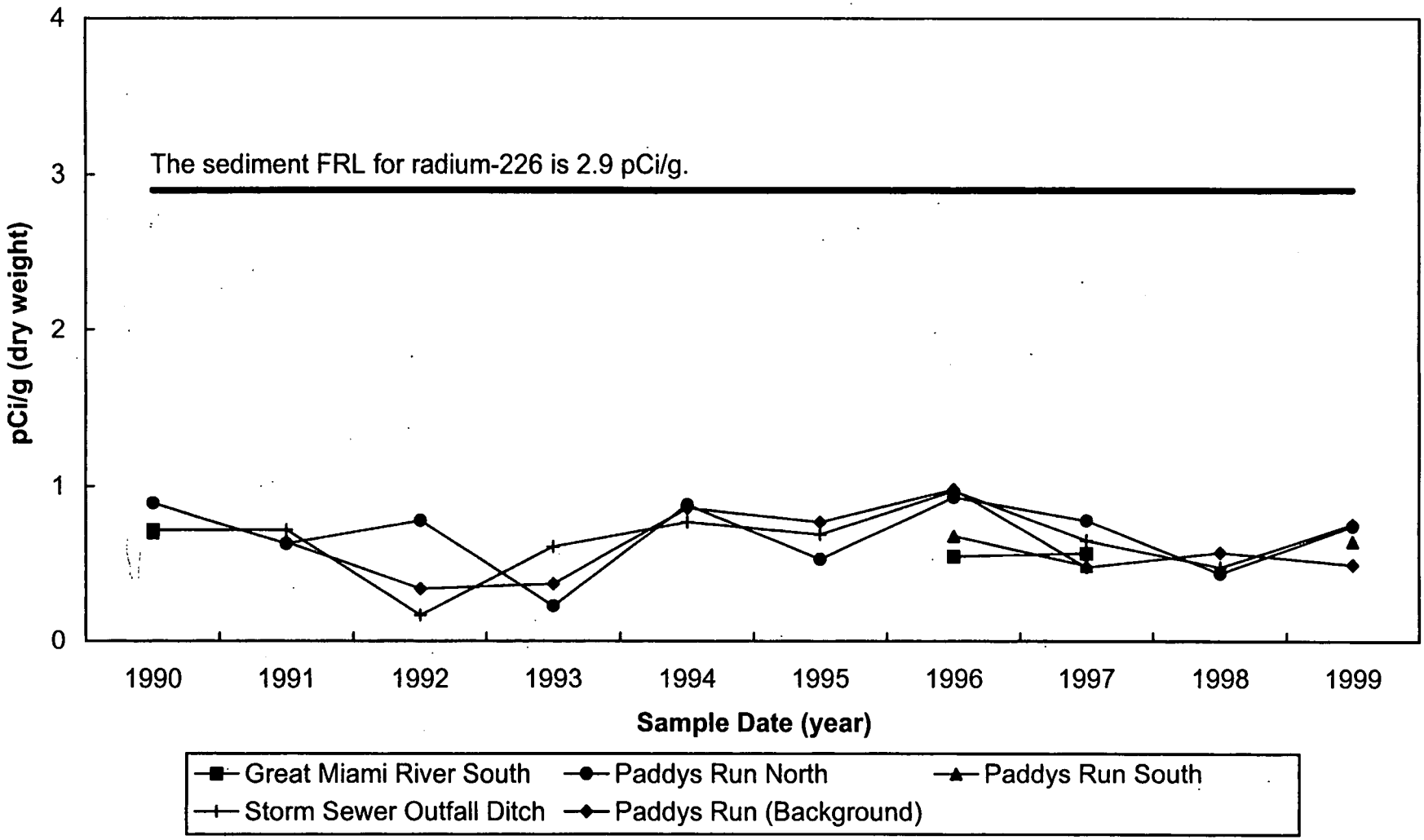


FIGURE B.2-2. RADIUM-226 CONCENTRATION VS. TIME PLOT FOR SEDIMENT

Note: The sediment BTV for thorium-228 is 4,900,000 pCi/g.

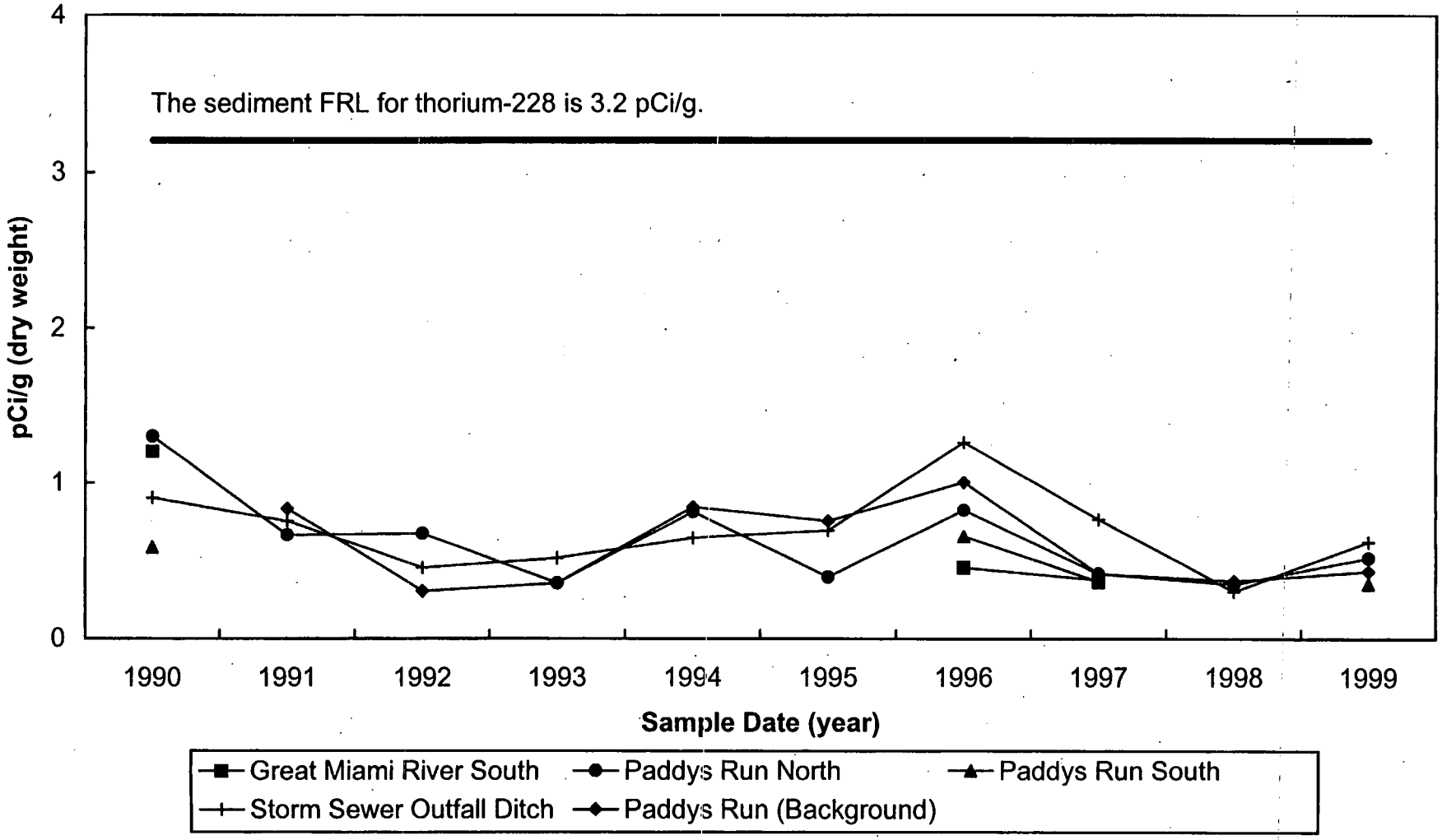


FIGURE B.2-3. THORIUM-228 CONCENTRATION VS. TIME PLOT FOR SEDIMENT



000340

Note: The sediment FRL for thorium-230 is 18,000 pCi/g and the BTV is 29,000,000 pCi/g.

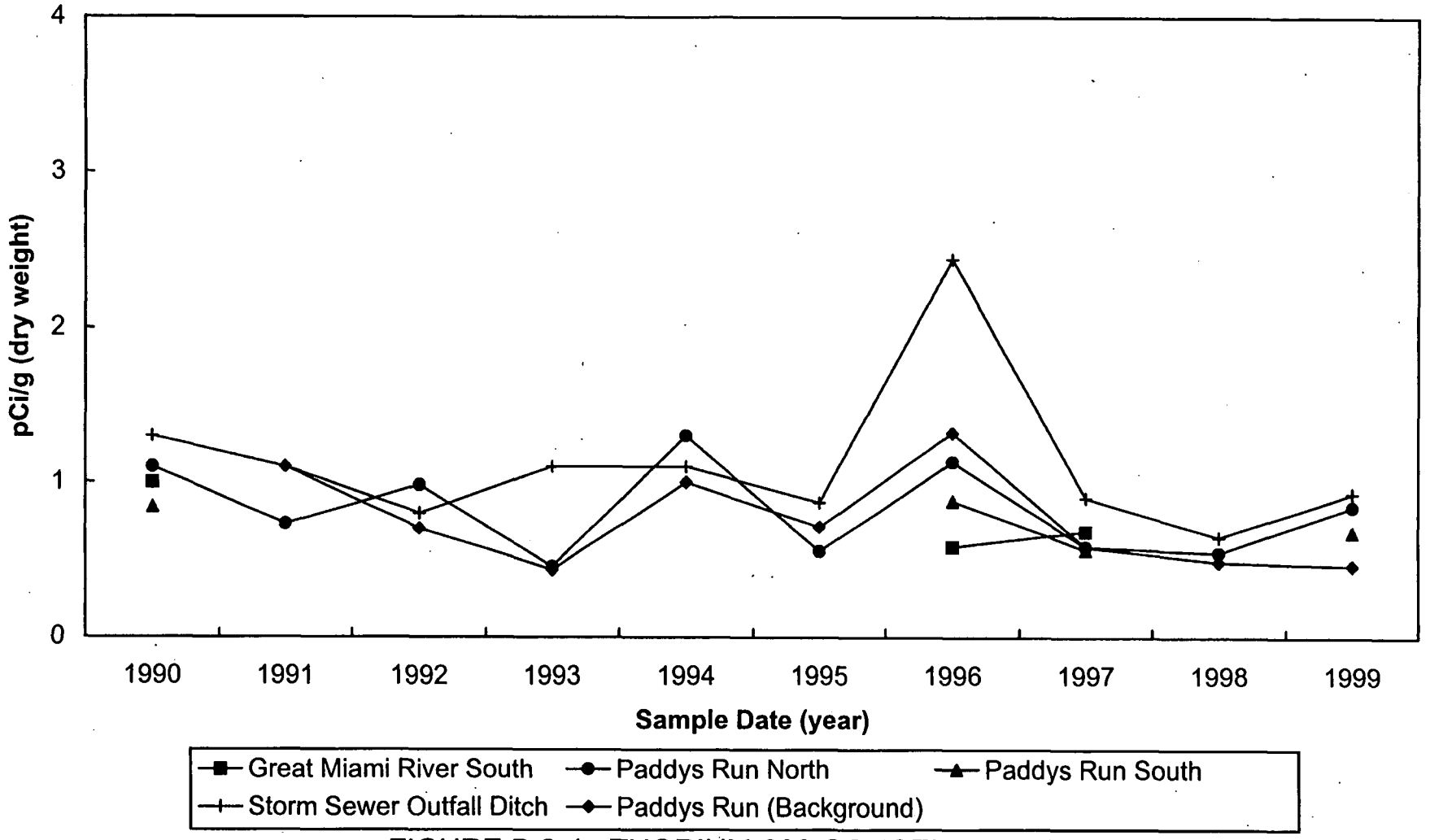


FIGURE B.2-4. THORIUM-230 CONCENTRATION VS. TIME PLOT FOR SEDIMENT

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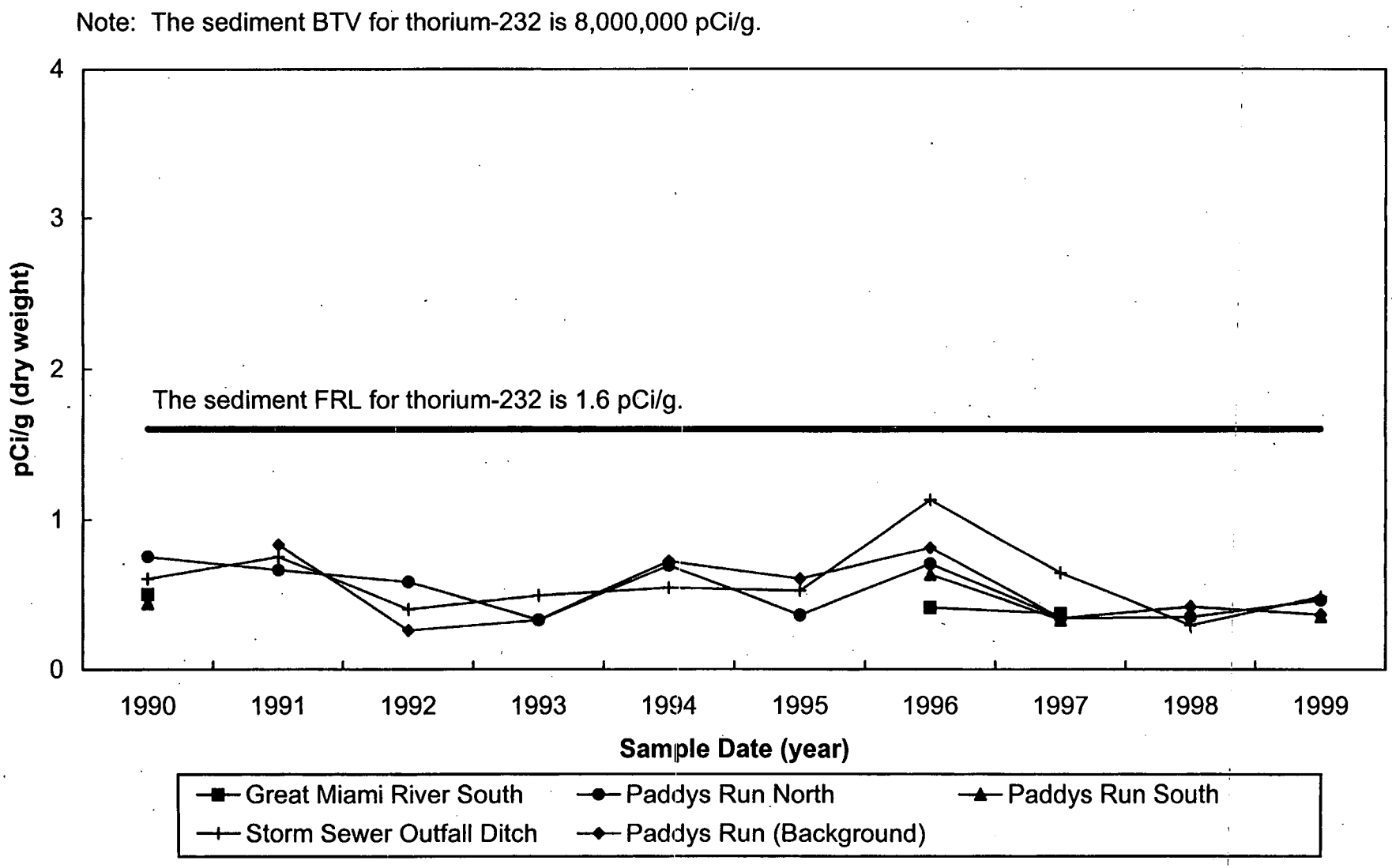


FIGURE B.2-5. THORIUM-232 CONCENTRATION VS. TIME PLOT FOR SEDIMENT

Note: The sediment FRL for total uranium is 210 mg/kg.

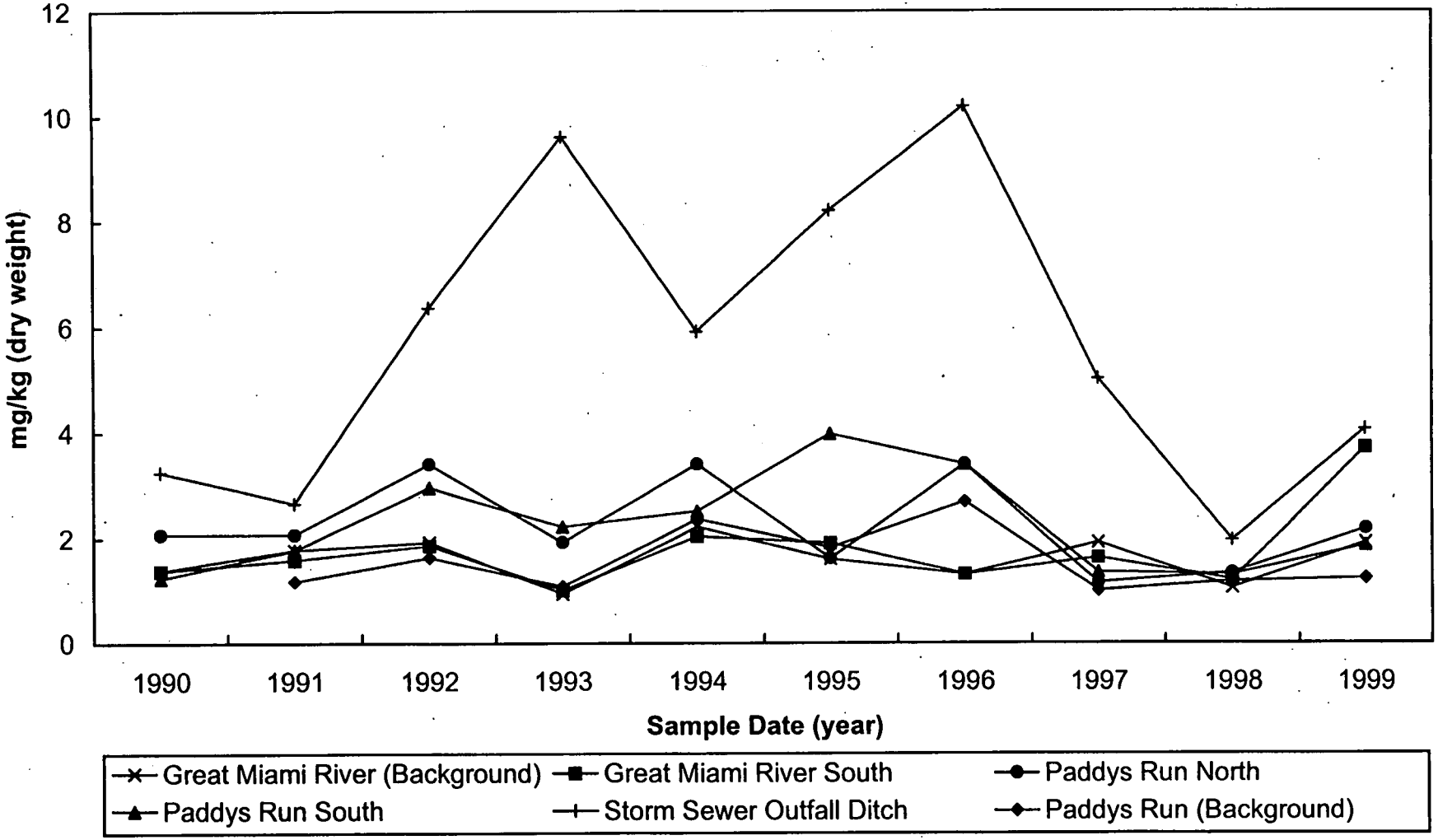


FIGURE B.2-6. TOTAL URANIUM CONCENTRATION VS. TIME PLOT FOR SEDIMENT

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# APPENDIX C

## SUPPLEMENTAL AIR INFORMATION

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Attachment C.4 Meteorological Data ..... C.4-1

# LIST OF ACRONYMS

| | |
|---|---|
| AMS | air monitoring station |
| °C | Degrees Centigrade |
| cm | centimeters |
| DOE | U.S. Department of Energy |
| °F | Degrees Fahrenheit |
| FEMP | Fernald Environmental Management Project |
| IEMP | Integrated Environmental Monitoring Plan |
| in | inches |
| kph | kilometers per hour |
| mph | miles per hour |
| mrem | millirem |
| pCi/L | picoCuries per liter |
| $pCi/m^3$ | picoCuries per cubic meter |
| TLD | thermoluminescent dosimeter |
| $\mu g/m^3$ | micrograms per cubic meter |
| WPRAP | Waste Pits Remedial Action Project |

# APPENDIX C

Appendix C presents additional air monitoring data and analysis in support of Chapter 5 of the 1999 Integrated Site Environmental Report. This appendix consists of four attachments as follows:

- Attachment C.1 provides the results of the radiological air particulate monitoring program, including an assessment of 1999 results with respect to historical data, and provides concentration versus time plots of the total uranium and total particulate data for 1999.
- Attachment C.2 provides the results of the radon monitoring program, including an assessment of radon data relative to continuous radon monitors. This discussion focuses on the U.S. Department of Energy (DOE) standards contained in DOE Order 5400.5 and an evaluation of trends observed in the 1999 data.
- Attachment C.3 provides the results of the direct radiation monitoring program including an assessment of 1999 results with respect to historical data.
- Attachment C.4 provides a summary of the meteorological data measured at the site during 1999.

## REFERENCES

U.S. Dept. of Energy, 1998, "Sewage Treatment Plant Complex Implementation Plan for Above-Grade Decontamination and Dismantlement," Final, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

# ATTACHMENT C.1

# RADIOLOGICAL AIR PARTICULATE

# ATTACHMENT C.1

Appendix C.1 provides a detailed discussion of the radiological air particulate data for 1999. This information is used to measure the emissions of uranium, thorium, and radium from the Fernald Environmental Monitoring Project (FEMP).

In 1999 the FEMP operated 20 air monitoring stations (AMS) 24 hours per day, seven days a week, as part of the Integrated Environmental Monitoring Plan (IEMP) Radiological Air Particulate Monitoring Program. The data from 16 fenceline monitoring stations and two background monitoring stations are used to demonstrate compliance with National Emissions Standards for Hazardous Air Pollutants Subpart H, and data from two project-specific air monitoring stations (WPTH-1 and WPTH-2) are used to track thorium emissions from the excavation of the waste pits. Figure C.1-1 provides the location of IEMP air particulate monitoring stations during 1999.

Additional project-specific air monitoring, which is not part of the IEMP program, was conducted for the dismantlement of the former sewage treatment plant complex during 1999. This monitoring was conducted under the Sewage Treatment Plant Complex Implementation Plan for Decontamination and Dismantlement (DOE 1998). During early 1999, the STP-1 monitor was located south of the sewage treatment plant complex. In May 1999, the STP-1 monitor was relocated to the FEMP fenceline and designated as STP-2. The relocation was necessary in order to accommodate the below-grade excavation of the sewage treatment plant complex. The sewage treatment plant complex excavation, decontamination and dismantlement work was completed on October 15, 1999. Figure C.1-1 provides the location of the STP-1 and STP-2 air monitoring stations during 1999.

Table C.1-1 provides an operational summary for the IEMP air monitoring stations in 1999. On average, the fenceline air monitors operated 98.5 percent of the time, and all monitors exceeded 95 percent operational time for the year. Routine maintenance and filter exchange combined with periodic electrical outages and equipment malfunctions create short periods of down time for each monitor throughout the year that result in operation times of less than 100 percent. In addition to these short periods of routine down time, several air monitors (AMS-7, AMS-27, WPTH-2, and AMS-6) along the western fenceline were down for longer periods due to vandalism. During the repair and replacement work, the air monitors were temporarily out of service resulting in a reduced number of operational hours, particularly at AMS-7.

Air filters were exchanged every two weeks at all the monitoring locations during 1999. The 16 fenceline monitors and two background monitors were analyzed for total uranium and total particulate. An aliquot of the 16 fenceline and two background filters was maintained to provide a quarterly composite sample to be analyzed for isotopes of uranium, thorium, and radium-226. Table C.1-2 summarizes the results of the biweekly total uranium analyses. Table C.1-3 summarizes results from the biweekly total particulate monitoring. Figures C.1-2 through C.1-19 provide graphical information on the total uranium and total particulate concentrations measured at each monitor during 1999.

The total uranium and particulate results for air monitoring in 1999 were generally consistent with the 1998 data and historical ranges. Temporary increases in total uranium and total particulate concentrations were observed along the eastern fenceline in August, September, and early October. These temporary increases, which are particularly evident at AMS-3, AMS-8A, and AMS-9C, are attributed to heightened levels of construction activities at the on-site disposal facility during this period. Table C.1-4 presents the annual average radionuclide concentrations calculated from the quarterly composite sample data. The results indicate the radionuclide concentrations are well below the DOE guidelines.

All air monitoring data are reviewed and evaluated according to criteria established in the IEMP. The data review focuses on tracking and trending data compared with historical data. Data evaluation includes a review of the quality control measures utilized in the analysis of the samples. As a result of this data evaluation process, some 1999 quarterly composite data were rejected or unavailable as explained below:

- During the first quarter of 1999, low thorium tracer recovery lead to the rejection of thorium data (thorium-228, thorium-230, and thorium-232) from AMS-4, AMS-22, AMS-24, and the two background monitors AMS-12 and AMS-16. In order to account for background concentrations of thorium, first quarter 1998 thorium data from AMS-12 and AMS-16 were substituted for the rejected 1999 background thorium data.

- First quarter 1999 radium-226 data from all monitors were rejected because the chemical recoveries were outside the detectors' calibrated range of recoveries. In order to account for radium-226 concentrations at all of the monitors, first quarter 1998 radium-226 data were substituted for the rejected first quarter 1999 data.

- Second quarter 1999 data also encountered low thorium tracer recoveries. During re-analysis, thorium recoveries improved, but an interference with thorium-228 results was observed at four monitoring stations (AMS-12, AMS-16, AMS-24, and AMS-25).

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This lead to the rejection of thorium-228 results from two fenceline and two background locations. In order to account for thorium-228 concentrations, thorium-228 was assumed to be in equilibrium with its parent, thorium-232. This assumption is supported by the thorium-228/thorium-232 equilibrium conditions that occur at the other fenceline monitors during the second quarter.

- During the third quarter of 1999, a portion of the composite sample for AMS-23 leaked during transport. While none of the sample escaped the shipping container, the leaked sample volume could not be recovered for analysis. As a result, there was insufficient sample volume available for the complete quarterly analyses. Therefore, the available sample was analyzed for uranium and thorium isotopes and no analysis for radium-226 was performed.

- During the fourth quarter of 1999, low radium tracer recovery lead to the rejection of the radium-226 result from AMS-28.

In an effort to improve data recovery and completeness, a new off-site (contract) laboratory is being used for the analysis of the quarterly composite air samples in 2000.

The WPTH-1 and WPTH-2 filters were analyzed for isotopic thorium (thorium-228, thorium-230, and thorium-232). Table C.1-5 summarizes the results of the biweekly isotopic thorium analyses. Figures C.1-20 and C.1-21 provide graphical information on the measured isotopic thorium concentrations. During 1999, the thorium-230 concentrations measured at WPTH-1 and WPTH-2 increased in September with the start of waste pit excavation. As expected, slightly elevated levels of thorium-230 were measured through December 1999 and some of the increased concentrations are attributed to the increase in material handling associated with the start-up of the Waste Pits Remedial Action Project (WPRAP) dryers in late December. These types of increases can be expected when large-scale remediation projects such as the excavation of the waste pits begin operations. Although the higher thorium-230 concentrations were measurable at the site fenceline, the annual average thorium-230 concentration at WPTH-1 and WPTH-2 remained below one percent of the DOE-derived concentration guide value for thorium-230. The elevated levels of thorium-230 concentrations at WPTH-1 and WPTH-2 were short-lived. During the first quarter of 2000, thorium-230 concentrations decreased to levels that were comparable to concentrations measured prior to the material handling operations associated with the start-up of the waste pit dryers. During the course of the waste pit excavation, thorium-230 concentrations continue to be monitored and the data provided to the remediation projects to ensure that emission controls are operating as expected.

Airborne concentrations of thorium-228 and thorium-232 measured at WPTH-1 and WPTH-2 were comparable to background concentrations throughout 1999. This fenceline data reflect the fact that, in comparison to thorium-230, the concentrations of thorium-228 and thorium-232 in the waste pit material are relatively low. WPRAP operations are not expected to significantly impact the fenceline concentrations of thorium-228 and thorium-232.

The STP-1 and STP-2 monitors were analyzed biweekly for total uranium and total particulate concentrations. Increases in particulate and total uranium concentrations were detected at the STP-2 location during August, September, and early October. These temporary increases were due to the demolition and excavation activity associated with the former sewage treatment plant complex. The STP-2 project monitor remained in place until all excavation activities were completed. Table C.1-2 presents the results of the biweekly total uranium analyses. Table C.1-3 presents the results from the biweekly total particulate analyses. Figures C.1-22 and C.1-23 provide graphical information on the total uranium and total particulate concentrations measured at the STP-1 and STP-2 monitors, respectively.

**Evaluation of Isotopic Dose Contributions from FEMP Airborne Emissions**

Historically, uranium is the major contributor to the air inhalation dose from FEMP emissions. Uranium typically contributes greater than 62 percent of the effective dose equivalent based on an evaluation of monitoring results from 1990 through 1998 (post production era). In 1999 uranium isotopes (uranium-234, uranium-235/236, and uranium-238) contributed an average of 45 percent of the dose at the fenceline, while radium-226 contributed an average of 16 percent, and thorium isotopes (thorium-228, thorium-230, and thorium-232) contributed an average of 39 percent. Although the dose contribution from uranium in 1999 was less than most historical values, uranium is still the major contributor to dose, particularly at the fenceline locations where the maximum annual dose occurs. Figures C.1-24 through C.1-26 illustrate the percentage contribution to dose from uranium, thorium, and radium-226 at each fenceline and background monitor. In order to improve the presentation of information and to focus on the primary contributors (uranium, thorium, and radium) to dose, only these contributions are shown in Figures C.1-24 through C.1-26. Contributions from radionuclides, which are assumed to be in equilibrium with their parent radionuclides, were not included in the figures. At all fenceline locations, the contribution from radionuclides assumed to be in equilibrium with their parent radionuclides was less than 10 percent of the dose from airborne emissions.

When compared to 1998, when uranium isotopes contributed on average 76 percent of dose at the fenceline, the average percentage contribution from uranium isotopes in 1999 (45 percent) is

significantly lower. There are three factors that account for the decreasing percentage of dose from uranium in 1999.

The first factor, discussed earlier, is that the off-site laboratory experienced difficulties during the thorium analysis that may have contributed to unusually high thorium results. Specifically, the laboratory encountered recurring interference during the thorium analysis resulting in low tracer recoveries. In adjusting the data for the low tracer recoveries, the thorium results may have been biased high, especially the thorium-230 results. The high bias in thorium results would contribute to the higher than expected dose from thorium isotopes in 1999 and serve to decrease the percentage of dose from uranium.

The second factor contributing to the decrease in the percentage of dose from uranium is attributed to continuing remediation of the site, and its effect on the composition of air emissions. As uranium-contaminated buildings are dismantled, and soil contamination areas are excavated, the amount of exposed uranium contaminated debris and soil is gradually decreasing. Because uranium is the principle contaminant in these buildings and soil areas, the amount of uranium contained in the wind blown soil is decreasing. Gradually, it is anticipated that the wind blown soil from the site will begin to resemble the isotopic composition of the windblown soil measured at the background monitors. Thus, the dose contribution from uranium at the fenceline monitors should be similar to the dose contribution from uranium at the background stations. In 1999 the uranium contributed an average of 14 percent of the dose at the background monitors.

The third factor contributing to the decreasing percentage of dose from uranium in 1999 is the excavation of the waste pits and the increase in material handling associated with the start-up of the WPRAP dryers in late December. As noted earlier, the waste pit materials contain comparatively high levels of thorium-230. Moreover, fugitive emissions from the excavation and handling of the pit materials are measurable at the site fenceline. Although the excavation of the waste pits did not begin until September 1999, pit emissions did contribute a small fraction of the annual dose measured at the site fenceline. As the WPRAP project progresses, pit emissions are expected to contribute a larger fraction of the annual fenceline dose and, in turn, increase the percentage dose from thorium-230.

The three highest fenceline doses were reported at AMS-3, AMS-8A, and AMS-9C (0.29, 0.25, and 0.21 millirem [mrem], respectively). Based on wind patterns in 1999, and the location of remediation activities, these monitoring locations are positioned downwind of most remediation activities which

occurred in 1999. The average uranium contribution from these three monitors was 57 percent. Thorium represents 18 percent, radium-226 represents 25 percent, and the remainder of the isotopes represent less than one percent of the dose contribution. Because uranium continues to be the major contributor to dose from FEMP airborne emissions, particularly at the fenceline location where the highest dose occurs, biweekly uranium measurements remain an effective indicator of air emission patterns at the FEMP. The biweekly tracking will continue to be reported in IEMP quarterly status reports.

## TABLE C.1-1

## OPERATIONAL SUMMARY FOR AIR PARTICULATE MONITORING STATIONS IN 1999

| Location | Number of Samples | Sample Start Date | Last Sample Collection Date | Operating Time (hours)[a] | Percent of Operation |
|---|---|---|---|---|---|
| **Fenceline** | | | | | |
| AMS-2 | 26 | 12/29/98 | 12/28/99 | 8675.0 | 99.3 |
| AMS-3 | 26 | 12/29/98 | 12/28/99 | 8648.7 | 99.0 |
| AMS-4 | 26 | 12/29/98 | 12/28/99 | 8573.6 | 98.1 |
| AMS-5 | 26 | 12/29/98 | 12/28/99 | 8718.6 | 99.8 |
| AMS-6 | 26 | 12/29/98 | 12/29/99 | 8587.6 | 98.0 |
| AMS-7 | 26 | 12/29/98 | 12/28/99 | 8430.3 | 96.5 |
| AMS-8A | 26 | 12/29/98 | 12/28/99 | 8615.5 | 98.6 |
| AMS-9C | 26 | 12/29/98 | 12/28/99 | 8541.1 | 97.8 |
| AMS-22 | 26 | 12/29/98 | 12/28/99 | 8580.8 | 98.2 |
| AMS-23 | 26 | 12/29/98 | 12/28/99 | 8631.9 | 98.8 |
| AMS-24 | 26 | 12/29/98 | 12/29/99 | 8685.6 | 99.2 |
| AMS-25 | 26 | 12/29/98 | 12/29/99 | 8582.8 | 98.0 |
| AMS-26 | 26 | 12/29/98 | 12/29/99 | 8643.5 | 98.7 |
| AMS-27 | 26 | 12/29/98 | 12/29/99 | 8611.4 | 98.3 |
| AMS-28 | 26 | 12/29/98 | 12/28/99 | 8728.6 | 99.9 |
| AMS-29 | 26 | 12/29/98 | 12/28/99 | 8628.6 | 98.8 |
| **Background** | | | | | |
| AMS-12 | 26 | 12/29/98 | 12/28/99 | 8726.7 | 99.9 |
| AMS-16 | 26 | 12/29/98 | 12/28/99 | 8459.9 | 96.8 |
| **Project Specific** | | | | | |
| STP-1 | 11 | 12/29/98 | 6/1/99 | 3423.0 | 97.0 |
| STP-2 | 16 | 5/25/99 | 12/28/99 | 5095.0 | 97.8 |
| WPTH-1 | 26 | 12/29/98 | 12/28/99 | 8701.0 | 99.6 |
| WPTH-2 | 26 | 12/29/98 | 12/28/99 | 8592.0 | 98.4 |

[a]8736 available operating hours from December 29, 1998 through December 28, 1999; 8760 available operating hours from December 29, 1998 through December 29, 1999; 3528 available operating hours from December 29, 1998 through June 1, 1999; and 5208 available operating hours from May 25, 1999 through December 28, 1999

# TABLE C.1-2

## TOTAL URANIUM PARTICULATE CONCENTRATIONS IN AIR

| Location[a] | Summary of 1999 Results[b] (pCi/m$^3$ x 1E-06) | | | | Summary of 1998 Results[b,c] (pCi/m$^3$ x 1E-06) | | | | 1990 through 1997 Summary Results[b,c,d] (pCi/m$^3$ x 1E-06) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. of Samples | Min. | Max. | Avg. | No. of Samples | Min. | Max. | Avg. | Min. | Max. |
| **Fenceline** | | | | | | | | | | |
| AMS-2 | 25 | 9.5 | 269 | 57 | 26 | 11 | 168 | 62 | 0 | 3500 |
| AMS-3 | 26 | 12 | 585 | 146 | 26 | 27 | 760 | 202 | 0 | 17000 |
| AMS-4 | 26 | 0 | 109 | 29 | 26 | 7.7 | 78 | 32 | 0 | 2300 |
| AMS-5 | 26 | 0 | 72 | 25 | 26 | 0 | 118 | 42 | 0 | 4400 |
| AMS-6 | 26 | 3.2 | 453 | 55 | 26 | 2.7 | 235 | 47 | 0 | 3200 |
| AMS-7 | 26 | 0 | 83 | 24 | 26 | 2.4 | 105 | 36 | 0 | 7800 |
| AMS-8A | 26 | 0 | 1135 | 130 | 26 | 7.9 | 338 | 116 | 0 | 900 |
| AMS-9C[e] | 26 | 9.2 | 409 | 102 | 26 | 5.7 | 562 | 129 | 0 | 431 |
| AMS-22 | 26 | 0 | 89 | 35 | 26 | 3.0 | 101 | 34 | 0 | 29 |
| AMS-23 | 26 | 0 | 202 | 49 | 26 | 9.0 | 194 | 44 | 9.8 | 53 |
| AMS-24 | 26 | 0 | 112 | 24 | 26 | 0 | 65 | 28 | 106 | NA |
| AMS-25 | 26 | 0 | 402 | 33 | 26 | 0 | 79 | 30 | 67 | 30 |
| AMS-26 | 26 | 0 | 171 | 31 | 26 | 0 | 98 | 40 | 0 | 41 |
| AMS-27 | 26 | 0 | 101 | 30 | 25[f] | 5.3 | 64 | 31 | 0 | 30 |
| AMS-28 | 26 | 0 | 445 | 40 | 26 | 2.6 | 216 | 30 | 0 | 29 |
| AMS-29 | 26 | 0 | 199 | 41 | 26 | 2.6 | 121 | 45 | 0 | 76 |
| **Background** | | | | | | | | | | |
| AMS-12 | 26 | 0 | 45 | 8.1 | 26 | 0 | 107 | 14 | 0 | 29 |
| AMS-16 | 26 | 0 | 37 | 16 | 26 | 0 | 35 | 18 | 0 | 106 |
| **Project-Specific** | | | | | | | | | | |
| STP-1[g,h] | 11 | 20 | 143 | 56 | 14 | 38 | 891 | 301 | NA | NA |
| STP-2[h] | 16 | 5.4 | 380 | 181 | NA | NA | NA | NA | NA | NA |

[a]Refer to Figure C.1-1 for sample locations
[b]For blank corrected concentrations less than or equal to 0.0 pCi/m$^3$, the concentration is set at 0.0 pCi/m$^3$.
[c]NA = not applicable
[d]If the total number of samples is equal to one, then the data point is reported as the minimum.
[e]Summary results for 1990 through 1997 include AMS-9B/C data.
[f]One data point was not obtained due to a damaged filter.
[g]Project-specific monitor was not in operaton prior to 1998.
[h]STP-1 was relocated to STP-2 on May 25, 1999.



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# TABLE C.1-3

## TOTAL PARTICULATE CONCENTRATIONS IN AIR

| | Summary of 1999 Results (µg/m³) | | | | Summary of 1998 Results[b] (µg/m³) | | | | 1990 through 1997 Summary Results[b,c] (µg/m³) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Location[a] | No. of Samples | Min. | Max. | Avg. | No. of Samples | Min. | Max. | Avg. | Min. | Max. |
| **Fenceline** | | | | | | | | | | |
| AMS-2 | 26 | 11 | 69 | 34 | 25[d] | 14 | 49 | 30 | 7 | 77 |
| AMS-3 | 26 | 19 | 83 | 37 | 26 | 13 | 52 | 32 | 8 | 159 |
| AMS-4 | 26 | 18 | 74 | 38 | 26 | 16 | 79 | 37 | 13 | 69 |
| AMS-5 | 26 | 18 | 45 | 29 | 26 | 9.6 | 54 | 30 | 11 | 62 |
| AMS-6 | 26 | 19 | 48 | 32 | 26 | 16 | 54 | 33 | 8 | 69 |
| AMS-7 | 26 | 20 | 84 | 34 | 26 | 6.8 | 60 | 33 | 13 | 76 |
| AMS-8A | 26 | 20 | 63 | 37 | 26 | 13 | 64 | 34 | 18 | 89 |
| AMS-9C[e] | 26 | 19 | 66 | 38 | 26 | 15 | 65 | 36 | 7.1 | 136 |
| AMS-22 | 26 | 16 | 53 | 37 | 26 | 13 | 57 | 34 | 21 | 30 |
| AMS-23 | 26 | 18 | 57 | 30 | 26 | 15 | 51 | 30 | 22 | 28 |
| AMS-24 | 26 | 13 | 57 | 38 | 26 | 18 | 79 | 42 | 74 | NA |
| AMS-25 | 26 | 17 | 45 | 31 | 26 | 21 | 69 | 40 | 26 | 40 |
| AMS-26 | 26 | 19 | 52 | 31 | 26 | 15 | 51 | 31 | 20 | 23 |
| AMS-27 | 26 | 16 | 92 | 50 | 26 | 24 | 86 | 46 | 33 | 49 |
| AMS-28 | 26 | 15 | 51 | 28 | 26 | 12 | 49 | 28 | 16 | 30 |
| AMS-29 | 26 | 18 | 52 | 33 | 26 | 11 | 62 | 32 | 19 | 30 |
| **Background** | | | | | | | | | | |
| AMS-12[f] | 26 | 16 | 48 | 29 | 26 | 12 | 47 | 28 | 6 | 416 |
| AMS-16[f] | 26 | 26 | 61 | 44 | 26 | 18 | 84 | 50 | 22 | 79 |
| **Project-Specific** | | | | | | | | | | |
| STP-1[g,h] | 11 | 21 | 54 | 31 | 14 | 25 | 93 | 43 | NA | NA |
| STP-2[h] | 16 | 19 | 72 | 43 | NA | NA | NA | NA | NA | NA |

[a]Refer to Figure C.1-1 for sample locations
[b]NA = not applicable
[c]If the total number of samples is equal to one, then the data point is reported as the minimum.
[d]One data point was not obtained due to a damaged filter.
[e]Summary results for 1990 through 1997 include AMS-9B/C data.
[f]Total particulate analysis was discontinued during 1994 and was reinstated for AMS-12 and AMS-16 in 1997.
[g]Project-specific monitor was not in operation prior to 1998.
[h]STP-1 was relocated to STP-2 on May 25, 1999.

# TABLE C.1-4

## RADIONUCLIDES IN AIR DURING 1999

| | Gross Concentrations (pCi/m$^3$) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location[a] | Uranium-238 | Uranium-234 | Uranium-235/ Uranium-236 | Thorium-228 | Thorium-230 | Thorium-232 | Radium-226[b] | Thorium-234[c] | Radium-228[c] | Actinium-228[c] | Radium-224[c] | Thorium-231[c] |
| **Fenceline** | | | | | | | | | | | | |
| AMS-2 | 3.8E-05 | 3.3E-05 | 1.3E-06 | 8.2E-06 | 1.8E-05 | 8.0E-06 | 3.2E-05 | 3.8E-05 | 8.0E-06 | 8.0E-06 | 8.0E-06 | 1.3E-06 |
| AMS-3 | 7.1E-05 | 6.8E-05 | 2.8E-06 | 7.6E-06 | 2.0E-05 | 7.4E-06 | 4.6E-05 | 7.1E-05 | 7.4E-06 | 7.4E-06 | 7.4E-06 | 2.8E-06 |
| AMS-4 | 3.0E-05 | 2.5E-05 | 8.1E-07 | 2.4E-05 | 1.8E-05 | 8.3E-06 | 2.2E-05 | 3.0E-05 | 8.3E-06 | 8.3E-06 | 8.3E-06 | 8.1E-07 |
| AMS-5 | 1.9E-05 | 1.7E-05 | 3.5E-07 | 4.5E-06 | 1.5E-05 | 5.3E-06 | 1.5E-05 | 1.9E-05 | 5.3E-06 | 5.3E-06 | 5.3E-06 | 3.5E-07 |
| AMS-6 | 3.4E-05 | 2.1E-05 | 9.0E-07 | 3.5E-06 | 2.2E-05 | 5.4E-06 | 1.9E-05 | 3.4E-05 | 5.4E-06 | 5.4E-06 | 5.4E-06 | 9.0E-07 |
| AMS-7 | 2.0E-05 | 1.6E-05 | 4.2E-07 | 3.8E-06 | 1.1E-05 | 5.7E-06 | 1.0E-05 | 2.0E-05 | 5.7E-06 | 5.7E-06 | 5.7E-06 | 4.2E-07 |
| AMS-8A | 7.9E-05 | 7.3E-05 | 3.6E-06 | 6.2E-06 | 1.8E-05 | 6.8E-06 | 3.2E-05 | 7.9E-05 | 6.8E-06 | 6.8E-06 | 6.8E-06 | 3.6E-06 |
| AMS-9C | 5.8E-05 | 5.2E-05 | 2.2E-06 | 7.0E-06 | 2.1E-05 | 7.7E-06 | 3.0E-05 | 5.8E-05 | 7.7E-06 | 7.7E-06 | 7.7E-06 | 2.2E-06 |
| AMS-22 | 3.1E-05 | 2.2E-05 | 9.5E-07 | 6.5E-06 | 2.0E-05 | 6.8E-06 | 1.8E-05 | 3.1E-05 | 6.8E-06 | 6.8E-06 | 6.8E-06 | 9.5E-07 |
| AMS-23 | 3.6E-05 | 3.1E-05 | 9.2E-07 | 1.5E-06 | 1.3E-05 | 4.0E-06 | 8.3E-05[d] | 3.6E-05 | 4.0E-06 | 4.0E-06 | 4.0E-06 | 9.2E-07 |
| AMS-24 | 2.0E-05 | 1.9E-05 | 8.4E-07 | 7.3E-06[e] | 1.7E-05 | 7.9E-06 | 3.3E-05 | 2.0E-05 | 7.9E-06 | 7.9E-06 | 7.9E-06 | 8.4E-07 |
| AMS-25 | 1.9E-05 | 1.3E-05 | 2.3E-07 | 2.6E-06[e] | 1.4E-05 | 4.4E-06 | 1.2E-05 | 1.9E-05 | 4.4E-06 | 4.4E-06 | 4.4E-06 | 2.3E-07 |
| AMS-26 | 2.4E-05 | 2.0E-05 | 9.0E-07 | 3.1E-06 | 2.5E-05 | 4.4E-06 | 2.1E-05 | 2.4E-05 | 4.4E-06 | 4.4E-06 | 4.4E-06 | 9.0E-07 |
| AMS-27 | 2.3E-05 | 1.9E-05 | 6.4E-07 | 7.6E-06 | 1.8E-05 | 8.0E-06 | 3.6E-05 | 2.3E-05 | 8.0E-06 | 8.0E-06 | 8.0E-06 | 6.4E-07 |
| AMS-28 | 2.5E-05 | 1.4E-05 | 4.9E-07 | 4.6E-06 | 2.0E-05 | 4.5E-06 | 7.8E-06[f] | 2.5E-05 | 4.5E-06 | 4.5E-06 | 4.5E-06 | 4.9E-07 |
| AMS-29 | 3.3E-05 | 2.7E-05 | 1.4E-06 | 9.3E-06 | 1.9E-05 | 6.2E-06 | 1.3E-05 | 3.3E-05 | 6.2E-06 | 6.2E-06 | 6.2E-06 | 1.4E-06 |
| **Background** | | | | | | | | | | | | |
| AMS-12 | 9.9E-06 | 1.0E-05 | 1.5E-07 | 3.6E-06[e,g] | 6.4E-06[g] | 3.9E-06[g] | 5.1E-06 | 9.9E-06 | 3.9E-06 | 3.9E-06 | 3.9E-06 | 1.5E-07 |
| AMS-16 | 1.3E-05 | 1.3E-05 | 3.7E-07 | 8.6E-06[e,g] | 1.4E-05[g] | 9.2E-06[g] | 2.5E-05 | 1.3E-05 | 9.2E-06 | 9.2E-06 | 9.2E-06 | 3.7E-07 |
| DCG[h] | 1.0E-01 | 9.0E-02 | 1.0E-01 | 4.0E-02 | 4.0E-02 | 7.0E-03 | 1.0E+00 | 4.0E+02 | 3.0E+00 | 4.0E+01 | 4.0E+00 | 1.0E+04 |

[a]Refer to Figure C.1-1 for sample locations
[b]First quarter 1999 radium-226 data were rejected and substituted with first quarter 1998 radium-226 data.
[c]Denotes isotopes assumed to be in equilibrium with their parents
[d]Third quarter 1999 radium-226 results were not available due to insufficient sample volume for analysis.
[e]Second quarter 1999 thorium-228 data are assumed to be in equilibrium with second quarter 1999 thorium-232 data.
[f]Fourth quarter 1999 radium-226 data were rejected.
[g]First quarter 1999 thorium data were rejected and substituted with first quarter 1998 thorium data.
[h]Derived concentration guidelines for air (μCi/mL · 1.0E+12 pCi/m$^3$) from DOE Order 5400.5., Radiation Protection of the Public and the Environment, February 1990. Continuous inhalation of this concentration for one year will result in a committed effective dose equivalent of 100 mrem (1mSv).



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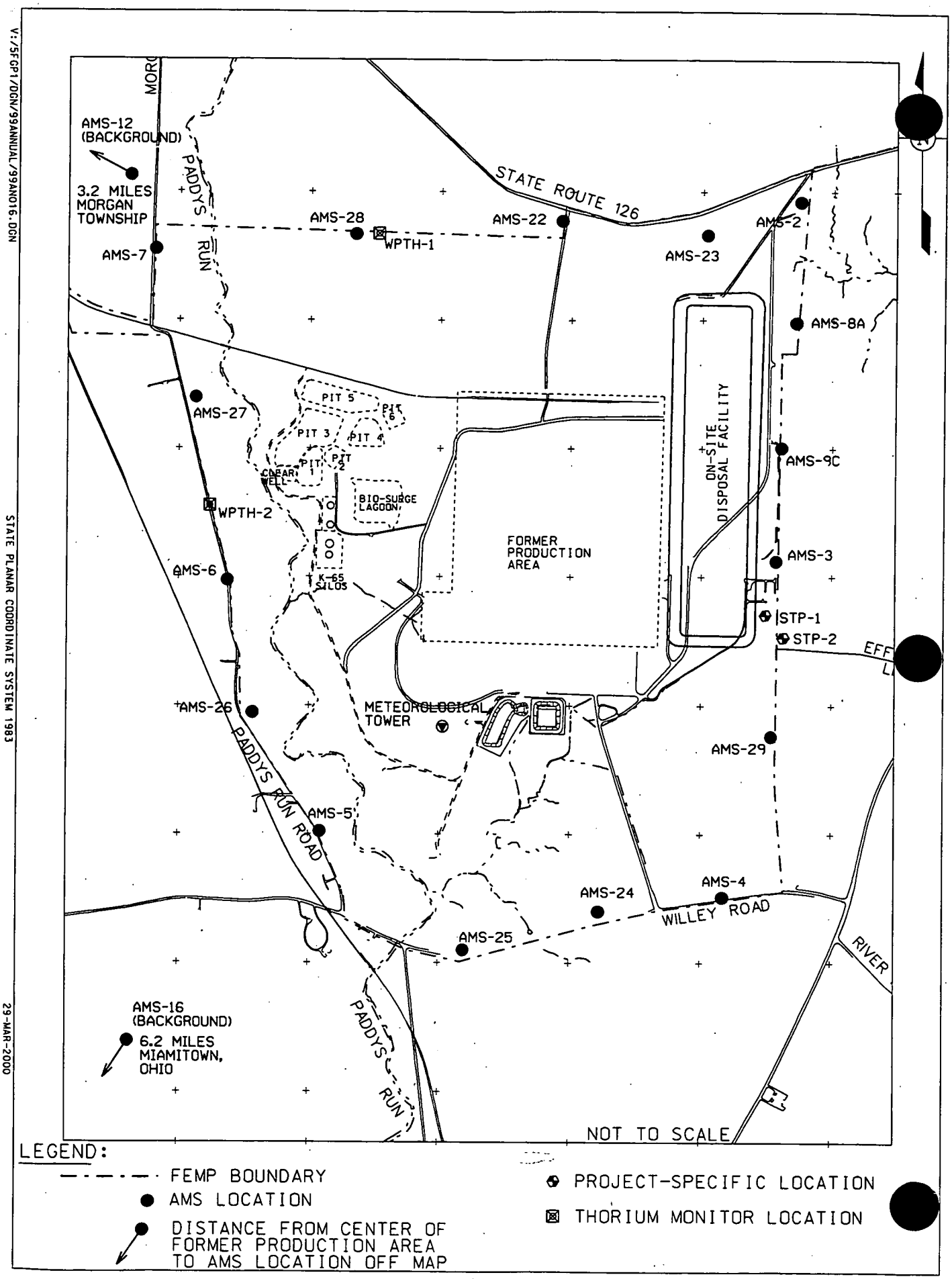
## TABLE C.1-5

## ISOTOPIC THORIUM CONCENTRATIONS IN AIR

| | Summary of 1999 Results (pCi/m$^3$) | | | | Project History to Date[d] (pCi/m$^3$) | | | |
|---|---|---|---|---|---|---|---|---|
| **Location**[a] Isotope | No. of Samples[b] | Min.[c] | Max. | Avg. | No. of Samples[b,e] | Min.[c] | Max. | Avg. |
| **WPTH-1** | | | | | | | | |
| Thorium-228 | 25 | 0.0E+00 | 1.4E-05 | 5.3E-06 | 27 | 0.0E+00 | 1.4E-05 | 5.3E-06 |
| Thorium-230 | 25 | 0.0E+00 | 8.3E-05 | 1.9E-05 | 27 | 0.0E+00 | 8.3E-05 | 1.8E-05 |
| Thorium-232 | 25 | 0.0E+00 | 1.2E-05 | 5.2E-06 | 27 | 0.0E+00 | 1.2E-05 | 5.1E-06 |
| **WPTH-2** | | | | | | | | |
| Thorium-228 | 26 | 0.0E+00 | 1.7E-05 | 8.4E-06 | 30 | 0.0E+00 | 1.7E-05 | 7.8E-06 |
| Thorium-230 | 26 | 1.2E-06 | 1.2E-04 | 2.4E-05 | 30 | 1.2E-06 | 1.2E-04 | 2.2E-05 |
| Thorium-232 | 26 | 0.0E+00 | 1.7E-05 | 7.8E-06 | 30 | 0.0E+00 | 1.7E-05 | 7.4E-06 |

[a]Refer to Figure C.1-1 for sample locations
[b]One WPTH-1 filter was lost due to cross-contamination.
[c]For blank corrected concentrations less than or equal to 0.0E+00 pCi/m$^3$, the concentration is set at 0.0E+00 pCi/m$^3$
[d]Project start date was November 3, 1998.
[e]Initial start-up of WPTH-1 was delayed for two sampling periods.




