Appendix A

Supplemental Groundwater Information

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Appendix A presents groundwater data and analysis in support of Chapter 3. This appendix consists of the following five attachments:

- Attachment A.1 provides operational data for the South Field Module, the South Plume Module, and the Waste Storage Area Module.
- Attachment A.2 provides total uranium data (including summary statistics) and plume maps for the first and second halves of 2015.
- Attachment A.3 provides groundwater elevation data and quarterly water level maps.
- Attachment A.4 provides an analysis of the non-uranium final remediation level exceedances both inside and outside the 2014 Operational Design remediation footprint.
- Attachment A.5 presents leak detection and leachate monitoring results associated with the On-Site Disposal Facility monitoring program.

Groundwater analytical data are available through the U.S. Department of Energy Office of Legacy Management's Geospatial Environmental Mapping System (http://www.lm.doe.gov/Fernald/Sites.aspx).

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Attachment A.1

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Abbreviations

CAWWT	Converted Advanced Waste Water Treatment Facility
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
GMA	Great Miami Aquifer
IX	ion-exchange vessel
Ohio EPA	Ohio Environmental Protection Agency
PRRS	Paddys Run Road Site
SWRB	Storm Water Retention Basin
UCL	upper confidence level
WSA	Waste Storage Area

Measurement Abbreviations

95% UCL	upper bound of the 95% confidence interval
ft amsl	feet above mean sea level
gpm	gallons per minute
lb	pounds
M gal	million gallons
µg/L	micrograms per liter
mg/L	milligrams per liter

A.1.0 Operational Assessment

This attachment presents:

- Operational data for each extraction well pumping in 2015.
- Uranium concentrations trends for each extraction well compared to model-predicted concentration trends.
- Estimates of uranium removal from the aquifer when the pump-and treat-remediation operation ends.

Operational changes were implemented on July 1, 2014. From January 1 to June 30, 2014, the remediation system operated to pumping rates defined in the Waste Storage Area (WSA) Phase II Design (DOE 2005), which was established in 2005. The WSA Phase II Design called for the operation of 23 extraction wells at a target pumping rate of 4,775 gallons per minute (gpm). From July 1 to December 31, 2014, the remediation system began operating to the Operational Design Adjustments-1 Design (DOE 2014). The new 2014 design requires the operation of 20 extraction wells at a target pumping rate of 5,075 gpm. The operational changes are further discussed in Section A.1.1.

Because of the operational change noted above, 20 extraction wells were operational in 2015. Figure A.1-1 depicts the locations of extraction and former re-injection wells and identifies surrounding monitoring wells. Table A.1-1 provides summaries of gallons pumped, total uranium removed, and uranium removal indices for 2015 and for August 1993 through December 2015.

Information in this attachment is organized into the following subsections:

- Summary of Operational Changes Implemented in 2014 (Section A.1.1)
- South Field Module (Section A.1.2)
- South Plume Module (Section A.1.3)
- Waste Storage Area Module (Section A.1.4)
- Total Uranium Data (Section A.1.5)
- Pumping Rates (Section A.1.6)
- Converted Advanced Wastewater Treatment (CAWWT) Capacity Reduction (Section A.1.7)

A.1.1 Summary of Operational Changes Implemented in 2014

From 2006 to July 2014, the pump-and-treat system operated to a design established in 2005, which was based on uranium concentrations measured in the aquifer up until 2005. Additional groundwater modeling was conducted in 2012 using the 2005 operational design but with an updated uranium plume. The *Operational Design Adjustments-1 WSA Phase-II Groundwater Remediation Design Fernald Preserve* (DOE 2014) provides additional details concerning that modeling effort. The updated plume contained 7 additional years of data and better reflected the actual plume at the start of 2012. Modeling runs with the updated uranium plume indicated that aquifer cleanup using pump-and-treat operations would take longer than previously predicted.

The table below compares model-predicted cleanup times for both the original 2005 design and updated model run.

Alternative	South Plume Module	South Field Module	Waste Storage Area Module
2005 Model Prediction Cleanup Date	2015	2022	2023
Updated Model Prediction Cleanup Date	2021	2028	2032
Model-Predicted Increase in Years	6	6	9

As shown above, model-predicted cleanup times were extended by 6 to 9 years. Additional groundwater modeling was conducted to determine if the predicted cleanup times could be shortened. Sixteen alternatives were modeled. All 16 alternatives and results are reported in the *Operational Design Adjustments-1 WSA Phase-II Groundwater Remediation Design Fernald Preserve* (DOE 2014). The selected alternative incorporates the following operational changes:

- Three extraction wells were turned off (EW-28a, EW-31, and EW-32) because the wells were no longer providing benefit to the ongoing remediation. When they were first installed, the wells were removing uranium-contaminated groundwater from the aquifer; however, by 2014 the wells were removing groundwater from areas of the plume that had achieved pump-and-treat cleanup goals.
- The pumping budget freed up from the three extraction wells that were turned off was re-allocated to selected extraction wells in the southern portion of the South Field and the South Plume to shorten the predicted cleanup times in those areas.
- The target system pumping rate was increased from 4,775 gpm to 5,075 gpm.

The groundwater model predicts that operating to the new design defined by the selected operational alternative will achieve cleanup in the southern South Field 7 years earlier than the 2005 design predicted. Figure A.1-2 compares model-predicted cleanup times for both designs. As shown in Figure A.1-2, the overall model-predicted cleanup time for the WSA is increased by 1 year, but the predicted accelerated cleanup of the southern South Field 7 years earlier makes the 1-year extension an acceptable tradeoff.

With concurrence and support of the U.S. Environmental Protection Agency (EPA), the Ohio Environmental Protection Agency (Ohio EPA), and site stakeholders, preparations to implement the operational changes occurred in the spring of 2014:

- Three extraction wells were turned off (EW-28a, EW-31, and EW-32).
- Seven existing extraction wells were chemically rehabilitated.
- Larger pumps were installed in seven extraction wells.

On July 1, 2014, the pump-and-treat system began operating to the new design rate of 5,075 gpm. As shown in Figure A.1-3, more uranium was removed from the aquifer after the operational changes were implemented in July 2014.

The new operational design is more aggressive than the 2005 design in that for the first 9 years the target system pumping rate is 300 gpm higher. The new design is also more efficient because pumping is more concentrated where the pumping is needed and when it is needed. The result is predicted lower pumping rates as the remedy progresses. The predicted lower pumping rates come with predicted cost savings of approximately $6 million over the life of the pump-and-treat operation.

The new, more aggressive pumping rates could involve higher maintenance costs due to iron fouling of the pumps and well screens. Figure A.1-4 shows the difference between a clean pump and one removed from an active pumping well at the Fernald Preserve after it had been operating for some time. As shown in the bottom photo, the pump pulled from the well is coated with iron, which interfered with operation of the pump and motor.

Operational experience has been used to create and refine an aggressive, successful well maintenance program to address this iron fouling. Extraction wells are treated with a chemical solution when operational indicators indicate that cleaning is warranted. As shown below, the number of chemical treatments was up slightly in 2015 when compared to 2014 and 2013.

Year	Number of Extraction Wells	Number of Chemical Treatments
2015	20	41
2014	23/20[a]	32
2013	23	38

[a] The number of operating extraction wells was reduced in July 2014.

Although the well treatment program has been successful to date, it appears that the repeated chemical treatments currently being used are corroding the metal in the pumps over time. If this issue continues, more pump replacements may be required in the future. DOE will continue to work with recognized well-field experts to determine if the program can be improved and the life of pumps extended.

A.1.2 South Field Module

Eleven extraction wells were operational in the South Field Module in 2015. The 11 active extraction wells were 31550 (EW-18), 31560 (EW-19), 31561 (EW-20), 33326 (EW-17a), 32276 (EW-22), 32446 (EW-24), 32447 (EW-23), 33061 (EW-25), 33262 (EW-15a), 33264 (EW-30), and 33298 (EW-21a).

The target combined pumping rate for the South Field Module wells in 2015 was 2,875 gpm. Table A.1-1 presents the combined performance data for the South Field Module. The target pumping rates are consistent with pumping rates defined for the Operational Design Adjustments-1 Design. Tables A.1-2 through A.1-12 provide individual extraction well performance data for the South Field Module wells in 2015. Target pumping rate adjustments are noted on each table. The footnotes explain individual extraction well outages of greater than 24 hours.

During 2015, 1,395.5 million gallons (M gal) of groundwater were pumped from the active extraction wells in the South Field Module, resulting in the removal of 341.6 pounds (lb) of uranium from the Great Miami Aquifer (GMA). Since startup in July 1998, the South Field Module has removed 20.12642 billion gallons of water and 7,785 lb of uranium from the GMA.

A.1.3 South Plume Module

Six extraction wells were operational in the South Plume Module in 2015. The six active recovery wells are 3924 (RW-1), 3925 (RW-2), 3926 (RW-3), 3927 (RW-4), 32308 (RW-6), and 32309 (RW-7). These wells are located south of Willey Road and north of New Haven Road.

The target combined pumping rate for the South Plume Module wells in 2015 was 1,400 gpm. Tables A.1-13 through A.1-18 provide individual extraction well performance data for the South Plume Module extraction wells in 2015. Target pumping rate adjustments are noted on each table. The footnotes explain individual extraction well outages of greater than 24 hours. Table A.1-1 presents the combined performance data for the South Plume Module.

During 2015, 621.73 M gal of groundwater were pumped from the six wells in the South Plume Module, resulting in the removal of 100.63 lb of uranium from the GMA. Since its startup in August 1993, the South Plume Module has removed 15.45401 billion gallons of groundwater and 3,073 lb of uranium from the GMA.

During 2015, 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 (3924 [RW-1], 3925 [RW-2], 3926 [RW-3], and 3927 [RW-4]).
- Actively remediating the higher-concentration region of the off-property plume (32308 [RW-6] and 32309 [RW-7]).

Attachment A.3 presents additional details concerning capture, along with supporting data.

In 2015, 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 were 2128, 2625, 2636, 2898, 2899, 2900, 3128, 3636, 3898, 3899, and 3900 (refer to Figure A.1-1).

The Mann-Kendall test for trend was run on PRRS data collected from these wells. As indicated in Table A.1-19, four parameters at six different wells monitored for PRRS constituents of concern had “up, significant” trends:

- Arsenic in monitoring wells 2898, 2899, 3636, 3898, and 3899
- Phosphorous in monitoring well 2625
- Potassium in monitoring wells 2898, 2899, 3898, and 3899
- Sodium in monitoring wells 2898, 2899, 3898, and 3899

Figures A.1-5 through A.1-18 provide plots of concentration versus time for these constituents and wells. Groundwater flow directions are reported in Attachment A.3 in the form of water table maps. The water table maps for 2015 indicate that flow to monitoring wells 2898, 3898, 2899, and 3899 was from the northeast to the southwest. This indicates that the increasing concentrations at these locations were moving toward the PRRS plume, not away from it. The water table maps also indicate that flow from monitoring wells 2625 and 3636 was away from the South Plume, not toward it.

The monitoring activity for PRRS constituents of concern also included sampling for volatile organic compounds. These compounds are monitored because they were present in the PRRS plume, which is not of Fernald origin (ERM Midwest, Inc. 1994). No volatile organic compounds were detected in 2015.

Monitoring water levels appears to be more effective than monitoring water quality for determining if pumping in the South Plume is pulling the PRRS plume toward the South Plume recovery wells.

A.1.4 Waste Storage Area Module

Three extraction wells were operational in the former WSA in 2015. The three extraction wells were 32761 (EW-26), 33062 (EW-27), and 33347 (EW-33a).

The target combined pumping rate for the WSA Module wells in 2015 was 800 gpm. Tables A.1-20 through A.1-22 provide individual extraction well performance data for the WSA Module wells for 2015. Target pumping rate adjustments are noted on each table. The footnotes explain individual extraction well outages of greater than 24 hours. The combined performance data for the WSA Module are presented in Table A.1-1.

During 2015, 406.33 M gal of groundwater were pumped from extraction wells in the WSA Module, resulting in the removal of 77.03 lb of uranium from the GMA. Since startup in May 2002, the WSA Module has removed 6.09280 billion gallons of water and 2,038 lb of uranium from the GMA.

A.1.5 Total Uranium Data

In 2015, water samples were collected monthly from the extraction wells and analyzed for total uranium. The total uranium concentrations were used to calculate an annual mass of uranium removed from the well. The total uranium concentrations were also used to determine if a well needed to be routed to treatment or to bypass treatment.

Under the 2005 operational design, the aquifer remedy had been able to achieve the uranium discharge limits (i.e., average monthly concentration of less than 30 micrograms per liter [µg/L] and 600 lb annually) established in the Operable Unit 5 Record of Decision (DOE 1996) without groundwater treatment since 2010. With implementation of the new operational design in July 2014 (Section A.1.1), groundwater treatment was needed from July 2014 to mid-November 2014 to achieve uranium discharge limits. In 2015, 2.42 billion gallons of groundwater were pumped from the GMA and 9.38 M gal of groundwater was treated. This equates to approximately 0.4%.

Uranium concentration data collected from the extraction wells are tracked graphically to assess how the concentrations are trending. Uranium concentrations are plotted over time and then a regression line is fitted to the data set. Figures A.1-19 through A.1-38 are uranium concentration versus time plots for each extraction well. Each graph displays three different data sets (operational data, the upper bound of the 95% confidence level [UCL] of the operational data, and model predictions). Trend lines for the operational data set and the 95% UCL of the operational data set were fitted using the regression analysis function in Microsoft Excel.

As pumping continues, the uranium concentration of the pumped groundwater will decrease. The slope of a fitted regression curve through the uranium concentration data set collected at each extraction well provides a prediction of how quickly pumping concentrations will continue to decrease. However, the slope of a fitted regression curve through the pumped uranium concentration data set is an insufficient statistical measure by itself because future measured concentrations could vary about the trend curve. EPA guidelines in *General Methods for Remedial Operation Performance Evaluations* (EPA 1992) suggest that a 95% UCL of the measured uranium concentration data set be used to help evaluate the uncertainty of the predicted data trend.

The graphs in Figures A.1-19 through A.1-38 predict for each extraction well when the actual measured concentrations and the 95% UCL calculated concentrations will reach the 30 µg/L final remediation level for total uranium. For example, the concentration trend of pumped water from extraction well 33298 (refer to Figure A.1-30) reached 30 µg/L in August of 2013 (trend for the measured data set). It is also predicted to reach 30 µg/L beyond 2024 based on the trend for the 95% UCL data.

Figures A.1-19 through A.1-38 also provide a comparison of the modeled uranium concentration predictions to the measured and 95% UCL data trends. The Fernald aquifer remediation was designed using the Variable Saturated Model in 3 Dimensions (VAM-3D). When the site transitioned to the DOE Office of Legacy Management in 2006, the remediation was operating to a 2005 design called the WSA (Phase II) Design (DOE 2005). As explained in Section A.1.1, a new design was implemented in July of 2014 (DOE 2014). Groundwater model predictions for both designs are based on the assumption that an equilibrium linear isotherm adequately describes the partitioning of total uranium between the sorbed and dissolved phases.

The Fernald groundwater model predicts the future average pounds of uranium that will be removed from the aquifer for each year of the modeled remedy. This prediction (broken down by year) is used to judge how closely the remediation is tracking the model predictions. The average annual pounds of uranium actually removed from the aquifer are compared to the model predictions to assess how reasonable the model predictions were. Regression equations based on measured concentration data collected at the extraction wells are used to provide a prediction of the number of pounds of uranium that will be removed from the aquifer in future years. Regression equations based on uranium concentration data collected at extraction wells through December 31, 2015, are summarized in Table A.1-23. Changing water levels in the aquifer result in cleanup variations and uncertainty. Modeling is therefore conducted under low water level conditions, high water level conditions, and nominal water level conditions to bracket the uncertainty in model-predicted cleanup times. This tracking exercise used model predictions for high water level conditions, as they were the most conservative (i.e., longest cleanup times).

At the end of December 2015, data indicated that 12,819 net lb of uranium had been removed from the GMA by the pump-and-treat remedy. Net pounds of uranium includes a small amount of uranium that was re-injected into the aquifer between 1998 to 2004. The new 2014 cleanup operational design predicts that cleanup objectives will be achieved in 2033, based on a start date of 2012.

Modeling predicts that from 2016 through 2033 an additional 2,949 lb of uranium will be removed from the GMA. The concentration data set indicates that an additional 3,283 lb of uranium will be removed from the GMA based on regression analyses of the individual well data. The 95% UCL measured concentration data set indicates that an additional 12,957 lb of uranium will be removed from the GMA based on regression analyses of the individual well data. A summary of the three predictions is provided below.

Net pounds of uranium extracted through December 2015	12,819		
	Data	**Model**	**95% UCL**
Predicted pounds of uranium to be extracted between 2016 and the end of the pump-and-treat stage of the aquifer remedy (per the new 2014 Operational Design)	3,283	2,949	12,957
Total predicted pounds of uranium to be removed	**16,102**	**15,768**	**25,776**
Estimated Percent Complete (based on pounds of uranium to be removed)	**79%**	**81%**	**50%**

Table A.1-24 provides a yearly breakdown for the three predictions. Figure A.1-39 illustrates the relationship between the three estimates. Tracking mass removal trends against groundwater modeling predictions provides an indirect status on progress being made to attain cleanup goals. A more direct method is presented in Attachment A.2 in the form of maximum uranium plume maps.

Results indicate that as of January 1, 2016, the uranium concentration data trend predicts that the estimated mass completeness of the pump-and-treat stage of the aquifer remedy is approximately 79%. The groundwater model predicted an estimated mass completeness of 81%. The estimated mass completeness of the pump-and-treat stage based on the 95% UCL is approximately 50%. Following the EPA guidelines mentioned earlier, the estimated mass completeness can be estimated as being between 50% and 79% complete.

The uranium decreases plotted at each extraction well illustrate that the concentration curves are trending asymptotic. This trend is a characteristic of pump-and-treat remediations in general. It was this trend in part that resulted in DOE implementing a more aggressive cleanup design in 2014. DOE will continue to track this trend while operating under the new 2014 Operational Design and may recommend operational changes in the future to improve uranium removal efficiencies as the remedy continues.

As discussed above, progress in achieving a concentration-based cleanup is being assessed by attributing uranium concentration declines being measured in the aquifer to the pounds of uranium being removed from the aquifer through active pumping. Reducing conditions in the aquifer could also be playing a minor role in lowering dissolved uranium concentrations in the groundwater. Reducing conditions could also play a role in why some areas of the aquifer may not respond as well to pump-and-treat as other areas of the aquifer. As the aquifer remedy progresses and the plume decreases in size, such that only recalcitrant areas are left, the need to have a better understanding of the geochemical conditions within the recalcitrant areas (such as oxidation-reduction conditions) could become more important for completing cleanup in those areas.

A comparison of groundwater model prediction concentration and the actual concentrations measured at each extraction well is provided in Table A.1-24. This is the first comparison for the new operational design that was implemented in July of 2014. The comparison shows that the average model-predicted concentration for 2015 (23.1 µg/L) is slightly higher than the actual average concentration measured in December 2015 (22.6 µg/L) for the 20 extraction wells. The average residual of uranium concentrations (actual uranium concentration minus model-predicted uranium concentration) for the 20 extraction wells was 0.48 µg/L. The standard deviation for the residual was 15. These two metrics will continue to be calculated and tracked over time to help determine how well the groundwater model predictions based on the new 2014 operational design are matching the actual uranium concentrations measured at the extraction wells.

A.1.6 Pumping Rates

Target extraction well pumping rates for 2015 are provided in Table A.1-25. The total target pumping rate of 5,075 gpm is consistent with the rate defined for the 2014 operational design (DOE 2014). As additional operational experience is gained, pumping rates may change as efforts are made to maximize the effectiveness of each module.

In September of 2012, with concurrence from EPA and Ohio EPA, a pulse pumping exercise was initiated at extraction wells 31550 (EW-18), 31560 (EW-19), 31561 (EW-20), and 33061 (EW-25). At the time, all four of these wells were equipped with pumps and motors that operated most efficiently at rates of approximately 300 gpm. The WSA (Phase II) Model Design called for a target pumping rate of 100 gpm for each of these wells. The 100 gpm rate was being achieved by throttling back on the flow from each of the wells; however, this type of operation was not energy efficient.

With the exception of extraction well 31561(EW-20), the new 2014 design also calls for a pumping rate of 100 gpm for each of these wells. To be more energy efficient, when weather or temperatures are above freezing, the three wells that remained at 100 gpm under the new operational design are being pumped at a higher rate for a shorter period of time each day in order to remove the daily volume of water prescribed by the operational design. Specifically, the wells are being pumped for 300 gpm for 8 hours a day (a total of 144,000 gallons per day) rather than 100 gpm for 24 hours a day (a total of 144,000 gallons per day). Flow and particle path monitoring predictions indicate that capture of the 30 µg/L uranium plume will be maintained by the new pumping schedule. Extraction well 31561(EW-20) has a target pumping rate of 200 gpm under the new operational design, so pulse pumping is no longer being used at this well.

A.1.7 CAWWT Capacity Reduction

The CAWWT is a portion of the site's former Advanced Wastewater Treatment Facility that was constructed in 1995. The CAWWT became operational in 2005 with a mission to handle the site's remaining water treatment needs, including treating groundwater, storm water, and wastewater. The CAWWT's design capacity was 1,800 gpm via three 600 gpm treatment trains. Per the design, two of the trains can treat groundwater only, and one train can treat groundwater, storm water, process wastewater, and leachate from the OSDF.

It has been successfully operated, as necessary, to ensure that the uranium concentration and mass in the site's treated effluent to the Great Miami River comply with uranium discharge limits specified in the Operable Unit 5 Record of Decision. The uranium discharge limits are

30 µg/L flow-weighted monthly average and 600 lb annually. Additional discharge limits required by the National Pollutant Discharge Elimination System permit are also being met.

As anticipated, the need for treating groundwater to meet uranium discharge limits has greatly diminished since 2005. It has not been necessary to continuously treat groundwater to meet discharge limits since 2010; therefore, CAWWT has been operated on an as-needed basis for the past 5 years. With concurrence from EPA and Ohio EPA, the throughput capacity of the CAWWT was safely reduced in 2012 from 1,800 gpm to approximately 500 to 600 gpm. Currently the CAWWT treatment system is primarily used to treat streams other than groundwater.

In the July 2014 operational changes, the overall system pumping rate was increased 300 gpm. The increased system pumping rate resulted in an increase in the mass of uranium being removed from the aquifer and a temporary need to treat more groundwater to meet discharge limits from July 2014 to mid-November 2014. With the exception of August 2015, groundwater treatment has not been needed to meet discharge limits since November 2014. During August 2015, well-field maintenance activities requiring the shutdown of some low uranium concentration wells precipitated the need for groundwater treatment to meet discharge limits.

The current CAWWT system is oversized and has reached the end of its useful life—equipment corrosion and corrective maintenance have become ongoing issues for facility operations. In 2013 one of the ion-exchange (IX) vessels began leaking. Inspection of four of the other IX vessels showed significant corrosion in all of them. The current CAWWT system requires decontamination and demolition to allow installation of a new treatment unit. Multimedia filters, IX vessels, and their associated piping must be removed to make room for the new treatment system.

The Storm Water Retention Basin (SWRB) Valve House is located along the south side of the access road. The main 24-inch discharge pipe runs west to east in the lower level of the SWRB Valve House. A branch from the 24-inch line transfers water to be treated to the CAWWT and the discharge line from CAWWT treatment connects to the 24-inch line. Between the CAWWT feed and discharge lines is a backpressure control valve. The purpose of the backpressure control valve was to send more water to the CAWWT for treatment when the valve was closed and to open when treatment capacity was reached to prevent deadheading well pumps. The backpressure control valve needs to be replaced; it is oversized for the current treatment system and will not close to allow smaller flows to be sent to the CAWWT.

In March 2015, a CAWWT Condition Assessment Report was finalized (Whitman, Requardt & Associates 2014). The path forward decided for the facility is to replace the CAWWT treatment system with a 50 gpm system inside the CAWWT building. The four existing multimedia filters, and four of the six existing IX vessels, and associated piping, will be removed to provide space for installation of the new system. The last two existing IX vessels and associated piping will remain in service until the new system is operational. The current CAWWT building will remain to house the laboratory, operations control room office, and maintenance shop.

DOE received concurrence on the path forward in July 2015 from EPA and Ohio EPA and in August 2015 from the Fernald Community Alliance. Planning for the project began in August 2015. Project completion is scheduled for 2018.

A.1.8 References

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Table A.1-1. Aquifer Restoration System Operational Summary

	Reporting Period					
	January 2015 through December 2015			**August 1993 through December 2015**		
	Gallons Pumped/ Re-injected (M gal)	**Total Uranium Removed/ Re-injected (lb)**	**Uranium Removal Index[a] (lb/M gal)**	**Gallons Pumped/ Re-injected (M gal)**	**Total Uranium Removed/ Re-injected (lb)**	**Uranium Removal Index[a] (lb/M gal)**
South Field Module	1,395.5	341.6	0.24	20,126.42	7,785	0.39
Waste Storage Area Module	406.33	77.03	0.19	6,092.80	2,038	0.33
South Plume Module	621.73	100.63	0.16	15,454.01	3,073	0.20
Re-injection Module[b]	0	0	NA	1,936.478	76	NA
Aquifer Restoration Systems Totals						
Extraction Wells	2,423.60	519.25	0.21	41,673.23	12,896	0.31
(Re-injection Wells[b])	0	0	NA	(1,936.478)	(76)	NA
Net	2,423.60	519.25	NA	39,736.75	12,819	NA

[a] NA = not applicable.
[b] Re-injection module was shut down in September 2004.

Table A.1-2. Extraction Well 31550 (EW-18) Operational Summary for 2015

Reference Elevation (feet above mean sea level [ft amsl]): 572.11 (top of well)
Northing Coordinate (1983): 477,018.5
Easting Coordinate (1983): 1,348,979.8

Hours in reporting period: 8,760
Hours not pumped: 912

Hours pumped: 7,848
Operational percent: 89.59

Adjusted operational percent[a]: 98.49

Target pumping rate: 100 gpm

Month	Monthly Average Pumping Rate[b] (gpm)	Volume Pumped (M gal)	Monthly Total Uranium Concentration[c] (µg/L)	Uranium Removal Index (lb of total uranium removed/M gal pumped)
Jan	110.4	4.927	29.8	0.25
Feb	110.4	4.453	31.1	0.26
Mar	106.3	4.744	35.6	0.30
Apr	102.1	4.413	32.3	0.27
May	67.5	3.013	30.1	0.25
Jun	32.3	1.397	33.8	0.28
Jul	110.3	4.925	33.4	0.28
Aug	111.5	4.978	35.9	0.30
Sep	112.4	4.854	33.2	0.28
Oct	112.4	5.019	30.6	0.26
Nov	112.6	4.863	31.7	0.26
Dec	101.4	4.526	30.4	0.25
	Average 99.1	Total 52.113	Average 32.3	Average 0.27

[a] Adjusted for planned annual well-field shutdowns.
[b] Well EW-18 was down from March 31, 2015, to April 1, 2015, for chemical treatment.
Well EW-18 was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well EW-18 was down from May 20, 2015, to June 22, 2015, for the annual well-field shutdown.
Well EW-18 was down from December 28, 2015, to December 31, 2015, due to high river level.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-3. Extraction Well 31560 (EW-19) Operational Summary for 2015

Reference Elevation (ft amsl): 574.93 (top of well)
Northing Coordinate (1983): 477,403.1
Easting Coordinate (1983): 1,349,028.9

Hours in reporting period: 8,760
Hours not pumped: 1003

Hours pumped: 7757
Operational percent: 86.8

Adjusted operational percent[a]: 97.35

Target pumping rate: 100 gpm

Monthly Measurements at Well Field							
Month	**Monthly Average Pumping Rate[b] (gpm)**		**Volume Pumped (M gal)**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lb of total uranium removed/M gal pumped)**
Jan	110.6		4.938		13.2		0.11
Feb	110.8		4.467		13.4		0.11
Mar	114.2		5.098		16.6		0.14
Apr	99.2		4.284		15.6		0.13
May	67.4		3.008		16.1		0.13
Jun	31.7		1.371		17.9		0.15
Jul	109.1		4.868		18.6		0.16
Aug	108.0		4.821		17.7		0.15
Sep	110.1		4.754		17.9		0.15
Oct	107.4		4.793		15.7		0.13
Nov	104.3		4.507		14.6		0.12
Dec	98.7		4.407		14.5		0.12
Average	97.6	Total	51.316	Average	16.0	Average	0.13

[a] Adjusted for planned annual well-field shutdowns.
[b] Well EW-19 was down from March 30, 2015, to March 31, 2015, for chemical treatment.
Well EW-19 was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well EW-19 was down from May 20, 2015, to June 22, 2015, for the annual well-field shutdown.
Well EW-19 was down from November 11, 2015, to November 12, 2015, for chemical treatment.
Well EW-19 was down from December 28, 2015, to December 31, 2015, due to high river level.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-4. Extraction Well 31561 (EW-20) Operational Summary for 2015

Reference Elevation (ft amsl): 578.77 (top of well)
Northing Coordinate (1983): 477,660.8
Easting Coordinate (1983): 1,349,254.5

Hours in reporting period: 8,760 | Hours pumped: 7,604 | Target pumping rate: 200 gpm
Hours not pumped: 1,156 | Operational percent: 86.80

Adjusted operational percent[a]: 95.43

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[b] (gpm)**		**Volume Pumped (M gal)**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lb of total uranium removed/M gal pumped)**
Jan		218.9		9.772		29.8		0.25
Feb		219.9		8.865		29.0		0.24
Mar		216.0		9.640		34.6		0.29
Apr		203.5		8.792		30.5		0.25
May		135.9		6.064		27.9		0.23
Jun		64.8		2.801		32.3		0.27
Jul		219.7		9.807		31.1		0.26
Aug		213.5		9.532		32.1		0.27
Sep		208.5		9.007		33.0		0.28
Oct		129.2		5.768		32.7		0.27
Nov		211.5		9.136		36.6		0.31
Dec		199.3		8.897		33.5		0.28
	Average	186.7	Total	98.082	Average	31.9	Average	0.27

[a] Adjusted for planned annual well-field shutdowns.
[b] Well EW-20 was down from March 30, 2015, to March 31, 2015, for chemical treatment.
Well EW-20 was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well EW-20 was down from May 20, 2015, to June 22, 2015, for the annual well-field shutdown.
Well EW-20 was down from August 6, 2015, to August 7, 2015, for chemical treatment.
Well EW-20 was down from October 1, 2015, to October 2, 2015, for chemical treatment.
Well EW-20 was down from October 13, 2015, to October 14, 2015, for chemical treatment.
Well EW-20 was down from October 27, 2015, to November 2, 2015, for a pump replacement.
Well EW-20 was down from December 28, 2015, to December 31, 2015, due to high river level.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-5. Extraction Well 33326 (EW-17a) Operational Summary for 2015

Reference Elevation (ft amsl): 574.84 (top of well)
Northing Coordinate (1983): 477,905.5
Easting Coordinate (1983): 1,348,854.1

Hours in reporting period: 8,760
Hours not pumped: 1,949.2

Hours pumped: 6,911
Operational percent: 78.89

Adjusted operational percent[a]: 86.73

Target pumping rate: 175 gpm

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**Volume Pumped (M gal)**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lb of total uranium removed/M gal pumped)**
Jan	187.2	8.358	12.8	0.11
Feb	188.9	7.615	11.9	0.10
Mar	189.4	8.456	13.0	0.11
Apr	180.0	7.776	12.2	0.10
May	120.0	5.357	12.8	0.11
Jun	0.0	0.000	0.0	0.00
Jul	30.6	1.366	12.5	0.10
Aug	191.1	8.529	15.6	0.13
Sep	187.3	8.093	13.6	0.11
Oct	195.5	8.728	12.1	0.10
Nov	196.0	8.468	12.8	0.11
Dec	177.1	7.904	13.1	0.11
	Average 153.6	Total 80.649	Average 11.9	Average 0.10

[a] Adjusted for planned annual well-field shutdowns.
[b] Well EW-17a was down on February 5, 2015, due to phase error on variable frequency drive.
Well EW-17a was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well EW-17a was down from March 23, 2015, to March 24, 2015, for chemical treatment.
Well EW-17a was down from May 20, 2015, to July 28, 2015, for the annual well-field shutdown and rehabilitation.
Well EW-17a was down from September 14, 2015, to September 15, 2015, for chemical treatment.
Well EW-17a was down from December 28, 2015, to December 31, 2015, due to high river level.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-6. Extraction Well 32276 (EW-22) Operational Summary for 2015

Reference Elevation (ft amsl): 567.14 (top of well)
Northing Coordinate (1983): 476,447.3
Easting Coordinate (1983): 1,348,857.3

Hours in reporting period: 8,760
Hours not pumped: 2,289.3
Hours pumped: 6,471
Operational percent: 73.87
Target pumping rate: 300 gpm

Adjusted operational percent[a]: 81.21

Month	Monthly Average Pumping Rate[b] (gpm)		Volume Pumped (M gal)		Monthly Total Uranium Concentration[c] (µg/L)		Uranium Removal Index (lb of total uranium removed/M gal pumped)
Jan	280.8		12.536		23.1		0.19
Feb	0.0		0.000		0.0		0.00
Mar	211.4		9.435		20.2		0.17
Apr	304.8		13.166		25.4		0.21
May	203.3		9.076		25.0		0.21
Jun	35.5		1.535		30.2		0.25
Jul	264.2		11.795		31.2		0.26
Aug	306.9		13.701		30.6		0.26
Sep	293.0		12.657		28.2		0.24
Oct	320.3		14.297		25.3		0.21
Nov	323.8		13.990		24.6		0.21
Dec	298.8		13.339		24.2		0.20
Average	236.9	Total	125.528	Average	24.0	Average	0.20

Monthly Measurements at Well Field

[a] Adjusted for planned annual well-field shutdowns.
[b] Well EW-22 was down from January 11, 2015, to January 12, 2015, due to a power interruption.
Well EW-22 was down from January 27, 2015, to March 9, 2015, due to a bad motor and variable frequency drive.
Well EW-22 was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well EW-22 was down from May 20, 2015, to June 22, 2015, for the annual well-field shutdown.
Well EW-22 was down from June 26, 2015, to July 6, 2015, due to an electrical current problem.
Well EW-22 was down from September 17, 2015, to September 21, 2015, due to an electrical issue.
Well EW-22 was down from December 28, 2015, to December 31, 2015, due to high river level.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-7. Extraction Well 32446 (EW-24) Operational Summary for 2015

Reference Elevation (ft amsl): 578.37 (top of well)
Northing Coordinate (1983): 476,634.5
Easting Coordinate (1983): 1,349,312.4

Hours in reporting period: 8,760
Hours not pumped: 972

Hours pumped: 7,788
Operational percent: 88.90

Adjusted operational percent[a]: 97.74

Target pumping rate: 400 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[b] (gpm)**		**Volume Pumped (M gal)**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lb of total uranium removed/M gal pumped)**
Jan		439.9		19.637		32.6		0.27
Feb		440.1		17.743		31.6		0.26
Mar		425.6		18.997		35.8		0.30
Apr		405.4		17.514		31.2		0.26
May		270.3		12.067		31.1		0.26
Jun		130.2		5.623		32.9		0.27
Jul		423.3		18.897		31.3		0.26
Aug		349.8		15.616		33.7		0.28
Sep		439.7		18.995		33.3		0.28
Oct		440.0		19.643		31.2		0.26
Nov		423.6		18.298		33.6		0.28
Dec		397.6		17.748		30.4		0.25
	Average	382.1	Total	200.778	Average	32.4	Average	0.27

[a] Adjusted for planned annual well-field shutdowns.
[b] Well EW-24 was down from March 16, 2015, to March 17, 2015, for chemical treatment.
Well EW-24 was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well EW-24 was down from May 20, 2015, to June 22, 2015, for the annual well-field shutdown.
Well EW-24 was down from August 5, 2015, to August 6, 2015, for chemical treatment.
Well EW-24 was down from November 10, 2015, to November 11, 2015, for chemical treatment.
Well EW-24 was down from December 28, 2015, to December 31, 2015, due to high river level.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-8. Extraction Well 32447 (EW-23) Operational Summary for 2015

Reference Elevation (ft amsl): 574.53 (top of well)
Northing Coordinate (1983): 477,150.2
Easting Coordinate (1983): 1,349,421.2

Hours in reporting period: 8,760
Hours not pumped: 1,049

Hours pumped: 7,711
Operational percent: 88.03

Adjusted operational percent[a]: 96.77

Target pumping rate: 500 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[b] (gpm)**		**Volume Pumped (M gal)**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lb of total uranium removed/M gal pumped)**
Jan		549.9		24.547		43.7		0.36
Feb		550.0		22.178		39.1		0.33
Mar		530.7		23.691		44.2		0.37
Apr		507.0		21.902		38.6		0.32
May		338.3		15.102		40.6		0.34
Jun		162.7		7.030		44.3		0.37
Jul		528.8		23.606		43.3		0.36
Aug		442.0		19.733		45.9		0.38
Sep		550.0		23.760		45.0		0.38
Oct		544.2		24.292		41.7		0.35
Nov		500.2		21.608		43.5		0.36
Dec		434.3		19.385		41.0		0.34
	Average	469.8	Total	246.834	Average	42.6	Average	0.36

[a] Adjusted for planned annual well-field shutdowns.
[b] Well EW-23 was down from March 16, 2015, to March 17, 2015, for chemical treatment.
Well EW-23 was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well EW-23 was down from May 20, 2015, to June 22, 2015, for the annual well-field shutdown.
Well EW-23 was down from August 5, 2015, to August 6, 2015, for chemical treatment.
Well EW-23 was down from November 10, 2015, to November 11, 2015, for chemical treatment.
Well EW-23 was down from December 22, 2015, to December 24, 2015, for chemical treatment.
Well EW-23 was down from December 28, 2015, to December 31, 2015, due to high river level.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-9. Extraction Well 33061 (EW-25) Operational Summary for 2015

Reference Elevation (ft amsl): 575.56 (top of well)
Northing Coordinate (1983): 478,318.8
Easting Coordinate (1983): 1,349,531.0

Hours in reporting period: 8,760
Hours not pumped: 1,871

Hours pumped: 6,889
Operational percent: 78.64

Adjusted operational percent[a]: 86.46

Target pumping rate: 100 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[b] (gpm)**		**Volume Pumped (M gal)**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lb of total uranium removed/M gal pumped)**
Jan		110.3		4.922		17.9		0.15
Feb		110.3		4.448		18.7		0.16
Mar		98.1		4.379		18.9		0.16
Apr		113.4		4.898		24.7		0.21
May		76.0		3.392		26.2		0.22
Jun		0.0		0.000		0.0		0.00
Jul		10.1		0.449		31.4		0.26
Aug		111.1		4.958		36.8		0.31
Sep		109.9		4.746		28.4		0.24
Oct		110.0		4.911		27.1		0.23
Nov		110.1		4.758		13.6		0.11
Dec		99.2		4.429		25.2		0.21
	Average	88.2	Total	46.290	Average	22.4	Average	0.19

[a] Adjusted for planned annual well-field shutdowns.
[b] Well EW-25 was down from March 10, 2015, to March 13, 2015, for chemical treatment.
Well EW-25 was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well EW-25 was down from May 20, 2015, to July 29, 2015, for the annual well-field shutdown and rehabilitation.
Well EW-25 was down from December 28, 2015, to December 31, 2015, due to high river level.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-10. Extraction Well 33262 (EW-15a) Operational Summary for 2015

Reference Elevation (ft amsl): 568.37 (top of well)
Northing Coordinate (1983): 477,799.9
Easting Coordinate (1983): 1,348,150.0

Hours in reporting period: 8,760
Hours not pumped: 937.5

Hours pumped: 7,823
Operational percent: 89.30

Adjusted operational percent[a]: 98.17

Target pumping rate: 300 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[b] (gpm)**		**Volume Pumped (M gal)**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lb of total uranium removed/M gal pumped)**
Jan		329.5		14.709		20.4		0.17
Feb		320.7		12.929		20.2		0.17
Mar		321.9		14.369		23.1		0.19
Apr		303.8		13.123		24.3		0.20
May		202.6		9.046		26.0		0.22
Jun		94.5		4.082		34.0		0.28
Jul		329.0		14.686		28.7		0.24
Aug		317.1		14.157		33.4		0.28
Sep		330.1		14.262		27.3		0.23
Oct		322.8		14.411		22.8		0.19
Nov		323.0		13.954		21.6		0.18
Dec		298.0		13.302		22.2		0.19
	Average	291.1	Total	153.028	Average	25.3	Average	0.21

[a] Adjusted for planned annual well-field shutdowns.
[b] Well EW-15a was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well EW-15a was down from May 20, 2015, to June 22, 2015, for the annual well-field shutdown.
Well EW-15a was down from December 28, 2015, to December 31, 2015, due to high river level.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-11. Extraction Well 33264 (EW-30) Operational Summary for 2015

Reference Elevation (ft amsl): 573.82 (top of well)
Northing Coordinate (1983): 477,200.9
Easting Coordinate (1983): 1,349,751.5

Hours in reporting period: 8,760 | Hours pumped: 7,738 | Target pumping rate: 400 gpm
Hours not pumped: 1,022 | Operational percent: 88.3

Adjusted operational percent[a]: 97.12

Monthly Measurements at Well Field

Month	Monthly Average Pumping Rate[b] (gpm)	Volume Pumped (M gal)	Monthly Total Uranium Concentration[c] (µg/L)	Uranium Removal Index (lb of total uranium removed/M gal pumped)
Jan	439.1	19.603	26.8	0.22
Feb	439.9	17.739	24.1	0.20
Mar	426.3	19.029	29.3	0.24
Apr	405.6	17.523	23.0	0.19
May	271.3	12.111	22.4	0.19
Jun	129.9	5.610	29.7	0.25
Jul	439.1	19.600	25.1	0.21
Aug	420.5	18.771	25.2	0.21
Sep	439.4	18.980	24.5	0.20
Oct	427.0	19.061	21.7	0.18
Nov	384.8	16.625	21.5	0.18
Dec	373.5	16.674	20.0	0.17
	Average 383.0	Total 201.325	Average 24.4	Average 0.20

[a] Adjusted for planned annual well-field shutdowns.
[b] Well EW-30 was down from March 17, 2015, to March 18, 2015, for chemical treatment.
Well EW-30 was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well EW-30 was down from May 20, 2015, to June 22, 2015, for the annual well-field shutdown.
Well EW-30 was down from August 10, 2015, to August 11, 2015, for chemical treatment.
Well EW-30 was down from November 10, 2015, to November 11, 2015, for chemical treatment.
Well EW-30 was down from November 24, 2015, to November 25, 2015, for chemical treatment.
Well EW-30 was down from December 28, 2015, to December 31, 2015, due to high river level.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-12. Extraction Well 33298 (EW-21a) Operational Summary for 2015

Reference Elevation (ft amsl): 576.21 (top of well)
Northing Coordinate (1983): 477,953.1
Easting Coordinate (1983): 1,349,499.9

Hours in reporting period: 8,760 Hours pumped: 7,120 Target pumping rate: 300 gpm
Hours not pumped: 1,640 Operational percent: 81.3

Adjusted operational percent[a]: 89.35

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**Volume Pumped (M gal)**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lb of total uranium removed/M gal pumped)**
Jan	324.2	14.471	22.9	0.19
Feb	320.8	12.934	25.1	0.21
Mar	285.6	12.748	29.3	0.24
Apr	304.2	13.142	32.6	0.27
May	204.6	9.132	32.0	0.27
Jun	0.0	0.000	0.0	0.00
Jul	188.2	8.402	36.4	0.30
Aug	315.2	14.070	31.8	0.27
Sep	328.4	14.189	38.2	0.32
Oct	310.8	13.875	31.2	0.26
Nov	323.8	13.987	29.5	0.25
Dec	283.3	12.648	25.2	0.21
	Average 265.8	Total 139.598	Average 35.13	Average 0.23

[a] Adjusted for planned annual well-field shutdowns.
[b] Well EW-21a was down from March 13, 2015, to March 16, 2015, due to variable frequency drive issue.
Well EW-21a was down from March 17, 2015, to March 18, 2015, for chemical treatment.
Well EW-21a was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well EW-21a was down from May 20, 2015, to July 14, 2015, for the annual well-field shutdown and rehabilitation.
Well EW-21a was down from October 1, 2015, to October 2, 2015, for chemical treatment.
Well EW-21a was down from December 21, 2015, to December 22, 2015, for chemical treatment.
Well EW-21a was down from December 28, 2015, to December 31, 2015, due to high river level.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-13. Extraction Well 3924 (RW-1) Operational Summary for 2015

Reference Elevation (ft amsl): 533.51 (top of well)
Northing Coordinate (1983): 474,219.7
Easting Coordinate (1983): 1,348,314.3

Hours in reporting period: 8,760
Hours not pumped: 600

Hours pumped: 8,160
Operational percent: 93.15

Target pumping rate: 200 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[a] (gpm)**		**Volume Pumped (M gal)**		**Monthly Total Uranium Concentration[b] (µg/L)**		**Uranium Removal Index (lb of total uranium removed/M gal pumped)**
Jan		186.2		8.310		18.9		0.16
Feb		197.4		7.958		18.6		0.16
Mar		212.5		9.486		20.1		0.17
Apr		201.4		8.700		16.3		0.14
May		219.5		9.796		15.6		0.13
Jun		204.4		8.830		15.3		0.13
Jul		198.8		8.876		14.0		0.12
Aug		178.2		7.956		14.5		0.12
Sep		209.5		9.049		15.0		0.13
Oct		166.1		7.413		13.2		0.11
Nov		220.3		9.515		13.9		0.12
Dec		184.7		8.245		14.6		0.12
	Average	198.2	Total	104.135	Average	15.8	Average	0.13

[a] Well RW-1 was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well RW-1 was down from June 1, 2015, to June 3, 2015, for valve annual preventive maintenance.
Well RW-1 was down from July 17, 2015, to July 20, 2015, due to electrical problems.
Well RW-1 was down from August 26, 2015, to August 30, 2015, due to a bad motor.
Well RW-1 was down from September 15, 2015, to September 16, 2015, for chemical treatment.
Well RW-1 was down from October 7, 2015, to October 13, 2015, due to an electrical fault.
Well RW-1 was down from December 21, 2015, to December 22, 2015, for chemical treatment.
Well RW-1 was down from December 28, 2015, to New Year due to high river level and electrical issues.
[b] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-14. Extraction Well 3925 (RW-2) Operational Summary for 2015

Reference Elevation (ft amsl): 542.01 (top of well)
Northing Coordinate (1983): 474,319.7
Easting Coordinate (1983): 1,348,565.4

Hours in reporting period: 8,760 | Hours pumped: 7647 | Target pumping rate: 200 gpm
Hours not pumped: 1113 | Operational percent: 87.3

Monthly Measurements at Well Field								
Month		Monthly Average Pumping Rate[a] (gpm)		Volume Pumped (M gal)		Monthly Total Uranium Concentration[b] (µg/L)		Uranium Removal Index (lb of total uranium removed/M gal pumped)
Jan		219.3		9.789		15.6		0.13
Feb		219.4		8.845		13.1		0.11
Mar		218.9		9.771		14.6		0.12
Apr		200.4		8.658		14.2		0.12
May		203.5		9.084		14.7		0.12
Jun		170.7		7.373		17.0		0.14
Jul		137.7		6.149		16.5		0.14
Aug		39.4		1.758		14.7		0.12
Sep		219.8		9.497		15.4		0.13
Oct		194.3		8.674		13.7		0.11
Nov		219.7		9.491		13.5		0.11
Dec		191.9		8.566		13.1		0.11
	Average	186.2	Total	97.654	Average	14.7	Average	0.12

[a] Well RW-2 was down from March 23, 2015, to March 24, 2015, for chemical treatment.
Well RW-2 was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well RW-2 was down from June 1, 2015, to June 3, 2015, for valve annual preventive maintenance.
Well RW-2 was down from July 7, 2015, to July 8, 2015, for chemical treatment.
Well RW-2 was down from July 23, 2015, to August 26, 2015, for rehabilitation.
Well RW-2 was down from October 3, 2015, to October 4, 2015, due to electrical problems.
Well RW-2 was down from December 8, 2015, to December 9, 2015, for chemical treatment.
Well RW-2 was down from December 28, 2015, to December 31, 2015, due to high river level.
[b] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-15. Extraction Well 3926 (RW-3) Operational Summary for 2015

Reference Elevation (ft amsl): 586.73 (top of well)
Northing Coordinate (1983): 474,428.6
Easting Coordinate (1983): 1,348,837.5

Hours in reporting period: 8,760 | Hours pumped: 8,104 | Target pumping rate: 200 gpm
Hours not pumped: 656 | Operational percent: 92.5

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[a] (gpm)**		**Volume Pumped (M gal)**		**Monthly Total Uranium Concentration[b] (µg/L)**		**Uranium Removal Index (lb of total uranium removed/M gal pumped)**
Jan		204.2		9.116		21.2		0.18
Feb		134.3		5.417		22.0		0.18
Mar		138.4		6.178		22.9		0.19
Apr		187.6		8.103		20.5		0.17
May		184.3		8.228		19.4		0.16
Jun		155.4		6.715		22.8		0.19
Jul		199.9		8.924		21.4		0.18
Aug		179.2		7.999		21.3		0.18
Sep		147.4		6.368		24.6		0.21
Oct		162.8		7.269		19.1		0.16
Nov		213.6		9.226		21.9		0.18
Dec		184.1		8.216		21.7		0.18
	Average	174.3	Total	91.759	Average	21.6	Average	0.28

[a] Well RW-3 was down from February 22, 2015, to March 12, 2015, due to a motor and VFD problem.
Well RW-3 was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well RW-3 was down from June 1, 2015, to June 3, 2015, for valve annual preventive maintenance.
Well RW-3 was down from July 1, 2015, to July 2, 2015, for chemical treatment.
Well RW-3 was down from September 15, 2015, to September 16, 2015, for chemical treatment.
Well RW-3 was down from September 29, 2015, to September 30, 2015, for chemical treatment.
Well RW-3 was down from October 22, 2015, to October 26, 2015, for a pump replacement.
Well RW-3 was down from December 28, 2015, to December 31, 2015, due to high river level.
[b] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-16. Extraction Well 3927 (RW-4) Operational Summary for 2015