V:/5FGP1/DGN/99ANNUAL/99AN016.DGN

STATE PLANAR COORDINATE SYSTEM 1983

29-MAR-2000

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FIGURE C.1-1. RADIOLOGICAL AIR MONITORING LOCATIONS

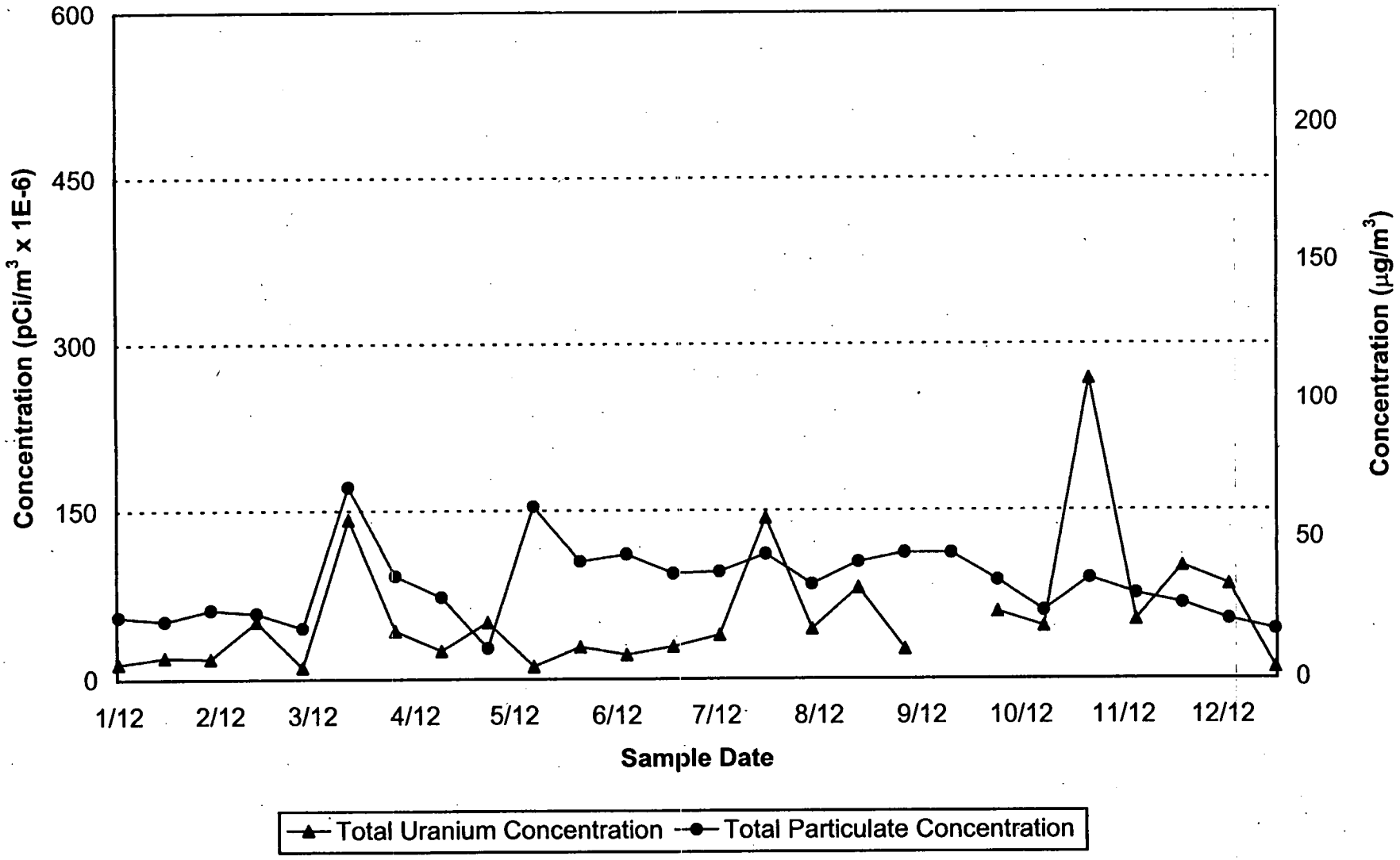


FIGURE C.1-2. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (AMS-2)

FINAL

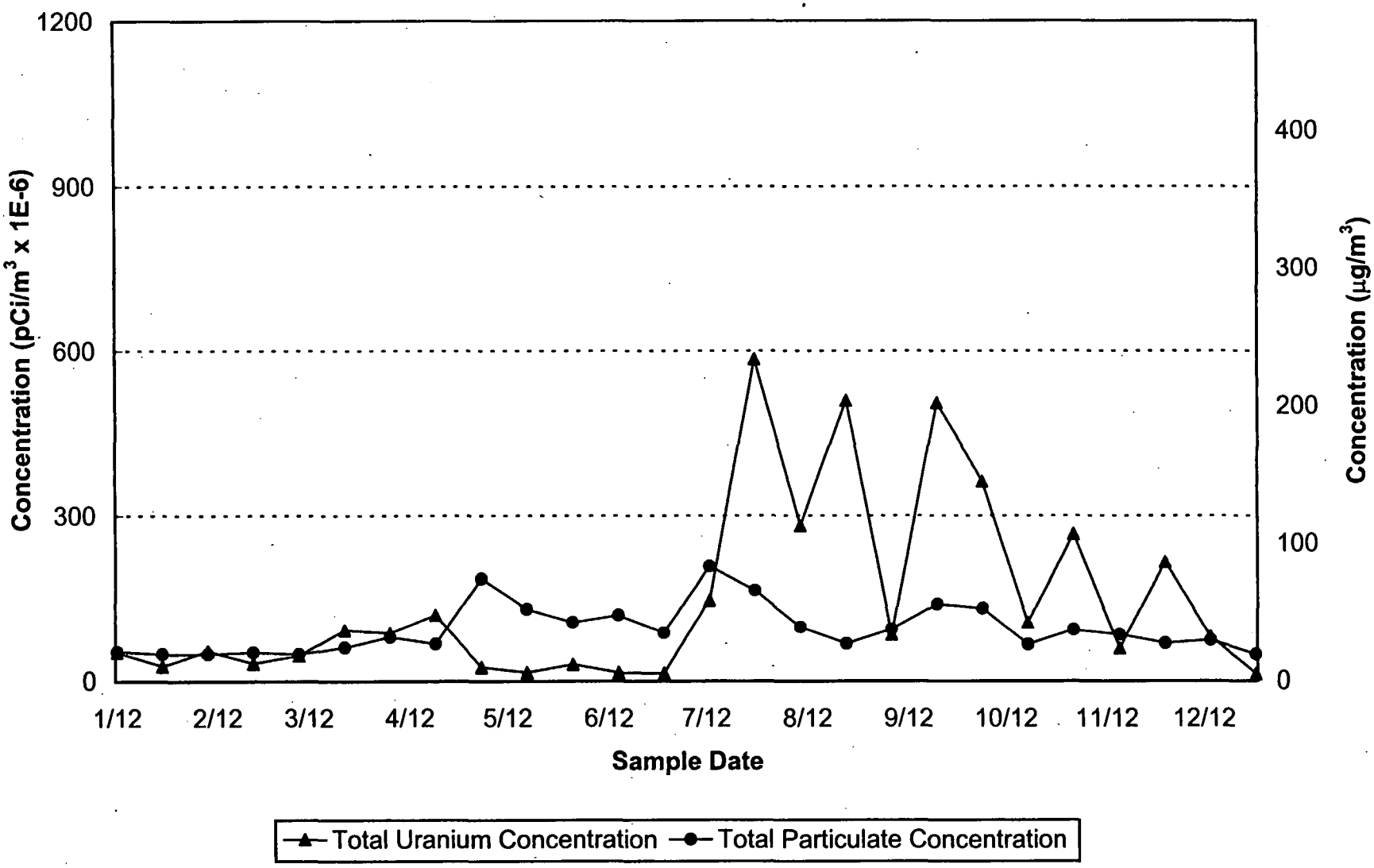


FIGURE C.1-3. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (AMS-3)

FINAL

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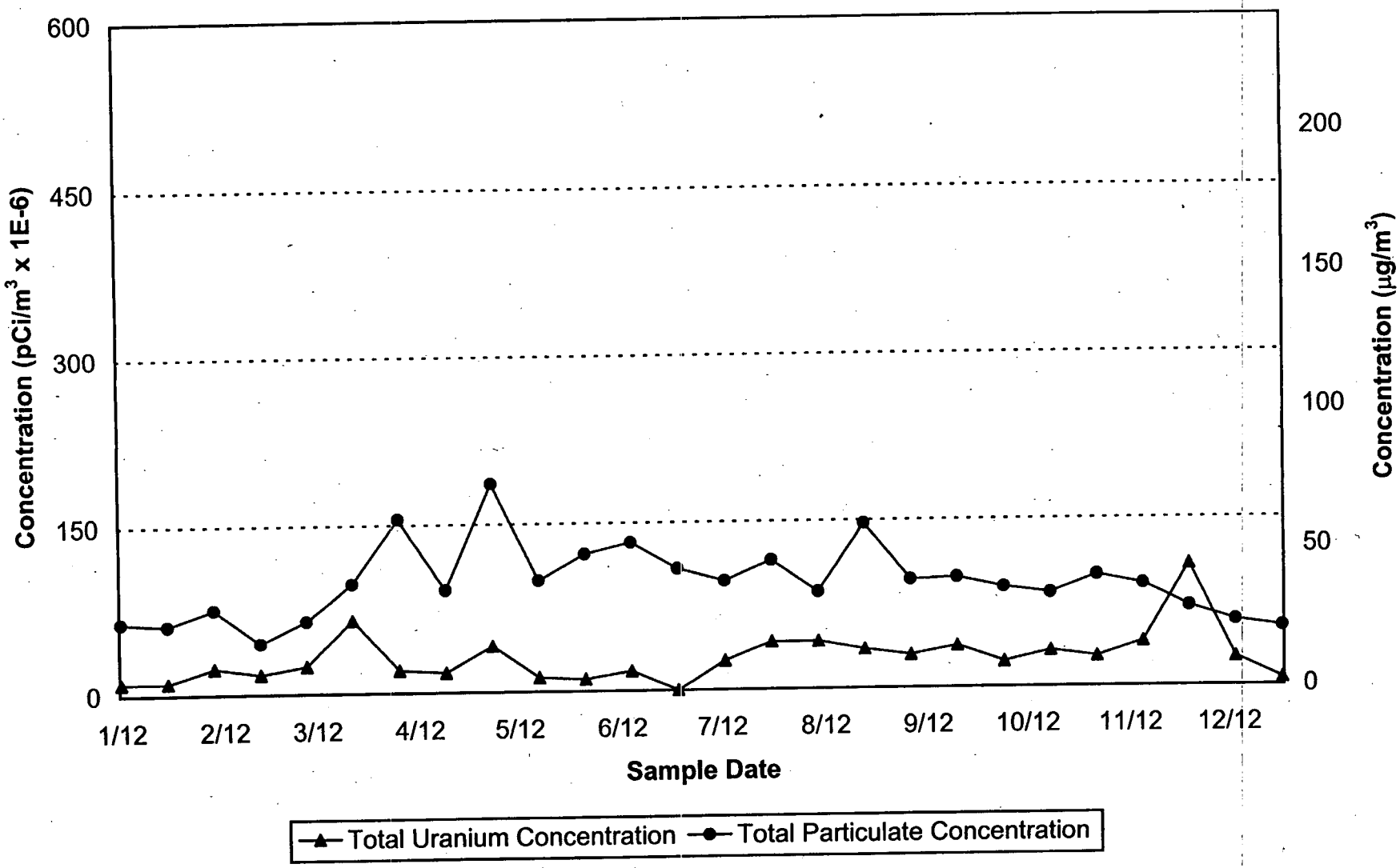


FIGURE C.1-4. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (AMS-4)

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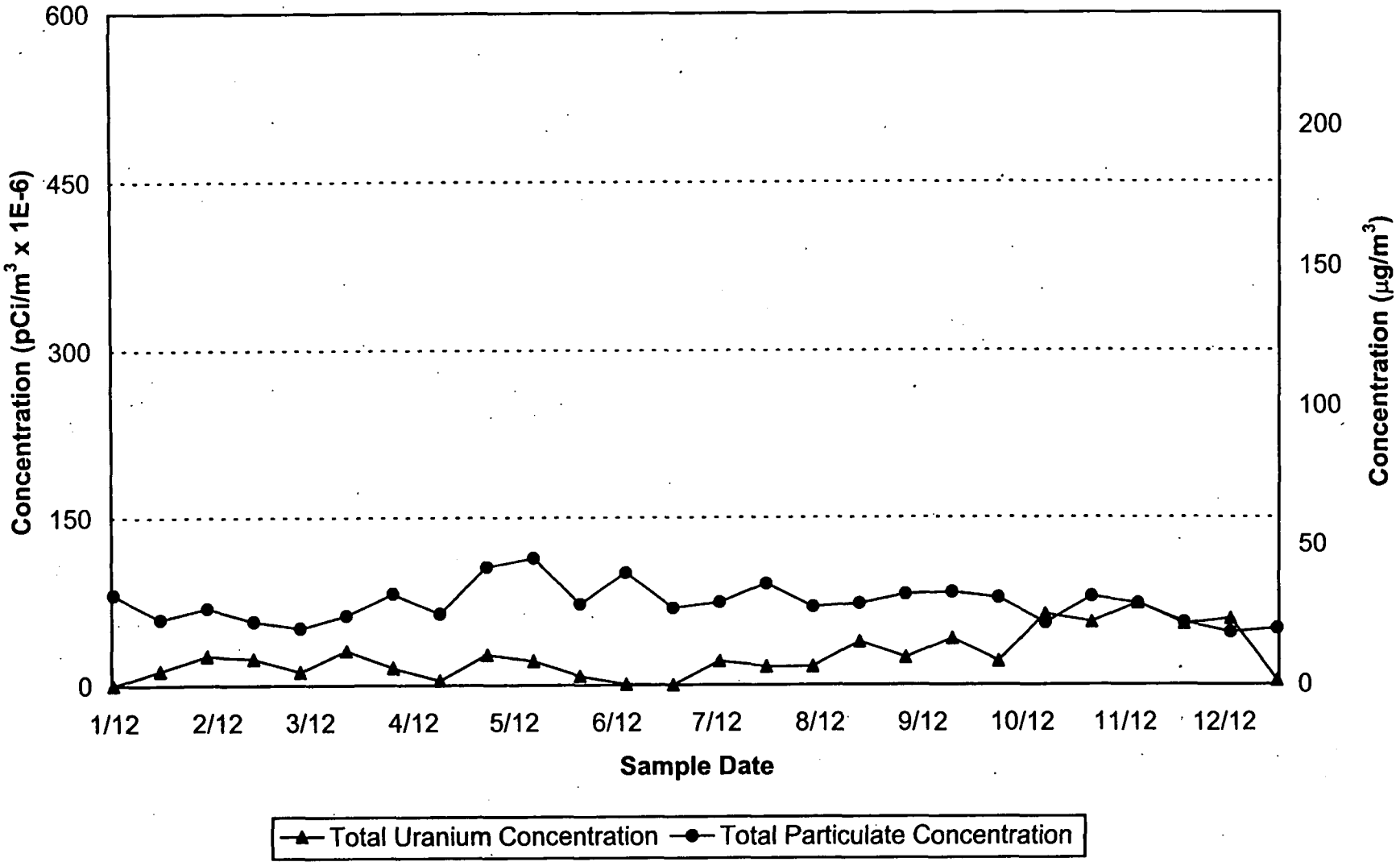


FIGURE C.1-5. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (AMS-5)

FINAL

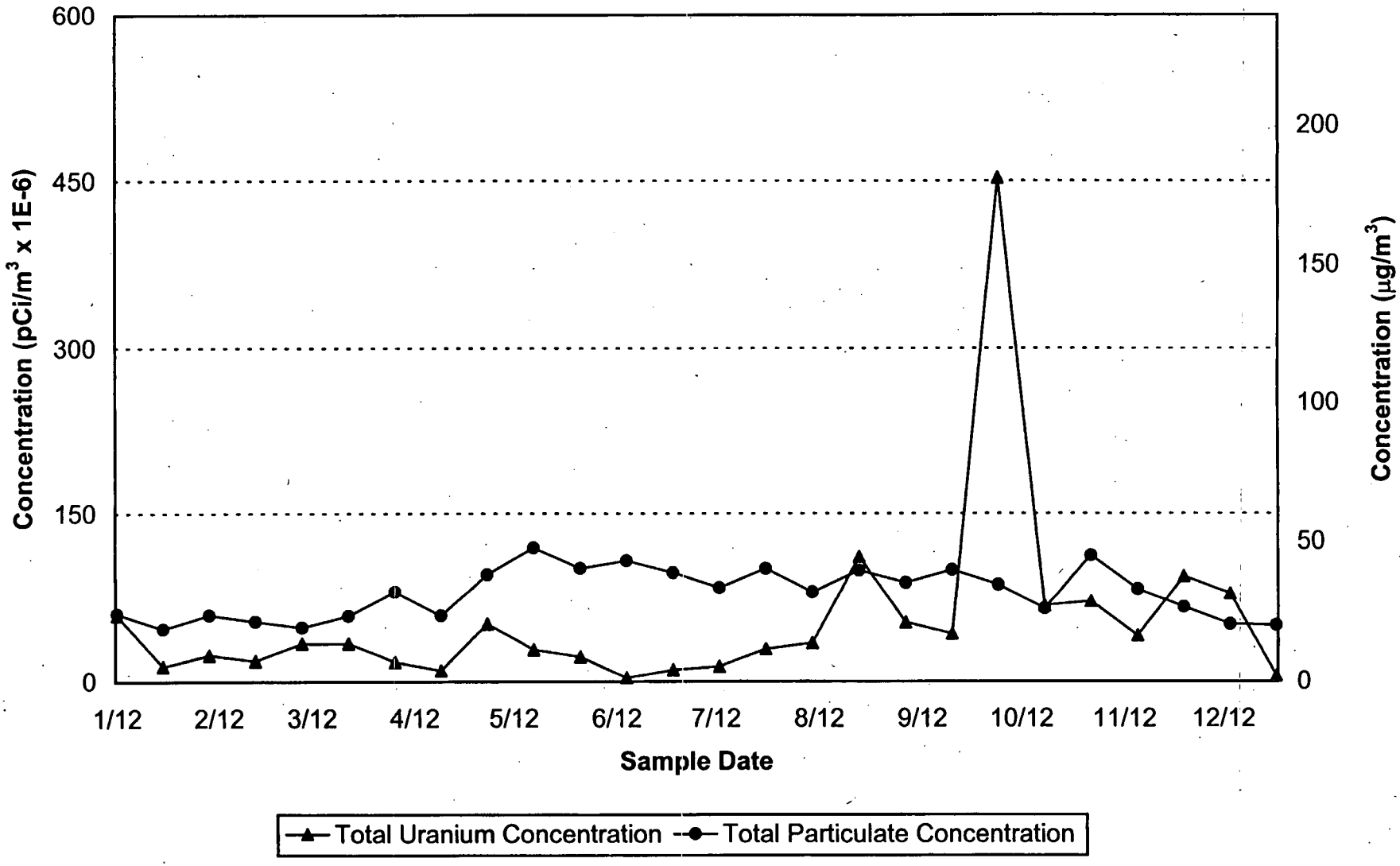


FIGURE C.1-6. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (AMS-6)

FINAL

000102

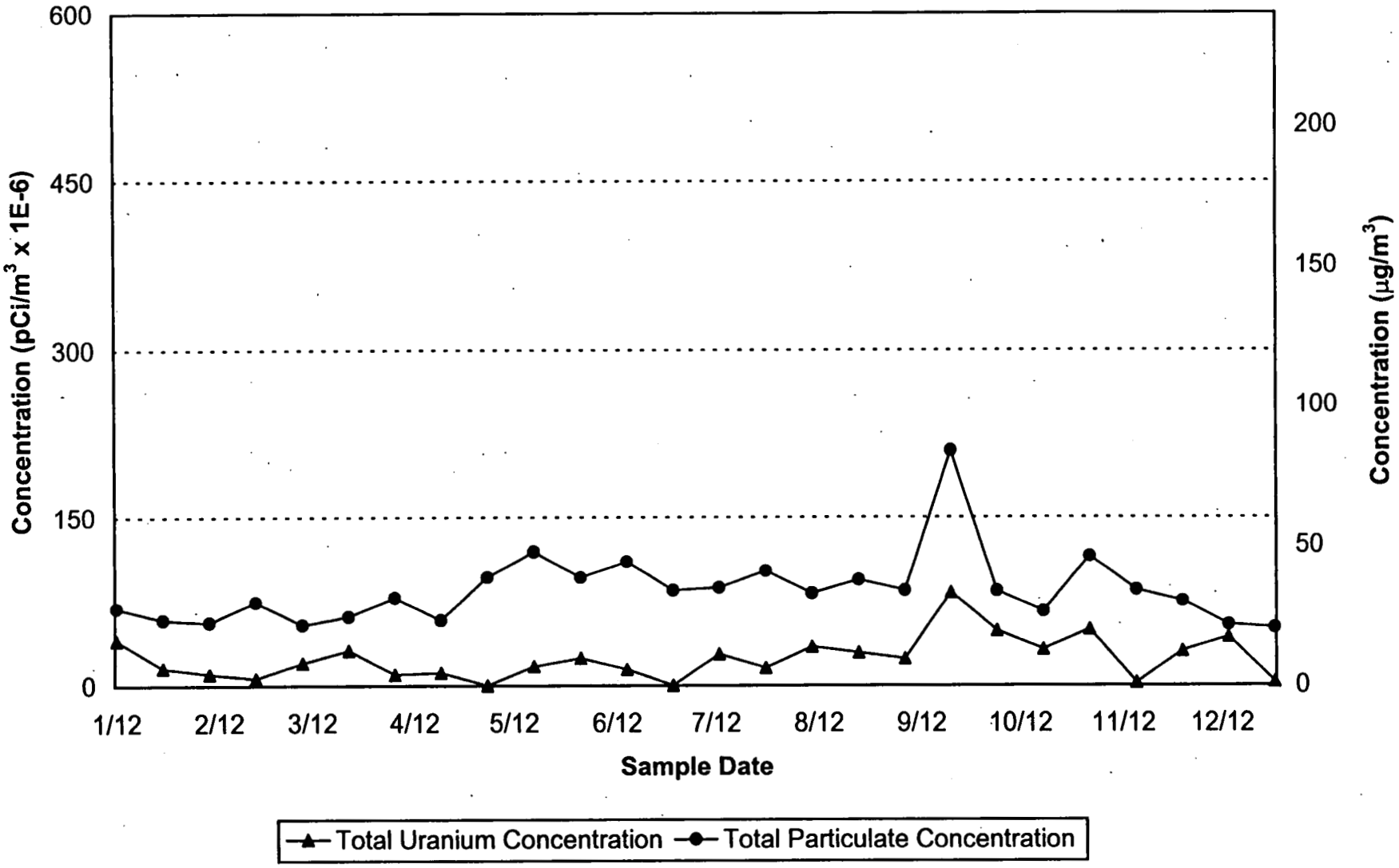


FIGURE C.1-7. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (AMS-7)

FINAL

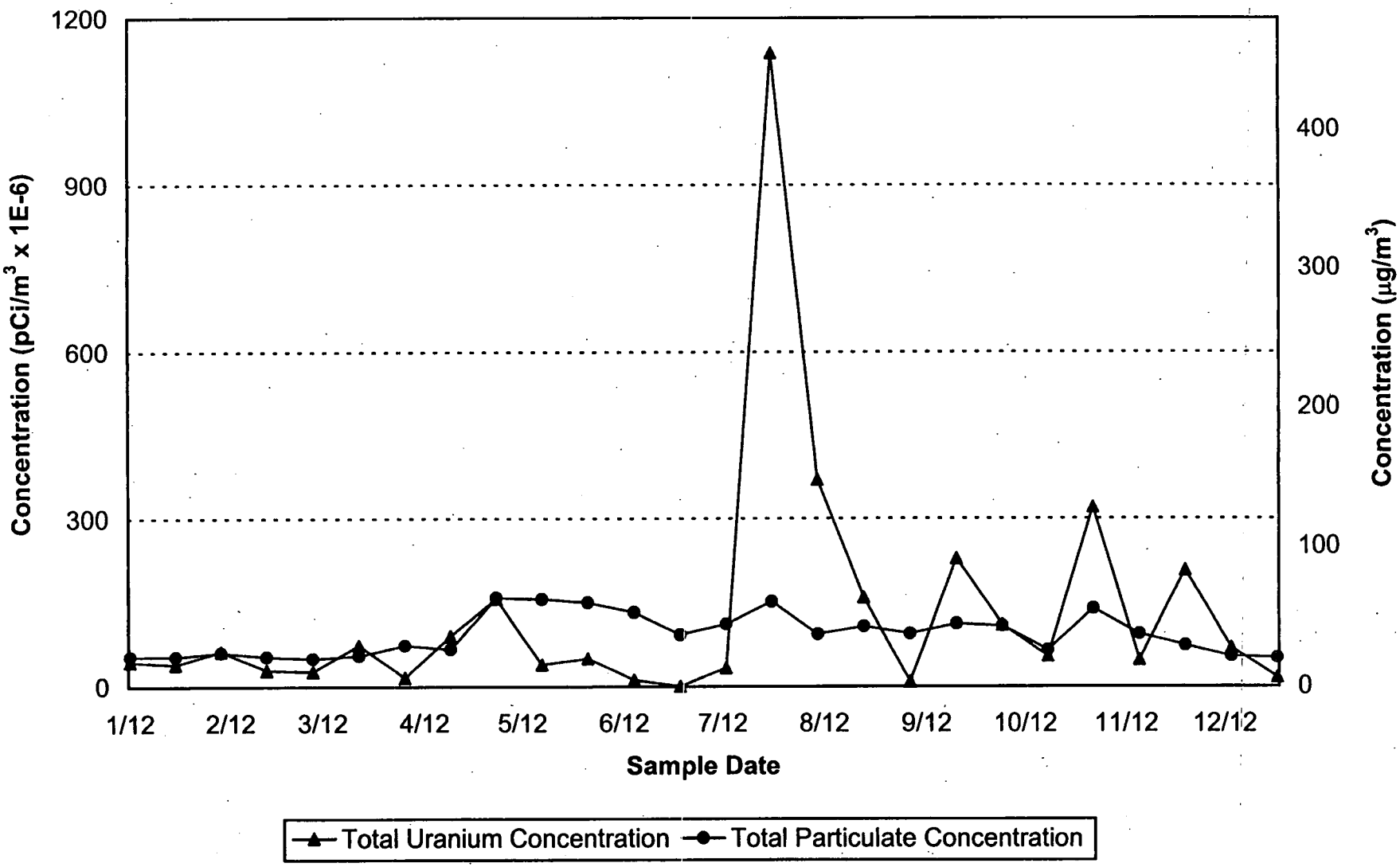


FIGURE C.1-8. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (AMS-8A)

FINAL



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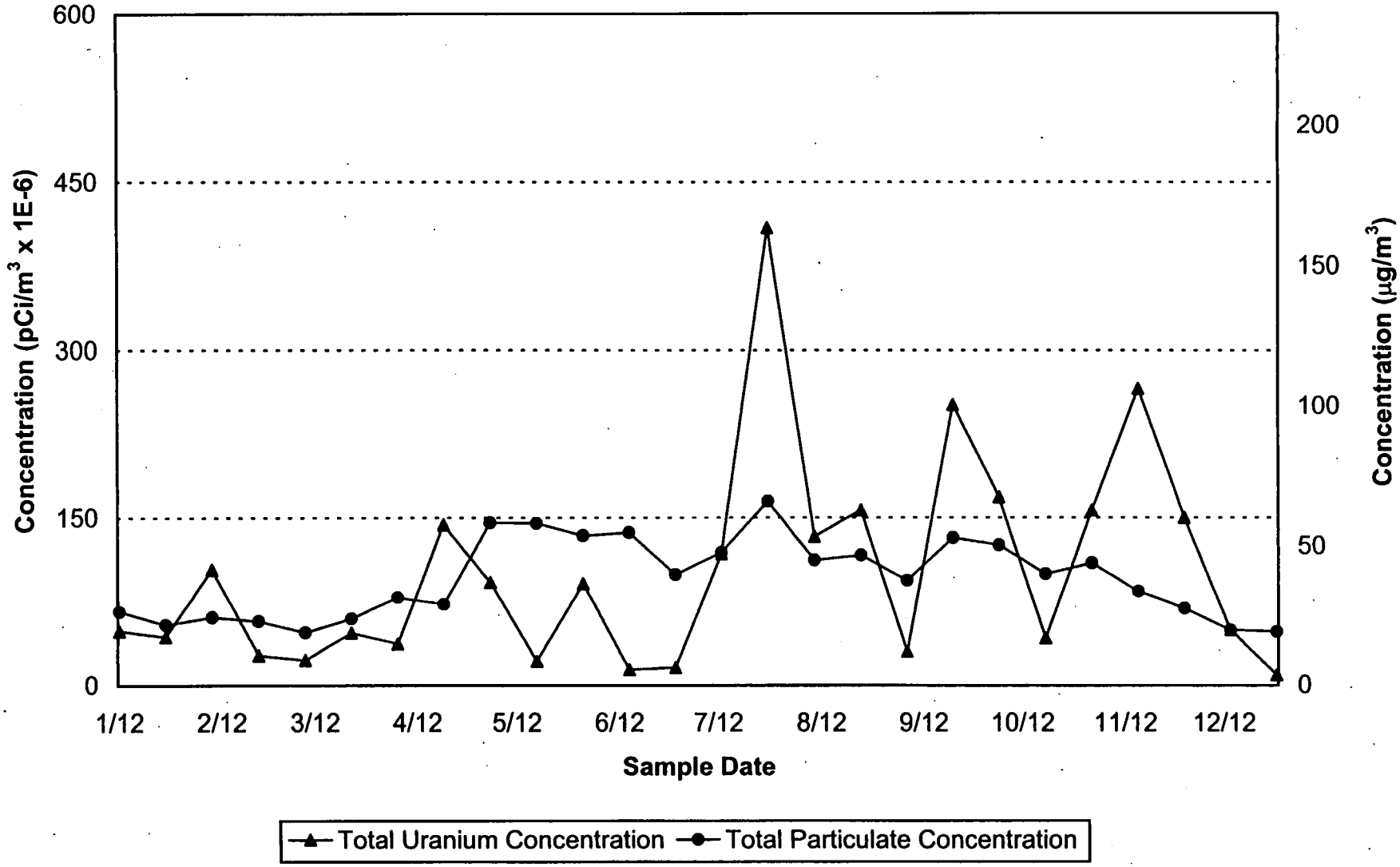


FIGURE C.1-9. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (AMS-9C)

FINAL

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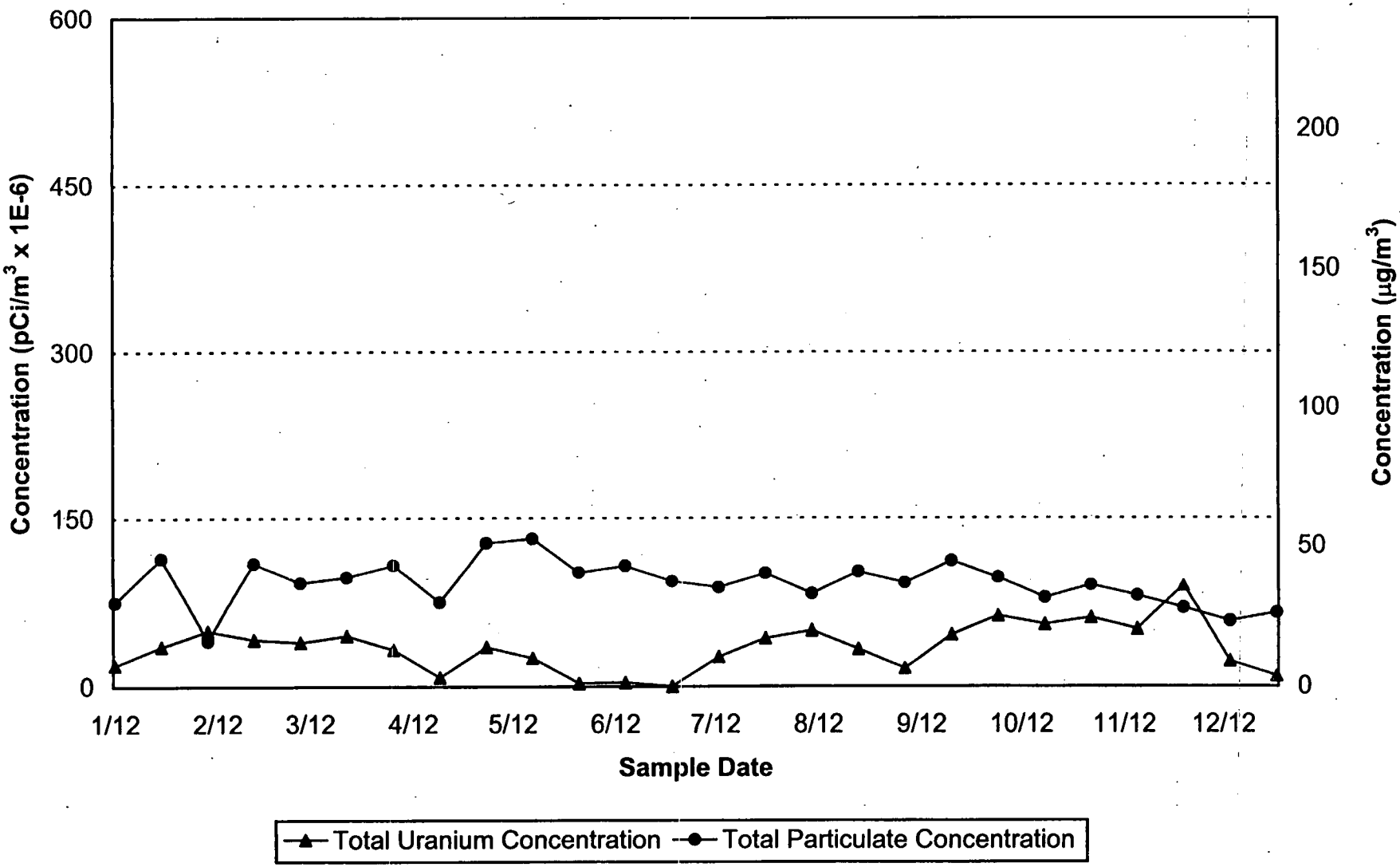


FIGURE C.1-10. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (AMS-22)

FINAL



000405

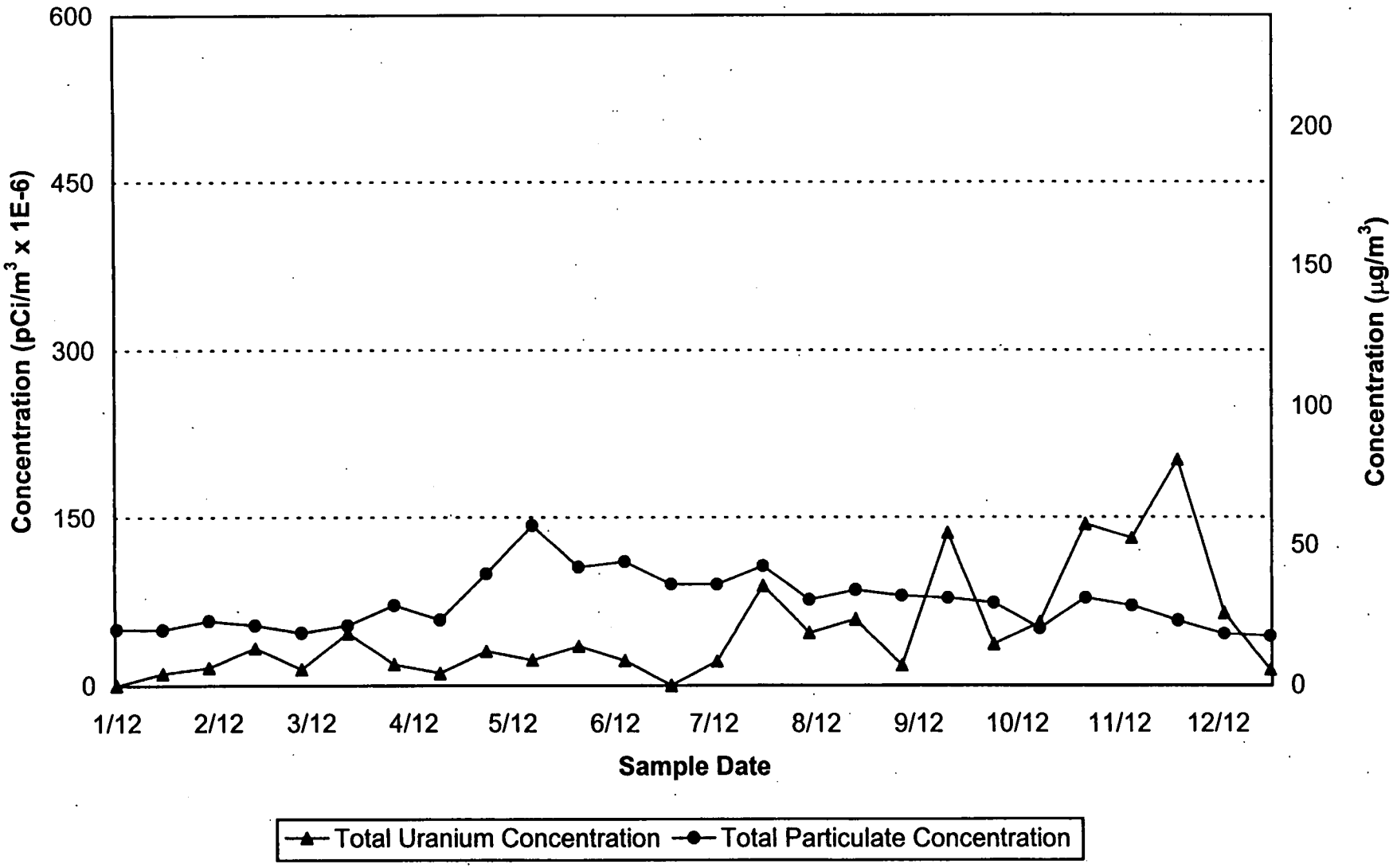


FIGURE C.1-11. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (AMS-23)

FINAL

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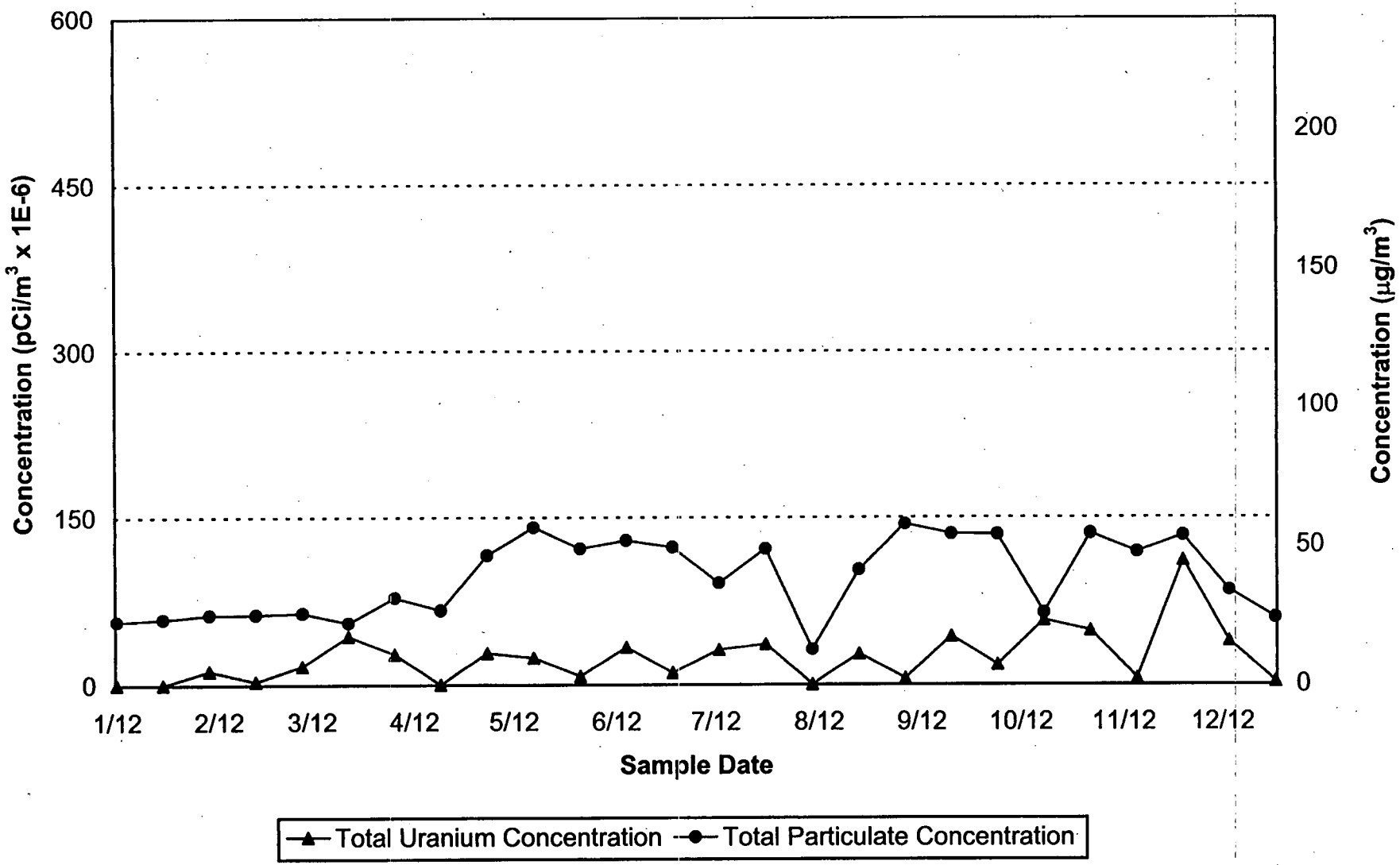


FIGURE C.1-12. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (AMS-24)

FINAL



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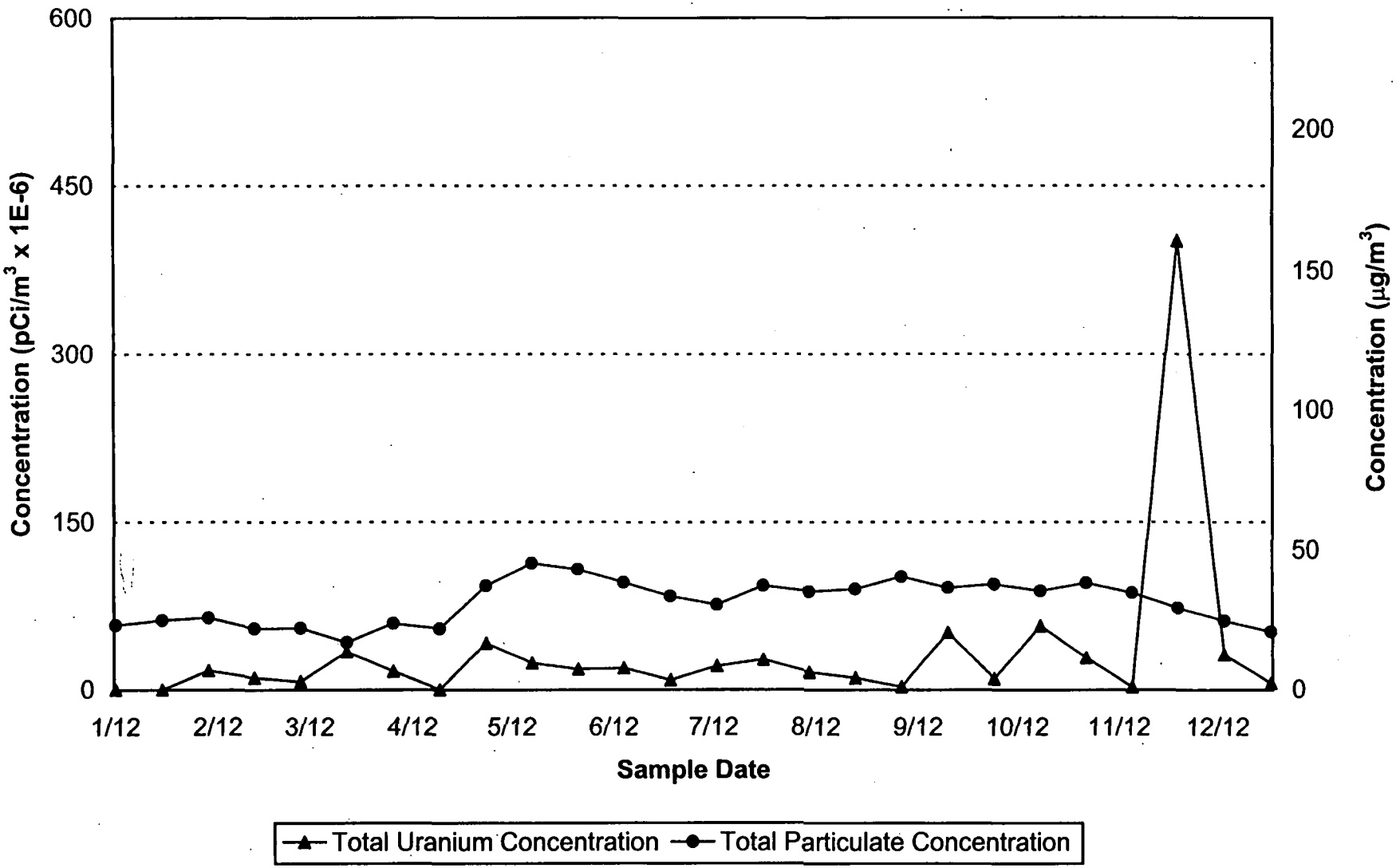


FIGURE C.1-13. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (AMS-25)

FINAL

000408

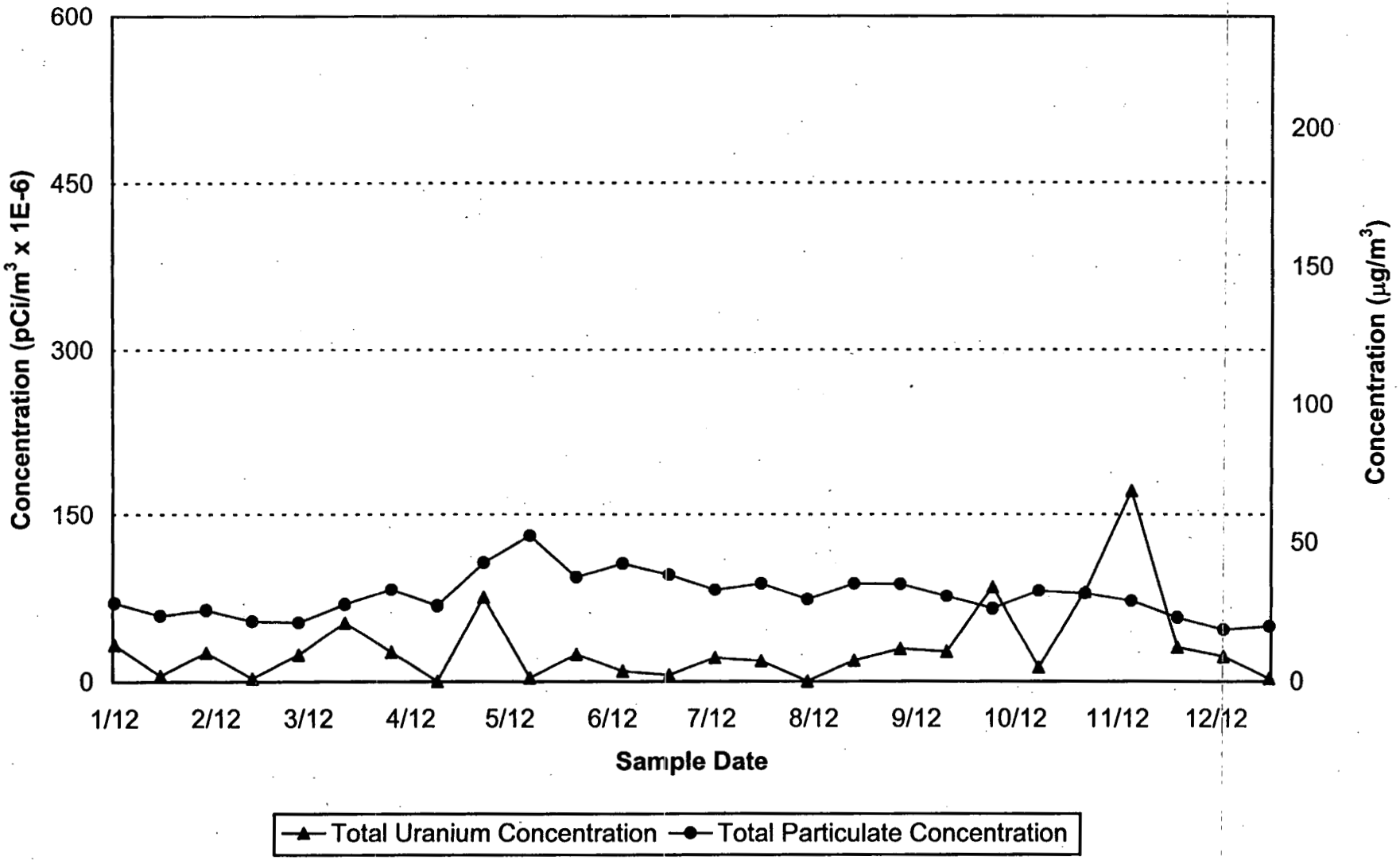


FIGURE C.1-14. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (AMS-26)

FINAL

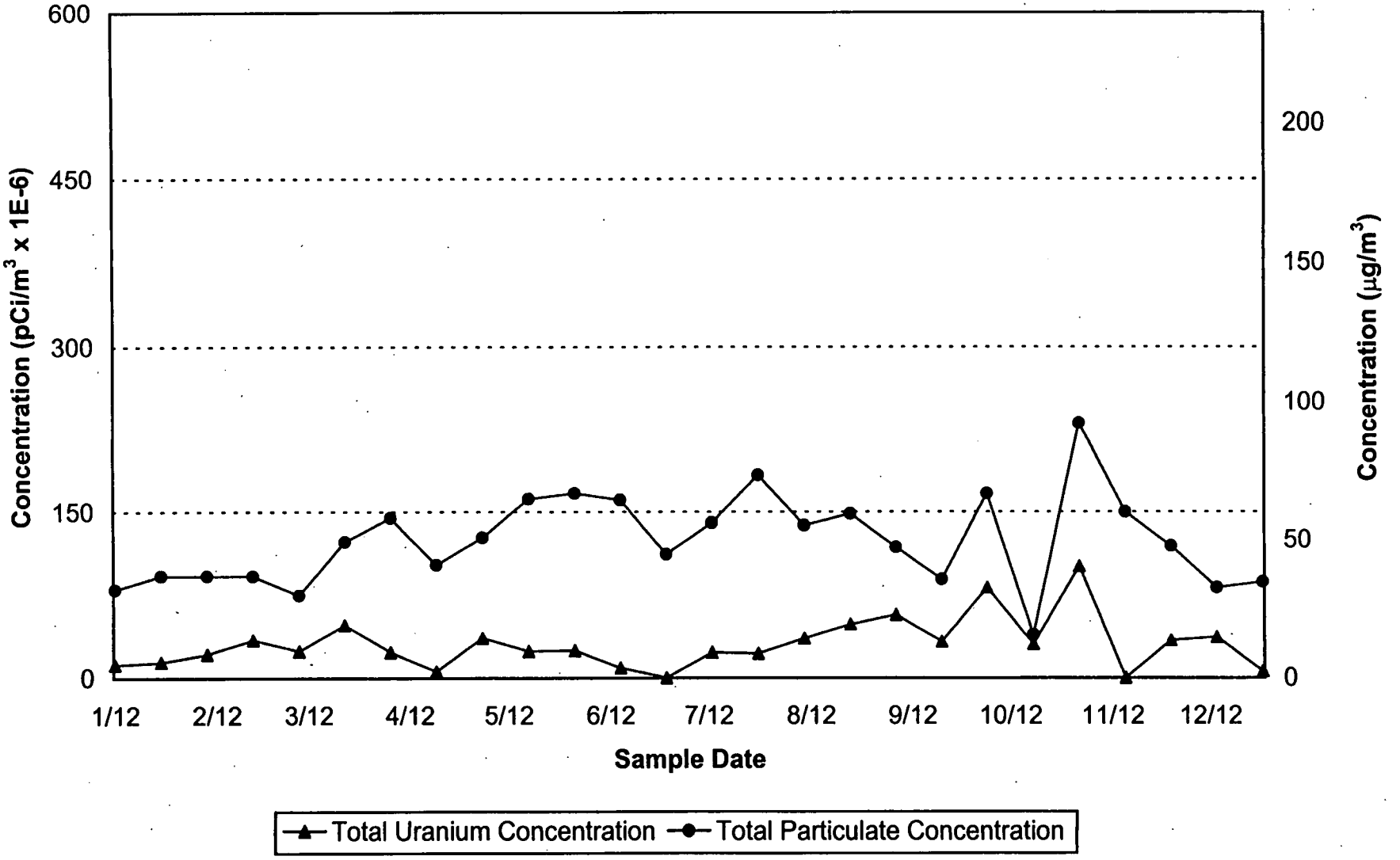


FIGURE C.1-15. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (AMS-27)

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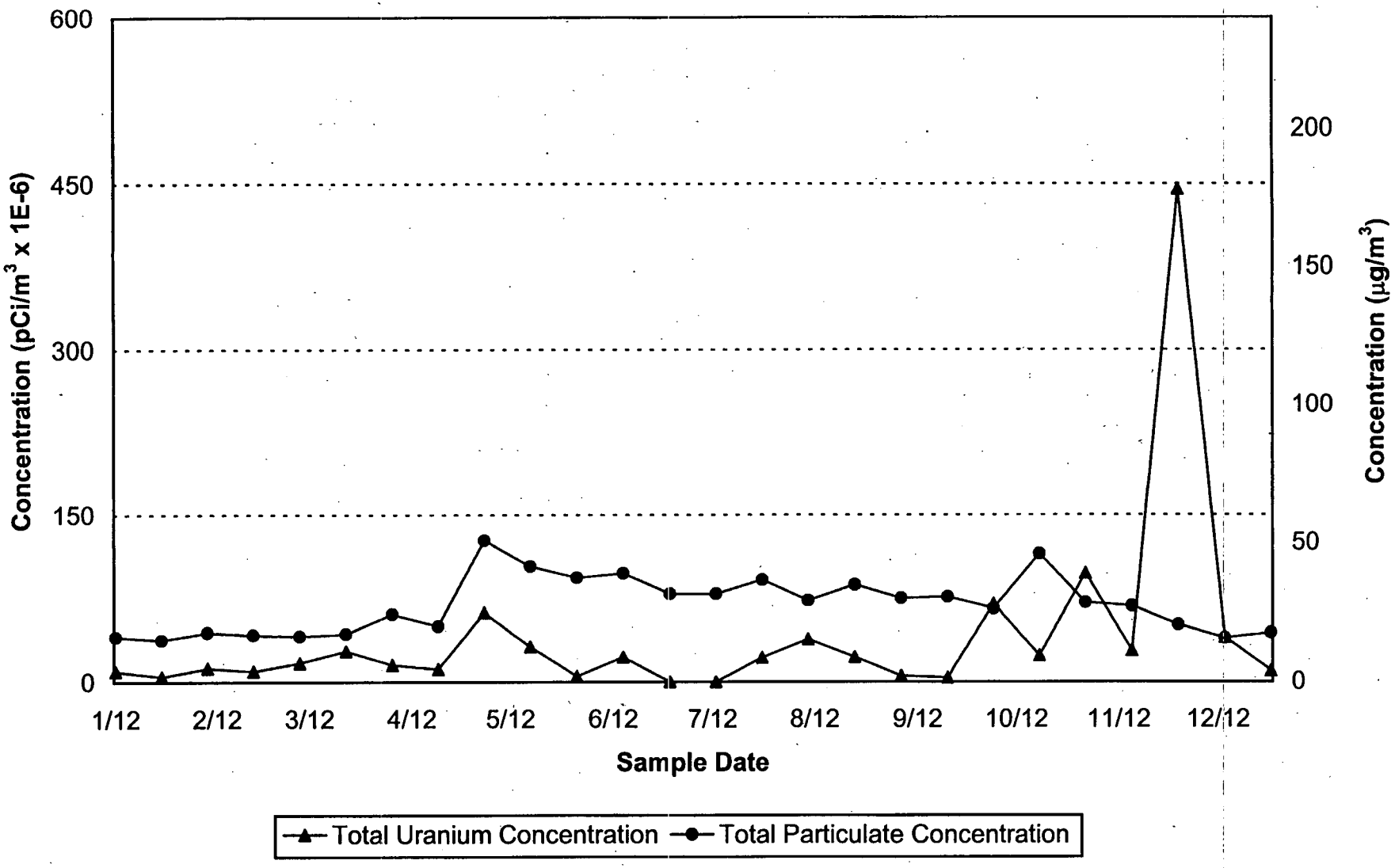


FIGURE C.1-16. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (AMS-28)

FINAL



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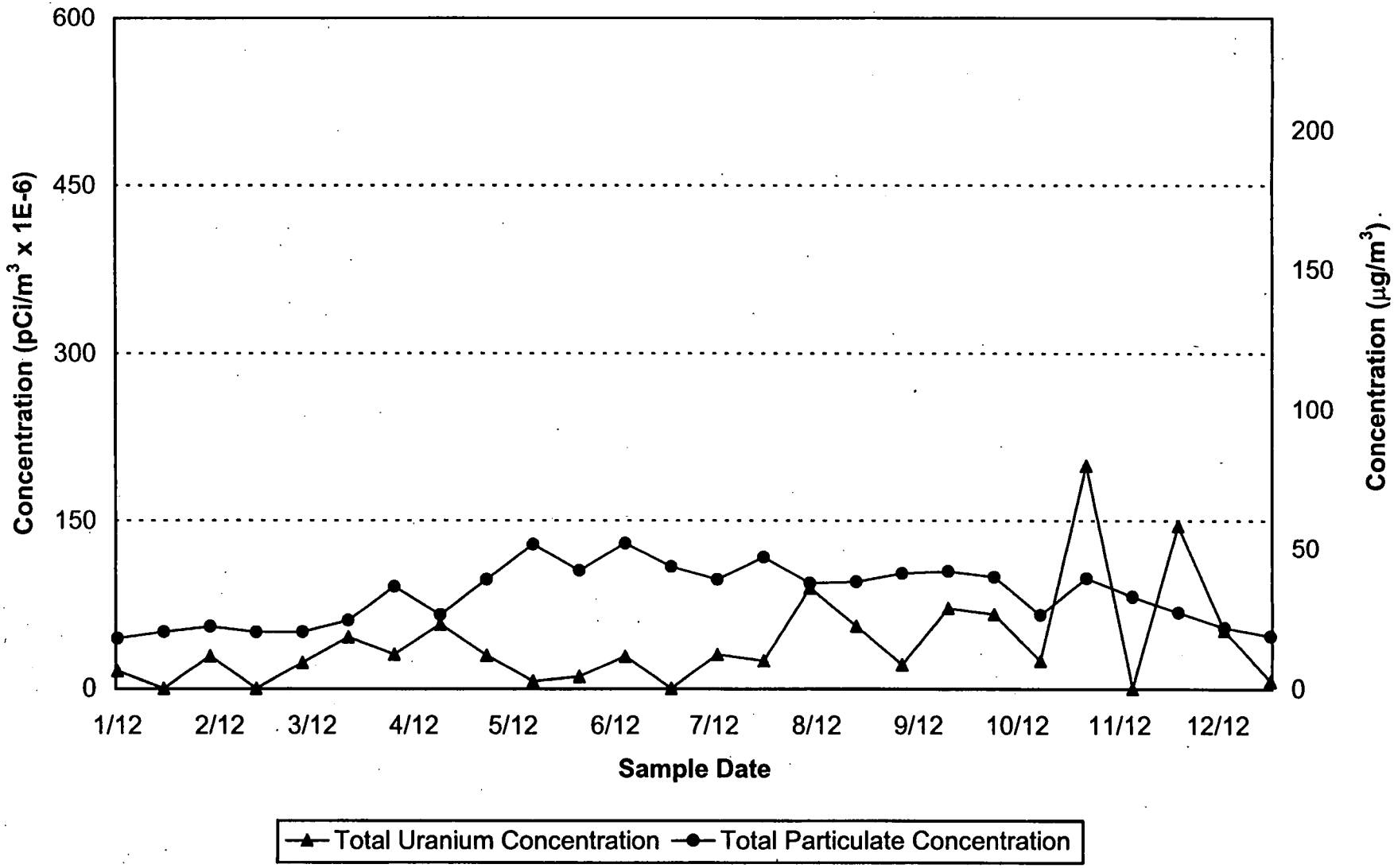


FIGURE C.1-17. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (AMS-29)

FINAL

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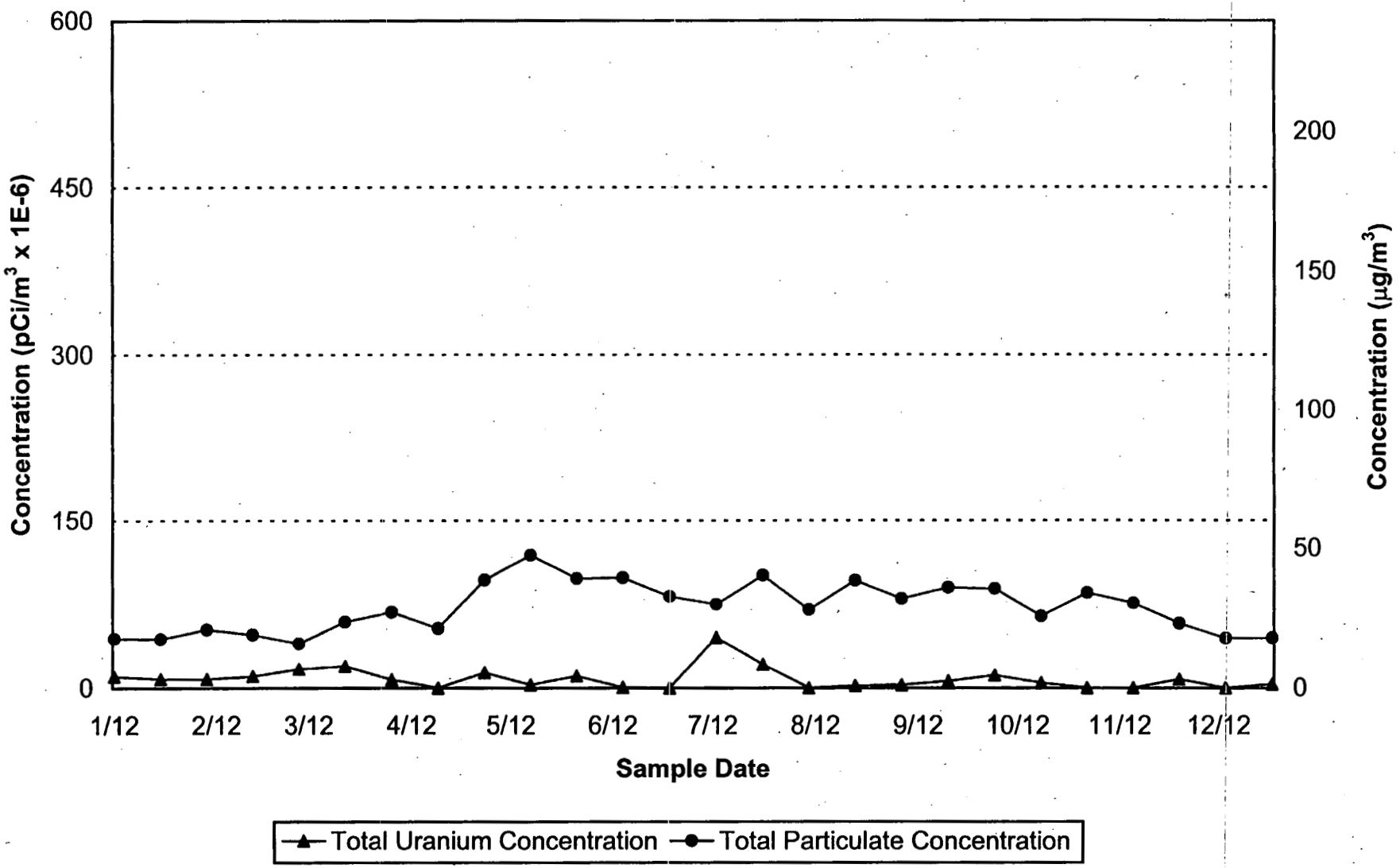


FIGURE C.1-18. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (AMS-12)

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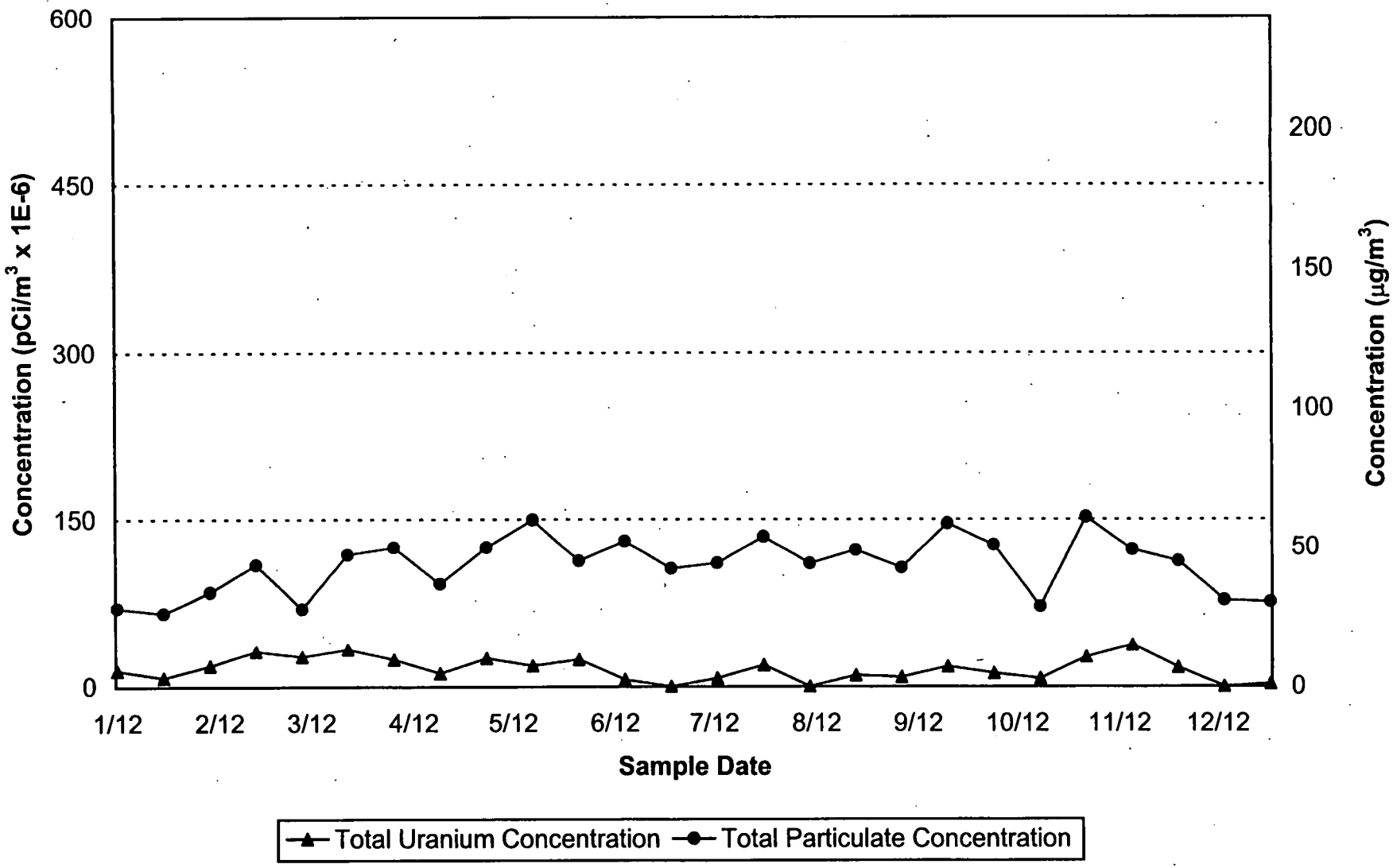


FIGURE C.1-19. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (AMS-16)

FINAL

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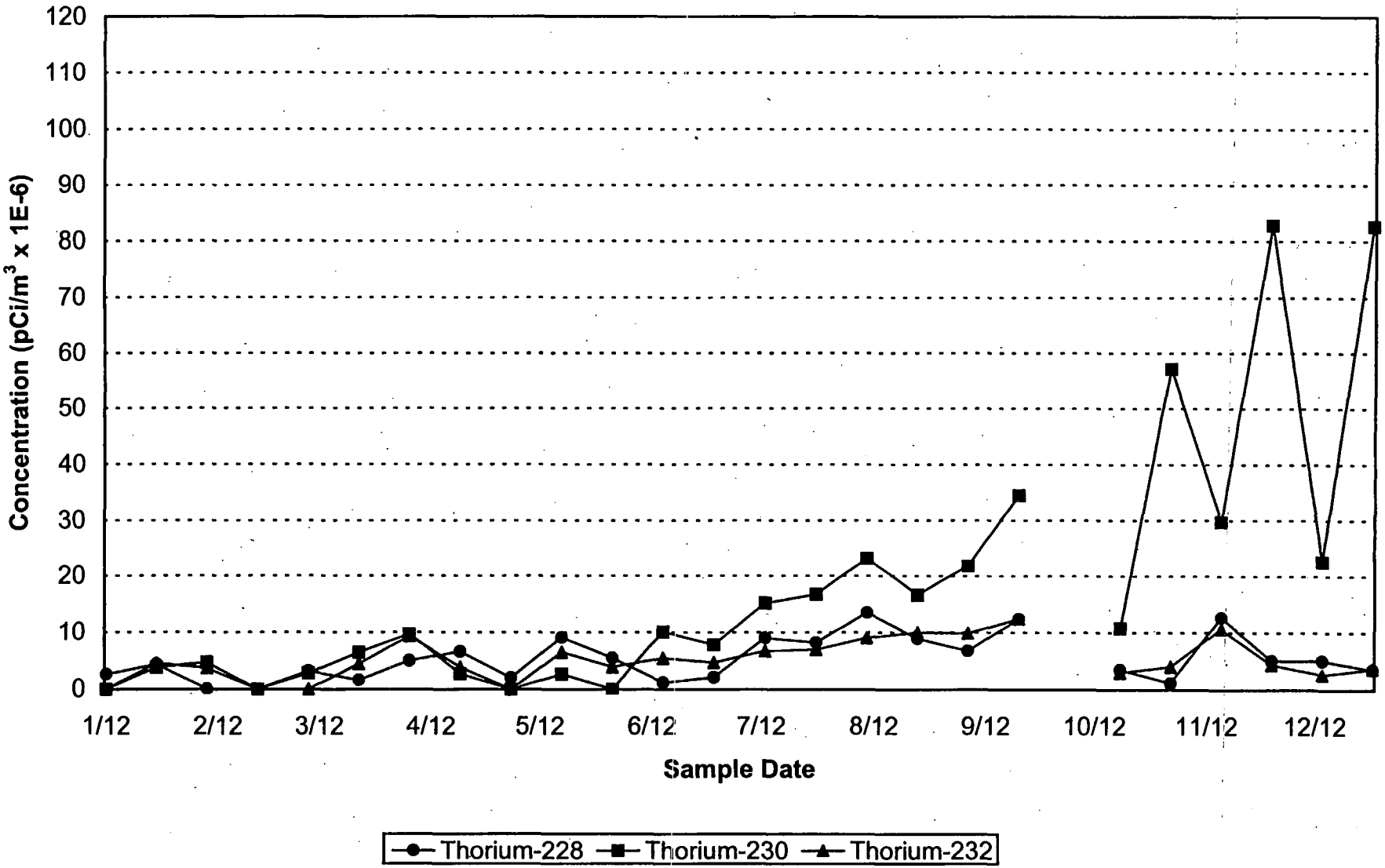


FIGURE C.1-20. 1999 THORIUM-228, THORIUM-230, AND THORIUM-232 CONCENTRATIONS IN AIR (WPTH-1)

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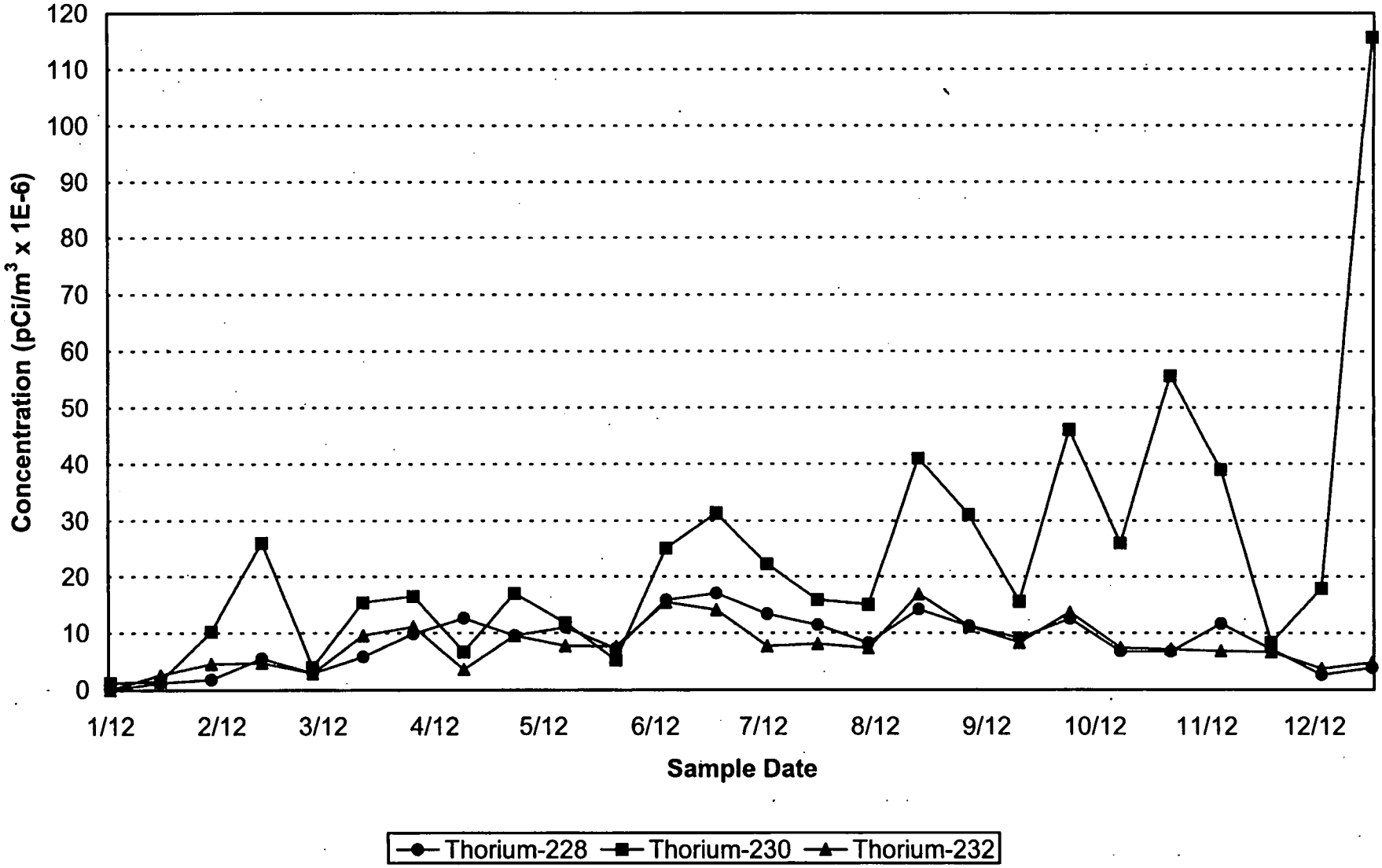


FIGURE C.1-21. 1999 THORIUM-228, THORIUM-230, AND THORIUM-232 CONCENTRATIONS IN AIR (WPTH-2)

FINAL

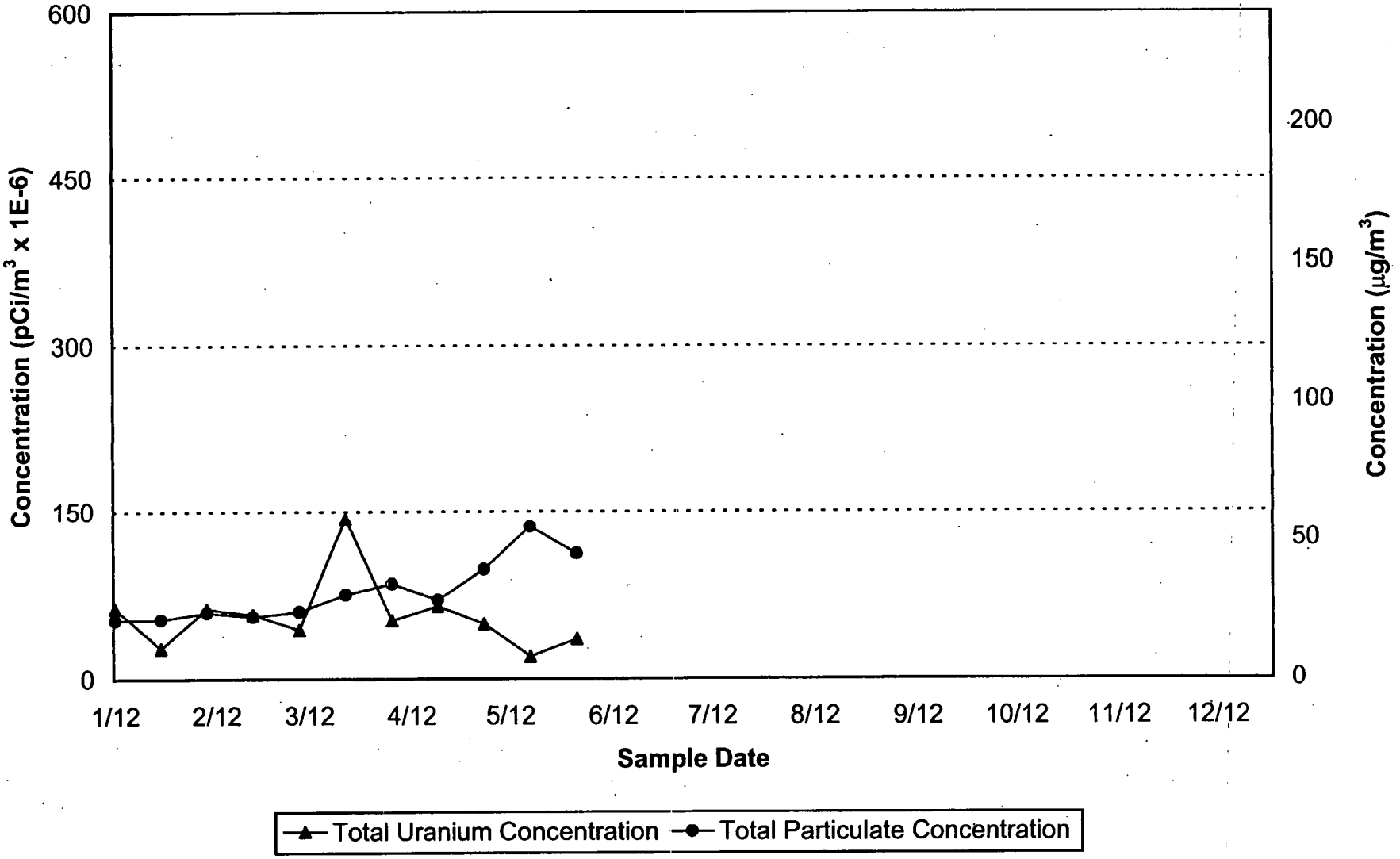


FIGURE C.1-22. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (STP-1)

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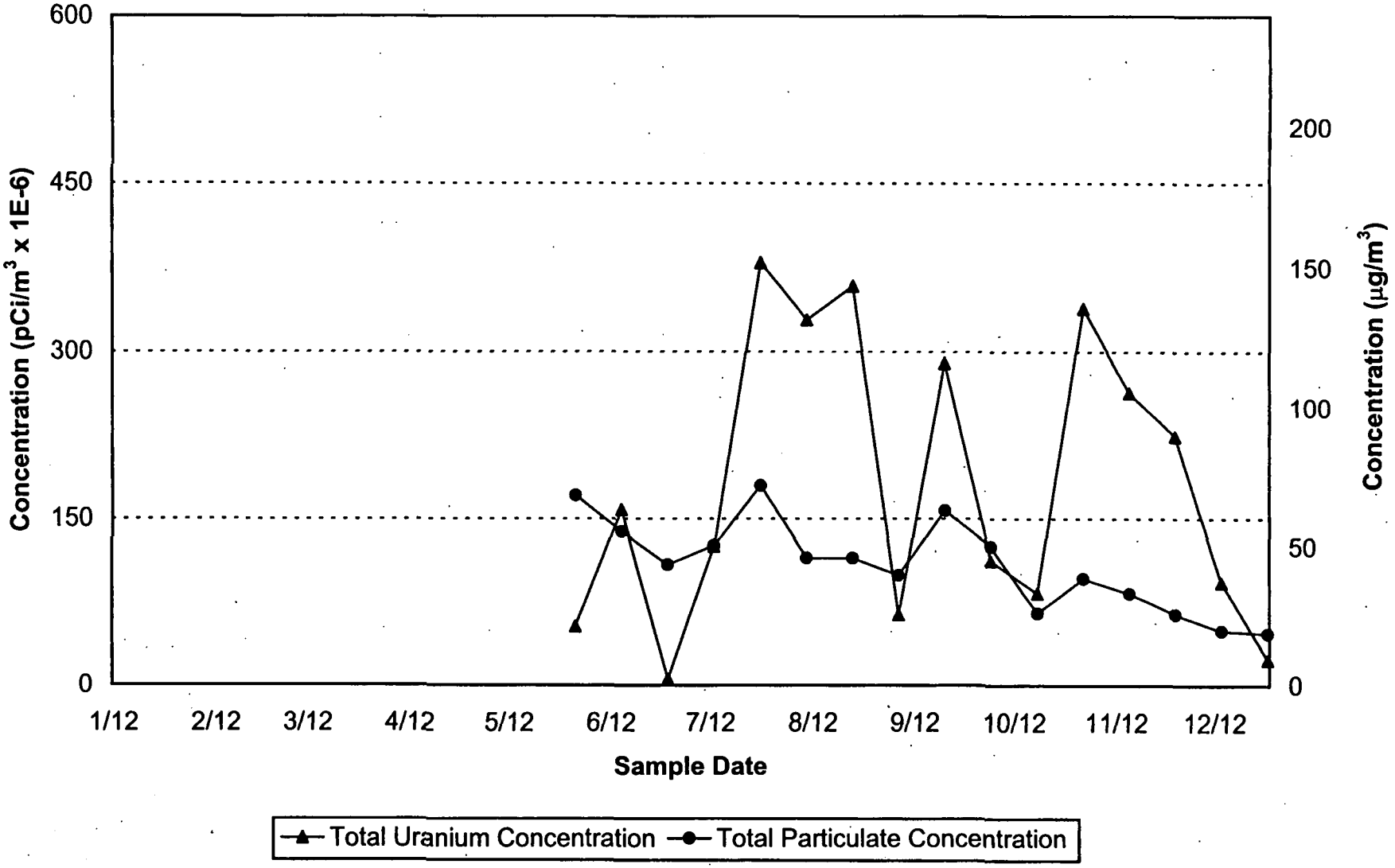


FIGURE C.1-23. 1999 TOTAL URANIUM AND PARTICULATE CONCENTRATIONS IN AIR (STP-2)

FINAL

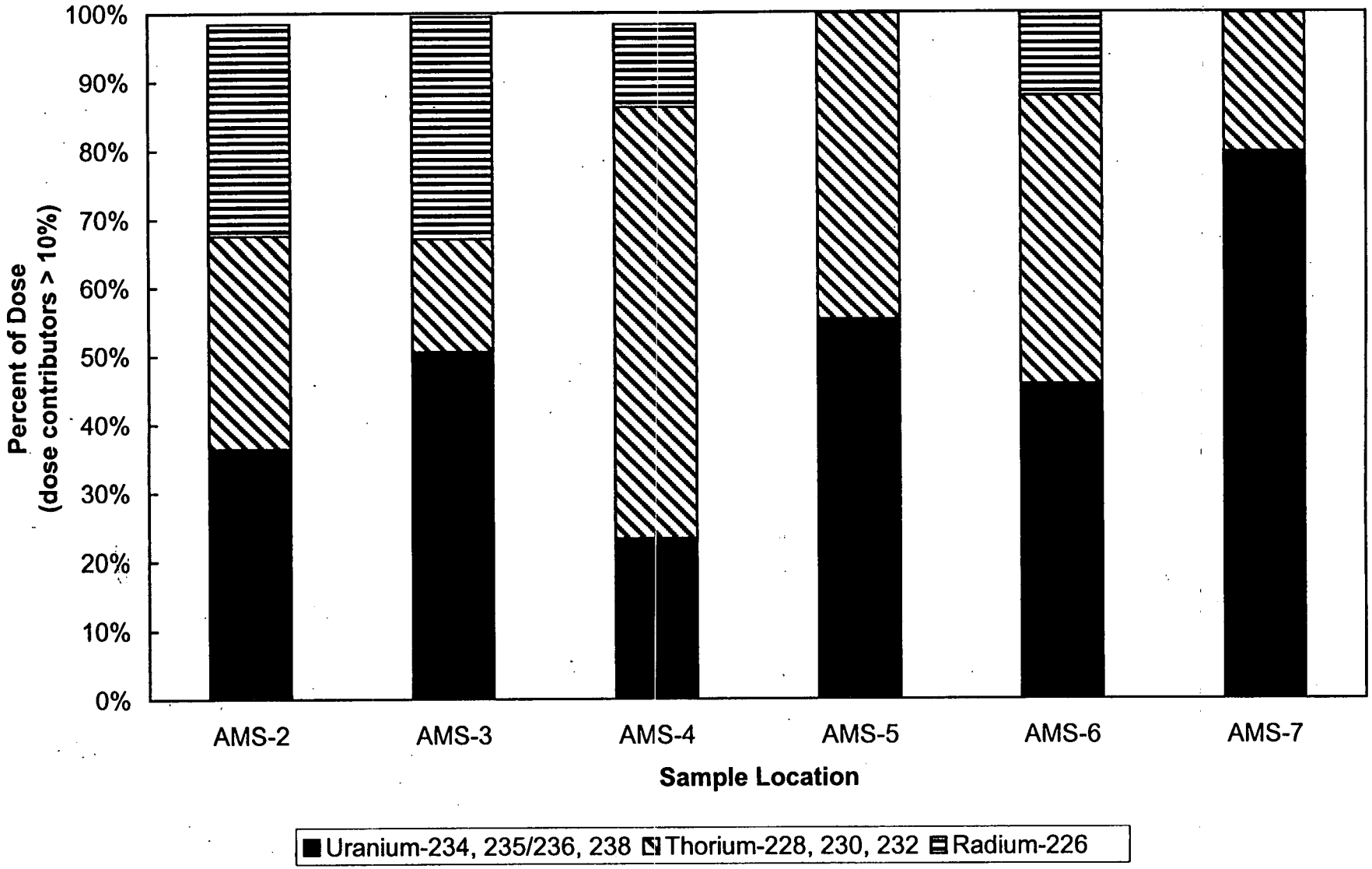


FIGURE C.1-24. 1999 DOSE CONTRIBUTIONS PER AMS LOCATION



000419

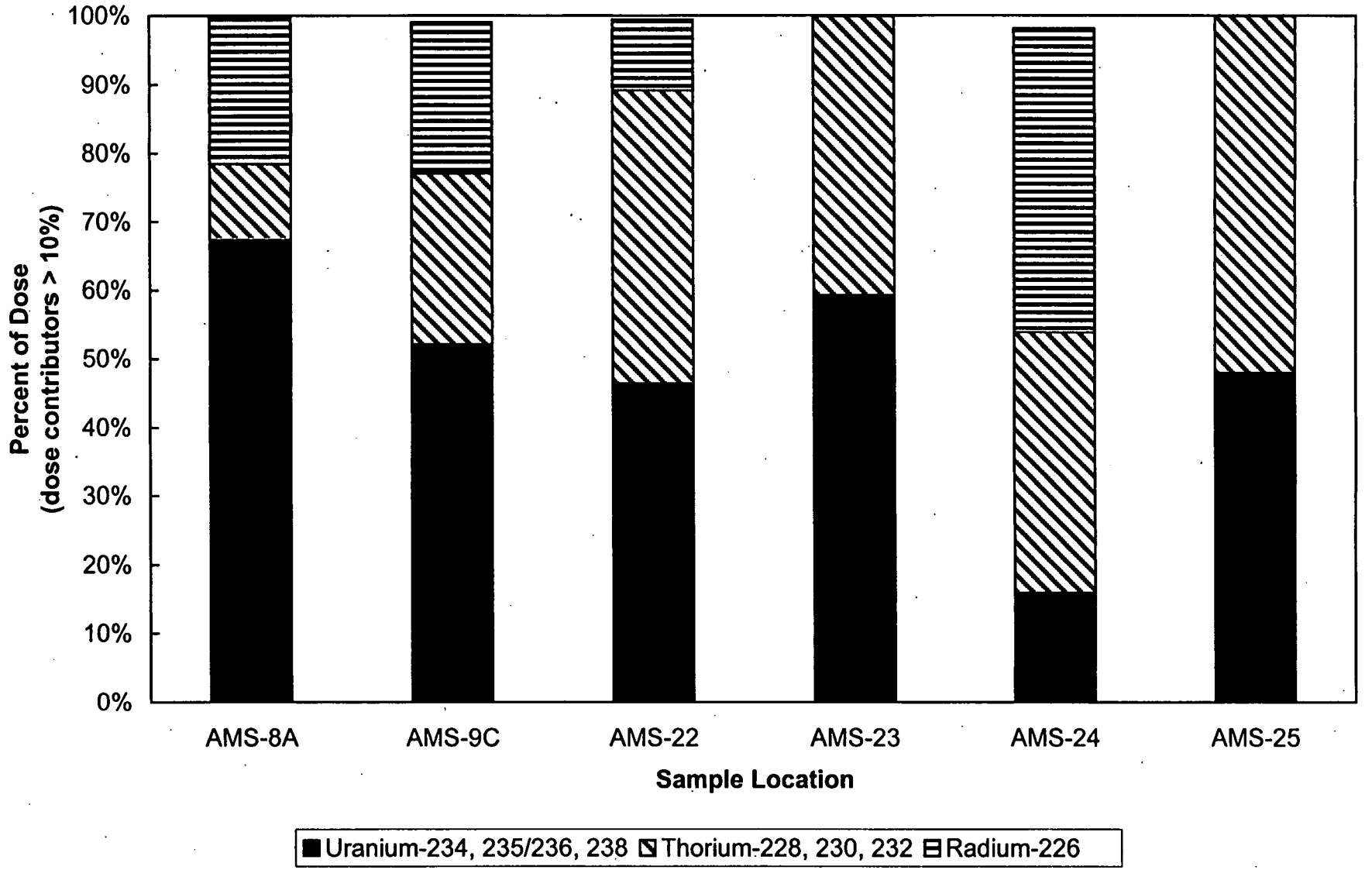


FIGURE C.1-25. 1999 DOSE CONTRIBUTIONS PER AMS LOCATION

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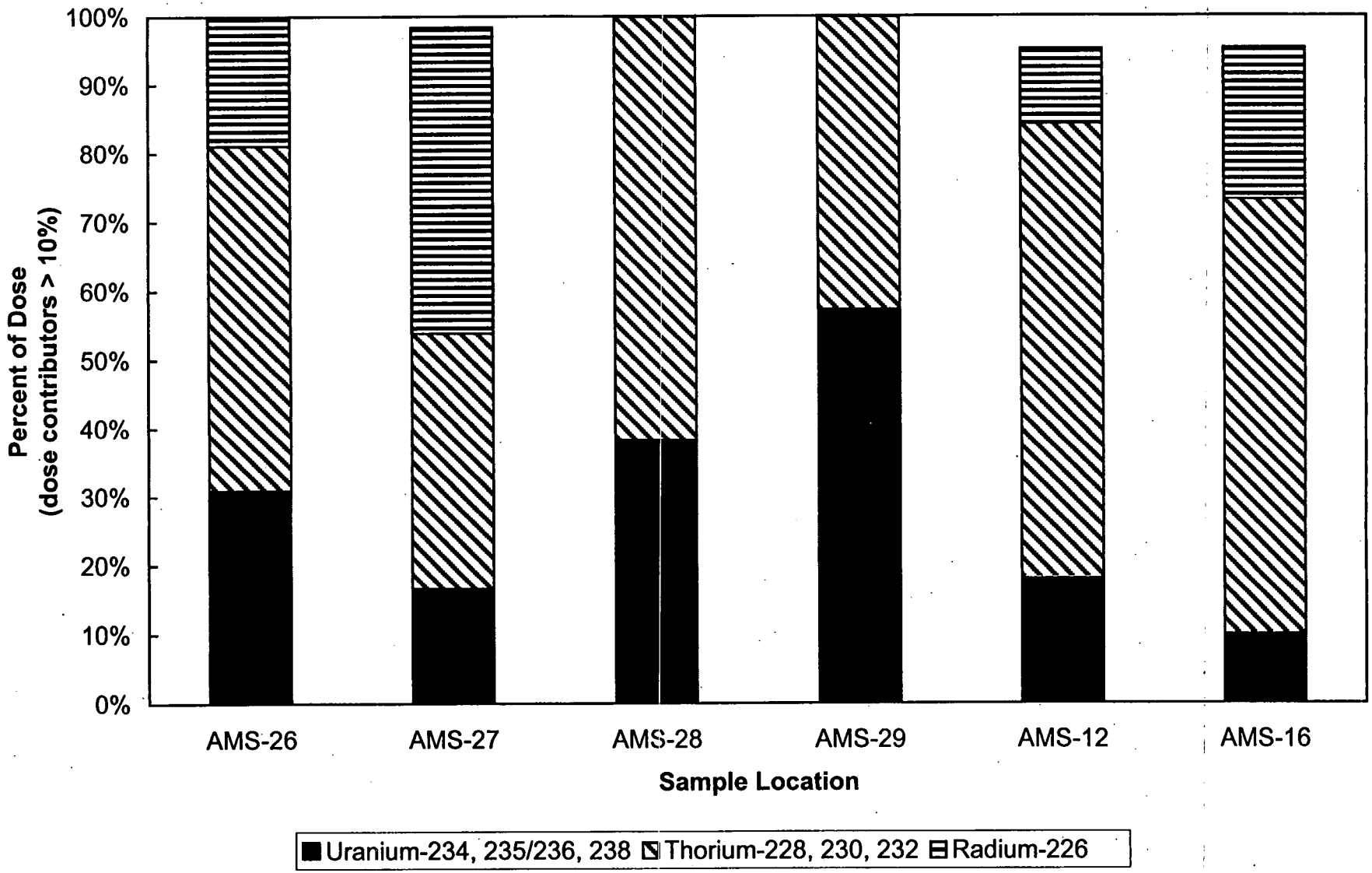



FIGURE C.1-26. 1999 DOSE CONTRIBUTIONS PER AMS LOCATION

**ATTACHMENT C.2**

**RADON**

# ATTACHMENT C.2

As discussed in Chapter 5 of the 1999 Integrated Site Environmental Report, the FEMP's radon monitoring program primarily focuses on assessing the effects of radon emissions from the K-65 Silos 1 and 2 on the surrounding environment. The radon data collected under the program are compared to the radon concentration standards contained in DOE Order 5400.5, Radiation Protection of the Public and the Environment. The pertinent standards and associated 1999 compliance status are provided below:

- The DOE annual average limit at and beyond the facility fenceline is 3 picoCuries per liter (pCi/L) above background; there were no exceedances in 1999.
- The DOE annual average limit over the facility is 30 pCi/L above background; this limit was not exceeded in 1999.
- The DOE limit measured at any point over the facility is 100 pCi/L; there were 47 exceedances during 1999.

Continuous monitors are used at the FEMP to determine compliance with these limits and track changes in radon concentrations. The following section summarizes the findings from the radon monitoring program for 1999.

## Continuous Monitoring Results

For 1999 the radon monitoring program operated 29 continuous environmental radon monitors for the entire year. The operational radon monitor run-time averaged approximately 97 percent for the 29 monitors. The three percent down-time was associated with downloading of instrument data, interruptions due to extreme cold temperatures, power interruptions, and/or routine maintenance activities.

Data from the continuous environmental radon monitors are provided in this attachment in the following two formats:

- Table C.2-1 provides a detailed summary of 100 pCi/L exceedances. During 1999 there were 47 exceedances of the 100 pCi/L DOE limit.
- Figure C.2-1 identifies the location of continuous environmental radon monitoring locations in 1999. Figures C.2-2 through C.2-30 present the monthly average radon concentrations plotted over time for the 29 continuous environmental radon monitoring stations which operated throughout 1998 and 1999. The 3 pCi/L (fenceline and off site)

and 30 pCi/L limits (on site) have been added as reference points to the appropriate graphs to assist in evaluating the data. The results for 1998 and 1999 have been corrected for instrument background. The practice of correcting measurements for instrument background was adopted by the FEMP in October 1997.

- Table C.2-2 provides a summary of monthly average radon concentrations for the continuous environmental radon monitoring stations.

During the fourth quarter of 1999, there was a noticeable increase in the number of exceedances of the DOE Order 5400.5 100 pCi/L radon limit recorded at the K-65 Silo exclusion fenceline. In response to the increasing radon concentrations in the vicinity of the K-65 Silos, DOE conducted detailed inspections of the silo domes using radiological survey instruments to pinpoint leak locations. As expected, leaks were found at the gasketed surfaces of man-way flanges, sounding ports, and other silo penetrations. Radon was also found to be leaking from the covered access ports that were cut into the center protective cap of each silo to allow for the bentonite installation. Over time the port covers have weathered, causing leakage at the seams. Short-term measures were taken to seal the port covers and lower silo emissions until a more permanent solution can be implemented.

Although the long-term solution for controlling radon emissions from the silos involves a radon control system related to the Accelerated Waste Retrieval Project, DOE decided to re-foam the areas on the domes where radon levels were high. Re-foaming activities were initiated in late May 1999 and were completed on June 4, 1999. Following the re-sealing of the silo domes, radon data from the K-65 Silo area has been closely monitored in order to gauge the effectiveness in reducing radon emissions.

Comparing the 1999 and 1998 fourth quarter average radon concentrations at the KNE and KSE exclusion fence monitors (chosen because of prevailing wind directions) provides some measure of the effectiveness of the re-sealing activities. The fourth quarter 1999 combined average radon concentration for the KNE and KSE monitors was approximately 70 percent lower than the fourth quarter 1998 average, suggesting the re-sealing activities contributed to a substantial reduction in radon concentrations at the K-65 Silo area.

A review of meteorological data provides further support for the effectiveness of the re-sealing activities. The number of strong inversion hours (as defined by a temperature gradient of greater than 1.5 degrees Celsius [°C] per 100 meters in elevation) recorded during fourth quarter 1999 was very similar to fourth quarter 1998 (987 hours in 1999 compared to 985 hours in 1998). However, approximately 20 percent more of the strongest "G" class inversion hours (temperature gradient of greater than 4°C per 100 meters

in elevation) were recorded for fourth quarter 1999. Given the larger and stronger inversions during the fourth quarter of 1999, radon concentrations at the K-65 exclusion fence monitors should have been greater during fourth quarter 1999 had the re-sealing activity been ineffective.

As Table C.2-1 indicates, there were 47 exceedances of the 100 pCi/L DOE limit measured on site during 1999 compared with 24 in 1998 and five in 1997. As in past years, the exceedances were observed at monitoring locations adjacent to the K-65 Silos and occurred during periods of atmospheric inversions. Of the exceedances recorded during 1999, the first 35 occurred prior to the dome re-sealing activities. The remaining 12 exceedances occurred during the fourth quarter of 1999. Of these, a majority occurred exclusively at the KNW monitor, in contrast to past years when most exceedances occurred at the KNE monitor. A review of activities occurring around the K-65 Silos indicated that the cause of the exceedances at the KNW monitor was related to the pumping of contaminated water from the K-65 Decant Sump, which collects contaminated water from the K-65 Silos. Because the pumping activities occurred during periods of strong inversions, radon emissions from the sump and the tanker were concentrated at relatively high levels on the western side of the K-65 Silos near the KNW monitor, and contributed to the exceedances. The increased radon concentrations at the KNW monitor were also attributable to relocating the monitor closer to the K-65 Silos, necessary due to road construction activities for the Accelerated Waste Retrieval Project.

In order to better monitor radon levels in the K-65 Silos area during the Accelerated Waste Retrieval Project, five radon monitoring locations will be added to the existing IEMP radon network in 2000. Four of the monitors will be located in the immediate vicinity of the silos and the fifth monitor will be located along the western fenceline of the FEMP. The data and specific locations of the additional radon monitors will be reported in future IEMP quarterly status reports and annual integrated site environmental reports.