Reference Elevation (ft amsl): 591.84 (top of well)
Northing Coordinate (1983): 474,541.8
Easting Coordinate (1983): 1,349,127.3

Hours in reporting period: 8,760 | Hours pumped: 7,634.5 | Target pumping rate: 200 gpm
Hours not pumped: 1,125.5 | Operational percent: 87.15

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[a] (gpm)**	**Volume Pumped (M gal)**	**Monthly Total Uranium Concentration[b] (µg/L)**	**Uranium Removal Index (lb of total uranium removed/M gal pumped)**
Jan	185.5	8.279	1.9	0.02
Feb	183.3	7.389	2.7	0.02
Mar	186.4	8.319	2.8	0.02
Apr	176.1	7.606	3.4	0.03
May	187.6	8.373	2.9	0.02
Jun	167.0	7.215	3.0	0.03
Jul	107.5	4.800	2.9	0.02
Aug	17.3	0.771	5.5	0.05
Sep	220.1	9.508	4.0	0.03
Oct	219.5	9.800	3.7	0.03
Nov	219.6	9.486	3.6	0.03
Dec	189.6	8.465	3.6	0.03
	Average 171.6	Total 90.011	Average 3.3	Average 0.03

[a] Well RW-4 was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well RW-4 was down from June 1, 2015, to June 3, 2015, for valve annual preventive maintenance.
Well RW-4 was down from July 21, 2015, to July 22, 2015, for chemical treatment.
Well RW-4 was down from July 23, 2015, to August 25, 2015, for rehabilitation.
Well RW-4 was down from December 8, 2015, to December 9, 2015, for chemical treatment.
Well RW-4 was down from December 28, 2015, to December 31, 2015, due to high river level.
[b] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-17. Extraction Well 32308 (RW-6) Operational Summary for 2015

Reference Elevation (ft amsl): 582.05 (top of casing)
Northing Coordinate (1983): 475,078.8
Easting Coordinate (1983): 1,348,693.9

Hours in reporting period: 8,760
Hours not pumped: 1,954

Hours pumped: 6,806
Operational percent: 77.69

Adjusted operational percent[a]: 85.42

Target pumping rate: 300 gpm

Month	Monthly Average Pumping Rate[b] (gpm)	Volume Pumped (M gal)	Monthly Total Uranium Concentration[c] (µg/L)	Uranium Removal Index (lb of total uranium removed/M gal pumped)
	Monthly Measurements at Well Field			
Jan	262.2	11.704	29.1	0.24
Feb	263.7	10.631	30.5	0.25
Mar	252.5	11.273	33.7	0.28
Apr	227.1	9.810	29.2	0.24
May	147.6	6.587	29.6	0.25
Jun	0.0	0.000	0.0	0.00
Jul	40.5	1.808	29.9	0.25
Aug	314.4	14.033	31.9	0.27
Sep	329.7	14.242	30.1	0.25
Oct	265.3	11.845	29.5	0.25
Nov	322.1	13.914	30.7	0.26
Dec	297.5	13.282	30.5	0.25
	Average 226.9	Total 119.129	Average 27.9	Average 0.23

[a] Adjusted for planned annual well-field shutdown.
[b] Well RW-6 was down from January 11, 2015, to January 12, 2015, due to a power interruption.
Well RW-6 was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well RW-6 was down from May 20, 2015, to Jul 28, 2015, for the annual well-field shutdown and rehabilitation.
Well RW-6 was down from October 6, 2015, to October 7, 2015, for chemical treatment.
Well RW-6 was down from October 23, 2015, to October 26, 2015, to add additional pipe to the downcomer.
Well RW-6 was down from December 28, 2015, to December 31, 2015, due to high river level.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-18. Extraction Well 32309 (RW-7) Operational Summary for 2015

Reference Elevation (ft amsl): 582.05 (top of casing)
Northing Coordinate (1983): 475,109.6
Easting Coordinate (1983): 1,348,366.3

Hours in reporting period: 8,760
Hours not pumped: 1,712.5

Hours pumped: 7,047.5
Operational percent: 80.45

Adjusted operational percent[a]: 88.45

Target pumping rate: 300 gpm

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**Volume Pumped (M gal)**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lb of total uranium removed/M gal pumped)**
Jan	253.5	11.314	23.6	0.20
Feb	261.2	10.531	22.0	0.18
Mar	258.1	11.524	27.2	0.23
Apr	233.2	10.074	25.9	0.22
May	153.5	6.854	25.6	0.21
Jun	0.0	0.000	0.0	0.00
Jul	188.6	8.418	26.7	0.22
Aug	324.3	14.477	28.8	0.24
Sep	315.8	13.643	28.3	0.24
Oct	221.1	9.869	25.1	0.21
Nov	275.0	11.878	26.2	0.22
Dec	234.3	10.459	24.4	0.20
	Average 226.5	Total 119.041	Average 23.6	Average 0.20

[a] Adjusted for planned annual well-field shutdown.
[b] Well RW-7 was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well RW-7 was down from May 20, 2015, to July 14, 2015, for the annual well-field shutdown, and pump/pipe replacement.
Well RW-7 was down from October 6, 2015, to October 7, 2015, for chemical treatment.
Well RW-7 was down from October 13, 2015, to October 14, 2015, for chemical treatment.
Well RW-7 was down from October 23, 2015, to October 27, 2015, to additional pipe to the downcomer.
Well RW-7 was down from December 15, 2015, to December 17, 2015, for camera inspection.
Well RW-7 was down from December 28, 2015, to December 31, 2015, due to high river level.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-19. PRRS Groundwater Summary Statistics and Trend Analysis

Analyte	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,e]	Trend[a,b,c,d,f]
Arsenic	2128	246	0.000195	0.188	0.0111	0.0203	Down
	2625	216	0.00110	0.194[g]	0.0127	0.0156	Down
	2636	185	0.0100	0.0939	0.0440	0.0185	Down
	2898	63	0.000147	0.0820	0.0042	0.0110	**Up**
	2899	56	0.00032	0.0283	0.0023	0.0039	**Up**
	2900	245	0.00032	0.0609	0.0049	0.0054	Down
	3128	66	0.0004	0.234	0.0071	0.0288	No Trend
	3636	63	0.0005	0.0233	0.0028	0.0037	**Up**
	3898	63	0.0005	0.0434	0.0043	0.0064	**Up**
	3899	64	0.000147	0.0307	0.0027	0.0045	**Up**
	3900	64	0.000375	0.0208	0.0028	0.0032	No Trend
Phosphorus	2128	72	0.025	16.2	1.36	2.33	Down
	2625	39	0.307	18.6	3.84	3.83	**Up**
	2636	37	9.60	170	83.9	42.9	Down
	2898	64	0.005	9.95	0.243	1.28	Down
	2899	55	0.005	0.831	0.058	0.115	No Trend
	2900	62	0.050	4.74	0.461	0.646	Down
	3128	73	0.005	13.0	0.231	1.52	No Trend
	3636	62	0.0091	1.10	0.069	0.141	No Trend
	3898	62	0.0075	1.24	0.098	0.168	No Trend
	3899	63	0.005	1.86	0.114	0.266	Down
	3900	64	0.005	1.38	0.087	0.230	Down
Potassium	2128	64	0.83	18.0	3.28	3.24	Down
	2625	41	0.64	38.8[g]	4.39	5.9	No Trend
	2636	37	4.60	218	51.0	51.0	Down
	2898	64	1.11	9.64	1.20	1.20	**Up**
	2899	56	1.36	8.85	4.10	0.95	**Up**
	2900	63	0.0095	6.00	1.99	1.06	No Trend
	3128	66	1.09	3.70	1.92	0.63	Down
	3636	62	1.09	4.24	2.15	0.55	Down
	3898	63	0.61	4.09	2.63	0.72	**Up**
	3899	64	0.875	4.54	2.72	0.72	**Up**
	3900	64	0.975	3.19	1.71	0.38	Down
Sodium	2128	64	12.3	75.2	34.1	11.3	Down
	2625	41	13.1	61.4	31.3	9.6	Down
	2636	37	19.1	148	52.0	26.6	Down
	2898	64	4.95	31.0	19.7	4.9	**Up**
	2899	56	11.2	25.1	18.0	3.5	**UP**
	2900	63	0.0136	43.3	26.4	7.3	Down
	3128	66	3.52	13.4	5.60	2.54	Down
	3636	62	3.14	13.0	5.78	2.73	Down
	3898	63	7.29	28.8	12.4	5.7	**Up**
	3899	64	6.24	43.6	12.7	9.4	**Up**
	3900	64	3.13	10.8	4.81	1.75	Down

Table A.1-19 (continued). PRRS Groundwater Summary Statistics and Trend Analysis

[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 2015 groundwater data (unfiltered and filtered for 2001 through 2015).
[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, standard deviation, and Mann-Kendall test for trend).
[c] Rejected data qualified with an R 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] SD = standard deviation.
[f] Trend starts on August 27, 1993, and is based on the startup of the South Plume extraction wells (DOE 1993).
[g] Some data from the September 30, 2015, sampling are not considered representative of aquifer conditions for monitoring well 2625. The water in the well was highly turbid; the well was nearly dry, and sample volume was insufficient for analysis of all constituents. Consequently, the monitoring well was resampled and analyzed on January 28, 2016. The results from this new sampling indicate that arsenic (0.0264 milligram per liter [mg/L]) and potassium (8.28 mg/L) would not be new maximum concentrations if the January 28, 2016, sample replaced the September 30, 2015, sample. Instead, the maximum concentrations for arsenic and potassium would be 0.0706 mg/L and 9.49 mg/L, respectively.

Table A.1-20. Extraction Well 32761 (EW-26) Operational Summary for 2015

Reference Elevation (ft amsl): 570.88 (top of casing)
Northing Coordinate (1983): 479,892.4
Easting Coordinate (1983): 1,347,364.0

Hours in reporting period: 8,760
Hours not pumped: 985

Hours pumped: 7,775
Operational percent: 88.8

Adjusted operational percent[a]: 97.58

Target pumping rate: 300 gpm

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**Volume Pumped (M gal)**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lb of total uranium removed/M gal pumped)**
Jan	330.5	14.752	21.4	0.18
Feb	319.9	12.897	20.4	0.17
Mar	325.5	14.531	24.6	0.21
Apr	302.1	13.049	22.0	0.18
May	202.2	9.026	21.6	0.18
Jun	97.5	4.214	31.4	0.26
Jul	329.2	14.695	24.9	0.21
Aug	311.9	13.925	24.8	0.21
Sep	327.4	14.143	23.7	0.20
Oct	317.8	14.188	20.9	0.17
Nov	323.0	13.952	21.6	0.18
Dec	297.8	13.295	21.4	0.18
	Average 290.4	Total 152.667	Average 23.2	Average 0.19

[a] Adjusted for planned annual well-field shutdowns.
[b] Well EW-26 was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well EW-26 was down from May 20, 2015, to June 22, 2015, for the annual well-field shutdown.
Well EW-26 was down from August 6, 2015, to August 7, 2015, for chemical treatment.
Well EW-26 was down from December 28, 2015, to December 31, 2015, due to high river level.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-21. Extraction Well 33062 (EW-27) Operational Summary for 2015

Reference Elevation (ft amsl): 575.10 (top of casing)
Northing Coordinate (1983): 480,013.0
Easting Coordinate (1983): 1,348,037.2

Hours in reporting period: 8,760
Hours not pumped: 996

Hours pumped: 7,764
Operational percent: 88.63

Adjusted operational percent[a]: 97.44

Target pumping rate: 200 gpm

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**Volume Pumped (M gal)**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lb of total uranium removed/M gal pumped)**
Jan	216.4	9.661	25.0	0.21
Feb	210.1	8.472	25.5	0.21
Mar	204.6	9.133	28.0	0.23
Apr	196.8	8.501	25.1	0.21
May	135.4	6.046	25.6	0.21
Jun	64.9	2.805	30.6	0.25
Jul	220.2	9.832	28.2	0.24
Aug	219.1	9.779	30.7	0.26
Sep	221.0	9.548	28.5	0.24
Oct	220.6	9.849	25.9	0.22
Nov	211.9	9.152	25.8	0.22
Dec	198.5	8.861	24.7	0.21
	Average 193.3	Total 101.639	Average 26.96	Average 0.23

[a] Adjusted for planned annual well-field shutdowns.
[b] Well EW-27 was down from March 11, 2015, to March 12, 2015, for chemical treatment.
Well EW-27 was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well EW-27 was down from May 20, 2015, to June 22, 2015, for the annual well-field shutdown.
Well EW-27 was down from November 11, 2015, to November 12, 2015, for chemical treatment.
Well EW-27 was down from December 28, 2015, to December 31, 2015, due to high river level.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-22. Extraction Well 33347 (EW-33a) Operational Summary for 2015

Reference Elevation (ft amsl): 574.86 (top of casing)
Northing Coordinate (1983): 481,031.8
Easting Coordinate (1983): 1,346,715.8

Hours in reporting period: 8,760
Hours not pumped: 960

Hours pumped: 7,800
Operational percent: 89

Adjusted operational percent[a]: 97.89

Target pumping rate: 300 gpm

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**Volume Pumped (M gal)**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lb of total uranium removed/M gal pumped)**
Jan	330.0	14.732	18.3	0.15
Feb	321.1	12.947	18.1	0.15
Mar	328.5	14.665	20.8	0.17
Apr	302.8	13.081	19.2	0.16
May	199.9	8.925	17.8	0.15
Jun	97.5	4.210	22.0	0.18
Jul	322.5	14.396	22.2	0.19
Aug	310.8	13.875	20.6	0.17
Sep	328.4	14.188	22.3	0.19
Oct	307.2	13.714	19.2	0.16
Nov	323.4	13.973	20.1	0.17
Dec	298.3	13.318	18.8	0.16
	Average 289.2	Total 152.024	Average 19.95	Average 0.17

[a] Adjusted for planned annual well-field shutdowns.
[b] Well EW-33a was down from April 21, 2015, to April 23, 2015, due to east side power outage for electrical upgrades project.
Well EW-33a was down from May 20, 2015, to June 22, 2015, for the annual well-field shutdown.
Well EW-33a was down from October 13, 2015, to October 14, 2015, for groundwater monitoring in the area.
Well EW-33a was down from December 28, 2015, to December 31, 2015, due to high river level.
[c] Average is used if more than one concentration measurement is available for a particular month.

Table A.1-23. Regression Equations for Uranium Concentration Data Collected at Extraction Wells—Data Collected Through December 31, 2015

Extraction Well Number	Database Identification	Data Trend	R^{2a}	95 Percent Upper Confidence Limit	R^{2a}	Function Type
RW-1	3924	y = 6.53E+04e^-2.05E-04x	0.79	y = 3.01E+03e^-1.04E-04x	0.72	Exponential Function
RW-2	3925	y = 9.089E-07x^2 - 7.400E-02x + 1.522E+03	0.71	y = 9.09E-07x^2 - 7.40E-02x + 1.54E+03	0.71	Polynomial
RW-3	3926	y = -1.76E-06x^2 + 1.36E-01x - 2.59E+03	0.73	y = -1.76E-06x^2 + 1.36E-01x - 2.57E+03	0.73	Polynomial
RW-4	3927	y = 2.24E-02e^1.23E-04x	0.29	y = 5.34E-01e^5.72E-05x	0.25	Exponential Function
RW-6	32308	y = 3.57E+04e^-1.72E-04x	0.85	y = 4.44E+03e^-1.04E-04x	0.84	Exponential Function
RW-7	32309	y = 1.40E+05e^-2.08E-04x	0.89	y = 7.24E+03e^-1.15E-04x	0.86	Exponential Function
EW-15a	33262	y = 1.21E+44x^-9.24E+00	0.79	y = 2.66E+26x^-5.34E+00	0.78	Power Function
EW-17a	33326	y = 1.15E+04e^-1.57E-04x	0.69	y = 1.57E+03e^-9.16E-05x	0.67	Exponential Function
EW-18	31550	y = 6.75E+03e^-1.30E-04x	0.48	y = 1.56E+03e^-7.55E-05x	0.46	Exponential Function
EW-19	31560	y = 3.31E+07e^-3.52E-04x	0.88	y = 2.24E+04e^-1.35E-04x	0.75	Exponential Function
EW-20	31561	y = 1.88E+03e^-1.01E-04x	0.52	y = 7.70E+02e^-6.69E-05x	0.50	Exponential Function
EW-21a	33298	y = 4.28E+05e^-2.29E-04x	0.79	y = 1.10E+04e^-1.14E-04x	0.75	Exponential Function
EW-22	32276	y = 2.44E+08e^-3.91E-04x	0.93	y = 6.29E+04e^-1.48E-04x	0.84	Exponential Function
EW-23	32447	y = 1.73E+07e^-3.14E-04x	0.88	y = 5.22E+04e^-1.43E-04x	0.81	Exponential Function
EW-24	32446	y = 4.40E+04e^-1.72-04x	0.77	y = 4.68E+03e^-9.98E-05x	0.71	Exponential Function
EW-25	33061	y = 3.41E+04e^-1.72E-04x	0.52	y = 2.96E+03e^-9.71E-05x	0.49	Exponential Function
EW-30	33264	y = 4.64E+08e^-3.99E-04x	0.93	y = 1.55E+05e^-1.76E-04x	0.88	Exponential Function
EW-26	32761	y = 5.99E+07e^-3.57E-04x	0.86	y = 4.83E+04e^-1.52E-04x	0.77	Exponential Function
EW-27	33062	y = 9.84E+07e^-3.66E-04x	0.8	y = 4.68E+04e^-1.45E-04x	0.67	Exponential Function
EW-33a	33347	y = 2E+43x^-9.102	0.18	y = 1E+23x^-4.599	0.22	Power Function

[a] R^2 = Coefficient of Determination

Table A.1-24. Estimate of Pounds of Uranium to be Removed and Mass Removal Completeness

Year	Estimate of Annual Pounds of Uranium to Be Extracted Based on Regression of Concentration Data	Estimate of Annual Pounds of Uranium to Be Extracted Based on Model Predictions	Estimate of Annual Pounds of Uranium to Be Extracted Based on Regression of 95% UCL
2016	473	430	1,548
2017	432	386	1,473
2018	394	350	1,401
2019	363	262	1,332
2020	337	232	1,266
2021	189	210	714
2022	175	193	691
2023	162	179	660
2024	150	166	631
2025	140	156	603
2026	130	59	576
2027	121	55	551
2028	112	52	527
2029	25	47	217
2030	23	46	206
2031	21	44	196
2032	19	42	187
2033	17	40	175
Estimate of Total To Be Extracted	3,283	2,949	12,957
Actual Pounds Extracted Through December 23, 2015	12,819	12,819	12,819
Estimate of Total Pounds to be Extracted	16,102	15,768	25,776
Year	**Estimate of Mass Removal Completeness Based on Concentration Data**	**Estimate of Mass Removal Completeness Based on Model Predictions**	**Estimate of Mass Removal Completeness Based on 95% UCL of Concentration Data**
2015	79	81	50
2014	77	78	46
2013	83	83	53
2012	77	80	47
2011	76	77	45
2010	75	74	43
2009	72	70	41
2008	69	66	39
2007	66	61	37
2006	59	55	33

Table A.1-25. Comparison of Model-Predicted Versus Actual Total Uranium Concentrations

Module/Extraction Well	Model-Predicted Total Uranium Concentration December 2015 (µg/L)	Actual Total Uranium Concentration December 2015 (µg/L)	Residual[a] Total Uranium Concentration (µg/L)
3924 (RW-1)	4.55	14.6	10.05
3924 (RW-2)	7.40	13.1	5.70
3925 (RW-3)	8.45	21.7	13.3
3927 (RW-4)	3.16	3.60	0.440
32308 (RW-6)	24.9	30.5	5.60
32309 (RW-7)	26.4	24.4	−2.00
33262 (EW-15a)	40.7	22.2	−18.5
33326 (EW-17a)	28.1	13.1	−15.0
31550 (EW-18)	23.4	30.4	7.00
31560 (EW-19)	18.0	14.5	-3.50
31561 (EW-20)	20.2	33.5	13.3
33298 (EW-21a)	26.8	25.2	−1.60
32276 (EW-22)	23.4	24.2	0.800
32447 (EW-23)	29.0	41.0	12.0
32446 (EW-24)	15.7	30.4	14.7
33061 (EW-25)	32.6	25.2	−7.40
32761 (EW-26)	36.0	21.4	−14.6
33062 (EW-27)	12.7	24.7	12.0
33264 (EW-30)	11.4	20.0	8.60
33347 (EW-33a)	69.2	18.8	-50.4
Average	23.1	22.6	−0.478
Standard Deviation	15.1	8.50	15.4
Maximum	69.2	41.0	14.7
Minimum	3.16	3.60	−50.4
Range	66.0	37.4	65.1

[a] Residual Total Uranium Concentration = Actual Total Uranium Concentration – Model Total Uranium Concentration.

Table A.1-26. Extraction Well Target Pumping Rates

Module/Extraction Well	Target Pumping Rate (gpm)
South Plume	
3924 (RW-1)	200
3924 (RW-2)	200
3925 (RW-3)	200
3927 (RW-4)	200
32308 (RW-6)	300
32309 (RW-7)	300
Subtotal	1,400
Waste Storage Area	
32761 (EW-26)	300
33062 (EW-27)	200
33347 (EW-33a)	300
Subtotal	800
South Field Extraction	
31550 (EW-18)	100
31560 (EW-19)	100
31561 (EW-20)	200
33298 (EW-21a)	300
33326 (EW-17a)	175
32276 (EW-22)	300
32446 (EW-24)	400
32447 (EW-23)	500
33061 (EW-25)	100
33264 (EW-30)	400
33262 (EW-15a)	300
Subtotal	2,875
Total Pumping	5,075

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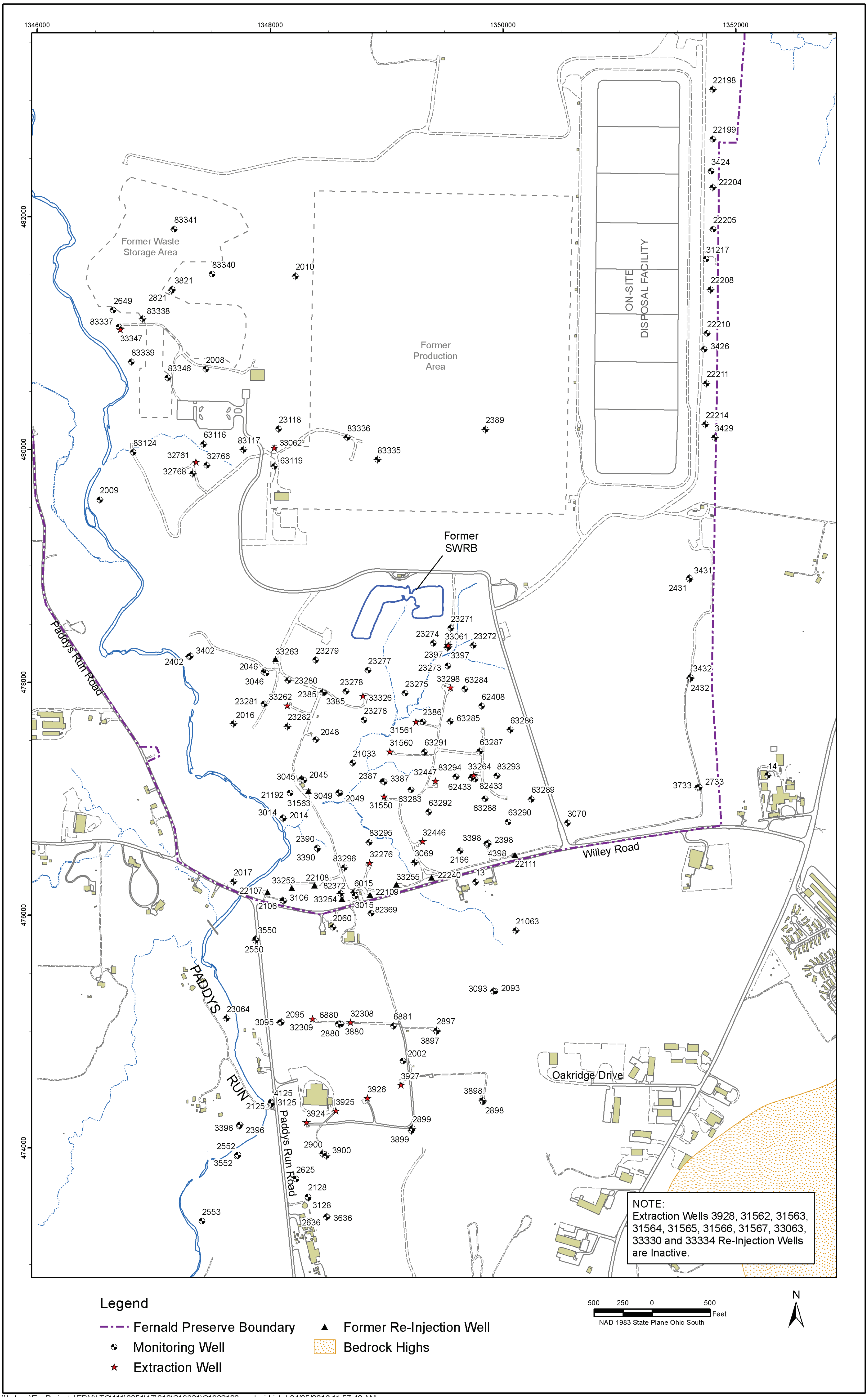

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Figure A.1-1. Well Locations for South Plume, South Field, Waste Storage Area, and PRRS Monitoring Activities

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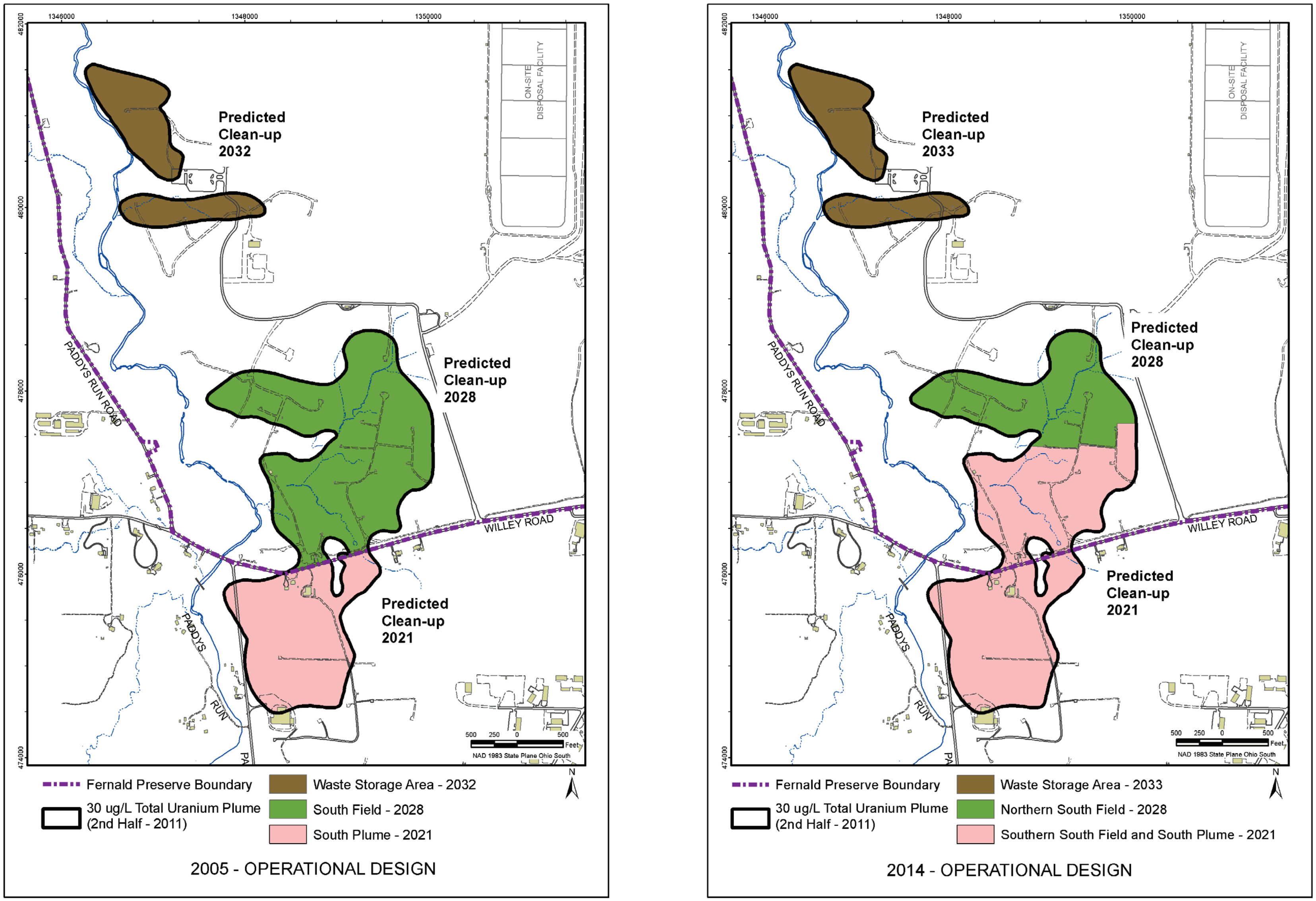

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Figure A.1-2. Comparison of Predicted Cleanup Dates, 2005 versus 2014 Operational Designs

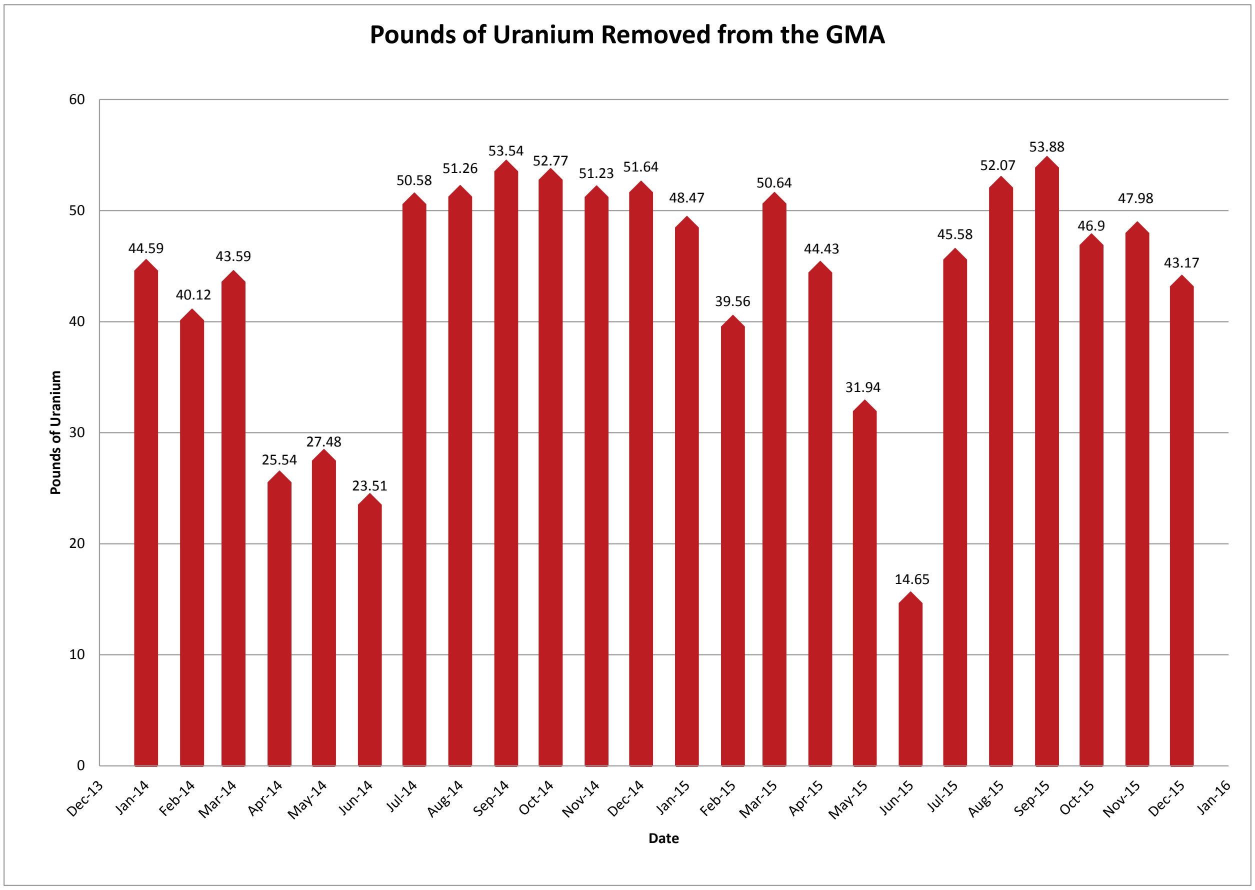

Figure A.1-3. Pounds of Uranium Removed from the Aquifer

Figure A.1-4. Clean Pump (Top) versus Iron-Fouled Pump (Bottom)

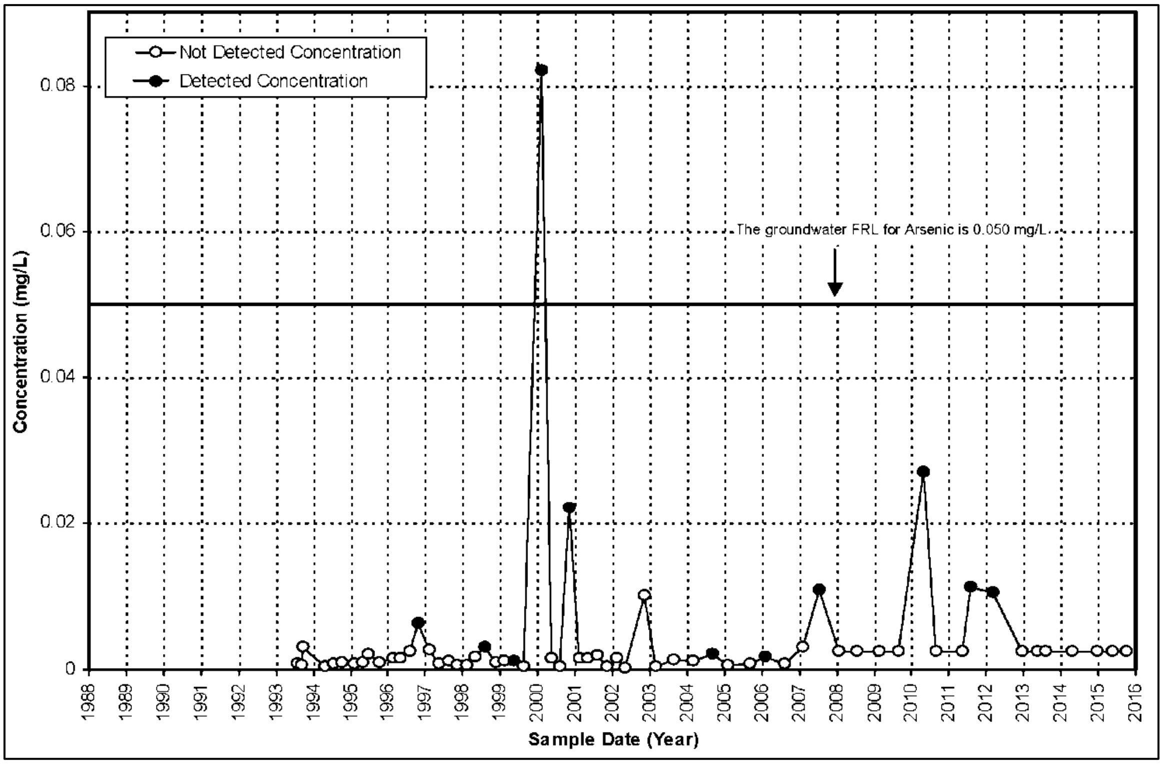

Figure A.1-5. Arsenic Concentration Versus Time Plot for Monitoring Well 2898

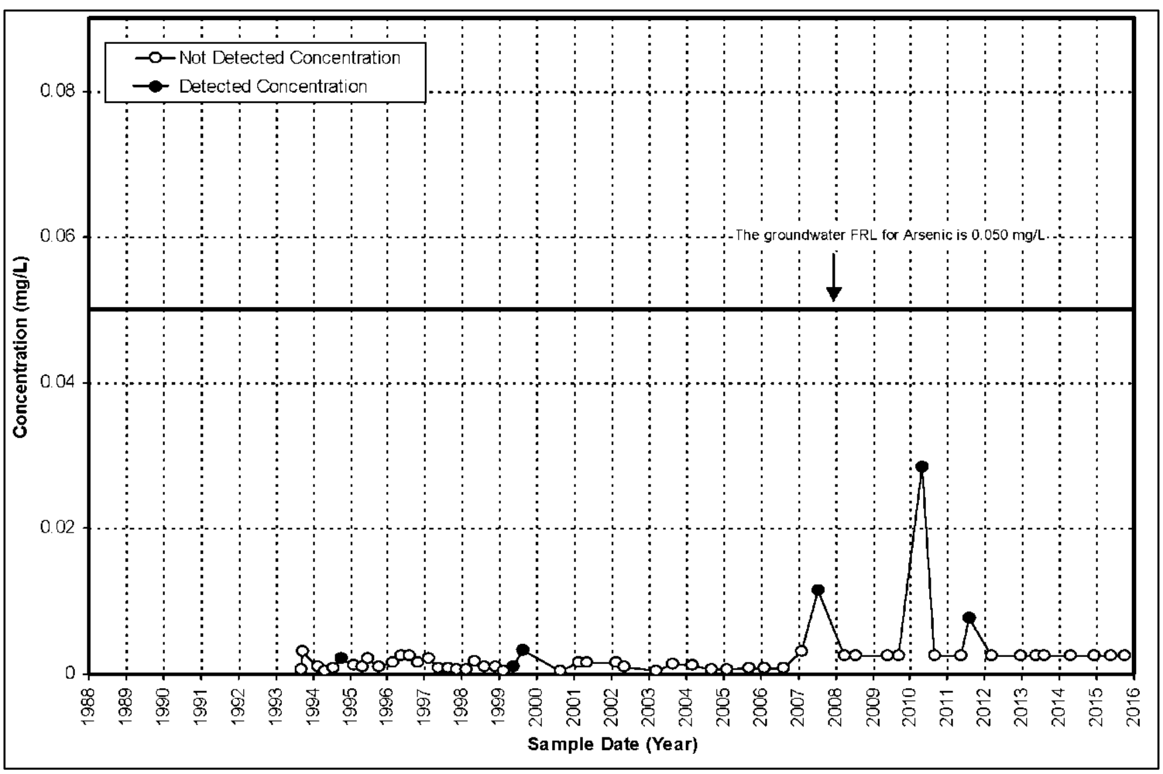

Figure A.1-6. Arsenic Concentration Versus Time Plot for Monitoring Well 2899

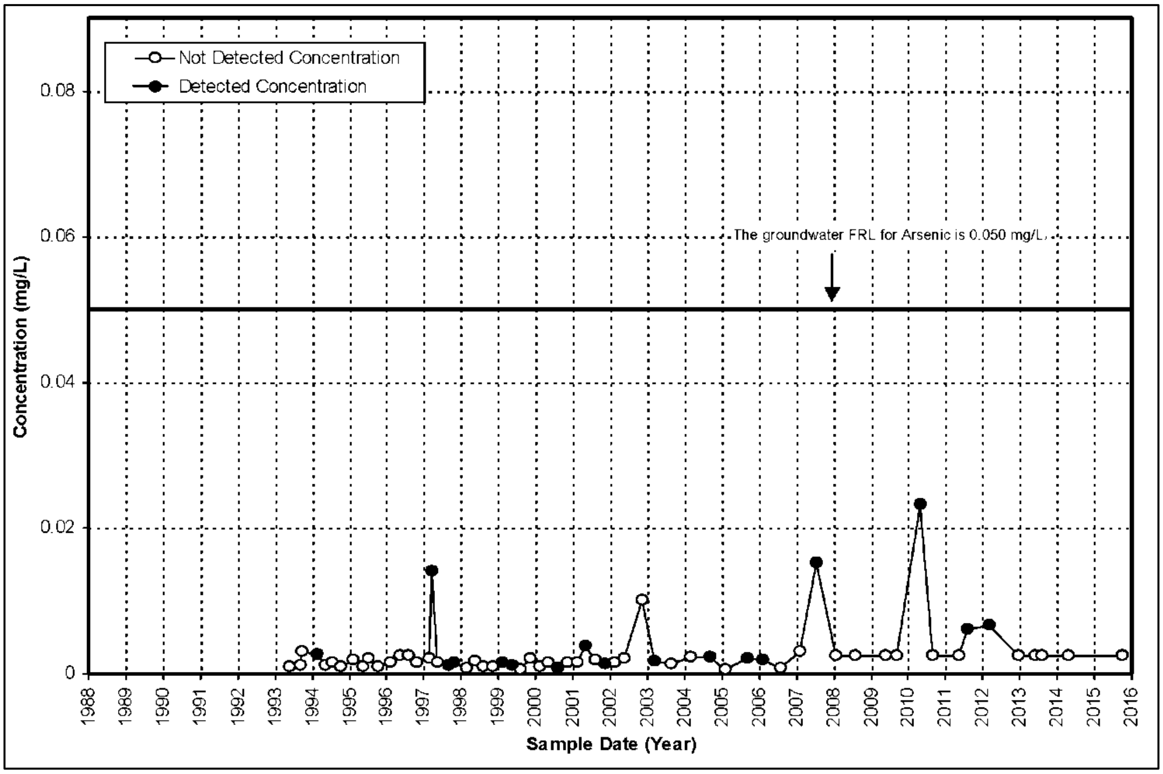

Figure A.1-7. Arsenic Concentration Versus Time Plot for Monitoring Well 3636

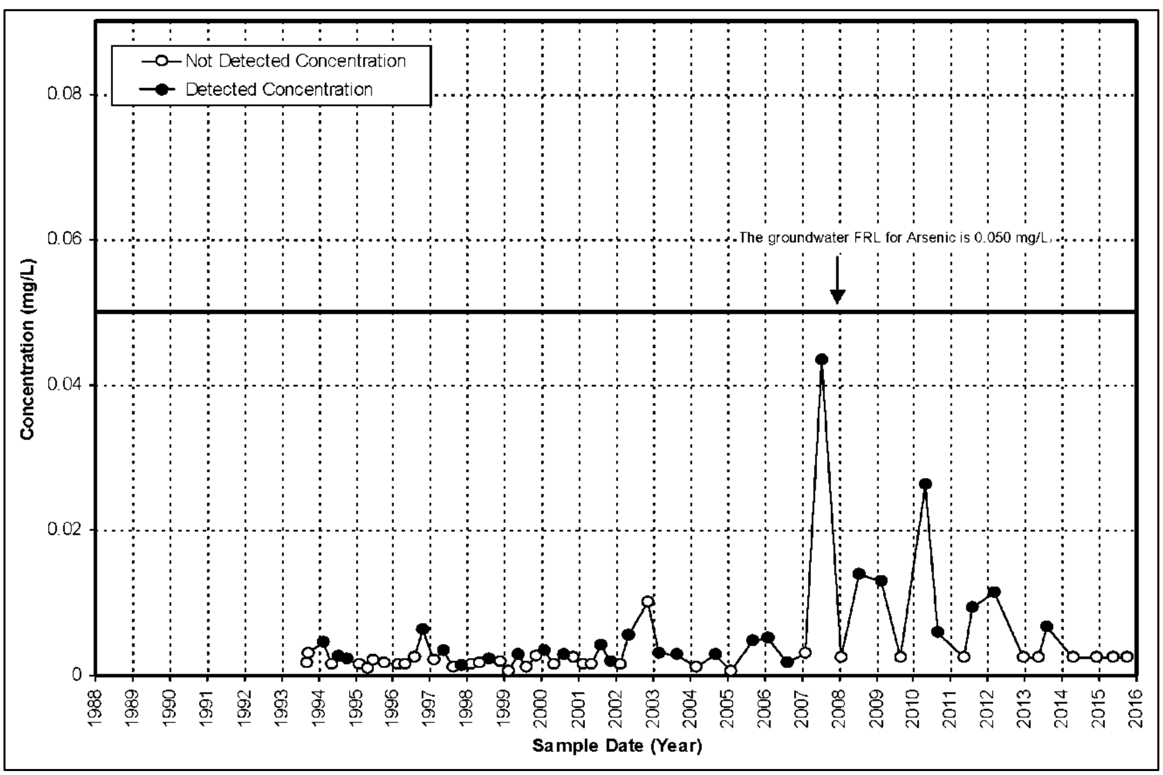

Figure A.1-8. Arsenic Concentration Versus Time Plot for Monitoring Well 3898

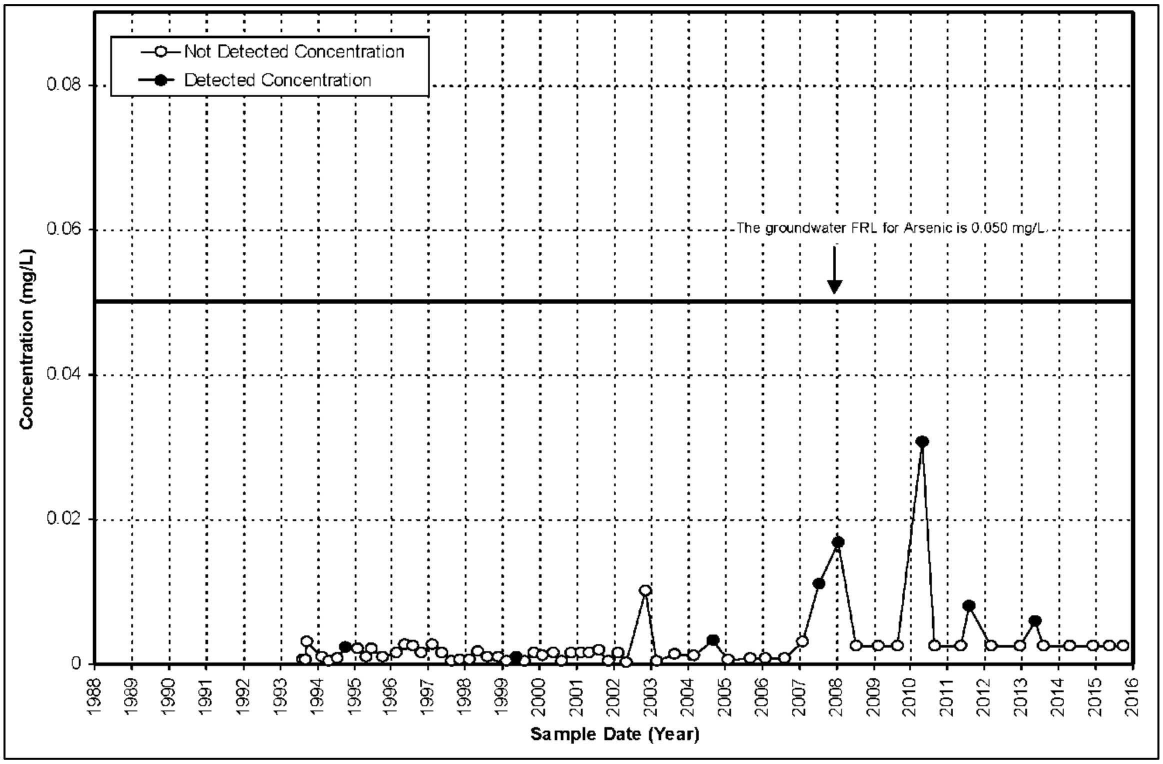

Figure A.1-9. Arsenic Concentration Versus Time Plot for Monitoring Well 3899

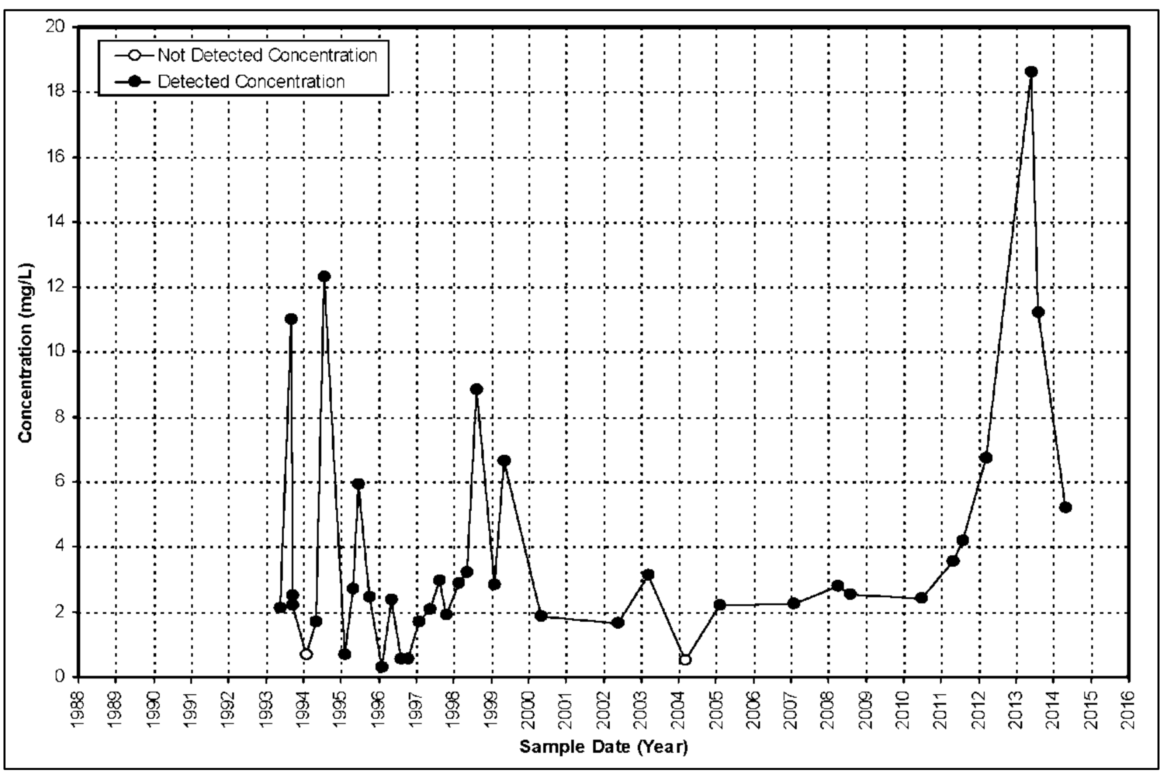

Figure A.1-10. Phosphorous Concentration Versus Time Plot for Monitoring Well 2625