## TABLE C.2-1

## 1999 RADON CONCENTRATIONS
## 100 pCi/L EXCEEDANCES AT THE K-65 SILOS 1 AND 2 EXCLUSION FENCE

| Exceedance Event Start Date | Duration of Exceedance (hours) | Maximum Recorded Hourly Radon Concentration (pCi/L) | Monitoring Locations[a] |
|---|---|---|---|
| 1/11 | 1 | 192 | KNE |
| 1/25 | 3 | 133 | KNE |
| 1/26 | 1 | 103 | KNE |
| 1/26 | 1 | 102 | KNW |
| 2/3 | 3 | 237 | KNE,KSE |
| 2/5 | 1 | 141 | KNE |
| 2/6 | 4 | 231 | KNE, KSE |
| 2/8 | 4 | 295 | KNE, KSE |
| 2/14 | 3 | 207 | KNE |
| 2/18 | 2 | 228 | KNE |
| 2/26 | 2 | 188 | KNE |
| 2/26 | 3 | 175 | KNE, KSE |
| 3/ 4 | 2 | 291 | KNE |
| 3/10 | 1 | 151 | KNE |
| 3/15 | 6 | 379 | KNE, KSE |
| 3/20 | 3 | 158 | KNE |
| 3/20 | 7 | 171 | KNE, KSE |
| 3/23 | 1 | 104 | KNE |
| 3/24 | 3 | 174 | KNE |
| 3/27 | 2 | 184 | KNE |
| 3/27 | 4 | 183 | KNE |
| 3/29 | 2 | 170 | KNE, KSE |
| 3/30 | 7 | 256 | KNE, KSE |
| 4/7 | 2 | 156 | KNE, KSE |
| 4/21 | 1 | 109 | KNE |
| 4/26 | 5 | 233 | KNE |
| 5/3 | 5 | 181 | KNE |
| 5/4 | 2 | 158 | KNE |
| 5/8 | 1 | 108 | KNE |
| 5/10 | 2 | 109 | KNE |
| 5/12 | 6 | 177 | KNE |
| 5/20 | 2 | 115 | KNE |
| 5/23 | 1 | 129 | KNE |
| 5/25 | 2 | 135 | KNE |
| 5/27 | 1 | 107 | KNE |

**TABLE C.2-1**
**(Continued)**

| Exceedance Event Start Date | Duration of Exceedance (hours) | Maximum Recorded Hourly Radon Concentration (pCi/L) | Monitoring Locations[a] |
|---|---|---|---|
| 10/5 | 2 | 112 | KNE |
| 10/12 | 4 | 200 | KNE |
| 10/20 | 2 | 172 | KNE |
| 10/27 | 3 | 172 | KNW |
| 10/28 | 3 | 169 | KNW |
| 10/29 | 3 | 135 | KNW |
| 10/31 | 6 | 318 | KNW |
| 11/1 | 5 | 334 | KNE, KSE, KNW |
| 11/7 | 1 | 101 | KNW |
| 11/8 | 2 | 184 | KNW |
| 11/21 | 1 | 115 | KNW |
| 12/2 | 3 | 108 | KNW |

[a]The location listed first had the highest recorded concentration.

NOTE: K-65 Decant Sump pumping activities occurred on October 13 through 15 and October 28 through 29. The tanker storing the water from the sump was stationed on the western side of the K-65 Silos near the KNW monitor from October 5 through November 4, 1999.

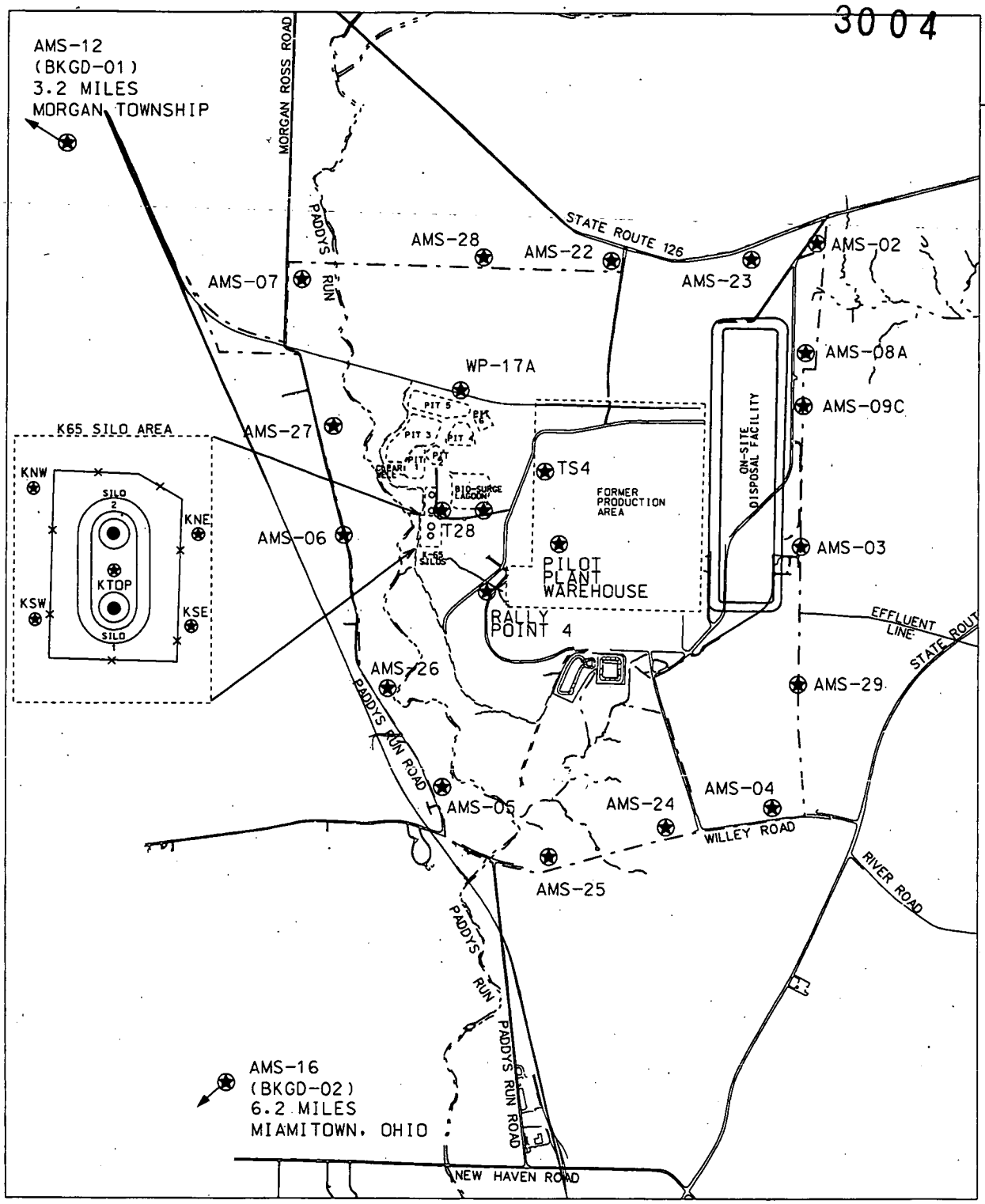
# TABLE C.2-2

## CONTINUOUS ENVIRONMENTAL RADON MONITORING MONTHLY AVERAGE CONCENTRATIONS[a]

| Location[b] | 1999 Summary Results[c] (Instrument Background Corrected) (pCi/L) | | | 1998 Summary Results[c,d] (Instrument Background Corrected) (pCi/L) | | |
|---|---|---|---|---|---|---|
| | Min. | Max. | Avg. | Min. | Max. | Avg. |
| **Fenceline** | | | | | | |
| AMS-02 | 0.2 | 1.0 | 0.5 | 0.2 | 0.7 | 0.4 |
| AMS-03[e] | 0.1 | 1.0 | 0.5 | 0.6 | 0.8 | 0.7 |
| AMS-04 | 0.1 | 0.8 | 0.4 | 0.1 | 0.7 | 0.4 |
| AMS-05 | 0.2 | 1.4 | 0.7 | 0.2 | 1.3 | 0.6 |
| AMS-06 | 0.2 | 0.8 | 0.5 | 0.2 | 0.9 | 0.5 |
| AMS-07 | 0.3 | 1.5 | 0.8 | 0.2 | 1.5 | 0.7 |
| AMS-08A[f] | 0.1 | 0.8 | 0.4 | 0.8 | NA | NA |
| AMS-09C[g] | 0.2 | 0.8 | 0.5 | 0.2 | 0.9 | 0.6 |
| AMS-22[g] | 0.1 | 0.5 | 0.3 | 0.2 | 0.7 | 0.4 |
| AMS-23[e] | 0.1 | 0.6 | 0.3 | 0.4 | 0.5 | 0.4 |
| AMS-24[f] | 0.2 | 1.1 | 0.6 | 0.7 | NA | NA |
| AMS-25[f] | 0.2 | 0.8 | 0.5 | 0.6 | NA | NA |
| AMS-26[g] | 0.2 | 0.8 | 0.5 | 0.2 | 0.8 | 0.6 |
| AMS-27[g] | 0.2 | 1.1 | 0.6 | 0.2 | 1.1 | 0.7 |
| AMS-28[f] | 0.1 | 0.8 | 0.4 | 0.4 | NA | NA |
| AMS-29[f] | 0.1 | 0.8 | 0.4 | 0.7 | NA | NA |
| **Background** | | | | | | |
| AMS-12 | 0.1 | 0.5 | 0.2 | 0.1 | 0.6 | 0.3 |
| AMS-16 | 0.1 | 0.5 | 0.3 | 0.2 | 0.6 | 0.4 |
| **On Site** | | | | | | |
| KNE | 1.7 | 18.3 | 9.6 | 2.0 | 18.2 | 9.1 |
| KNW | 2.1 | 8.2 | 3.8 | 1.0 | 4.8 | 2.4 |
| KSE | 1.2 | 9.9 | 4.9 | 2.4 | 16.9 | 8.3 |
| KSW | 1.7 | 4.8 | 3.1 | 1.4 | 5.2 | 3.1 |
| KTOP | 3.4 | 15.8 | 8.4 | 7.2 | 24.6 | 13.0 |
| Pilot Plant Warehouse | 0.3 | 0.8 | 0.4 | 0.1 | 0.9 | 0.4 |
| Rally Point 4 | 0.5 | 1.3 | 0.8 | 0.2 | 1.3 | 0.7 |
| Surge Lagoon | 0.4 | 1.0 | 0.7 | 0.3 | 1.3 | 0.7 |
| T28 | 1.1 | 3.8 | 2.2 | 0.9 | 2.8 | 1.8 |
| TS4[h] | 0.2 | 0.9 | 0.5 | NA | NA | NA |
| WP-17A | 0.1 | 1.1 | 0.6 | 0.2 | 0.9 | 0.5 |

[a]Monthly average radon concentrations are calculated from daily average concentrations. Daily average concentrations are calculated by summing all hourly count data, treating the sum as a single daily measurement, and then converting the sum to a (daily average) concentration.
[b]Refer to Figure C.2-1 for sample locations
[c]Instrument background changes as monitors are replaced.
[d]NA = not applicable
[e]Unit was placed in service in August 1998.
[f]Unit was placed in service in December 1998.
[g]Unit was placed in service in June 1998.
[h]Unit was placed in service in January 1999.

000428




LEGEND:

FEMP BOUNDARY

ENVIRONMENTAL RADON MONITORING - CONTINUOUS ALPHA SCINTILLATION LOCATION

DISTANCE FROM CENTER OF FORMER PRODUCTION AREA TO LOCATION OFF MAP

SILO HEAD SPACE RADON MONITORING - CONTINOUS ALPHA SCINTILLATION LOCATION

SCALE

2000 1000 0 2000 FEET

FIGURE C.2-1. 1999 RADON MONITORING - CONTINOUS ALPHA SCINTILLATION LOCATIONS

V:/5FGP1/DGN/99ANNUAL/99ANO17.DGN

STATE PLANAR COORDINATE SYSTEM 1983

11-24-99

000430

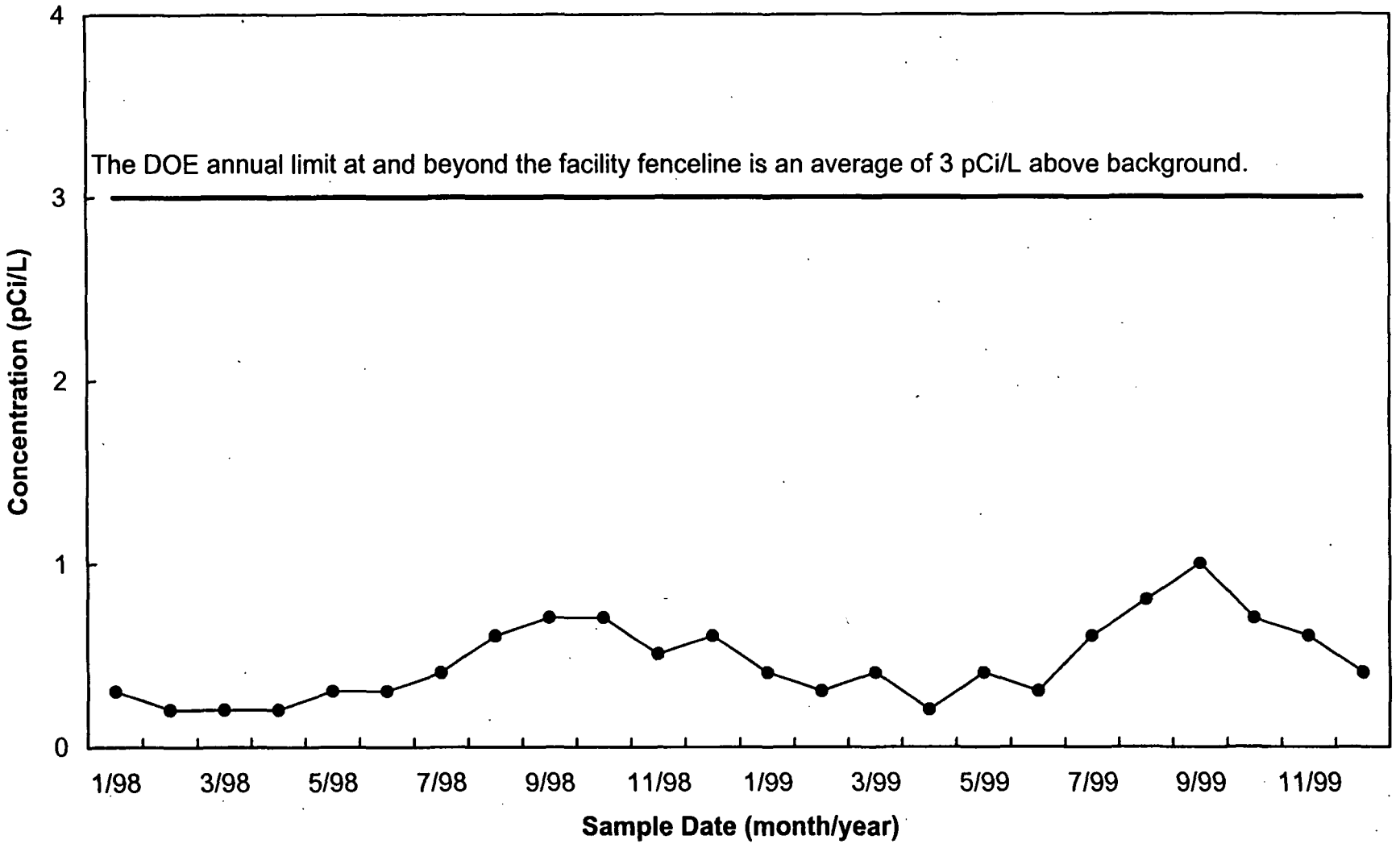



FIGURE C.2-2. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR AMS-02

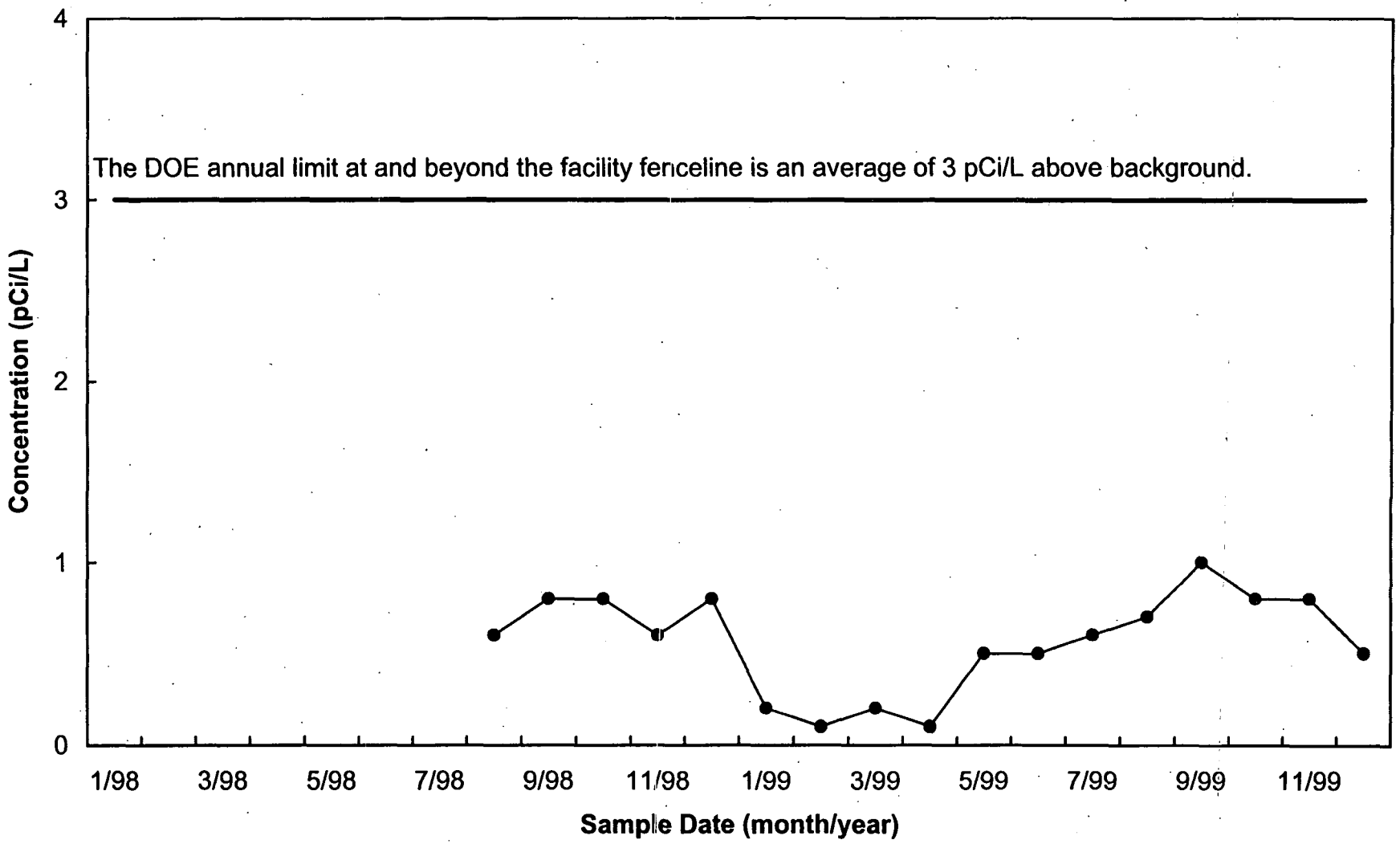



FIGURE C.2-3. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR AMS-03

000432

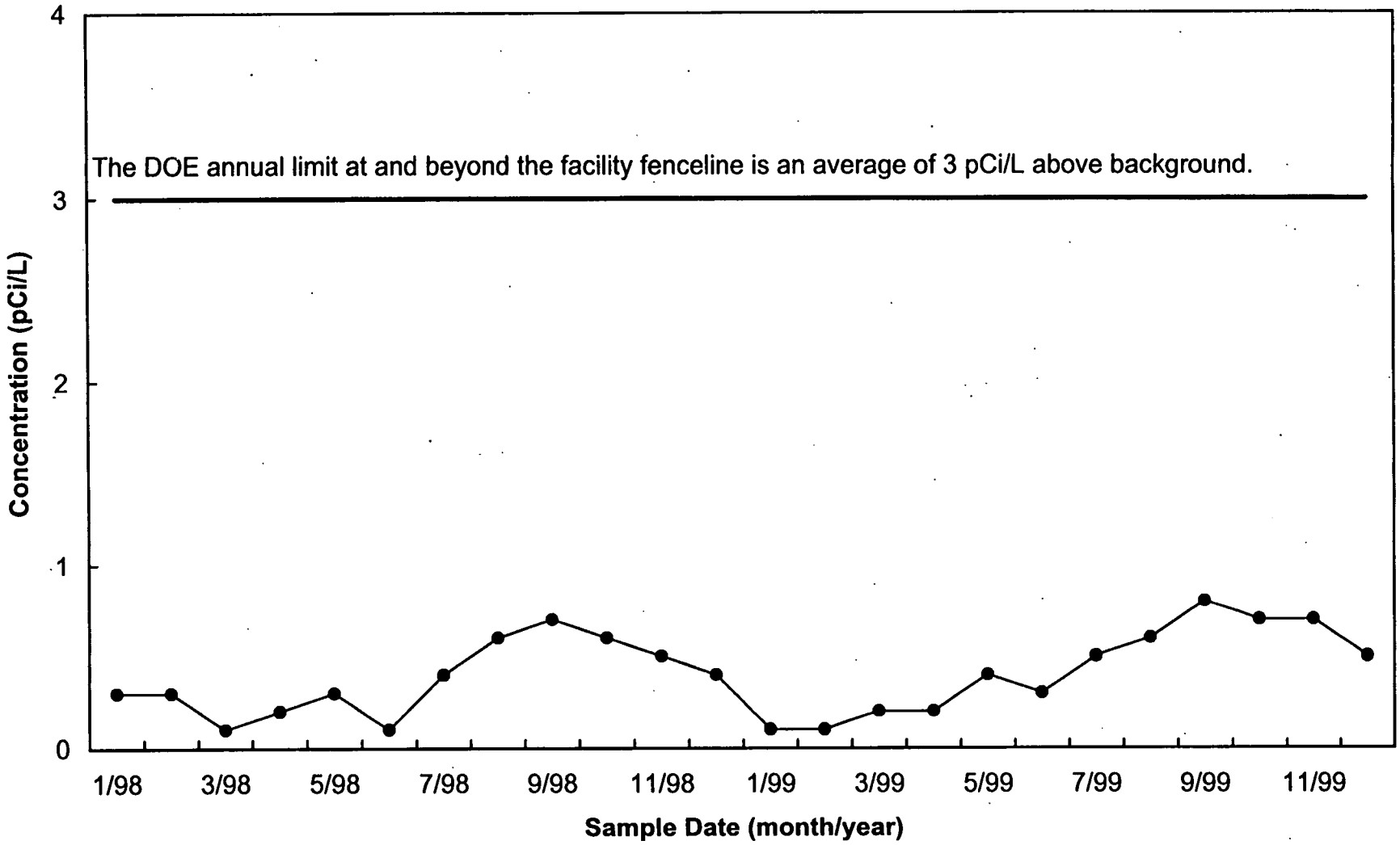



FIGURE C.2-4. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR AMS-04

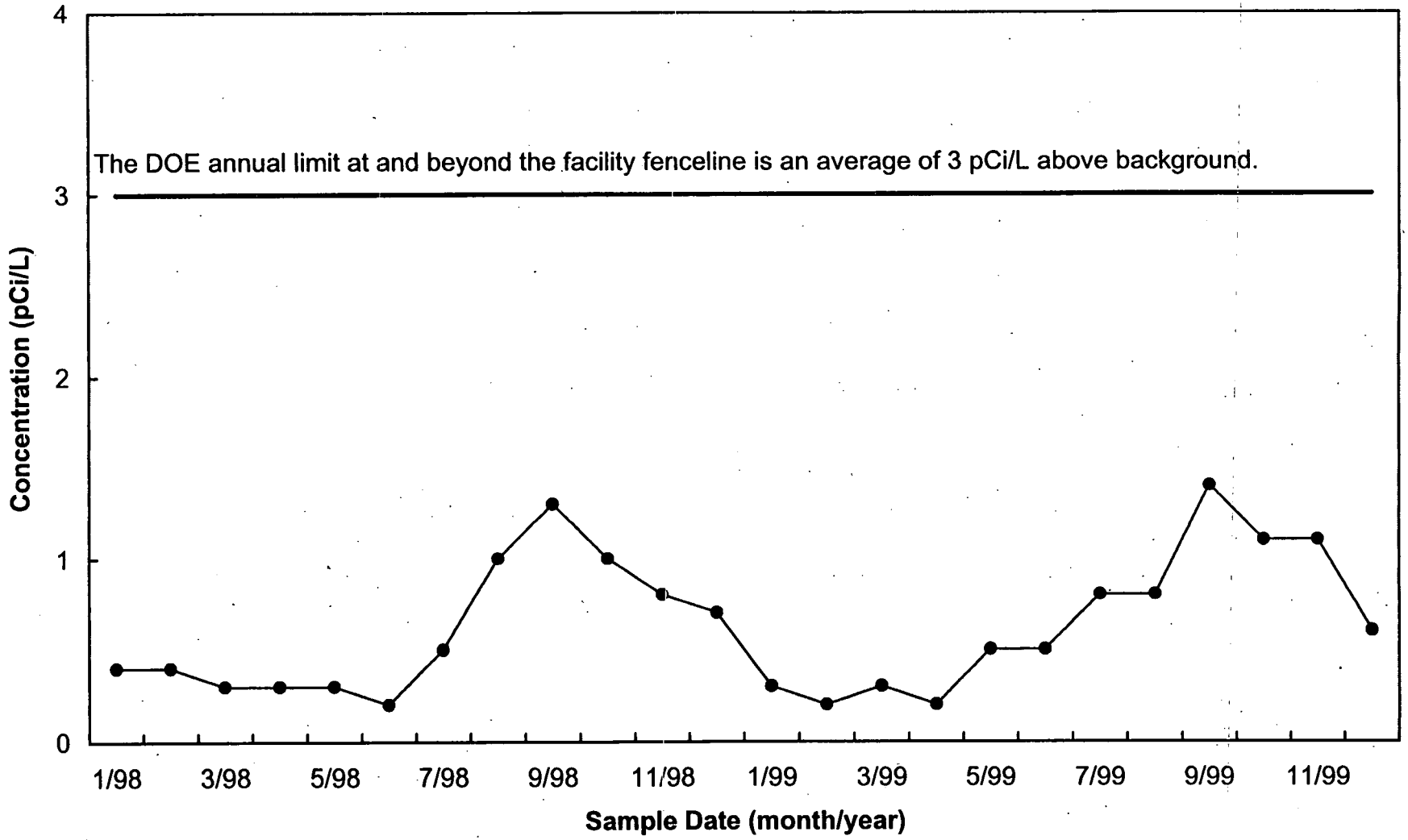



FIGURE C.2-5. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR AMS-05

000434

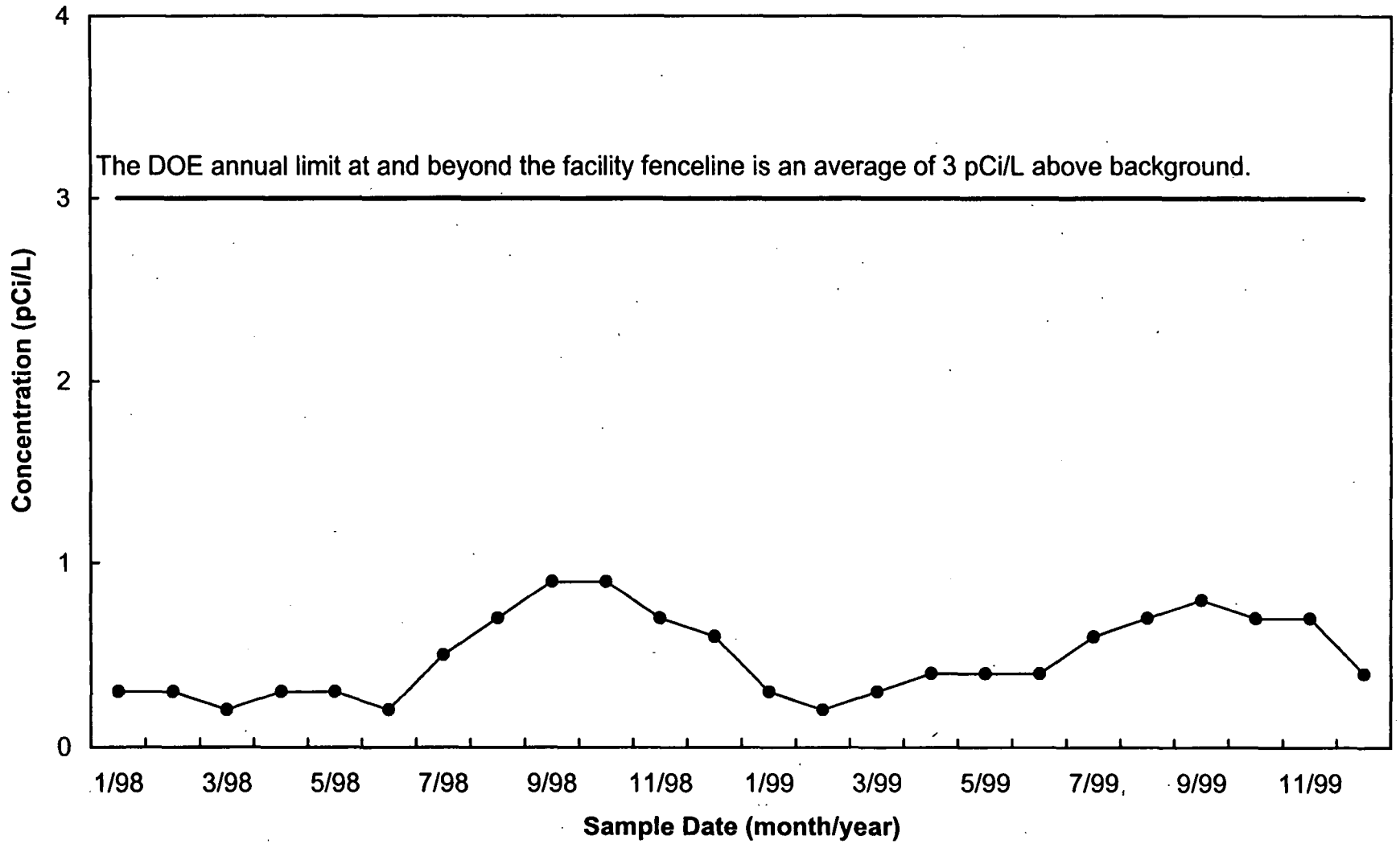



FIGURE C.2-6. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR AMS-06

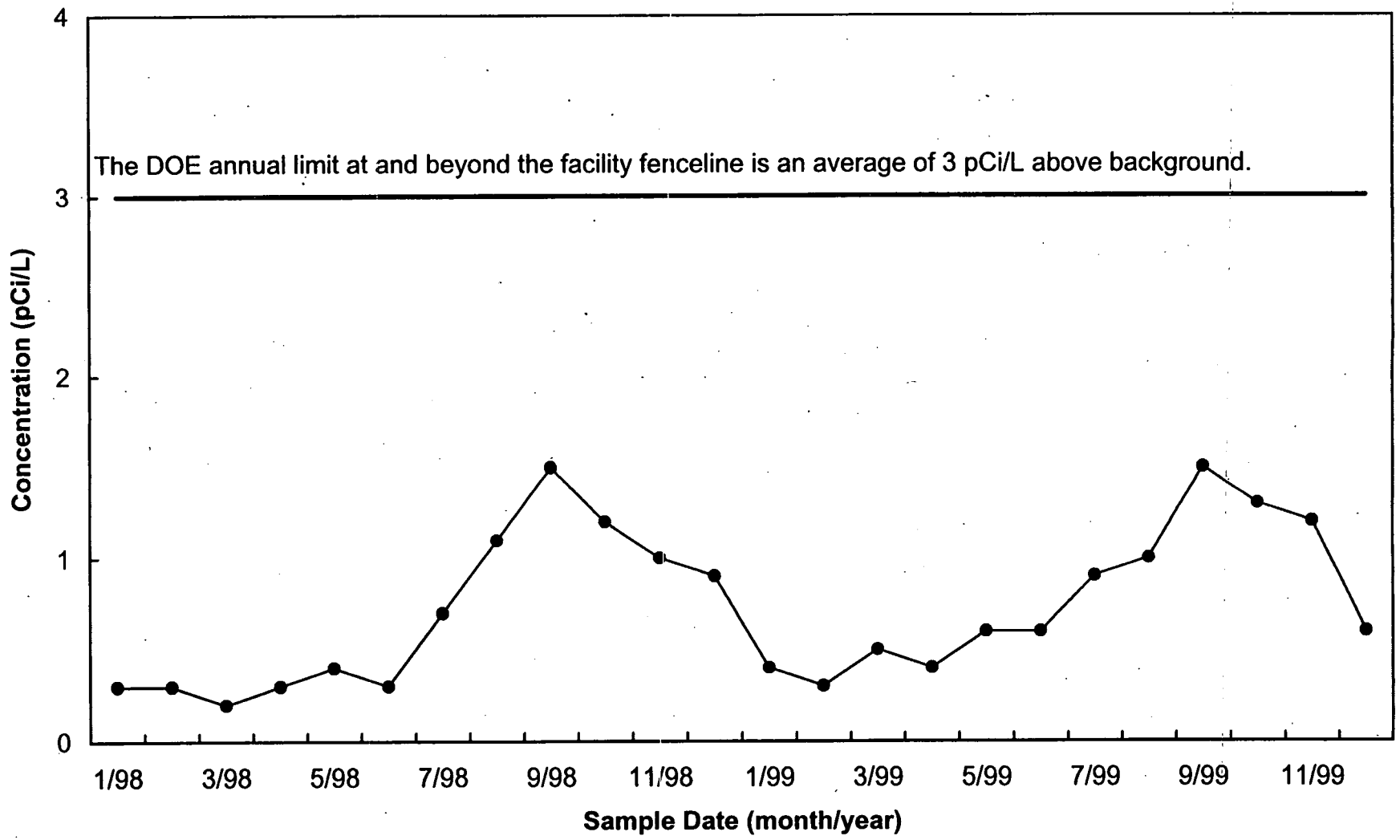



FIGURE C.2-7. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR AMS-07

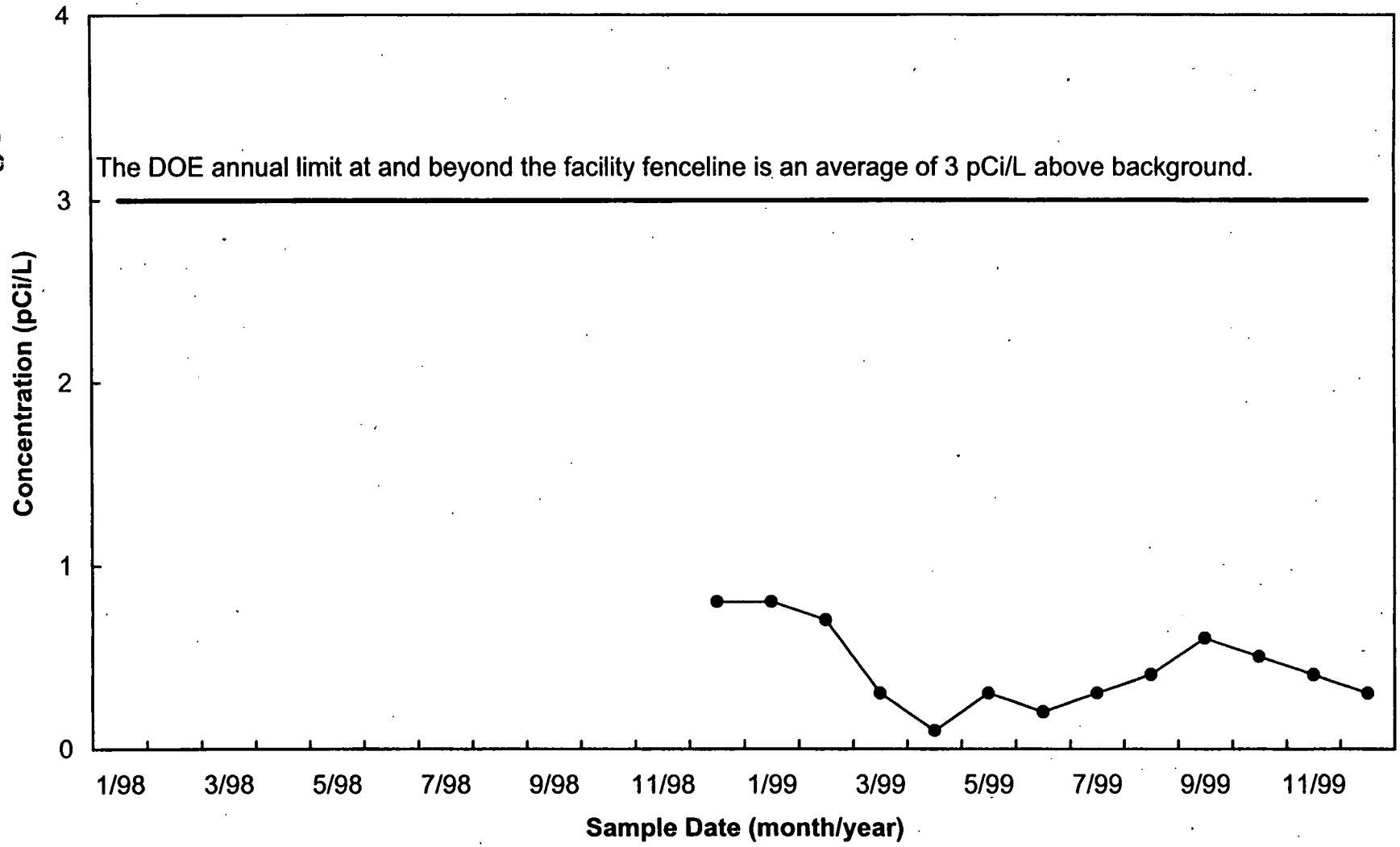



FIGURE C.2-8. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR AMS-08A

000436

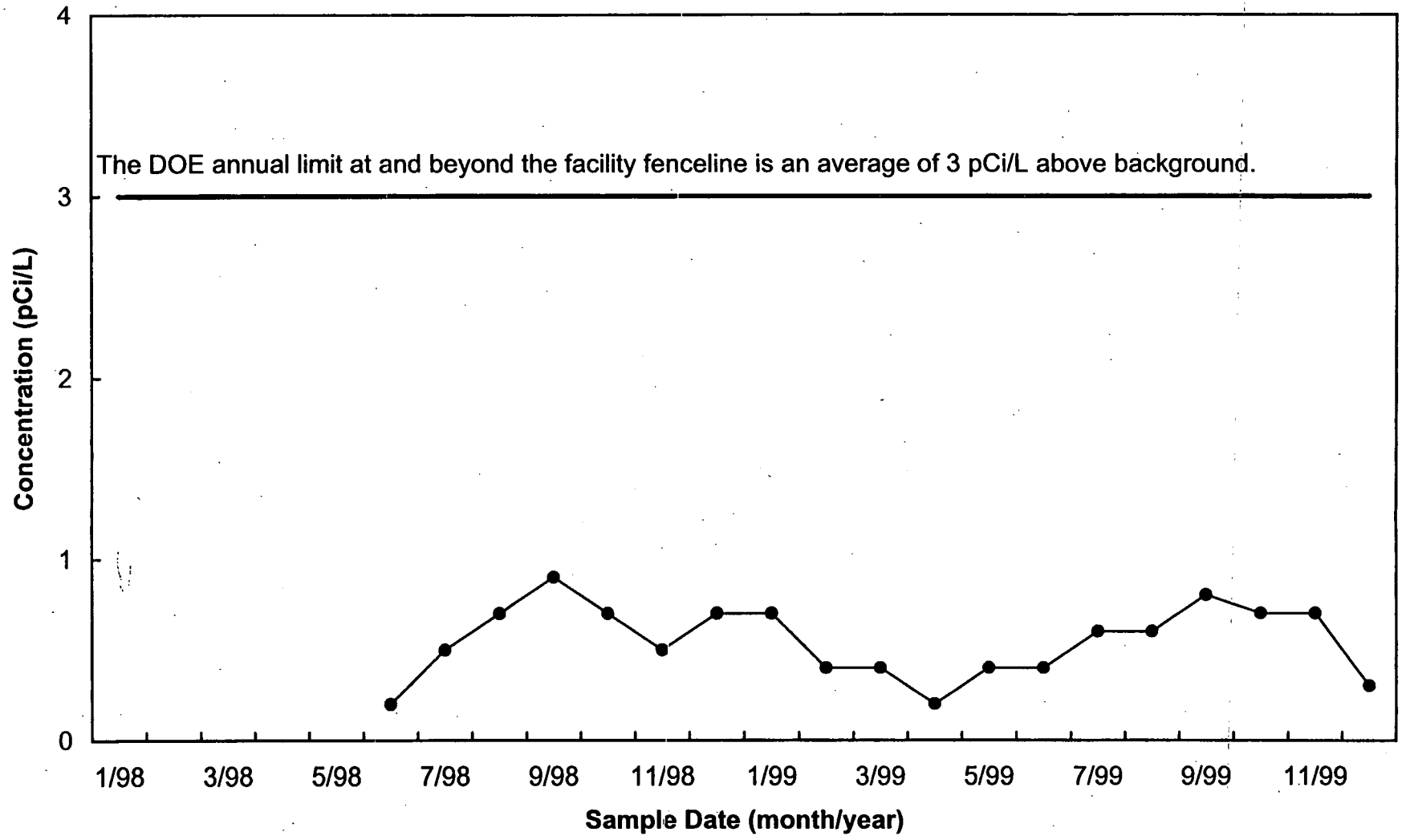



FIGURE C.2-9. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR AMS-09C



000437

000438

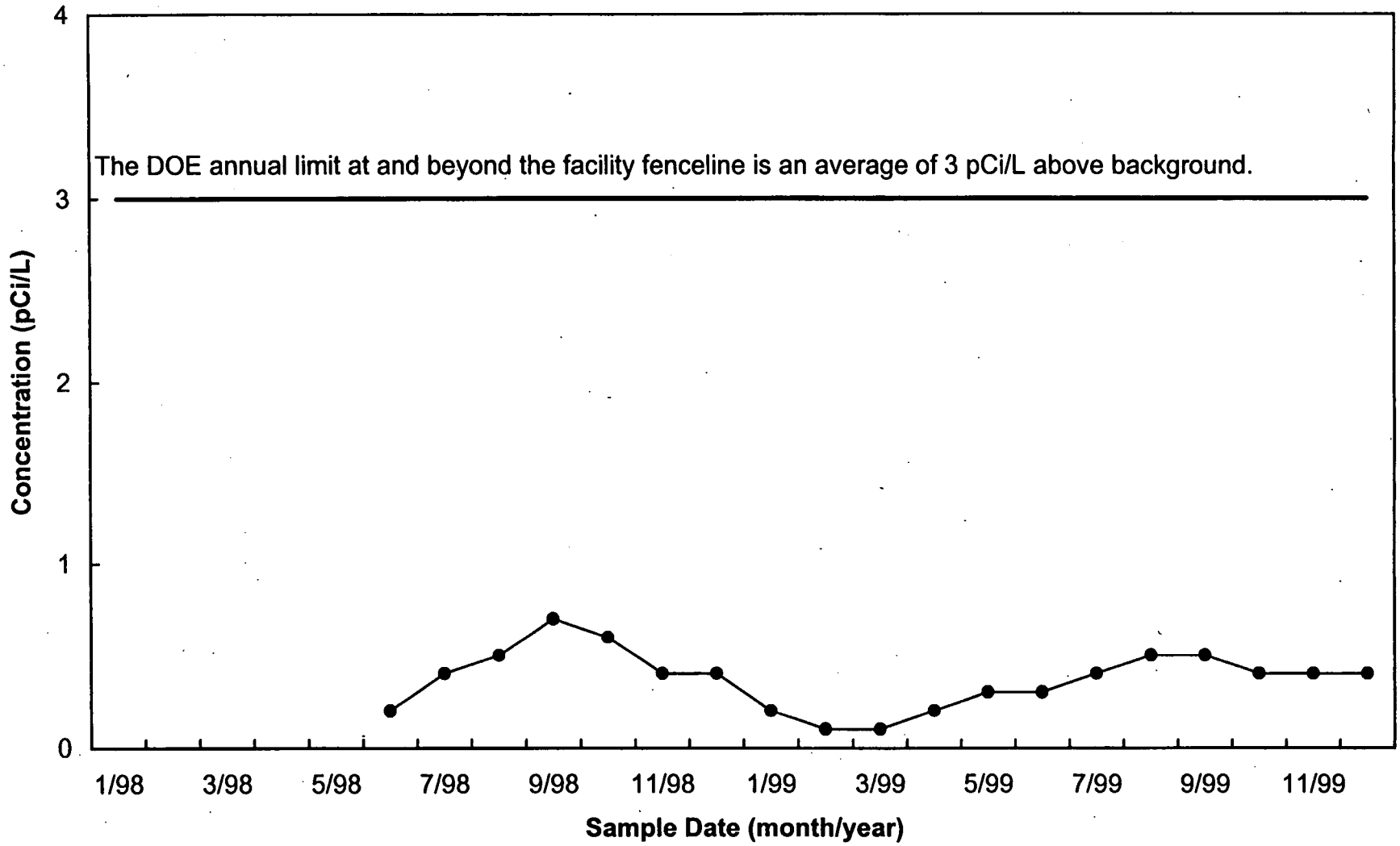



FIGURE C.2-10. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR AMS-22

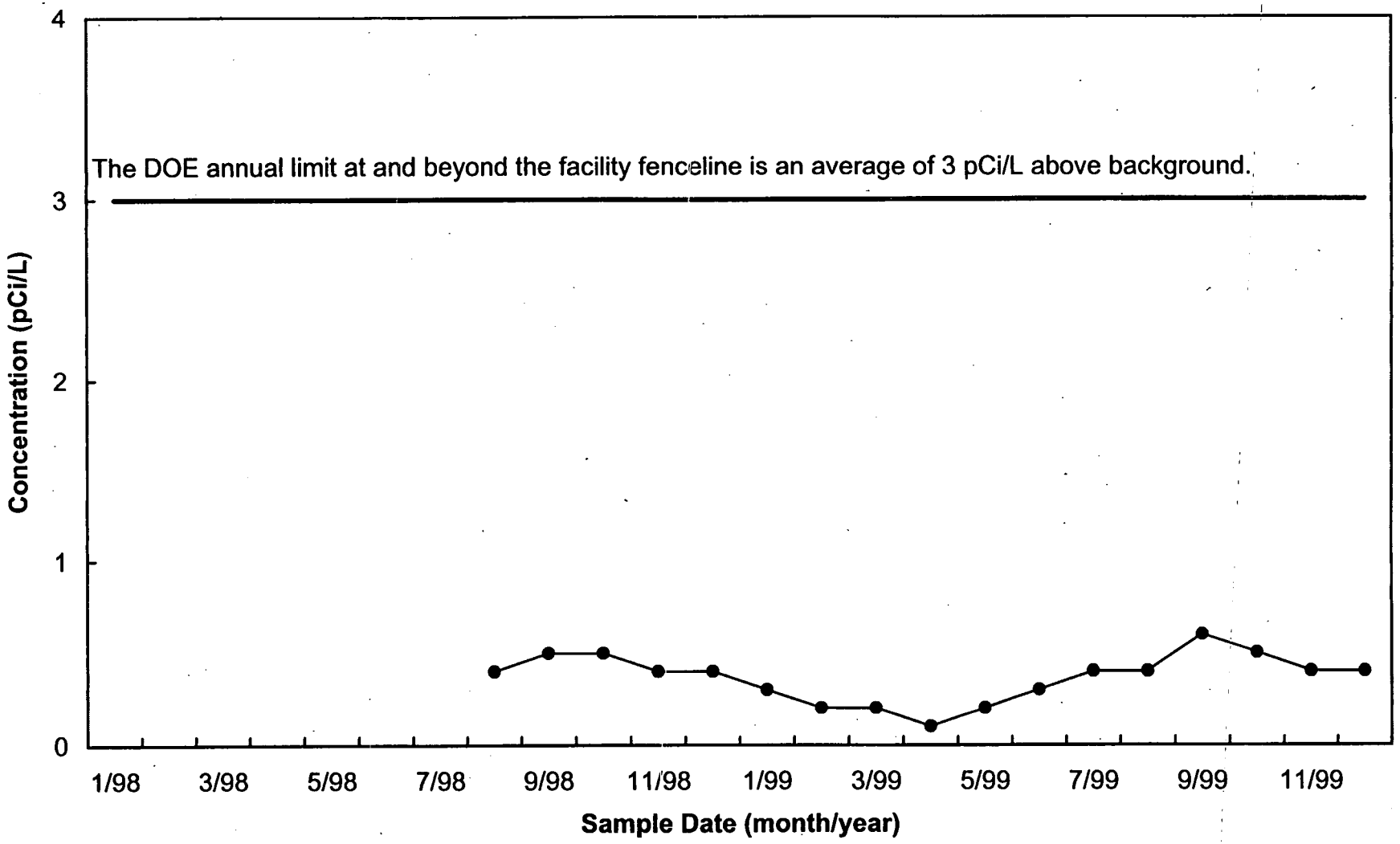



FIGURE C.2-11. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR AMS-23

0004439

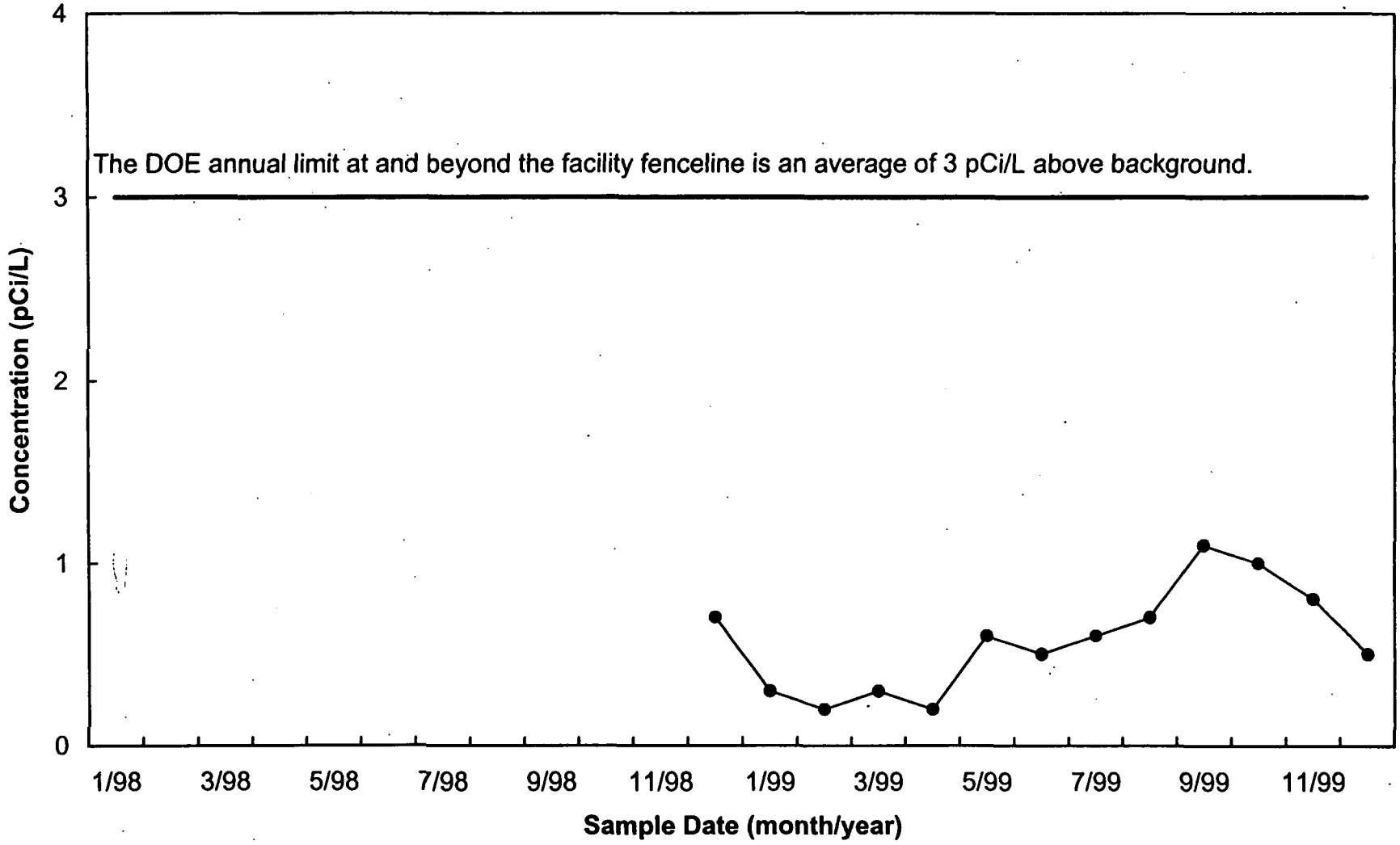



FIGURE C.2-12. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR AMS-24

000440

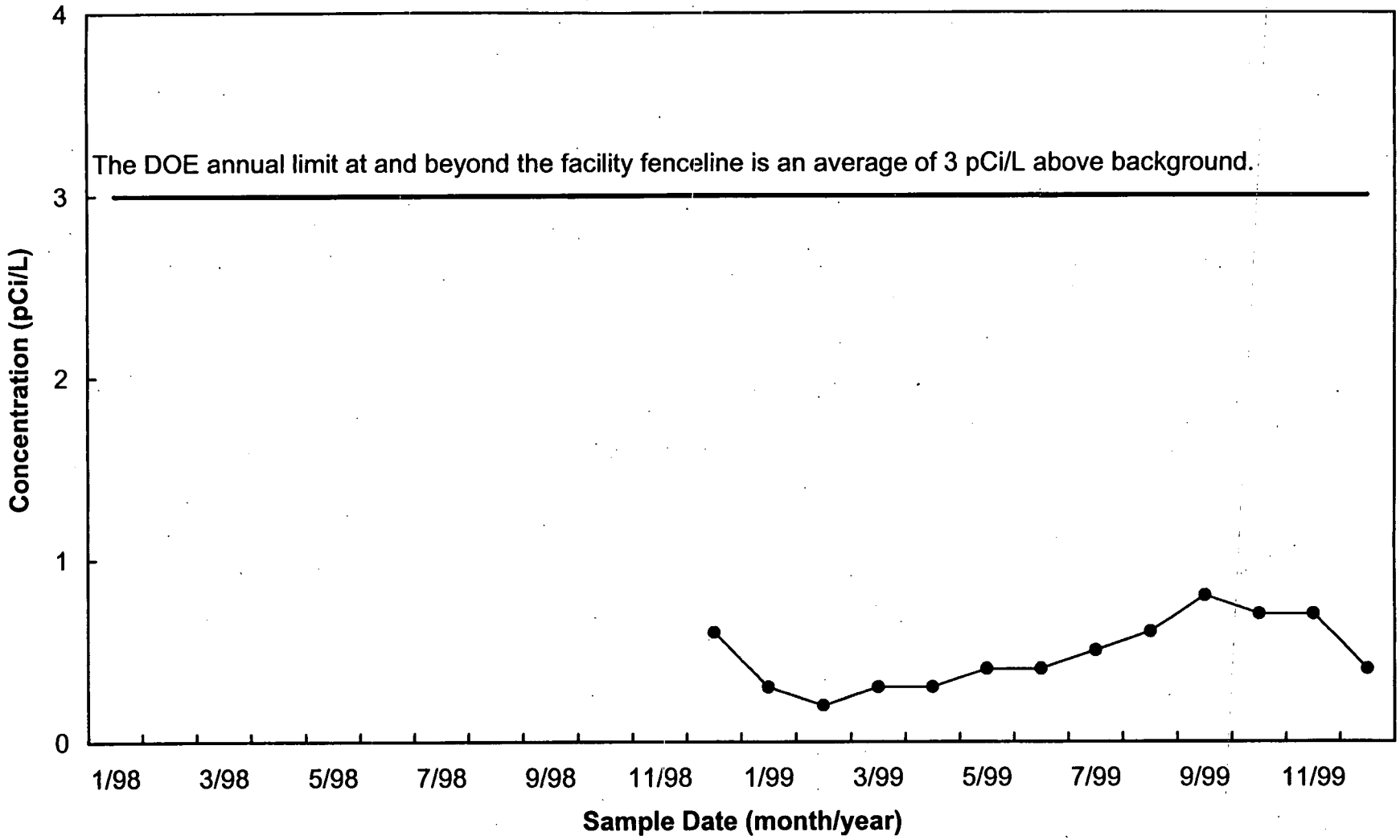



FIGURE C.2-13. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR AMS-25



000443

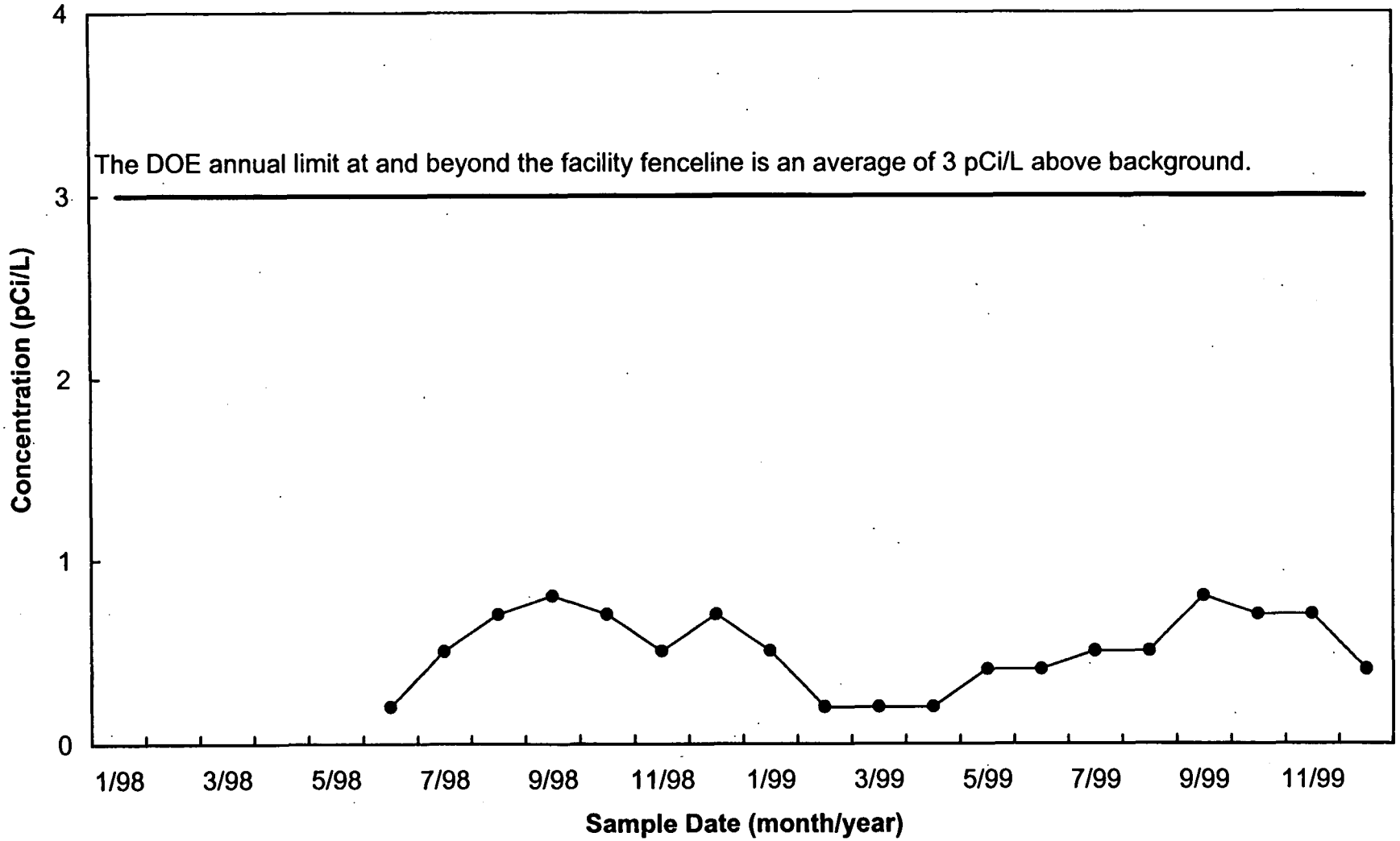



FIGURE C.2-14. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR AMS-26

000442

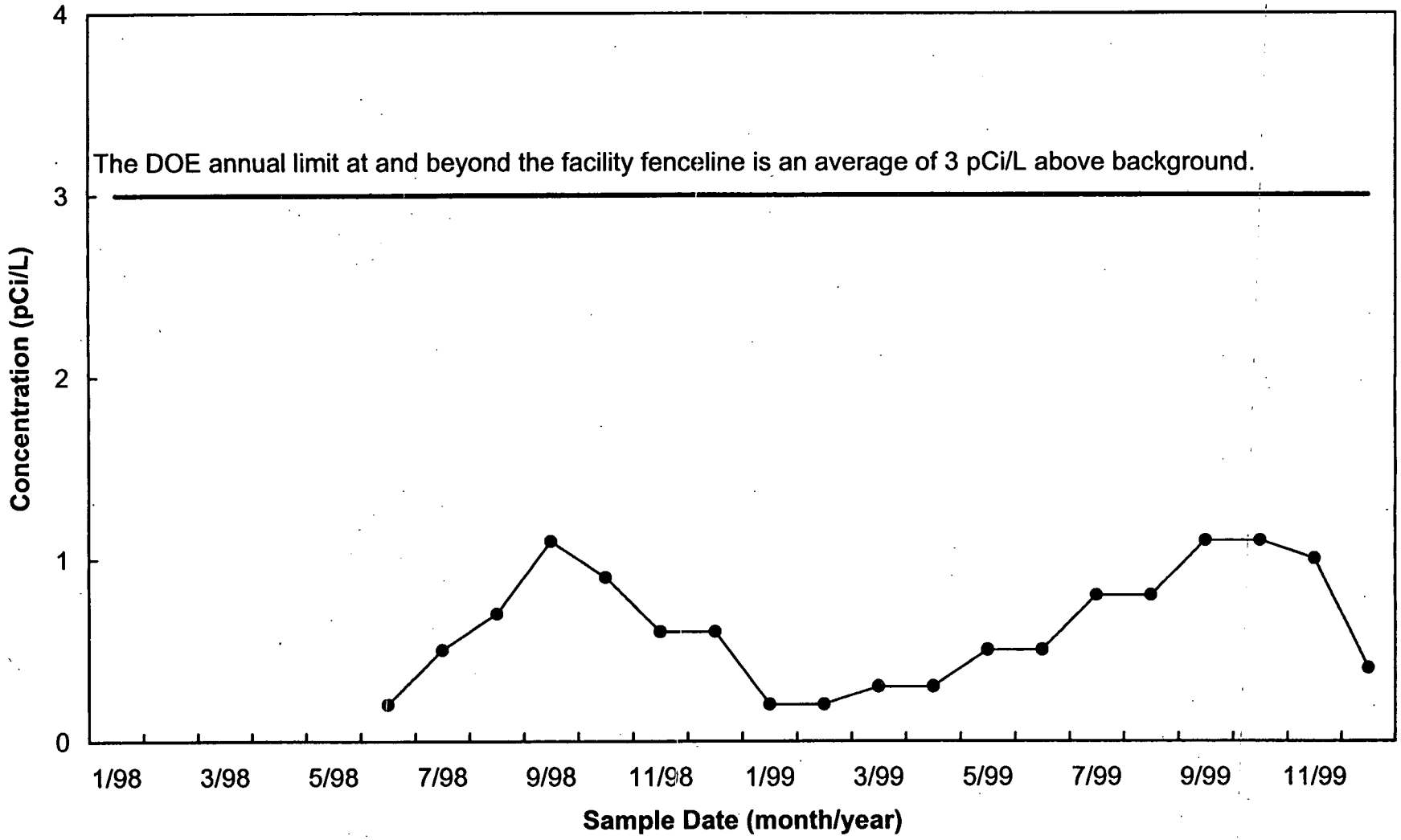



FIGURE C.2-15. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR AMS-27



000423

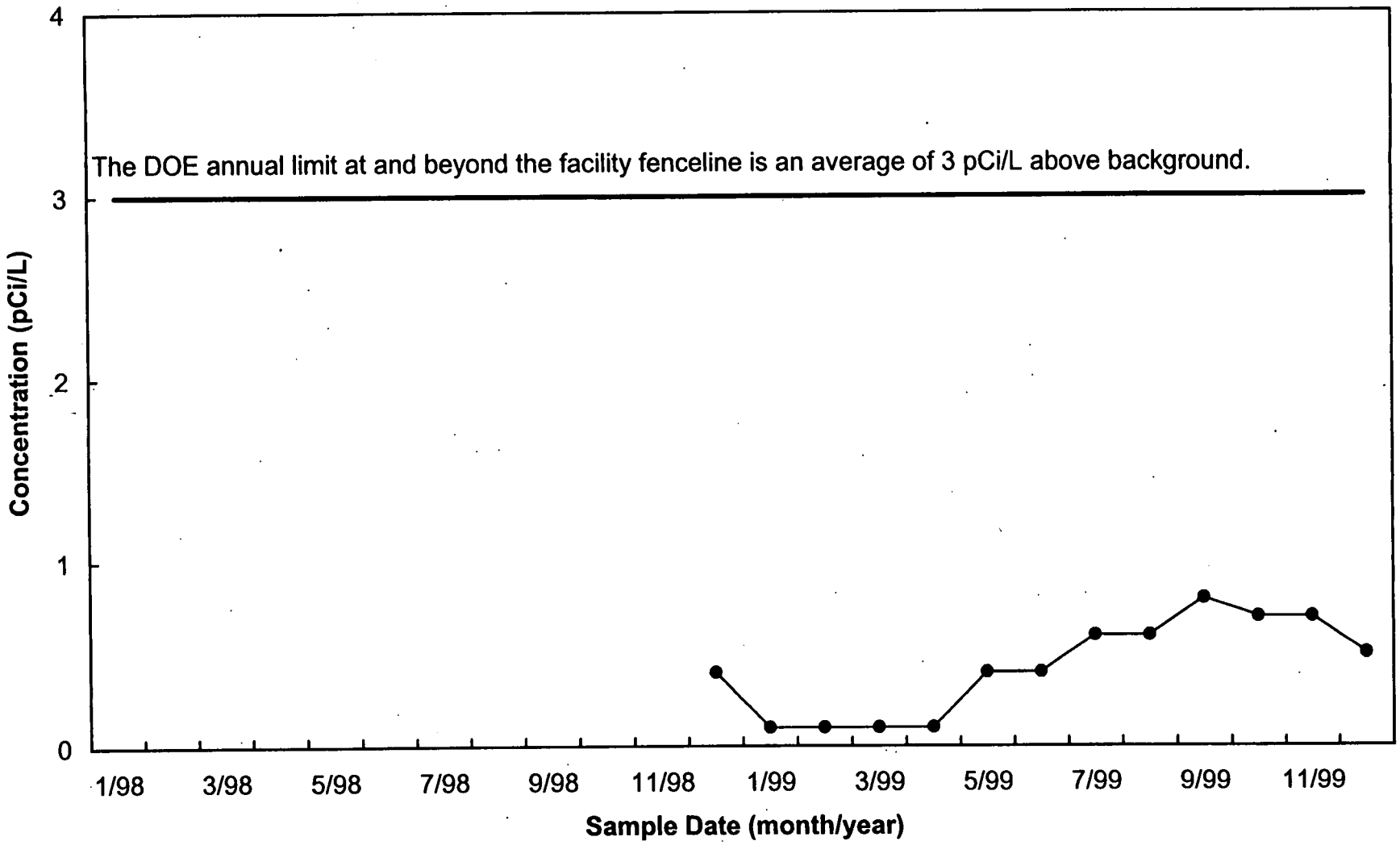



FIGURE C.2-16. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR AMS-28

000144

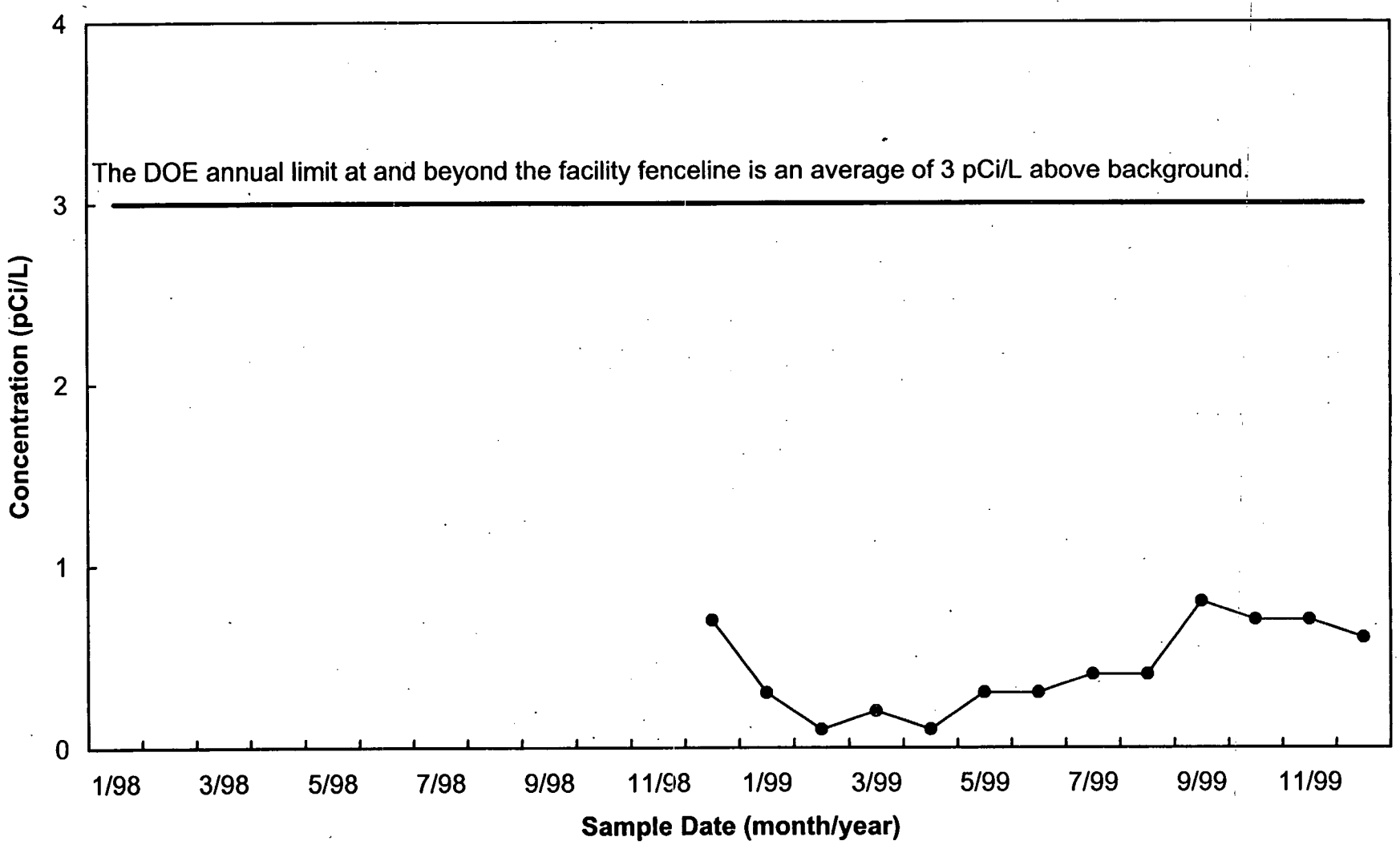



FIGURE C.2-17. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR AMS-29

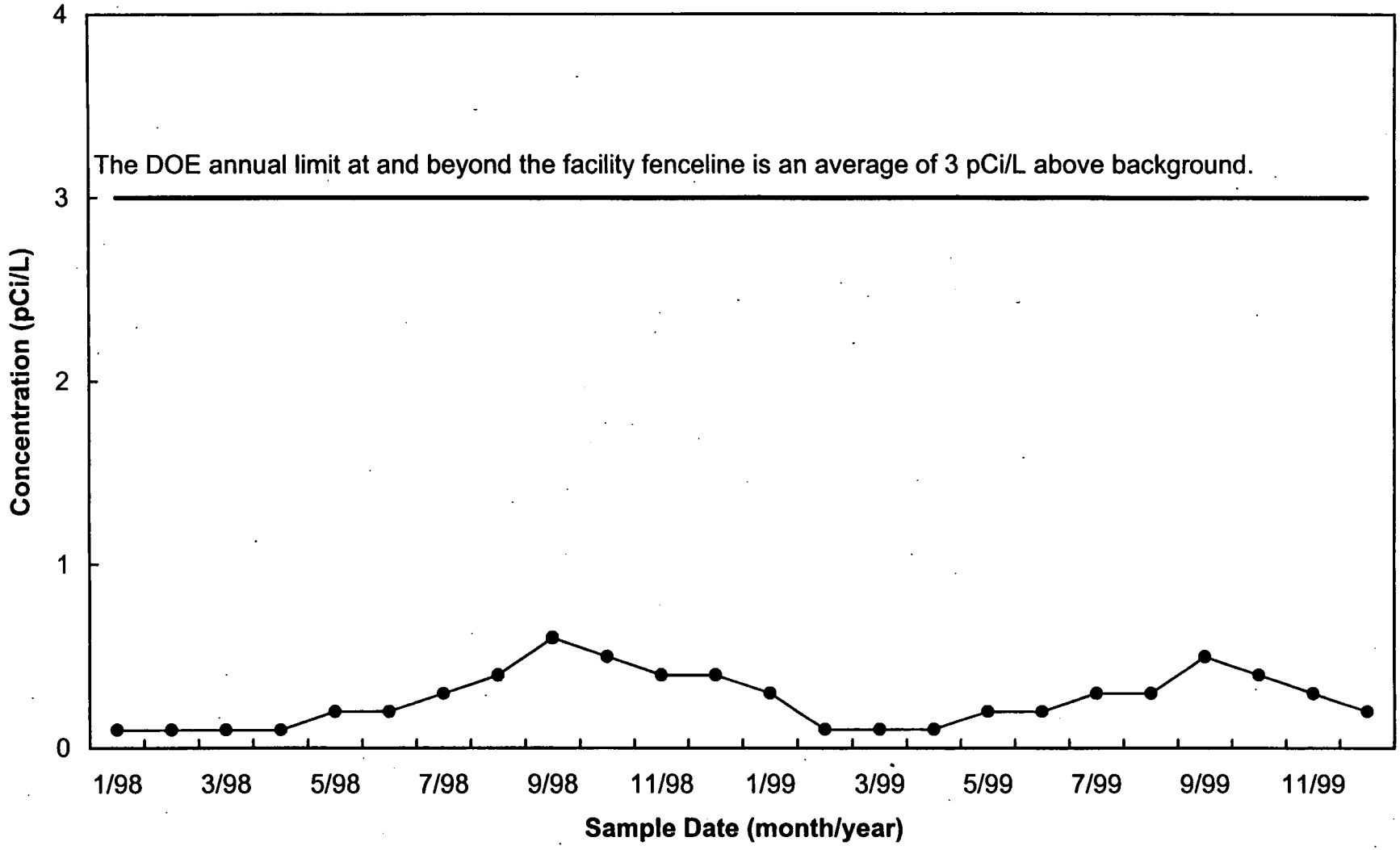



FIGURE C.2-18. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR AMS-12

000466

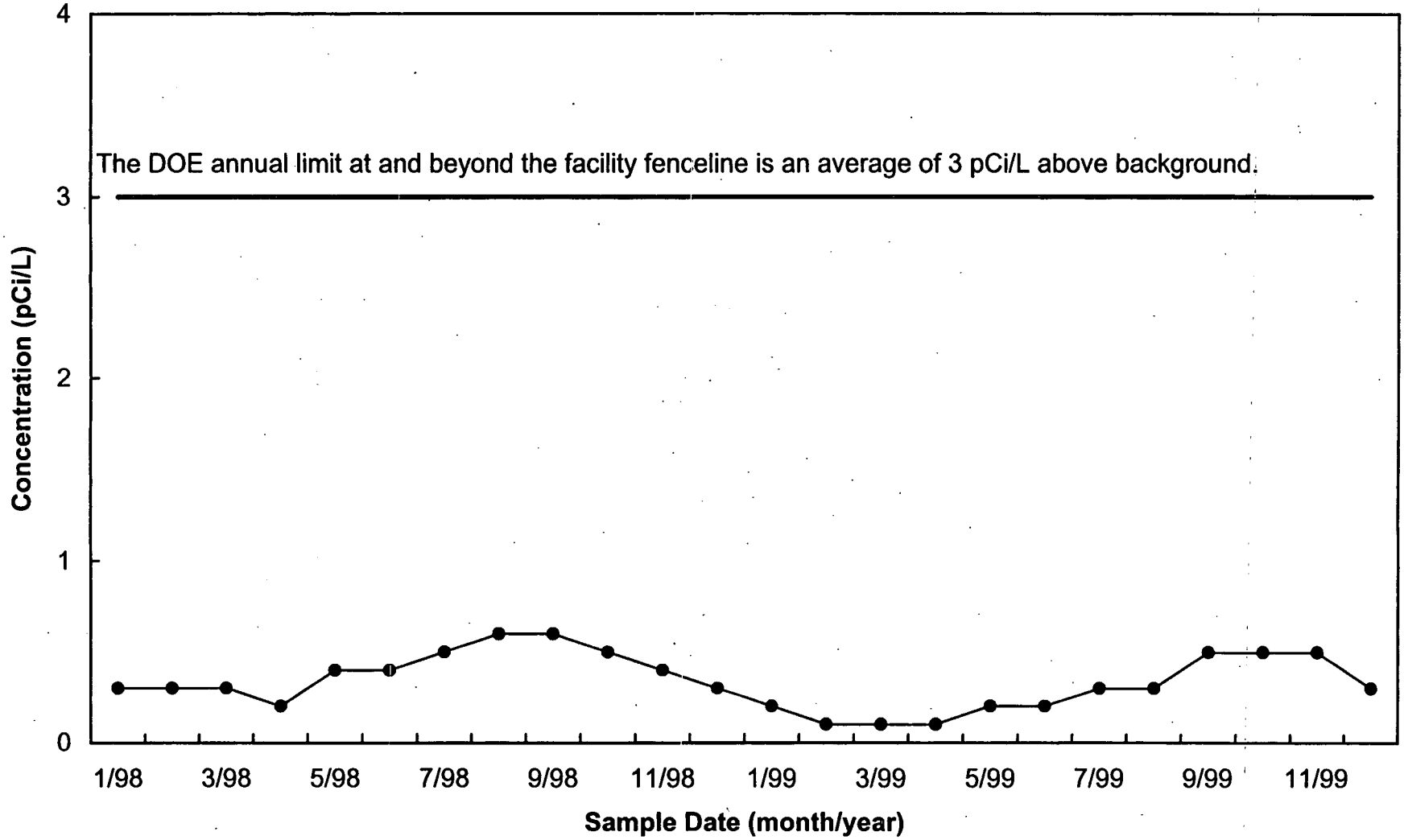



FIGURE C.2-19. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR AMS-16



000447

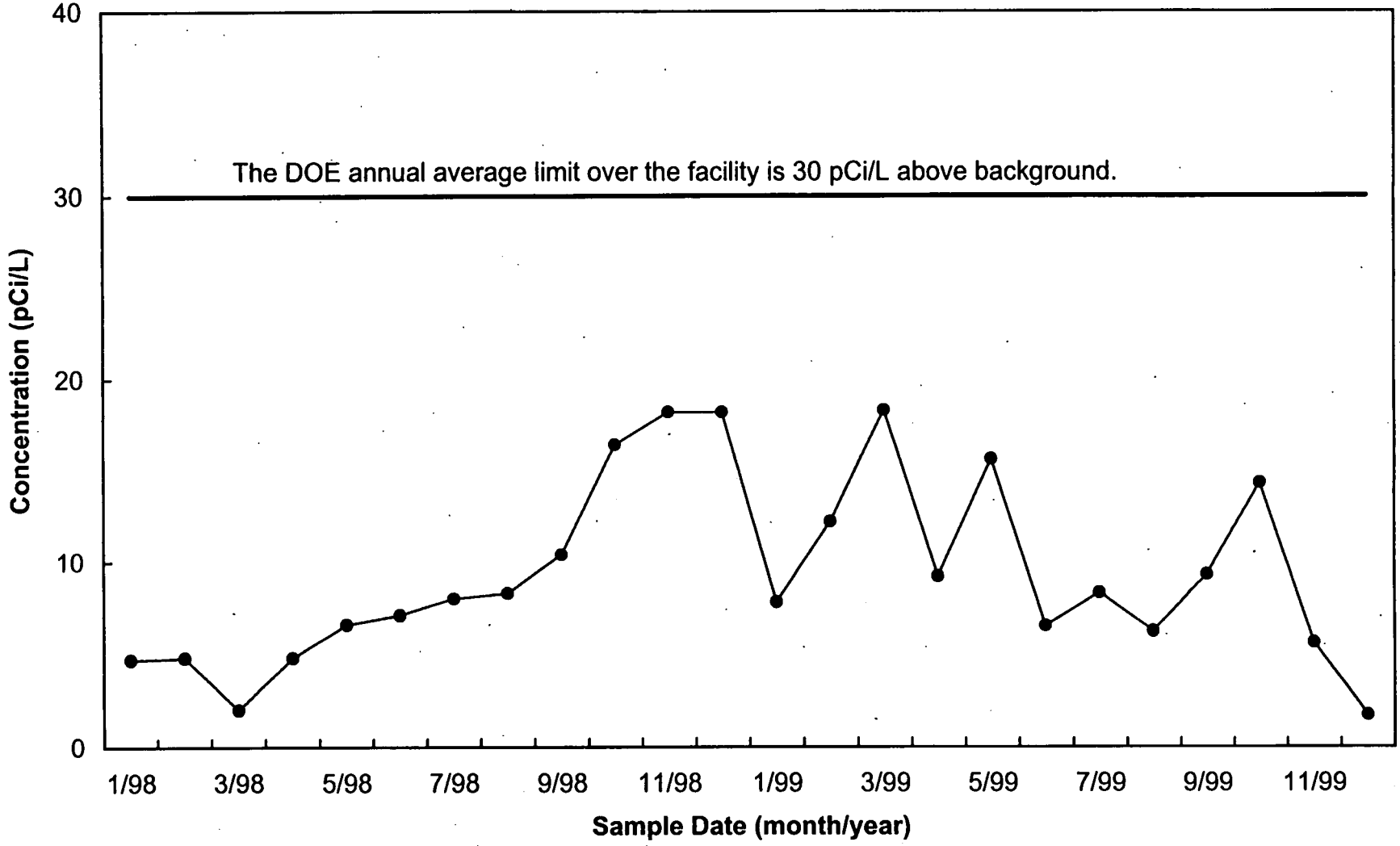



FIGURE C.2-20. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR KNE

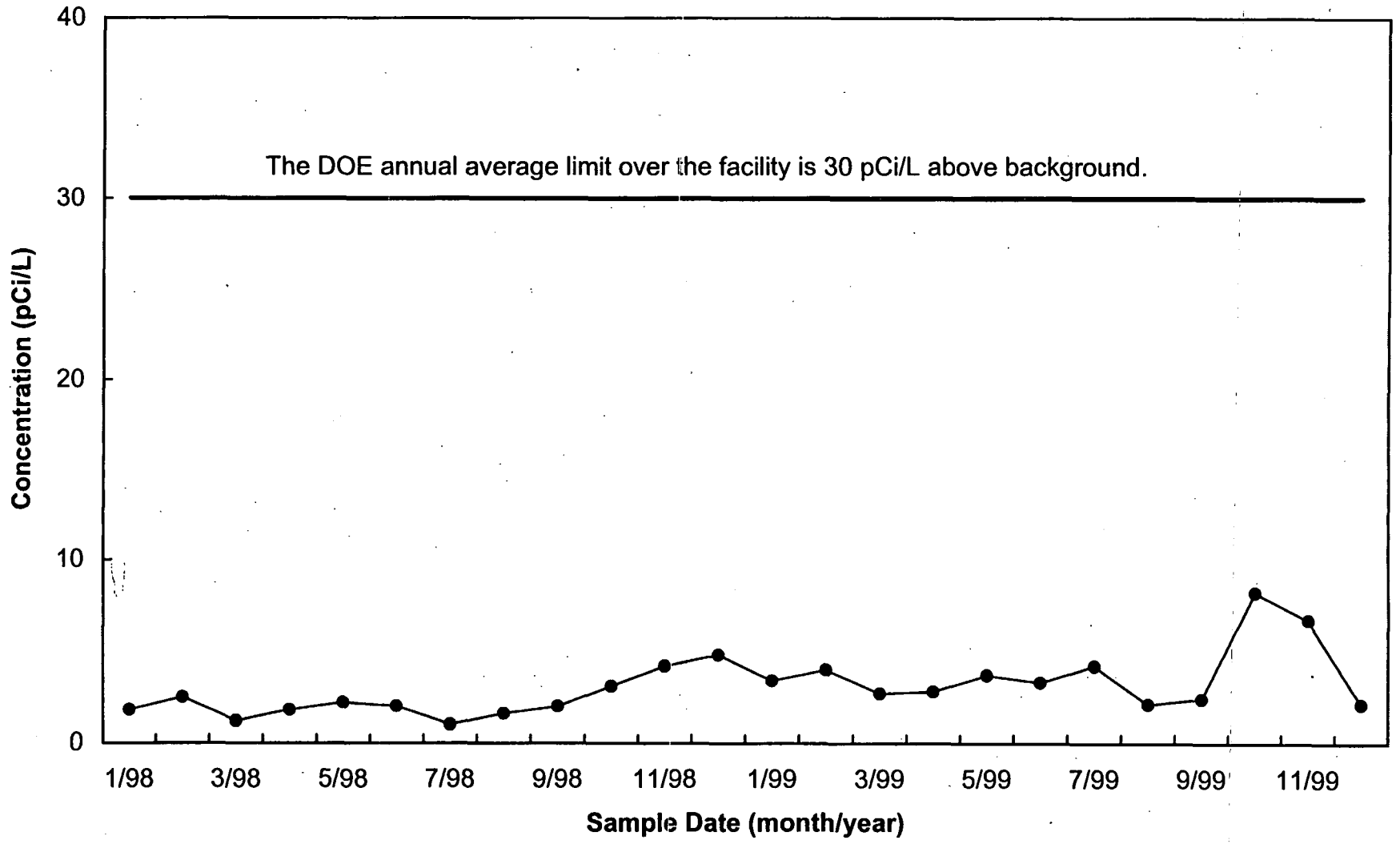



FIGURE C.2-21. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR KNW

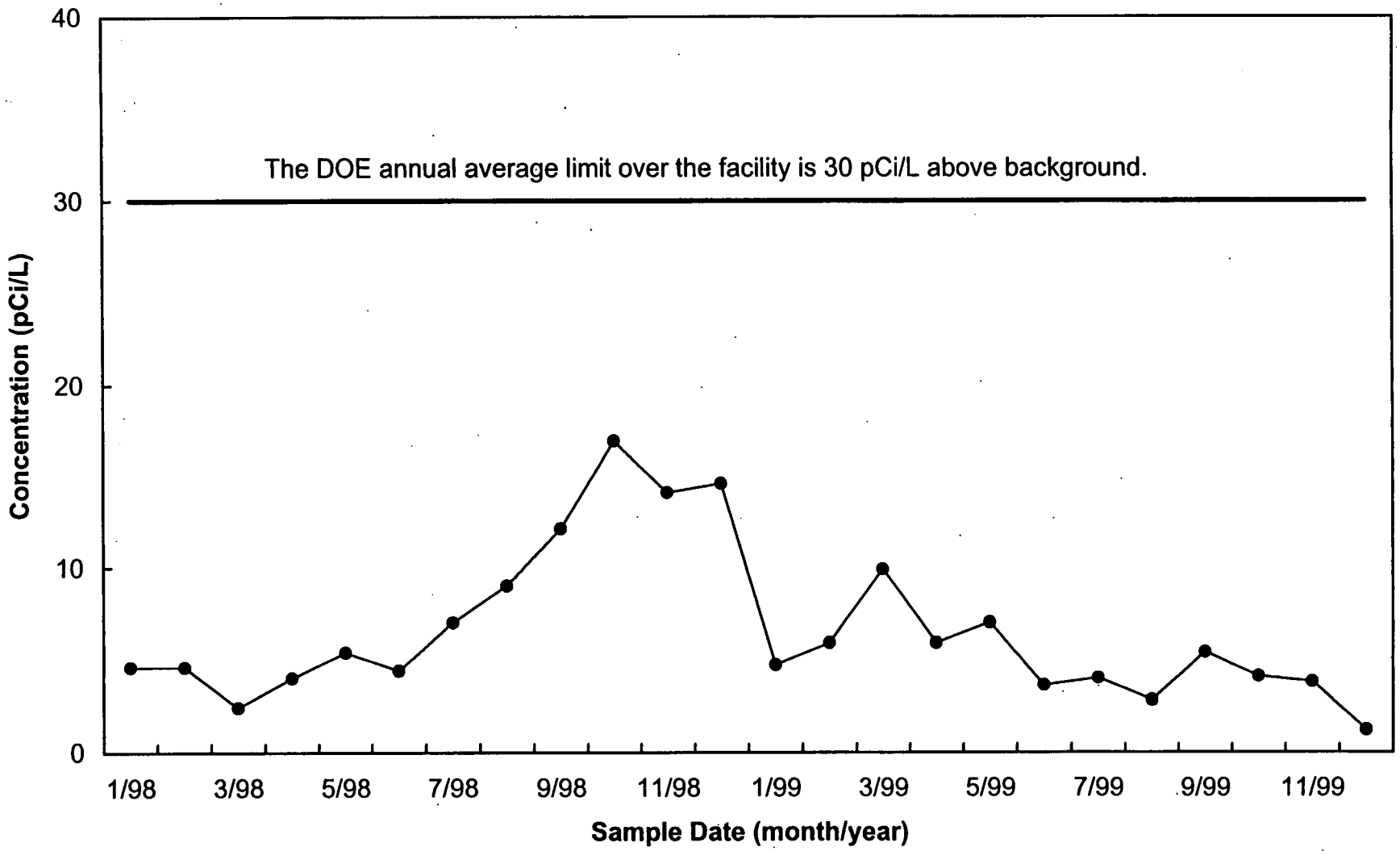



FIGURE C.2-22. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR KSE

000450

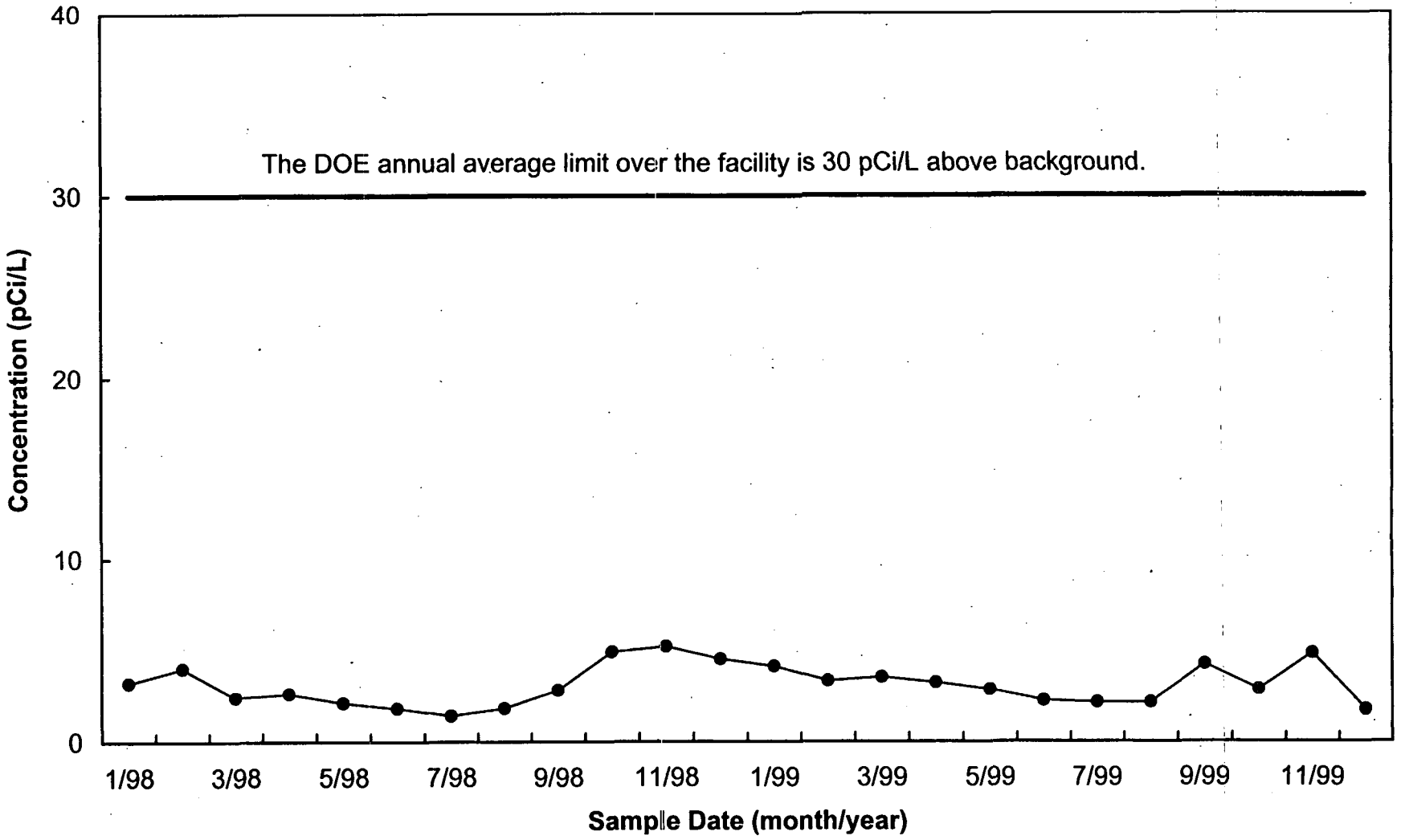



FIGURE C.2-23. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR KSW



000454

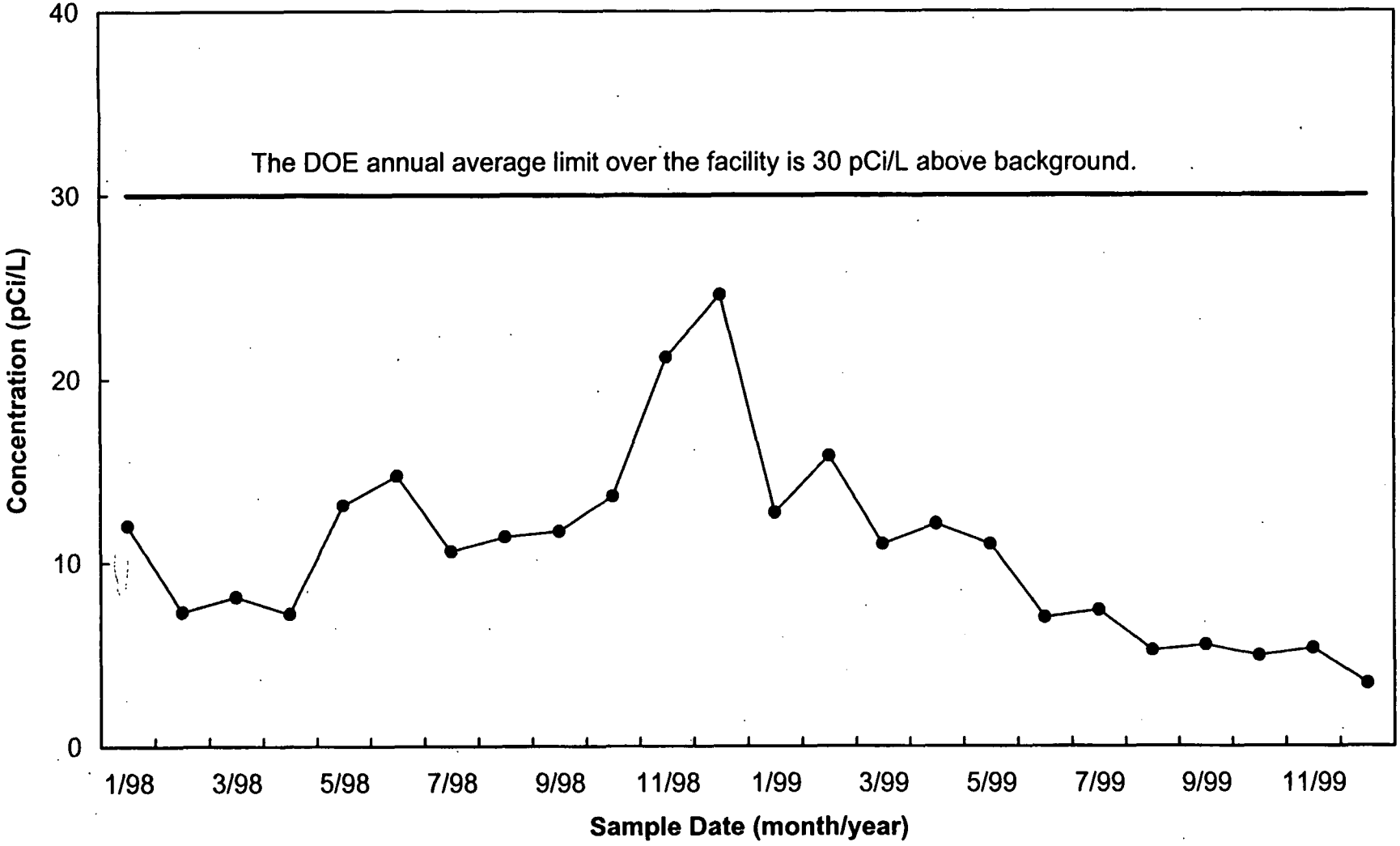



FIGURE C.2-24. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR KTOP

000452

Note: The DOE annual average limit over the facility is 30 pCi/L above background.

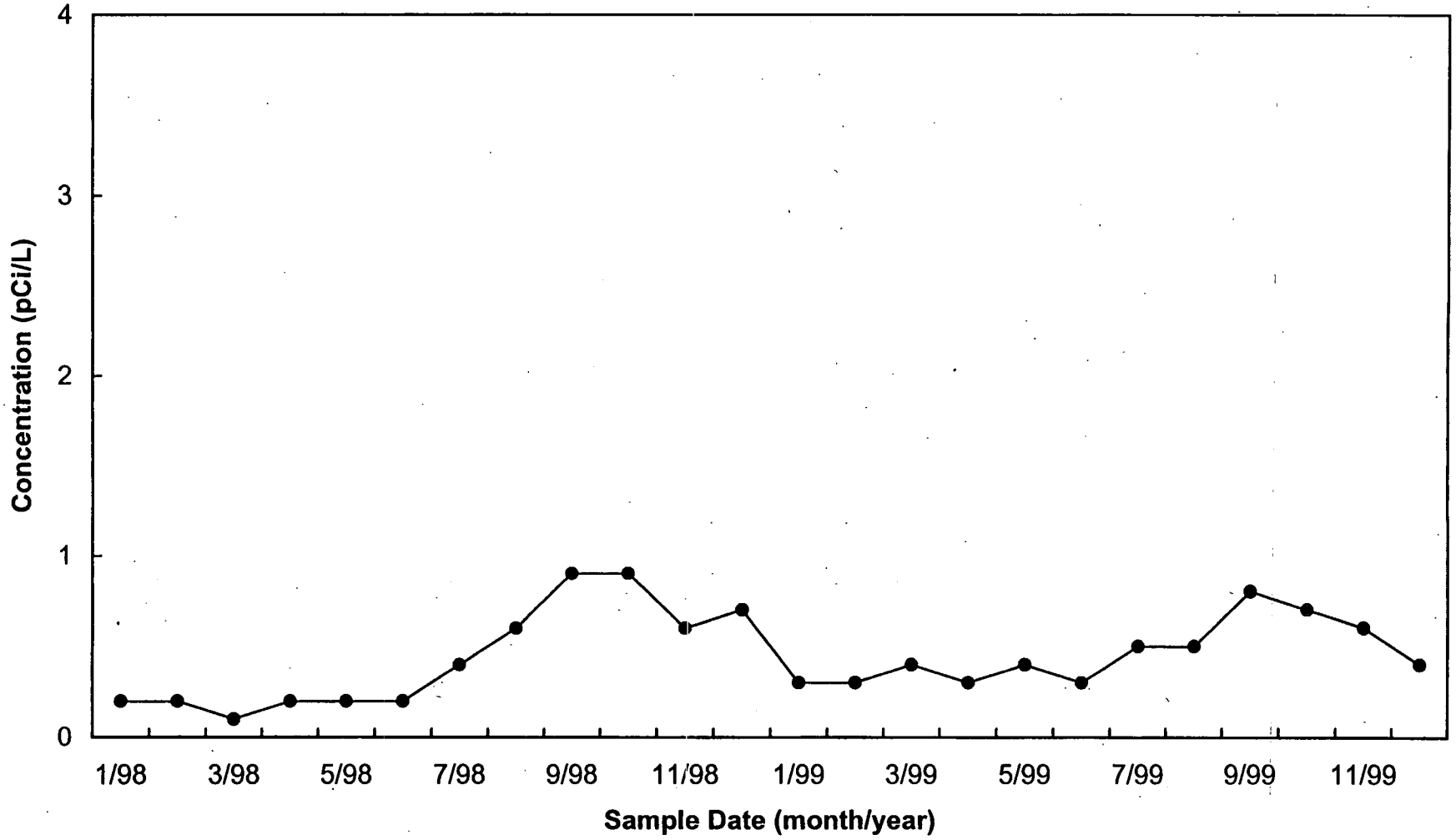



FIGURE C.2-25. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR PILOT PLANT WAREHOUSE

Note: The DOE annual average limit over the facility is 30 pCi/L above background.

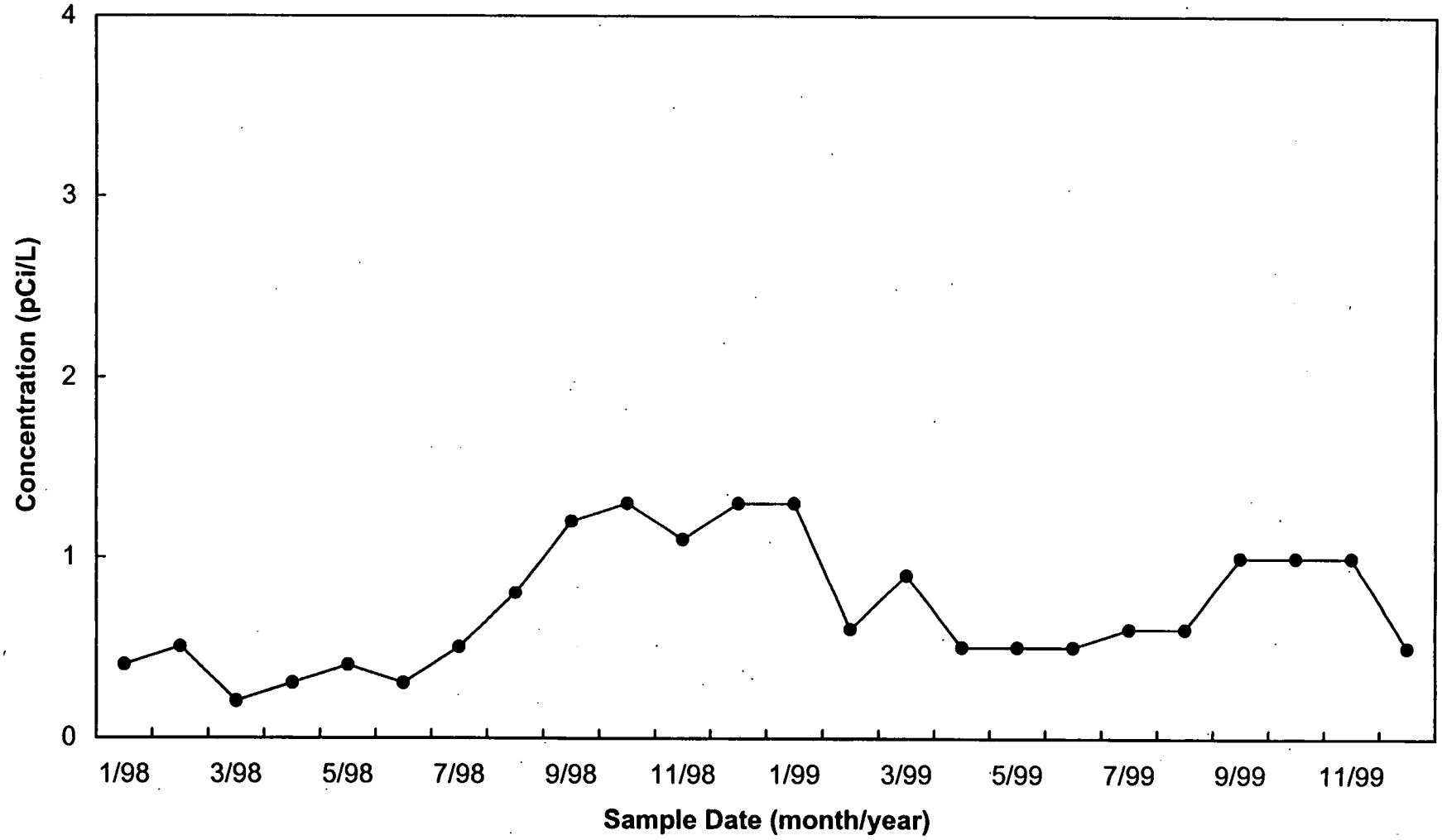



FIGURE C.2-26. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR RALLY POINT 4

000459

Note: The DOE annual average limit over the facility is 30 pCi/L above background.