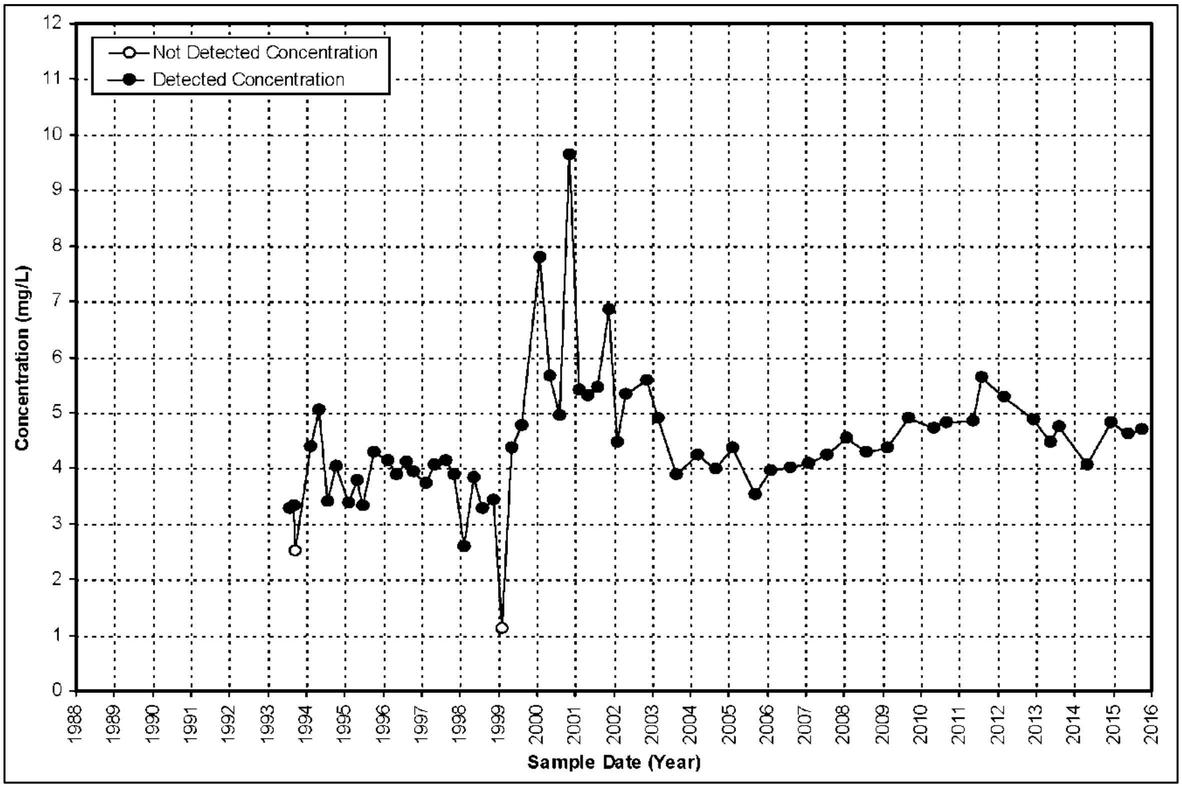

Figure A.1-11. Potassium Concentration Versus Time Plot for Monitoring Well 2898

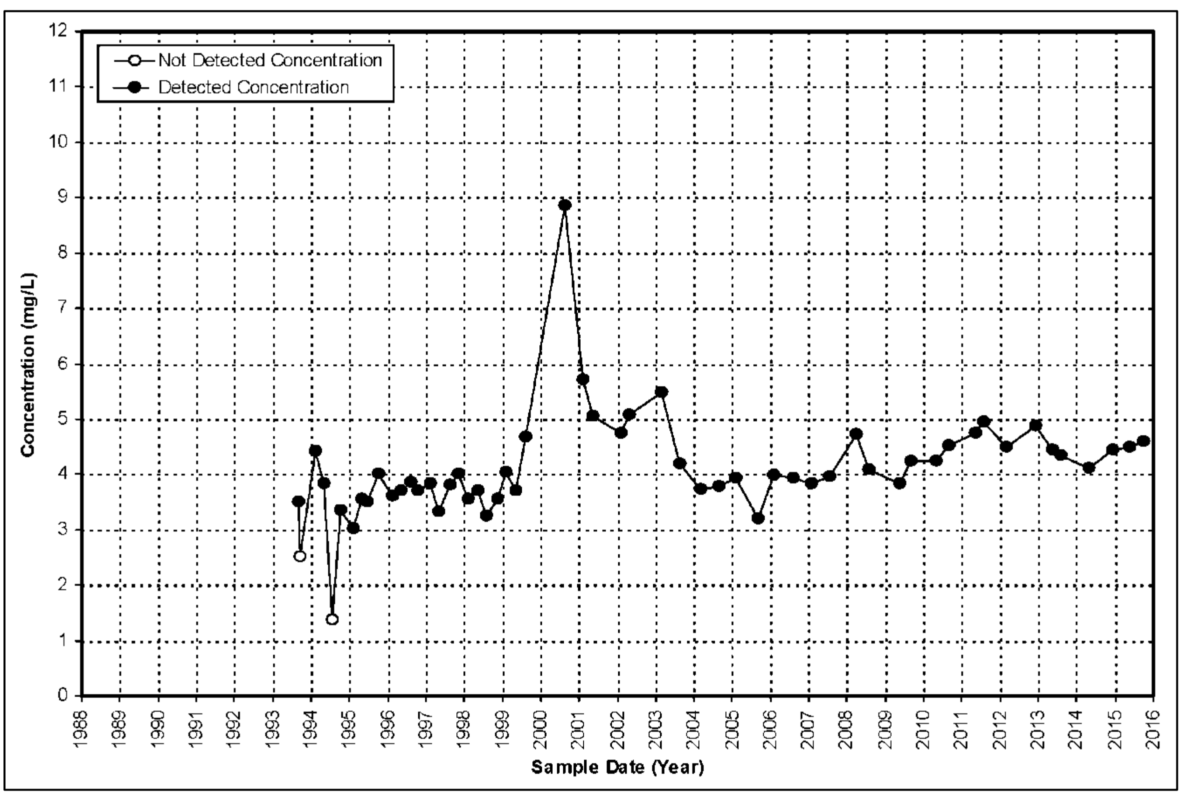

Figure A.1-12. Potassium Concentration Versus Time Plot for Monitoring Well 2899

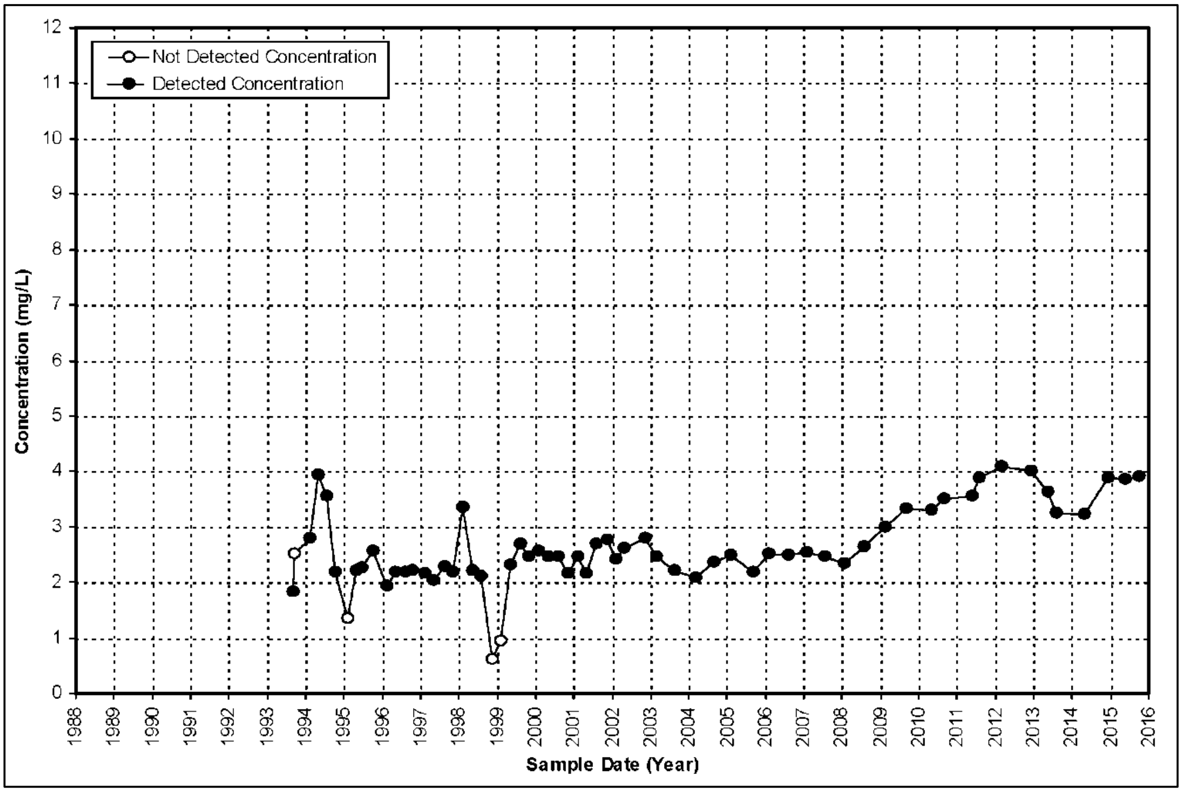

Figure A.1-13. Potassium Concentration Versus Time Plot for Monitoring Well 3898

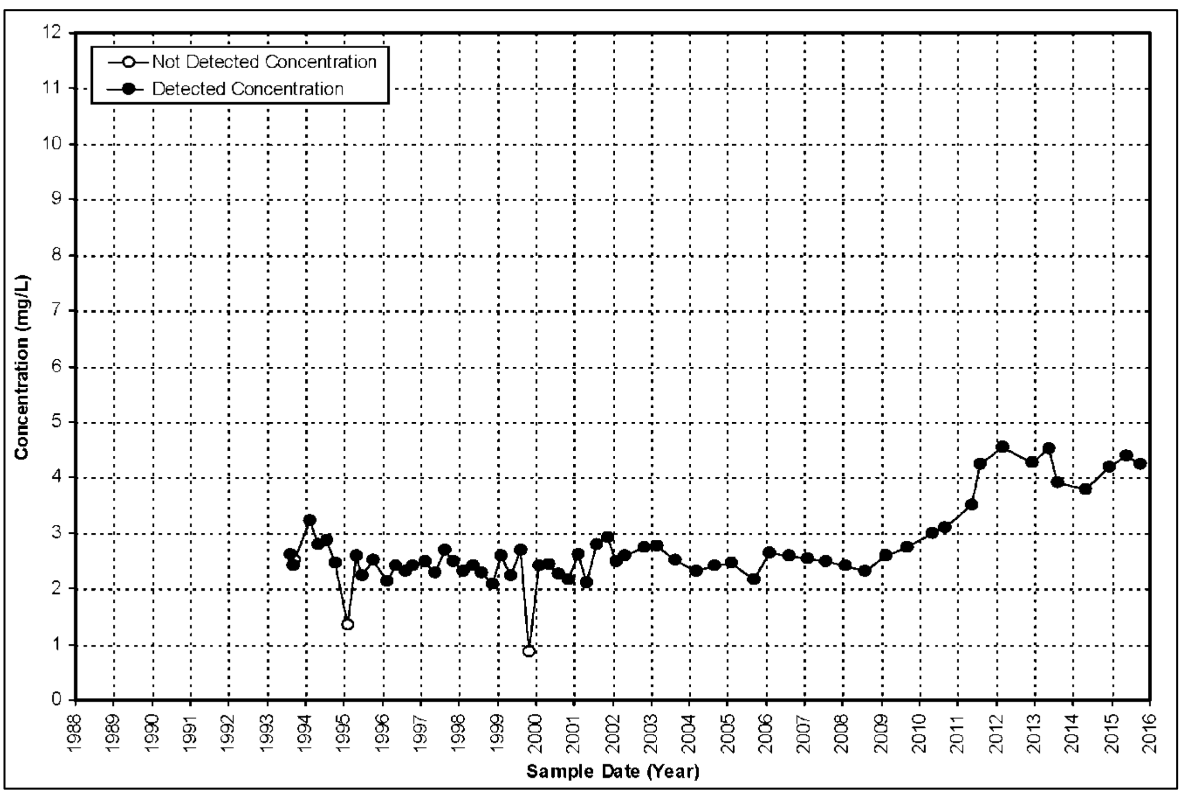

Figure A.1-14. Potassium Concentration Versus Time Plot for Monitoring Well 3899

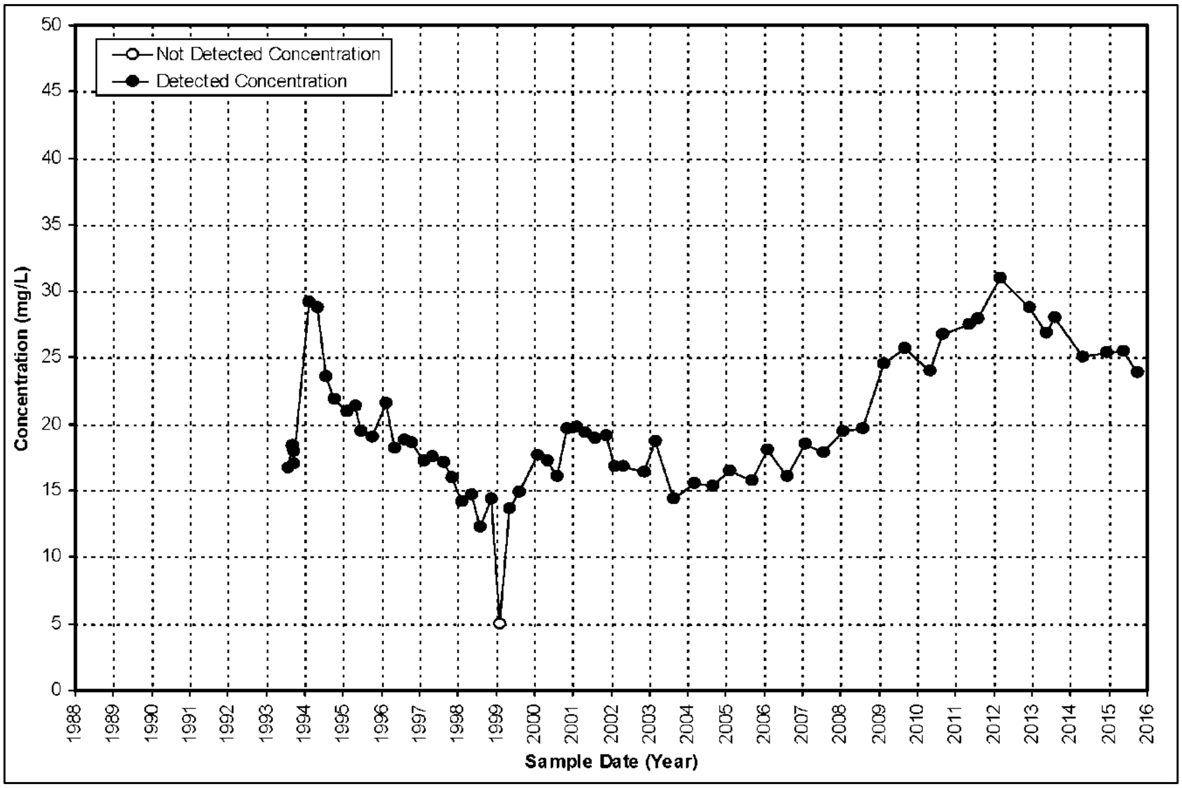

Figure A.1-15. Sodium Concentration Versus Time Plot for Monitoring Well 2898

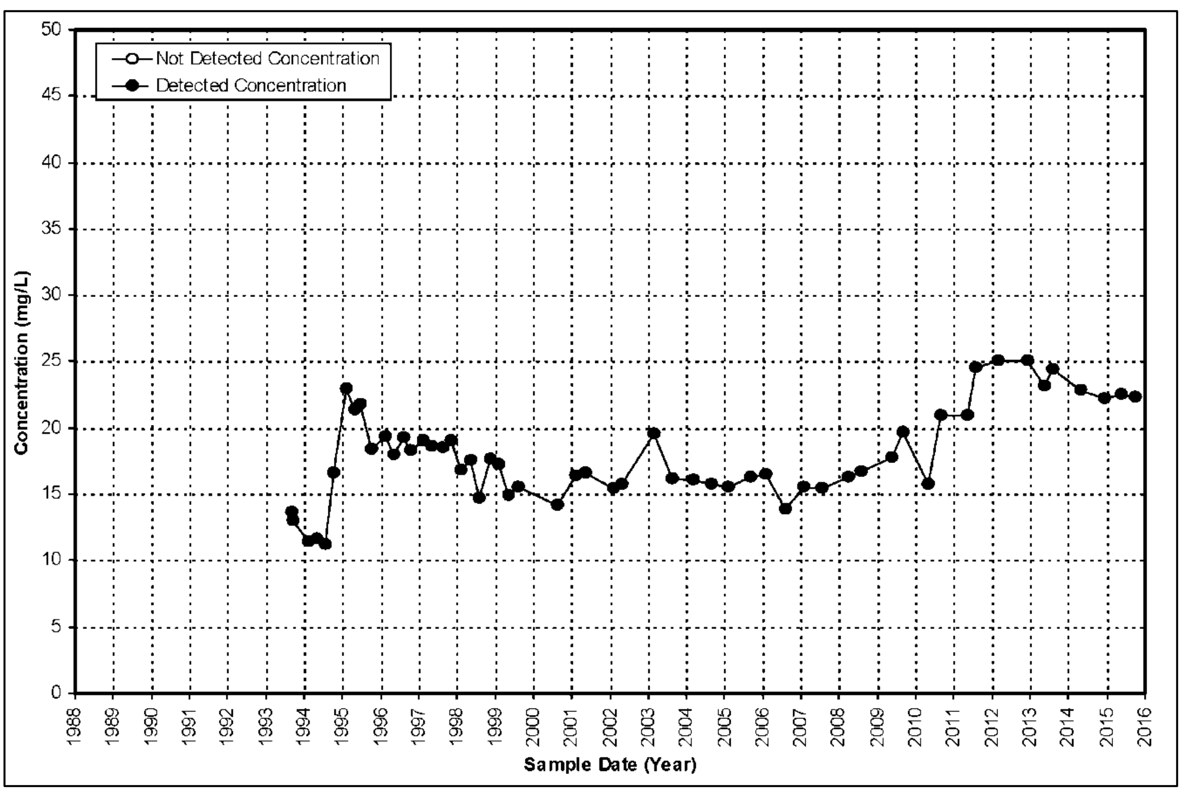

Figure A.1-16. Sodium Concentration Versus Time Plot for Monitoring Well 2899

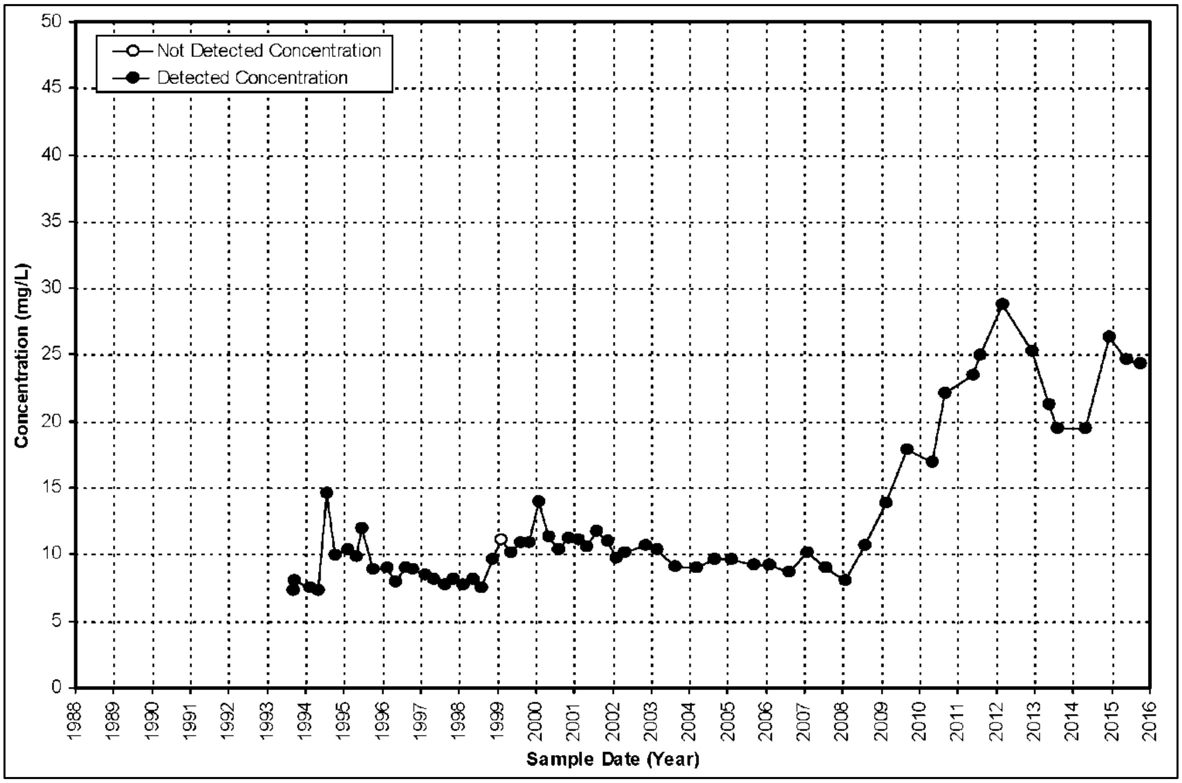

Figure A.1-17. Sodium Concentration Versus Time Plot for Monitoring Well 3898

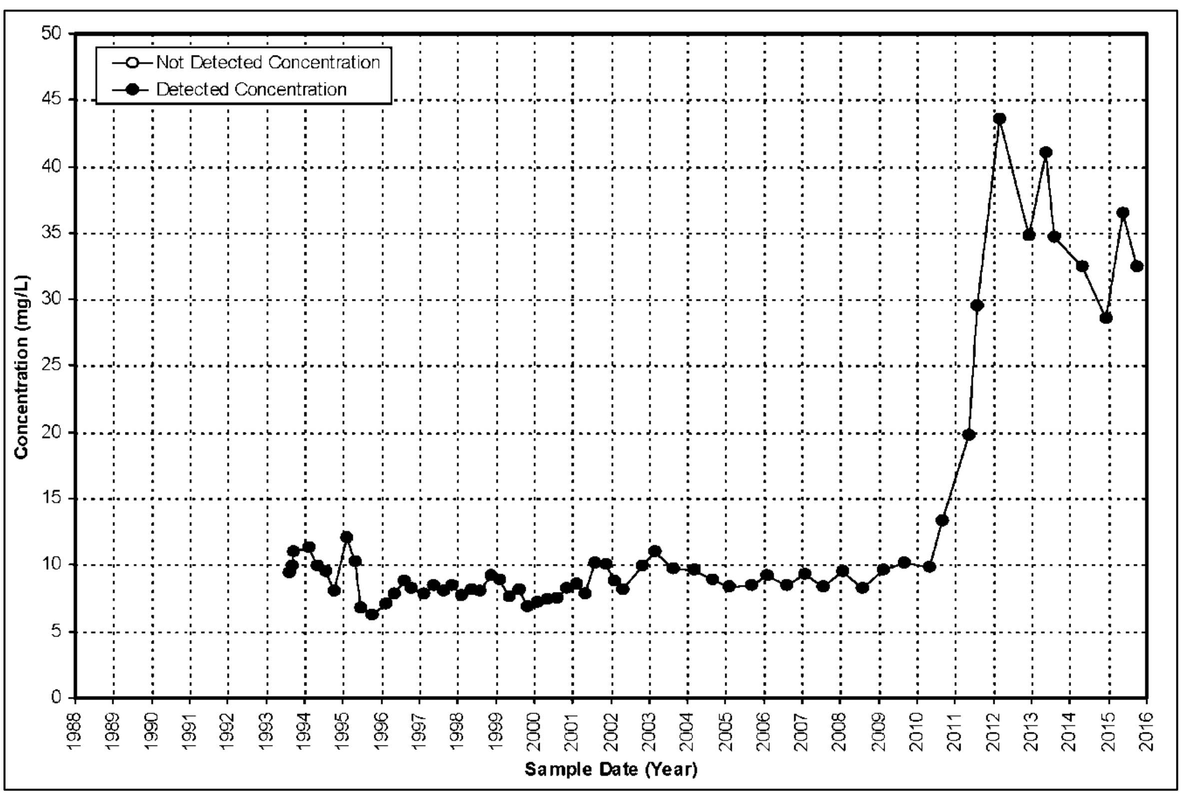

Figure A.1-18. Sodium Concentration Versus Time Plot for Monitoring Well 3899

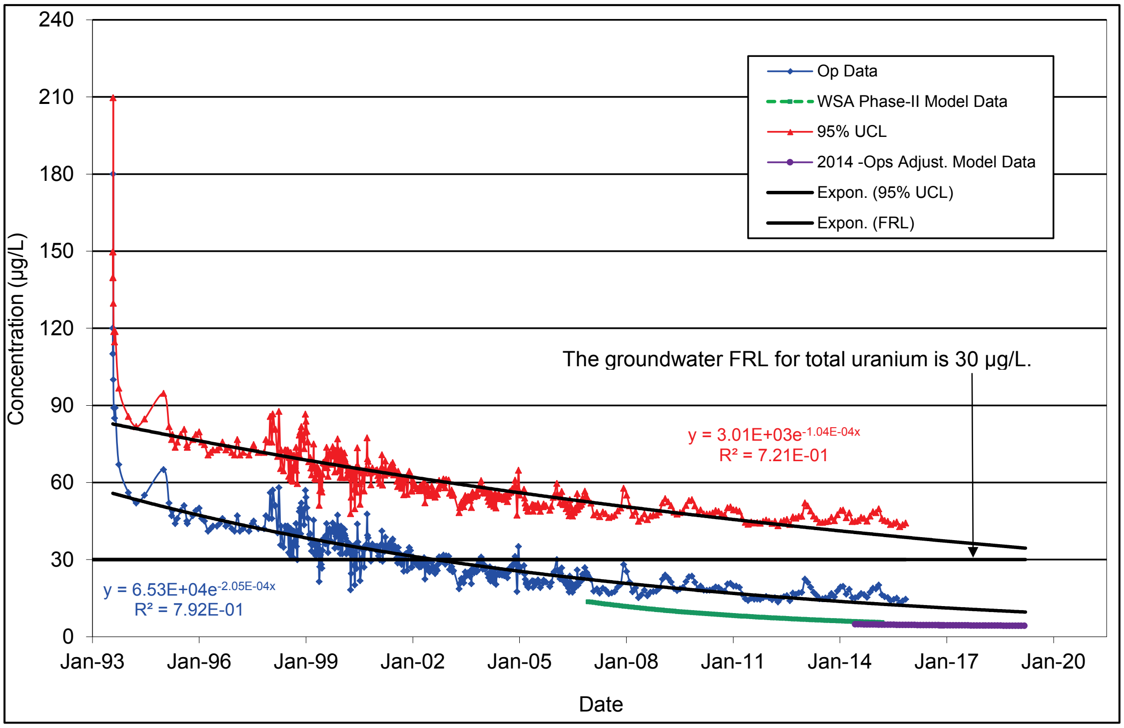

Figure A.1-19. Total Uranium Concentration Versus Time Plot for Extraction Well 3924 (RW-1) with Regression Analysis

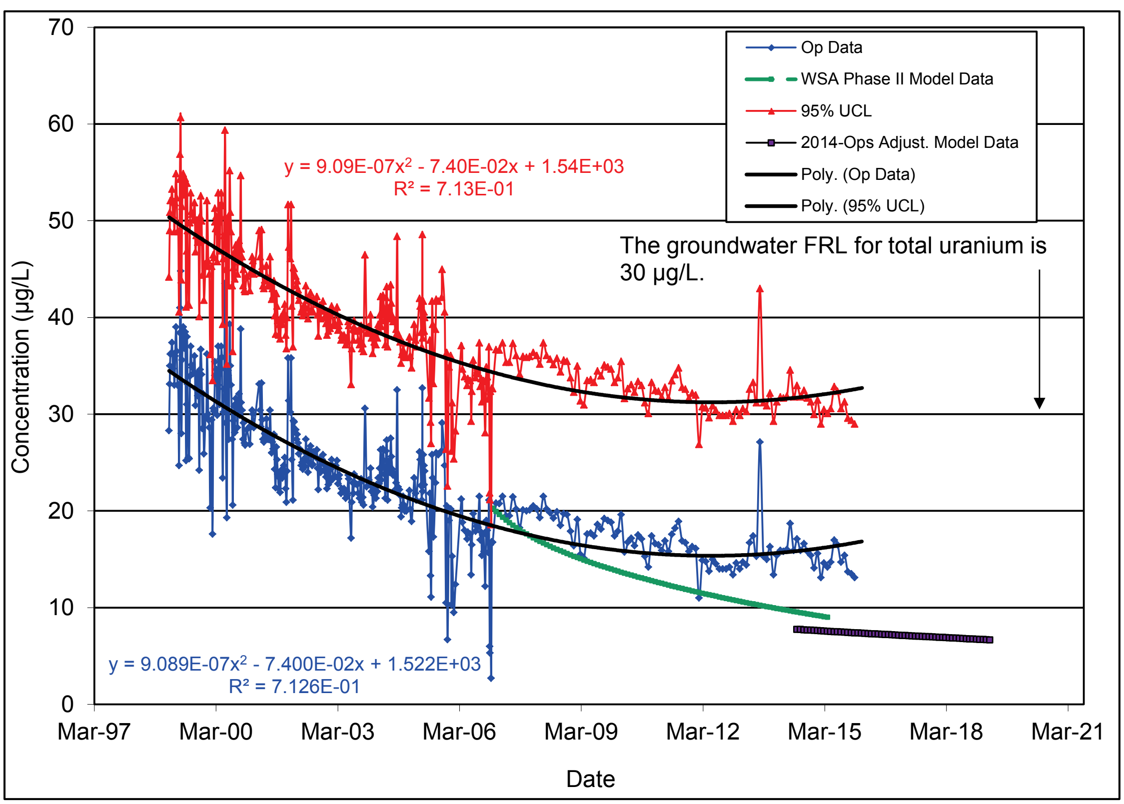

Figure A.1-20. Total Uranium Concentration Versus Time Plot for Extraction Well 3925 (RW-2) with Regression Analysis

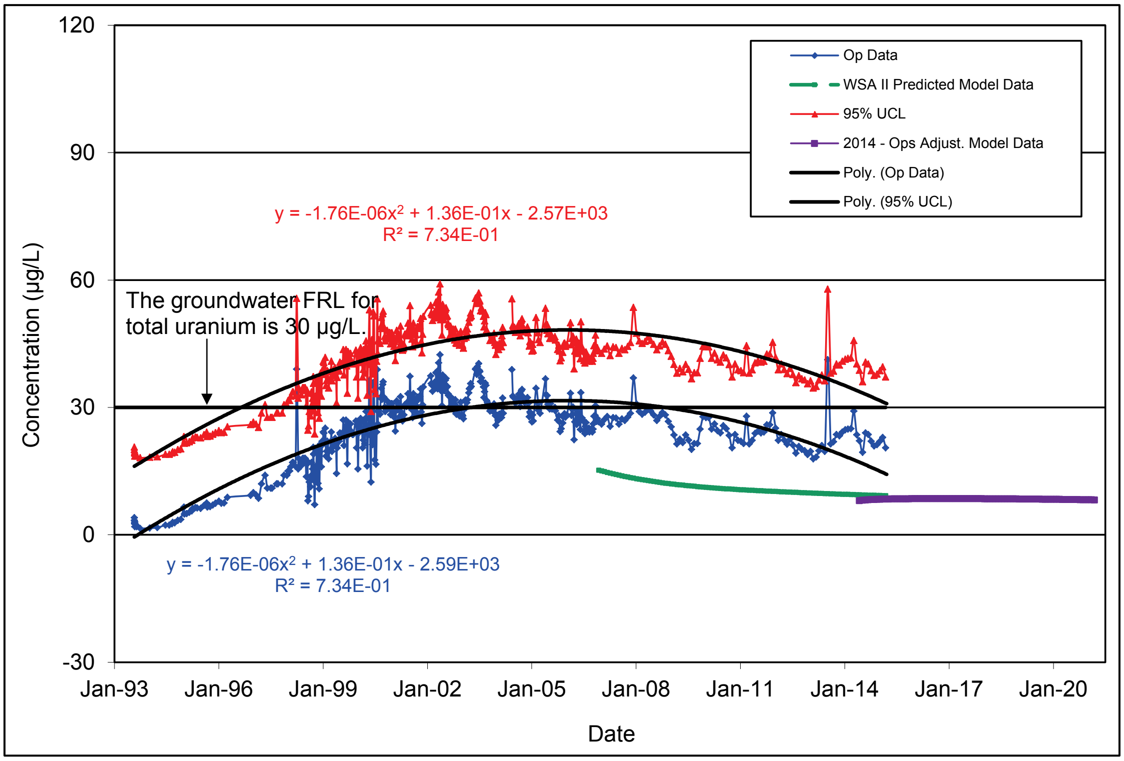

Figure A.1-21. Total Uranium Concentration Versus Time Plot for Extraction Well 3926 (RW-3) with Regression Analysis

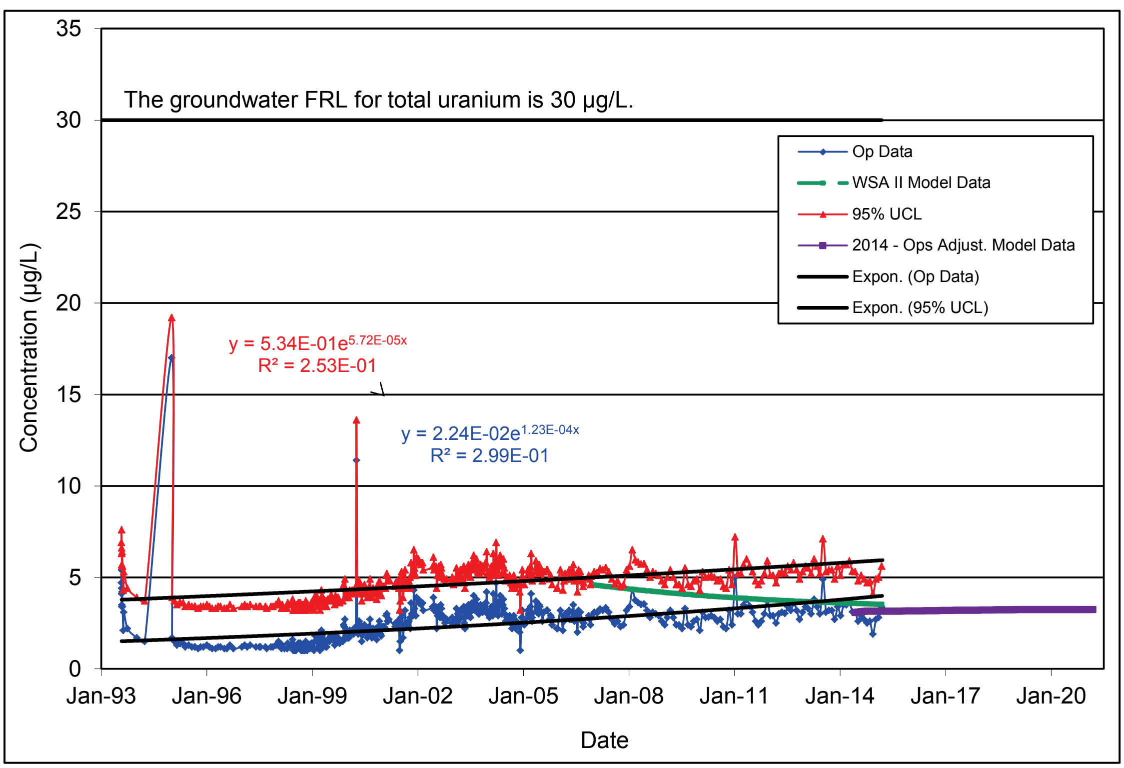

Figure A.1-22. Total Uranium Concentration Versus Time Plot for Extraction Well 3927 (RW-4) with Regression Analysis

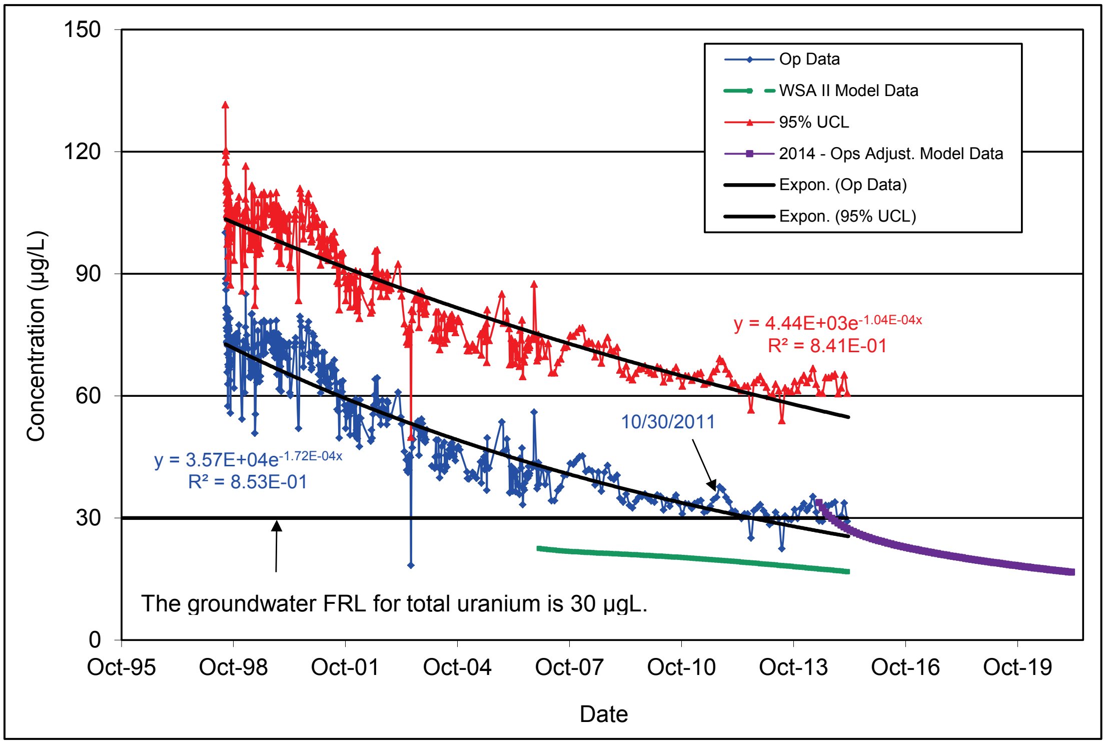

Figure A.1-23. Total Uranium Concentration Versus Time Plot for Extraction Well 32308 (RW-6) with Regression Analysis

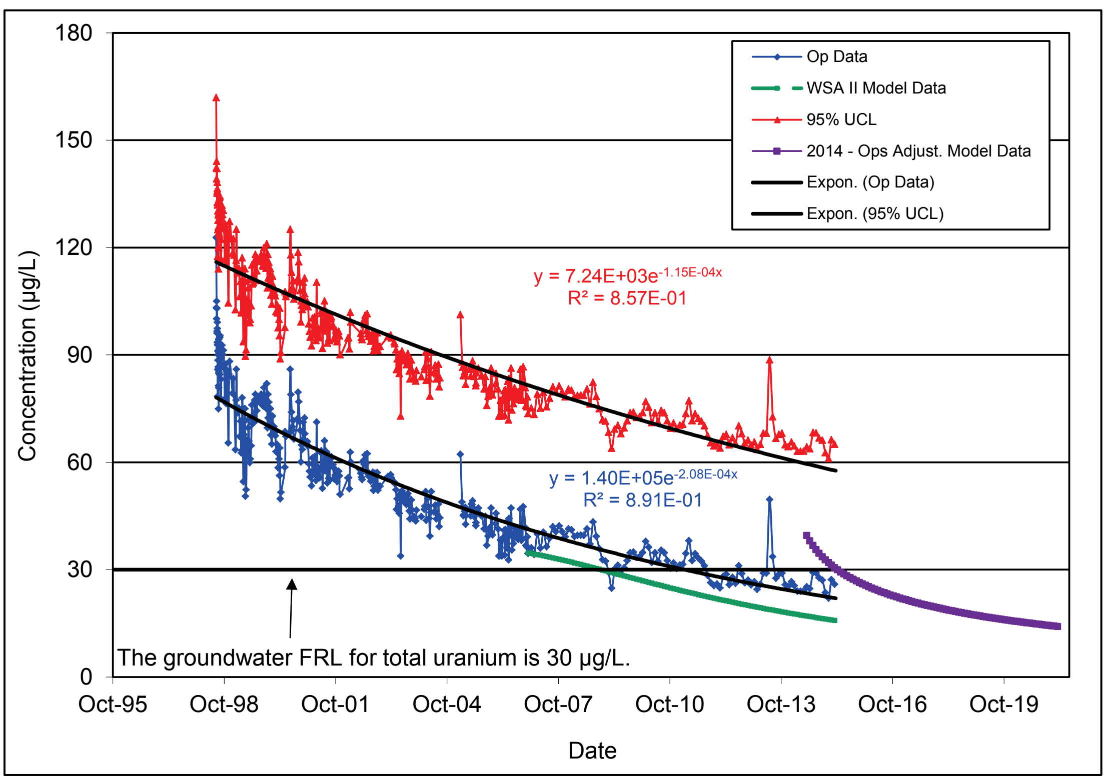

Figure A.1-24. Total Uranium Concentration Versus Time Plot for Extraction Well 32309 (RW-7) with Regression Analysis

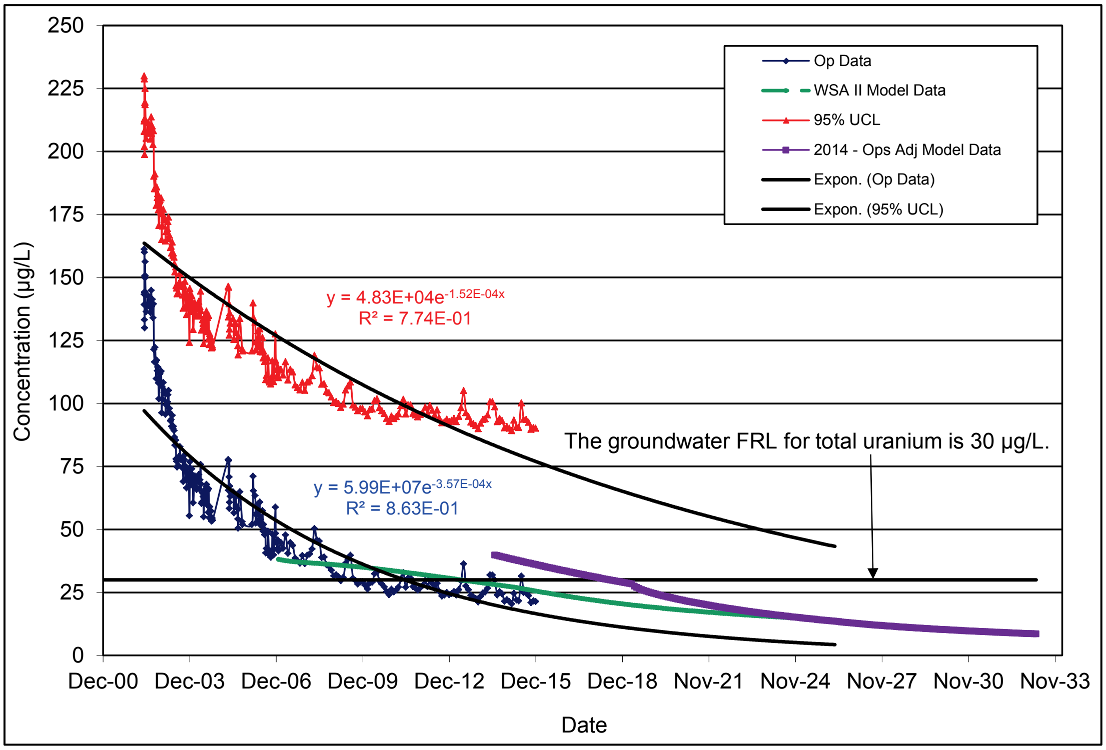

Figure A.1-25. Total Uranium Concentration Versus Time Plot for Extraction Well 32761 (EW-26) with Regression Analysis

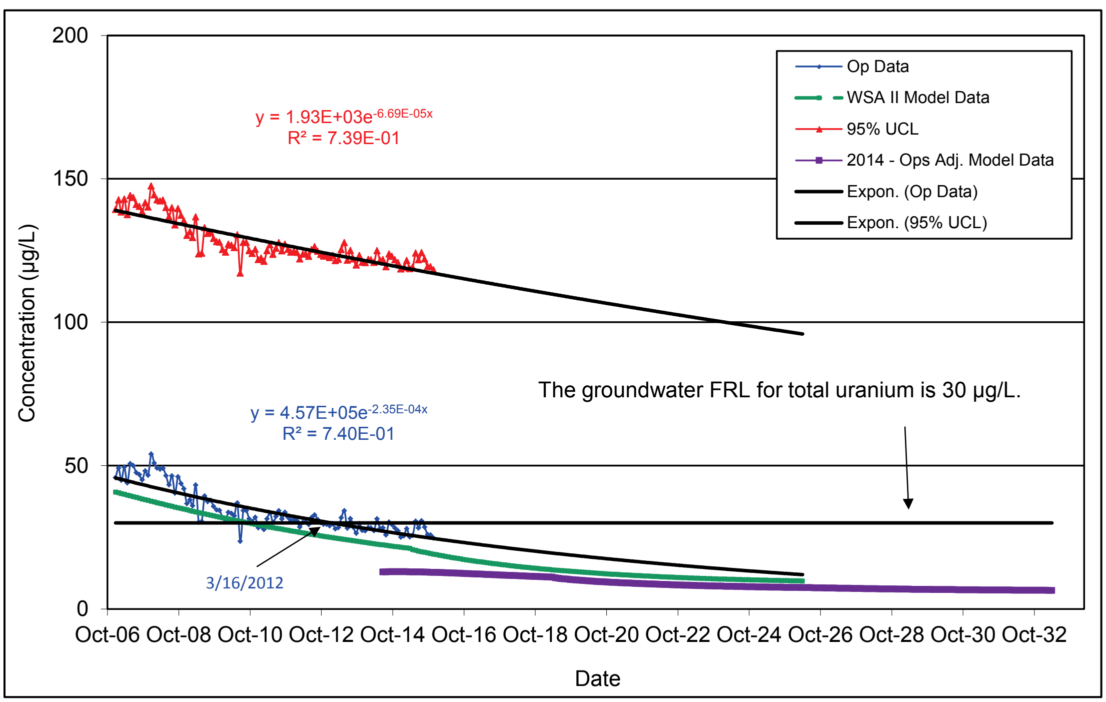

Figure A.1-26. Total Uranium Concentration Versus Time Plot for Extraction Well 33062 (EW-27) with Regression Analysis

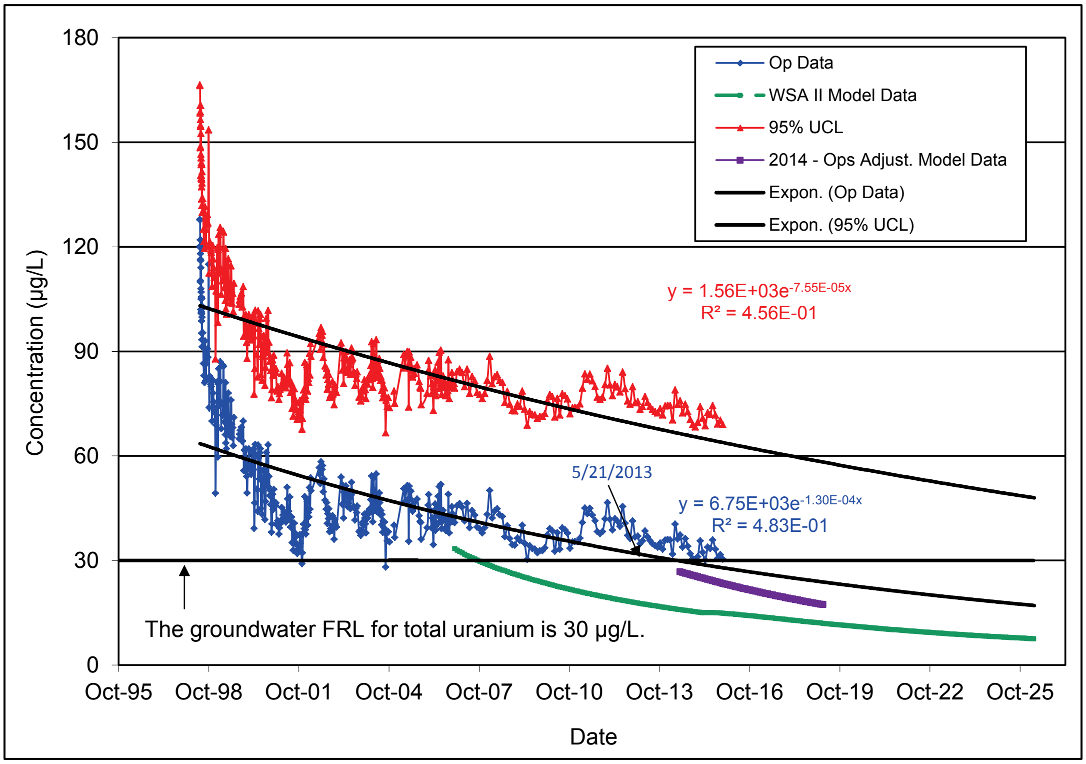

Figure A.1-27. Total Uranium Concentration Versus Time Plot for Extraction Well 31550 (EW-18) with Regression Analysis

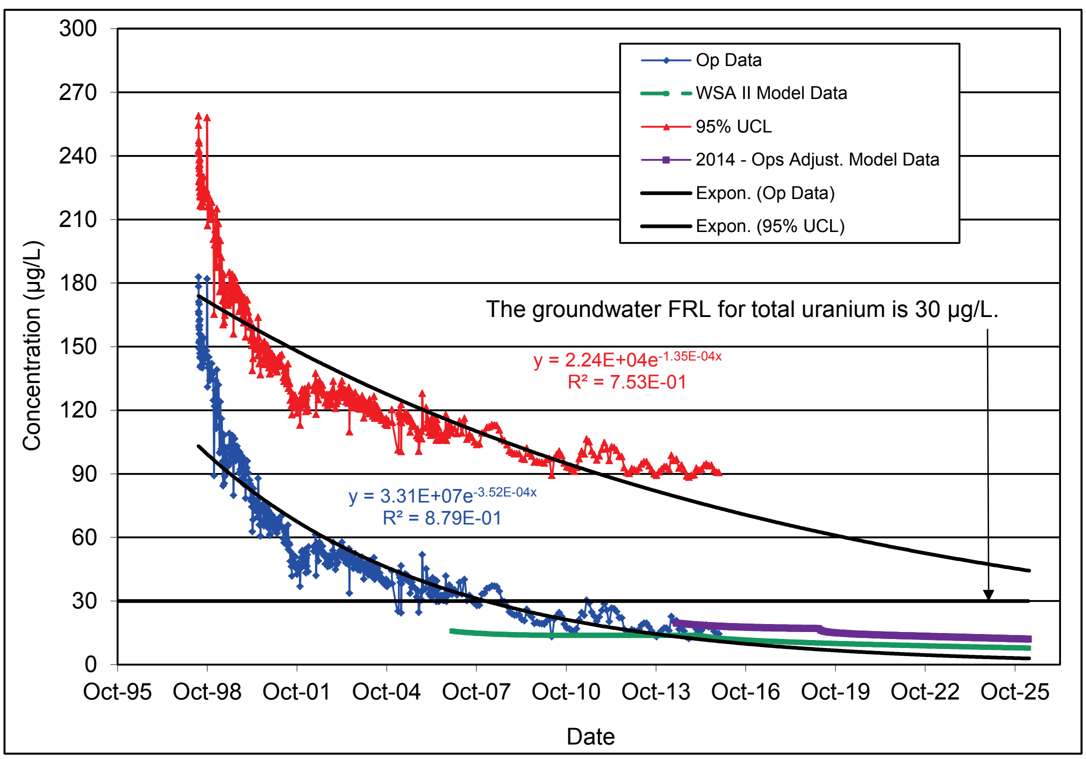

Figure A.1-28. Total Uranium Concentration Versus Time Plot for Extraction Well 31560 (EW-19) with Regression Analysis

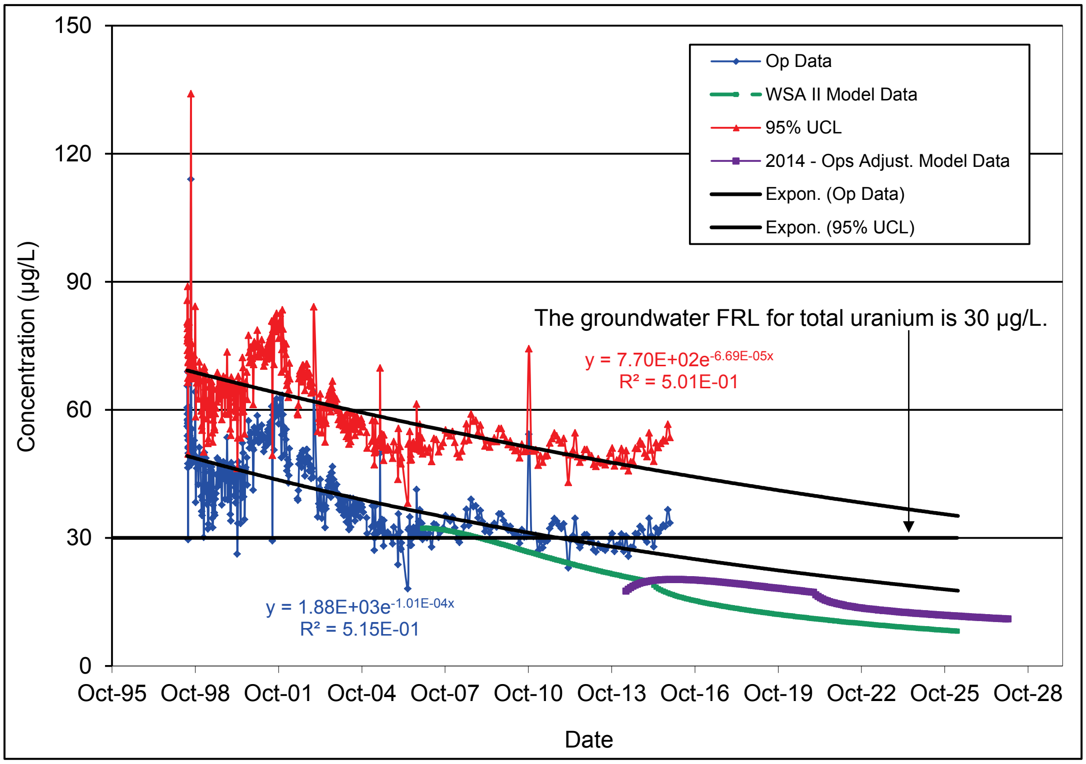

Figure A.1-29. Total Uranium Concentration Versus Time Plot for Extraction Well 31561 (EW-20) with Regression Analysis

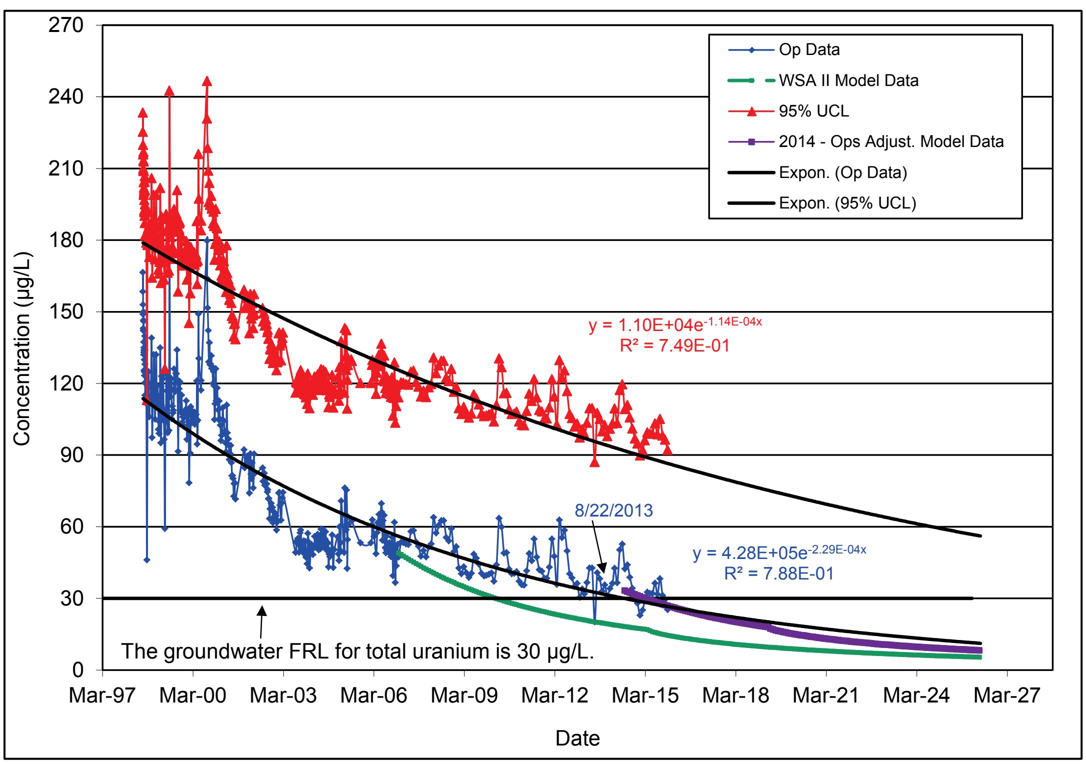

Figure A.1-30. Total Uranium Concentration Versus Time Plot for Extraction Well 31562 (EW-21)/ 33298 (EW-21a) with Regression Analysis

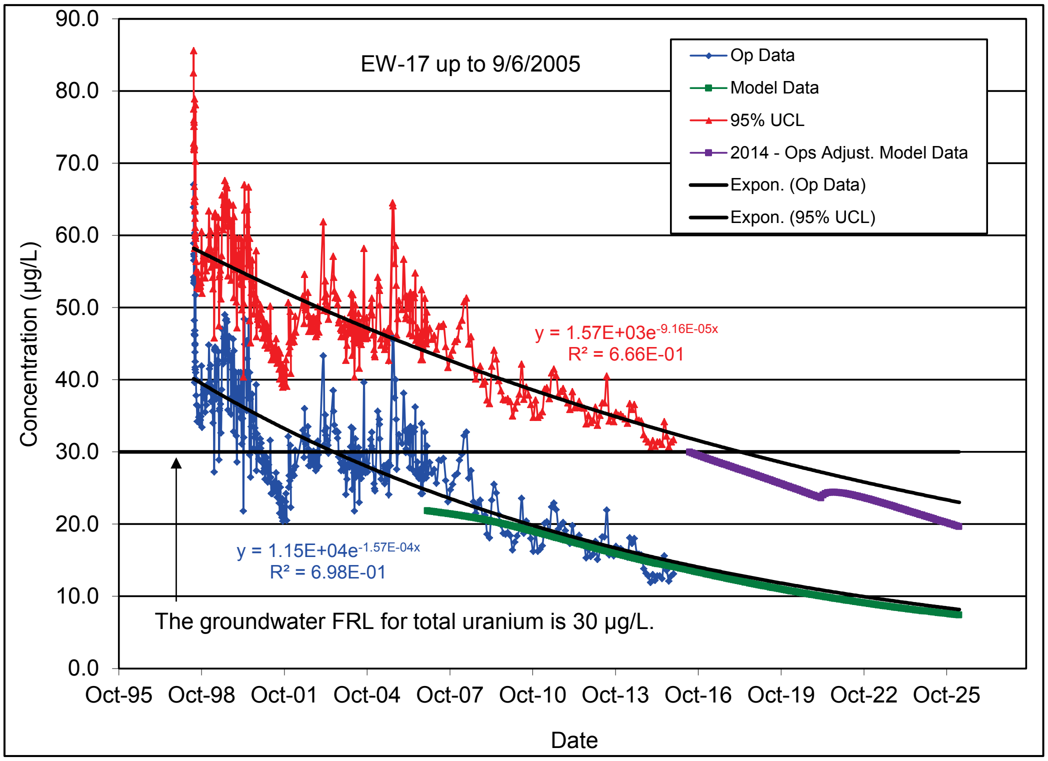

Figure A.1-31. Total Uranium Concentration Versus Time Plot for Extraction Well 31567 (EW-17)/ 33326 (EW-17a) with Regression Analysis

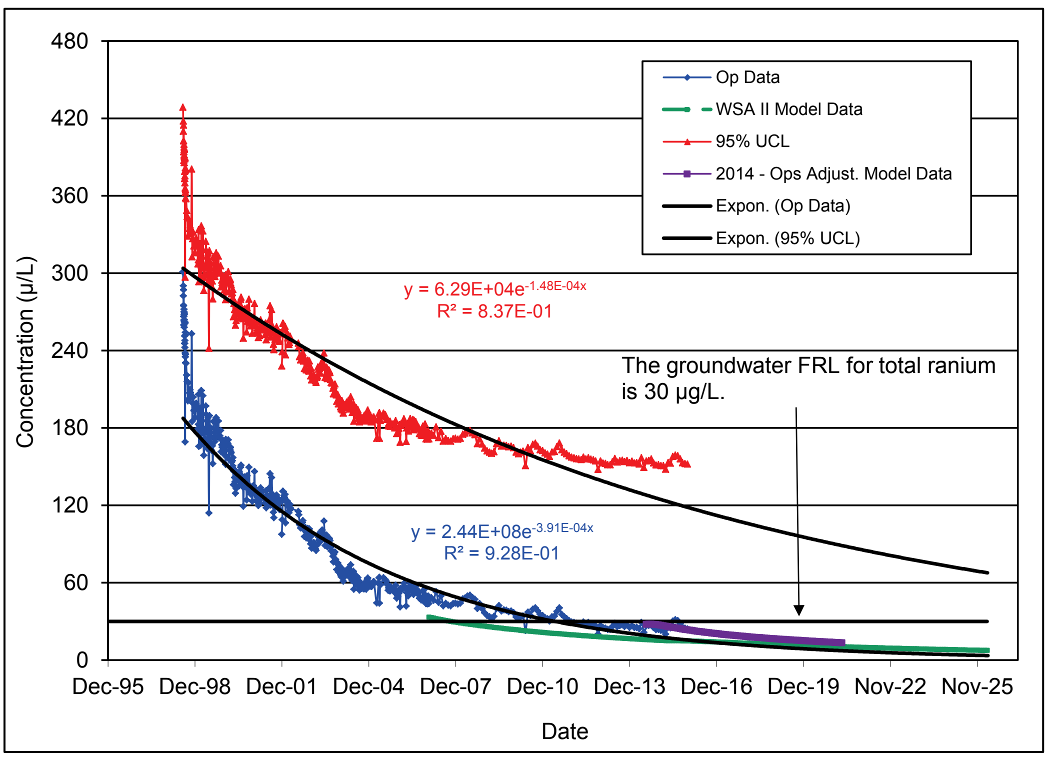

Figure A.1-32. Total Uranium Concentration Versus Time Plot for Extraction Well 32276 (EW-22) with Regression Analysis

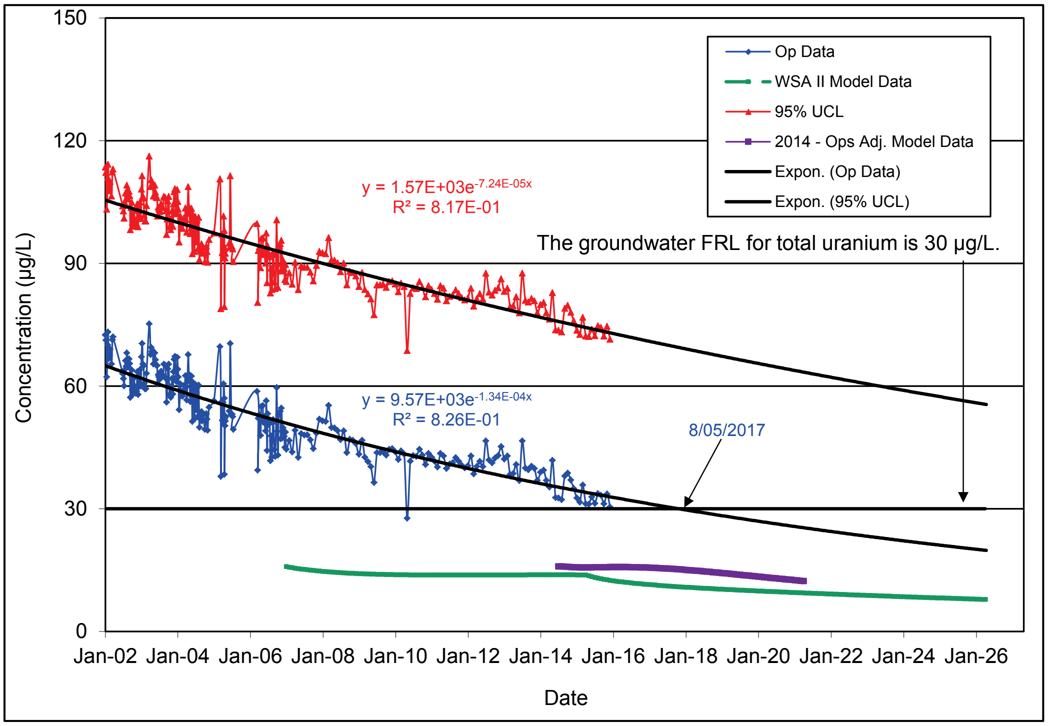

Figure A.1-33. Total Uranium Concentration Versus Time Plot for Extraction Well 32446 (EW-24) with Regression Analysis

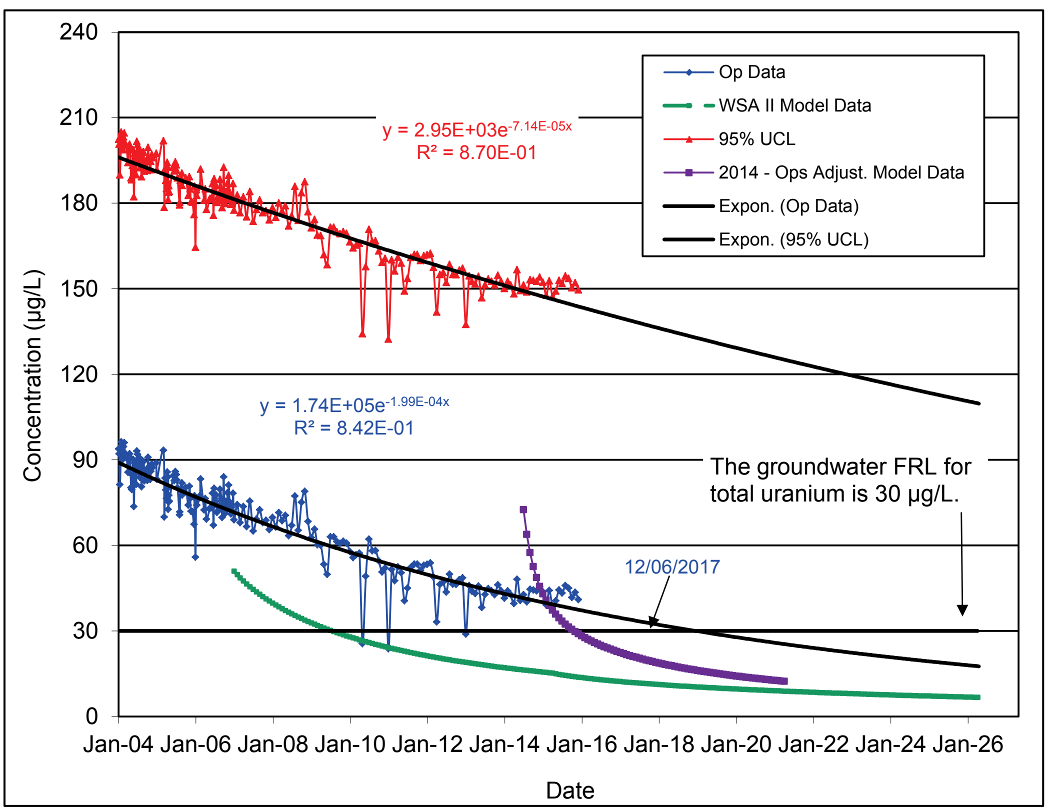

Figure A.1-34. Total Uranium Concentration Versus Time Plot for Extraction Well 32447 (EW-23) with Regression Analysis

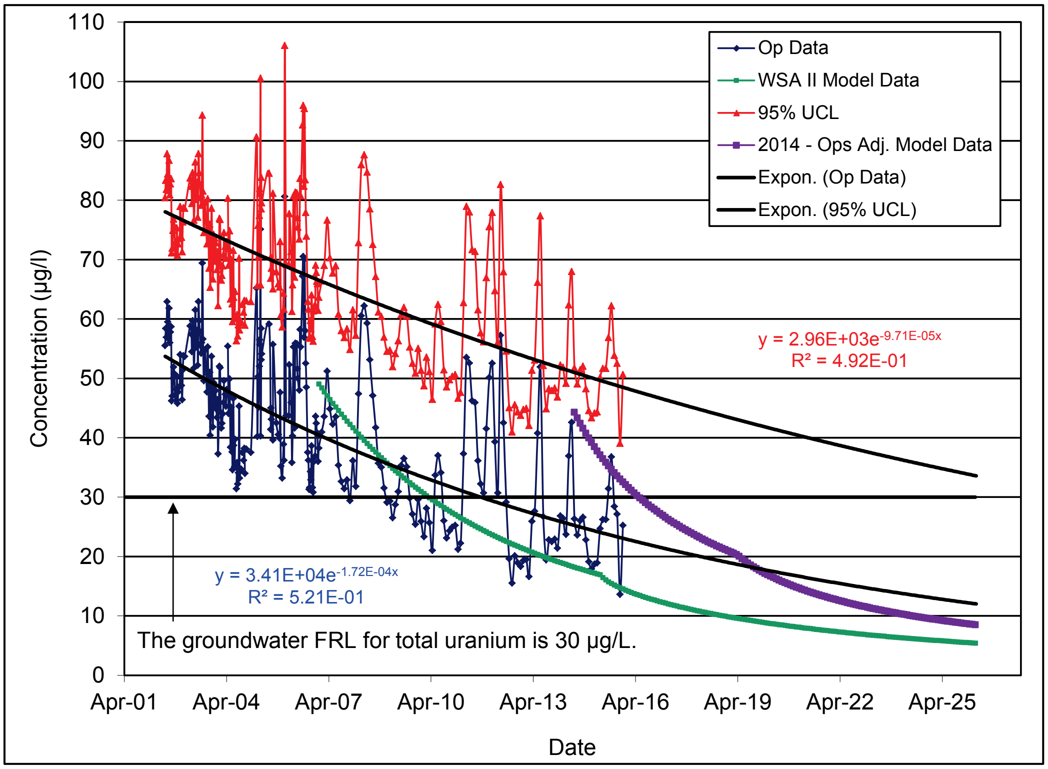

Figure A.1-35. Total Uranium Concentration Versus Time Plot for Extraction Well 33061 (EW-25) with Regression Analysis

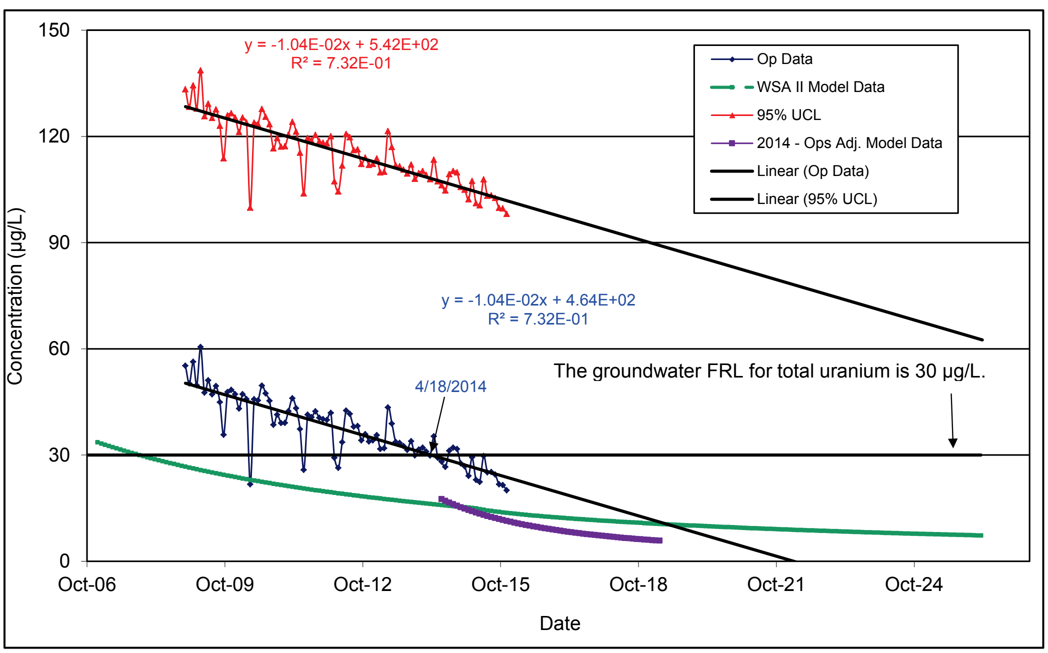

Figure A.1-36. Total Uranium Concentration Versus Time Plot for Extraction Well 33264 (EW-30) with Regression Analysis

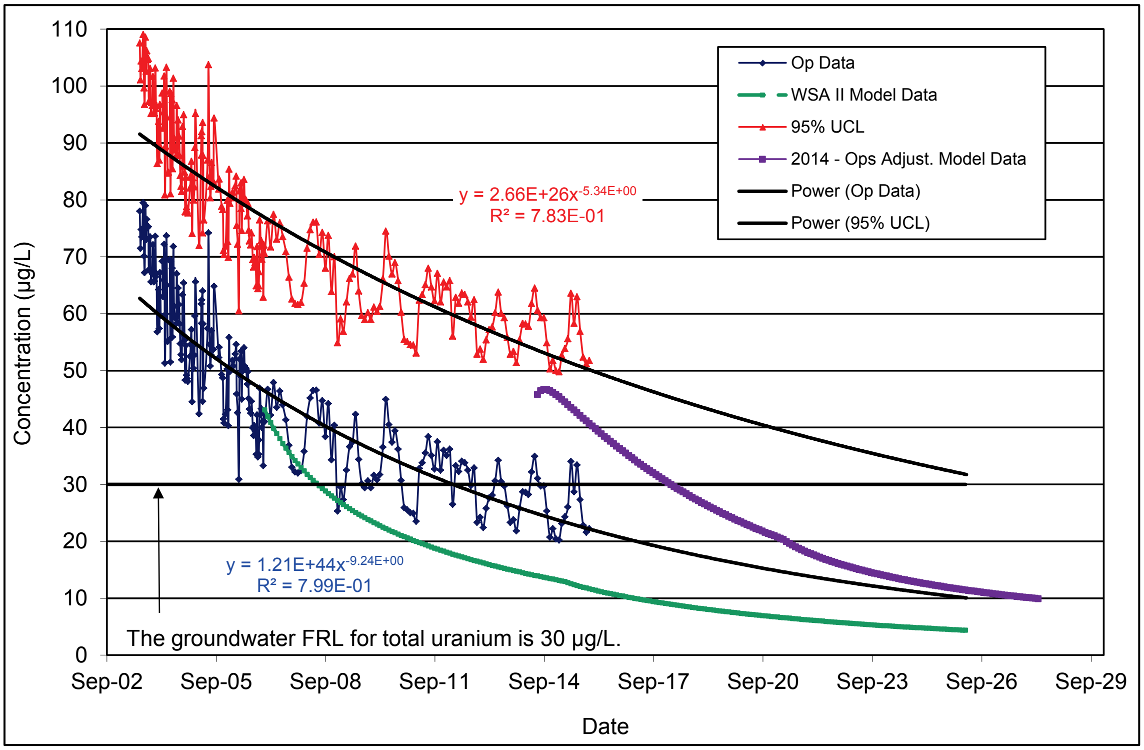

Figure A.1-37. Total Uranium Concentration Versus Time Plot for Extraction Well 33262 (EW-15a) with Regression Analysis

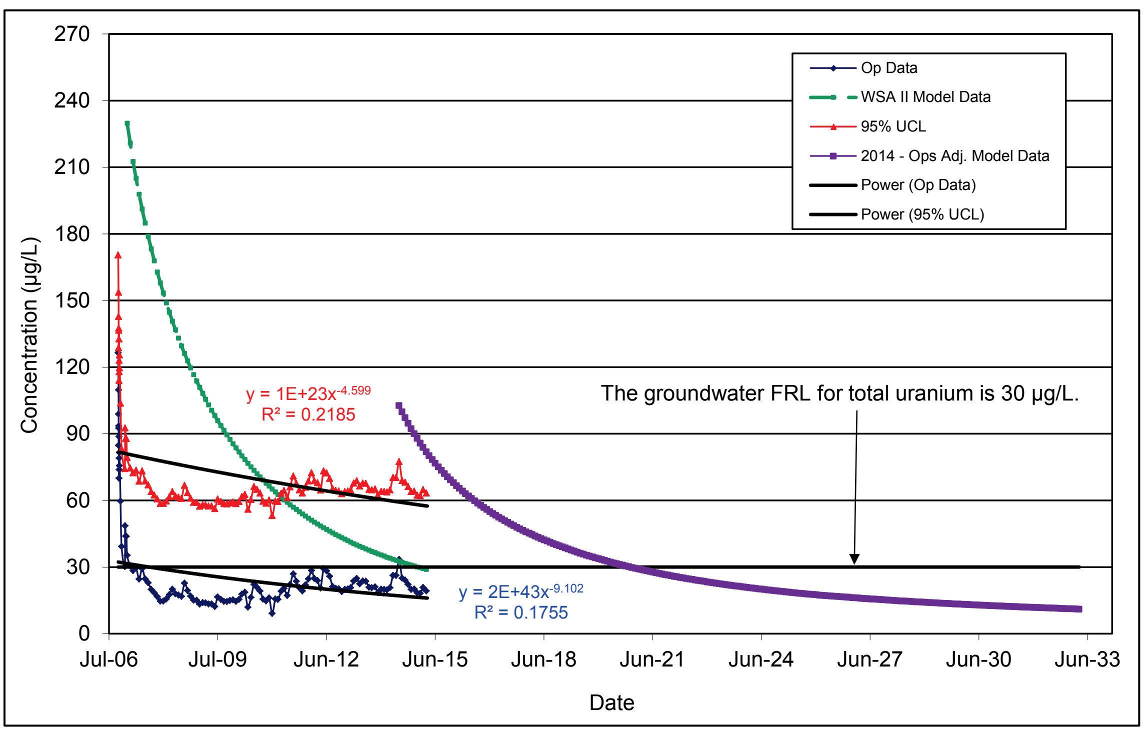

Figure A.1-38. Total Uranium Concentration Versus Time Plot for Extraction Well 33347 (EW-33a) with Regression Analysis

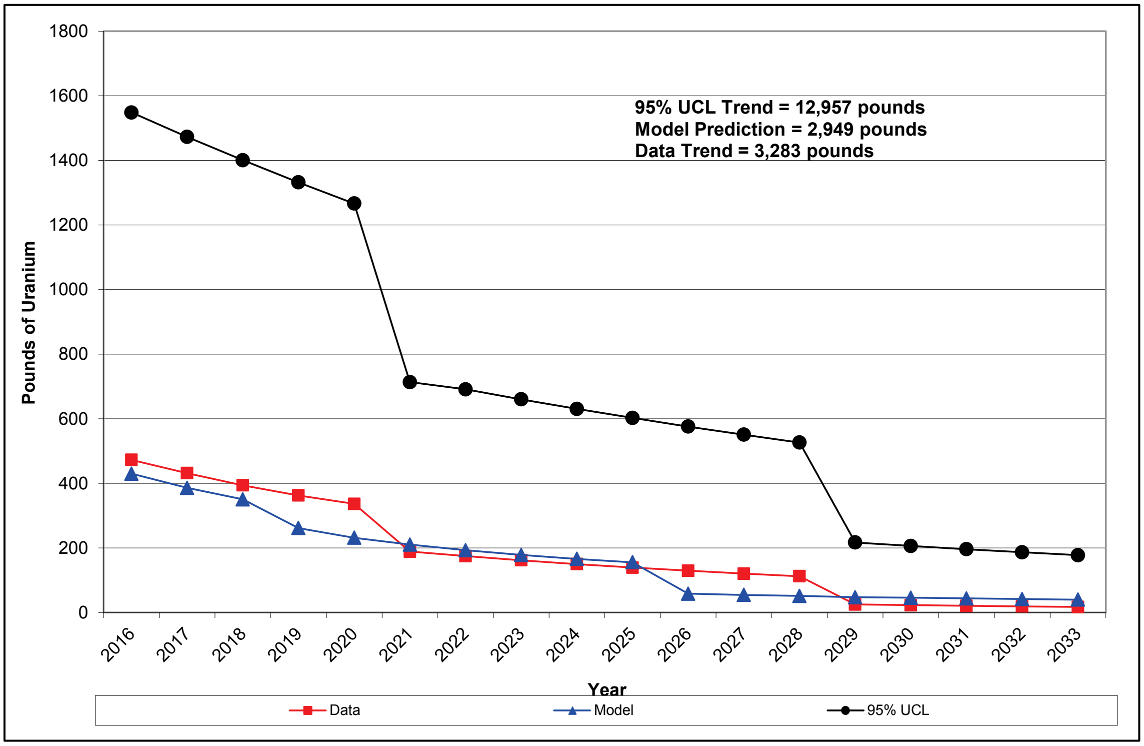

Figure A.1-39. Estimate of Yearly Pounds of Uranium to be Pumped from Aquifer (Model Predictions Versus Measured Concentration Trends) Data Collected Through 2015

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Attachment A.2

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Contents

Tables

Figures

Abbreviations

DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FRL	final remediation level
IEMP	Integrated Environmental Monitoring Plan
LMICP	*Comprehensive Legacy Management and Institutional Controls Plan*
Ohio EPA	Ohio Environmental Protection Agency
OSDF	On-Site Disposal Facility
PPDD	Pilot Plant Drainage Ditch
PRRS	Paddys Run Road Site
WSA	Waste Storage Area

Measurement Abbreviations

amsl	above mean sea level
ft	feet
µg/L	micrograms per liter

A.2.0 Assessment of Total Uranium Results

This attachment discusses groundwater monitoring total uranium results through 2015. The groundwater remediation at Fernald is a concentration-based cleanup. The *Record of Decision for Operable Unit 5* (DOE 1996) states that "areas of the Great Miami Aquifer exceeding final remediation levels will be restored through extraction methods." Uranium is the primary constituent of concern for groundwater. The groundwater final remediation level (FRL) for total uranium is 30 micrograms per liter (µg/L). The background total uranium concentration for unfiltered groundwater samples from the Great Miami Aquifer near the Fernald Preserve is 1.2 µg/L. This background value is based on the 95th percentile of unfiltered samples (*Remedial Investigation Report for Operable Unit 5* [DOE 1995], Section 4, Table 4-8). Both the area of the aquifer targeted for remediation and the statistical procedures that will be used to verify that aquifer cleanup objectives have been achieved are described in the *Fernald Groundwater Certification Plan* (DOE 2006).

Groundwater total uranium sampling requirements are presented in the Integrated Environmental Monitoring Plan (IEMP), which is Attachment D of the *Comprehensive Legacy Management and Institutional Controls Plan* (LMICP) (DOE 2016). IEMP groundwater monitoring and extraction well locations are shown in Figure A.2-1. For integration purposes, the On-Site Disposal Facility monitoring well locations are also shown in Figure A.2-1.

In addition to the routine well monitoring specified in the IEMP, 27 locations were sampled using a direct-push sampling tool (Geoprobe) in 2015. Direct-push sampling results for the 27 locations (12230C, 12411C, 12618E, 12814C, 13229D, 13233B, 13234C, 13237C, 13239B, 13240D, 13306C, 13369B, 13374B, 13376A, 13421D, 13423B, 13457A, 13461A, 13463A, 13464A, 13477A, 13481, 13482, 13483, 13484, 13485, and 13486) are presented in Tables A.2-1 through A.2-27. Direct-push sampling locations are often sampled several times over the course of the remediation. When a direct-push location is resampled, the convention is to identify the new sample with the same location number but with an alphabetic extension to differentiate the earlier sample (e.g., 12230, 12230A, 12230B). If a resample location is moved more than 50 feet (ft) from the original location, a new number is assigned.

Figures A.2-2A, A.2-2B, A.2-3A, and A.2-3B show maximum total uranium plume maps for the first and second halves of 2015, respectively. Figures A.2-2A and A.2-3A show direct-push data. Figures A.2-2B and A.2-3B show monitoring well and extraction well data. Data collected from the aquifer are used to progressively update the maximum total uranium plume maps in the following conservative manner:

- Total uranium concentration data are posted on a map with the contours from the previous map. The highest representative total uranium value at a monitoring well location is posted. The highest concentration associated with each direct-push location is also posted.
- If a recently measured concentration from a well is greater than the previous concentration contour value at that location, then the plume is recontoured using the higher value.
- If the most recent concentration measurement from a well is less than the previous contour for that location, then the new data are posted, but the plume contours are not adjusted using the new data until confirmatory direct-push sampling can be conducted.

- If direct-push data or multilevel monitoring well data are available and a complete vertical profile of an area indicates that concentrations have changed, then the map is recontoured using the new direct-push data or multilevel well data. Under this strategy, a reduction in the size of the mapped plume is based on vertical profile data.
- If a location has a history of intermittent exceedances and the location appears to be isolated from the main plume, then the location is identified on the maximum uranium plume map as a location with intermittent exceedances. This serves to keep track of the locations with intermittent exceedances so that their presence can be carried forward into the certification stage of the remediation project.

Table A.2-28 lists the monitoring wells where total uranium concentrations exceeded the 30 µg/L FRL during 2015. Included in the table are total uranium statistical summaries for each well, which include Mann-Kendall trend analyses. Table A.2-29 provides total uranium statistical summaries for the extraction wells, including Mann-Kendall trend analyses. Extraction well trends were discussed in Attachment A.1. Figure A.2-4 illustrates the statistics presented in Table A.2-28 (e.g., where total uranium concentrations have, an upward trend, downward trend, or no trend). Monitoring wells with an upward trend based on the Mann-Kendell analysis are discussed further.

Tracking the acreage of the maximum total uranium plume footprint provides a means for assessing progress in achieving remediation goals. Figure A.2-5 shows the footprint of the 30 µg/L total uranium plume from the second half of 2014 compared to the footprint of the 30 µg/L total uranium plume from the second half of 2015. The 2014 plume is highlighted in yellow; the yellow indicates areas where the plume was reduced for 2015. Acreage changes within the 30 µg/L footprint (i.e., area above 50 µg/L and area above 100 µg/L) are also tracked and reported. A breakdown for the past 2 years is provided below.

Comparison of 2014 and 2015 Maximum Total Uranium Plume Footprint Area

Year	Area Greater Than 30 µg/L	Area Greater Than 50 µg/L	Area Greater Than 100 µg/L
2014 (acres)	110.9	65.5	34.9
2015 (acres)	108.1	65.0	33.8
Difference (acres)	2.8	0.5	1.1
Difference (percent)	2.5%	0.8%	3.2%

Monitoring results are presented in three sections as outlined below.

- Section A.2.1, “Former Waste Storage Area,” including the Pilot Plant Drainage Ditch (PPDD) Area
- Section A.2.2, “Former Plant 6 Area”
- Section A.2.3, “South Field and Off-Property South Plume Total Uranium Plumes”

For each of the three sections, information is presented concerning:

- New direct-push sampling data,
- Intermittent total uranium FRL exceedance locations, and
- Monitoring wells with increasing total uranium concentration trends.

The remainder of the attachment is organized as follows:

- Section A.2.4 presents information concerning monitoring well maintenance.
- Section A.2.5 presents information concerning center-of-mass calculations for the total uranium plumes.
- Section A.2.6 presents total uranium cross sections.
- Section A.2.7 presents a groundwater monitoring program assessment.

A.2.1 Former Waste Storage Area

A.2.1.1 Former Waste Storage Area Maximum Total Uranium Plume

The size of the mapped footprint of the 30 µg/L maximum total uranium plume in the former Waste Storage Area (WSA) at the end of 2015 was essentially the same as interpretation in 2014. In Figure A.2-5, the area in yellow indicates the portion of the plume that was reduced. The area of the plume immediately southeast of the reduced area was expanded as a result of additional monitoring well and direct-push sampling data obtained in 2015, effectively countering most of the reduction in area. At the end of 2014, the mapped footprint (excluding the PPDD area described below) was estimated to be 11.1 acres. At the end of 2015, this mapped footprint was estimated to be 10.7 acres, a decrease of 3.6%.

A.2.1.1.1 New Direct-Push Sampling Data in the Former WSA

Direct-push sampling was conducted in 2015 at six locations in the former WSA (locations 13374B, 13369B, 13463A, 13484, 13485, and 12618E). Tables A.2-1 through A.2-6 provide sampling results.

<u>Location 13374B</u>
Direct-push sampling location 13374B is located northwest of extraction well 33347. Total uranium concentration data collected in 2015 for this location are provided in Table A.2-1. The location is shown in Figure A.2-3A.

As shown in Table A.2-1, the highest total uranium concentration measured in 2015 was 36.9 µg/L. This location was previously sampled in 2008 and 2013. Total uranium concentration data for all three sampling dates are presented below.

Location 13374 (2008)		Location 13374A (2013)		Location 13374B (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
517	74.0	519	293	515	36.9
507	70.1	509	13.2	505	1.92
		499	2.05	495	2.57
		489	6.46	485	3.93

amsl = above mean sea level

The total uranium concentrations data presented above indicates that the 2015 water samples were collected at elevations that were approximately 4 ft lower than those of the 2013 water samples and 2 ft lower than those of the 2008 water samples. Higher total uranium groundwater concentrations correspond to higher water levels in this area. This location is in a former source area, and uranium contamination is sorbed to aquifer sediments in the vadose zone. The elevation of the water sample collected in 2015 was too low to warrant changing the maximum total uranium plume interpretation.

Location 13369B

Direct-push sampling location 13369B is located northwest of extraction well 33347. Total uranium concentration data collected in 2015 for this location are provided in Table A.2-2. The location is shown in Figure A.2-3A.

As shown in Table A.2-2, the highest total uranium concentration measured in 2015 was 177 µg/L. This location was previously sampled in 2007 and 2013. Total uranium concentration data for all three sampling dates are presented below.

Location 13369 (2007)		Location 13369A (2013)		Location 13369B (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
514	166	517	202	515	177
504	16.4	507	42.0	505	28.1
494	4.10	497	6.08	495	5.70
484	10.4				

amsl = above mean sea level

The total uranium concentrations presented above indicate that the 2015 water sample was collected at an elevation that was approximately 2 ft lower than the elevation of the 2013 water sample and 1 ft lower than that of the 2007 water sample. High total uranium groundwater concentrations correspond to high water levels in this area. This location is in a former source area, and total uranium contamination is sorbed to aquifer sediments in the vadose zone. The elevation of the water sample collected in 2015 was too low to warrant changing the maximum total uranium plume interpretation.

Location 13463A

Direct-push sampling location 13463A is located northwest of extraction well 33347. Total uranium concentration data collected in 2015 for this location are provided in Table A.2-3. The location is shown in Figure A.2-3A.

As shown in Table A.2-3, the highest total uranium concentration measured in 2015 was 54.4 µg/L. This location was previously sampled in 2013. Total uranium concentration data for both sampling dates are presented below.

Location 13463 (2013)		Location 13463A (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
516	50.2	515	40.2
506	40.2	505	54.4
496	7.72	495	11.9
		485	3.21

amsl = above mean sea level

The total uranium concentration data collected in 2015 are consistent with the data collected in 2013, such that a change to the maximum total uranium plume map for 2015 is not warranted.

Location 13484

Direct-push sampling location 13484 is located northwest of extraction well 33347. Total uranium concentration data collected in 2015 for this location are provided in Table A.2-4. The location is shown in Figure A.2-3A.

As shown in Table A.2-4, the highest total uranium concentration measured in 2015 was 3.86 µg/L. This location was sampled for the first time to better characterize the southwest edge of the total uranium plume. Given the low total uranium concentration measured (compared to 30 µg/L), the maximum uranium plume map for 2015 was adjusted to honor this lower concentration for the 2015 interpretation.

Location 13485

Direct-push sampling location 13485 is located southeast of extraction well 33347. Total uranium concentration data collected in 2015 for this location are provided in Table A.2-5. The location is shown in Figure A.2-3A.

As shown in Table A.2-5, the highest total uranium concentration measured in 2015 was 194 µg/L. This location was sampled for the first time in 2015 to better characterize the interior of the 30 µg/L total uranium plume in this area. Based on older direct-push data collected at nearby locations, this location was mapped in 2014 as being above 500 µg/L. Although it is recognized that concentrations could be higher if water levels had been higher, the 2015 the maximum total uranium plume map for 2015 was adjusted to honor this lower concentration, resulting in a slight decrease of the size of the 30 µg/L total uranium plume footprint, compared to the 2014 interpretation. Future direct-push sampling will be completed near this area as the remedy progresses.

Location 12618E

Direct-push sampling location 12618E is located southeast of extraction well 33347. Total uranium concentration data collected in 2015 for this location are provided in Table A.2-6. The location is shown in Figure A.2-3A.

As shown in Table A.2-6, the highest total uranium concentration measured in 2015 was 167 µg/L. This location was previously sampled in 1999, 2004, 2011, and 2014. Total uranium concentration data for all five sampling dates are presented below.

Location 12618 (1999)		Location 12618B (2004)		Location 12618C (2011)		Location 12618D (2014)		Location 12618E (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
515	31.0	516	50.5	514	117	515	26.9	515	167
506	6.00	507	10.9	504	7.89	505	16.1	505	15.1
496	7.20	497	7.50	494	11.2	495	8.35	495	5.31
486	0.90	487	4.00	484	8.26	485	9.81	485	9.94
		477	4.10						

amsl = above mean sea level

These data indicate that the maximum total uranium concentration increased between 1999 and 2011 from 31.0 µg/L to 117 µg/L, but in 2014 the maximum concentration was 26.9 µg/L, so the 2014 maximum total uranium plume map was revised to honor the 2014 data. However, in 2015, the maximum concentration was 167 µg/L. The maximum total uranium total plume map for 2015 was adjusted to honor this increased concentration, resulting in an increase in the size of the total uranium plume footprint. The cause for the increase in 2015 is not known. Future direct-push sampling will be completed near this area as the remedy progresses to document if the concentration continues to increase.

A.2.1.1.2 Intermittent Total Uranium FRL Exceedance Locations in the Former WSA

Two monitoring wells are identified on the maximum total uranium plume maps for 2015 in the former WSA (Figures A.2-2B and A.2-3B) as being monitoring locations with intermittent total uranium FRL exceedances. These two locations are 83340 and 83341. Monitoring well 83340_C1 is also identified in Table A.2-28 as having an increasing total uranium concentration trend.

Figure A.2-6 is a time versus concentration graph for monitoring well 83340. The graph shows that the total uranium concentrations for channel 1 were briefly below 30 µg/L in the first half of 2015, then were above 30 µg/L during the second half of 2015. Although the overall trend is up (based on a Mann-Kendell interpretation), the data indicate that concentrations have been trending down from a high of approximately 45 µg/L measured in 2011.

Figure A.2-7 is a time versus concentration graph for monitoring well 83341. The graph shows that the total uranium concentrations for two of the channels (channels 2 and 3) were below 30 µg/L in 2015. Channel 1 of monitoring well 83341 was dry in 2015.

Monitoring wells 83340 and 83341 will continue to be monitored. If future monitoring indicates that the intermittent total uranium FRL exceedances are continuing or increasing, additional direct-push sampling may be conducted in the area when water levels are high to determine if a plume can be defined. Monitoring wells 83340 and 83341 will continue to be identified on maximum total uranium plume maps as being locations where intermittent total uranium FRL exceedances have been measured so that their presence will be carried forward into the certification stage of the aquifer remediation.

A.2.1.1.3 Monitoring Wells with Increasing Total Uranium Concentration Trends in the Former WSA

As shown in Figure A.2-4, three monitoring wells (2649, 3821, and 83340_C1) have increasing total uranium concentration trends in the former WSA. These three wells were reported in the 2013 and 2014 Site Environmental Reports (DOE 2014 and DOE 2015) as having increasing concentration trends in 2013 and 2014. Table A.2-28 provides summary statistics for the three wells. All three monitoring locations are within capture of the groundwater remediation system.

Figure A.2-9 is a total uranium concentration versus time plot for monitoring well 2649. The figure shows a correlation between high water levels and high total uranium concentrations. Figure A.2-6 is a total uranium concentration versus time plot for monitoring well 83340. The increasing trend is shown for the shallowest channel in the well, channel 1. The increasing trends at these two monitoring wells (2649 and 83340_C1) are attributed to residual total uranium contamination that is sorbed to aquifer sediments in the vadose zone. When water levels are high, higher total uranium concentrations are measured.

Figure A.2-9 and Figure A.2-10 are total uranium concentration versus time plots for monitoring wells 2821 and 3821, respectively. As shown in Table A.2-28 and in Figure A.2-9, monitoring well 3821 had a statistically significant upward trend in total uranium concentration in 2015. Monitoring well 3821 is screened several feet beneath the water table. As shown in Figure A.2-10, since 2012 the total uranium concentration in monitoring well 3821 is intermittently above 30 µg/L. Monitoring well 2821 is situated at the same location as monitoring well 3821, but is screened across the water table at a higher elevation than the screen in 3821. As shown in Figure A.2-9, the total uranium concentration at monitoring well 2821 has also increased slightly since 2012 but is still well below 30 µg/L. The U.S. Department of Energy (DOE) plans to continue to monitor this location to see if the total uranium concentration trend in well 3821 continues. If the upward concentration trend continues, then the increase may represent a small area of contamination that migrated past the monitoring well location in response to nearby pumping.

A.2.1.1.4 Former WSA Summary

High total uranium concentrations that correspond to high water levels continue to be a concern for the former WSA plume. Located beneath a former source area, total uranium contamination is sorbed to aquifer sediments in the vadose zone. When pumping is stopped and the water level rises, total uranium concentrations dissolved in the groundwater may increase (rebound) enough to exceed groundwater FRLs.