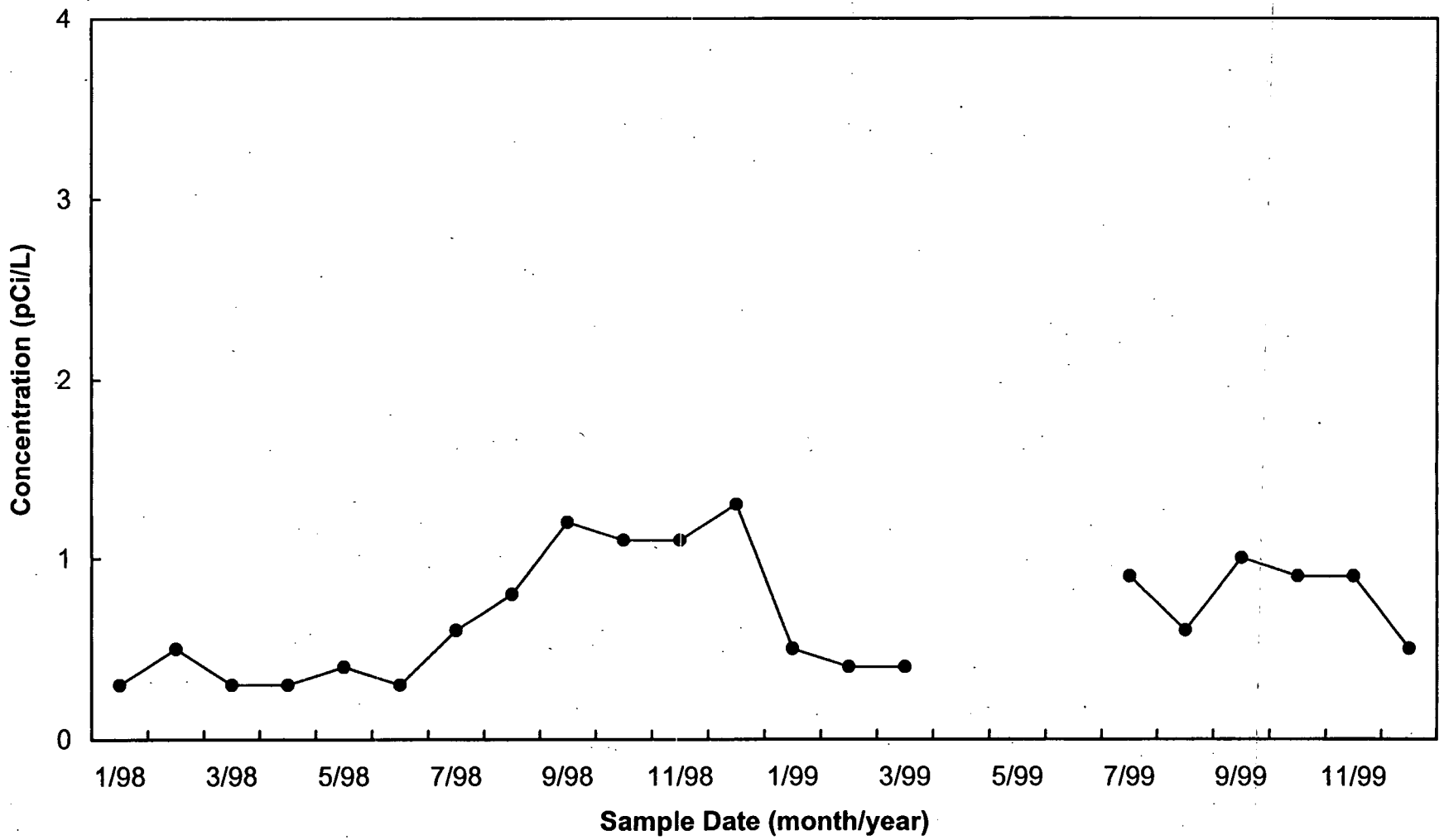



FIGURE C.2-27. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR SURGE LAGOON



000455

000459

Note: The DOE annual average limit over the facility is 30 pCi/L above background.

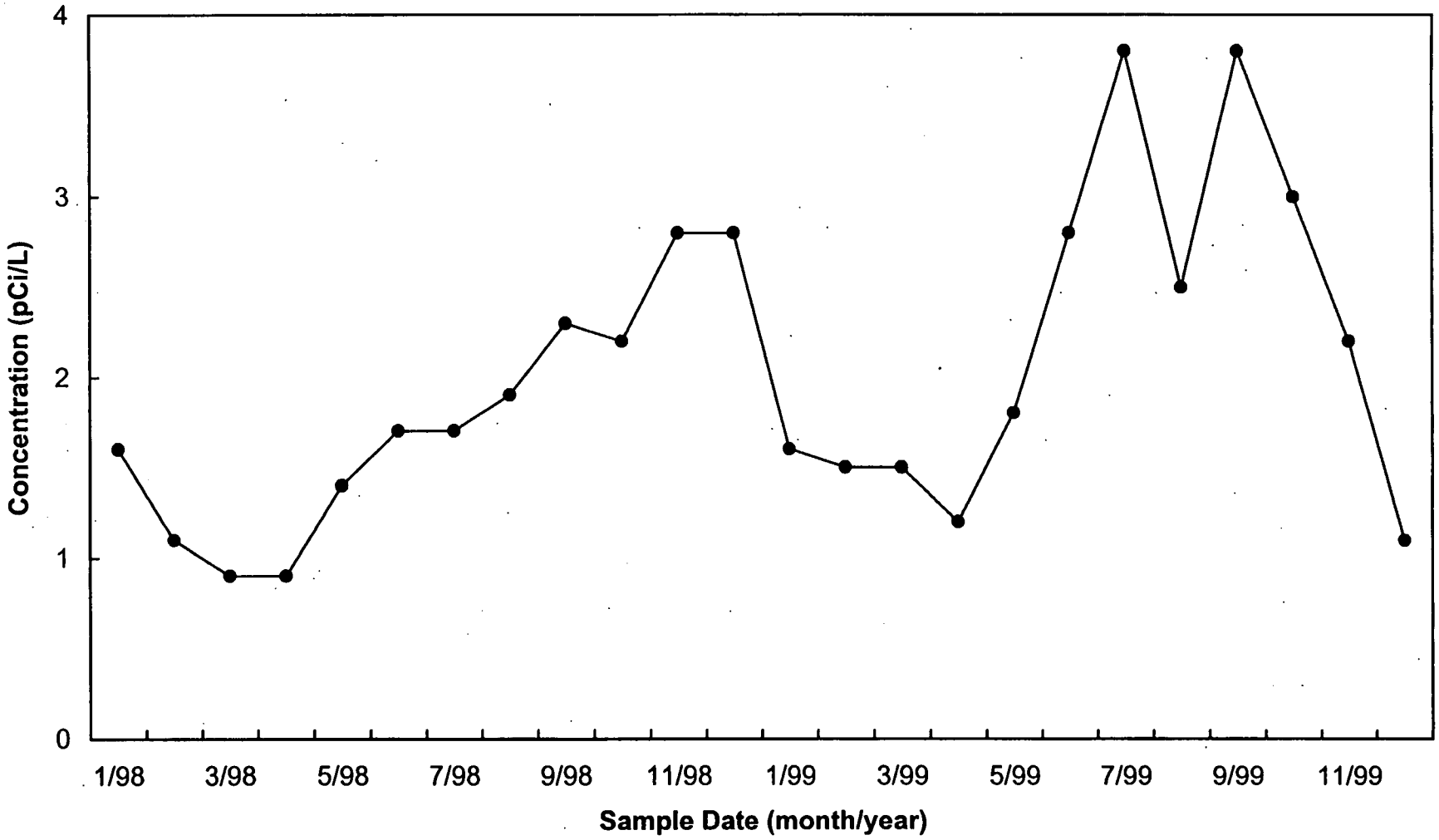



FIGURE C.2-28. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR T28

Note: The DOE annual average limit over the facility is 30 pCi/L above background.

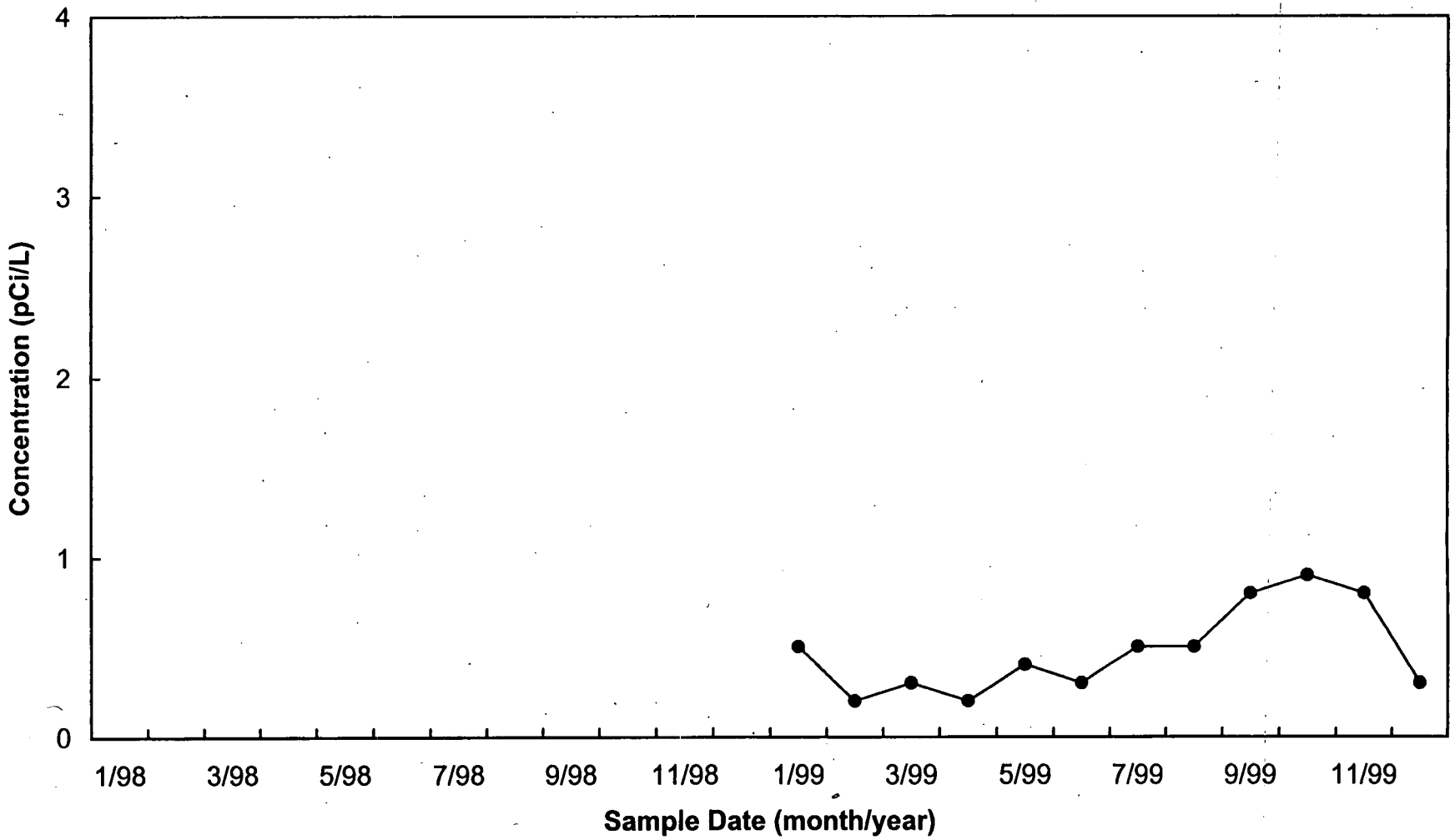



FIGURE C.2-29. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR TS4

Note: The DOE annual average limit over the facility is 30 pCi/L above background.

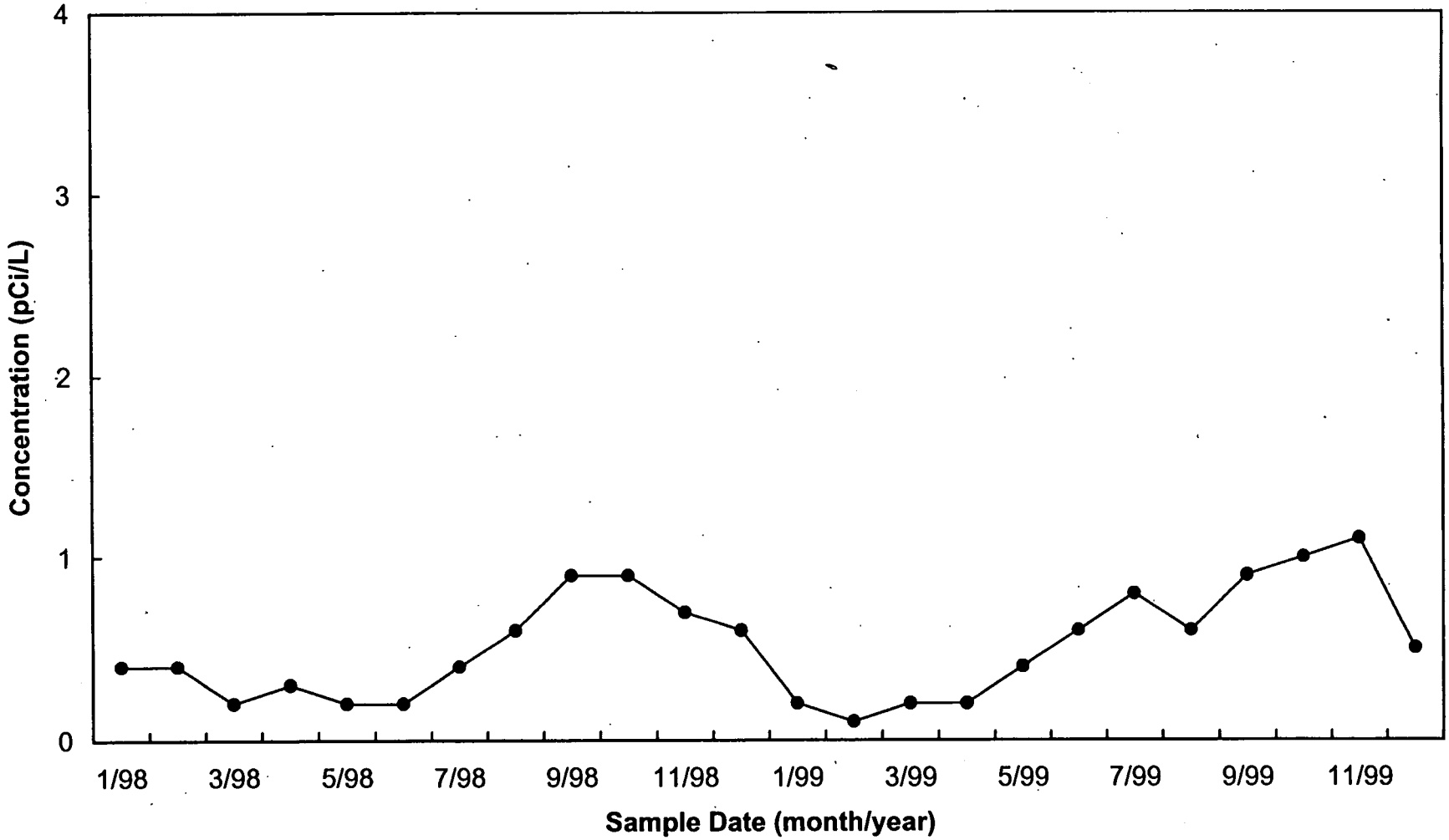



FIGURE C.2-30. 1998 AND 1999 MONTHLY AVERAGE RADON CONCENTRATION FOR WP-17A

0004158

**ATTACHMENT C.3**

**DIRECT RADIATION**

# ATTACHMENT C.3

Direct radiation measurements were conducted at 32 locations using thermoluminescent dosimeters (TLDs) during 1999. Figure C.3-1 identifies all TLD locations for 1999. Three TLDs are deployed at each location and the measurements from each TLD are averaged on a quarterly basis. These measurements are used to track and evaluate environmental direct radiation levels. Five locations are near the K-65 Silos, seven are in various places on site, and 21 are located at the site fenceline. Five locations are also placed off site to measure background in areas unaffected by site activities.

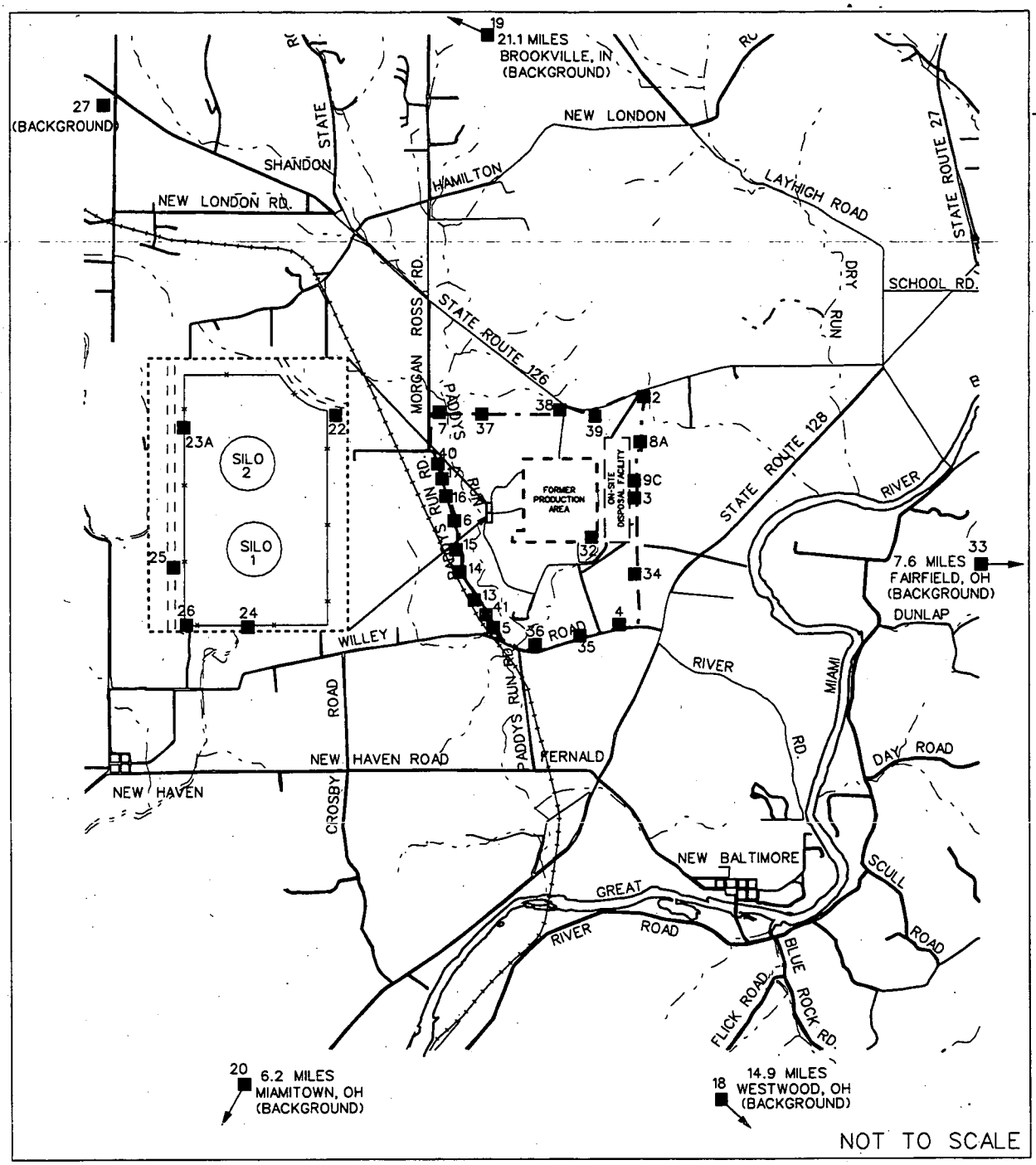
Table C.3-1 provides the data collected and averaged for four quarters in 1999. For comparison, annual average data collected during 1998 has been included. As discussed in Chapter 5 of this 1999 Integrated Site Environmental Report, an increasing trend has been identified at the locations around the K-65 Silos 1 and 2 exclusion fence (locations 22 through 26). To a lesser degree, an increase in direct radiation levels has also been measured as well as at the site fenceline near the K-65 Silos (location 6). The relatively small increases in direct radiation at the fenceline are difficult to measure consistently because of variations in the sensitivity and accuracy of the environmental TLDs. The increasing direct radiation levels in these areas are the result of the increasing radon (and associated decay products) concentrations in the headspace of the K-65 Silos 1 and 2. While an increasing trend is evident, the 1999 results are still less than the levels observed prior to the addition of bentonite to the silos in 1991. These data are being considered in the design of the Advanced Waste Retrieval Project for K-65 Silos 1 and 2 which will address both radon and direct radiation concerns associated with the K-65 waste materials. The radon control system associated with this project is scheduled to be operational in 2001. Monitoring for direct radiation will continue during 2000 as specified in the IEMP.

# TABLE C.3-1

## DIRECT RADIATION (TLD) MEASUREMENTS

| Location[a] | Direct Radiation (mrem) | |
|---|---|---|
| | 1999 Summary Results[b] | 1998 Summary Results[c] |
| **Fenceline** | | |
| 2 | 75 | 74 |
| 3 | 72 | 67 |
| 4 | 68 | 66 |
| 5 | 70 | 68 |
| 6 | 81 | 84 |
| 7 | 68 | 69 |
| 8A | 74 | 75 |
| 9C | 76 | 79 |
| 13 | 74 | 74 |
| 14 | 71 | 77 |
| 15 | 79 | 79 |
| 16 | 81 | 81 |
| 17 | 70[d] | 73 |
| 34 | 75 | 75 |
| 35 | 71 | 70 |
| 36 | 64 | 65 |
| 37 | 76 | 77 |
| 38 | 63 | 63 |
| 39 | 79 | 79 |
| 40 | 68 | 67 |
| 41 | 72 | 73 |
| **Min.** | **63** | **63** |
| **Max.** | **81** | **84** |
| **On Site** | | |
| 22 | 904 | 776 |
| 23[e,f] | 441 | 817 |
| 23A[e,f] | 650 | NA |
| 24 | 707 | 632[g] |
| 25 | 881 | 698 |
| 26 | 547 | 496 |
| 32 | 55 | 55 |
| **Min.** | **55** | **55** |
| **Max.** | **904** | **817** |
| **Background** | | |
| 18 | 77 | 77 |
| 19 | 63 | 65 |
| 20 | 62 | 61 |
| 27 | 62 | 64 |
| 33 | 67 | 68 |
| **Min.** | **62** | **61** |
| **Max.** | **77** | **77** |

[a]Refer to Figure C.3-1 for sample locations
[b]1999 summary result value may not always agree with quarterly results due to rounding differences.
[c]NA = not applicable
[d]Estimated second quarter direct radiation levels due to invalid TLD data from this location
[e]Direct radiation levels for TLD locations 23 and 23A were extrapolated for second quarter results.
[f]TLD location 23 was relocated to TLD location 23A on May 26, 1999.
[g]Direct radiation value includes estimated second quarter results which were based on first quarter results.




LEGEND:

DISTANCE FROM CENTER OF FORMER PRODUCTION AREA TO SAMPLE LOCATIONS OFF MAP

FEMP BOUNDARY

DIRECT RADIATION (TLD) MONITORING LOCATION

FIGURE C.3-1. DIRECT RADIATION (THERMOLUMINESCENT DOSIMETER) MONITORING LOCATIONS

V:/5FCP1/DGN/99ANNUAL/99AN018.DGN

11-24-99

# ATTACHMENT C.4

# METEOROLOGICAL DATA

# ATTACHMENT C.4



Meteorological data were recorded at the site meteorological station during 1999. Meteorological data recovery for 1999 was 97.5 percent. As shown in Table C.4-1, data from the 10-meter and 60-meter elevations are reported as a monthly maximum hourly average and a monthly minimum hourly average. Ambient air temperature is provided which includes monthly average temperature, and daily maximum and minimum values per month. The precipitation totals include the monthly total and daily maximum values recorded during 1999. Table C.4-2 presents the 1999 average wind speed and percent of time from direction at the 10-meter and 60-meter elevations.

For 1999 the highest hourly average wind speed at the 10-meter elevation was measured at 22.7 miles per hour during May 1999. At the 60-meter elevation, the highest hourly average wind speed was measured at 35 miles per hour during April 1999. The prevailing winds were from directions west through south-southwest approximately 40 percent of the time at both elevations. The winds out of the east-southeast and southeast were least predominant, occurring less than three percent of the time.

Total precipitation for 1999 measured 34.39 inches, which is 6.81 inches below the annual average precipitation of 41.20 inches for the period 1949 through 1998. For comparison, the total annual precipitation in 1998 was 48.4 inches. The highest amount of precipitation was measured during January 1999 (4.95 inches).

The monthly average temperatures during 1999 ranged from 32 degrees Fahrenheit (°F) in January to 79 °F in July. The coldest day was –9.4 °F recorded in January and the warmest day was 100 °F recorded in July.

# TABLE C.4-1

## 1999 METEOROLOGICAL DATA

| | Units | January | February | March | April | May | June | July | August | September | October | November | December |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **10-Meter Wind Speed** | | | | | | | | | | | | | |
| Maximum hourly average | mph | 17.8 | 20.7 | 17.7 | 21.6 | 22.7 | 15.4 | 16.5 | 12.1 | 13.5 | 14.6 | 18.1 | 18.8 |
| | kph | 28.6 | 33.3 | 28.5 | 34.8 | 36.5 | 24.8 | 26.6 | 19.5 | 21.7 | 23.5 | 29.1 | 30.3 |
| Minimum hourly average | mph | 0.8 | 0.2 | 0.6 | 0.8 | 0.5 | 0.5 | 0.6 | 0.6 | 0.3 | 0.4 | 0.4 | 0.2 |
| | kph | 1.3 | 0.3 | 1.0 | 1.3 | 0.8 | 0.8 | 1.0 | 1.0 | 0.5 | 0.6 | 0.6 | 0.3 |
| **60-Meter Wind Speed** | | | | | | | | | | | | | |
| Maximum hourly average | mph | 30.4 | 33.0 | 26.0 | 35.0 | 32.3 | 31.4 | 23.7 | 18.9 | 18.5 | 25.0 | 24.4 | 28.8 |
| | kph | 48.9 | 53.1 | 41.8 | 56.3 | 52.0 | 50.5 | 38.1 | 30.4 | 29.8 | 40.2 | 39.3 | 46.3 |
| Minimum hourly average | mph | 0.9 | 1.0 | 0.7 | 0.7 | 0.8 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.9 | 0.9 |
| | kph | 1.4 | 1.6 | 1.1 | 1.1 | 1.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 1.4 | 1.4 |
| **Ambient Air Temperature** | | | | | | | | | | | | | |
| Average | °F | 32 | 39 | 37 | 57 | 64 | 73 | 79 | 72 | 64 | 54 | 48 | 36 |
| | °C | 0 | 4 | 3 | 14 | 18 | 23 | 26 | 22 | 18 | 12 | 9 | 2 |
| Maximum daily | °F | 66 | 73 | 72 | 79 | 91 | 91 | 100 | 91 | 93 | 79 | 77 | 63 |
| | °C | 19 | 23 | 22 | 26 | 33 | 33 | 38 | 33 | 34 | 26 | 25 | 17 |
| Minimum daily | °F | -9.4 | 16 | 10 | 36 | 48 | 48 | 55 | 52 | 36 | 27 | 21 | 1.4 |
| | °C | -23 | -9.0 | -12 | 2.0 | 9.0 | 9.0 | 13 | 11 | 2.0 | -3.0 | -6.0 | -17 |
| **Precipitation** | | | | | | | | | | | | | |
| Monthly total | in | 4.95 | 4.01 | 2.03 | 3.67 | 1.64 | 4.9 | 1.75 | 2.37 | 1.12 | 2.46 | 2.05 | 3.44 |
| | cm | 12.6 | 10.2 | 5.16 | 9.32 | 4.17 | 12 | 4.44 | 6.02 | 2.84 | 6.25 | 5.21 | 8.74 |
| Daily maximum | in | 1.3 | 1.5 | 1.0 | 1.1 | 0.5 | 2.0 | 0.4 | 1.4 | 1.0 | 1.8 | 1.0 | 0.9 |
| | cm | 3.2 | 3.7 | 2.5 | 2.7 | 1.3 | 5.2 | 1.1 | 3.5 | 2.5 | 4.5 | 2.6 | 2.3 |



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## TABLE C.4-2

## 1999 AVERAGE WIND SPEED AND PERCENT OF TIME FROM DIRECTION AT TEN AND SIXTY METERS ABOVE GROUND LEVEL

| Direction | Average 10-meter Wind Speed (mph) | Average 10-meter Wind Speed (kph) | Percent of Time from Direction | Average 60-meter Wind Speed (mph) | Average 60-meter Wind Speed (kph) | Percent of Time from Direction |
|---|---|---|---|---|---|---|
| N | 5.5 | 8.8 | 4.7 | 8.1 | 13.0 | 5.0 |
| NNE | 5.8 | 9.3 | 4.5 | 7.6 | 12.2 | 5.3 |
| NE | 5.6 | 9.0 | 5.7 | 7.1 | 11.4 | 10.8 |
| ENE | 5.2 | 8.4 | 6.9 | 6.6 | 10.6 | 6.5 |
| E | 4.0 | 6.4 | 4.5 | 7.0 | 11.3 | 3.4 |
| ESE | 3.1 | 5.0 | 2.6 | 6.1 | 9.8 | 2.3 |
| SE | 3.0 | 4.8 | 2.2 | 6.4 | 10.3 | 2.6 |
| SSE | 4.1 | 6.6 | 3.0 | 7.4 | 11.9 | 3.6 |
| S | 5.6 | 9.0 | 5.8 | 9.2 | 14.8 | 8.6 |
| SSW | 6.8 | 10.9 | 10.2 | 9.8 | 15.8 | 11.1 |
| SW | 5.2 | 8.4 | 11.1 | 9.8 | 15.8 | 10.6 |
| WSW | 4.2 | 6.8 | 9.1 | 9.6 | 15.4 | 8.3 |
| W | 4.3 | 6.9 | 9.0 | 9.7 | 15.6 | 6.3 |
| WNW | 4.3 | 6.9 | 7.9 | 9.1 | 14.6 | 5.0 |
| NW | 4.3 | 6.9 | 7.9 | 8.6 | 13.8 | 5.8 |
| NNW | 5.1 | 8.2 | 5.1 | 7.7 | 12.4 | 4.8 |

3004

# 1999 NATIONAL EMISSIONS STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHAP) ANNUAL REPORT

## FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
## FERNALD, OHIO

MAY 2000

U.S. DEPARTMENT OF ENERGY

60200-RP-0003
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# 1999 NATIONAL EMISSIONS STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHAP) ANNUAL REPORT

## FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
## FERNALD, OHIO

MAY 2000

U.S. DEPARTMENT OF ENERGY

FINAL

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**U.S. Department of Energy**
**Radionuclide Air Emissions Annual Report**
**(under Subpart H of 40 CFR Part 61)**
**Calendar Year 1999**

Site Name: Fernald Environmental Management Project (FEMP), Fernald, Ohio

Field Office Information:

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Cincinnati, Ohio 45253-8705

Contact: Ed Skintik Phone: (513) 648-3050

Site Information

Operating Contractor: Fluor Fernald, Inc.

Address: 7400 Willey Road
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Contact: Tony Tetsuwari Phone: (513) 648-7516

# APPENDIX D

## 1999 NATIONAL EMISSIONS STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHAP) ANNUAL REPORT FOR THE FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

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## ATTACHMENT D.1

CAP88-PC Computer Model Runs as Supporting Documentation for 40 CFR 61.96

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Figure D-1 Radiological Air Monitoring Station Locations

Figure D-2 1999 Wind Rose Data, 10-Meter Height

# LIST OF ACRONYMS

| | |
|---|---|
| ALARA | As Low As Reasonably Achievable |
| AMS | air monitoring station |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| D&D | decontamination and dismantlement |
| DOE | U.S. Department of Energy |
| EPA | U.S. Environmental Protection Agency |
| FEMP | Fernald Environmental Management Project |
| HEPA | high-efficiency particulate air |
| IEMP | Integrated Environmental Monitoring Plan |
| mrem | millirem |
| mSv | millisieverts |
| NESHAP | National Emission Standards for Hazardous Air Pollutants |
| OEPA | Ohio Environmental Protection Agency |
| WPRAP | Waste Pit Remedial Action Project |

## PREAMBLE

On May 23, 1997, the U.S. Department of Energy (DOE) Fernald Environmental Management Project (FEMP) submitted a written request to the U.S. Environmental Protection Agency (EPA) for approval to use an alternate approach for demonstrating compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP), Subpart H requirements (DOE 1997). The alternate approach utilizes environmental measurements of airborne radionuclide concentrations (as provided for under 40 Code of Federal Regulations [CFR] 61.93[b][5]) rather than air dispersion modeling to demonstrate that radionuclide emissions resulting from FEMP operations remain below the annual NESHAP Subpart H standard. The request for approval of the alternative approach was driven by the recognition that the dominant sources of radiological emissions at the FEMP had changed as the mission of the FEMP changed from uranium metal production (which ended in 1989) to environmental remediation. During production, the primary emission sources from the facility were point sources (stacks and vents); however, under the current mission of full scale environmental remediation, the dominant emission sources are fugitive emissions from diffuse sources (i.e., large scale excavations, wind erosion from stockpiled materials, decontamination and dismantling projects, etc.). Because there is a high degree of uncertainty associated with modeling fugitive emissions, environmental measurements were proposed as an alternative to provide a more accurate assessment of FEMP emissions.

On August 11, 1997, the EPA granted approval to use environmental measurements as an alternative methodology for demonstrating NESHAP compliance (EPA 1997). The FEMP began utilizing environmental measurements for NESHAP compliance purposes in 1998.

## SUMMARY

For 1999 the maximum effective dose equivalent from emissions of radionuclides to the ambient air, based on radionuclide measurements at the FEMP fenceline, is estimated to be 0.29 millirem (mrem) (2.9E-03 millisieverts [mSv]), which is in compliance with the Subpart H standard of 10 mrem. This estimation is based on the FEMP's radiological air particulate monitoring program which consists of a network of high volume air monitoring stations (AMS) operated continuously during the year at the FEMP facility fenceline and background locations.

During 1999 there were several cases in which concerns about data recovery and data quality led to the loss or rejection of the data for the purpose of demonstrating compliance with the Subpart H standard. On an individual and cumulative basis, the lost or rejected data were evaluated and found to have minimal influence on the compliance demonstration.

## SECTION I: FACILITY INFORMATION

A. Site Description

The FEMP is located on a 1,050 acre (425 hectare) area approximately 18 miles (29 km) northwest of downtown Cincinnati, Ohio. The former production area covers approximately 136 acres (55 hectares) in the center of the FEMP. The facility is sited just north of the small farming community of Fernald, Ohio.

The area immediately surrounding the FEMP is primarily rural in nature, characterized by the predominance of agriculture, with some light industry and private residences. The FEMP is located on a relatively level plain, outside of the 500-year flood plain of the Great Miami River, in an ancestral river valley known as the New Haven Trough.

The climate is characterized as continental, with average temperatures ranging from approximately 29°F (-1.7°C) in January, to 76°F (24.4°C) in July. Average annual precipitation is approximately 41 inches (104 centimeters) per year. Prevailing wind flow is from the south-southwest.

For 37 years, the former Feed Materials Production Center (Fernald site) produced uranium metals for DOE and its predecessors. On July 10, 1989, uranium metals production was suspended. Management responsibilities of the Fernald site were transferred from the Defense Programs organization to the DOE's Office of Environmental Restoration and Waste Management.

Currently, most activities at the FEMP are conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). These activities include sample analysis; waste characterization; the management, treatment, storage and disposal of hazardous, mixed, low-level and solid wastes; and the decontamination and cleanup of radioactively contaminated buildings, equipment, soils, and waters. The site also manages thorium wastes and K-65 Silos waste material which contains radium and produces radon gas.

B. Source Descriptions

The majority of the radioactive airborne contaminants at the FEMP consist of uranium and uranium compounds. Additional radioactive airborne contaminants consist of daughter products from the uranium, actinium, and thorium series decay chains.

For 1999 potential radionuclide emissions sources at the FEMP included:

- Building 11*, emissions from the laundry facilities resulting from the processing of contaminated clothing used at the FEMP and from the respirator washing facility located in the building
- Building 12, fugitive emissions from Tank Farm/Maintenance decontamination and dismantlement (D&D) project
- Building 15, emissions from laboratory operations
- Building 51, emissions from the advanced wastewater treatment facility
- Building 53, emissions from laboratory operations
- Building 56, fugitive emissions from packaging of enriched ingots and derbies
- Building 65, emissions from thorium repackaging operations
- Building 71*, emissions from material sorting and repackaging operations
- Building 78, emissions from repackaging operations
- Building 80, fugitive emissions from metal fuel-core repackaging operations
- Plant 9, fugitive emissions generated from the Thorium/Plant 9 Complex above-grade D&D project
- Waste Pit Remedial Action Project* (WPRAP) dryer stack operations
- Other sources: Fugitive emissions from the D&D of the sewage treatment plant complex, WPRAP excavations of waste pits 3 and 5, on-site disposal facility excavations/ construction, various borrow area excavations, wind erosion of stockpiles (i.e., flyash piles, southern waste units, etc.), earth moving equipment, and material handling operations.

Note: *Indicates 1999 point sources were continuously monitored during process operations. Table D-1 provides a summary of data from point source monitors, and is included as supporting documentation and is not used to demonstrate 40 CFR 61.92 compliance.

All monitored stacks are equipped with a high-efficiency particulate air (HEPA) filter used for effluent controls. HEPA filters are 99.97 percent efficient for particles of 0.3 microns or larger. Additionally, HEPA filtration systems are utilized throughout the FEMP in adhering to the As Low As Reasonably Achievable (ALARA) philosophy. In accordance with 40 CFR 61.94(b)(5), some examples of HEPA filters used at the FEMP include vacuum cleaner exhaust controls, negative pressure ventilation controls, venting glove bags and glove boxes, and general decontamination efforts. Table D-2 is provided to

comply with 40 CFR 61.94 (b)(6) which provides the distance from the points of release to the nearest residence, etc. This table is not used to demonstrate compliance with 40 CFR 61.92.

C. Radiological Air Particulate Monitoring Program Description

The FEMP's radiological air monitoring program is defined in the Integrated Environmental Monitoring Plan (IEMP) (DOE 1999). The program design, as approved by the EPA, is summarized below:

Monitoring Equipment and Locations

- A network of 18 high-volume environmental air samplers comprise the FEMP's radiological air particulate monitoring program for NESHAP compliance (refer to Figure D-1 for monitoring locations). The samplers draw air continuously through an 8-inch by 10-inch filter at a rate of 40-50 cubic feet per minute. The air monitoring stations contain a flow-rate chart recorder and an hour-meter which provides a record of the monitors' operational run-time over the sampling period. Additionally, the samplers are equipped with a flow controller which maintains a constant air flow through the sampler by an electronic probe which automatically adjusts blower/motor speed to correct for variations in line voltage, temperature, pressure, or filter loading.

- The 18 air monitoring stations are divided among on-site and background monitoring locations. Sixteen monitors are located on the FEMP fenceline corresponding to the 16 windrose sectors. Two monitors serve as background monitors, located in the predominant upwind directions of the northwest (3.2 miles from the center of the FEMP) and the southwest (6.2 miles from the center of the FEMP). The EPA siting criteria (40 CFR 58, Appendix E) were considered when selecting these locations.

Analytical Regime and Sampling Frequency

The analytical regime and sampling frequency for this program was designed to account for the major contributors to dose as defined in 40 CFR 61.93(b)(5)(ii) for the purpose of demonstrating NESHAP Subpart H compliance.

- Filters are exchanged on a biweekly basis and analyzed for total uranium and total particulates. These data are used to track site emissions routinely throughout the year to ensure emission controls at the FEMP are operating effectively.

- A portion of each biweekly filter is retained and is used to form a quarterly composite sample. The composite sample is analyzed for the radionuclides expected to be the major contributors to dose from site emissions. The results of the quarterly data are used to track compliance against the NESHAP Subpart H standard during the year and for demonstrating compliance at the end of the year.

Isotopes which comprise the quarterly composite analysis were selected based on the following considerations:

- Radionuclides which are stored in large quantities at the FEMP and which will be handled or processed during the remediation effort (uranium, thorium-230, thorium-232, and radium-226)
- Radionuclides which have been the major contributors to dose based on environmental and stack filter measurements (uranium)
- Radionuclides which, due to their concentrations in waste and contaminated soil, will be the major contributors to dose (uranium, thorium-228, and thorium-230).

Uranium-238, thorium-232, and uranium-235 are initial radionuclides in the uranium, thorium, and actinide decay chains, respectively. The majority of uranium and thorium received and processed during the production era of the FEMP had been separated from its decay chain progeny prior to shipment to the FEMP. As a result, decay chain progeny products were not in equilibrium with the parent concentrations, but may have grown into equilibrium with their parents during the history of operations at the FEMP. In addition to the potential in-growth of decay chain progeny, some of the progeny are difficult to quantify using standard radiochemistry analytical techniques. Analysis is particularly difficult given the limited sample volume and low environmental concentrations of all radionuclides in the quarterly composite samples. In order to account for the progeny's contribution to dose (while avoiding analytical difficulties), a number of progeny radionuclides can conservatively be considered to be present in equilibrium with their parents. These radionuclides (thorium-234, radium-228, actinium-228, radium-224, and thorium-231) are assumed to be in equilibrium with their parent concentrations as measured in the quarterly composites. Refer to Table D-3 for measured net air concentrations.

Air Emission Data Reporting

In addition to this report, the biweekly and quarterly composite data associated with this program were tracked and reported to the EPA and Ohio Environmental Protection Agency (OEPA) through IEMP quarterly status reports during 1999. In conjunction with the quarterly reports, all monitoring data were provided to the EPA and OEPA via electronic media (data diskettes or CD-ROM) on a quarterly basis.

## SECTION II: AIR EMISSIONS DATA

### A. Air Monitoring Data Completeness Status

During 1999 there were six cases in which concerns about data recovery and data quality of the quarterly composite results led to the loss or rejection of the data for purposes of demonstrating NESHAP compliance. In some cases, comparable data from 1998 quarterly composite samples were substituted in

place of the rejected data. In each case where data were lost, rejected, and/or substituted, an evaluation was performed in order to determine the impacts with respect to demonstrating NESHAP compliance. On an individual basis, each case of rejected or substituted data had minimal influence on the compliance demonstration. A summary of each case is provided below:

- During the first quarter of 1999, low thorium tracer recovery during laboratory analysis led to the rejection of thorium data (thorium-228, thorium-230, and thorium-232) from the two background monitors AMS-12 and AMS-16. In order to account for background concentrations of thorium, first quarter 1998 thorium data from AMS-12 and AMS-16 were substituted for the rejected 1999 background thorium data. This substitution is supported by the first quarter 1999 isotopic uranium concentrations at the background monitors (AMS-12 and AMS-16) which were slightly lower, yet comparable, to first quarter 1998 isotopic uranium concentrations at the background monitors. The relative agreement between the background uranium concentrations suggests that background isotopic thorium concentrations from the first quarters of 1998 and 1999 would also be similar. Thus, substitution of first quarter 1998 background thorium data in place of the rejected first quarter 1999 background thorium data would not significantly influence the calculation of the net fenceline thorium concentrations or the subsequent calculation of doses from thorium.

- During the first quarter of 1999, low thorium tracer recovery during laboratory analysis also led to the rejection of thorium data (thorium-228, thorium-230, and thorium-232) from monitoring locations AMS-4, AMS-22, and AMS-24. The rejection of isotopic thorium data from AMS-4, AMS-22, and AMS-24 does not significantly affect the compliance demonstration because thorium has not historically contributed the major fraction of dose from FEMP emissions. Furthermore, these monitors are not downwind of the major remediation projects and have not historically been the location of maximum fenceline doses.

- First quarter 1999 radium-226 data from all monitors were rejected because the chemical recoveries were above the laboratory detectors' calibrated range of recoveries. In order to account for radium-226 concentrations at all of the monitors, first quarter 1998 radium-226 data were substituted for the rejected first quarter 1999 data. The substitution would not be expected to significantly change the radium-226 contribution to fenceline doses because there were no significant changes in remediation activities during the first quarters of 1998 or 1999 that involved moving, repackaging, or processing radium-226 bearing wastes. Therefore, radium-226 concentrations during the first quarter of 1999 would be expected to be similar to the radium-226 emissions during the first quarter of 1998.

- Low thorium tracer recoveries during laboratory analysis were also encountered during the second quarter of 1999. During re-analysis, thorium recoveries improved, but an interference with thorium-228 results was observed for the samples from four monitoring stations (AMS-12, AMS-16, AMS-24, and AMS-25). This led to the rejection of thorium-228 data from two fenceline and two background stations. In order to account for thorium-228 concentrations, thorium-228 was assumed to be in equilibrium with thorium-232. This assumption is supported by the thorium-228/thorium-232 equilibrium conditions that occurred at the other fenceline monitors during the second quarter of 1999. This assumption does not significantly affect the compliance demonstration

because thorium-228 has not historically contributed the major fraction of dose from FEMP emissions.

- During the third quarter of 1999, a portion of the composite sample for AMS-23 leaked during transport. While none of the sample escaped the shipping container, the leaked sample volume could not be recovered for analysis. As a result, there was insufficient sample volume available for the complete quarterly analyses. Therefore, the available sample was analyzed for uranium and thorium isotopes and no analysis for radium-226 was performed. The lack of radium-226 data from AMS-23 during the third quarter does not significantly affect the compliance demonstration because radium-226 has not historically contributed the major fraction of dose from FEMP emissions.

- During the fourth quarter of 1999, low radium tracer recovery at the laboratory resulted in the rejection of the radium-226 result from AMS-28. The rejection of radium-226 data from AMS-28 during the fourth quarter does not significantly affect the compliance demonstration because radium-226 has not historically contributed the major fraction of dose from FEMP emissions.

In addition to evaluating each individual case, an assessment of the combined effects of the lost, rejected, and substituted data was made. This assessment, which is described below, considered the maximum fenceline dose with and without corrections for background concentrations of radionuclides. Based on this assessment, the combined effects of the rejected or substituted data had minimal influence on the compliance demonstration.

An assessment of the combined effects of the lost, rejected and substituted data was made by considering the maximum fenceline dose with and without corrections for background concentrations of radionuclides. Accounting for the background concentrations of radionuclides, the maximum effective dose of 0.29 mrem occurred at AMS-3 with AMS-8A and AMS-9C representing the next highest doses at 0.25 mrem and 0.21 mrem, respectively. These doses are well below the Subpart H standard of 10 mrem. If, for the sake of a conservative estimate, fenceline doses are re-calculated without accounting for the background concentrations of isotopic uranium, isotopic thorium, and radium-226, the maximum effective dose is 0.53 mrem, at AMS-3, and remains below the Subpart H standard of 10 mrem. Therefore, based on this assessment, the combined effects of the rejected or substituted data had minimal influence on the compliance demonstration.

Based on the discussion above, substituted data had minimal influence on the compliance demonstration. However, in an effort to improve data recovery and completeness, a different off-site (contract) laboratory is being used for the analysis of the quarterly composite air samples in 2000.

B. Air Monitoring Station Operational Performance

During 1999, operational run-times for the 18 NESHAP air monitoring stations averaged 98.5 percent, with all monitors operating in excess of the 95 percent minimum expectation. In general, interruptions in monitor operations that were encountered during 1999 were the result of power failures and/or equipment failures (refer to Table D-4).

## SECTION III: DOSE ASSESSMENT

Based on the sum of the quarterly isotopic results and annual air volumes, the net measured concentrations for each radionuclide were calculated at each fenceline air monitor to determine annual average concentrations. The annual average concentrations at each fenceline air monitor are divided by the corresponding values listed in Subpart H of 40 CFR 61, Appendix E, Table 2 to form a radionuclide-specific compliance ratio. At each fenceline air monitor, the sum of the radionuclide-specific compliance ratios was determined. Refer to Table D-5 for the NESHAP compliance ratios at each air monitor. The maximum value of the sum of the ratios was 0.029 and occurred at AMS-3. AMS-3 operated 99 percent of the time during 1999.

In accordance with 40 CFR 61.107, compliance with the NESHAP standard is demonstrated when the sum of the ratios is less than 1. Based on this approach for demonstrating compliance, the 40 CFR 61, Appendix E, Table 2 values can be assumed to represent the annual average radionuclide concentrations that correspond to a 10 mrem annual effective dose equivalent. It follows that a fraction of the 40 CFR 61, Appendix E, Table 2 values would correspond to an equivalent fraction of a 10 mrem annual effective dose equivalent.

Based on the assumption above, the sum of the radionuclide-specific compliance ratios can be converted to a dose by multiplying the ratio by 10. The maximum value of the sum of the ratios (0.029) converts to a maximum effective dose equivalent of 0.29 mrem (2.9E-03 mSv) at the fenceline (AMS-3). Because the nearest residence is located approximately 1,555 feet (474 meters) downwind (east-southeast) from AMS-3, the actual dose received by this receptor would be substantially lower than 0.29 mrem.

## SECTION IV: COMPLIANCE ASSESSMENT

For 1999 the maximum effective dose equivalent from emissions of radionuclides to the ambient air, based on radionuclide measurements at the FEMP fenceline, is estimated to be 0.29 mrem (2.9E-03 mSv), which is in compliance with the Subpart H standard of 10 mrem.

## SECTION V: ADDITIONAL INFORMATION

A. Meteorological Data

Refer to Figure D-2 for the 1999 wind rose data.

B. Construction/Modifications at the FEMP

Three projects were completed in 1999 for which the requirements to apply to the EPA for approval to construct or modify were waived due to the provisions of 40 CFR 61.96. These projects were:

- Building 80, uranium metal fuel-core repackaging HEPA system
- Building 56, packaging of enriched ingots and derbies
- Building 12, Tank Farm/ Maintenance D&D Project.

Refer to Attachment D.1 for CAP88-PC computer model runs as supporting documentation for the waivers.

C. Unplanned Releases of Radionuclides

For 1999 no unplanned releases of radionuclides were identified in a review of the 358 notifications received by the site's release evaluators.

## TABLE D-1

## NESHAP STACK EMISSIONS MONITORING RESULTS

| | 1999 Annual Results | |
|---|---|---|
| Stack Location/ Analysis | Number of Samples (Including Rinsate)[a,b] | Total Pounds[c,d,e] |
| **Building 71 Stack** | | |
| Uranium, Total | 5 | 2.6E-05 |
| Thorium-232 | 5 | 5.2E-05 |
| Thorium-230 | 5 | 1.0E-09 |
| Total Particulate | 3 | 5.8E-01 |
| **Laundry Stack** | | |
| Uranium, Total | 9 | 2.6E-05 |
| Thorium-232 | 9 | 5.8E-04 |
| Thorium-230 | 9 | 6.9E-09 |
| Total Particulate | 7 | 6.0E-01 |
| **WPRAP Dryer Stack** | | |
| Uranium-238 | 1 | ND |
| Uranium-235/236 | 1 | ND |
| Uranium-234 | 1 | ND |
| Thorium-232 | 1 | ND |
| Thorium-230 | 1 | ND |
| Thorium-228 | 1 | ND |
| Radium-226 | 1 | ND |
| Total Particulate | NS | NS |
| Total Radon[f] | -- | 3.9E-03(Ci) |

[a]NS = not sampled
[b]WPRAP sample is composite of 23 filters (collected over five days).
[c]Total pounds are only determined from detected results.
[d]ND = non-detectable
[e]Some particulate result(s) could not be determined due to a damaged filter(s).
[f]Sample results are continuously collected and recorded.