High total uranium concentrations in the northwest corner of the plume continue to be a concern. Direct-push sampling has provided data that indicate that the western extent of the 30 µg/L maximum total uranium plume is properly identified. Intermittent puddles of surface water collect in a swale located northwest of the former WSA total uranium plume. The swale is bounded by Paddys Run to the west and former waste pits to the east. As presented in Appendix B, the total uranium concentration of many of the surface water samples collected from this area exceeds the groundwater FRL.

Surface water runoff in the former WSA is directed to where the Clear Well and Pit 3 were once located. The surface water infiltrates into the ground and serves as a source of recharge to the aquifer. The area of infiltration is within capture of the groundwater remediation system. Because the area is within capture, there is no risk to the public from the high total uranium concentrations in the groundwater in this area. Of concern, however (as noted by the increasing total uranium concentrations in the northwest corner of the plume), is that a residual source may be present in the area that is allowing uranium contamination to seep into the aquifer in the area of the swale.

In 2014 groundwater modeling was conducted to determine the potential impact to model-predicted aquifer cleanup times if uranium-contaminated groundwater is infiltrating into the aquifer from the swale. A modeled worst-case scenario was based on the highest total uranium concentration measured in ponded water within the swale and high infiltration rates. The conservative groundwater modeling scenario:

- Took no credit for attenuation of uranium in glacial till or alluvium.
- Input infiltration rates of 50 inches per year rather than 6 inches per year.
- Input infiltrating total uranium concentration of 1,900 µg/L, which is the highest total uranium concentration measured in ponded water within the swale between 2007 and 2014.

Modeling under these extreme conservative conditions had no impact to model-predicted cleanup times for the aquifer in this area. DOE will continue to work with the U.S. Environmental Protection Agency (EPA) and the Ohio EPA to determine the best path forward for remediation of the aquifer in this area given its unique challenge of having contamination in the vadose zone.

A.2.1.2 PPDD Maximum Total Uranium Plume

A very small reduction (1.2%) was made to the size of the mapped 30 µg/L total uranium plume footprint in the PPDD Area for this report. The size of the 30 µg/L total uranium plume footprint was reduced from 7.9 acres in 2014 to 7.8 acres in 2015 (Figure A.2-5).

A.2.1.2.1 New Direct-Push Sampling Data in the PPDD Area

Two direct-push samples were collected in the PPDD Area in 2015 (locations 13376A and 13481). Total uranium concentration data collected in 2015 at locations 13376A and 13481 are provided in Table A.2-7 and Table A.2-8, respectively. Locations 13376A and 13481 are shown in Figure A.2-3A.

Location 13376A

Direct-push sampling location 13376A is located near extraction well 32761. Total uranium concentration data collected in 2015 for this location are provided in Table A.2-7. The location is shown in Figure A.2-3A.

As shown in Table A.2-7, the highest total uranium concentration measured in 2015 was 204 µg/L. This location was previously sampled in 2008. Total uranium concentration data for both sampling dates are presented below.

Location 13376 (2008)		Location 13376A (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
516	218	514	204
506	118	504	55.0
496	51.8	494	24.3
486	26.8	484	26.6
		474	23.8

amsl = above mean sea level

The total uranium concentration data collected in 2015 are consistent with the data collected in 2008 such that a change to the maximum total uranium plume map for 2015 was not warranted.

Location 13481

Direct-push sampling location 13481 is located near extraction well 33062. Total uranium concentration data collected in 2015 for this location are provided in Table A.2-8. The location is shown in Figure A.2-3A.

As shown in Table A.2-8, the highest total uranium concentration measured in 2015 was 9.0 µg/L. This location was sampled for the first time to better characterize the southeast edge of the plume. The maximum total uranium plume map for 2015 was adjusted to honor the sampling result.

A.2.1.2.2 Intermittent Total Uranium FRL Exceedance Locations in the PPDD Area

One monitoring well, 83335, is identified on the maximum total uranium plume maps for 2015 in the former PPDD Area (Figures A.2-2B and A.2-3B) as being a monitoring location with intermittent total uranium FRL exceedances.

Figure A.2-11 provides a time versus total uranium concentration plot for monitoring well 83335. The figure shows that total uranium concentrations measured in 2015 were below the total uranium groundwater FRL for all monitoring channels. This well will continue to be identified on maximum total uranium plume maps as being a location where intermittent total uranium FRL exceedances have been measured so that its presence will be carried forward into the certification stage of the aquifer remediation.

A.2.1.2.3 Monitoring Wells with Increasing Total Uranium Concentration Trends in the PPDD Area

As shown in Table A.2-28, one monitoring well had an increasing total uranium concentration trend in 2015 in the PPDD Area (83124_C4). This well is a multichannel monitoring well with six monitoring horizons referred to as channels (numbered from 1 through 6 with increasing depth); C4 is the fourth channel. Table A.2-28 provides summary statistics for monitoring well 83124_C4.

Figure A.2-12 is a total uranium concentration versus time plot for all of the channels in monitoring well 83124. This well was also reported in the 2013 and 2014 Site Environmental Reports (DOE 2014 and DOE 2015) as having an increasing concentration trend. The historical ranges of total uranium concentrations in channels 2 through 6 are less than approximately 100 µg/L. The total uranium concentration measured in channel 1 has fluctuated between 200 µg/L and 800 µg/L. The increasing concentration trend in channel 4 is attributed to contamination moving toward the monitoring well in response to nearby pumping. DOE will continue to monitor this well but plans no action at this time in response to the increasing concentration trend in channel 4. This well is within capture of the groundwater remediation system.

A.2.2 Former Plant 6 Area

A.2.2.1 New Direct-Push Sampling Data in the Plant 6 Area

No new direct-push samples were collected in 2015 in the Plant 6 Area.

A.2.2.2 Intermittent Total Uranium FRL Exceedance Locations and Monitoring Wells with Increasing Total Uranium Concentration Trends

Plans for a groundwater restoration module in the former Plant 6 Area were abandoned in 2001 based on the outcome of the *Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas* (DOE 2001). The data in this design indicated that the total uranium plume in the former Plant 6 Area was no longer present. EPA and Ohio EPA concurred with this decision.

Monitoring well 2389 is the only groundwater monitoring well remaining in the area where Plant 6 was located in the Former Production Area (Figure A.2-1). This well is identified as a location with intermittent total uranium FRL exceedances on the maximum total uranium plume maps (Figures A.2-2B and A.2-3B). It is also identified as a monitoring location where total uranium concentrations are trending up (Figure A.2-4 and Table A.2-28).

Figure A.2-13 is a total uranium concentration versus time plot for monitoring well 2389 that shows that between 2002 and 2010 sporadic total uranium FRL exceedances were detected at this well. As discussed below, FRL exceedances are detected in this area when the water elevation is approximately 515 ft above mean sea level (amsl) or higher. Since 2011, water levels have been at or near 515 ft amsl and the uranium FRL exceedances have been consistent. In 2015, total uranium concentrations were above 30 µg/L. As shown in Figure A.2-13, the water level during both sampling events was approximately 515 ft amsl.

Previous direct-push sampling in this area indicates that the total uranium FRL exceedances are associated with high water table conditions. The former Plant 6 Area is targeted for direct-push sampling when the water-table elevation is above 515 ft amsl. As shown below, unless the water table is above an elevation of 515 ft amsl, total uranium FRL exceedances are normally not detected. The last direct-push sampling was collected in 2011 (13360C). The regional water table was high enough in 2011 for the sampling to detect an exceedance. The concentration of the exceedance (37.7 µg/L) is similar to the exceedance detected in 2008 (37.2 µg/L).

Year	Location	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)
2007	13360	<1.00	512
2008	13360A	37.2	515
2010	13360B	4.40	510
2011	13360C	37.7	515

Monitoring well 2389 will continue to be identified on maximum total uranium plume map as being a location where intermittent total uranium FRL exceedances have been measured so that its presence will be carried forward into the certification stage of the aquifer remediation. This well is within capture of the groundwater remediation system.

A.2.3 South Field and Off-Property South Plume Total Uranium Plumes

The mapped footprint of the 30 µg/L maximum total uranium plume in the South Field and off-property South Plume decreased from an estimated 91.8 acres in 2014 to 89.6 acres in 2015, a decrease of 2.2 acres (2.4%) (Figure A.2-5).

The footprint of the plume greater than 50 µg/L increased from 52.4 acres in 2014 to 52.9 acres in 2015, an increase of 0.5 acre (1%). The footprint of the plume greater than 100 µg/L remained constant at 25.5 acres in both 2014 and 2015.

A.2.3.1 South Field

In 2015, direct-push sampling was conducted at five locations in the South Field (locations 12814C, 13457A, 12411C, 12230C, and 13486).

Location 12814C

Location 12814C is situated in the former Flyash Pile Area of the South Field. Table A.2-9 provides direct-push sampling results for location 12814C. The location is identified in Figure A.2-3A.

This location was previously sampled in 2000, 2007, and 2010. The following table provides total uranium concentrations from those samples and the 2015 samples.

Location 12814 (2000)		Location 12814A (2007)		Location 12814B (2010)		Location 12814C (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
513	31.5	510	51.9	513	103.3	512	163.6
506	23.4	500	6.4	503	11	502	21.2
496	9.6	490	3.2	493	5.8	492	4.7
486	12.2	480	1.2			482	3.2
476	15.9	470	9.1				
466	3.2						
456	5.9						

amsl = above mean sea level

The maximum total uranium concentration at this location has increased steadily from 2000 through 2015. This sampling location is within capture of nearby extraction well 33262. The cause for the increased total uranium concentration at this sampling location is not known. The monitoring well is located upgradient of extraction well 33262 but near the tailing edge of the plume, so it is not apparent how pumping could be moving total uranium toward this monitoring well. The monitoring well is also located near surface water sampling location SWD-08. As discussed in Appendix B, SWD-08 is a cross-media impact surface water sampling location. In March 2015, the surface water sample collected at SWD-08 had a total uranium concentration of 33.8 µg/L (very near the groundwater FRL of 30 µg/L) and not considered to be the cause of the trend in this area The area west of location 12814C will be targeted for direct-push sampling in 2016 verify that the western trailing edge of the total uranium plume has been properly characterized.

Location 13457A

Location 13457A is situated in the former Flyash Pile Area of the South Field. Direct-push sampling results for location 13457A are provided in Table A.2-10. The location is identified in Figure A.2-3A.

This location was previously sampled in 2012. The sample collected in 2012 was identified as location 13457. The sample collected in 2015 is identified as 13457A. Total uranium concentrations from 2012 and 2015 are provided below.

Location 13457 (2012)		Location 13457A (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
513	62.4	512	66.6
503	5.0	502	30.2
493	2.9	492	3.3

amsl = above mean sea level

The maximum total uranium concentration has remained fairly constant at this location between 2012 and 2015. This location is within capture of extraction well 31561. Future direct-push sampling will be conducted in and near this area as the remedy progresses.

In 2015, three direct-push sampling locations were situated along the eastern edge of the 50 µg/L contour of the South Field Plume (12411C, 12230C, and 13486). These three locations were selected to better characterize the 50 µg/L contour in this area.

Location 12411C

Location 12411C is situated northwest of extraction well 32276 along the eastern edge of the 50 µg/L plume contour. Direct-push sampling results for location 12411C are provided in Table A.2-11. The location is identified in Figure A.2-3A.

This location was first sampled in 1999 and was subsequently sampled in 2003, 2012, and 2015. The sample collected in 1999 was identified as location 12411. The sample collected in 2015 is identified as 12411C. Total uranium concentrations are provided below.

Location 12411 (1999)		Location 12411A (2003)		Location 12411B (2012)		Location 12411C (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
518	51.0	515	33.4	515	35.6	512	39.1
509	40.0	506	39.7	505	22.2	502	16.0
499	44.0	496	48.2	495	13.5	492	11.6
489	62.0	486	24.1	485	7.1	482	5.2
479	26.0	476	18.7	475	5.2	472	6.6
469	20.0	466	31.7	465	4.1		
459	25.0	456	19.1	455	5.9		
449	25.0	446	4.0	445	1.4		
439	1.9	436	4.9				
429	2.6						
419	<1.0						

amsl = above mean sea level

The maximum total uranium concentration at this location has steadily decreased from 62.0 µg/L to 39.1 µg/L. The maximum total uranium concentration measured in 2015 (39.1 µg/L) was consistent with the existing maximum total uranium plume interpretation for this area, and therefore a change to the map in 2015 was not needed.

Location 12230C

Location 12230C is situated northwest of extraction well 32276, along the eastern edge of the 50 µg/L plume contour. Direct-push sampling results for location 12230C are provided in Table A.2-12. The location is identified in Figure A.2-3A.

This location was first sampled in 1997 and was subsequently sampled in 2003, 2013, and 2015. The sample collected in 1997 was identified as location 12230. The sample collected in 2015 is identified as 12230C. Total uranium concentrations from 1997 to 2015 are provided below.

Location 12230 (1997)		Location 12230A (2003)		Location 12230B (2013)		Location 12230C (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
520	168						
511	258	514	151.3	511	43.4	511	55.3
501	193	506	60.7	501	33.6	501	48.0
491	245	496	104	491	36.7	491	23.8
481	125	486	95.5	481	19.3	481	17.7
471	69.0	476	13.2	471	9.90	471	7.4
461	59.0	466	45.8	461	15.7	461	21.0
451	13.0	456	31.7	451	6.00	451	10.4
441	6.00	446	8.9	441	5.50		
431	3.00	436	3.4				

amsl = above mean sea level

The maximum total uranium concentration at this location has decreased between 1997 (258 µg/L) and 2015 (55.3 µg/L). The maximum total uranium concentration measured in 2015 (53.5 µg/L) was slightly higher than the maximum total uranium concentration measured in 2014 (43.4 µg/L). A slight adjustment to the 50 µg/L total uranium contour on the 2015 maximum total uranium plume map was made to honor the 2015 concentration in this area.

Location 13486

Location 13486 is situated in the South Field, just northwest of extraction well 32276, along the eastern edge of the 50 µg/L plume contour. Direct-push sampling results for location 13486 are provided in Table A.2-13. The location is identified in Figure A.2-3A.

As shown in Table A.2-13, the maximum total uranium concentration measured in 2015 at this location was 95.5 µg/L. The 2015 maximum total uranium concentration was consistent with the way this area of the plume was mapped in 2014; therefore, no change was made for the 2015 plume interpretation.

A.2.3.1.1 Intermittent Total Uranium FRL Exceedance Locations in the South Field

No intermittent total uranium FRL exceedance locations were identified for the South Field.

A.2.3.1.2 Monitoring Wells with Increasing Total Uranium Concentration Trends in the South Field

As Table A.2-28 shows, five monitoring wells—2045, 23275, 2387, 83294_C1, and 83295_C6—had upward trends for total uranium concentrations in 2015. The locations are shown in Figure A.2-4. For multichannel wells (e.g., 83294 and 83295), the figure shows the trend for the channels with the highest average concentration; therefore, 83294_C1 and 83295_C6 are not identified in Figure A.2-4. These are the same five wells that were identified as having upward trends in the 2013 and 2014 Site Environmental Reports (DOE 2014 and DOE 2015). Figures A.2-14 through A.2-18 provide time versus total uranium concentration plots for these five wells. The total uranium concentration increases are attributed to changes in the plume caused by the active groundwater remediation. Uranium contamination is being pulled toward the extraction wells.

DOE will continue to monitor these wells but plans no action at this time in response to the increasing concentration trends. All of these wells are within capture of the groundwater remediation system.

A.2.3.2 South Plume

A.2.3.2.1 New Direct-Push Sampling Data in the South Plume

In 2015, direct-push sampling was conducted at 14 locations in the South Plume (13229D, 13233B, 13234C, 13237C, 13239B, 13240D, 13306C, 13421D, 13423B, 13461A, 13464A, 13477A, 13482, and 13483). Sampling locations are shown in Figure A.2-3A. Sampling results are discussed below.

Location 13229D

Location 13229D is situated northwest of extraction well 32309. Direct-push sampling results for location 13229D are provided in Table A.2-14. The location is identified in Figure A.2-3A.

This location was first sampled in 2002 and was subsequently sampled in 2003, 2008, 2013, and 2015. The location sampled in 2002 was identified as 13229. The location sampled in 2015 is identified as 13229D. Total uranium concentration data from 2002, 2003, 2008, 2013, and 2015 are provided below.

Location 13229 (2002)		Location 13229A (2003)		Location 13229B (2008)		Location 13229C (2013)		Location 13229D (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
517	58.0	515	81.8						
508	101	506	89.3	509	72.7	510	61.2	511	47.1
498	47.0	496	92.7	499	65.3	500	40.8	501	49.8
488	29.0	486	51.2	489	42.2	490	41.2	491	39.8
478	19.0	476	11.3	479	37.4	480	15.2	481	26.7
468	15.0	466	4.50	469	17.8	470	5.9	471	11.6
458	3.20	456	1.20			460	3.4		
448	<1.0								

amsl = above mean sea level

The maximum total uranium concentration at this location has decreased between 2002 (101 µg/L, 508 ft amsl) and 2015 (49.8 µg/L, 501 ft amsl). The 50 µg/L contour on the 2015 maximum total uranium plume map was adjusted based on the 2015 concentration.

Location 13233B

Location 13233B is situated just north of extraction wells 32308 and 32309. Direct-push sampling results for location 13233B are provided in Table A.2-15. The location is identified in Figure A.2-3A.

This location was first sampled in 2002 and was subsequently sampled in 2013 and 2015. The location sampled in 2002 was identified as 13233. The location sampled in 2015 is identified as 13233B. Total uranium concentration data from 2002, 2013, and 2015 are provided below.

Location 13233 (2002)		Location 13233A (2013		Location 13233B (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
513	20.0	511	44.8	510	39.0
505	54.0	501	20.4	500	41.1
495	55.0	491	16.7	490	28.1
485	38.0	481	10.2	480	20.3
475	33.0	471	<1.0		
465	4.20	461	<1.0		
455	1.30	451	3.10		

amsl = above mean sea level

The maximum total uranium concentration at this location has decreased between 2002 (55 µg/L, elevation 495 ft amsl) and 2015 (41.1 µg/L, elevation of 500 ft amsl). The maximum total uranium concentration measured in 2015 was consistent with the total uranium plume interpretation for this location; therefore, no change was made to the 2015 plume interpretation based on the 2015 result.

Location 13234C

Direct-push sampling location 13234C is situated along the eastern edge of the maximum total uranium plume. Direct-push sampling results for location 13234C are provided in Table A.2-16. The location is identified in Figure A.2-3A.

This location was first sampled in 2002 and was subsequently sampled in 2013, 2014, and 2015. The location sampled in 2002 was identified as location 13234. The location sampled in 2015 was identified as location 13234C. Total uranium concentrations from 2002, 2013, 2014, and 2015 are provided below.

Location 13234 (2002)		Location 13234A (2013)		Location 13234B (2014)		Location 13234C (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
516	6.10						
507	32.0	510	32.8	511	15.6	510	20.8
497	12.0	500	37.8	501	28.4	500	37.8
487	2.40	490	2.7	491	11.6	490	4.1
477	1.50						
467	1.30						
457	<1.0						

amsl = above mean sea level

The maximum total uranium concentration at this location has remained consistent between 2002 (32.0 µg/L, 507 ft amsl) and 2015 (37.8 µg/L, 500 ft amsl). A slight correction to the position of the 30 µg/L total uranium concentration contour was made to the 2015 maximum total uranium plume map based on the 2015 sampling result.

Location 13237C

This location is situated south of Willey Road in the northern part of the South Plume. Direct-push sampling results for location 13237C are provided in Table A.2-17. The location is identified in Figure A.2-3A.

This location was first sampled in 2002 and was subsequently sampled in 2007, 2014, and 2015. The location sampled in 2002 was identified as location 13237. The location sampled in 2015 was identified as location 13237C. Total uranium concentrations from 2002, 2007, 2014, and 2015 are provided below.

Location 13237 (2002)		Location 13237A (2007)		Location 13237B (2014)		Location 13237C (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
518	9.50						
509	80.0	510	22.7	512	30.4	512	75.1
499	92.2	500	85.6	502	29.5	502	37.5
489	33.9	490	22.6	492	22.5	492	36.8
479	16.0	480	5.2	482	25.5		
469	3.90	470	2.3	472	13.9		

amsl = above mean sea level

The maximum total uranium concentration at this location decreased between 2002 (92.2 µg/L, 499 ft amsl) and 2014 (30.4 µg/L, 512 ft amsl) but increased in 2015 (75.1 µg/L, 512 ft amsl). The 50 µg/L contour on the 2015 maximum total uranium plume map was adjusted at this location to honor the 2015 sampling results. This increase in maximum concentration is attributed to an increased pumping rate in the area that was implemented in July 2014. Future direct-push sampling will be done in and near this area as the remedy progresses.

Location 13239B

This location is situated north of extraction well 32309. Direct-push sampling results for location 13239B are provided in Table A.2-18. The location is identified in Figure A.2-3A.

This location was first sampled in 2002 and was subsequently sampled in 2013 and 2015. The location sampled in 2002 was identified as location 13239. The location sampled in 2015 was identified as location 13239B. Total uranium concentrations for 2002, 2013, and 2015 are provided below.

Location 13239 (2002)		Location 13239A (2013)		Location 13239B (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
515	65.0				
507	49.0	511	64.0	511	62.0
497	69.0	501	43.5	501	50.6
487	32.0	491	25.5	491	30.9
477	12.0	481	5.70	481	10.9
467	4.90	471	2.00	471	4.8
457	1.90				
447	1.20				

amsl = above mean sea level

The maximum total uranium concentration at this location for 2015 (62.0 µg/L, 511 ft amsl) shows little change from the concentration recorded in 2013 (64.0 µg/L, 511 ft amsl). The small change in concentration did not warrant a change to the 50 µg/L contour on the 2015 maximum total uranium plume map.

Location 13240D

Location 13240D is situated on the eastern edge of the south plume. Direct-push sampling results for location 13240D are provided in Table A.2-19. The location is identified in Figure A.2-3A.

This location was first sampled in 2002 and was subsequently sampled in 2003, 2005, 2013, and 2015. The location sampled in 2002 was identified 13240. The location sampled in 2015 was identified as location 13240D. Total uranium concentrations from 2002, 2003, 2005, 2013, and 2015 are provided below.

Location 13240 (2002)		Location 13240A (2003)		Location 13240B (2005)		Location 13240C (2013)		Location 13240D (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
515	4.70	516	11.0						
508	23.0	507	123	509	28.6	511	18.7	510	26.5
498	114	497	62.3	499	62.4	501	26.0	500	36.8
488	92.0	487	53.9	489	63.0	491	29.7	490	23.9
478	36.0	477	15.2	479	15.5	481	23.1	480	21.5
468	3.40	467	4.40	469	5.90	471	1.4	470	6.9
458	1.60	457	1.30	459	4.40	461	3.3	460	1.4
448	1.70								

amsl = above mean sea level

The maximum total uranium concentration at this location has decreased from 2002 (114 µg/L, 498 ft amsl) to 2015 (36.8 µg/L, 500 ft amsl). The total uranium concentration increased slightly between 2014 and 2015 to warrant a slight adjustment to the 30 µg/L plume contour on the 2015 maximum total uranium plume map.

Location 13306C
Location 13306C is situated on the southern edge of the south plume. Direct-push sampling results for location 13306C are provided in Table A.2-20. The location is identified in Figure A.2-3A.

This location was first sampled in 2003 and was subsequently sampled in 2009, 2013, and 2015. The location sampled in 2003 was identified as location 13306. The location sampled in 2015 was identified as location 13306C. Total uranium concentrations from 2003, 2009, 2013, and 2015 are provided below.

Location 13306 (2003)		Location 13306A (2009)		Location 13306B (2013)		Location 13306C (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
515	69.7						
506	30.7	508	13.7	511	43.0	509	38.9
496	24.4	498	43.1	501	11.8	499	11.0
486	39.9	488	10.7	491	9.8	489	17.4
476	47.2	478	15.7	481	12.5	479	33.8
466	5.90	468	5.0	471	9.6	469	30.6
456	5.10	458	2.2				
446	<1.0						
436	<1.0						
426	<1.0						

amsl = above mean sea level

The maximum total uranium concentration at this location has decreased from 2003 (69.7 µg/L, 515 ft amsl) to 2015 (38.9 µg/L, 509 ft amsl). The slight change in concentration between 2014 and 2015 did not warrant an adjustment to the 30 µg/L contour on the 2015 maximum total uranium plume map.

Location 13421D
Location 13421D is situated in the northeast corner of the South Plume. Direct-push sampling results for location 13421D are provided in Table A.2-21. The location is identified in Figure A.2-3A.

This area of the plume was first sampled in 1996. From 1996 to 2007 the location was identified as 12196. In 2011, the location was moved 50 ft to accommodate a landowner request and renamed 13421. Location 12196 was first sampled in 1996 and subsequently in 2005 and 2007. Results for the three sampling events are provided below.

Location 12196 (1996)		Location 12196A (2005)		Location 12196B (2007)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
518	0.5	515	4.3		
509	0.3	505	87.5	512	6.7
499	0.7	495	101	502	59.6
489	0.5	485	14.4	492	104
479	0.3	475	37.4	482	3.2
469	0.5	465	18.7	472	9.0
459	0.7			462	3.0
449	0.4				
439	1.6				

amsl = above mean sea level

As the data above indicate, it appears that the total uranium plume migrated into this area between 1996 and 2005. From 2005 to 2007 the plume was located above an elevation of 465 ft amsl and had concentrations near 100 µg/L.

Location 13421 was first sampled in 2011 and was subsequently sampled in 2014 and 2015. The location was sampled twice in 2011. These samples were identified as 13421 and 13421A. Although not shown on the table, this location was actually sampled twice in 2015. The results of the first sample (13421C) were rejected because it was later determined that a field error concerning the elevation of the results could not be rectified with certainty; therefore, the location was resampled as 13421D. Total uranium concentrations from 2011 through 2015 are provided below.

Location 13421 (2011)		Location 13421A (2011)		Location 13421B (2014)		Location 13421D (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
		514	3.7	513	6.4	510	2.1
506	42.3	504	116	503	111	500	78.2
596	167	494	216	493	253	490	101
486	85.9	484	82.3	483	93.6	480	71.1
476	5.3	474	5.1	473	4.9	470	1.3
466	2.4	464	3.5	463	15.6	460	55.3
456	60.9	454	7.2	453	9.8	450	4.3
		444	6.4				

amsl = above mean sea level

The initial sampling event at location13421 in 2011 resulted in a total uranium concentration of 60.9 µg/L below 456 ft amsl. The high concentration at that elevation had not been measured before in this area (see data from 12196 above). Therefore, it was considered suspect and resampled in the same year (13421A). As shown above, the total uranium concentrations measured in 13421A and subsequently in 2014 (13421B) indicated that the total uranium plume was above an elevation of 456 ft amsl. The sample collected in 2015, however, had a total uranium concentration of 55.3 µg/L at an elevation below 460 ft amsl. It is possible that uranium is being pulled deeper into the aquifer at this location as a result of nearby pumping, but that does not explain the lack of higher concentrations being detected in 2011 and 2014 at the deeper elevations.

The maximum total uranium concentration at location 13421 increased between 2011 (116 µg/L, 504 ft amsl) and 2014 (253 µg/L, 493 ft amsl), but subsequently decreased in 2015 (101 µg/L, 490 ft amsl). The decrease in the maximum total uranium concentration recorded in 2015 is being attributed to higher pumping rates in the area that were initiated in July of 2014. Additional direct-push sampling will be conducted in this area to determine if the decreasing trend continues.

Location 13423B

Location 13423B is situated in the northeast corner of the South Plume. Direct-push sampling results for location 13423B are provided in Table A.2-22. The location is identified in Figure A.2-3A.

This location was first sampled in 2011 and was subsequently sampled in 2014 and 2015. The location sampled in 2011 was identified as location 13423. The location sampled in 2015 is identified as location 13423B. Total uranium concentrations from 2011, 2014, and 2015 are provided below.

Location 13423 (2011)		Location 13423A (2014)		Location 13423B (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
514	1.2	514	<1.0	510	<1.0
504	3.7	504	22.4	500	19.7
494	73.7	494	1.4	490	26.8
484	16.0	484	47.2	480	32.4
474	3.9	474	12.2	470	<1.0
464	3.1			460	<1.0
454	1.0				
444	2.7				

amsl = above mean sea level

The maximum total uranium concentration at this location has decreased from 2011 (73.7 µg/L, 494 ft amsl) to 2015 (32.4 µg/L, 480 ft amsl). The slight change in concentration between 2014 and 2015 did not warrant an adjustment to the 2015 maximum total uranium plume map.

Location 13461A

Location 13461A is situated west of extraction well 32309. Direct-push sampling results for location 13461A are provided in Table A.2-23. The location is identified in Figure A.2-3A.

This location first sampled in 2013 and was subsequently sampled in 2015. The location sampled in 2013 was identified as location 13461. The location sampled in 2015 was identified as location 13461A. Total uranium concentrations from both sampling events are provided below.

Location 13461 (2013)		Location 13461A (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
511	31.5	511	16.3
501	30.2	501	22.1
491	21.8	491	15.0
481	14.5	481	11.5
471	13.7	471	8.2

amsl = above mean sea level

The maximum total uranium concentration at this location has decreased from 2013 (31.5 µg/L, 511 ft amsl) to 2015 (22.1 µg/L, 501 ft amsl). This is attributed to capture from extraction well 32309, which is directly downgradient of this location. The 2015 maximum total uranium plume map was revised to honor the 2015 concentration.

<u>Location 13464A</u>

Location 13464A is located south of extraction well 32309. Direct-push sampling results for location 13464A are provided in Table A.2-24. The location is identified in Figure A.2-3A.

This location was first sampled in 2013 and was subsequently sampled in 2015. The location sampled in 2013 was identified as location 13464. The location sampled in 2015 is identified as location 13464A. Total uranium concentrations from 2013 and 2015 are provided below.

Location 13464 (2013)		Location 13464A (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
511	23.4	510	27.7
501	6.1	500	14.4
491	15.5	490	13.2
481	22.4	480	20.7
471	42.4	470	34.3
461	40.6	460	29.1
451	23.8	450	18.0
		440	2.0

amsl = above mean sea level

The maximum total uranium concentration at this location has decreased from 2013 (42.4 µg/L, 471 ft amsl) to 2015 (34.3 µg/L, 470 ft amsl). The change in concentration did not warrant a change to the 2015 maximum total uranium plume interpretation.

Location 13477A

Location 13477A is situated in the northeast corner of the South Plume. Direct-push sampling results for location 13477A are provided in Table A.2-25. The location is identified in Figure A.2-3A.

This location was first sampled in 2014 and was subsequently sampled in 2015. The location sampled in 2014 was identified as location 13477. The location sampled in 2015 is identified as location 13477A. Total uranium concentrations from 2014 and 2015 are provided below.

Location 13477 (2014)		Location 13477A (2015)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
512	1.4	511	<1.0
502	31.8	501	18.4
492	58.6	491	52.0
482	2.6	481	3.6
472	2.7	471	5.7

amsl = above mean sea level

The maximum total uranium concentration at this location has decreased from 2014 (58.6 µg/L, 492 ft amsl) to 2015 (52.0 µg/L, 491 ft amsl). The change in concentration did not warrant a change to the 2015 maximum total uranium plume map.

Location 13482

Location 13482 is situated in the southeast corner of the South Plume. Direct-push sampling results for location 13482 are provided in Table A.2-26. The location is identified in Figure A.2-3A.

As indicated in Table A.2-26, the maximum total uranium concentration measured in 2015 was 37.3 µg/L. This concentration was consistent with the 2014 maximum total uranium plume interpretation; therefore, a change to the 2015 maximum total uranium plume map was not warranted.

Location 13483

Location 13483 is situated in the northwest corner of the South Plume. Direct-push sampling results for location 13483 are provided in Table A.2-27. The location is identified in Figure A.2-3A.

As indicated in Table A.2-27, the maximum total uranium concentration measured in 2015 was 27.3 µg/L. The 2015 maximum total uranium plume map was modified based on this concentration.

A.2.3.2.2 Intermittent Total Uranium FRL Exceedance Locations in the South Plume

Two monitoring wells (2552 and 2900) are identified on the maximum total uranium plume maps for 2015 in the South Plume (Figures A.2-2A, A.2-2B, A.2-3A, and A.2-3B) as being monitoring locations with intermittent total uranium FRL exceedances.

A time versus total uranium concentration plot for monitoring well 2552 is provided in Figure A.2-19. The figure shows that no total uranium FRL exceedances occurred in 2015. The last FRL exceedance was in the second half of 2014 (32.6 µg/L).

A time versus total uranium concentration plot for monitoring well 2900 is provided in Figure A.2-20. The figure shows that only two total uranium FRL exceedances have been measured at this well since 1993. The last one occurred in 2012.

These wells will continue to be identified on maximum total uranium plume maps as being locations where intermittent total uranium FRL exceedances have been measured so that their presence will be carried forward into the certification stage of the aquifer remediation.

A.2.3.2.3 Monitoring Wells with Increasing Total Uranium Concentration Trends in the South Plume

As shown in Figure A.2-4 and Table A.2-28, one monitoring well (2880) had an upward trend for total uranium concentration in the South Plume in 2015. This well was reported as having an increasing total uranium concentration trend in the 2014 Site Environmental Report (DOE 2015).

Table A.2-28 and Figure A.2-4 show that total uranium concentrations at monitoring well 2880 had an upward trend in 2015. Figure A.2-21 is a time versus concentration graph for monitoring well 2880. The total uranium concentration trend in monitoring well 6880 is downward (Figure A.2-22). The well screen in monitoring well 2880 is positioned at the water table. The well screen in monitoring well 6880 is positioned below the water table. Both monitoring wells are within capture of nearby extraction well 32308. The total uranium concentration upward trend in monitoring well 2880 and the downward trend in monitoring well 6880 are attributed to nearby pumping well 32308 pulling uranium contamination toward the monitoring well.

A.2.4 Monitoring Well Inspection and Maintenance

All monitoring wells were inspected in 2015 with particular emphasis on those wells that are not actively monitored. All monitoring wells inspected were found to be protective of the subsurface environment and capable of yielding representative groundwater samples. Many inspection findings are corrected immediately (e.g., rust, vegetation removal, number legibility). Deficiencies that cannot be corrected immediately (e.g., removal of overhanging trees) are corrected as time permits.

A.2.5 Total Uranium Plume Center-of-Mass Calculations

At the request of the Ohio EPA, DOE conducted a center-of-mass contaminant plume stability analysis for total uranium following the approach presented by Joseph A. Ricker in *A Practical Method to Evaluate Ground Water Contaminant Plume Stability* (Ricker 2008). The center-of-mass approach is commonly applied to natural attenuation situations to demonstrate how the plume is moving over time.

Three years of monitoring well data were selected for the analysis: 2006, 2010, and 2014. A consistent set of monitoring wells was used that spanned all 3 selected years. Surfer software (Version 11.6) was used for kriging the data and mapping the results. The analysis was conducted for three separate plume areas: the PPDD, the South Field and South Plume, and the former WSA.

Figure A.2-23 provides the results of the plume center of mass calculated for each plume area for each of the 3 years (2006, 2010, and 2014), the monitoring wells used, and the kriged results of the total uranium plume concentrations for 2014. As shown in Figure A.2-23, the center of mass in each area has remained fairly stationary over time, indicating that the surrounding pumping wells are capturing the plume and not allowing the center of mass to migrate as it would if no pumping were taking place. Of note is that the center of mass in the PPDD Plume shifted to the west between 2006 and 2010. This shift is attributed to the total uranium concentrations in the eastern portion of the PPDD plume achieving cleanup levels. In fact, the extraction well that was once operating in the eastern portion of the PPDD was turned off in 2014 because the total uranium concentration in this area of the plume was below 30 µg/L, and the pumping well in this area was no longer needed.

A.2.6 Total Uranium Plume Cross Sections

Five total uranium plume cross sections are presented to provide a vertical interpretation of the total uranium plume. The locations of each cross section are shown on Figures A.2-24A, A.2-24B, and A.2-24C. These three figures also display the maximum total uranium plume interpretation for the second half of 2015. The cross sections (A–A′, B–B′, C–C′, D–D′, and E–E′) are provided in Figures A.2-25 through A.2-29, respectively.

Surfer software (Version 11.6) was used to krig the total uranium concentration data sets and produce the cross sections. Point kriging of the data for all total cross sections was performed using the Surfer default settings with the exception of the anisotropy ratio. For anisotropy, a ratio of 10 to 1 (vertical to horizontal) was used.

The plume interpretations shown in the cross sections provide a less conservative plume interpretation than the maximum total uranium plume maps presented in Figures A.2-2A, A.2-2B, A.2-3A, and A.2-3B. The cross sections, therefore, do not correlate directly with the maximum total uranium plume interpretations presented in those figures. The cross sections provide an additional interpretation of the total uranium concentration data that were used to develop the maximum total uranium plume maps.

Each cross section depicts the ground surface, the base of the glacial till (clay overburden), the top of the unconsolidated sand and gravel Great Miami Aquifer, and the average water table elevation. Monitoring well data are the maximum total uranium concentrations measured in 2015. Geoprobe data are the most recent available for the location. The posted water table elevation is the elevation recorded at the time that the sample was collected. The midpoint of the monitoring well screen or Geoprobe screen is shown for each location using a "+" symbol.

Vertical depth total uranium profiles are provided for each Geoprobe location. Extraction well screen locations and depths are also shown in the cross sections, if applicable.

As illustrated in the cross sections, the top of the 30 μg/L total uranium plume is normally situated at the water table, but in a few areas in the aquifer the top of the 30 μg/L total uranium plume is located beneath the water table. Some of the plume areas depicted in the maximum total uranium plume maps appear as smaller, separated plume areas in the cross sections. The separate areas help to point out where most of the total uranium concentrations are located based on the kriging results. Tracking the location and size of the plume areas beneath the water table should prove helpful in making operational decisions as the remedy progresses.

A.2.7 Groundwater Monitoring Program Assessment

An assessment of the scope of the groundwater monitoring program for total uranium was conducted in 2015. Consistent total uranium concentration trends that are below the groundwater FRL for total uranium at several monitoring well locations, coupled with a 1-year demonstration that the increased pumping rates implemented in July of 2014 have not impacted those consistent concentration trends, indicate that additional sampling at selected monitoring wells is no longer needed to define the extent of the total uranium plume as the remedy progresses.

As prescribed in Table 5 of the Fernald IEMP, (Attachment D of the LMICP), 142 monitoring wells are sampled twice a year for uranium. For the assessment, time versus total uranium concentration graphs were prepared for each monitoring well and evaluated against the following criteria:

1. The monitoring well has never had a total uranium FRL exceedance.
2. It has been at least 10 years since the monitoring well had a total uranium FRL exceedance.
3. The trend of the total uranium concentration data is steady or decreasing.

Monitoring wells were grouped into four different categories for the assessment.

1. Outside the 2014 total uranium plume footprint, but not included as a Property/Plume Boundary or Paddys Run Road Site (PRRS) monitoring wells
2. Inside the 2014 total uranium plume footprint
3. Property/Plume Boundary Monitoring Wells
4. PRRS Monitoring Wells

Monitoring wells included in the Property/Plume Boundary (category 3) and PRRS (category 4) are defined in the IEMP (DOE 2016) and briefly discussed below.

Category 3: Property/Plume Boundary Monitoring Wells
As explained in Section 3.2.2 of the IEMP, the September 10, 1993, Ohio EPA Director's final Findings and Orders required groundwater monitoring at the Fernald Preserve's property boundary to satisfy Resource Conservation and Recovery Act facility groundwater monitoring requirements (Ohio EPA 1993). The 1993 Final Findings and Orders were superseded by the September 7, 2000, Director's Final Findings and Orders (Ohio EPA 2000), which specifies that the site's groundwater monitoring activities will be implemented in accordance with the IEMP.

The revised language allows modification of the groundwater monitoring program as necessary via the IEMP revision process without issuance of a new order.

Twenty-five monitoring wells are located along the eastern property boundary and the leading edge of the offsite total uranium plume that are identified as Property/Plume Boundary monitoring wells (Figure A.2 1). Eight of these are also defined as On-Site Disposal Facility (OSDF) groundwater monitoring program wells (22198, 22199, 22204, 22205, 22208, 22210, 22211, and 22214). Continued monitoring at these eight OSDF wells for total uranium is directed in the Groundwater/Leak Detection and Leachate Monitoring Plan section of the LMICP (DOE 2016) for OSDF constituents; therefore, from a total uranium monitoring perspective, these eight wells were excluded from the assessment presented below.

Category 4: PRRS Monitoring Wells

As explained in Section 3.3 of the IEMP, DOE imposed best management practices to monitor 11 wells south of the leading edge of the South Plume for constituents that were present in the PRRS plume. The PRRS plume is a separate plume that is south of the Fernald total uranium plume. DOE samples these 11 wells for PRRS constituents to assess the nature of the 30 µg/L total uranium plume south of an established administrative boundary and the impact that pumping the South Plume extraction wells has on the PRRS plume. The sampling will continue until certification of the off-property South Plume is complete.

Although regulatory and best management practices defined in the IEMP call for continued monitoring at category 3 and 4 monitoring wells, the frequency of the sampling can be modified if deemed appropriate.

Assessment Results

Table A.2-30 provides a list of the groundwater monitoring wells that meet one of more of the assessment criteria. The first column in the table identifies the monitoring well number. The second column identifies the category of the monitoring well (1 through 4 as defined above). The third column identifies the location of the monitoring well. The fourth column lists the figure number of the time versus total uranium concentration graph for the monitoring well (Figures A.2-30 through A.2-103). The fifth column states the number of years of data collected. Column 6 provides the criteria met (as defined above), and the last column provides a recommendation to either stop monitoring the well or reduce the sampling frequency from semiannual to annual.

As shown in Table A.2-30, the recommendation based on the total uranium data set for each monitoring well is to stop monitoring at 47 of the 142 groundwater monitoring wells. Thirty-four of the 47 wells are Category 1 wells (located outside of the 2014 total uranium plume footprint and not included in the Property/Plume Boundary or PRRS programs). Thirteen of the 47 wells are Category 2 wells (located inside of the 2014 total uranium plume footprint). The concentrations and trends at these locations are well established, and additional sampling will not provide additional value to the ongoing remediation. DOE would continue to measure water levels at the 47 monitoring wells to verify capture of the maximum total uranium plume.

As shown in Table A.2-30, it is recommended that the sampling frequency at 17 of the Property Plume Boundary Monitoring wells (Category 3) and 10 of the PRRS monitoring wells (Category 4) be reduced from biannual to annual. One PRRS well (monitoring well 2900) did not meet the criteria presented above, because sample results have shown intermittent total uranium FRL exceedances in the past 10 years (Figure A.2-20). This well is discussed in Section A.2.3.2.2, and it will continue to be monitored on a semiannual basis.

Monitoring well 2625 is identified on Table A.2-30 as a PRRS well where the sampling frequency is recommended to be reduced from semiannual to annual. The September 30, 2015, sample collected from this well had a total uranium concentration of 29 µg/L. As illustrated in Figure A.2-95, this is an unusually elevated concentration for this well. Previously, the total uranium concentration was never above 10 µg/L. The well was resampled on January 28, 2016, and the analytical result was 5.07 µg/L, which is more consistent with historical results for this well. Given the historical record of total uranium results at well 2625, the sample collected on September 30, 2015, is considered to be non-representative of aquifer conditions at that location. Attachment A.4 provides additional discussion on the September sampling of monitoring well 2625.

The data presented in Figures A.2-30 through A.2-103 indicate that monitoring changes for total uranium recommended in Table A.2-30 are warranted. Figure A.2-104 shows the locations of the wells listed on Table A.2-30. Monitoring for non-uranium constituents is also taking place at the Property/Plume Boundary (Category 3) and the PRRS monitoring wells (Category 4). The non-uranium results of the monitoring are presented in Attachment A.4.

DOE intends to propose changes to the IEMP groundwater monitoring program based on the data presented above in the upcoming 2016 revision of the Fernald LMICP. If approved by EPA, Ohio EPA, and stakeholders during the LMICP revision process, the monitoring changes will be reflected in the 2017 LMICP revision and would take effect on January 1, 2017.

A.2.8 References

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Ricker, Joseph A., 2008. "A Practical Method to Evaluate Ground Water Contaminant Plume Stability," *Groundwater Monitoring and Remediation* 28(4):85–94.

Table A.2-1. Geoprobe Location 13374B

Easting '83:	**1346352**	feet
Northing '83:	**481505**	feet
Ground Elevation:	**558**	feet above mean sea level (AMSL)
Depth to Water Table:	**38**	feet below ground surface (BGS)
Water Table Elevation:	**520**	feet AMSL
Work Completed:	**6/2/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium[a,b] (µg/L) (FRL=30)	Uranium[c] (µg/L) (FRL=30)	Technetium-99[c] (pCi/L) (FRL=94)	Nitrate/Nitrite (mg/L) (FRL=11)	Manganese[c] (mg/L) (FRL=0.90)	Molybdenum[c] (mg/L) (FRL=0.1)	Nickel[c] (mg/L) (FRL=0.1)	Temperature[a] (^{0}C)	pH[a] (SU)	Specific Conductance[a] (mS/cm)	Turbidity (NTU)	Turbidity[a] (NTU)	Dissolved Oxygen[a] (mg/L)
1	515	43	0-10	18.9	36.9	0.604	0.296	0.465	0.0306	0.00859	16.18	6.66	0.834	>1000	502	6.85
2	505	53	10-20	1.92	1.76	1.76	0.101	0.288	0.0115	0.00540	16.67	7.62	0.772	>1000	877	5.84
3	495	63	20-30	2.18	2.57	3.48	0.085	0.322	0.0219	0.00522	16.47	7.52	0.815	>1000	>1000	5.64
4	485	73	30-40	3.93	2.05	-1.12	0.085	0.446	0.0063	0.00203	16.19	7.83	0.782	>1000	>1000	5.45

[a]Samples are filtered through a 5 micron filter.
[b]Maximum uranium result reported regardless of laboratory (i.e., onsite versus offsite) analyzing samples.
[c]Samples are filtered through a 0.45 micron filter.

Table A.2-2. Geoprobe Location 13369B

Easting '83:	**1346417**	feet
Northing '83:	**481313**	feet
Ground Elevation:	**558**	feet above mean sea level (AMSL)
epth to Water Table:	**38**	feet below ground surface (BGS)
ater Table Elevation:	**520**	feet AMSL
Work Completed:	**6/3/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium[a,b] (µg/L) (FRL=30)	Uranium[c] (µg/L) (FRL=30)	Technetium-99[c] (pCi/L) (FRL=94)	Nitrate/Nitrite (mg/L) (FRL=11)	Manganese[c] (mg/L) (FRL=0.90)	Molybdenum[c] (mg/L) (FRL=0.1)	Nickel[c] (mg/L) (FRL=0.1)	Temperature[a] (^{0}C)	pH[a] (SU)	Specific Conductance[a] (mS/cm)	Turbidity (NTU)	Turbidity[a] (NTU)	Dissolved Oxygen[a] (mg/L)
1	515	43	0-10	177	154	4.07	0.274	0.368	0.0256	0.00329	13.65	6.80	0.605	>1000	131	8.31
2	505	53	10-20	28.1	19.7	6.47	0.994	1.04	0.0282	0.00646	11.90	6.88	0.712	>1000	358	5.67
3	495	63	20-30	5.70	5.1	6.53	0.510	0.862	0.0174	0.00848	12.50	7.69	0.728	>1000	121	4.99

[a]Samples are filtered through a 5 micron filter.
[b]Maximum uranium result reported regardless of laboratory (i.e., onsite versus offsite) analyzing samples.
[c]Samples are filtered through a 0.45 micron filter.

Table A.2-3. Geoprobe Location 13463A

Easting '83:	**1346653**	feet
Northing '83:	**481346**	feet
Ground Elevation:	**555**	feet above mean sea level (AMSL)
Depth to Water Table:	**36**	feet below ground surface (BGS)
Water Table Elevation:	**520**	feet AMSL
Work Completed:	**6/9/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium[a,b] (µg/L) (FRL=30)	Uranium[c] (µg/L) (FRL=30)	Technetium-99[c] (pCi/L) (FRL=94)	Nitrate/Nitrite (mg/L) (FRL=11)	Manganese[c] (mgL) (FRL=0.90)	Molybdenum[c] (mgL) (FRL=0.1)	Nickel[c] (mgL) (FRL=0.1)	Temperature[a] (^{0}C)	pH[a] (SU)	Specific Conductance[a] (mS/cm)	Turbidity (NTU)	Turbidity[a] (NTU)	Dissolved Oxygen[a] (mg/L)
1	515	41	0-10	40.2	35.5	234	69.5	0.27	0.256	0.0057	17.95	7.22	1.49	>1000	>1000	8.00
2	505	51	10-20	54.4	54.1	7.25	0.46	0.81	0.043	0.0119	14.20	7.47	0.785	>1000	246	5.60
3	495	61	20-30	11.9	9.2	6.05	1.26	0.56	0.012	0.0070	15.76	7.78	0.804	>1000	960	6.41
4	485	71	30-40	3.21	2.54	-4.48	0.085	1.02	0.036	0.0144	16.61	7.36	0.705	>1000	979	5.00

[a]Samples are filtered through a 5 micron filter.
[b]Maximum uranium result reported regardless of laboratory (i.e., onsite versus offsite) analyzing samples.
[c]Samples are filtered through a 0.45 micron filter.

Table A.2-4. Geoprobe Location 13484

Easting '83:	**1346417**	feet
Northing '83:	**481148**	feet
Ground Elevation:	**555**	feet above mean sea level (AMSL)
)epth to Water Table:	**36**	feet below ground surface (BGS)
/ater Table Elevation:	**520**	feet AMSL
Work Completed:	**6/4/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium[a,b] (µg/L) (FRL=30)	Uranium[c] (µg/L) (FRL=30)	Technetium-99[c] (pCi/L) (FRL=94)	Nitrate/Nitrite (mg/L) (FRL=11)	Manganese[c] (mg/L) (FRL=0.90)	Molybdenum[c] (mg/L) (FRL=0.1)	Nickel[c] (mg/L) (FRL=0.1)	Temperature[a] (^{0}C)	pH[a] (SU)	Specific Conductance[a] (mS/cm)	Turbidity (NTU)	Turbidity[a] (NTU)	Dissolved Oxygen[a] (mg/L)
1	515	41	0-10	2.72	3.86	6.77	0.939	0.444	0.030	0.01260	16.07	7.48	0.719	>1000	519	6.70
2	505	51	10-20	1.99	1.62	0.77	0.596	0.367	0.035	0.00950	16.64	7.45	0.686	>1000	>1000	7.41
3	495	61	20-30	1.42	1.34	4.21	1.420	0.317	0.039	0.00796	14.94	7.71	0.627	>1000	739	7.41
4	485	71	30-40	2.18	2.17	2.40	0.258	0.154	0.008	0.00460	11.78	7.65	0.673	>1000	387	8.93

[a]Samples are filtered through a 5 micron filter.
[b]Maximum uranium result reported regardless of laboratory (i.e., onsite versus offsite) analyzing samples.
[c]Samples are filtered through a 0.45 micron filter.

Table A.2-5. Geoprobe Location 13485

Easting '83:	**1346804**	feet
Northing '83:	**480911**	feet
Ground Elevation:	**571**	feet above mean sea level (AMSL)
Depth to Water Table:	**51**	feet below ground surface (BGS)
Water Table Elevation:	**520**	feet AMSL
Work Completed:	**6/10/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium[a,b] (µg/L) (FRL=30)	Uranium[c] (µg/L) (FRL=30)	Technetium-99[c] (pCi/L) (FRL=94)	Nitrate/Nitrite (mg/L) (FRL=11)	Manganese[c] (mg/L) (FRL=0.90)	Molybdenum[c] (mg/L) (FRL=0.1)	Nickel[c] (mg/L) (FRL=0.1)	Temperature[a] (°C)	pH[a] (SU)	Specific Conductance[a] (mS/cm)	Turbidity (NTU)	Turbidity[a] (NTU)	Dissolved Oxygen[a] (mg/L)
1	515	56	0-10	186	194	12.2	0.449	0.282	0.0133	0.00353	15.60	7.04	0.799	>1000	>1000	8.94
2	505	66	10-20	4.63	4.63	5.16	0.378	0.461	0.0325	0.00916	14.26	7.49	0.690	>1000	97.7	6.48
3	495	76	20-30	3.09	2.82	2.72	1.15	0.231	0.0154	0.00342	15.00	8.11	0.657	>1000	>1000	7.78
4	485	86	30-40	5.41	4.20	0.024	0.696	0.359	0.0145	0.00627	15.06	7.42	0.769	>1000	>1000	6.17

[a]Samples are filtered through a 5 micron filter.
[b]Maximum uranium result reported regardless of laboratory (i.e., onsite versus offsite) analyzing samples.
[c]Samples are filtered through a 0.45 micron filter.

Table A.2-6. Geoprobe Location 12618E

Easting '83:	**1347180**	feet
Northing '83:	**480411**	feet
Ground Elevation:	**579**	feet above mean sea level (AMSL)
Depth to Water Table:	**59**	feet below ground surface (BGS)
Water Table Elevation:	**520**	feet AMSL
Work Completed:	**6/18/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium[a,b] (µg/L) (FRL=30)	Uranium[c] (µg/L) (FRL=30)	Technetium-99[c] (pCi/L) (FRL=94)	Nitrate/Nitrite (mg/L) (FRL=11)	Manganese[c] (mg/L) (FRL=0.90)	Molybdenum[c] (mg/L) (FRL=0.1)	Nickel[c] (mg/L) (FRL=0.1)	Temperature[a] (°C)	pH[a] (SU)	Specific Conductance[a] (mS/cm)	Turbidity (NTU)	Turbidity[a] (NTU)	Dissolved Oxygen[a] (mg/L)
1	515	64	0-10	166	167	1.29	1.04	0.23	0.0076	0.0046	16.34	7.66	0.845	>1000	>1000	7.45
2	505	74	10-20	15.1	10.9	1.58	1.38	0.22	0.0177	0.0089	16.83	7.63	0.762	>1000	>1000	7.89
3	495	84	20-30	5.31	5.08	2.69	1.07	0.16	0.0101	0.0063	18.21	7.62	0.777	>1000	>1000	7.91
4	485	94	30-40	9.70	9.94	3.94	1.34	0.15	0.0058	0.0028	16.57	7.60	0.660	>1000	>1000	7.41

[a]Samples are filtered through a 5 micron filter.
[b]Maximum uranium result reported regardless of laboratory (i.e., onsite versus offsite) analyzing samples.
[c]Samples are filtered through a 0.45 micron filter.

Table A.2-7. Geoprobe Location 13376A

Easting '83:	**1347266**	feet
Northing '83:	**479926**	feet
Ground Elevation:	**572**	feet above mean sea level (AMSL)
Depth to Water Table:	**53**	feet below ground surface (BGS)
Water Table Elevation:	**519**	feet AMSL
Work Completed:	**6/24/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (μg/L)	Temperature filtered[a] (^{0}C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	514	58	0-10	204	17.6	7.45	0.917	>1000	793	8.05
2	504	68	10-20	55.0	15.5	7.37	0.881	>1000	922	8.10
3	494	78	20-30	24.3	15.2	7.47	0.774	>1000	376	7.17
4	484	88	30-40	26.6	15.5	7.33	0.613	>1000	>1000	8.41
5	474	98	40-50	23.8	14.7	7.41	0.596	>1000	416	5.91

[a]Samples are filtered through a 5 micron filter.

Table A.2-8. Geoprobe Location 13481

Easting '83:	**1348111**	feet
Northing '83:	**479939**	feet
Ground Elevation:	**574**	feet above mean sea level (AMSL)
Depth to Water Table:	**56**	feet below ground surface (BGS)
Water Table Elevation:	**518**	feet AMSL
Work Completed:	**6/22/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (μg/L)	Temp filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	513	61	0-10	9.0	17.5	7.10	0.866	>1000	>1000	7.25
2	503	71	10-20	5.7	17.8	7.63	0.701	>1000	>1000	7.51
3	493	81	20-30	6.9	18.2	7.41	0.737	>1000	439	7.24
4	483	91	30-40	7.3	17.6	7.39	0.718	>1000	>1000	6.36
5	473	101	40-50	<1.0	17.8	7.37	0.708	>1000	194	5.47

[a]Samples are filtered through a 5 micron filter.

Table A.2-9. Geoprobe Location 12814C

Easting '83:	**1347675**	feet
Northing '83:	**477890**	feet
Ground Elevation:	**539**	feet above mean sea level (AMSL)
Depth to Water Table:	**22**	feet below ground surface (BGS)
Water Table Elevation:	**517**	feet AMSL
Work Completed:	**6/11/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temperature filtered[a] (^{0}C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	512	27	0-10	163.6	19.8	7.16	0.608	>1000	103	7.27
2	502	37	10-20	21.2	13.6	7.54	0.647	>1000	>1000	7.96
3	492	47	20-30	4.7	12.5	7.41	0.636	>1000	>1000	4.96
4	482	57	30-40	3.2	10.5	8.24	0.625	>1000	693	6.81

[a]Samples are filtered through a 5 micron filter.

Table A.2-10. Geoprobe Location 13457A

Easting '83:	**1348898**	feet
Northing '83:	**477748**	feet
Ground Elevation:	**574**	feet above mean sea level (AMSL)
Depth to Water Table:	**57**	feet below ground surface (BGS)
Water Table Elevation:	**517**	feet AMSL
Work Completed:	**6/15/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temperature filtered[a] (^{0}C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	512	62	0-10	66.6	18.8	7.33	0.798	>1000	274	6.22
2	502	72	10-20	30.2	14.9	7.40	0.639	>1000	>1000	6.33
3	492	82	20-30	3.30	15.5	7.17	0.635	>1000	464	5.47

[a]Samples are filtered through a 5 micron filter.

Table A.2-11. Geoprobe Location 12411C

Easting '83:	**1348468**	feet
Northing '83:	**476845**	feet
Ground Elevation:	**570**	feet above mean sea level (AMSL)
Depth to Water Table:	**53**	feet below ground surface (BGS)
Water Table Elevation:	**517**	feet AMSL
Work Completed:	**6/30/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temperature filtered[a] (^{0}C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	512	58	0-10	39.1	16.5	6.83	0.795	>1000	>1000	7.46
2	502	68	10-20	16.0	16.8	7.46	0.773	>1000	490	6.08
3	492	78	20-30	11.6	17.5	7.48	0.739	>1000	>1000	7.16
4	482	88	30-40	5.2	18.5	7.57	0.730	>1000	214	6.60
5	472	98	40-50	6.6	16.9	7.74	0.720	>1000	>1000	6.95

[a]Samples are filtered through a 5 micron filter.

Table A.2-12. Geoprobe Location 12230C

Easting '83:	**1348627**	feet
Northing '83:	**476760**	feet
Ground Elevation:	**570**	feet above mean sea level (AMSL)
Depth to Water Table:	**54**	feet below ground surface (BGS)
Water Table Elevation:	**516**	feet AMSL
Work Completed:	**7/6/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temperature filtered[a] (^{0}C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	511	59	0-10	55.3	17.5	7.63	0.775	>1000	834	7.95
2	501	69	10-20	48.0	17.4	7.66	0.746	>1000	>1000	7.87
3	491	79	20-30	23.8	17.8	7.78	0.725	>1000	371	5.82
4	481	89	30-40	17.7	17.3	7.79	0.725	>1000	305	6.34
5	471	99	40-50	7.4	17.1	7.98	0.717	>1000	>1000	7.29
6	461	109	50-60	21.0	17.1	7.86	0.686	>1000	212	6.80
7	451	119	60-70	10.4	17.6	7.87	0.685	>1000	140	6.63

[a]Samples are filtered through a 5 micron filter.

Table A.2-13. Geoprobe Location 13486

Easting '83:	**1348818**	feet
Northing '83:	**4776657**	feet
Ground Elevation:	**564**	feet above mean sea level (AMSL)
Depth to Water Table:	**49**	feet below ground surface (BGS)
Water Table Elevation:	**515**	feet AMSL
Work Completed:	**8/24/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temperature filtered[a] (^{0}C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	510	54	0-10	95.5	17.1	7.57	0.720	>1000	928	8.98
2	500	64	10-20	49.5	15.7	7.67	0.720	>1000	964	8.00
3	490	74	20-30	56.4	16.6	7.78	0.700	>1000	>1000	7.47
4	480	84	30-40	26.0	15.1	7.62	0.790	>1000	>1000	7.18
5	470	94	40-50	18.9	15.3	7.67	0.710	>1000	>1000	7.28
6	460	104	50-60	23.5	16.0	7.57	0.880	>1000	>1000	6.98

[a]Samples are filtered through a 5 micron filter.

Table A.2-14. Geoprobe Location 13229D

Easting '83:	**1348247**	feet
Northing '83:	**475528**	feet
Ground Elevation:	**571**	feet above mean sea level (AMSL)
Depth to Water Table:	**56**	feet below ground surface (BGS)
Water Table Elevation:	**516**	feet AMSL
Work Completed:	**5/26/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temperature filtered[a] (^{0}C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	511	61	0-10	47.1	18.7	7.41	0.800	>1000	>1000	7.45
2	501	71	10-20	49.8	15.8	6.17	0.785	>1000	>1000	8.20
3	491	81	20-30	39.8	15.1	7.65	0.742	>1000	315	6.04
4	481	91	10-20	26.7	14.8	7.76	0.680	>1000	72	4.35
5	471	101	20-30	11.6	14.7	7.68	0.693	>1000	>1000	4.50

[a]Samples are filtered through a 5 micron filter.

Table A.2-15. Geoprobe Location 13233B

Easting '83:	**1348644**	feet
Northing '83:	**475199**	feet
Ground Elevation:	**581**	feet above mean sea level (AMSL)
Depth to Water Table:	**66**	feet below ground surface (BGS)
Water Table Elevation:	**515**	feet AMSL
Work Completed:	**4/29/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temperature filtered[a] (^{0}C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	510	71	0-10	39.0	15.0	7.53	0.820	>1000	855	6.97
2	500	81	10-20	41.1	14.7	7.76	0.730	>1000	>1000	6.07
3	490	91	20-30	28.1	14.3	7.82	0.728	>1000	>1000	6.21
4	480	101	30-40	20.3	15.1	7.86	0.772	>1000	481	7.29

[a]Samples are filtered through a 5 micron filter.

Table A.2-16. Geoprobe Location 13234C

Easting '83:	**1349045**	feet
Northing '83:	**475203**	feet
Ground Elevation:	**580**	feet above mean sea level (AMSL)
Depth to Water Table:	**65**	feet below ground surface (BGS)
Water Table Elevation:	**515**	feet AMSL
Work Completed:	**4/27/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temperature filtered[a] (^{0}C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	510	70	0-10	20.8	14.6	7.21	1.263	>1000	>1000	7.45
2	500	80	10-20	37.8	14.3	7.09	0.772	>1000	77.1	2.97
3	490	90	20-30	4.1	14.4	7.42	0.708	>1000	47.5	3.54

[a]Samples are filtered through a 5 micron filter.

Table A.2-17. Geoprobe Location 13237C

Easting '83:	**1348860**	feet
Northing '83:	**475802**	feet
Ground Elevation:	**576**	feet above mean sea level (AMSL)
Depth to Water Table:	**59**	feet below ground surface (BGS)
Water Table Elevation:	**517**	feet AMSL
Work Completed:	**4/28/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temperature filtered[a] (^{0}C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	512	64	0-10	75.1	15.2	7.13	0.998	>1000	>1000	6.98
2	502	74	10-20	37.5	15.9	7.53	0.936	>1000	>1000	6.20
3	492	84	20-30	36.8	16.7	7.55	0.753	>1000	>1000	5.88

[a]Samples are filtered through a 5 micron filter.

Table A.2-18. Geoprobe Location 13239B

Easting '83:	**1348443**	feet
Northing '83:	**475398**	feet
Ground Elevation:	**579**	feet above mean sea level (AMSL)
Depth to Water Table:	**63**	feet below ground surface (BGS)
Water Table Elevation:	**516**	feet AMSL
Work Completed:	**4/23/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temperature filtered[a,b] (^{0}C)	pH filtered[a,b] (SU)	Specific Conductance filtered[a,b] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a,b] (NTU)	Dissolved Oxygen filtered[a,b] (mg/L)
1	511	68	0-10	62.0	NS	NS	NS	NS	NS	NS
2	501	78	10-20	50.6	13.1	6.94	0.757	>1000	309	8.42
3	491	88	20-30	30.9	13.3	6.95	0.649	>1000	83	6.14
4	481	98	30-40	10.9	13.9	6.96	0.684	>1000	45	6.00
5	471	108	40-50	4.8	13.8	7.22	0.755	>1000	329	8.75

[a]Samples are filtered through a 5 micron filter.
[b] NS = Not sampled

Table A.2-19. Geoprobe Location 13240D

Easting '83:	**1348842**	feet
Northing '83:	**475401**	feet
Ground Elevation:	**579**	feet above mean sea level (AMSL)
Depth to Water Table:	**64**	feet below ground surface (BGS)
Water Table Elevation:	**515**	feet AMSL
Work Completed:	**4/28/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temperature filtered[a] (^{0}C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	510	69	0-10	26.5	15.0	7.66	0.793	>1000	>1000	6.22
2	500	79	10-20	36.8	14.7	7.75	0.779	>1000	305	3.61
3	490	89	20-30	23.9	15.3	7.90	0.761	>1000	150	4.50
4	480	99	30-40	21.5	15.7	7.84	0.756	>1000	356	5.00
5	470	109	40-50	6.9	16.1	7.65	0.766	>1000	>1000	5.11
6	460	119	50-60	1.4	15.5	7.58	0.794	>1000	997	5.41

[a]Samples are filtered through a 5 micron filter.

Table A.2-20. Geoprobe Location 13306C

Easting '83:	**1348310**	feet
Northing '83:	**474543**	feet
Ground Elevation:	**533**	feet above mean sea level (AMSL)
Depth to Water Table:	**19**	feet below ground surface (BGS)
Water Table Elevation:	**514**	feet AMSL
Work Completed:	**5/28/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temperature filtered[a] (^{0}C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	509	24	0-10	38.9	18.2	6.47	0.993	>1000	398	5.65
2	499	34	10-20	11.0	15.8	7.53	0.750	>1000	282	6.58
3	489	44	20-30	17.4	15.2	7.62	0.720	>1000	115	0.86
4	479	54	30-40	33.8	15.1	7.46	0.775	>1000	184	4.48
5	469	64	40-50	30.6	15.7	7.55	0.827	>1000	347	4.51

[a]Samples are filtered through a 5 micron filter.

Table A.2-21. Geoprobe Location 13421D

Easting '83:	**1349310**	feet
Northing '83:	**476023**	feet
Ground Elevation:	**571**	feet above mean sea level (AMSL)
Depth to Water Table:	**56**	feet below ground surface (BGS)
Water Table Elevation:	**515**	feet AMSL
Work Completed:	**5/21/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temperature filtered[a] (^{0}C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	510	61	0-10	2.1	14.3	7.15	0.963	>1000	933	8.29
2	500	71	10-20	78.2	13.6	7.37	0.849	>1000	>1000	5.64
3	490	81	20-30	101.1	14.3	7.61	0.758	>1000	200	5.15
4	480	91	30-40	71.1	14.2	7.64	0.783	>1000	887	5.97
5	470	101	40-50	1.3	14.2	7.63	0.742	>1000	448	5.81
6	460	111	50-60	55.3	14.3	7.61	0.747	>1000	>1000	5.51
7	450	121	60-70	4.3	13.6	7.49	0.775	>1000	825	5.57

[a]Samples are filtered through a 5 micron filter.

Table A.2-22. Geoprobe Location 13423B

Easting '83:	**1349405**	feet
Northing '83:	**476022**	feet
Ground Elevation:	**570**	feet above mean sea level (AMSL)
Depth to Water Table:	**56**	feet below ground surface (BGS)
Water Table Elevation:	**515**	feet AMSL
Work Completed:	**5/12/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (µg/L)	Temperature filtered[a] (^{0}C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	510	60.5	0-10	<1.0	14.3	7.21	0.909	>1000	243	7.11
2	500	70.5	10-20	19.7	15.6	7.22	0.865	>1000	>1000	5.65
3	490	80.5	20-30	26.8	15.4	7.28	0.777	>1000	439	5.16
4	480	90.5	30-40	32.4	15.4	7.40	0.729	>1000	>1000	6.50
5	470	100.5	40-50	<1.0	15.4	7.54	0.719	>1000	908	5.28
6	460	110.5	50-60	<1.0	15.4	7.56	0.748	>1000	>1000	6.39

[a]Samples are filtered through a 5 micron filter.

[b] NR=Not Recorded

Table A.2-23. Geoprobe Location 13461A

Easting '83:	**1348184**	feet
Northing '83:	**475199**	feet
Ground Elevation:	**536**	feet above mean sea level (AMSL)
Depth to Water Table:	**20**	feet below ground surface (BGS)
Water Table Elevation:	**516**	feet AMSL
Work Completed:	**4/24/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (μg/L)	Temperature filtered[a] (^{0}C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	511	25	0-10	16.3	11.7	5.52	0.773	>1000	4.00	7.27
2	501	35	10-20	22.1	12.5	6.79	0.677	>1000	45.1	8.22
3	491	45	20-30	15.0	10.0	6.94	0.622	>1000	14.6	6.25
4	481	55	30-40	11.5	9.32	7.28	0.617	>1000	14.0	4.53
5	471	65	40-50	8.2	9.19	7.72	0.624	>1000	2.78	2.32

[a]Samples are filtered through a 5 micron filter.

Table A.2-24. Geoprobe Location 13464A

Easting '83:	**1348269**	feet
Northing '83:	**474769**	feet
Ground Elevation:	**546**	feet above mean sea level (AMSL)
Depth to Water Table:	**31**	feet below ground surface (BGS)
Water Table Elevation:	**515**	feet AMSL
Work Completed:	**5/27/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (μg/L)	Temperature filtered[a] (^{0}C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	510	36	0-10	27.7	19.0	7.16	0.912	>1000	23.9	7.59
2	500	46	10-20	14.4	16.0	7.44	0.753	>1000	845	4.78
3	490	56	20-30	13.2	16.5	7.43	0.779	>1000	>1000	5.20
4	480	66	30-40	20.7	16.81	7.59	0.800	>1000	61.0	3.70
5	470	76	40-50	34.3	18.00	7.59	0.796	>1000	197	4.39
6	460	86	50-60	29.1	15.5	7.67	0.750	>1000	210	5.14
7	450	96	60-70	18.0	15.5	7.71	0.714	>1000	>1000	0.28
8	440	106	70-80	2.00	15.9	7.64	0.709	>1000	863	4.84

[a]Samples are filtered through a 5 micron filter.

Table A.2-25. Geoprobe Location 13477A

Easting '83:	**1349241**	feet
Northing '83:	**475821**	feet
Ground Elevation:	**580**	feet above mean sea level (AMSL)
Depth to Water Table:	**64**	feet below ground surface (BGS)
Water Table Elevation:	**516**	feet AMSL
Work Completed:	**4/29/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (μg/L)	Temperature filtered[a] (^{0}C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	511	69	0-10	<1.0	14.7	7.06	0.973	>1000	94	5.60
2	501	79	10-20	18.4	15.8	7.60	0.932	>1000	1000	6.90
3	491	89	20-30	52.0	15.6	7.64	0.792	>1000	84	5.25
4	481	99	30-40	3.6	16.4	7.64	0.741	>1000	31	6.08
5	471	109	40-50	5.7	16.8	7.69	0.716	>1000	256	4.30

[a]Samples are filtered through a 5 micron filter.

Table A.2-26. Geoprobe Location 13482

Easting '83:	**1348877**	feet
Northing '83:	**474672**	feet
Ground Elevation:	**582**	feet above mean sea level (AMSL)
Depth to Water Table:	**68**	feet below ground surface (BGS)
Water Table Elevation:	**514**	feet AMSL
Work Completed:	**5/11/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (μg/L)	Temperature filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	509	73	0-10	37.3	17.2	7.06	0.773	>1000	85	5.67
2	499	83	10-20	30.6	15.5	6.28	0.737	>1000	>1000	5.93
3	489	93	20-30	20.6	15.6	7.48	0.750	>1000	48	4.29
4	479	103	30-40	8.7	16.5	7.56	0.758	>1000	467	5.58

[a]Samples are filtered through a 5 micron filter.

Table A.2-27. Geoprobe Location 13483

Easting '83:	**1347989**	feet
Northing '83:	**475678**	feet
Ground Elevation:	**539**	feet above mean sea level (AMSL)
Depth to Water Table:	**24**	feet below ground surface (BGS)
Water Table Elevation:	**515**	feet AMSL
Work Completed:	**5/20/2015**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium filtered[a] (μg/L)	Temperature filtered[a] (C)	pH filtered[a] (SU)	Specific Conductance filtered[a] (mS/cm)	Turbidity unfiltered (NTU)	Turbidity filtered[a] (NTU)	Dissolved Oxygen filtered[a] (mg/L)
1	510	29	0-10	27.3	14.1	7.44	1.041	>1000	741	7.09
2	500	39	10-20	10.0	15.3	7.67	0.823	>1000	58	5.77
3	490	49	20-30	13.6	14.0	7.64	0.742	>1000	68	6.08
4	480	59	30-40	14.3	13.4	7.69	0.743	>1000	81	7.05

[a]Samples are filtered through a 5 micron filter.

Table A.2-28. Summary Statistics and Trend Analysis of Monitoring Wells for Total Uranium with 2015 Results Above FRLs

Well	No. of Samples	Minimum (µg/L)[a,b,c,d]	Maximum (µg/L)[a,b,c,d]	Average (µg/L)[a,b,c,d,e]	Standard Deviation (µg/L)[a,b,c,d,e]	Trend[a,b,c,d,e,f]
2045	74	12.0	462	120	102	Up
2046	73	20	907	144	201	Down
2049	57	3.0	178	73.5	43.2	Down
2060	85	8.4	332	76.0	59.6	Down
23271	28	34.6	144	73.6	31.1	Down
23273	28	114	421	240	79	Down
23274	43	109	384	178	61	Down
23275	27	119	349	176	54	Up
23276	28	54.7	115	83.0	15.2	No Trend
23278	28	32.5	201	86.1	45.4	Down
23280	28	45.5	700	152	139	Down
23281	28	27.6	367	126	79	Down
2385	51	22.9	592	219	116	Down
2386	51	6.67	43.4	21.3	8.2	No Trend
2387	51	18.1	492	157	82	Up
2389	40	0.899	120	31.8	24.5	Up
2390	50	21.6	163	69.6	31.7	Down
2397	37	135	737	375	129	No Trend
2550	61	3.3	120	56.7	21.6	Down
2649	47	6.01	1110	207	297	Up
2880	51	0.4	64.9	21.6	24.4	Up
3069	77	0.5	398	120	95	Down
3095	71	2.0	94.0	27.1	17.6	No Trend
3821	44	7.95	152	23.8	30.3	Up
62433	40	23.5	845	298	212	Down
63285	28	74.9	277	195	48	No Trend
63287	28	34.2	316	141	73	Down
6880	38	55.7	145	84.5	22.8	Down
6881	38	17.5	60.5	26.7	7.2	No Trend
82369_C1	6	12.1	210	126	68	No Trend
83269_C2	6	25.1	38.5	30.9	4.7	No Trend
82372_C1	8	33.5	62.4	43.3	9.4	No Trend
82433_C3	30	31.0	506	184	141	Down
83117_C1	30	440	1620	809	286	Down
83117_C2	15	33.4	330	125	113	Down
83117_C4	15	65.9	111	83.0	13.6	No Trend
83124_C1	45	102	1070	479	210	No Trend
83124_C2	24	27.8	103	50.8	18.2	Down
83124_C4	15	25.4	62.2	40.1	9.2	Up
83124_C5	15	24.4	61.4	49.3	8.9	No Trend
83294_C1	23	98.5	327	199	56	Up
83294_C2	36	188	575	357	90	Down
83294_C3	18	20.5	539	278	163	Down
83295_C2	24	84.4	178	130	33	Down
83295_C3	19	66.7	175	124	36.7	Down
83295_C4	16	32.5	199	94.2	59.2	Down
83295_C5	15	42.4	155	74.6	32.2	Down
83295_C6	15	3.4	64.4	34.0	20.9	Up
83296_C1	12	56.7	135	85.1	21.6	No Trend

Table A.2–28 (continued). Summary Statistics and Trend Analysis of Monitoring Wells for Total Uranium with 2015 Results Above FRLs

Well	No. of Samples	Minimum (µg/L)[a,b,c,d]	Maximum (µg/L)[a,b,c,d]	Average (µg/L)[a,b,c,d,e]	Standard Deviation (µg/L)[a,b,c,d,e]	Trend[a,b,c,d,e,f]
83296_C3	19	16.5	75.0	35.9	21.1	Down
83337_C1	21	255	2660	1690	630	No Trend
83337_C2	33	2.48	835	148	188	No Trend
83338_C1	15	454	1100	583	160	No Trend
83340_C1	16	13.2	44.8	28.8	8.6	Up
83346_C2	13	10.7	70.7	39.5	13.8	Down

[a] Summary statistics and Mann-Kendall test for trend are primarily based on unfiltered samples with some filtered samples from the Operable Unit 5 Remedial Investigation/Feasibility Study data set (1988 through 1993) and 1994 through 2015 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 representative concentration is used for determining the summary statistics (minimum, maximum, average, and standard deviation) and Mann-Kendall test for trend.
[c] Rejected data qualified with an R were not included in this count, the summary statistics, or Mann-Kendall test for trend.
[d] If the number of samples is greater than or equal to four, then all of the summary statistics and the Mann-Kendall test for trend 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.
[e] 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.
[f] Mann-Kendall test for trend is performed using data from third quarter 1998 through 2015.

Table A.2-29. Summary Statistics and Trend Analysis of Extraction Wells for Total Uranium

Well	Number of Samples[a,b]	Minimum (µg/L)[a,b,c]	Maximum (µg/L)[a,b,c]	Average (µg/L)[a,b,c]	Standard Deviation (µg/L)[a,b,c]	Trend[a,b,c]
South Plume Module (August 27, 1993, through December 31, 2015)						
3924	636	1.8	180	29.2	14.8	Down
3925	636	0.5	84	23.7	7.9	Down
3926	625	1.5	42.4	25.1	8.0	Up
3927	629	1.0	17	2.64	1.09	Up
South Plume Optimization Module (August 9, 1998, through December 31, 2015)						
32308	557	18.4	100	52.1	16.1	Down
32309	569	22.0	123	52.6	19.8	Down
South Field Module (July 13, 1998, through December 31, 2015)						
31550	586	16.2	128	49.9	18.4	Down
31560	613	12.1	183	56.3	37.7	Down
31561	586	18.1	114[d]	39.7	10.3	Down
32276	628	15.6	290	95.5	63.2	Down
32446	481	24.5	168	58.1	20.1	Down
32447	504	21.9	302	102	54.1	Down
33061	383	13.6	98.5	44.2	14.9	Down
33262	342	20.2	110	44.7	14.0	Down
33264	335	15.8	364	75.8	41.6	Down
33298	291	10.1	76.2	49.8	11.2	Down
33326	241	8.3	62.2	24.2	7.2	Down
Waste Storage Area Module (May 8, 2002, through December 31, 2015)						
32761	374	20.4	161	57.2	32.5	Down
33062	390	10.2	236	64.4	44.0	Down
33347	198	7.0	126	26.1	18.4	Down

[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 representative concentration is used for determining the summary statistics (minimum, maximum, average, and standard deviation) and Mann-Kendall test for trend.
[b] Rejected data qualified with an R 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 August 31, 1998) appears to be an outlier. It is suspected that the sample for this well was switched with the sample from extraction well 31562.

Table A.2-30. Groundwater Monitoring Assessment Summary

Well	Category[a]	Location	Figure Number	Years of Data	Criteria[b]	Recommendation
2008	1	Waste Storage Area	A.2-30	26	2 and 3	Stop Monitoring
2009	1	Waste Storage Area	A.2-31	26	2 and 3	Stop Monitoring
23118	1	Waste Storage Area	A.2-32	12	2 and 3	Stop Monitoring
32768	1	Waste Storage Area	A.2-33	12	2 and 3	Stop Monitoring
63116	1	Waste Storage Area	A.2-34	12	2 and 3	Stop Monitoring
2014	1	South Field	A.2-35	26	2 and 3	Stop Monitoring
2016	1	South Field	A.2-36	26	1 and 3	Stop Monitoring
2017	1	South Field	A.2-37	26	1 and 3	Stop Monitoring
2048	1	South Field	A.2-38	25	1 and 3	Stop Monitoring
2106	1	South Field	A.2-39	25	2 and 3	Stop Monitoring
2166	1	South Field	A.2-40	19	1 and 3	Stop Monitoring
2402	1	South Field	A.2-41	22	1 and 3	Stop Monitoring
3014	1	South Field	A.2-42	26	2 and 3	Stop Monitoring
3106	1	South Field	A.2-43	25	1 and 3	Stop Monitoring
3402	1	South Field	A.2-44	21	1 and 3	Stop Monitoring
23272	1	South Field	A.2-45	12	2	Stop Monitoring
23277	1	South Field	A.2-46	12	1 and 3	Stop Monitoring
23279	1	South Field	A.2-47	12	1 and 3	Stop Monitoring
23282	1	South Field	A.2-48	12	2 and 3	Stop Monitoring
63284	1	South Field	A.2-49	12	2 and 3	Stop Monitoring
63286	1	South Field	A.2-50	12	1 and 3	Stop Monitoring
63289	1	South Field	A.2-51	12	1 and 3	Stop Monitoring
63290	1	South Field	A.2-52	12	1 and 3	Stop Monitoring
2002	1	South Plume	A.2-53	25	1 and 3	Stop Monitoring
2125	1	South Plume	A.2-54	25	2 and 3	Stop Monitoring
2396	1	South Plume	A.2-55	24	1 and 3	Stop Monitoring
2553	1	South Plume	A.2-56	20	1 and 3	Stop Monitoring
2897	1	South Plume	A.2-57	21	1 and 3	Stop Monitoring
3125	1	South Plume	A.2-58	24	2 and 3	Stop Monitoring
3396	1	South Plume	A.2-59	24	1 and 3	Stop Monitoring
3552	1	South Plume	A.2-60	21	1 and 3	Stop Monitoring
3897	1	South Plume	A.2-61	21	1 and 3	Stop Monitoring
4125	1	South Plume	A.2-62	24	1 and 3	Stop Monitoring
23064	1	South Plume	A.2-63	13	1 and 3	Stop Monitoring
3015	2	South Field	A.2-64	26	2 and 3	Stop Monitoring
3045	2	South Field	A.2-65	24	1	Stop Monitoring
3046	2	South Field	A.2-66	24	1 and 3	Stop Monitoring
3049	2	South Field	A.2-67	25	1 and 3	Stop Monitoring
3385	2	South Field	A.2-68	24	1 and 3	Stop Monitoring
3387	2	South Field	A.2-69	25	2 and 3	Stop Monitoring
3390	2	South Field	A.2-70	23	2 and 3	Stop Monitoring
3397	2	South Field	A.2-71	23	1 and 3	Stop Monitoring
3550	2	South Plume	A.2-72	23	2 and 3	Stop Monitoring
3880	2	South Plume	A.2-73	21	1 and 3	Stop Monitoring
6015	2	South Field	A.2-74	10	1	Stop Monitoring
63283	2	South Field	A.2-75	12	2 and 3	Stop Monitoring

Table A.2-30 (continued). Groundwater Monitoring Assessment Summary

Well	Category[a]	Location	Figure Number	Years of Data	Criteria[b]	Recommendation
63292	2	South Field	A.2-76	12	1 and 3	Stop Monitoring
2093	3	South Plume	A.2-77	26	1 and 3	Reduce to Annual
2398	3	South Field	A.2-784	23	2 and 3	Reduce to Annual
2431	3	East Side	A.2-79	21	1	Reduce to Annual
2432	3	East Side	A.2-80	21	1	Reduce to Annual
2733	3	East Side	A.2-81	21	1 and 3	Reduce to Annual
3070	3	South Field	A.2-82	26	2 and 3	Reduce to Annual
3093	3	South Plume	A.2-83	26	1 and 3	Reduce to Annual
3398	3	South Field	A.2-84	21	2 and 3	Reduce to Annual
3424	3	On-Site Disposal Facility	A.2-85	21	1 and 3	Reduce to Annual
3426	3	On-Site Disposal Facility	A.2-86	21	1 and 3	Reduce to Annual
3429	3	On-Site Disposal Facility	A.2-87	21	1 and 3	Reduce to Annual
3431	3	East Side	A.2-88	21	1 and 3	Reduce to Annual
3432	3	East Side	A.2-89	21	1 and 3	Reduce to Annual
3733	3	East Side	A.2-90	21	1 and 3	Reduce to Annual
4398	3	South Field	A.2-919	21	1 and 3	Reduce to Annual
21063	3	South Plume	A.2-92	21	1 and 3	Reduce to Annual
31217	3	On-Site Disposal Facility	A.2-93	21	1 and 3	Reduce to Annual
2128	4	Paddys Run Road Site	A.2-94	24	1 and 3	Reduce to Annual
2625	4	Paddys Run Road Site	A.2-95	23	1 and 3	Reduce to Annual
2636	4	Paddys Run Road Site	A.2-96	23	1 and 3	Reduce to Annual
2898	4	Paddys Run Road Site	A.2-97	21	1	Reduce to Annual
2899	4	Paddys Run Road Site	A.2-98	21	1 and 3	Reduce to Annual
3128	4	Paddys Run Road Site	A.2-99	24	2 and 3	Reduce to Annual
3636	4	Paddys Run Road Site	A.2-100	23	1 and 3	Reduce to Annual
3898	4	Paddys Run Road Site	A.2-101	21	2 and 3	Reduce to Annual
3899	4	Paddys Run Road Site	A.2-102	21	1 and 3	Reduce to Annual
3900	4	Paddys Run Road Site	A.2-103	21	1 and 3	Reduce to Annual

[a] 1 = Outside 2014 total uranium plume footprint, but not included in the Property/Plume Boundary or PRRS Program.
2 = Inside the 2014 total uranium plume footprint.
3 = Included in the Property/Plume Boundary Program.
4 = Included in the PRRS monitoring program.
[b] 1 = Total uranium never exceed the FRL.
2 = Over 10 years since the last total uranium FRL exceedance.
3 = Total uranium trend steady or decreasing.

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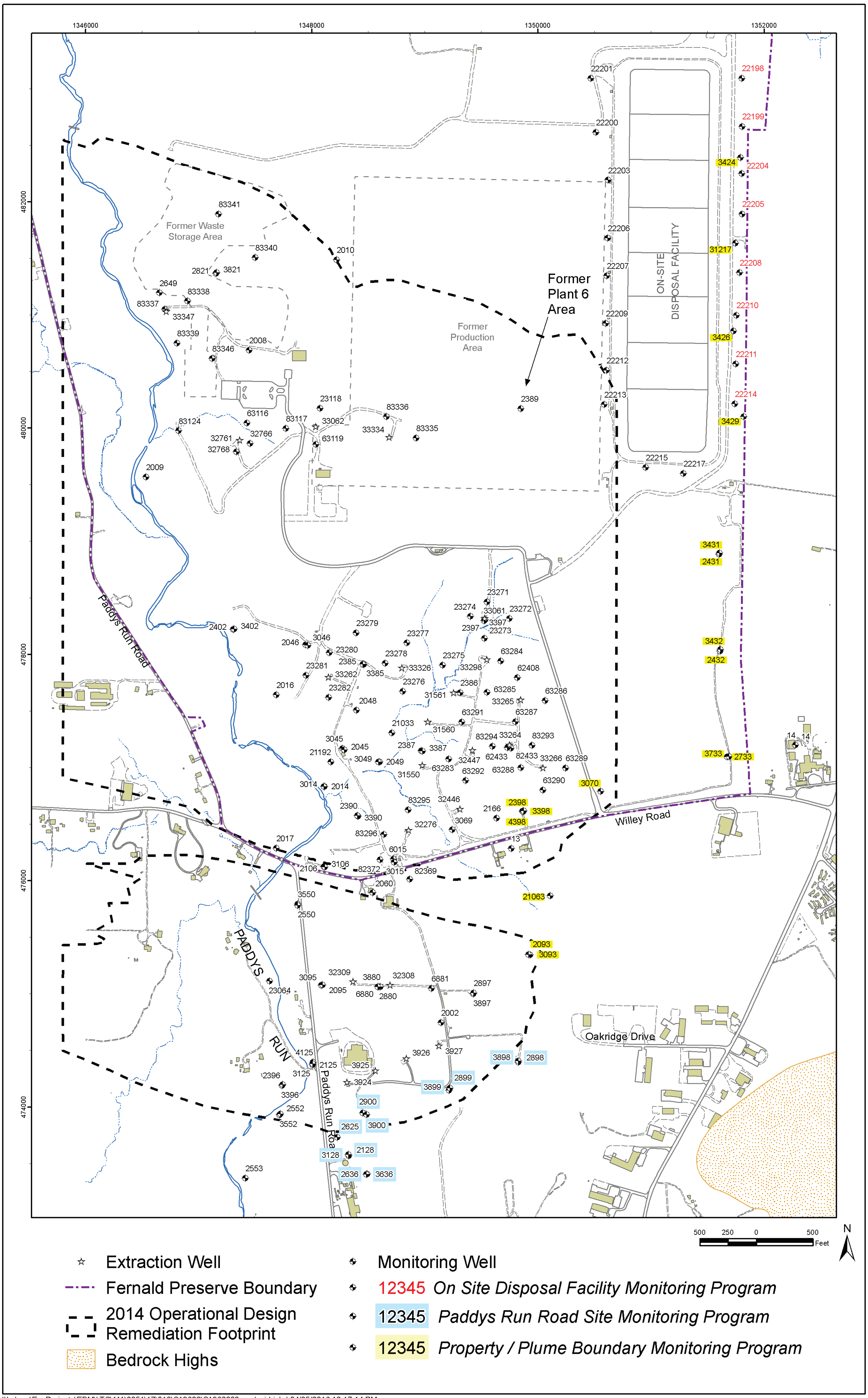

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Figure A.2-1. IEMP Water Quality Monitoring Wells and Extraction Wells

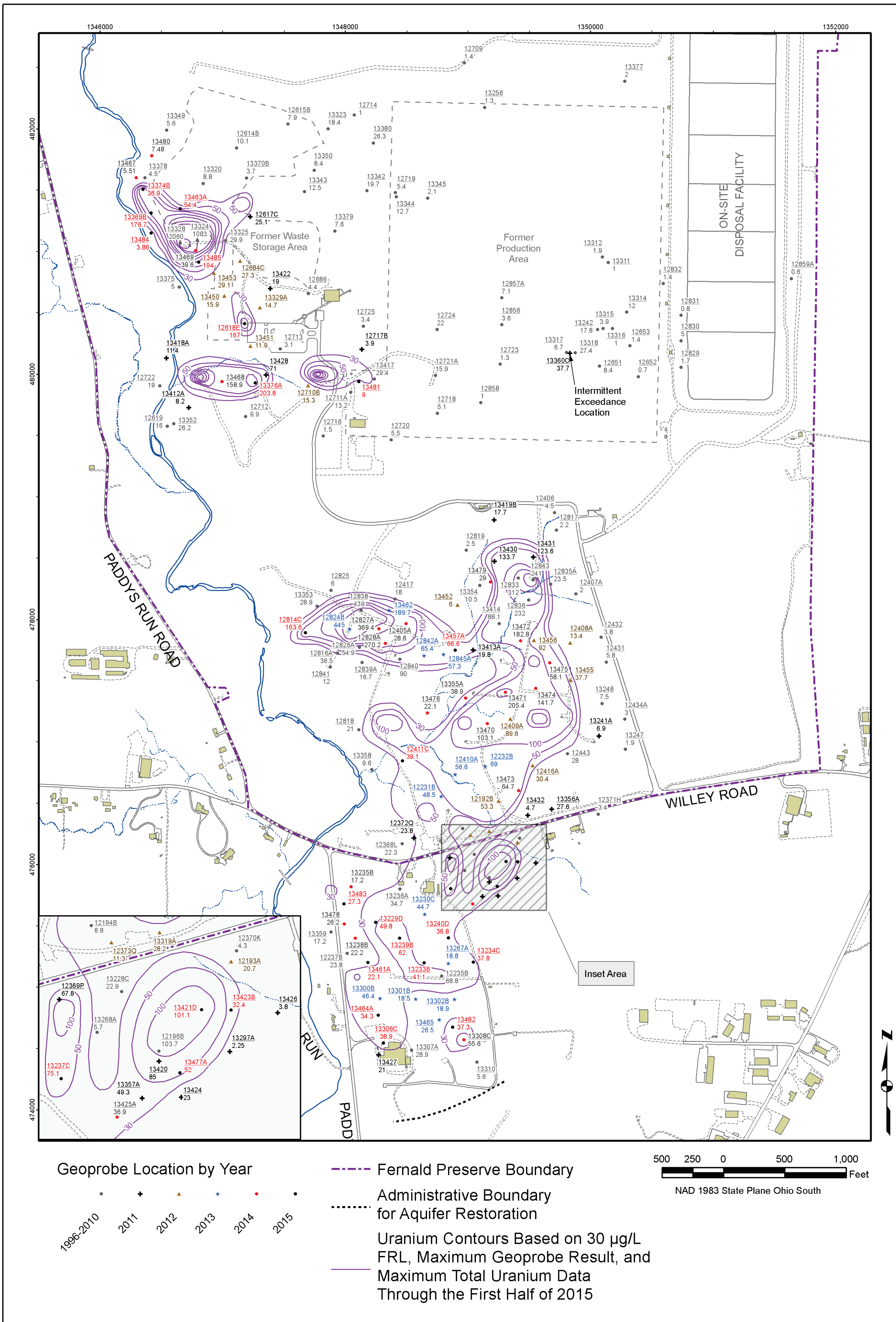


Figure A.2-2A. Direct-Push Data and Maximum Total Uranium Plume Through the First Half of 2015

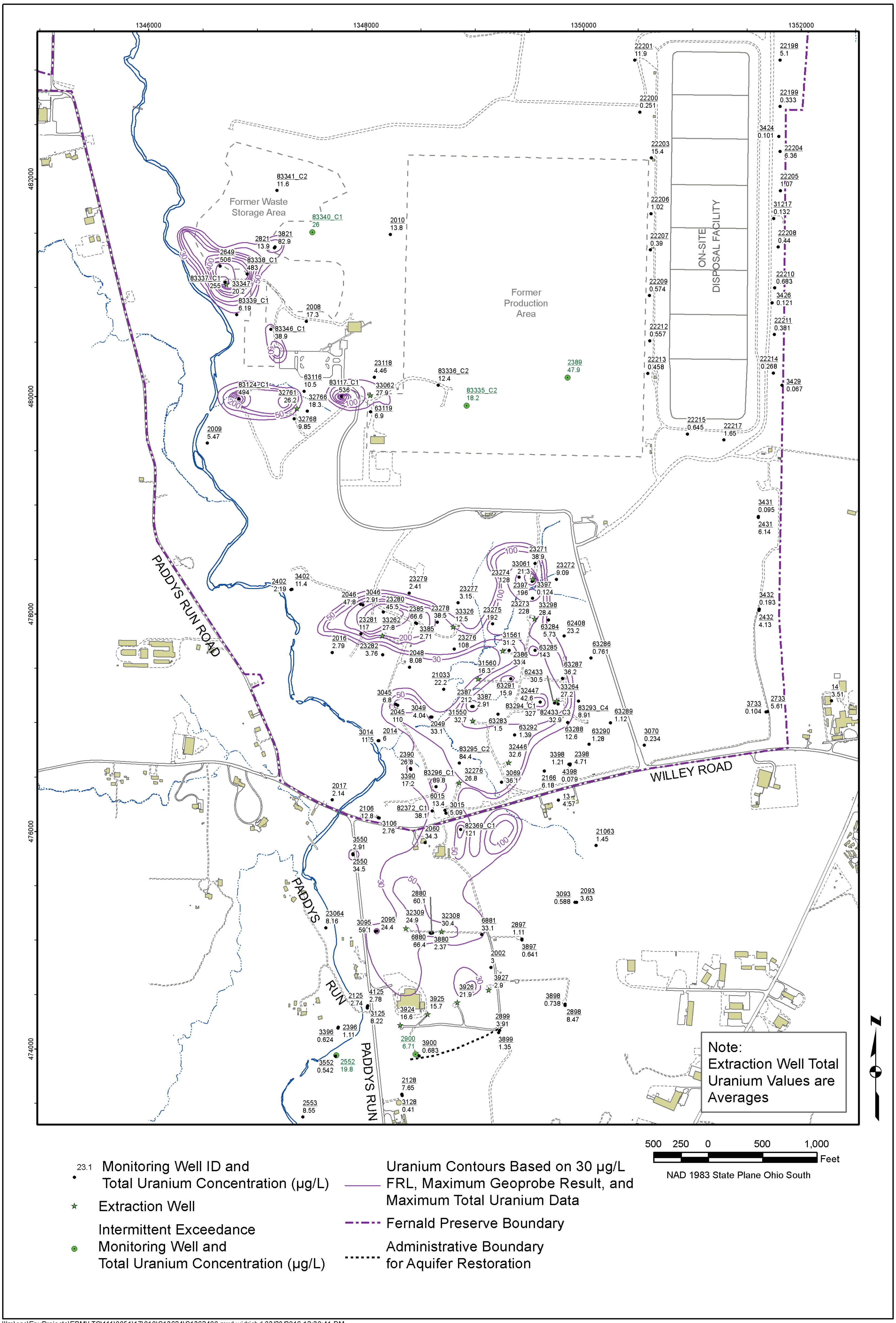


Figure A.2-2B. Monitoring Well Data and Maximum Total Uranium Plume Through the First Half of 2015