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## TABLE D-2[a]

## DISTANCE AND DIRECTION FROM POINTS OF RELEASE TO RECEPTORS

| Source | Type of Control | Percent Efficiency[b] | Dist. and Direction to Nearest Off Site Receptor |
|---|---|---|---|
| Plant 9 | None | NA | 959m ESE |
| Building 11 | | | |
| Laundry Dryer Exhaust | HEPA | 99.97 | 1016m WSW |
| Respirator Washing Facility | HEPA | 99.97 | 1017m WSW |
| Building 12 | None | NA | 959m NNE |
| Building 15 | | | |
| Perchloric Stacks | None | NA | 921m WSW |
| HEPA Exhaust | HEPA | 99.97 | 921m WSW |
| General Exhaust | None | NA | 921m WSW |
| Building 51 | None | NA | 671m W |
| Building 53 | None | NA | 939m ESE |
| Building 56 | None | NA | 750m N |
| Building 65 | HEPA | 99.97 | 844m N |
| Building 71 | HEPA | 99.97 | 944m N |
| Building 78 | HEPA | 99.97 | 833m N |
| Building 80 | None | NA | 869m WSW |
| WPRAP Dryer | HEPA | 99.97 | 904m NNE |

[a]Table D-2 is included to comply with 40 CFR 61.94 (b)(6) and not used to demonstrate compliance with 40 CFR 61.92
[b]NA = not applicable

## TABLE D-3

## NET AIR CONCENTRATIONS[a]

| | Uranium (pCi/m$^3$) | | | Thorium (pCi/m$^3$) | | | Radium (pCi/m$^3$)[b] |
|---|---|---|---|---|---|---|---|
| Location | 234 | 235/236 | 238 | 228 | 230 | 232 | 226 |
| **Fenceline** | | | | | | | |
| AMS-2 | 2.1E-05 | 1.1E-06 | 2.6E-05 | 2.2E-06 | 7.6E-06 | 1.4E-06 | 1.7E-05 |
| AMS-3 | 5.6E-05 | 2.6E-06 | 6.0E-05 | 1.5E-06 | 1.0E-05 | 8.1E-07 | 3.1E-05 |
| AMS-4 | 1.4E-05 | 5.5E-07 | 1.8E-05 | 1.8E-05 | 8.4E-06 | 1.7E-06 | 6.9E-06 |
| AMS-5 | 5.7E-06 | 9.0E-08 | 7.3E-06 | 0.0E+00 | 4.5E-06 | 0.0E+00 | 0.0E+00 |
| AMS-6 | 9.4E-06 | 6.3E-07 | 2.2E-05 | 0.0E+00 | 1.2E-05 | 0.0E+00 | 3.5E-06 |
| AMS-7 | 4.7E-06 | 1.6E-07 | 8.2E-06 | 0.0E+00 | 1.4E-06 | 0.0E+00 | 0.0E+00 |
| AMS-8A | 6.1E-05 | 3.3E-06 | 6.8E-05 | 1.1E-07 | 7.7E-06 | 2.6E-07 | 1.7E-05 |
| AMS-9C | 4.0E-05 | 1.9E-06 | 4.6E-05 | 8.8E-07 | 1.1E-05 | 1.1E-06 | 1.5E-05 |
| AMS-22 | 1.0E-05 | 6.8E-07 | 1.9E-05 | 4.2E-07 | 1.0E-05 | 1.9E-07 | 2.7E-06 |
| AMS-23 | 1.9E-05 | 6.5E-07 | 2.4E-05 | 8.7E-06 | 3.3E-06 | 0.0E+00 | 0.0E+00 |
| AMS-24 | 6.8E-06 | 5.7E-07 | 8.0E-06 | 1.2E-06[c] | 7.4E-06 | 1.3E-06 | 1.8E-05 |
| AMS-25 | 1.7E-06 | 0.0E+00 | 7.3E-06 | 0.0E+00[c] | 4.0E-06 | 0.0E+00 | 0.0E+00 |
| AMS-26 | 8.5E-06 | 6.4E-07 | 1.3E-05 | 0.0E+00 | 1.5E-05 | 0.0E+00 | 5.5E-06 |
| AMS-27 | 6.9E-06 | 3.8E-07 | 1.2E-05 | 1.5E-06 | 8.4E-06 | 1.4E-06 | 2.1E-05 |
| AMS-28 | 1.8E-06 | 2.3E-07 | 1.3E-05 | 0.0E+00 | 1.0E-05 | 0.0E+00 | 0.0E+00 |
| AMS-29 | 1.6E-05 | 1.1E-06 | 2.2E-05 | 3.2E-06 | 8.7E-06 | 0.0E+00 | 0.0E+00 |
| **Background** | | | | | | | |
| AMS-12 | 1.0E-05 | 1.5E-07 | 9.9E-06 | 3.6E- | 6.4E-06[d] | 3.9E-06[d] | 5.1E-06 |
| AMS-16 | 1.3E-05 | 3.7E-07 | 1.3E-05 | 8.6E- | 1.4E-05[d] | 9.2E-06[d] | 2.5E-05 |

[a]Thorium-234, radium-228, actinium-228, radium-224, and thorium-231 are considered to be in equilibrium with their parent of the primordial decay chain (i.e., uranium-238 pCi/m$^3$ = thorium-234 pCi/m$^3$, thorium-232 pCi/m$^3$ = radium-228, actinium-228, and radium-224 pCi/m$^3$, uranium-235 pCi/m$^3$ = thorium-231 pCi/m$^3$).
[b]First quarter 1999 radium-226 data were rejected and substituted with first quarter 1998 radium-226 data.
[c]Second quarter 1999 thorium-228 data are assumed to be in equilibrium with second quarter 1999 thorium-232 data (primordial decay chain parent).
[d]First quarter 1999 thorium data were rejected and substituted with first quarter 1998 thorium data.

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## TABLE D-4

## OPERATIONAL SUMMARY FOR AIR PARTICULATE MONITORING STATIONS IN 1999

| Location | Number of Samples | Sample Start-Date | Last Sample Collection Date | Operating Time (hours)[a] | Percent of Operation |
|---|---|---|---|---|---|
| **Fenceline** | | | | | |
| AMS-2 | 26 | 12/29/98 | 12/28/99 | 8675.0 | 99.3 |
| AMS-3 | 26 | 12/29/98 | 12/28/99 | 8648.7 | 99.0 |
| AMS-4 | 26 | 12/29/98 | 12/28/99 | 8573.6 | 98.1 |
| AMS-5 | 26 | 12/29/98 | 12/28/99 | 8718.6 | 99.8 |
| AMS-6 | 26 | 12/29/98 | 12/29/99 | 8587.6 | 98.0 |
| AMS-7 | 26 | 12/29/98 | 12/28/99 | 8430.3 | 96.5 |
| AMS-8A | 26 | 12/29/98 | 12/28/99 | 8615.5 | 98.6 |
| AMS-9C | 26 | 12/29/98 | 12/28/99 | 8541.1 | 97.8 |
| AMS-22 | 26 | 12/29/98 | 12/28/99 | 8580.8 | 98.2 |
| AMS-23 | 26 | 12/29/98 | 12/28/99 | 8631.9 | 98.8 |
| AMS-24 | 26 | 12/29/98 | 12/29/99 | 8685.6 | 99.2 |
| AMS-25 | 26 | 12/29/98 | 12/29/99 | 8582.8 | 98.0 |
| AMS-26 | 26 | 12/29/98 | 12/29/99 | 8643.5 | 98.7 |
| AMS-27 | 26 | 12/29/98 | 12/29/99 | 8611.4 | 98.3 |
| AMS-28 | 26 | 12/29/98 | 12/28/99 | 8728.6 | 99.9 |
| AMS-29 | 26 | 12/29/98 | 12/28/99 | 8628.6 | 98.8 |
| **Background** | | | | | |
| AMS-12 | 26 | 12/29/98 | 12/28/99 | 8726.7 | 99.9 |
| AMS-16 | 26 | 12/29/98 | 12/28/99 | 8459.9 | 96.8 |

[a]8736 available operating hours from December 29, 1998 through December 28, 1999, and 8760 available operating hours through December 29, 1999.

# TABLE D-5

## ANNUAL NESHAP COMPLIANCE RATIO REPORT

| | 40 CFR 61 (NESHAP) Subpart H Appendix E, Table 2; Net Ratios[a] | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location | Actinium-228[b] | Radium-224[b] | Radium-226[c] | Radium-228[b] | Thorium-228 | Thorium-230 | Thorium-231[b] | Thorium-232 | Thorium-234[b] | Uranium-234 | Uranium-235 Uranium-236 | Uranium-238 | Ratio Totals | Dose[d] (mrem) |
| **Fenceline** | | | | | | | | | | | | | | |
| AMS-2 | 3.9E-07 | 9.5E-06 | 5.2E-03 | 2.4E-04 | 6.9E-04 | 2.2E-03 | 3.7E-09 | 2.3E-03 | 1.2E-05 | 2.8E-03 | 1.5E-04 | 3.2E-03 | 1.7E-02 | 0.17 |
| AMS-3 | 2.2E-07 | 5.4E-06 | 9.5E-03 | 1.4E-04 | 4.8E-04 | 3.0E-03 | 8.8E-09 | 1.3E-03 | 2.7E-05 | 7.2E-03 | 3.5E-04 | 7.2E-03 | 2.9E-02 | 0.29 |
| AMS-4 | 4.5E-07 | 1.1E-05 | 2.1E-03 | 2.8E-04 | 5.7E-03 | 2.5E-03 | 1.9E-09 | 2.7E-03 | 8.3E-06 | 1.8E-03 | 7.4E-05 | 2.2E-03 | 1.7E-02 | 0.17 |
| AMS-5 | - | - | - | - | - | 1.3E-03 | 3.1E-10 | - | 3.3E-06 | 7.4E-04 | 1.2E-05 | 8.8E-04 | 3.0E-03 | 0.030 |
| AMS-6 | - | - | 1.1E-03 | - | - | 3.6E-03 | 2.2E-09 | - | 1.0E-05 | 1.2E-03 | 8.6E-05 | 2.7E-03 | 8.7E-03 | 0.087 |
| AMS-7 | - | - | - | - | - | 4.1E-04 | 5.4E-10 | - | 3.7E-06 | 6.2E-04 | 2.1E-05 | 9.9E-04 | 2.0E-03 | 0.020 |
| AMS-8A | 7.0E-08 | 1.7E-06 | 5.2E-03 | 4.4E-05 | 3.5E-05 | 2.3E-03 | 1.2E-08 | 4.2E-04 | 3.1E-05 | 8.0E-03 | 4.5E-04 | 8.1E-03 | 2.5E-02 | 0.25 |
| AMS-9C | 3.0E-07 | 7.4E-06 | 4.7E-03 | 1.9E-04 | 2.9E-04 | 3.2E-03 | 6.6E-09 | 1.8E-03 | 2.1E-05 | 5.2E-03 | 2.6E-04 | 5.6E-03 | 2.1E-02 | 0.21 |
| AMS-22 | 5.2E-08 | 1.3E-06 | 8.1E-04 | 3.3E-05 | 1.4E-04 | 2.9E-03 | 2.4E-09 | 3.1E-04 | 8.6E-06 | 1.3E-03 | 9.2E-05 | 2.3E-03 | 7.9E-03 | 0.079 |
| AMS-23 | - | - | - | - | 2.8E-03 | 9.6E-04 | 2.3E-09 | - | 1.1E-05 | 2.5E-03 | 8.8E-05 | 2.9E-03 | 9.2E-03 | 0.092 |
| AMS-24 | 3.5E-07 | 8.6E-06 | 5.4E-03 | 2.2E-04 | 3.8E-04[e] | 2.2E-03 | 2.0E-09 | 2.1E-03 | 3.6E-06 | 8.9E-04 | 7.7E-05 | 9.6E-04 | 1.2E-02 | 0.12 |
| AMS-25 | - | - | - | - | -[e] | 1.2E-03 | - | - | 3.3E-06 | 2.2E-04 | - | 8.8E-04 | 2.3E-03 | 0.023 |
| AMS-26 | - | - | 1.7E-03 | - | - | 4.4E-03 | 2.2E-09 | - | 5.8E-06 | 1.1E-03 | 8.7E-05 | 1.5E-03 | 8.8E-03 | 0.088 |
| AMS-27 | 3.9E-07 | 9.6E-06 | 6.3E-03 | 2.4E-04 | 4.9E-04 | 2.5E-03 | 1.3E-09 | 2.3E-03 | 5.3E-06 | 9.0E-04 | 5.2E-05 | 1.4E-03 | 1.4E-02 | 0.14 |
| AMS-28 | - | - | - | - | - | 3.0E-03 | 7.8E-10 | - | 6.0E-06 | 2.3E-04 | 3.1E-05 | 1.6E-03 | 4.9E-03 | 0.049 |
| AMS-29 | - | - | - | - | 1.0E-03 | 2.5E-03 | 3.8E-09 | - | 9.8E-06 | 2.0E-03 | 1.5E-04 | 2.6E-03 | 8.4E-03 | 0.084 |
| **Background** | | | | | | | | | | | | | | |
| AMS-12 | 1.1E-06 | 2.6E-05 | 1.5E-03 | 6.7E-04 | 1.2E-03[e,f] | 1.9E-03[f] | 5.3E-10 | 6.3E-03[f] | 4.5E-06 | 1.3E-03 | 2.1E-05 | 1.2E-03 | NA[g] | |
| AMS-16 | 2.5E-06 | 6.2E-05 | 7.6E-03 | 1.6E-03 | 2.8E-03[e,f] | 4.0E-03[f] | 1.3E-09 | 1.5E-02[f] | 6.1E-06 | 1.7E-03 | 5.0E-05 | 1.6E-03 | NA[g] | |

**Maximum Year-to-Date Ratio: 0.0293**
**Maximum Year-to-Date Dose (mrem): 0.293**

[a]A "-" indicates the filter results were less than or equal to the blank results, and/or the indicator concentrations were less than or equal to the average net background concentrations.
[b]Isotopes are assumed to be in equilibrium with their primordial decay chain parent.
[c]First quarter 1999 radium-226 data were rejected and substituted with first quarter 1998 radium-226 data.
[d]Dose conversions are based on the NESHAP standard of 10 mrem per year.
[e]Second quarter 1999 thorium-228 data assumed to be in equilibrium with second quarter 1999 thorium-232 data (primordial decay chain parent).
[f]First quarter 1999 thorium data were rejected and substituted with first quarter 1998 thorium data.
[g]NA = not applicable



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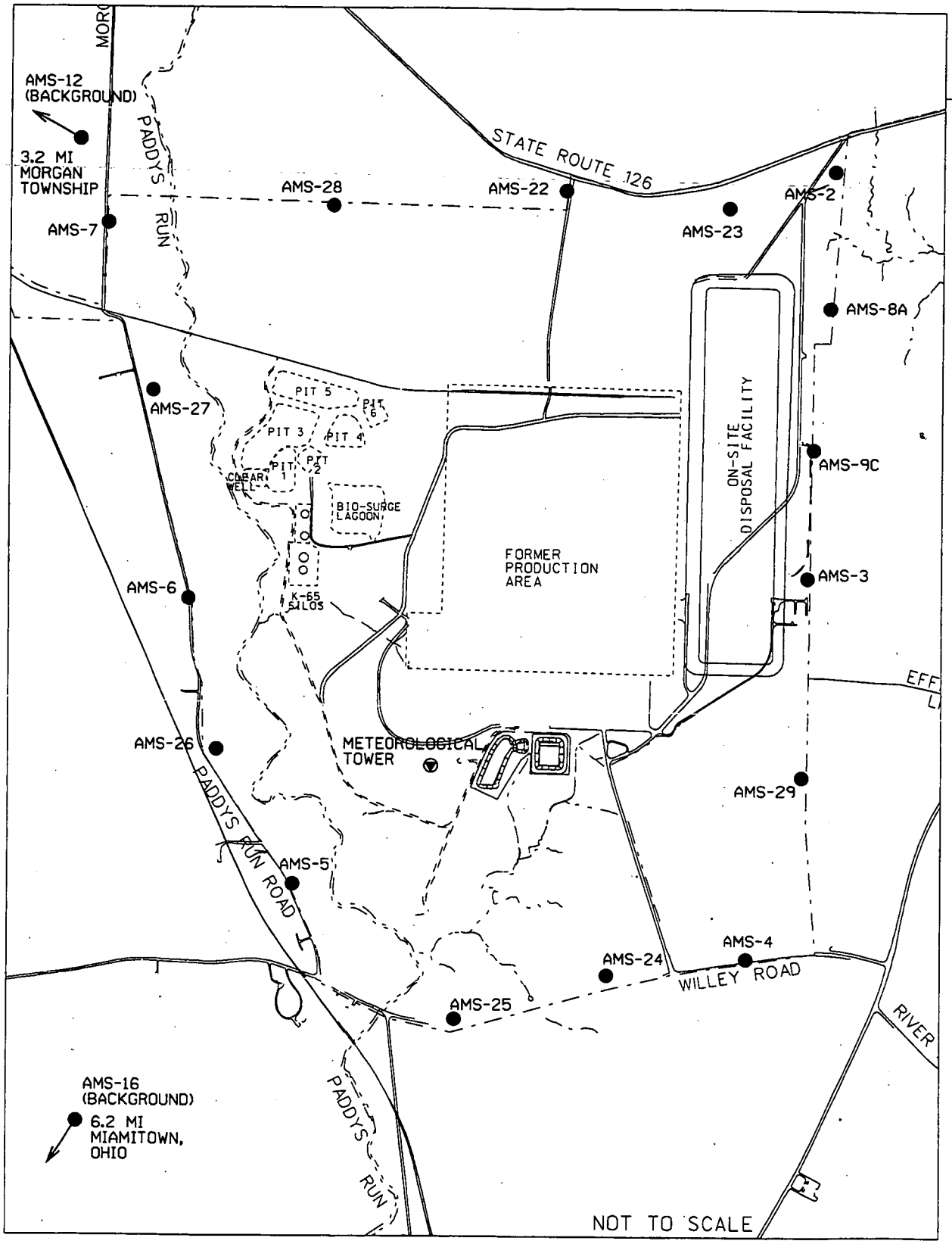



LEGEND:

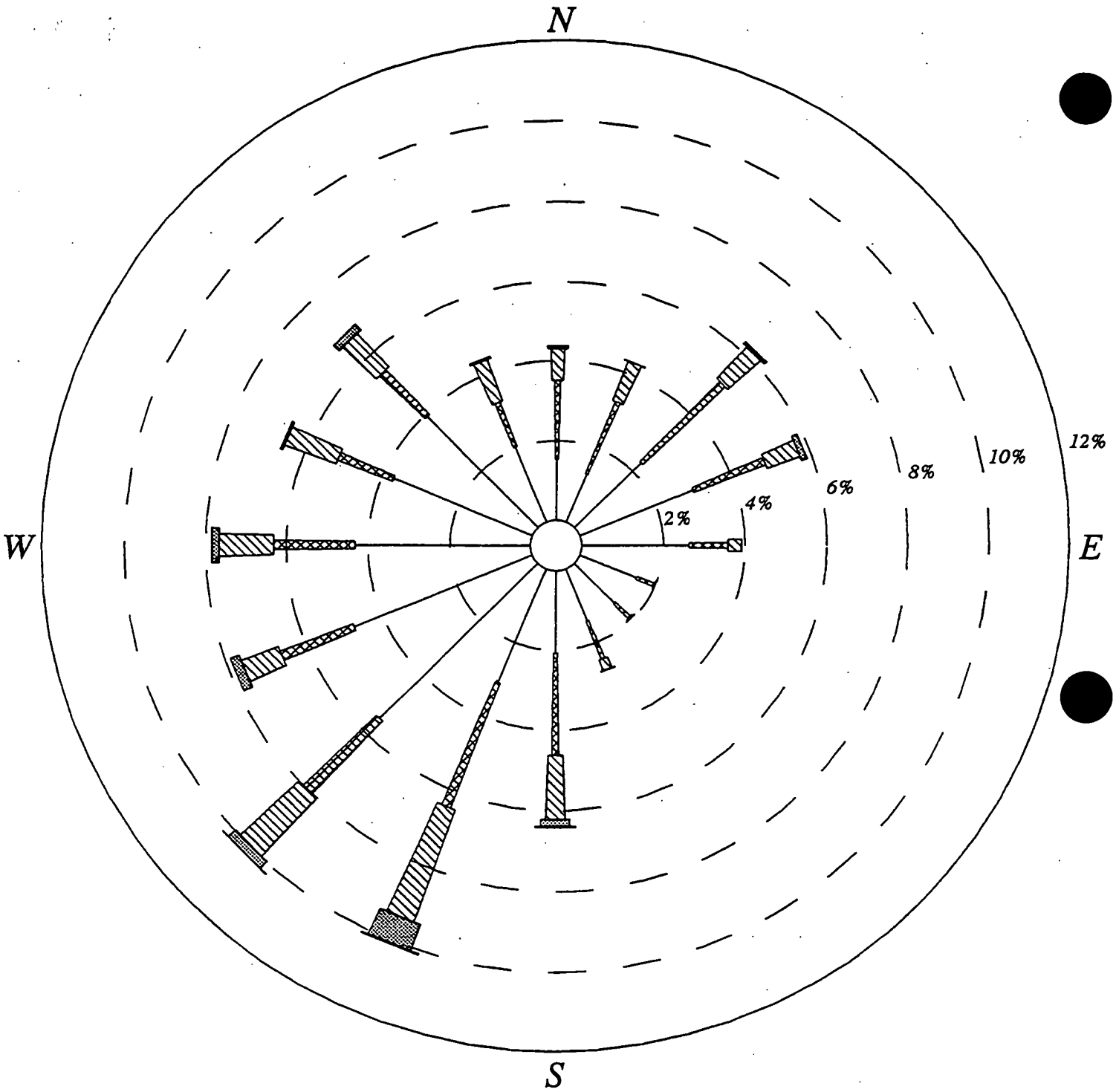
FEMP BOUNDARY

AMS LOCATION

DISTANCE FROM CENTER OF FORMER PRODUCTION AREA TO AMS LOCATION OFFSITE

FIGURE D-1. RADIOLOGICAL AIR MONITORING STATION LOCATIONS

v:\5fgp1\dgn\99annual\99an029.dgn
STATE PLANAR COORDINATE SYSTEM 1927
05-APR-2000
000488




CALM WINDS 8.27%

WIND SPEED (KNOTS)

*NOTE: Frequencies indicate direction from which the wind is blowing.*

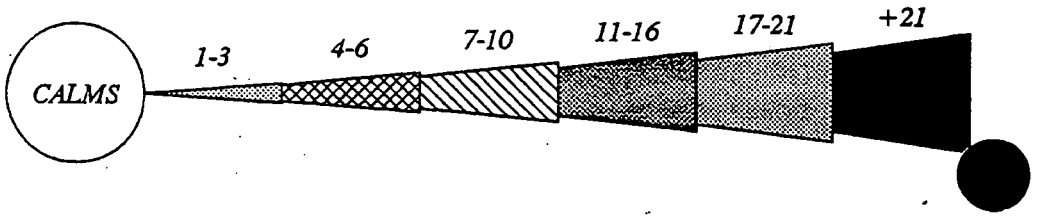



FIGURE D-2. 1999 WIND ROSE DATA, 10-METER HEIGHT

## REFERENCES

U.S. Dept. of Energy, 1999, "Integrated Environmental Monitoring Plan, Revision 1," Final, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1997, DOE-0980-97, Johnny Reising to James Saric and Michael Murphy, "Application for Approval to Use Environmental Measurements to Demonstrate Compliance with the National Emission Standards for Hazardous Air Pollutants Subpart H," dated May 23, 1997.

U.S. Environmental Protection Agency, 1997, Jack Barnett to Johnny Reising, "Application for Approval to Use Environmental Measurements to Demonstrate Compliance with the National Emission Standards for Hazardous Air Pollutants Subpart H," dated August 11, 1997.

## SECTION VI: CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment (see 18 U.S.C. 1001).

Name: JACK CRAIG

Signature: [signature]

Date: 5/25/00

# ATTACHMENT D.1

## CAP88-PC COMPUTER MODEL RUNS AS SUPPORTING DOCUMENTATION FOR 40 CFR 61.96

# BUILDING 80, URANIUM METAL FUEL-CORE REPACKAGING HEPA SYSTEM

# C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

## S Y N O P S I S  R E P O R T

Non-Radon Individual Assessment
Aug 11, 1999 9:41 am

Facility: Fernald Environmental Management Project
Address: P.O. Box 538704
7400 Willey Road
City: Cincinnati
State: OH Zip: 45253-8704

Effective Dose Equivalent
(mrem/year)

1.19E-03

At This Location: 869 Meters North Northeast

Source Category: point
Source Type: Stack
Emission Year: 1999

Comments: Appendix D EDE determination.

Dataset Name: 99CORESEDE
Dataset Date: Aug 11, 1999 9:40 am
Wind File: WNDFILES\FEMPSTD.WND

## MAXIMALLY EXPOSED INDIVIDUAL

Location Of The Individual: 869 Meters North Northeast
Lifetime Fatal Cancer Risk: 1.56E-08

## ORGAN DOSE EQUIVALENT SUMMARY

| Organ | Dose Equivalent (mrem/y) |
|---|---|
| GONADS | 1.85E-06 |
| BREAST | 2.14E-06 |
| R MAR | 5.58E-05 |
| LUNGS | 9.51E-03 |
| THYROID | 1.81E-06 |
| ENDOST | 7.20E-04 |
| RMNDR | 6.45E-05 |
| EFFEC | 1.19E-03 |

RADIONUCLIDE EMISSIONS DURING THE YEAR 1999

| Nuclide | Class | Size | Source #1 Ci/y | TOTAL Ci/y |
|---|---|---|---|---|
| U-238 | Y | 0.30 | 2.0E-05 | 2.0E-05 |
| U-235 | Y | 1.00 | 1.9E-09 | 1.9E-09 |

SITE INFORMATION

| | |
|---|---|
| Temperature: | 20 degrees C |
| Precipitation: | 146 cm/y |
| Mixing Height: | 965 m |

## SOURCE INFORMATION

Source Number: 1

Stack Height (m): 6.10
Diameter (m): 0.31

Plume Rise
Momentum (m/s): 7.98E+00
(Exit Velocity)

## AGRICULTURAL DATA

| | Vegetable | Milk | Meat |
|---|---|---|---|
| Fraction Home Produced: | 0.700 | 0.399 | 0.442 |
| Fraction From Assessment Area: | 0.300 | 0.601 | 0.558 |
| Fraction Imported: | 0.000 | 0.000 | 0.000 |

Food Arrays were not generated for this run.
Default Values used.

## DISTANCES USED FOR MAXIMUM INDIVIDUAL ASSESSMENT

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1246 | 1907 | 1513 | 1204 | 2178 | 869 | 982 | 1058 | 1275 | 1221 |
| 1421 | 1270 | 1270 | 1829 | 1779 | 1331 | | | | |

# C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

## D O S E  A N D  R I S K  E Q U I V A L E N T  S U M M A R I E S

Non-Radon Individual Assessment
Aug 11, 1999 9:41 am

Facility: Fernald Environmental Management Project
Address: P.O. Box 538704
7400 Willey Road
City: Cincinnati
State: OH Zip: 45253-8704

Source Category: point
Source Type: Stack
Emission Year: 1999

Comments: Appendix D EDE determination.

Dataset Name: 99CORESEDE
Dataset Date: Aug 11, 1999 9:40 am
Wind File: WNDFILES\FEMPSTD.WND

## ORGAN DOSE EQUIVALENT SUMMARY

| Organ | Selected Individual (mrem/y) |
|---|---|
| GONADS | 1.85E-06 |
| BREAST | 2.14E-06 |
| R MAR | 5.58E-05 |
| LUNGS | 9.51E-03 |
| THYROID | 1.81E-06 |
| ENDOST | 7.20E-04 |
| RMNDR | 6.45E-05 |
| EFFEC | 1.19E-03 |

## PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

| Pathway | Selected Individual (mrem/y) |
|---|---|
| INGESTION | 4.63E-05 |
| INHALATION | 1.14E-03 |
| AIR IMMERSION | 4.03E-13 |
| GROUND SURFACE | 7.49E-08 |
| INTERNAL | 1.19E-03 |
| EXTERNAL | 7.49E-08 |
| TOTAL | 1.19E-03 |

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

| Nuclide | Selected Individual (mrem/y) |
|---|---|
| U-238 | 1.19E-03 |
| U-235 | 7.17E-08 |
| TOTAL | 1.19E-03 |

## CANCER RISK SUMMARY

| Cancer | Selected Individual Total Lifetime Fatal Cancer Risk |
|---|---|
| LEUKEMIA | 6.99E-11 |
| BONE | 3.88E-11 |
| THYROID | 3.23E-13 |
| BREAST | 3.99E-12 |
| LUNG | 1.54E-08 |
| STOMACH | 2.59E-12 |
| BOWEL | 5.35E-12 |
| LIVER | 2.09E-12 |
| PANCREAS | 1.69E-12 |
| URINARY | 1.40E-10 |
| OTHER | 2.07E-12 |
| TOTAL | 1.56E-08 |

## PATHWAY RISK SUMMARY

| Pathway | Selected Individual Total Lifetime Fatal Cancer Risk |
|---|---|
| INGESTION | 2.56E-10 |
| INHALATION | 1.54E-08 |
| AIR IMMERSION | 8.68E-18 |
| GROUND SURFACE | 1.58E-12 |
| INTERNAL | 1.56E-08 |
| EXTERNAL | 1.58E-12 |
| TOTAL | 1.56E-08 |

NUCLIDE RISK SUMMARY

| Nuclide | Selected Individual Total Lifetime Fatal Cancer Risk |
|---|---|
| U-238 | 1.56E-08 |
| U-235 | 9.38E-13 |
| TOTAL | 1.56E-08 |

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

| Direction | Distance (m) 1246 | 1907 | 1513 | 1204 | 2178 | 869 | 982 |
|---|---|---|---|---|---|---|---|
| N | 3.4E-04 | 1.8E-04 | 2.5E-04 | 3.6E-04 | 1.4E-04 | 6.2E-04 | 5.0E-04 |
| NNW | 1.5E-04 | 7.7E-05 | 1.1E-04 | 1.6E-04 | 6.3E-05 | 2.7E-04 | 2.2E-04 |
| NW | 1.2E-04 | 6.6E-05 | 9.2E-05 | 1.3E-04 | 5.4E-05 | 2.1E-04 | 1.8E-04 |
| WNW | 1.1E-04 | 5.7E-05 | 8.0E-05 | 1.1E-04 | 4.7E-05 | 1.9E-04 | 1.5E-04 |
| W | 1.5E-04 | 8.2E-05 | 1.2E-04 | 1.6E-04 | 6.7E-05 | 2.7E-04 | 2.2E-04 |
| WSW | 4.3E-04 | 2.2E-04 | 3.1E-04 | 4.5E-04 | 1.7E-04 | 7.7E-04 | 6.2E-04 |
| SW | 2.7E-04 | 1.4E-04 | 2.0E-04 | 2.9E-04 | 1.2E-04 | 4.8E-04 | 4.0E-04 |
| SSW | 3.8E-04 | 1.9E-04 | 2.7E-04 | 4.0E-04 | 1.5E-04 | 6.9E-04 | 5.6E-04 |
| S | 3.5E-04 | 1.8E-04 | 2.5E-04 | 3.7E-04 | 1.4E-04 | 6.3E-04 | 5.1E-04 |
| SSE | 3.3E-04 | 1.7E-04 | 2.4E-04 | 3.5E-04 | 1.3E-04 | 6.1E-04 | 4.9E-04 |
| SE | 2.9E-04 | 1.6E-04 | 2.2E-04 | 3.1E-04 | 1.3E-04 | 5.0E-04 | 4.2E-04 |
| ESE | 4.3E-04 | 2.2E-04 | 3.2E-04 | 4.5E-04 | 1.8E-04 | 7.7E-04 | 6.3E-[illegible] |
| E | 3.0E-04 | 1.5E-04 | 2.2E-04 | 3.1E-04 | 1.3E-04 | 5.3E-04 | 4.3E-[illegible] |
| ENE | 3.3E-04 | 1.7E-04 | 2.4E-04 | 3.5E-04 | 1.4E-04 | 6.0E-04 | 4.9E-04 |
| NE | 3.7E-04 | 1.9E-04 | 2.7E-04 | 3.9E-04 | 1.5E-04 | 6.7E-04 | 5.4E-04 |
| NNE | 6.7E-04 | 3.5E-04 | 5.0E-04 | 7.1E-04 | 2.8E-04 | 1.2E-03 | 9.7E-04 |

| Direction | Distance (m) 1058 | 1275 | 1221 | 1421 | 1270 | 1270 | 1829 |
|---|---|---|---|---|---|---|---|
| N | 4.5E-04 | 3.3E-04 | 3.6E-04 | 2.8E-04 | 3.3E-04 | 3.3E-04 | 1.9E-04 |
| NNW | 1.9E-04 | 1.4E-04 | 1.5E-04 | 1.2E-04 | 1.4E-04 | 1.4E-04 | 8.2E-05 |
| NW | 1.6E-04 | 1.2E-04 | 1.3E-04 | 1.0E-04 | 1.2E-04 | 1.2E-04 | 7.0E-05 |
| WNW | 1.4E-04 | 1.0E-04 | 1.1E-04 | 8.8E-05 | 1.0E-04 | 1.0E-04 | 6.1E-05 |
| W | 2.0E-04 | 1.5E-04 | 1.6E-04 | 1.3E-04 | 1.5E-04 | 1.5E-04 | 8.7E-05 |
| WSW | 5.5E-04 | 4.1E-04 | 4.4E-04 | 3.4E-04 | 4.1E-04 | 4.1E-04 | 2.3E-04 |
| SW | 3.5E-04 | 2.6E-04 | 2.8E-04 | 2.2E-04 | 2.7E-04 | 2.7E-04 | 1.5E-04 |
| SSW | 4.9E-04 | 3.6E-04 | 3.9E-04 | 3.0E-04 | 3.6E-04 | 3.6E-04 | 2.0E-04 |
| S | 4.5E-04 | 3.3E-04 | 3.6E-04 | 2.8E-04 | 3.4E-04 | 3.4E-04 | 1.9E-04 |
| SSE | 4.4E-04 | 3.2E-04 | 3.5E-04 | 2.7E-04 | 3.2E-04 | 3.2E-04 | 1.8E-04 |
| SE | 3.7E-04 | 2.8E-04 | 3.0E-04 | 2.4E-04 | 2.8E-04 | 2.8E-04 | 1.7E-04 |
| ESE | 5.6E-04 | 4.1E-04 | 4.4E-04 | 3.5E-04 | 4.2E-04 | 4.2E-04 | 2.3E-04 |
| E | 3.8E-04 | 2.9E-04 | 3.1E-04 | 2.4E-04 | 2.9E-04 | 2.9E-04 | 1.6E-[illegible] |
| ENE | 4.3E-04 | 3.2E-04 | 3.4E-04 | 2.7E-04 | 3.2E-04 | 3.2E-04 | 1.8E-[illegible] |
| NE | 4.8E-04 | 3.6E-04 | 3.8E-04 | 3.0E-04 | 3.6E-04 | 3.6E-04 | 2.0E-04 |
| NNE | 8.7E-04 | 6.5E-04 | 6.9E-04 | 5.5E-04 | 6.5E-04 | 6.5E-04 | 3.7E-04 |

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

| | Distance (m) | |
|---|---|---|
| Direction | 1779 | 1331 |
| N | 2.0E-04 | 3.1E-04 |
| NNW | 8.5E-05 | 1.3E-04 |
| NW | 7.3E-05 | 1.1E-04 |
| WNW | 6.3E-05 | 9.7E-05 |
| W | 9.1E-05 | 1.4E-04 |
| WSW | 2.4E-04 | 3.8E-04 |
| SW | 1.6E-04 | 2.5E-04 |
| SSW | 2.1E-04 | 3.4E-04 |
| S | 2.0E-04 | 3.1E-04 |
| SSE | 1.9E-04 | 3.0E-04 |
| SE | 1.7E-04 | 2.7E-04 |
| ESE | 2.4E-04 | 3.9E-04 |
| E | 1.7E-04 | 2.7E-04 |
| ENE | 1.9E-04 | 3.0E-04 |
| NE | 2.1E-04 | 3.3E-04 |
| NNE | 3.9E-04 | 6.1E-04 |

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

| Direction | Distance (m) 1246 | 1907 | 1513 | 1204 | 2178 | 869 | 982 |
|---|---|---|---|---|---|---|---|
| N | 4.5E-09 | 2.3E-09 | 3.3E-09 | 4.7E-09 | 1.8E-09 | 8.1E-09 | 6.6E-09 |
| NNW | 1.9E-09 | 9.6E-10 | 1.4E-09 | 2.0E-09 | 7.8E-10 | 3.5E-09 | 2.8E-09 |
| NW | 1.6E-09 | 8.2E-10 | 1.2E-09 | 1.7E-09 | 6.7E-10 | 2.8E-09 | 2.3E-09 |
| WNW | 1.4E-09 | 7.1E-10 | 1.0E-09 | 1.4E-09 | 5.8E-10 | 2.4E-09 | 2.0E-09 |
| W | 2.0E-09 | 1.0E-09 | 1.5E-09 | 2.1E-09 | 8.4E-10 | 3.5E-09 | 2.8E-09 |
| WSW | 5.5E-09 | 2.8E-09 | 4.1E-09 | 5.9E-09 | 2.2E-09 | 1.0E-08 | 8.1E-09 |
| SW | 3.6E-09 | 1.8E-09 | 2.6E-09 | 3.7E-09 | 1.5E-09 | 6.3E-09 | 5.2E-09 |
| SSW | 4.9E-09 | 2.4E-09 | 3.5E-09 | 5.2E-09 | 1.9E-09 | 9.0E-09 | 7.3E-09 |
| S | 4.5E-09 | 2.3E-09 | 3.3E-09 | 4.8E-09 | 1.8E-09 | 8.2E-09 | 6.6E-09 |
| SSE | 4.3E-09 | 2.1E-09 | 3.1E-09 | 4.6E-09 | 1.7E-09 | 8.0E-09 | 6.4E-09 |
| SE | 3.8E-09 | 2.0E-09 | 2.8E-09 | 4.0E-09 | 1.6E-09 | 6.6E-09 | 5.4E-09 |
| ESE | 5.6E-09 | 2.8E-09 | 4.1E-09 | 5.9E-09 | 2.3E-09 | 1.0E-08 | 8.2E[illegible] |
| E | 3.9E-09 | 2.0E-09 | 2.8E-09 | 4.1E-09 | 1.6E-09 | 6.9E-09 | 5.6E[illegible] |
| ENE | 4.3E-09 | 2.2E-09 | 3.2E-09 | 4.6E-09 | 1.8E-09 | 7.9E-09 | 6.4E-09 |
| NE | 4.8E-09 | 2.4E-09 | 3.5E-09 | 5.1E-09 | 1.9E-09 | 8.7E-09 | 7.1E-09 |
| NNE | 8.8E-09 | 4.5E-09 | 6.5E-09 | 9.3E-09 | 3.7E-09 | 1.6E-08 | 1.3E-08 |

| Direction | Distance (m) 1056 | 1275 | 1221 | 1421 | 1270 | 1270 | 1829 |
|---|---|---|---|---|---|---|---|
| N | 5.8E-09 | 4.3E-09 | 4.6E-09 | 3.6E-09 | 4.3E-09 | 4.3E-09 | 2.4E-09 |
| NNW | 2.5E-09 | 1.8E-09 | 2.0E-09 | 1.5E-09 | 1.9E-09 | 1.9E-09 | 1.0E-09 |
| NW | 2.0E-09 | 1.5E-09 | 1.6E-09 | 1.3E-09 | 1.5E-09 | 1.5E-09 | 8.8E-10 |
| WNW | 1.8E-09 | 1.3E-09 | 1.4E-09 | 1.1E-09 | 1.3E-09 | 1.3E-09 | 7.5E-10 |
| W | 2.5E-09 | 1.9E-09 | 2.0E-09 | 1.6E-09 | 1.9E-09 | 1.9E-09 | 1.1E-09 |
| WSW | 7.2E-09 | 5.3E-09 | 5.7E-09 | 4.5E-09 | 5.4E-09 | 5.4E-09 | 3.0E-09 |
| SW | 4.6E-09 | 3.4E-09 | 3.7E-09 | 2.9E-09 | 3.4E-09 | 3.4E-09 | 1.9E-09 |
| SSW | 6.4E-09 | 4.7E-09 | 5.1E-09 | 3.9E-09 | 4.7E-09 | 4.7E-09 | 2.6E-09 |
| S | 5.9E-09 | 4.4E-09 | 4.7E-09 | 3.7E-09 | 4.4E-09 | 4.4E-09 | 2.4E-09 |
| SSE | 5.7E-09 | 4.2E-09 | 4.5E-09 | 3.5E-09 | 4.2E-09 | 4.2E-09 | 2.3E-09 |
| SE | 4.9E-09 | 3.7E-09 | 3.9E-09 | 3.1E-09 | 3.7E-09 | 3.7E-09 | 2.1E-09 |
| ESE | 7.3E-09 | 5.4E-09 | 5.8E-09 | 4.5E-09 | 5.4E-09 | 5.4E-09 | 3.0E-09 |
| E | 5.0E-09 | 3.7E-09 | 4.0E-09 | 3.1E-09 | 3.8E-09 | 3.8E-09 | 2.1E[illegible] |
| ENE | 5.6E-09 | 4.2E-09 | 4.5E-09 | 3.5E-09 | 4.2E-09 | 4.2E-09 | 2.3E[illegible] |
| NE | 6.3E-09 | 4.6E-09 | 5.0E-09 | 3.9E-09 | 4.7E-09 | 4.7E-09 | 2.6E-09 |
| NNE | 1.1E-08 | 8.5E-09 | 9.1E-09 | 7.2E-09 | 8.6E-09 | 8.6E-09 | 4.8E-09 |

000509

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

| | Distance (m) | |
|---|---|---|
| Direction | 1779 | 1331 |
| N | 2.5E-09 | 4.0E-09 |
| NNW | 1.1E-09 | 1.7E-09 |
| NW | 9.1E-10 | 1.4E-09 |
| WNW | 7.9E-10 | 1.2E-09 |
| W | 1.1E-09 | 1.8E-09 |
| WSW | 3.1E-09 | 5.0E-09 |
| SW | 2.0E-09 | 3.2E-09 |
| SSW | 2.7E-09 | 4.4E-09 |
| S | 2.5E-09 | 4.1E-09 |
| SSE | 2.4E-09 | 3.9E-09 |
| SE | 2.2E-09 | 3.5E-09 |
| ESE | 3.2E-09 | 5.0E-09 |
| E | 2.2E-09 | 3.5E-09 |
| ENE | 2.4E-09 | 3.9E-09 |
| NE | 2.7E-09 | 4.3E-09 |
| NNE | 5.0E-09 | 7.9E-09 |

## 40 CFR PART 61.96(b) - APPLICATION FOR APPROVAL

1. Assumptions

- 1,329,000 pounds of depleted uranium metal cores
- Depleted uranium metal cores are by weight 0.2% $U^{235}$ & rest $U^{238}$
- Activity of $U^{235}$ is 15.8 µCi / kg-$U^{235}$
- Activity of $U^{238}$ is 333.6 µCi / kg-$U^{238}$
- Emission estimate from Appendix D, 40 CFR 61, for solid metal is $10^{-6}$
- Emissions are particulates
- Particulate control factor for HEPA filter control is 0.99 per Appendix D
- EF means emission factor

2. Calculation of $U^{235}$ & $U^{238}$ Emissions

$U^{235}$ Emissions

| | | | | | | |
|---|---|---|---|---|---|---|
| 1,329,000 lbs-U | 0.002 lbs-$U^{235}$ | $10^{-6}$ lbs-solids | 1 kg | 1 - .99 (EF) | 15.8 µCi | = 1.905E-3 µCi |
| | 1 lbs-U | 1 lb-solids | 2.205 lbs | | kg-$U^{235}$ | |

$U^{238}$ Emissions

| | | | | | | |
|---|---|---|---|---|---|---|
| 1,329,000 lbs-U | 0.998 lbs-$U^{235}$ | $10^{-6}$ lbs-solids | 1 kg | 1 - .99 (EF) | 333.6 µCi | = 20.07 µCi |
| | 1 lbs-U | 1 lb-solids | 2.205 lbs | | kg-$U^{238}$ | |

Used these values of nearest receptors for Uranium Metal Fuel Core Repackaging at Building 80

# FEMP RECEPTOR LOCATOR PROGRAM

Distances to Offsite receptors

— R. Palmer 8/10/99

3004

| SOURCE: | Bldg. 80 OEP Tank Breathing HEPA System | |
|---|---|---|
| | N-S | E-W |
| | 480080 | 1380150 |

| MONITOR | N-S (ft) | E-W (ft) | DISTANCE (meters) | DIRECTION | |
|---|---|---|---|---|---|
| 1 | 484280 | 1380920 | 1301 | N | |
| 2 | 484160 | 1380410 | 1246 | N | 1 |
| 3 | 485470 | 1376970 | 1907 | NNW | 2 |
| 4 | 483380 | 1376440 | 1513 | NW | 3 |
| 5 | 482190 | 1376812 | 1204 | WNW | 4 |
| 6 | 479190 | 1377440 | 869 | WSW | 6 |
| 7 | 477630 | 1378060 | 982 | SW | 7 |
| 8 | 477060 | 1378440 | 1058 | SSW | 8 |
| 9 | 476910 | 1378470 | 1094 | SSW | |
| 10 | 476220 | 1378810 | 1245 | SSW | |
| 11 | 476160 | 1379000 | 1245 | SSW | |
| 12 | 475900 | 1380000 | 1275 | S | 9 |
| 13 | 476190 | 1381100 | 1221 | SSE | 10 |
| 14 | 476250 | 1381380 | 1226 | SSE | |
| 15 | 474780 | 1383190 | 1862 | SSE | |
| 16 | 476840 | 1383500 | 1421 | SE | 11 |
| 17 | 479060 | 1384190 | 1270 | ESE | 12 |
| 18 | 479340 | 1384250 | 1270 | E | 13 |
| 19 | 483380 | 1385160 | 1829 | ENE | 14 |
| 20 | 484720 | 1383690 | 1779 | NE | 15 |
| 21 | 484120 | 1381810 | 1331 | NNE | 16 |
| 22 | 485190 | 1379730 | 1563 | N | |
| 23 | 481839 | 1374096 | 1922 | WNW | |
| 24 | 480015 | 1386674 | 1989 | E | |
| 25 | 482361 | 1388613 | 2672 | ENE | |
| 26 | 479562 | 1373023 | 2178 | W | 5 |
| 27 | 475060 | 1385970 | 2343 | SE | |
| 28 | 485440 | 1379375 | 1651 | N | |
| 29 | 476940 | 1384000 | 1514 | SE | |
| 30 | 481557 | 1387895 | 2403 | E | |
| 31 | 481767 | 1388075 | 2470 | ENE | |
| 32 | 485630 | 1379200 | 1716 | N | |
| A | 479562 | 1372826 | 2238 | W | |
| B | 483560 | 1376440 | 1550 | NW | |
| C | 485310 | 1376810 | 1891 | NNW | |
| D | 485500 | 1376560 | 1982 | NNW | |
| E | 485310 | 1376560 | 1934 | NW | |
| F | 477000 | 1375340 | 1741 | WSW | |
| G | 477000 | 1375220 | 1772 | WSW | |
| H | 485220 | 1383620 | 1890 | NE | |

FILE: do-dist.wk4

# BUILDING 56, PACKAGING OF ENRICHED INGOTS AND DERBIES

# C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

## S Y N O P S I S  R E P O R T

Non-Radon Individual Assessment
Oct 12, 1999 1:36 pm

Facility: Fernald Environmental Management Project
Address: 7400 Willey Road
City: Fernald
State: OH Zip: 45013

Effective Dose Equivalent
(mrem/year)

3.04E-03

At This Location: 750 Meters North Northeast
Source Category: DOE Facility - Remediation
Source Type: Area
Emission Year: 1999

Comments: PACKAGING Enriched Ingots and Derbies in Bldg. 56

Dataset Name: BLDG56pkgappl
Dataset Date: Oct 12, 1999 1:35 pm
Wind File: WNDFILES\FEMPSTD.WND

MAXIMALLY EXPOSED INDIVIDUAL

Location Of The Individual: 750 Meters North Northeast
Lifetime Fatal Cancer Risk: 4.00E-08

ORGAN DOSE EQUIVALENT SUMMARY

| Organ | Dose Equivalent (mrem/y) |
|---|---|
| GONADS | 4.37E-06 |
| BREAST | 5.08E-06 |
| R MAR | 1.26E-04 |
| LUNGS | 2.44E-02 |
| THYROID | 4.28E-06 |
| ENDOST | 1.63E-03 |
| RMNDR | 1.46E-04 |
| EFFEC | 3.04E-03 |

Oct 12, 1999 1:36 pm



RADIONUCLIDE EMISSIONS DURING THE YEAR 1999

| Nuclide | Class | Size | Source #1 Ci/y | TOTAL Ci/y |
|---|---|---|---|---|
| U-235 | Y | 1.00 | 1.4E-07 | 1.4E-07 |
| U-238 | Y | 0.30 | 3.8E-05 | 3.8E-05 |

SITE INFORMATION

Temperature: 12 degrees C
Precipitation: 102 cm/y
Mixing Height: 950 m

## SOURCE INFORMATION

Source Number: 1

Source Height (m): 5.00
Area (sq m): 6.28E+02

Plume Rise
Momentum (m/s): 1.00E+00
(Exit Velocity)

## AGRICULTURAL DATA

| | Vegetable | Milk | Meat |
|---|---|---|---|
| Fraction Home Produced: | 0.700 | 0.399 | 0.442 |
| Fraction From Assessment Area: | 0.300 | 0.601 | 0.558 |
| Fraction Imported: | 0.000 | 0.000 | 0.000 |

Food Arrays were not generated for this run.
Default Values used.