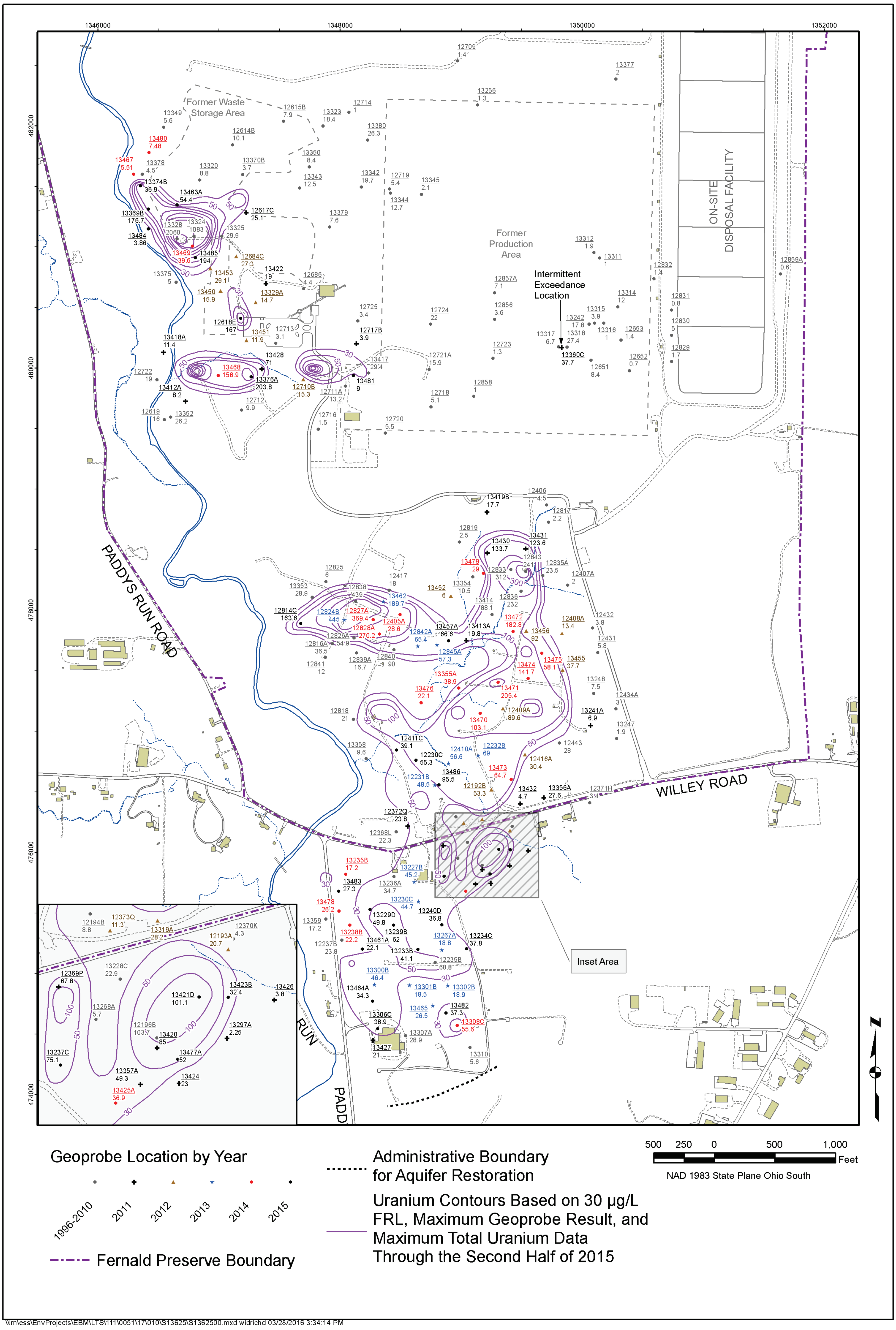
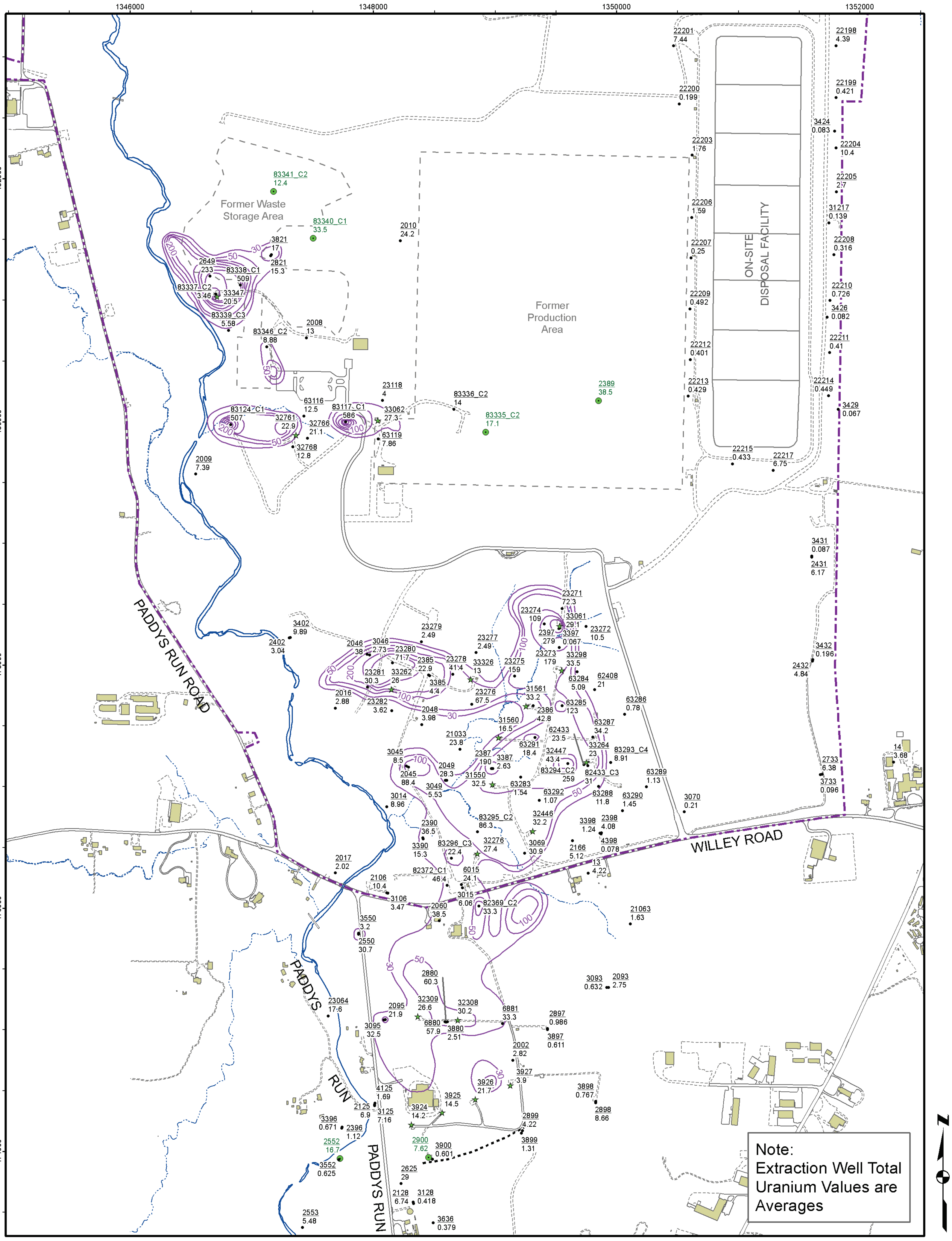


Figure A.2-3A. Direct-Push Data and Maximum Total Uranium Plume Through the Second Half of 2015



• 23.1 Monitoring Well ID and Total Uranium Concentration (µg/L)

Extraction Well

Intermittent Exceedance Monitoring Well and Total Uranium Concentration (µg/L)

Uranium Contours Based on 30 µg/L FRL, Maximum Geoprobe Result, and Maximum Total Uranium Data

Fernald Preserve Boundary

Administrative Boundary for Aquifer Restoration

500 250 0 500 1,000 Feet

NAD 1983 State Plane Ohio South

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Figure A.2-3B. Monitoring Well Data and Maximum Detected Total Uranium Plume Through the Second Half of 2015

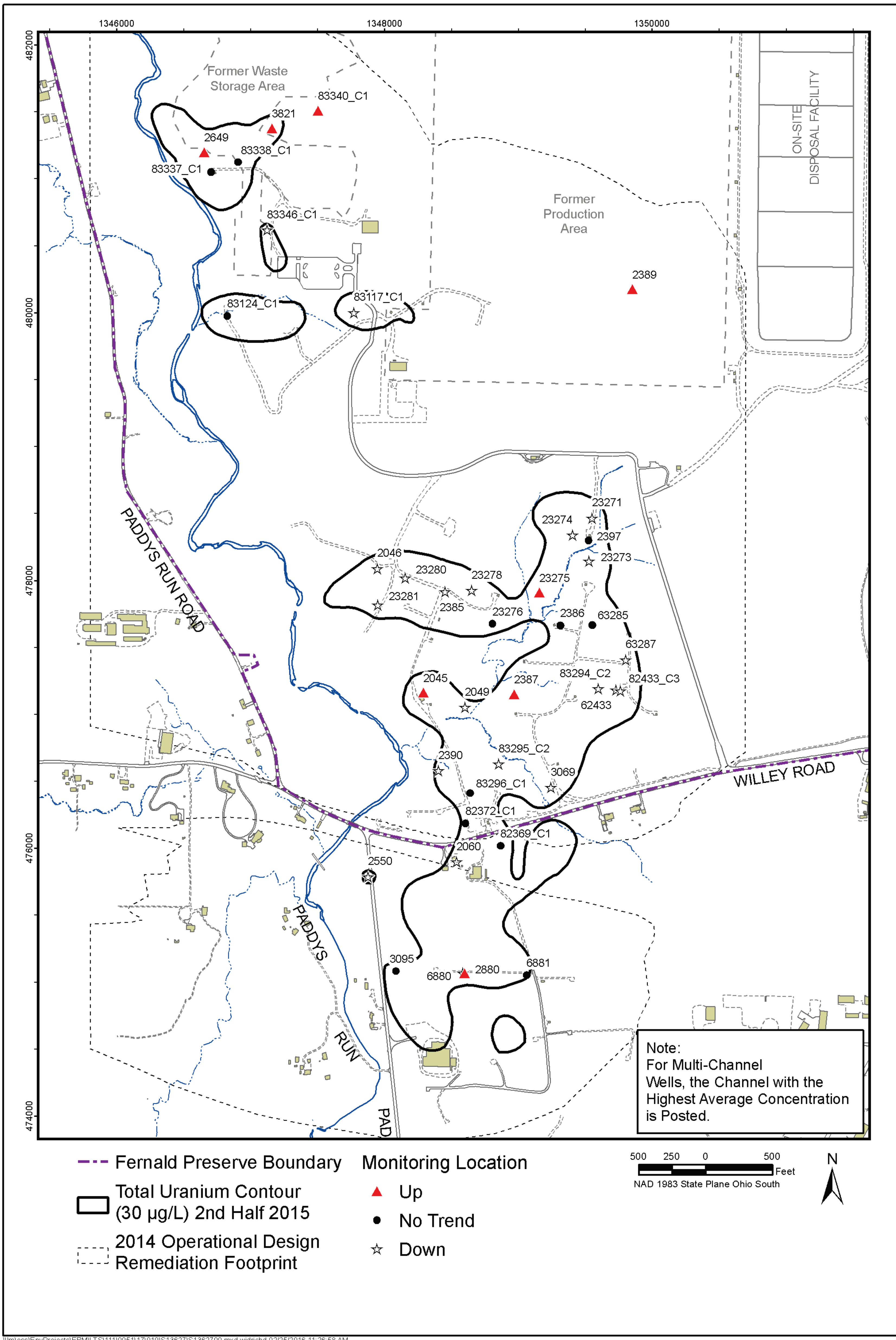

Figure A.2-4. Monitoring Wells with 2015 Exceedances for Total Uranium with Up, Down, or No Significant Trends

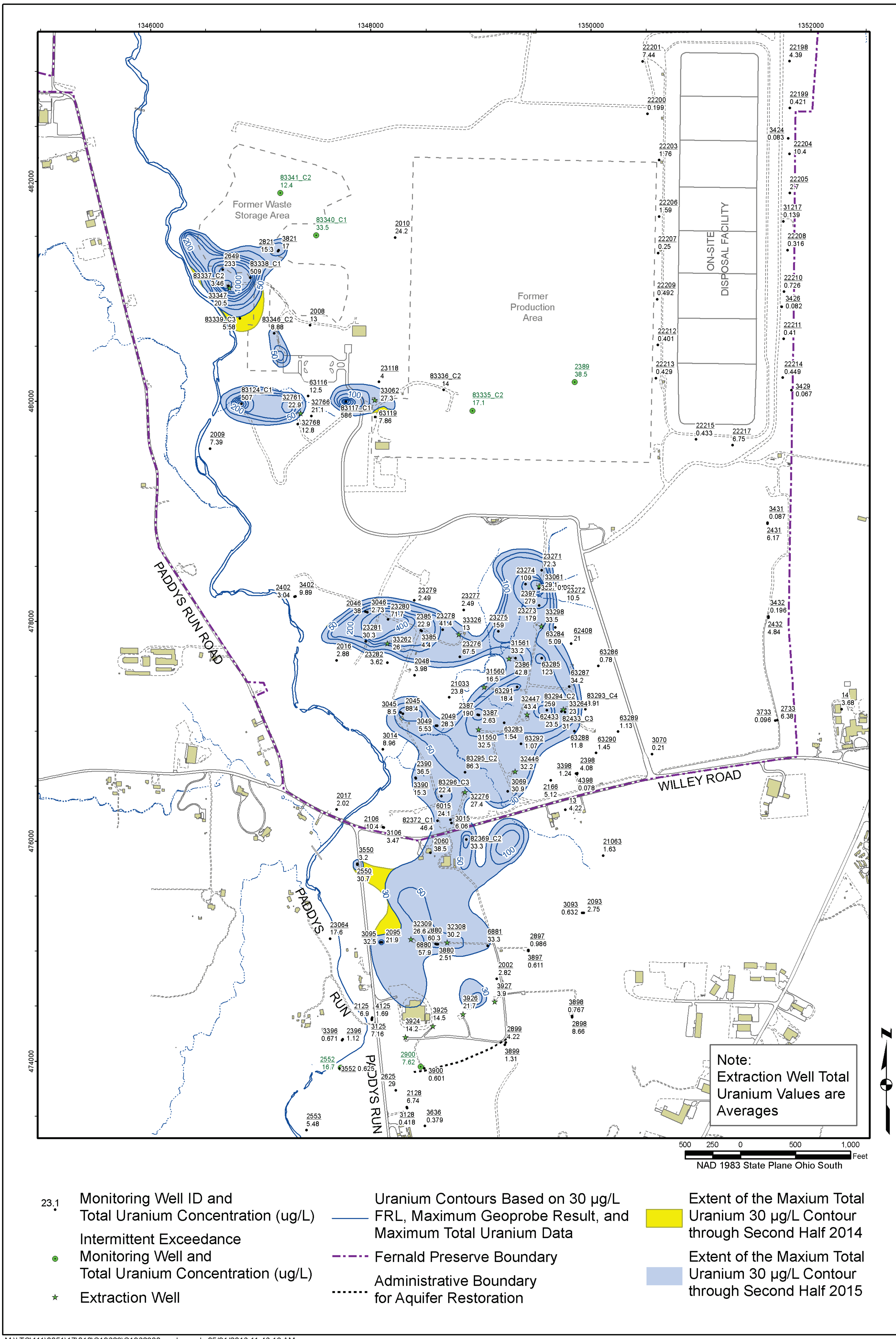

Figure A.2-5. Monitoring Well Data Through the Second Half of 2015 with Maximum Total Uranium Plume Footprint Through the Second Half of 2014 and 2015

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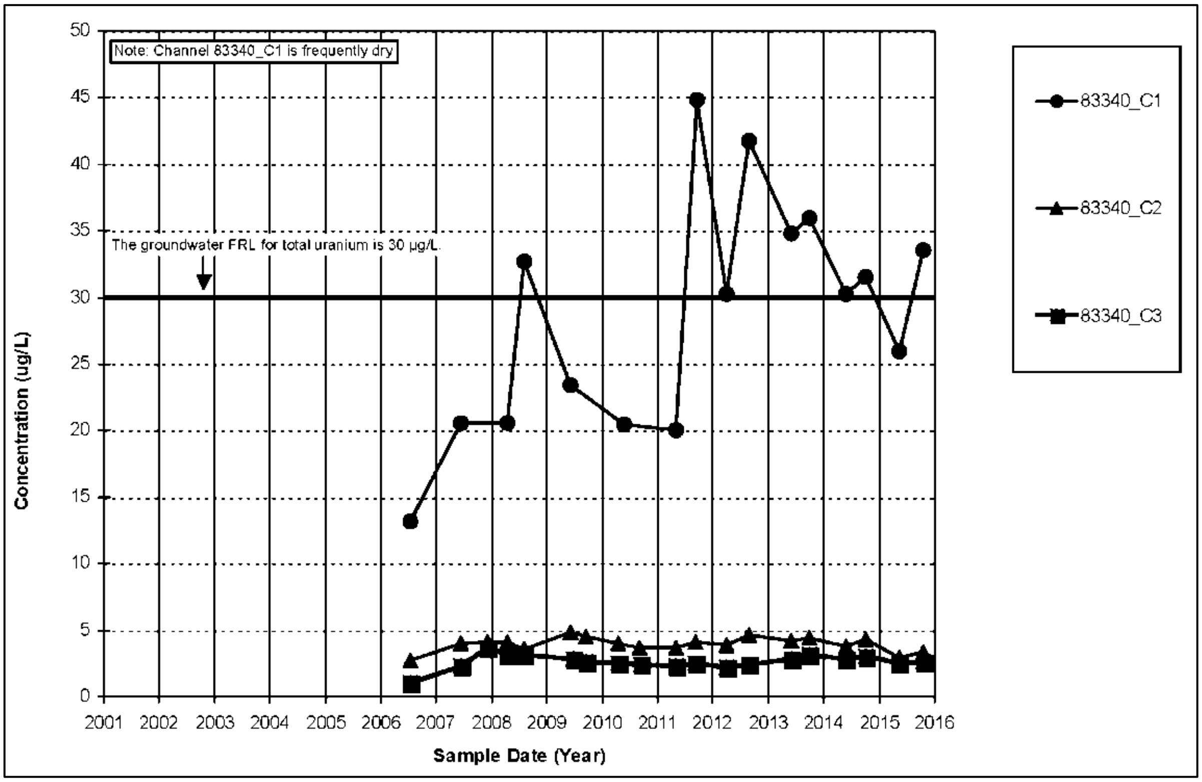

Figure A.2-6. Total Uranium Concentration Versus Time Plot for Monitoring Well 83340

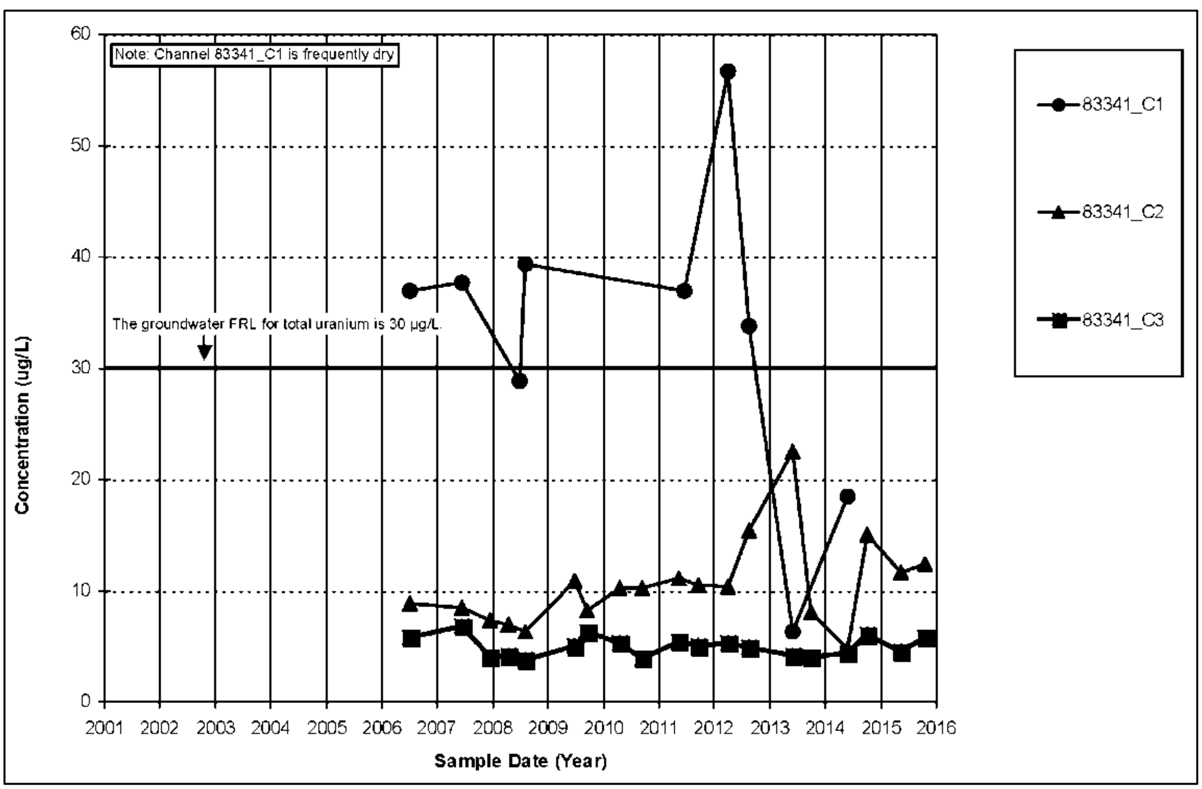

Figure A.2-7. Total Uranium Concentration Versus Time Plot for Monitoring Well 83341

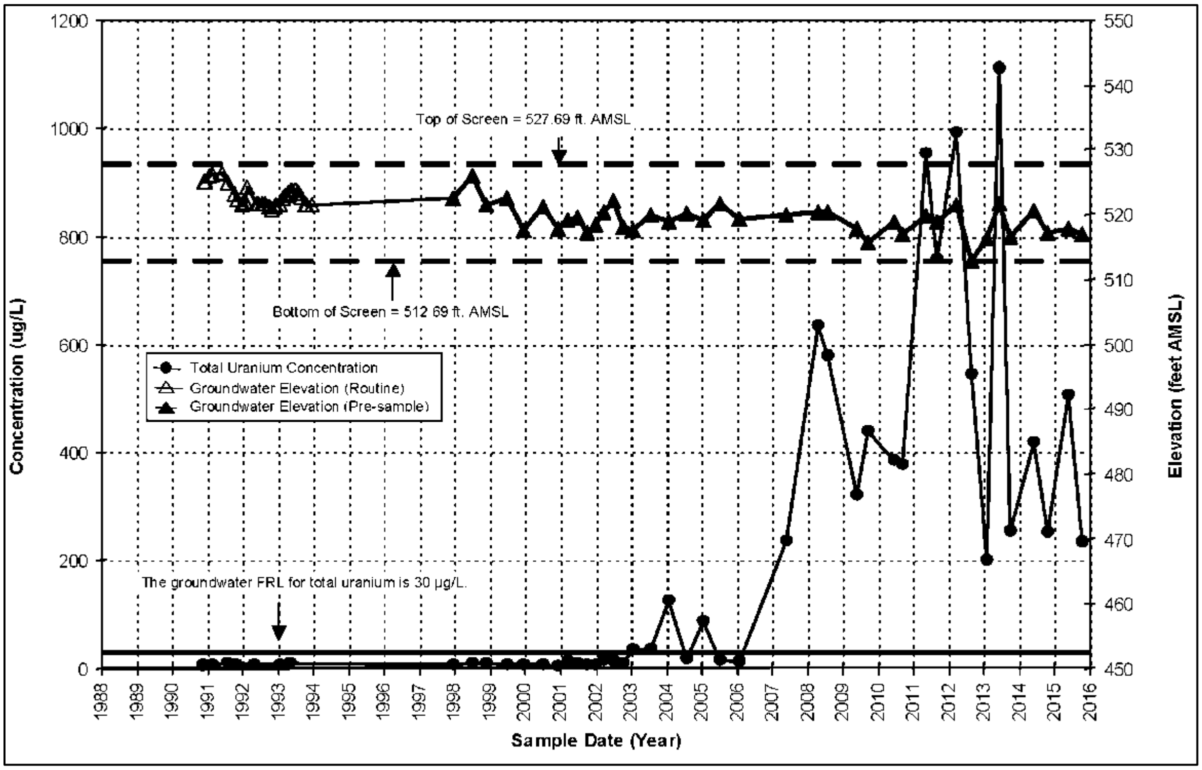

Figure A.2-8. Total Uranium Concentration Versus Time Plot for Monitoring Well 2649

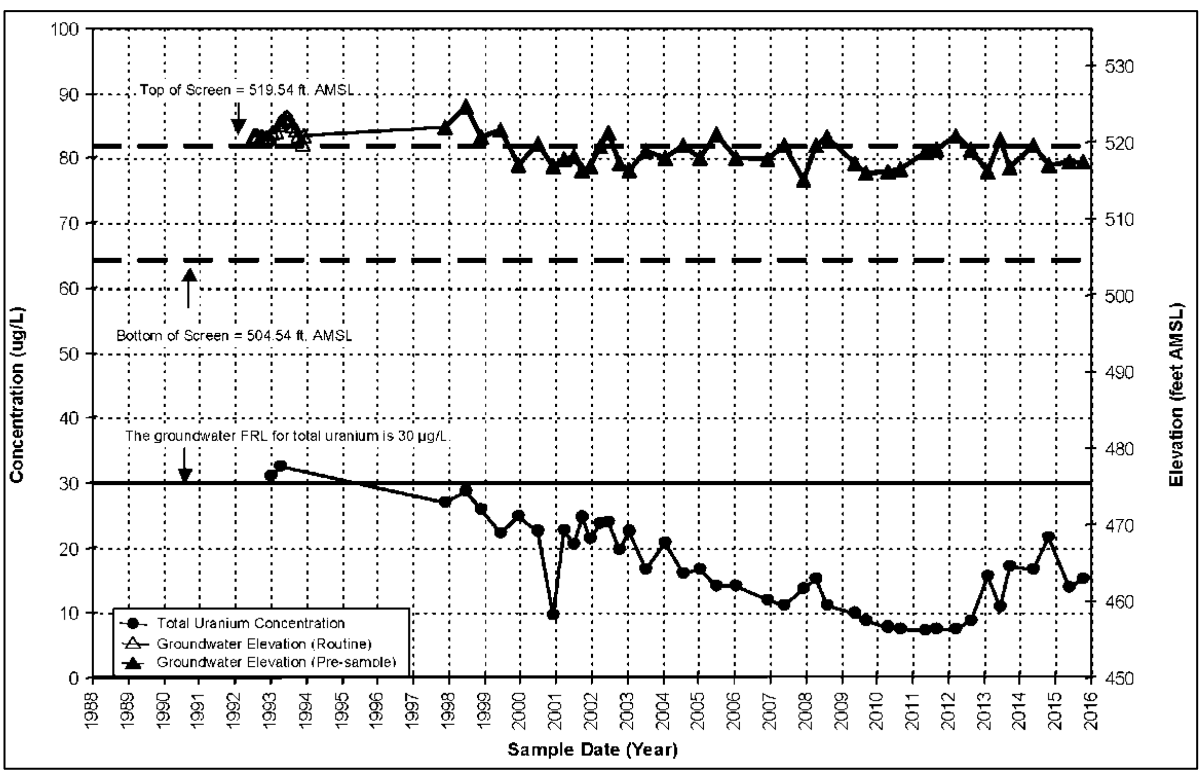

Figure A.2-9. Total Uranium Concentration Versus Time Plot for Monitoring Well 2821

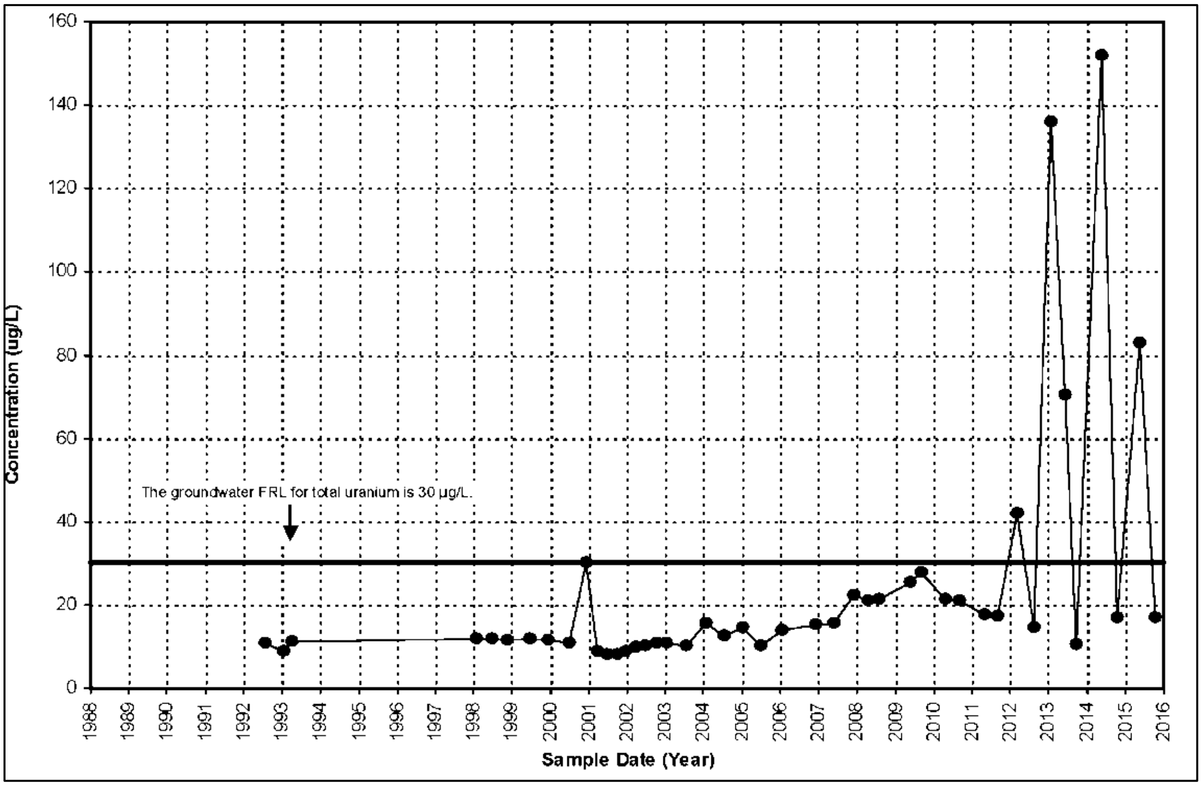

Figure A.2-10. Total Uranium Concentration Versus Time Plot for Monitoring Well 3821

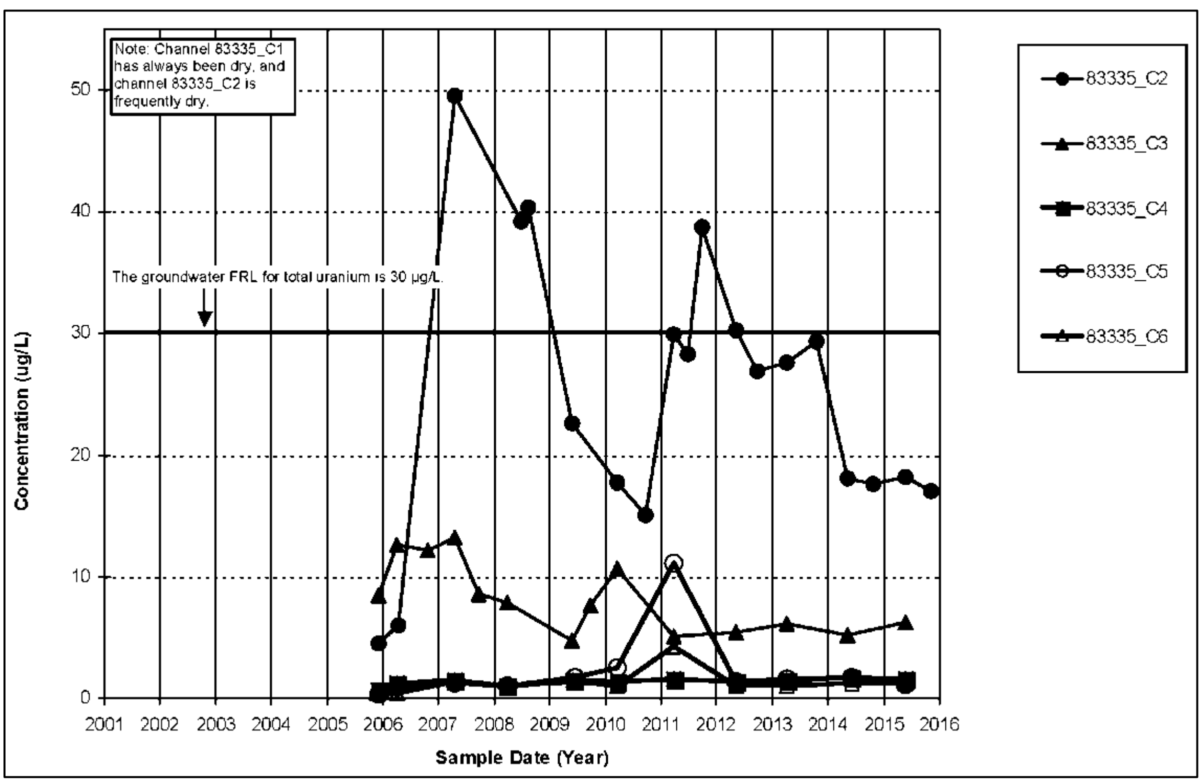

Figure A.2-11. Total Uranium Concentration Versus Time Plot for Monitoring Well 83335

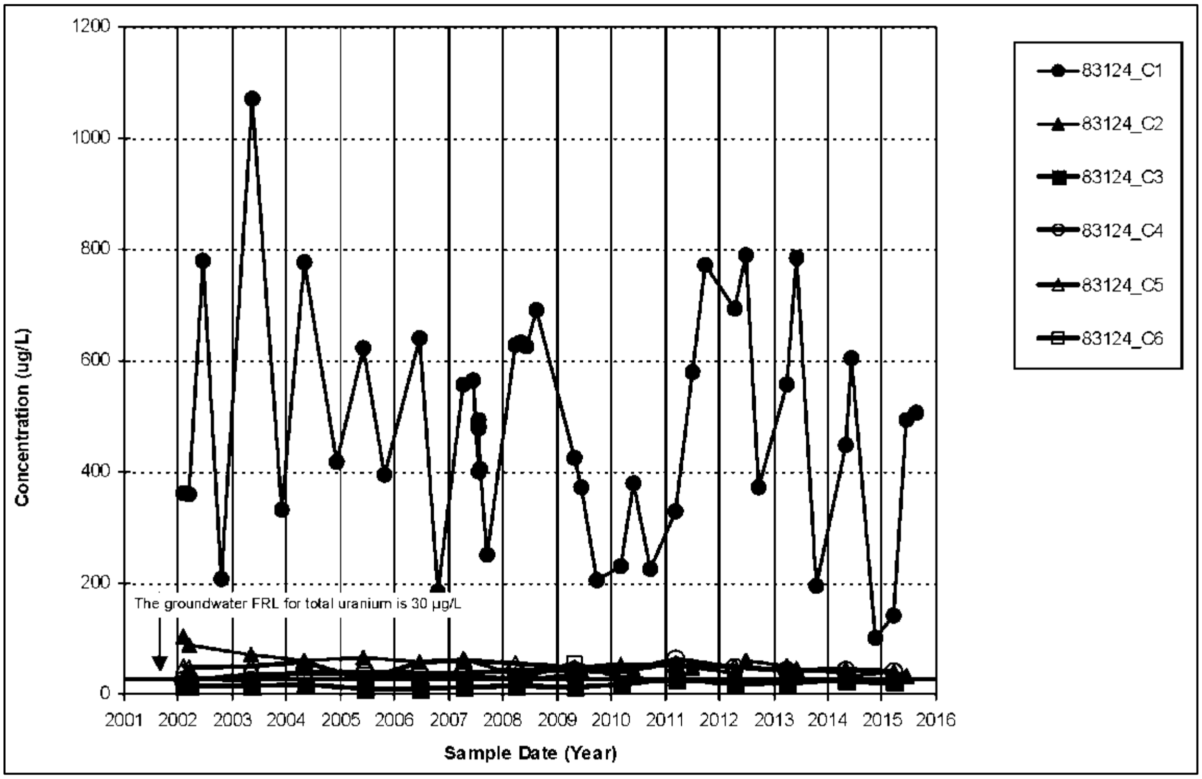

Figure A.2-12. Total Uranium Concentration Versus Time Plot for Monitoring Well 83124

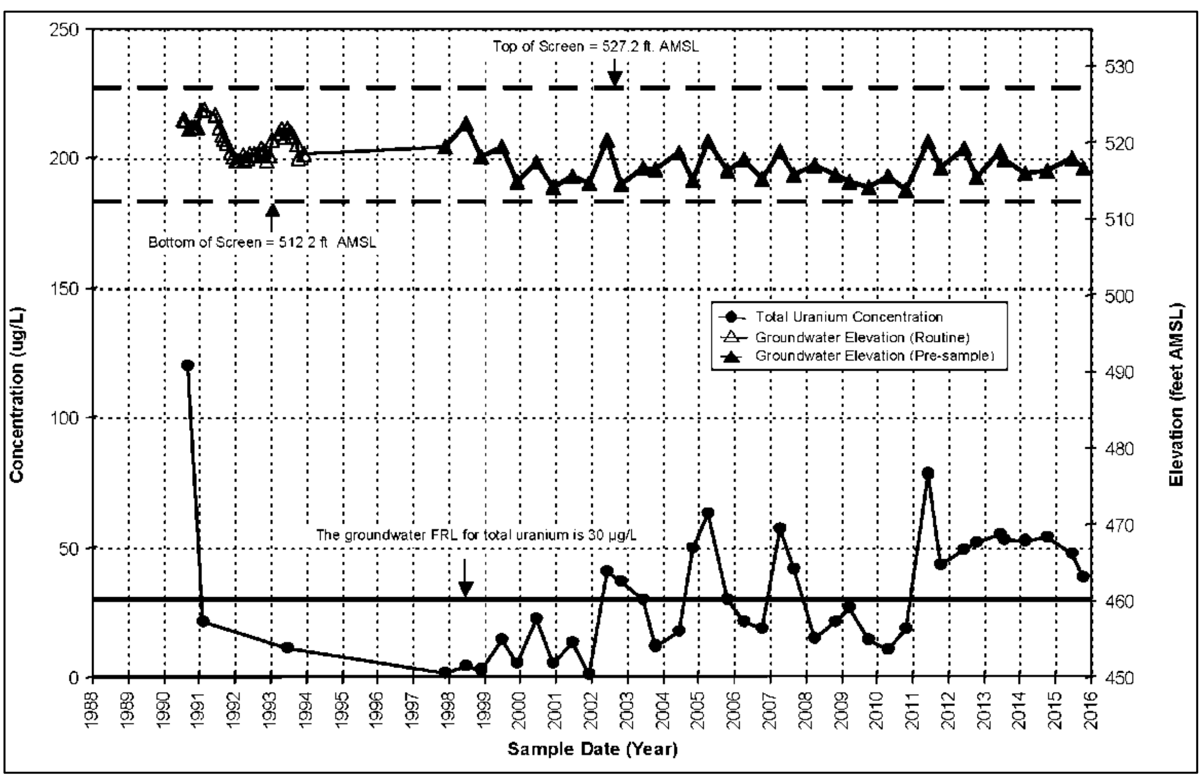

Figure A.2-13. Total Uranium Concentration Versus Time Plot for Monitoring Well 2389

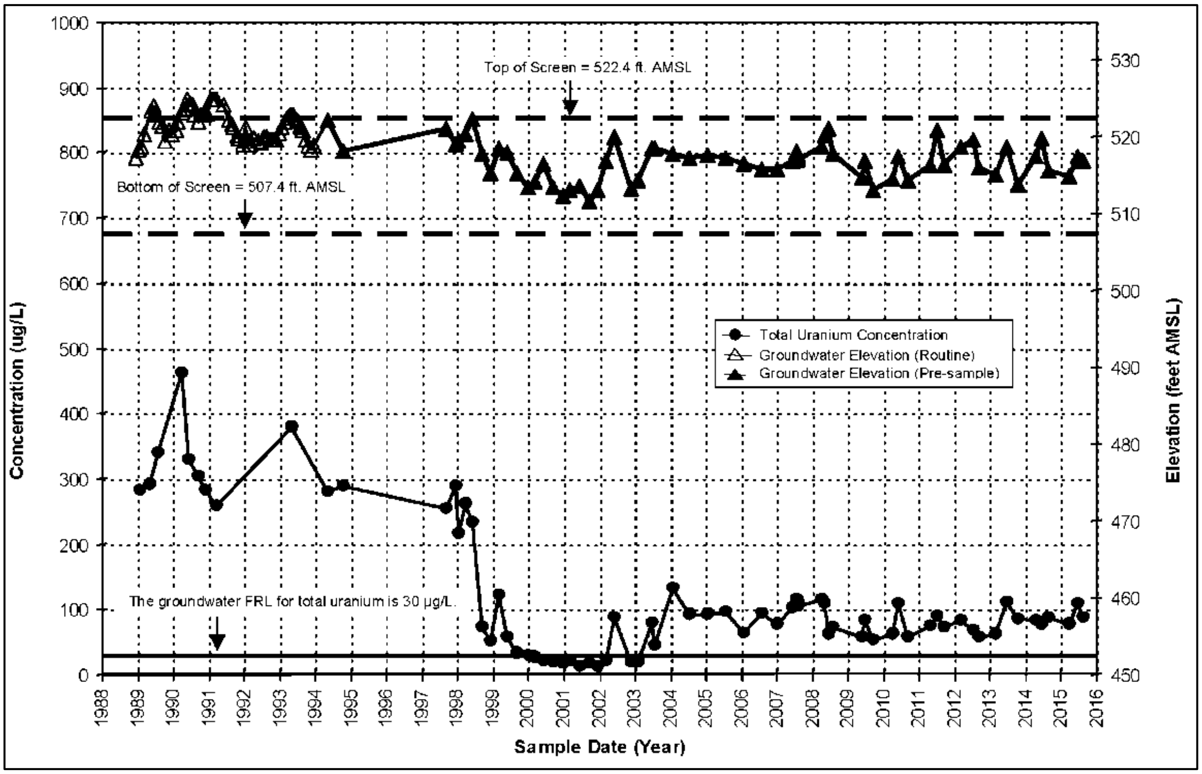

Figure A.2-14. Total Uranium Concentration Versus Time Plot for Monitoring Well 2045

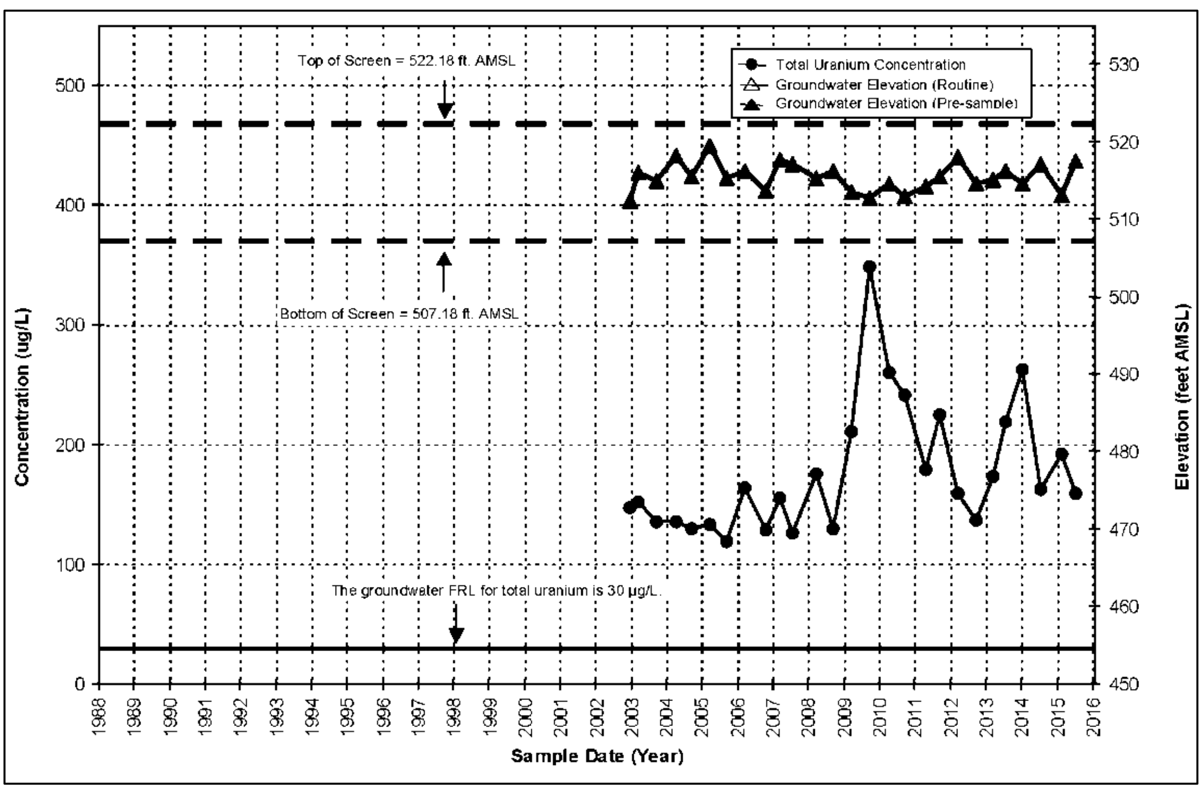

Figure A.2-15. Total Uranium Concentration Versus Time Plot for Monitoring Well 23275

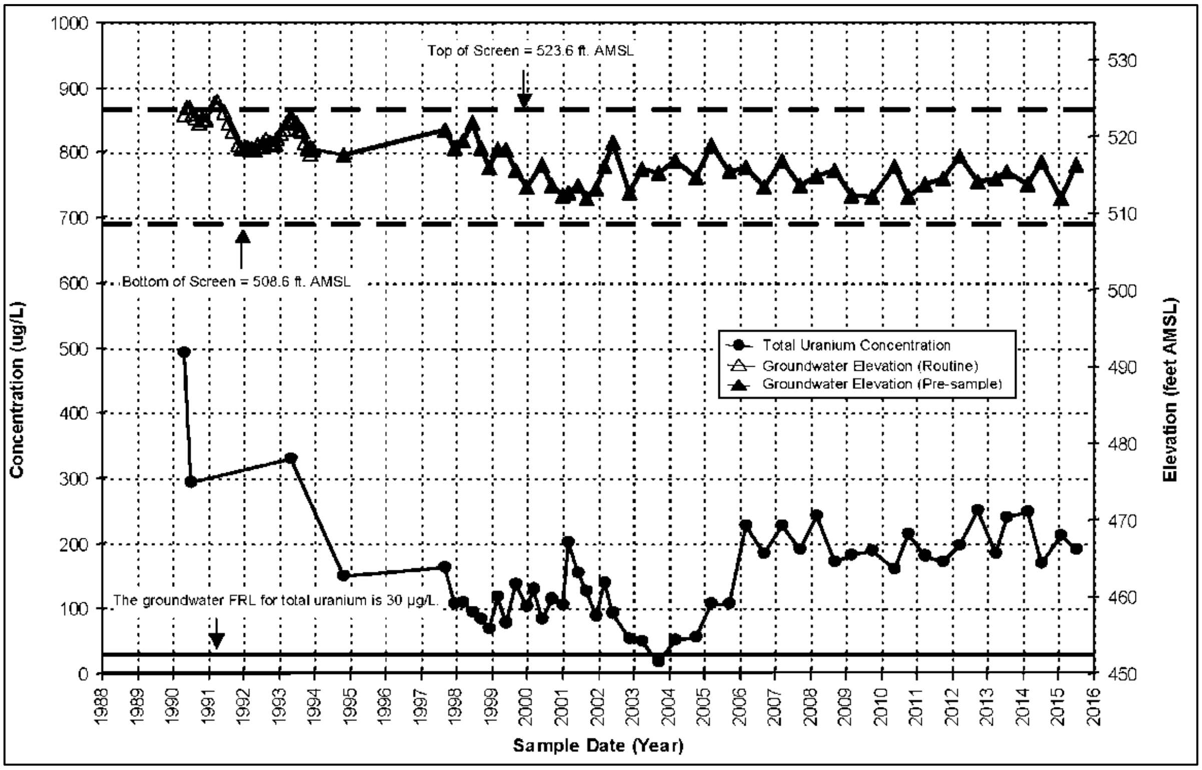

Figure A.2-16. Total Uranium Concentration Versus Time Plot for Monitoring Well 2387

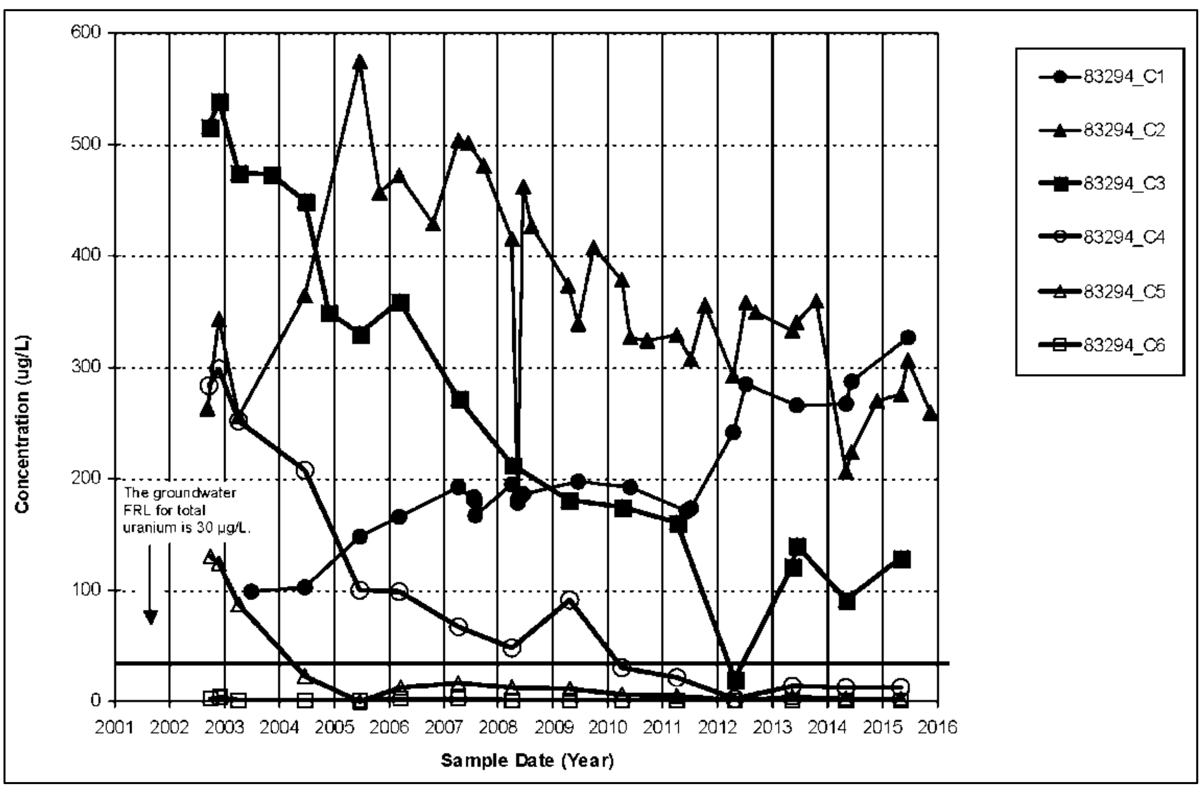

Figure A.2-17. Total Uranium Concentration Versus Time Plot for Monitoring Well 83294