## DISTANCES USED FOR MAXIMUM INDIVIDUAL ASSESSMENT

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 750 | 1089 | 1574 | 1339 | 1134 | 2370 | 1206 | 1446 | 1683 | 1741 |
| 1383 | 1351 | 2254 | 1510 | 1339 | 839 | | | | |

# CAP88-PC

Version 1.00

Clean Air Act Assessment Package - 1988

## DOSE AND RISK EQUIVALENT SUMMARIES

Non-Radon Individual Assessment
Oct 12, 1999 1:36 pm

Facility: Fernald Environmental Management Project
Address: 7400 Willey Road
City: Fernald
State: OH Zip: 45013

Source Category: DOE Facility - Remediation
Source Type: Area
Emission Year: 1999

Comments: PACKAGING Enriched Ingots and Derbies in Bldg. 56

Dataset Name: BLDG56pkgappl
Dataset Date: Oct 12, 1999 1:35 pm
Wind File: WNDFILES\FEMPSTD.WND

## ORGAN DOSE EQUIVALENT SUMMARY

| Organ | Selected Individual (mrem/y) |
|---|---|
| GONADS | 4.37E-06 |
| BREAST | 5.08E-06 |
| R MAR | 1.26E-04 |
| LUNGS | 2.44E-02 |
| THYROID | 4.28E-06 |
| ENDOST | 1.63E-03 |
| RMNDR | 1.46E-04 |
| EFFEC | 3.04E-03 |

## PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

| Pathway | Selected Individual (mrem/y) |
|---|---|
| INGESTION | 1.04E-04 |
| INHALATION | 2.93E-03 |
| AIR IMMERSION | 5.95E-12 |
| GROUND SURFACE | 3.33E-07 |
| INTERNAL | 3.04E-03 |
| EXTERNAL | 3.33E-07 |
| TOTAL | 3.04E-03 |

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

| Nuclide | Selected Individual (mrem/y) |
|---|---|
| U-235 | 7.17E-06 |
| U-238 | 3.03E-03 |
| TOTAL | 3.04E-03 |

## CANCER RISK SUMMARY

| Cancer | Selected Individual Total Lifetime Fatal Cancer Risk |
|---|---|
| LEUKEMIA | 1.59E-10 |
| BONE | 8.78E-11 |
| THYROID | 8.16E-13 |
| BREAST | 9.93E-12 |
| LUNG | 3.94E-08 |
| STOMACH | 6.31E-12 |
| BOWEL | 1.28E-11 |
| LIVER | 5.19E-12 |
| PANCREAS | 4.10E-12 |
| URINARY | 3.18E-10 |
| OTHER | 5.01E-12 |
| TOTAL | 4.00E-08 |

## PATHWAY RISK SUMMARY

| Pathway | Selected Individual Total Lifetime Fatal Cancer Risk |
|---|---|
| INGESTION | 5.76E-10 |
| INHALATION | 3.94E-08 |
| AIR IMMERSION | 1.37E-16 |
| GROUND SURFACE | 7.40E-12 |
| INTERNAL | 4.00E-08 |
| EXTERNAL | 7.40E-12 |
| TOTAL | 4.00E-08 |

NUCLIDE RISK SUMMARY

| Nuclide | Selected Individual Total Lifetime Fatal Cancer Risk |
|---|---|
| U-235 | 9.42E-11 |
| U-238 | 3.99E-08 |
| TOTAL | 4.00E-08 |

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

| | Distance (m) | | | | | | |
|---|---|---|---|---|---|---|---|
| Direction | 750 | 1089 | 1574 | 1339 | 1134 | 2370 | 1206 |
| N | 1.6E-03 | 8.3E-04 | 4.5E-04 | 5.9E-04 | 7.7E-04 | 2.4E-04 | 7.0E-04 |
| NNW | 6.7E-04 | 3.5E-04 | 2.0E-04 | 2.5E-04 | 3.3E-04 | 1.0E-04 | 3.0E-04 |
| NW | 5.5E-04 | 3.0E-04 | 1.7E-04 | 2.2E-04 | 2.8E-04 | 9.1E-05 | 2.5E-04 |
| WNW | 4.8E-04 | 2.6E-04 | 1.5E-04 | 1.9E-04 | 2.4E-04 | 7.9E-05 | 2.2E-04 |
| W | 6.9E-04 | 3.8E-04 | 2.1E-04 | 2.8E-04 | 3.6E-04 | 1.1E-04 | 3.2E-04 |
| WSW | 1.9E-03 | 1.0E-03 | 5.6E-04 | 7.3E-04 | 9.6E-04 | 2.9E-04 | 8.7E-04 |
| SW | 1.2E-03 | 6.7E-04 | 3.7E-04 | 4.8E-04 | 6.3E-04 | 1.9E-04 | 5.7E-04 |
| SSW | 1.7E-03 | 8.9E-04 | 4.8E-04 | 6.3E-04 | 8.3E-04 | 2.5E-04 | 7.5E-04 |
| S | 1.6E-03 | 8.4E-04 | 4.6E-04 | 6.0E-04 | 7.8E-04 | 2.4E-04 | 7.1E-04 |
| SSE | 1.5E-03 | 8.0E-04 | 4.4E-04 | 5.7E-04 | 7.5E-04 | 2.2E-04 | 6.8E-04 |
| SE | 1.3E-03 | 7.3E-04 | 4.1E-04 | 5.3E-04 | 6.9E-04 | 2.2E-04 | 6.2E-04 |
| ESE | 2.0E-03 | 1.0E-03 | 5.8E-04 | 7.5E-04 | 9.8E-04 | 3.0E-04 | 8.9E-04 |
| E | 1.4E-03 | 7.3E-04 | 4.0E-04 | 5.2E-04 | 6.8E-04 | 2.1E-04 | 6.2E-04 |
| ENE | 1.5E-03 | 8.0E-04 | 4.4E-04 | 5.7E-04 | 7.5E-04 | 2.3E-04 | 6.8E-04 |
| NE | 1.7E-03 | 8.8E-04 | 4.8E-04 | 6.3E-04 | 8.3E-04 | 2.5E-04 | 7.5E-04 |
| NNE | 3.0E-03 | 1.6E-03 | 9.1E-04 | 1.2E-03 | 1.5E-03 | 4.7E-04 | 1.4E-03 |

| | Distance (m) | | | | | | |
|---|---|---|---|---|---|---|---|
| Direction | 1446 | 1683 | 1741 | 1383 | 1351 | 2254 | 1510 |
| N | 5.2E-04 | 4.1E-04 | 3.9E-04 | 5.6E-04 | 5.8E-04 | 2.6E-04 | 4.9E-04 |
| NNW | 2.2E-04 | 1.8E-04 | 1.7E-04 | 2.4E-04 | 2.5E-04 | 1.1E-04 | 2.1E-04 |
| NW | 1.9E-04 | 1.5E-04 | 1.5E-04 | 2.1E-04 | 2.1E-04 | 9.8E-05 | 1.8E-04 |
| WNW | 1.7E-04 | 1.3E-04 | 1.3E-04 | 1.8E-04 | 1.8E-04 | 8.5E-05 | 1.6E-04 |
| W | 2.4E-04 | 1.9E-04 | 1.8E-04 | 2.6E-04 | 2.7E-04 | 1.2E-04 | 2.3E-04 |
| WSW | 6.4E-04 | 5.0E-04 | 4.8E-04 | 6.9E-04 | 7.2E-04 | 3.1E-04 | 6.0E-04 |
| SW | 4.2E-04 | 3.3E-04 | 3.2E-04 | 4.6E-04 | 4.7E-04 | 2.1E-04 | 4.0E-04 |
| SSW | 5.6E-04 | 4.3E-04 | 4.1E-04 | 6.0E-04 | 6.2E-04 | 2.7E-04 | 5.2E-04 |
| S | 5.3E-04 | 4.1E-04 | 3.9E-04 | 5.7E-04 | 5.9E-04 | 2.6E-04 | 4.9E-04 |
| SSE | 5.0E-04 | 3.9E-04 | 3.7E-04 | 5.4E-04 | 5.6E-04 | 2.4E-04 | 4.7E-04 |
| SE | 4.7E-04 | 3.7E-04 | 3.5E-04 | 5.1E-04 | 5.2E-04 | 2.4E-04 | 4.4E-04 |
| ESE | 6.6E-04 | 5.2E-04 | 4.9E-04 | 7.1E-04 | 7.4E-04 | 3.2E-04 | 6.2E-04 |
| E | 4.6E-04 | 3.6E-04 | 3.4E-04 | 5.0E-04 | 5.2E-04 | 2.3E-04 | 4.3E-04 |
| ENE | 5.0E-04 | 3.9E-04 | 3.7E-04 | 5.4E-04 | 5.6E-04 | 2.5E-04 | 4.7E-04 |
| NE | 5.6E-04 | 4.3E-04 | 4.1E-04 | 6.0E-04 | 6.2E-04 | 2.7E-04 | 5.2E-04 |
| NNE | 1.0E-03 | 8.2E-04 | 7.7E-04 | 1.1E-03 | 1.2E-03 | 5.1E-04 | 9.7E-04 |

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

| | Distance (m) | |
|---|---|---|
| Direction | 1339 | 839 |
| N | 5.9E-04 | 1.3E-03 |
| NNW | 2.5E-04 | 5.5E-04 |
| NW | 2.2E-04 | 4.5E-04 |
| WNW | 1.9E-04 | 4.0E-04 |
| W | 2.8E-04 | 5.8E-04 |
| WSW | 7.3E-04 | 1.6E-03 |
| SW | 4.8E-04 | 1.0E-03 |
| SSW | 6.3E-04 | 1.4E-03 |
| S | 6.0E-04 | 1.3E-03 |
| SSE | 5.7E-04 | 1.3E-03 |
| SE | 5.3E-04 | 1.1E-03 |
| ESE | 7.5E-04 | 1.6E-03 |
| E | 5.2E-04 | 1.1E-03 |
| ENE | 5.7E-04 | 1.3E-03 |
| NE | 6.3E-04 | 1.4E-03 |
| NNE | 1.2E-03 | 2.5E-03 |

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

| Direction | Distance (m) 750 | 1089 | 1574 | 1339 | 1134 | 2370 | 1206 |
|---|---|---|---|---|---|---|---|
| N | 2.1E-08 | 1.1E-08 | 5.9E-09 | 7.7E-09 | 1.0E-08 | 3.0E-09 | 9.1E-09 |
| NNW | 8.8E-09 | 4.6E-09 | 2.5E-09 | 3.3E-09 | 4.3E-09 | 1.3E-09 | 3.9E-09 |
| NW | 7.2E-09 | 3.9E-09 | 2.2E-09 | 2.8E-09 | 3.6E-09 | 1.1E-09 | 3.3E-09 |
| WNW | 6.3E-09 | 3.3E-09 | 1.9E-09 | 2.4E-09 | 3.1E-09 | 9.7E-10 | 2.8E-09 |
| W | 9.1E-09 | 4.9E-09 | 2.7E-09 | 3.6E-09 | 4.6E-09 | 1.4E-09 | 4.2E-09 |
| WSW | 2.6E-08 | 1.3E-08 | 7.3E-09 | 9.5E-09 | 1.3E-08 | 3.7E-09 | 1.1E-08 |
| SW | 1.6E-08 | 8.7E-09 | 4.8E-09 | 6.2E-09 | 8.2E-09 | 2.5E-09 | 7.4E-09 |
| SSW | 2.3E-08 | 1.2E-08 | 6.3E-09 | 8.3E-09 | 1.1E-08 | 3.2E-09 | 9.8E-09 |
| S | 2.1E-08 | 1.1E-08 | 6.0E-09 | 7.8E-09 | 1.0E-08 | 3.0E-09 | 9.2E-09 |
| SSE | 2.0E-08 | 1.0E-08 | 5.7E-09 | 7.4E-09 | 9.8E-09 | 2.8E-09 | 8.8E-09 |
| SE | 1.7E-08 | 9.5E-09 | 5.4E-09 | 6.9E-09 | 9.0E-09 | 2.8E-09 | 8.2E-09 |
| ESE | 2.6E-08 | 1.4E-08 | 7.5E-09 | 9.8E-09 | 1.3E-08 | 3.8E-09 | 1.2E-08 |
| E | 1.8E-08 | 9.5E-09 | 5.2E-09 | 6.8E-09 | 8.9E-09 | 2.7E-09 | 8.1E-09 |
| ENE | 2.0E-08 | 1.0E-08 | 5.7E-09 | 7.5E-09 | 9.8E-09 | 2.9E-09 | 8.9E-09 |
| NE | 2.2E-08 | 1.2E-08 | 6.3E-09 | 8.2E-09 | 1.1E-08 | 3.2E-09 | 9.8E-09 |
| NNE | 4.0E-08 | 2.1E-08 | 1.2E-08 | 1.5E-08 | 2.0E-08 | 6.1E-09 | 1.8E-08 |

| Direction | Distance (m) 1446 | 1683 | 1741 | 1383 | 1351 | 2254 | 1510 |
|---|---|---|---|---|---|---|---|
| N | 6.8E-09 | 5.3E-09 | 5.0E-09 | 7.3E-09 | 7.6E-09 | 3.3E-09 | 6.3E-09 |
| NNW | 2.9E-09 | 2.2E-09 | 2.1E-09 | 3.1E-09 | 3.2E-09 | 1.4E-09 | 2.7E-09 |
| NW | 2.5E-09 | 1.9E-09 | 1.8E-09 | 2.6E-09 | 2.7E-09 | 1.2E-09 | 2.3E-09 |
| WNW | 2.1E-09 | 1.7E-09 | 1.6E-09 | 2.3E-09 | 2.4E-09 | 1.0E-09 | 2.0E-09 |
| W | 3.1E-09 | 2.5E-09 | 2.3E-09 | 3.4E-09 | 3.5E-09 | 1.5E-09 | 2.9E-09 |
| WSW | 8.4E-09 | 6.6E-09 | 6.2E-09 | 9.0E-09 | 9.4E-09 | 4.1E-09 | 7.8E-09 |
| SW | 5.5E-09 | 4.3E-09 | 4.1E-09 | 5.9E-09 | 6.2E-09 | 2.7E-09 | 5.1E-09 |
| SSW | 7.3E-09 | 5.6E-09 | 5.3E-09 | 7.8E-09 | 8.1E-09 | 3.5E-09 | 6.8E-09 |
| S | 6.9E-09 | 5.3E-09 | 5.1E-09 | 7.4E-09 | 7.7E-09 | 3.3E-09 | 6.4E-09 |
| SSE | 6.5E-09 | 5.1E-09 | 4.8E-09 | 7.0E-09 | 7.3E-09 | 3.1E-09 | 6.1E-09 |
| SE | 6.1E-09 | 4.8E-09 | 4.6E-09 | 6.6E-09 | 6.8E-09 | 3.0E-09 | 5.7E-09 |
| ESE | 8.6E-09 | 6.7E-09 | 6.4E-09 | 9.3E-09 | 9.6E-09 | 4.2E-09 | 8.0E-09 |
| E | 6.0E-09 | 4.7E-09 | 4.4E-09 | 6.5E-09 | 6.7E-09 | 2.9E-09 | 5.6E-09 |
| ENE | 6.6E-09 | 5.1E-09 | 4.8E-09 | 7.1E-09 | 7.3E-09 | 3.2E-09 | 6.1E-09 |
| NE | 7.3E-09 | 5.6E-09 | 5.3E-09 | 7.8E-09 | 8.1E-09 | 3.5E-09 | 6.7E-09 |
| NNE | 1.4E-08 | 1.1E-08 | 1.0E-08 | 1.5E-08 | 1.5E-08 | 6.7E-09 | 1.3E-08 |

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

| | Distance (m) | |
|---|---|---|
| Direction | 1339 | 839 |
| N | 7.7E-09 | 1.7E-08 |
| NNW | 3.3E-09 | 7.2E-09 |
| NW | 2.8E-09 | 5.9E-09 |
| WNW | 2.4E-09 | 5.2E-09 |
| W | 3.6E-09 | 7.5E-09 |
| WSW | 9.5E-09 | 2.1E-08 |
| SW | 6.2E-09 | 1.4E-08 |
| SSW | 8.3E-09 | 1.8E-08 |
| S | 7.8E-09 | 1.7E-08 |
| SSE | 7.4E-09 | 1.7E-08 |
| SE | 6.9E-09 | 1.4E-08 |
| ESE | 9.8E-09 | 2.1E-08 |
| E | 6.8E-09 | 1.5E-08 |
| ENE | 7.5E-09 | 1.6E-08 |
| NE | 8.2E-09 | 1.8E-08 |
| NNE | 1.5E-08 | 3.3E-08 |

## 40 CFR PART 61.96(b) - APPLICATION FOR APPROVAL FOR BUILDING 56

1. Assumptions

- 46,270 pounds of enriched uranium metal ingots
- 207,006 pounds of enriched uranium metal derbies
- Enriched uranium metal cores are by weight 1.25% $U^{235}$ & rest $U^{238}$
- Activity of $U^{235}$ is Correction Factor (1.25/.2) * 98.8 µCi / kg-$U^{235}$
- Activity of $U^{238}$ is 333.6 µCi / kg-$U^{238}$
- Emission estimate from Appendix D, 40 CFR 61, for solid metal is $10^{-6}$
- Emissions are particulates
- EF means emission factor

2. Calculation of $U^{235}$ & $U^{238}$ Emissions

Activity of $U^{235}$ Emissions

| | | | | | |
|---|---|---|---|---|---|
| 253,276 lbs-U | 0.0125 lbs-$U^{235}$ | $10^{-6}$ lbs-solids | 1 kg | 98.8 µCi | = 0.142 µCi |
| | 1 lbs-U | 1 lb-solids | 2.205 lbs | kg-$U^{235}$ | |

Activity of $U^{238}$ Emissions

| | | | | | |
|---|---|---|---|---|---|
| 253,276 lbs-U | 0.9875 lbs-$U^{235}$ | $10^{-6}$ lbs-solids | 1 kg | 333.6 µCi | = 37.84 µCi |
| | 1 lbs-U | 1 lb-solids | 2.205 lbs | kg-$U^{235}$ | |

# FEMP RECEPTOR LOCATOR PROGRAM

Distances to Offsite receptors

| SOURCE: | Building 56 | |
|---|---|---|
| | N-S | E-W |
| | 481700 | 1380500 |

| RECEPTOR | N-S (ft) | E-W (ft) | DISTANCE (meters) | DIRECTION | |
|---|---|---|---|---|---|
| 1 | 484280 | 1380920 | 797 | N | |
| 2 | 484160 | 1380410 | 750 | N | 1 |
| 3 | 485470 | 1376970 | 1574 | NW | 3 |
| 4 | 483380 | 1376440 | 1339 | WNW | 4 |
| 5 | 482190 | 1376812 | 1134 | W | 5 |
| 6 | 479190 | 1377440 | 1206 | SW | 7 |
| 7 | 477630 | 1378060 | 1446 | SSW | 8 |
| 8 | 477060 | 1378440 | 1547 | SSW | |
| 9 | 476910 | 1378470 | 1586 | SSW | |
| 10 | 476220 | 1378810 | 1748 | SSW | |
| 11 | 476160 | 1379000 | 1749 | SSW | |
| 12 | 475900 | 1380000 | 1774 | S | |
| 13 | 476190 | 1381100 | 1689 | S | |
| 14 | 476250 | 1381380 | 1683 | S | 9 |
| 15 | 474780 | 1383190 | 2263 | SSE | |
| 16 | 476840 | 1383500 | 1741 | SSE | 10 |
| 17 | 479060 | 1384190 | 1383 | SE | 11 |
| 18 | 479340 | 1384250 | 1351 | ESE | 12 |
| 19 | 483380 | 1385160 | 1510 | ENE | 14 |
| 20 | 484720 | 1383690 | 1339 | NE | 15 |
| 21 | 484120 | 1381810 | 839 | NNE | 16 |
| 22 | 485190 | 1379730 | 1089 | NNW | 2 |
| 23 | 481839 | 1374096 | 1952 | W | |
| 24 | 480015 | 1386674 | 1951 | ESE | |
| 25 | 482361 | 1388613 | 2481 | E | |
| 26 | 479562 | 1373023 | 2370 | WSW | 6 |
| 27 | 475060 | 1385970 | 2622 | SE | |
| 28 | 485440 | 1379375 | 1190 | NNW | |
| 29 | 476940 | 1384000 | 1801 | SE | |
| 30 | 481557 | 1387895 | 2254 | E | 13 |
| 31 | 481767 | 1388075 | 2309 | E | |
| 32 | 485630 | 1379200 | 1262 | NNW | |
| A | 479562 | 1372826 | 2428 | WSW | |
| B | 483560 | 1376440 | 1361 | WNW | |
| C | 485310 | 1376810 | 1573 | NW | |
| D | 485500 | 1376560 | 1668 | NW | |
| E | 485310 | 1376560 | 1629 | NW | |
| F | 477000 | 1375340 | 2127 | SW | |
| G | 477000 | 1375220 | 2155 | SW | |
| H | 485220 | 1383620 | 1434 | NE | |

FILE: do-dist.wk4

# BUILDING 12, TANK FARM/ MAINTENANCE D&D PROJECT

Building 12

Tank Farm/Maintenance D&D Project

Distances to Receptors

| Direction | Distance |
|---|---|
| N | 986 |
| NNW | 973 |
| NW | 1848 |
| WNW | 1360 |
| W | 2156 |
| WSW | 1258 |
| SW | 1400 |
| SSW | 1499 |
| S | 1465 |
| SSE | 1473 |
| SE | 1529 |
| ESE | 1086 |
| E | 1721 |
| ENE | 1420 |
| NE | 1365 |
| NNE | 959 |

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

S Y N O P S I S  R E P O R T

Non-Radon Individual Assessment
Aug 26, 1997  2:49 pm

Facility: Fernald Environmental Management Project
Address: P.O. Box 398704
7400 Willey Road
City: Cincinnati
State: OH  Zip: 25253-8704

Effective Dose Equivalent
(mrem/year)

2.49E-03

At This Location: 959 Meters North Northeast

Source Category: Remediation Site
Source Type: Area
Emission Year: 1997

Comments: Monitor Determination for Tank Farm,
Maint. Blgd D&D Project

Dataset Name: tankfarm/maintbl
Dataset Date: Aug 26, 1997  2:49 pm
Wind File: WNDFILES\FEMPSTD.WND

3004

MAXIMALLY EXPOSED INDIVIDUAL

Location Of The Individual: 959 Meters North Northeast
Lifetime Fatal Cancer Risk: 3.22E-08

ORGAN DOSE EQUIVALENT SUMMARY

| Organ | Dose Equivalent (mrem/y) |
|---|---|
| GONADS | 6.10E-06 |
| BREAST | 7.05E-06 |
| R MAR | 1.80E-04 |
| LUNGS | 1.94E-02 |
| THYROID | 5.95E-06 |
| ENDOST | 2.33E-03 |
| RMNDR | 2.08E-04 |
| EFFEC | 2.49E-03 |

## RADIONUCLIDE EMISSIONS DURING THE YEAR 1997

| Nuclide | Class | Size | Source #1 Ci/y | TOTAL Ci/y |
|---|---|---|---|---|
| U-238 | Y | 1.00 | 7.5E-05 | 7.5E-05 |
| U-235 | Y | 1.00 | 1.5E-07 | 1.5E-07 |
| U-234 | Y | 1.00 | 1.5E-08 | 1.5E-08 |

## SITE INFORMATION

| | |
|---|---|
| Temperature: | 12 degrees C |
| Precipitation: | 102 cm/y |
| Mixing Height: | 950 m |

## SOURCE INFORMATION

Source Number: 1

Source Height (m): 3.00
Area (sq m): 2.71E+04

Plume Rise
Momentum (m/s): 2.00E+00
(Exit Velocity)

## AGRICULTURAL DATA

| | Vegetable | Milk | Meat |
|---|---|---|---|
| Fraction Home Produced: | 0.700 | 0.399 | 0.442 |
| Fraction From Assessment Area: | 0.300 | 0.601 | 0.558 |
| Fraction Imported: | 0.000 | 0.000 | 0.000 |

Food Arrays were not generated for this run.
Default Values used.

## DISTANCES USED FOR MAXIMUM INDIVIDUAL ASSESSMENT

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 986 | 973 | 1848 | 1360 | 2156 | 1258 | 1400 | 1499 | 1465 | 1473 |
| 1529 | 1086 | 1721 | 1420 | 1365 | 959 | | | | |

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

D O S E  A N D  R I S K  E Q U I V A L E N T  S U M M A R I E S

Non-Radon Individual Assessment
Aug 26, 1997 2:49 pm

Facility: Fernald Environmental Management Project
Address: P.O. Box 398704
7400 Willey Road
City: Cincinnati
State: OH Zip: 25253-8704

Source Category: Remediation Site
Source Type: Area
Emission Year: 1997

Comments: Monitor Determination for Tank Farm,
Maint. Blgd D&D Project

Dataset Name: tankfarm/maintbl
Dataset Date: Aug 26, 1997 2:49 pm
Wind File: WNDFILES\FEMPSTD.WND

## ORGAN DOSE EQUIVALENT SUMMARY

| Organ | Selected Individual (mrem/y) |
|---|---|
| GONADS | 6.10E-06 |
| BREAST | 7.05E-06 |
| R MAR | 1.80E-04 |
| LUNGS | 1.94E-02 |
| THYROID | 5.95E-06 |
| ENDOST | 2.33E-03 |
| RMNDR | 2.08E-04 |
| EFFEC | 2.49E-03 |

## PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

| Pathway | Selected Individual (mrem/y) |
|---|---|
| INGESTION | 1.52E-04 |
| INHALATION | 2.34E-03 |
| AIR IMMERSION | 4.97E-12 |
| GROUND SURFACE | 3.61E-07 |
| INTERNAL | 2.49E-03 |
| EXTERNAL | 3.61E-07 |
| TOTAL | 2.49E-03 |

## NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

| Nuclide | Selected Individual (mrem/y) |
|---|---|
| U-238 | 2.48E-03 |
| U-235 | 5.31E-06 |
| U-234 | 5.44E-07 |
| TOTAL | 2.49E-03 |

## CANCER RISK SUMMARY

| Cancer | Selected Individual Total Lifetime Fatal Cancer Risk |
|---|---|
| LEUKEMIA | 2.26E-10 |
| BONE | 1.25E-10 |
| THYROID | 1.10E-12 |
| BREAST | 1.35E-11 |
| LUNG | 3.14E-08 |
| STOMACH | 8.47E-12 |
| BOWEL | 1.58E-11 |
| LIVER | 6.97E-12 |
| PANCREAS | 5.62E-12 |
| URINARY | 4.55E-10 |
| OTHER | 6.87E-12 |
| TOTAL | 3.22E-08 |

## PATHWAY RISK SUMMARY

| Pathway | Selected Individual Total Lifetime Fatal Cancer Risk |
|---|---|
| INGESTION | 8.39E-10 |
| INHALATION | 3.14E-08 |
| AIR IMMERSION | 1.13E-16 |
| GROUND SURFACE | 7.90E-12 |
| INTERNAL | 3.22E-08 |
| EXTERNAL | 7.90E-12 |
| TOTAL | 3.22E-08 |

## NUCLIDE RISK SUMMARY

| Nuclide | Selected Individual Total Lifetime Fatal Cancer Risk |
|---|---|
| U-238 | 3.22E-08 |
| U-235 | 6.96E-11 |
| U-234 | 6.99E-12 |
| TOTAL | 3.22E-08 |

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

| Direction | Distance (m) 986 | 973 | 1848 | 1360 | 2156 | 1258 | 1400 |
|---|---|---|---|---|---|---|---|
| N | 1.2E-03 | 1.2E-03 | 4.3E-04 | 7.0E-04 | 3.3E-04 | 7.9E-04 | 6.7E-04 |
| NNW | 5.0E-04 | 5.1E-04 | 1.9E-04 | 3.0E-04 | 1.5E-04 | 3.4E-04 | 2.9E-04 |
| NW | 4.4E-04 | 4.5E-04 | 1.7E-04 | 2.6E-04 | 1.3E-04 | 3.0E-04 | 2.5E-04 |
| WNW | 3.8E-04 | 3.8E-04 | 1.4E-04 | 2.3E-04 | 1.1E-04 | 2.6E-04 | 2.2E-04 |
| W | 5.6E-04 | 5.8E-04 | 2.1E-04 | 3.4E-04 | 1.7E-04 | 3.8E-04 | 3.2E-04 |
| WSW | 1.5E-03 | 1.5E-03 | 5.2E-04 | 8.6E-04 | 4.1E-04 | 9.8E-04 | 8.2E-04 |
| SW | 9.7E-04 | 9.9E-04 | 3.5E-04 | 5.8E-04 | 2.8E-04 | 6.5E-04 | 5.5E-04 |
| SSW | 1.3E-03 | 1.3E-03 | 4.5E-04 | 7.4E-04 | 3.5E-04 | 8.4E-04 | 7.0E-04 |
| S | 1.2E-03 | 1.2E-03 | 4.3E-04 | 7.1E-04 | 3.4E-04 | 8.0E-04 | 6.8E-04 |
| SSE | 1.1E-03 | 1.2E-03 | 4.1E-04 | 6.7E-04 | 3.2E-04 | 7.6E-04 | 6.4E-04 |
| SE | 1.1E-03 | 1.1E-03 | 4.0E-04 | 6.5E-04 | 3.1E-04 | 7.4E-04 | 6.2E-04 |
| ESE | 1.5E-03 | 1.6E-03 | 5.4E-04 | 8.9E-04 | 4.2E-04 | 1.0E-03 | 8.5E-04 |
| E | 1.1E-03 | 1.1E-03 | 3.8E-04 | 6.3E-04 | 3.0E-04 | 7.1E-04 | 6.0E-04 |
| ENE | 1.1E-03 | 1.2E-03 | 4.1E-04 | 6.8E-04 | 3.2E-04 | 7.7E-04 | 6.5E-04 |
| NE | 1.3E-03 | 1.3E-03 | 4.5E-04 | 7.5E-04 | 3.5E-04 | 8.5E-04 | 7.1E-04 |
| NNE | 2.4E-03 | 2.4E-03 | 8.5E-04 | 1.4E-03 | 6.7E-04 | 1.6E-03 | 1.3E-03 |

| Direction | Distance (m) 1499 | 1465 | 1473 | 1529 | 1086 | 1721 | 1420 |
|---|---|---|---|---|---|---|---|
| N | 6.0E-04 | 6.2E-04 | 6.1E-04 | 5.8E-04 | 1.0E-03 | 4.8E-04 | 6.5E-04 |
| NNW | 2.6E-04 | 2.7E-04 | 2.6E-04 | 2.5E-04 | 4.3E-04 | 2.1E-04 | 2.8E-04 |
| NW | 2.3E-04 | 2.4E-04 | 2.3E-04 | 2.2E-04 | 3.7E-04 | 1.8E-04 | 2.5E-04 |
| WNW | 2.0E-04 | 2.0E-04 | 2.0E-04 | 1.9E-04 | 3.2E-04 | 1.6E-04 | 2.1E-04 |
| W | 2.9E-04 | 3.0E-04 | 3.0E-04 | 2.8E-04 | 4.8E-04 | 2.3E-04 | 3.2E-04 |
| WSW | 7.3E-04 | 7.6E-04 | 7.6E-04 | 7.1E-04 | 1.2E-03 | 5.9E-04 | 8.0E-04 |
| SW | 4.9E-04 | 5.1E-04 | 5.1E-04 | 4.8E-04 | 8.3E-04 | 3.9E-04 | 5.4E-04 |
| SSW | 6.3E-04 | 6.5E-04 | 6.5E-04 | 6.1E-04 | 1.1E-03 | 5.0E-04 | 6.9E-04 |
| S | 6.0E-04 | 6.3E-04 | 6.2E-04 | 5.9E-04 | 1.0E-03 | 4.8E-04 | 6.6E-04 |
| SSE | 5.7E-04 | 5.9E-04 | 5.9E-04 | 5.5E-04 | 9.8E-04 | 4.6E-04 | 6.3E-04 |
| SE | 5.6E-04 | 5.8E-04 | 5.7E-04 | 5.4E-04 | 9.3E-04 | 4.5E-04 | 6.1E-04 |
| ESE | 7.6E-04 | 7.9E-04 | 7.8E-04 | 7.4E-04 | 1.3E-03 | 6.1E-04 | 8.3E-04 |
| E | 5.4E-04 | 5.6E-04 | 5.5E-04 | 5.2E-04 | 9.1E-04 | 4.3E-04 | 5.9E-04 |
| ENE | 5.8E-04 | 6.0E-04 | 5.9E-04 | 5.6E-04 | 9.8E-04 | 4.6E-04 | 6.3E-04 |
| NE | 6.4E-04 | 6.6E-04 | 6.5E-04 | 6.2E-04 | 1.1E-03 | 5.1E-04 | 6.9E-04 |
| NNE | 1.2E-03 | 1.2E-03 | 1.2E-03 | 1.2E-03 | 2.0E-03 | 9.6E-04 | 1.3E-03 |

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

| | Distance (m) | |
|---|---|---|
| Direction | 1365 | 959 |
| N | 7.0E-04 | 1.2E-03 |
| NNW | 3.0E-04 | 5.3E-04 |
| NW | 2.6E-04 | 4.6E-04 |
| WNW | 2.3E-04 | 3.9E-04 |
| W | 3.4E-04 | 5.9E-04 |
| WSW | 8.6E-04 | 1.5E-03 |
| SW | 5.7E-04 | 1.0E-03 |
| SSW | 7.3E-04 | 1.3E-03 |
| S | 7.0E-04 | 1.3E-03 |
| SSE | 6.7E-04 | 1.2E-03 |
| SE | 6.5E-04 | 1.1E-03 |
| ESE | 8.9E-04 | 1.6E-03 |
| E | 6.3E-04 | 1.1E-03 |
| ENE | 6.7E-04 | 1.2E-03 |
| NE | 7.4E-04 | 1.3E-03 |
| NNE | 1.4E-03 | 2.5E-03 |

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

| Direction | Distance (m) 986 | 973 | 1848 | 1360 | 2156 | 1258 | 1400 |
|---|---|---|---|---|---|---|---|
| N | 1.5E-08 | 1.6E-08 | 5.4E-09 | 8.9E-09 | 4.2E-09 | 1.0E-08 | 8.5E-09 |
| NNW | 6.4E-09 | 6.5E-09 | 2.3E-09 | 3.8E-09 | 1.8E-09 | 4.3E-09 | 3.6E-09 |
| NW | 5.5E-09 | 5.7E-09 | 2.0E-09 | 3.3E-09 | 1.6E-09 | 3.7E-09 | 3.1E-09 |
| WNW | 4.7E-09 | 4.9E-09 | 1.7E-09 | 2.8E-09 | 1.4E-09 | 3.2E-09 | 2.7E-09 |
| W | 7.2E-09 | 7.3E-09 | 2.6E-09 | 4.2E-09 | 2.0E-09 | 4.8E-09 | 4.0E-09 |
| WSW | 1.9E-08 | 1.9E-08 | 6.6E-09 | 1.1E-08 | 5.1E-09 | 1.3E-08 | 1.1E-08 |
| SW | 1.2E-08 | 1.3E-08 | 4.4E-09 | 7.3E-09 | 3.4E-09 | 8.3E-09 | 7.0E-09 |
| SSW | 1.6E-08 | 1.7E-08 | 5.7E-09 | 9.4E-09 | 4.4E-09 | 1.1E-08 | 9.0E-09 |
| S | 1.5E-08 | 1.6E-08 | 5.4E-09 | 9.0E-09 | 4.2E-09 | 1.0E-08 | 8.6E-09 |
| SSE | 1.5E-08 | 1.5E-08 | 5.1E-09 | 8.6E-09 | 3.9E-09 | 9.8E-09 | 8.2E-09 |
| SE | 1.4E-08 | 1.4E-08 | 5.0E-09 | 8.3E-09 | 3.9E-09 | 9.4E-09 | 7.9E-09 |
| ESE | 2.0E-08 | 2.0E-08 | 6.9E-09 | 1.1E-08 | 5.3E-09 | 1.3E-08 | 1.1E-08 |
| E | 1.4E-08 | 1.4E-08 | 4.8E-09 | 8.0E-09 | 3.7E-09 | 9.1E-09 | 7.6E-09 |
| ENE | 1.5E-08 | 1.5E-08 | 5.2E-09 | 8.6E-09 | 4.0E-09 | 9.8E-09 | 8.2E-09 |
| NE | 1.6E-08 | 1.7E-08 | 5.7E-09 | 9.5E-09 | 4.4E-09 | 1.1E-08 | 9.1E-09 |
| NNE | 3.1E-08 | 3.1E-08 | 1.1E-08 | 1.8E-08 | 8.5E-09 | 2.1E-08 | 1.7E-08 |

| Direction | Distance (m) 1499 | 1465 | 1473 | 1529 | 1086 | 1721 | 1420 |
|---|---|---|---|---|---|---|---|
| N | 7.6E-09 | 7.9E-09 | 7.8E-09 | 7.4E-09 | 1.3E-08 | 6.1E-09 | 8.3E-09 |
| NNW | 3.2E-09 | 3.3E-09 | 3.3E-09 | 3.1E-09 | 5.4E-09 | 2.6E-09 | 3.5E-09 |
| NW | 2.8E-09 | 2.9E-09 | 2.9E-09 | 2.7E-09 | 4.7E-09 | 2.3E-09 | 3.1E-09 |
| WNW | 2.4E-09 | 2.5E-09 | 2.5E-09 | 2.3E-09 | 4.0E-09 | 1.9E-09 | 2.6E-09 |
| W | 3.6E-09 | 3.8E-09 | 3.7E-09 | 3.5E-09 | 6.1E-09 | 2.9E-09 | 3.9E-09 |
| WSW | 9.4E-09 | 9.8E-09 | 9.7E-09 | 9.1E-09 | 1.6E-08 | 7.5E-09 | 1.0E-08 |
| SW | 6.2E-09 | 6.5E-09 | 6.4E-09 | 6.0E-09 | 1.1E-08 | 5.0E-09 | 6.8E-09 |
| SSW | 8.0E-09 | 8.3E-09 | 8.3E-09 | 7.8E-09 | 1.4E-08 | 6.4E-09 | 8.8E-09 |
| S | 7.7E-09 | 8.0E-09 | 7.9E-09 | 7.4E-09 | 1.3E-08 | 6.1E-09 | 8.4E-09 |
| SSE | 7.3E-09 | 7.5E-09 | 7.5E-09 | 7.0E-09 | 1.3E-08 | 5.8E-09 | 8.0E-09 |
| SE | 7.1E-09 | 7.3E-09 | 7.3E-09 | 6.8E-09 | 1.2E-08 | 5.6E-09 | 7.7E-09 |
| ESE | 9.7E-09 | 1.0E-08 | 1.0E-08 | 9.4E-09 | 1.7E-08 | 7.7E-09 | 1.1E-08 |
| E | 6.8E-09 | 7.1E-09 | 7.0E-09 | 6.6E-09 | 1.2E-08 | 5.4E-09 | 7.5E-09 |
| ENE | 7.3E-09 | 7.6E-09 | 7.6E-09 | 7.1E-09 | 1.3E-08 | 5.8E-09 | 8.0E-09 |
| NE | 8.1E-09 | 8.4E-09 | 8.3E-09 | 7.8E-09 | 1.4E-08 | 6.4E-09 | 8.9E-09 |
| NNE | 1.5E-08 | 1.6E-08 | 1.6E-08 | 1.5E-08 | 2.6E-08 | 1.2E-08 | 1.7E-08 |

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

| | Distance (m) | |
|---|---|---|
| Direction | 1365 | 959 |
| N | 8.9E-09 | 1.6E-08 |
| NNW | 3.7E-09 | 6.7E-09 |
| NW | 3.3E-09 | 5.8E-09 |
| WNW | 2.8E-09 | 5.0E-09 |
| W | 4.2E-09 | 7.5E-09 |
| WSW | 1.1E-08 | 2.0E-08 |
| SW | 7.3E-09 | 1.3E-08 |
| SSW | 9.4E-09 | 1.7E-08 |
| S | 9.0E-09 | 1.6E-08 |
| SSE | 8.5E-09 | 1.6E-08 |
| SE | 8.2E-09 | 1.5E-08 |
| ESE | 1.1E-08 | 2.1E-08 |
| E | 8.0E-09 | 1.4E-08 |
| ENE | 8.6E-09 | 1.6E-08 |
| NE | 9.5E-09 | 1.7E-08 |
| NNE | 1.8E-08 | 3.2E-08 |

# APPENDIX E

## SPLIT/CO-LOCATED SAMPLING COMPARISON WITH OEPA

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# LIST OF ACRONYMS

| | |
|---|---|
| DOE | U.S. Department of Energy |
| OEPA | Ohio Environmental Protection Agency |
| pCi/g | picoCuries per grams |
| pCi/L | picoCuries per liter |
| µg/L | micrograms per liter |

# APPENDIX E

Appendix E presents split/co-located sample data in support of Chapter 2 of this 1999 Integrated Site Environmental Report. The data reflect results from split/co-located samples for analysis between the U.S. Department of Energy (DOE) and the Ohio Environmental Protection Agency (OEPA) for groundwater, surface water, and sediment. The results are provided in Table E-1 and the sample locations for groundwater, surface water, and sediment are depicted in Figures E-1, E-2, and E-3, respectively.

The data from the split/co-located sampling program shows reasonable agreement between DOE and OEPA results for groundwater (except the April sample at location 12 [2060]), surface water (except radium-228 results), and sediment samples. The exceptions will continue to be monitored. It is likely that laboratory variability, actual sampling date differences, or sampling methodology differences are the cause of the variability in the results. The slight differences in DOE and OEPA sample results presented for 1999 do not impact the Fernald Environmental Management Project's compliance with federal or state regulations.

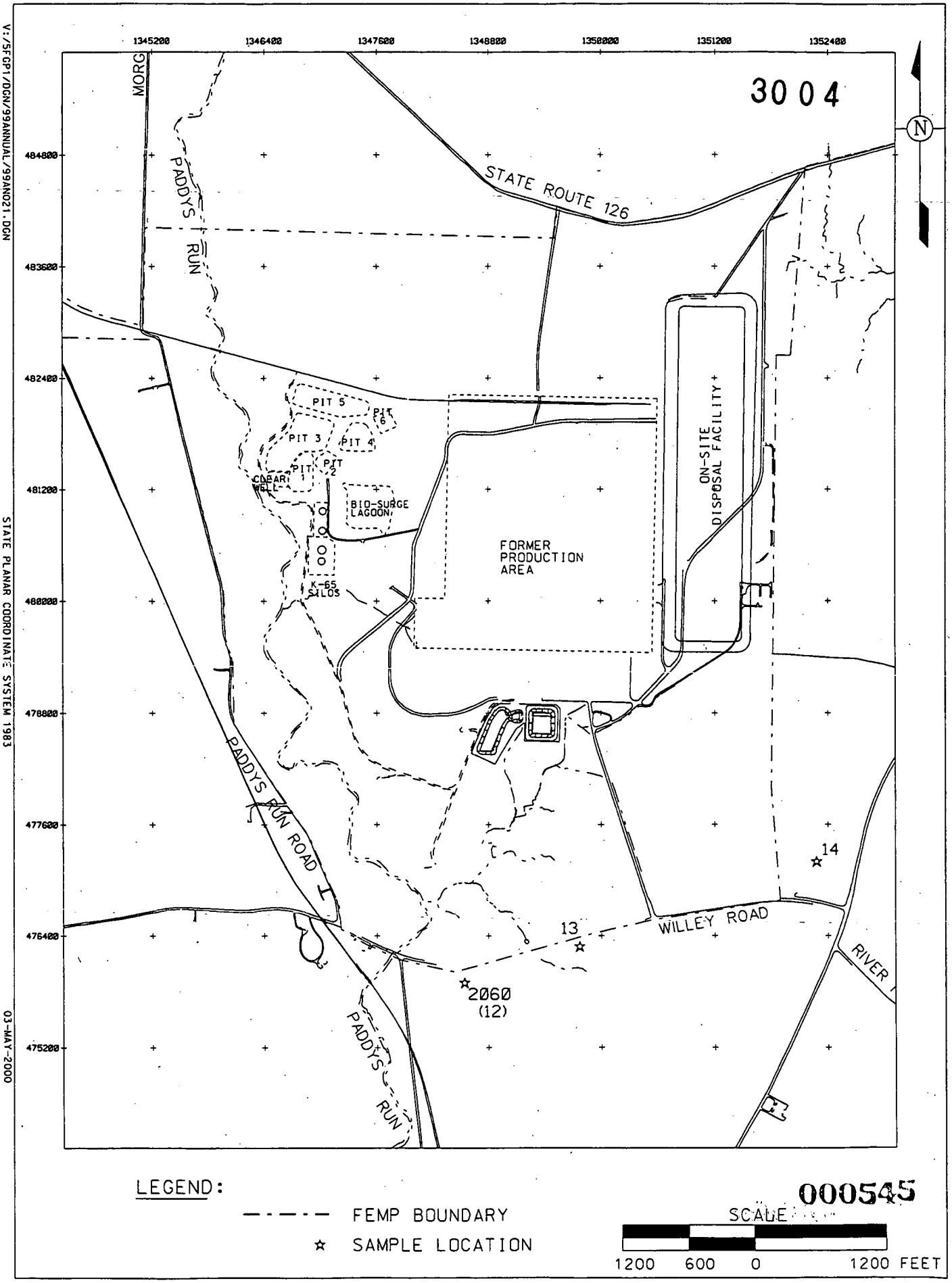
# TABLE E-1

## 1999 FEMP DOE-OEPA SPLIT/CO-LOCATED SAMPLING COMPARISON

| Media | Sample Location | Sample Date | Constituent | DOE Result | OEPA Result | FRL |
|---|---|---|---|---|---|---|
| Groundwater[a] | | | | (µg/L) | (µg/L) | (µg/L) |
| | 12 (2060) | Not Sampled | Not Applicable | - | - | 20 |
| | 12 (2060) | April | Total Uranium | 46 | 79 | 20 |
| | 12 (2060) | July | Total Uranium | 106 | 120 | 20 |
| | 12 (2060) | October | Total Uranium | 99 | 120 | 20 |
| | 13 | January | Total Uranium | 38 | 33 | 20 |
| | 13 | April | Total Uranium | 31 | 30 | 20 |
| | 13 | July | Total Uranium | 30 | 32 | 20 |
| | 13 | October | Total Uranium | 27 | 33 | 20 |
| | 14 | January | Total Uranium | 3.2 | 3.0 | 20 |
| | 14 | April | Total Uranium | 3.4 | 3.1 | 20 |
| | 14 | July | Total Uranium | 2.8 | 2.9 | 20 |
| | 14 | October | Total Uranium | 2.8 | 3.3 | 20 |
| Surface Water[b,c] | | | | (pCi/L) | (pCi/L) | (pCi/L) |
| | SWR-01 | First Quarter | Radium-226 | 0.211 | 0.20 | 38 |
| | SWR-01 | First Quarter | Radium-228 | 5.884 | 1.2 | 47 |
| | SWR-01 | First Quarter | Total Uranium (µg/L) | 1.835 | 1.9 | 530 |
| | SWR-01 | Second Quarter | Radium-226 | 0.621 | 0.17 | 38 |
| | SWR-01 | Second Quarter | Radium-228 | 0.257 | 1.3 | 47 |
| | SWR-01 | Second Quarter | Total Uranium (µg/L) | 1.297 | 1.7 | 530 |
| | SWR-01 | Third Quarter | Radium-226 | 0.446 | 0.35 | 38 |
| | SWR-01 | Third Quarter | Radium-228 | 0.189 | 1.6 | 47 |
| | SWR-01 | Third Quarter | Total Uranium (µg/L) | 1.012 | 1.7 | 530 |
| | SWR-01 | Fourth Quarter | Radium-226 | 0.474 | 0.69 | 38 |
| | SWR-01 | Fourth Quarter | Radium-228 | 0.175 | 1.8 | 47 |
| | SWR-01 | Fourth Quarter | Total Uranium (µg/L) | 1.97 | 1.3 | 530 |
| Sediment[d,e] | | | | (pCi/g) | (pCi/g) | (pCi/g) |
| | P1 | August/June | Radium-226 | 0.494 | 0.68 | 2.9 |

[a]See Figure E-1 for groundwater sample locations (splits)
[b]See Figure E-2 for surface water sample location (co-located)
[c]DOE samples were collected quarterly while OEPA samples were collected bi-monthly; the highest OEPA result for a quarter is being reported.
[d]See Figure E-3 for sediment sample location (co-located)
[e]The DOE sample was collected in August while OEPA sample was collected in June.

000544




LEGEND:

FEMP BOUNDARY

SAMPLE LOCATION

SCALE

1200 600 0 1200 FEET

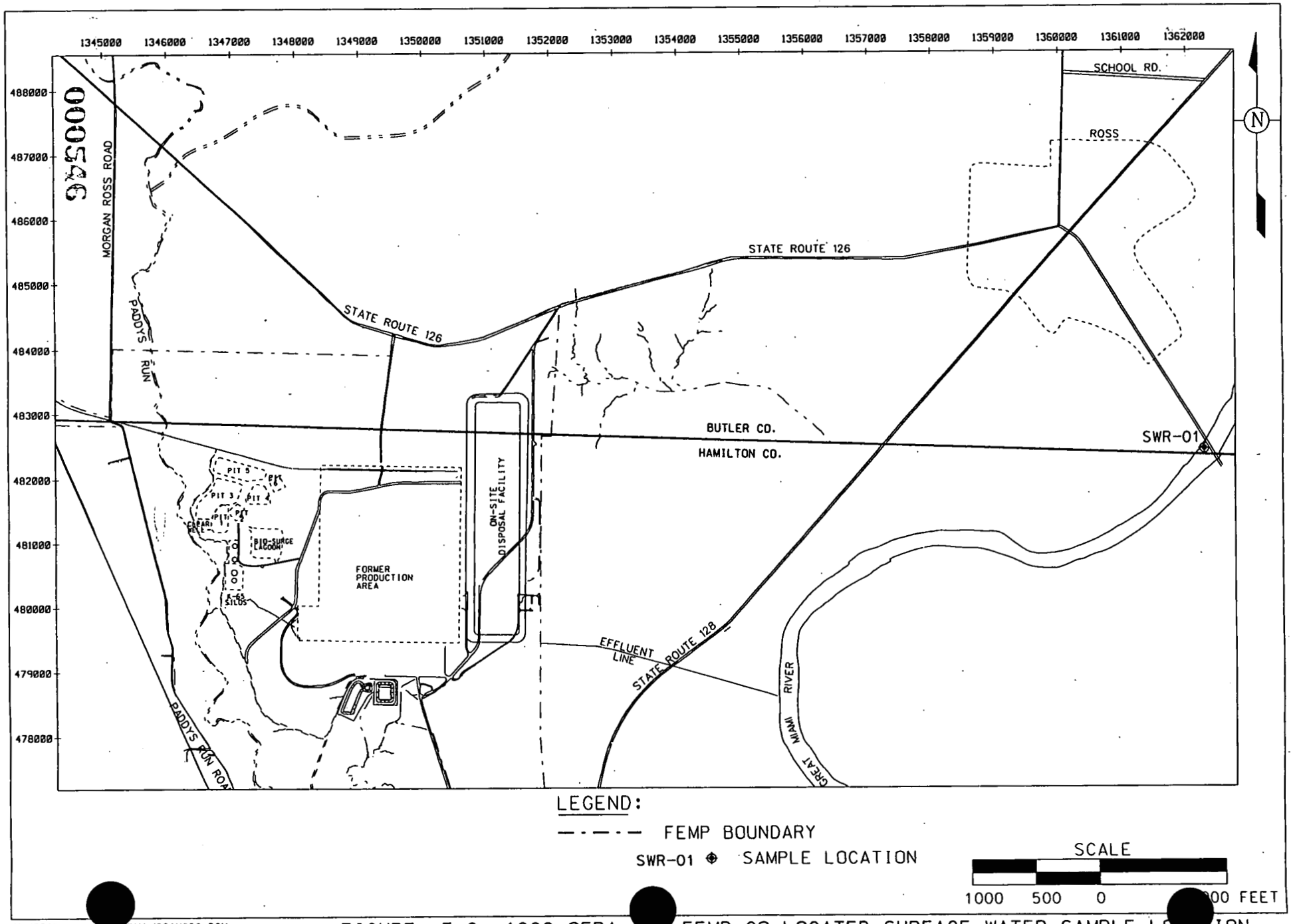
000545

FIGURE E-1. 1999 OEPA AND FEMP SPLIT GROUNDWATER SAMPLE LOCATIONS

V:/5FGP1/DGN/99ANNUAL/99AN021.DGN

STATE PLANAR COORDINATE SYSTEM 1983

03-MAY-2000




LEGEND:

FEMP BOUNDARY

SWR-01 ⊕ SAMPLE LOCATION

SCALE

1000 500 0 1000 FEET

V:/5FGP1/DGN/99ANNUAL/99AN020.DGN
STATE PLANAR COORDINATE SYSTEM 1983

FIGURE E-2. 1999 OEPA AND FEMP CO-LOCATED SURFACE WATER SAMPLE LOCATION

000546

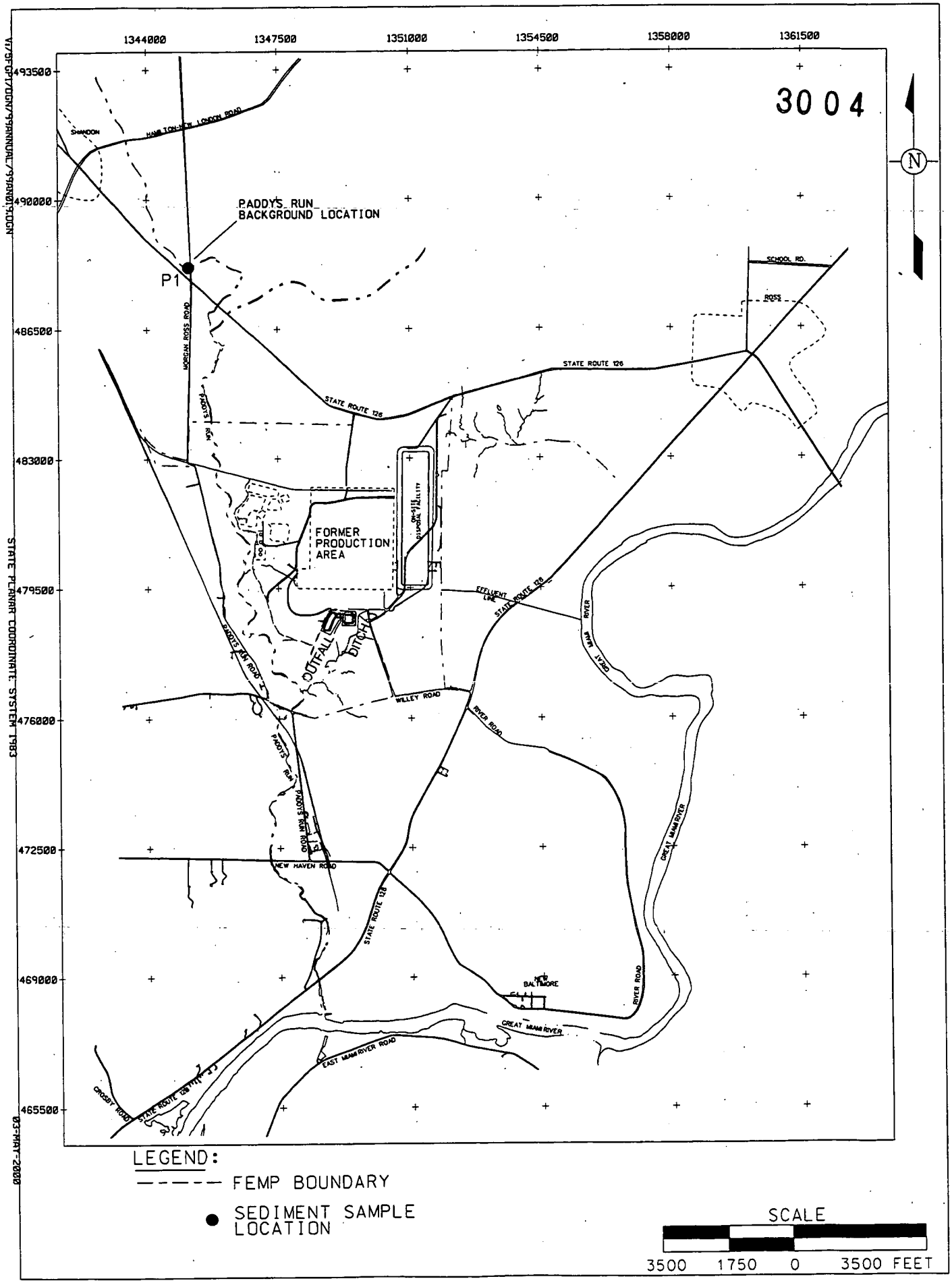



FIGURE E-3. 1999 OEPA AND FEMP CO-LOCATED SEDIMENT SAMPLE LOCATIONS