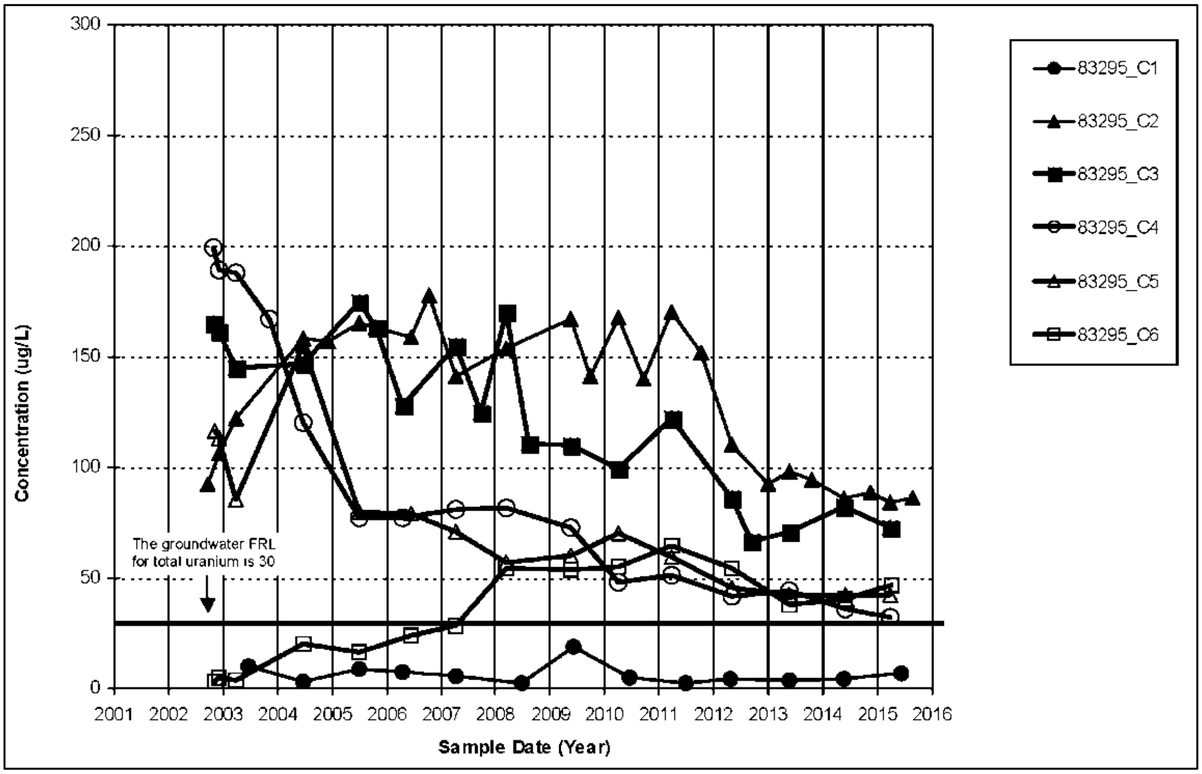

Figure A.2-18. Total Uranium Concentration Versus Time Plot for Monitoring Well 83295

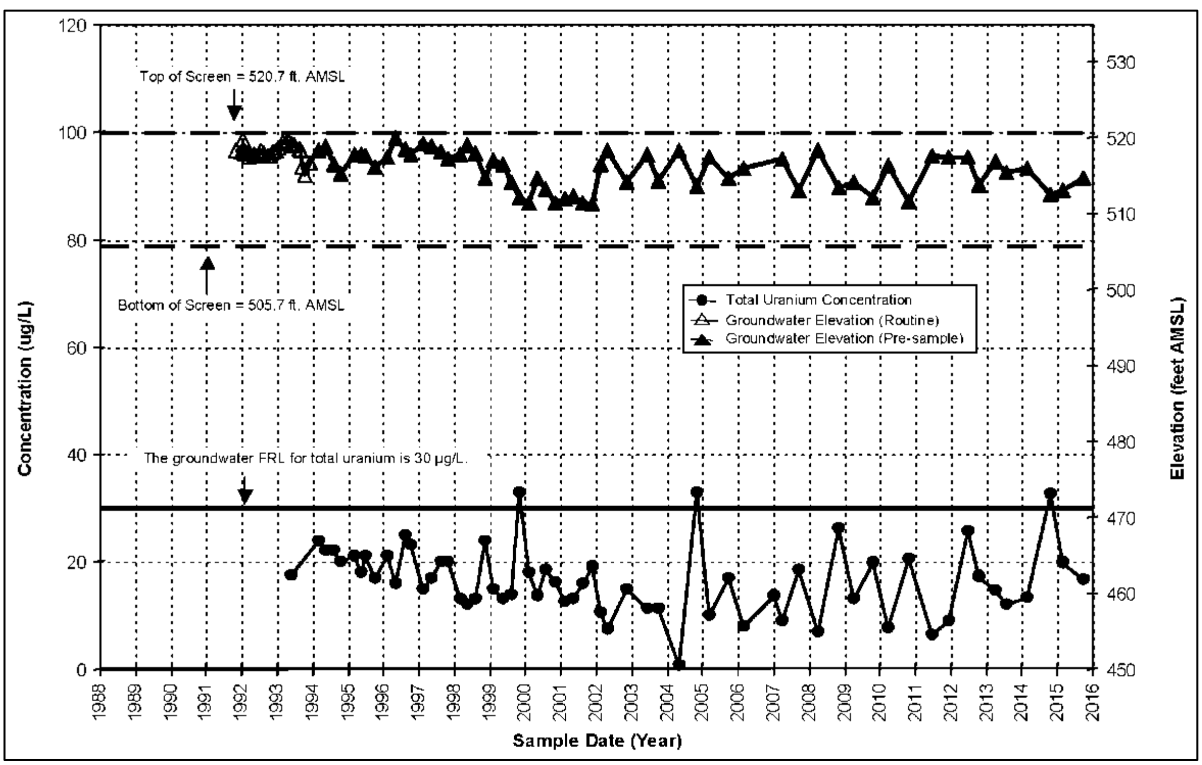

Figure A.2-19. Total Uranium Concentration Versus Time Plot for Monitoring Well 2552

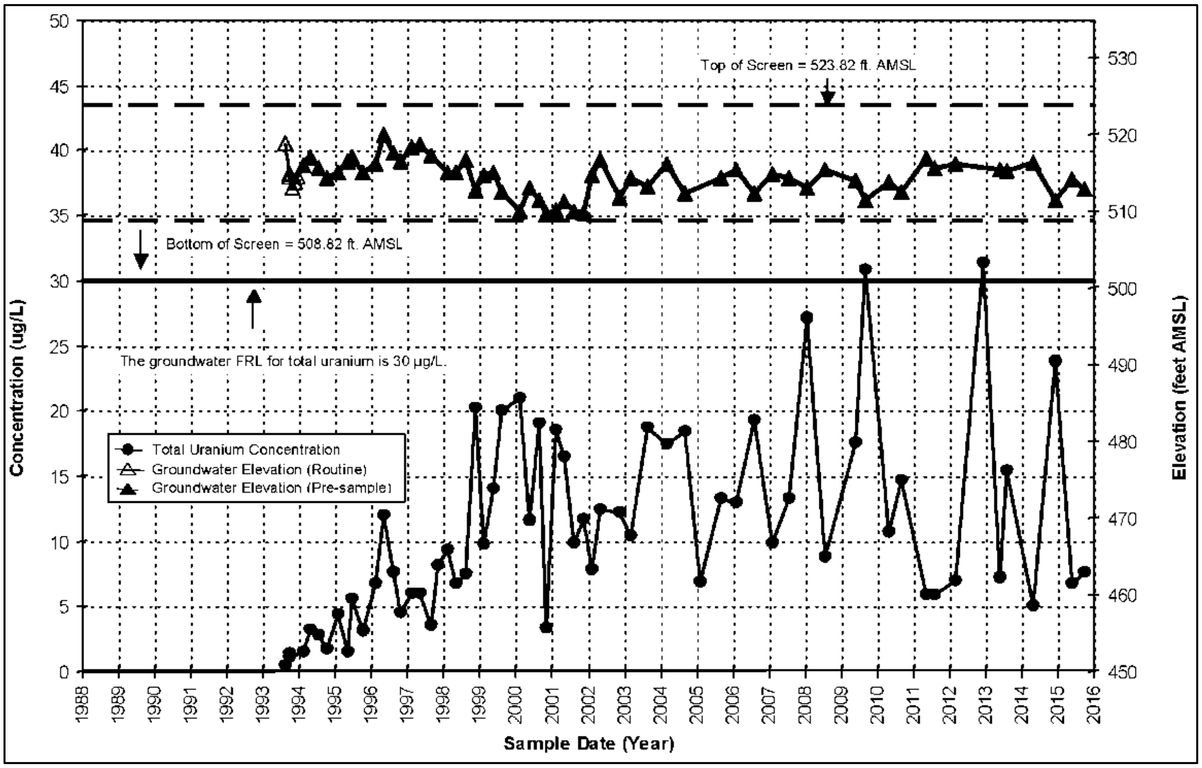

Figure A.2-20. Total Uranium Concentration Versus Time Plot for Monitoring Well 2900

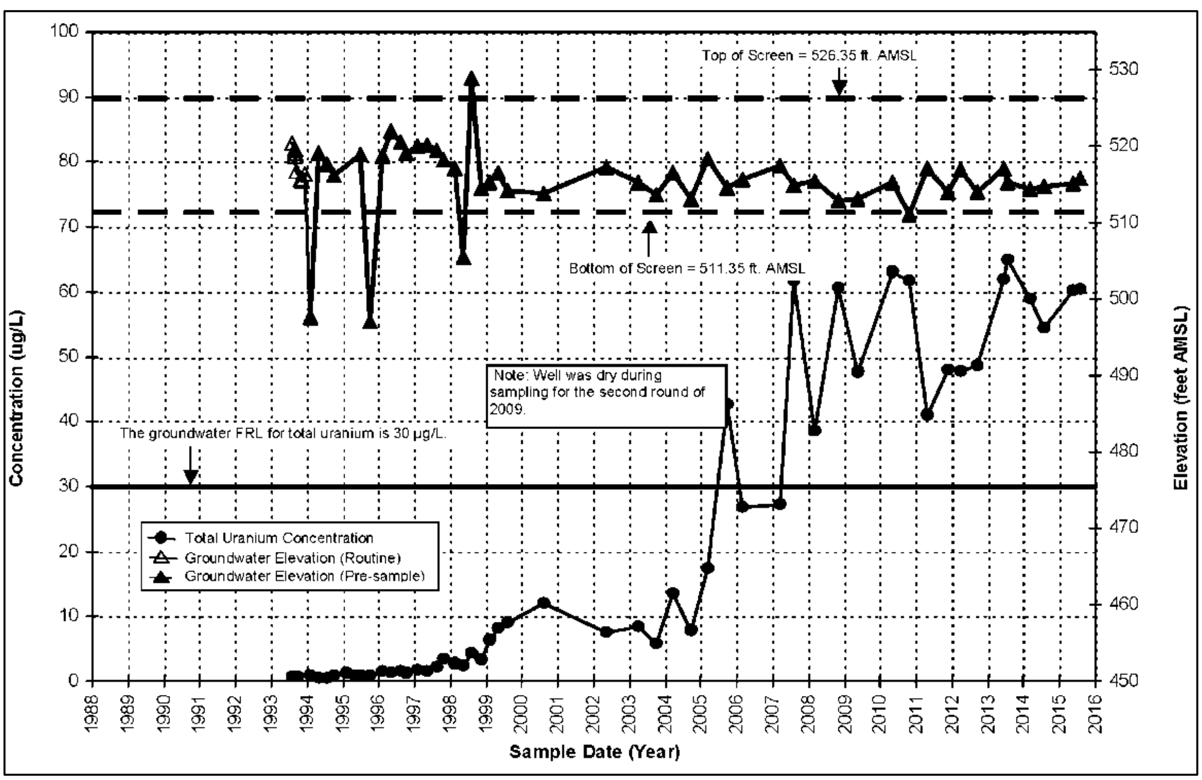

Figure A.2-21. Total Uranium Concentration Versus Time Plot for Monitoring Well 2880

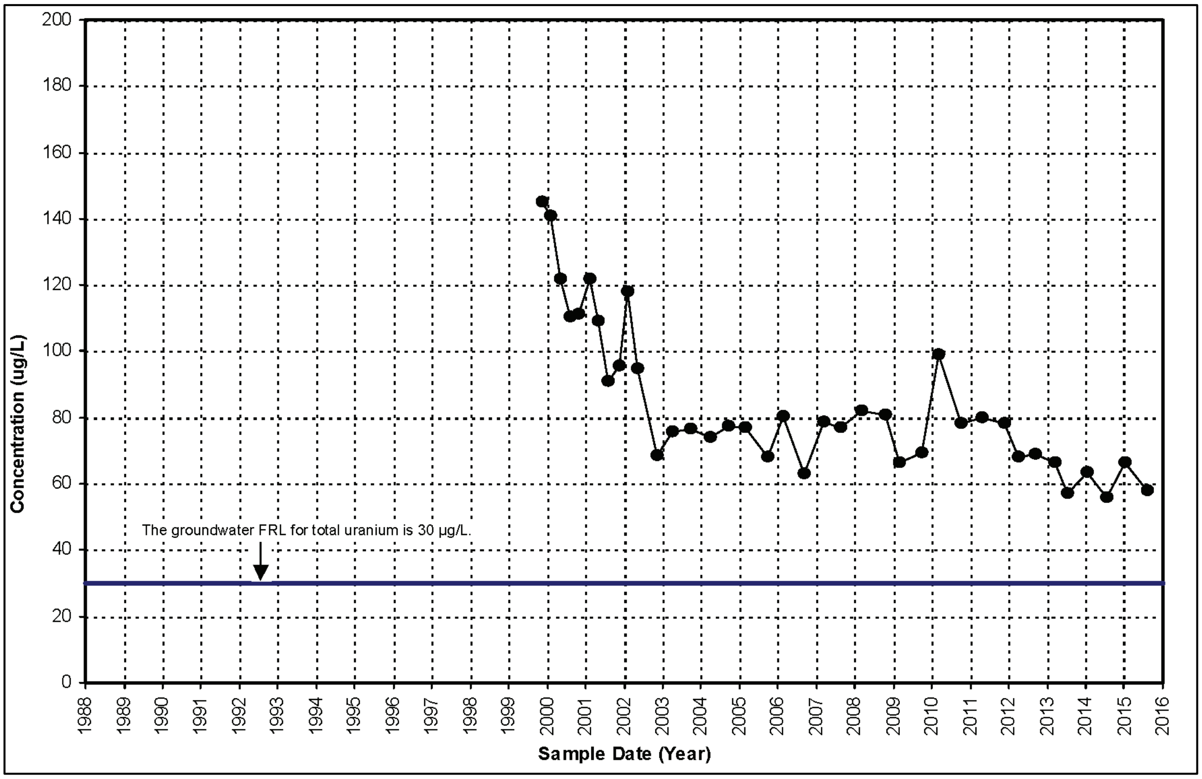

Figure A.2-22. Total Uranium Concentration Versus Time Plot for Monitoring Well 6880

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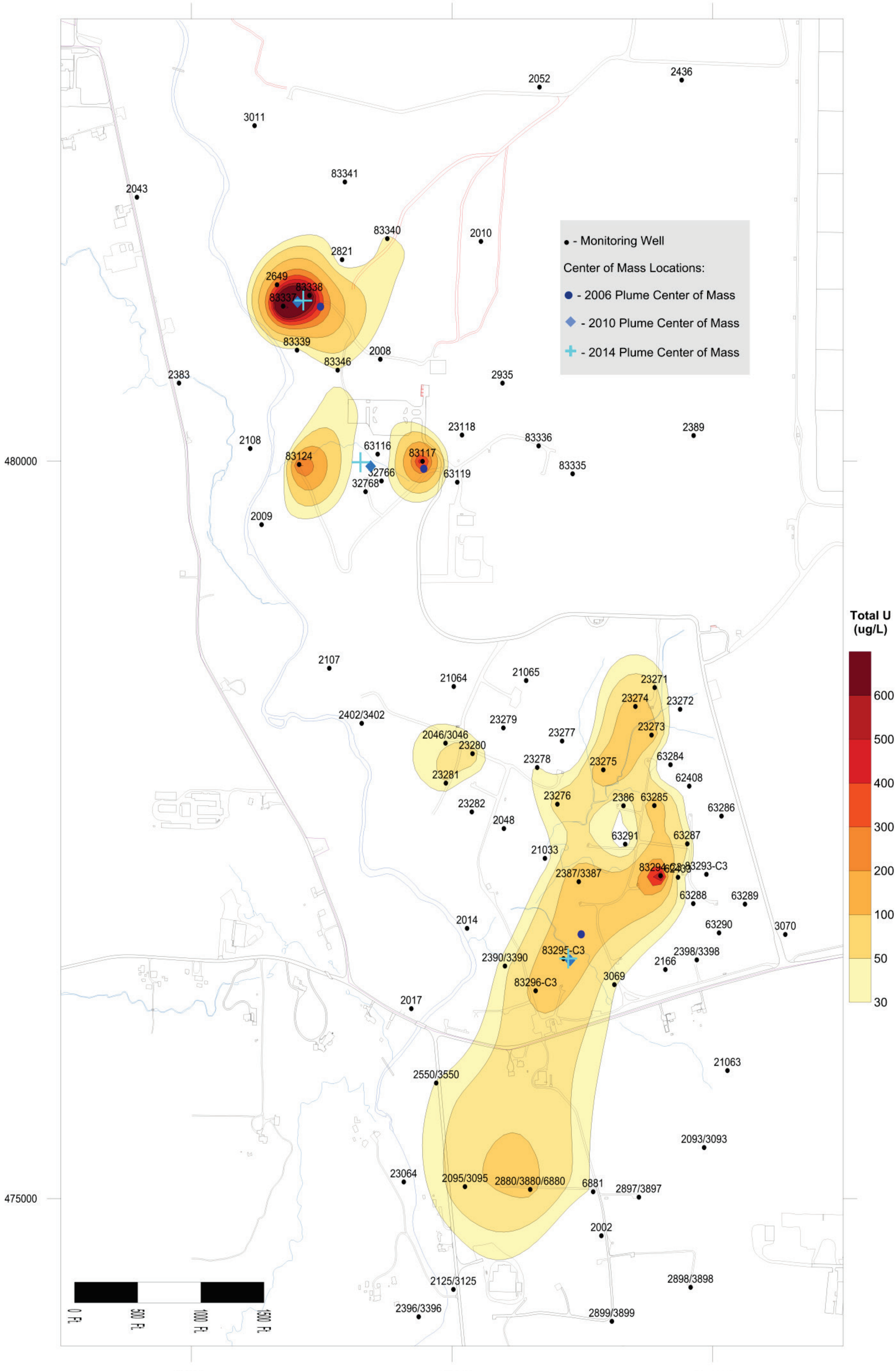


Figure A.2-23. Center of Mass Plume Results

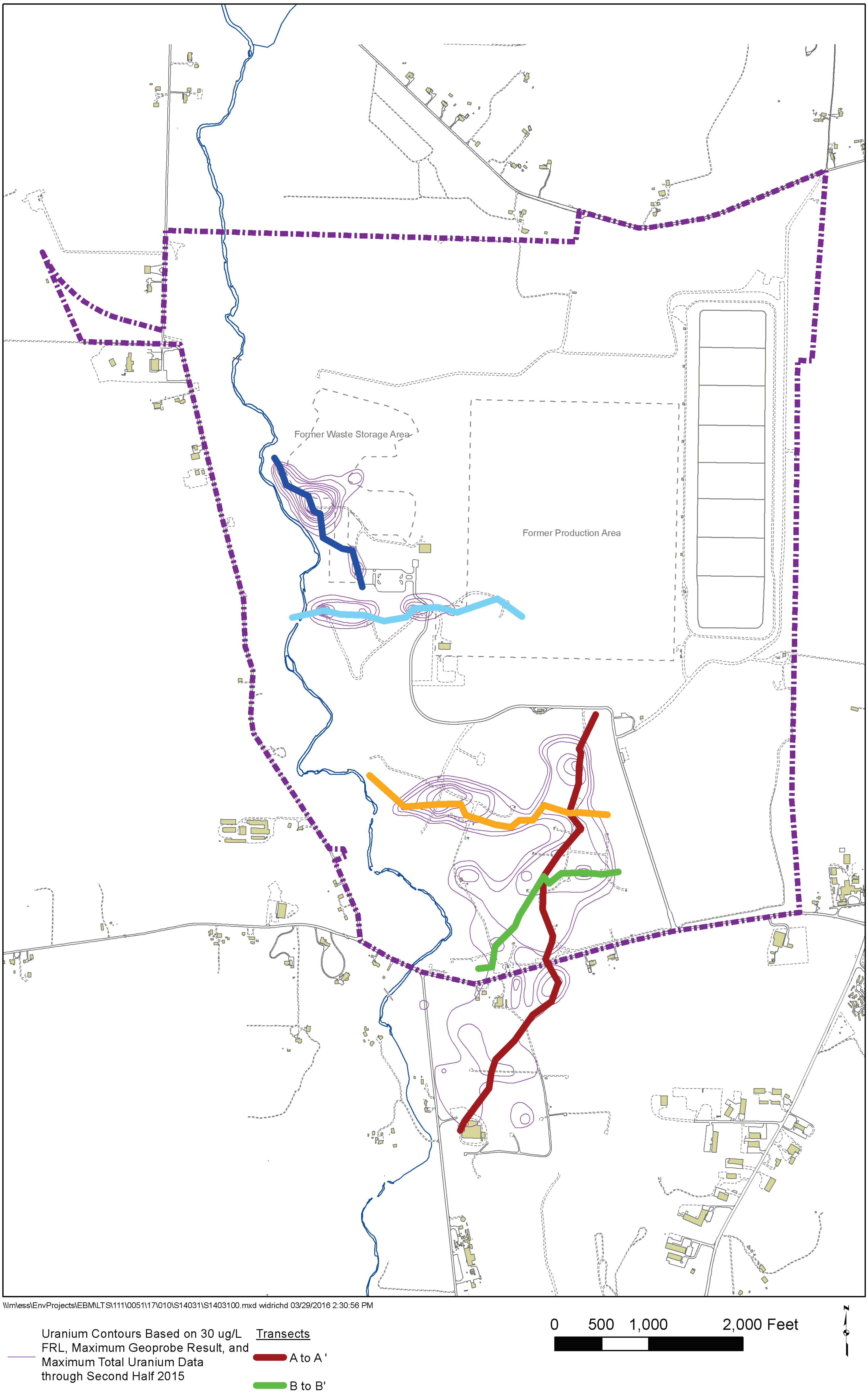


Figure A.2-24A. Cross Section Location Map

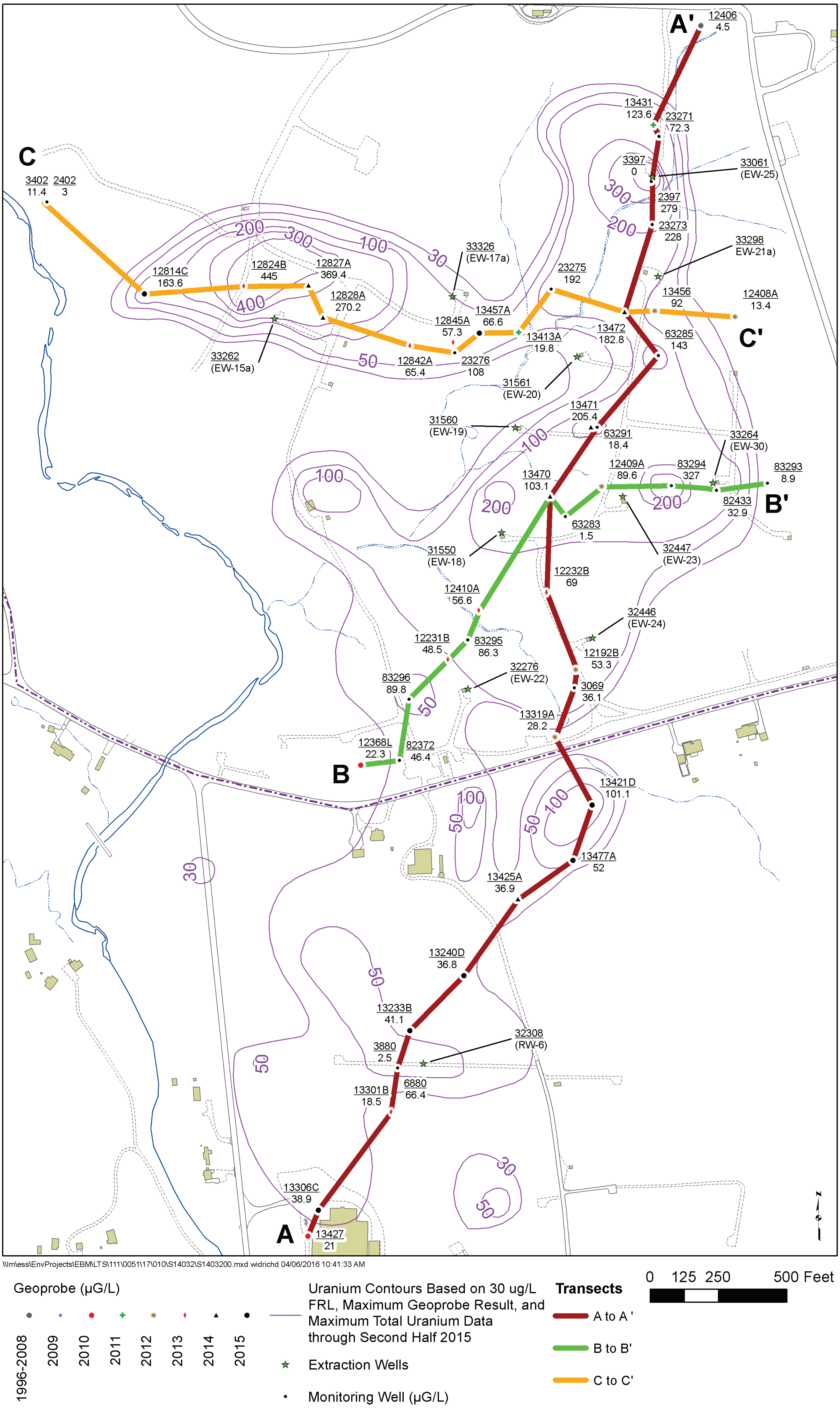


Figure A.2-24B. South Cross Section Location Map

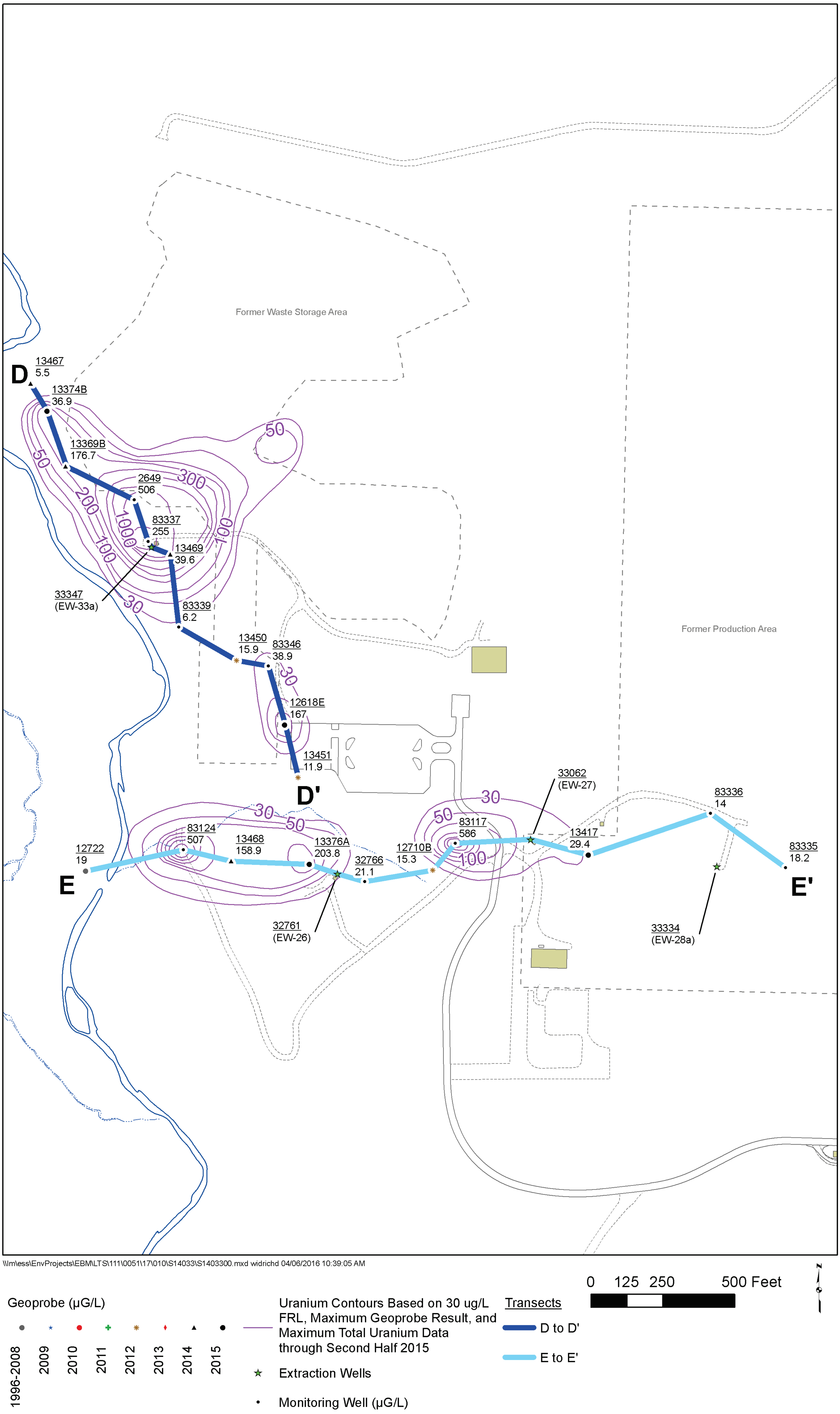


Figure A.2-24C. North Cross Section Location Map

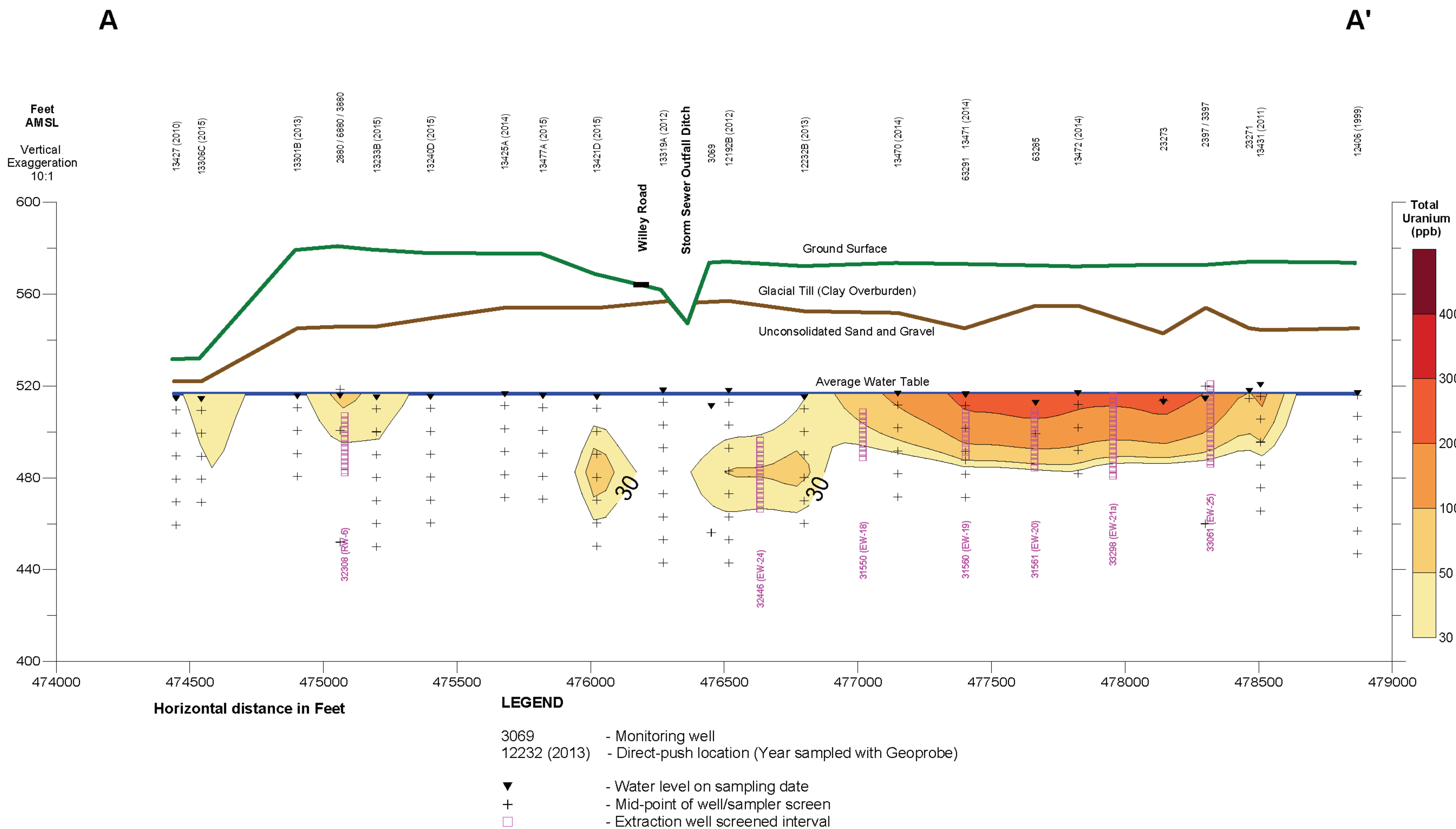
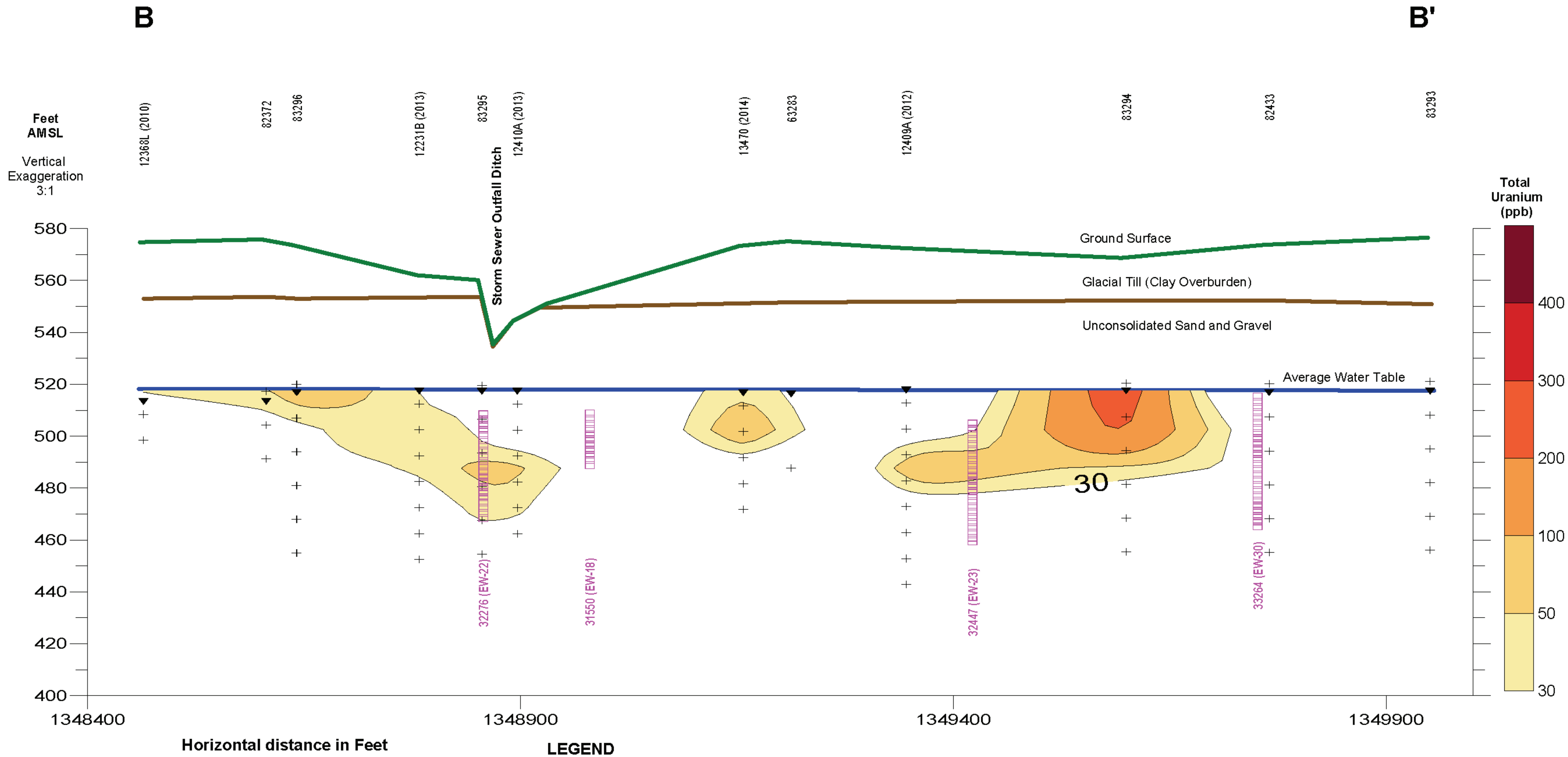


Figure A.2-25. Total Uranium Cross Section A–A'

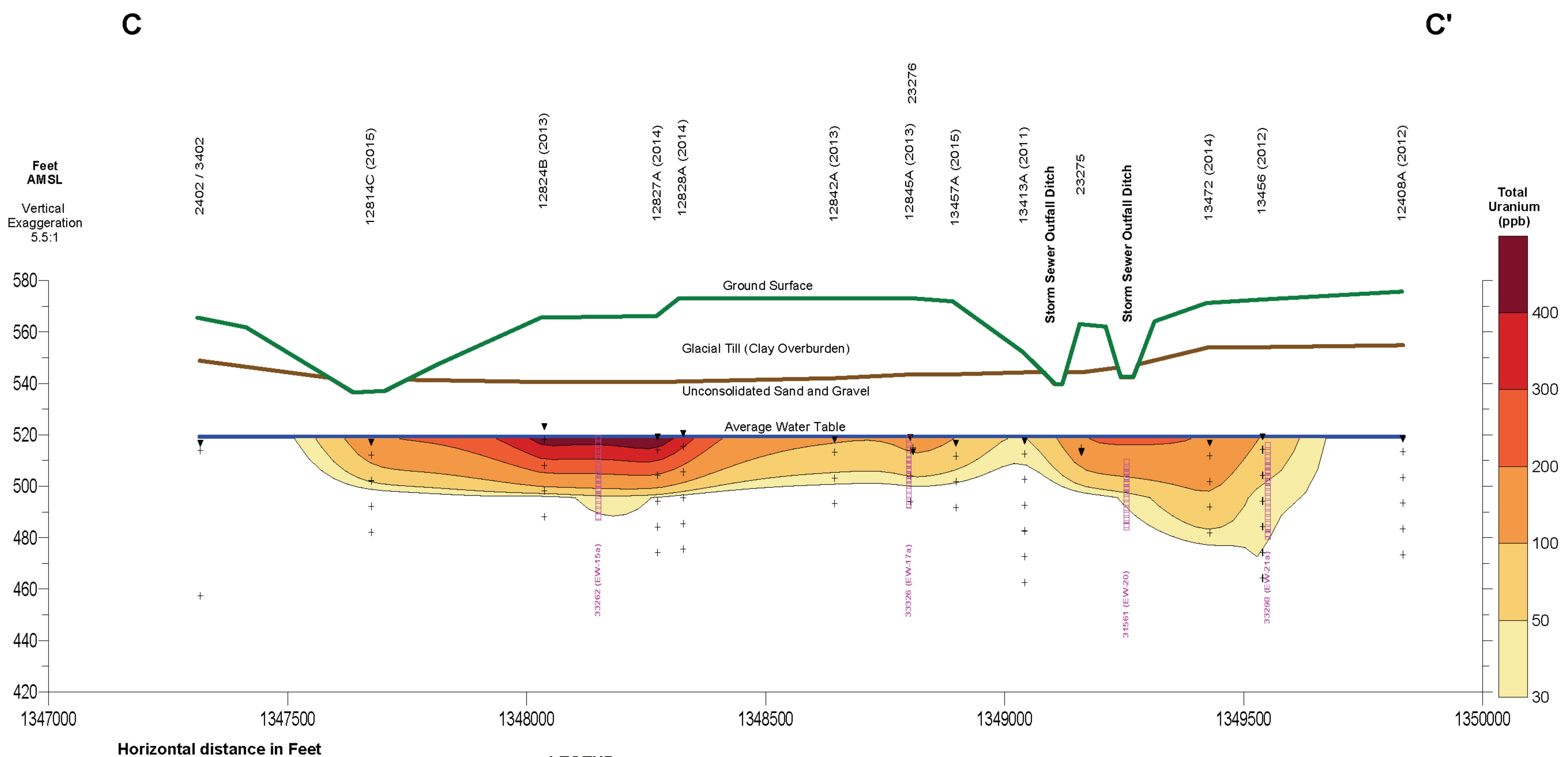


LEGEND

3069 - Monitoring well
12232 (2013) - Direct-push location (Year sampled with Geoprobe)

▼ - Water level on sampling date
+ - Mid-point of well/sampler screen
□ - Extraction well screened interval

Figure A.2-26. Total Uranium Cross Section B-B'

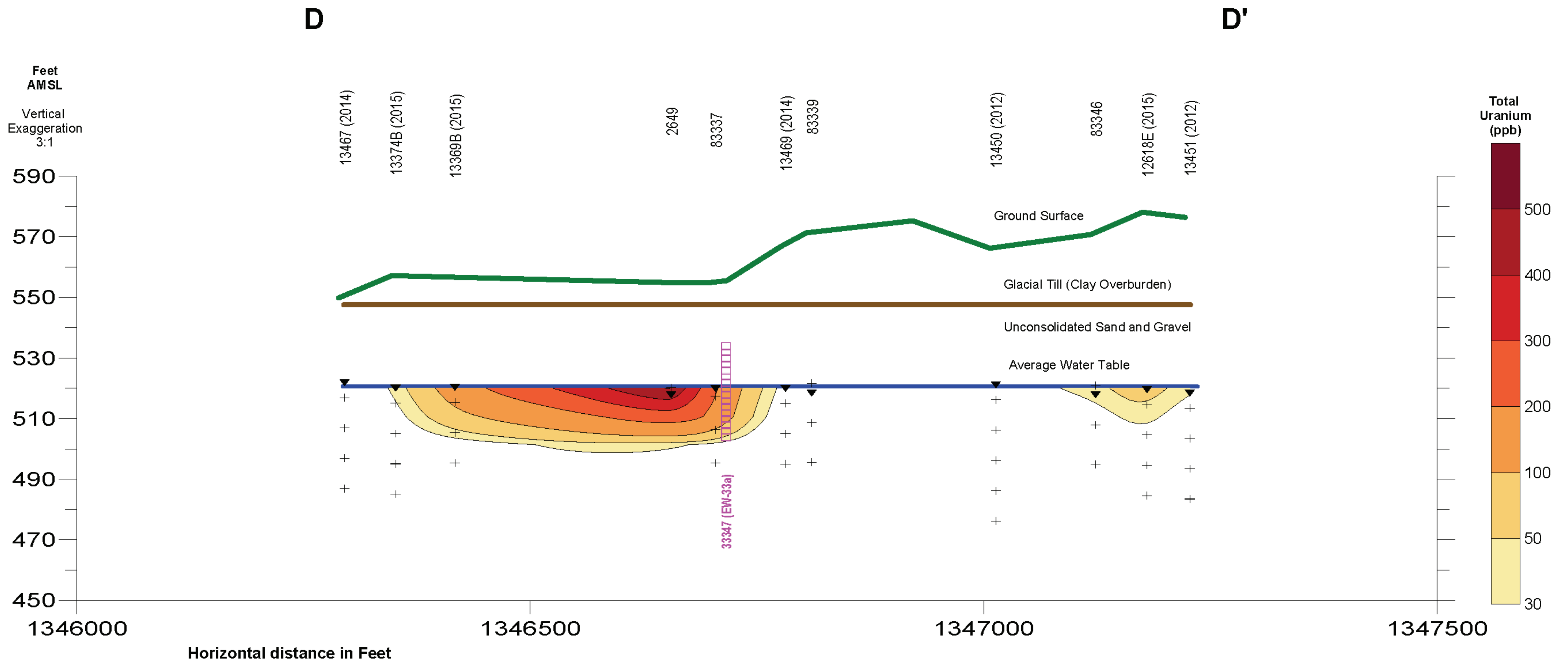


LEGEND

3069 - Monitoring well
12232 (2013) - Direct-push location (Year sampled with Geoprobe)

▼ - Water level on sampling date
+ - Mid-point of well/sampler screen
□ - Extraction well screened interval

Figure A.2-27. Total Uranium Cross Section C-C'

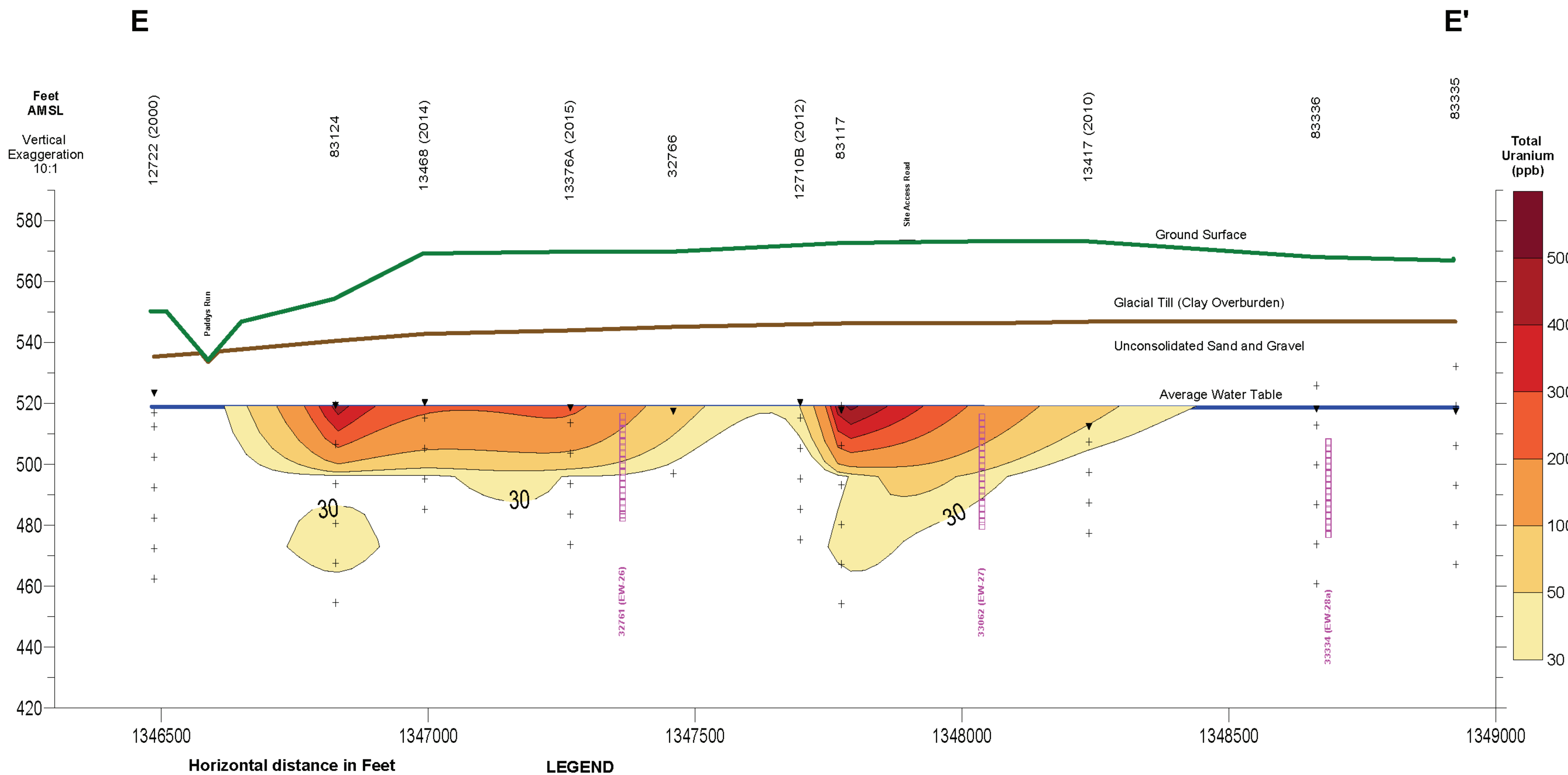


LEGEND

3069 - Monitoring well
12232 (2013) - Direct-push location (Year sampled with Geoprobe)

▼ - Water level on sampling date
+ - Mid-point of well/sampler screen
□ - Extraction well screened interval

Figure A.2-28. Total Uranium Cross Section D-D'



LEGEND

3069 - Monitoring well

12232 (2013) - Direct-push location (Year sampled with Geoprobe)

▼ - Water level on sampling date

+ - Mid-point of well/sampler screen

□ - Extraction well screened interval

Figure A.2-29. Total Uranium Cross Section E-E'

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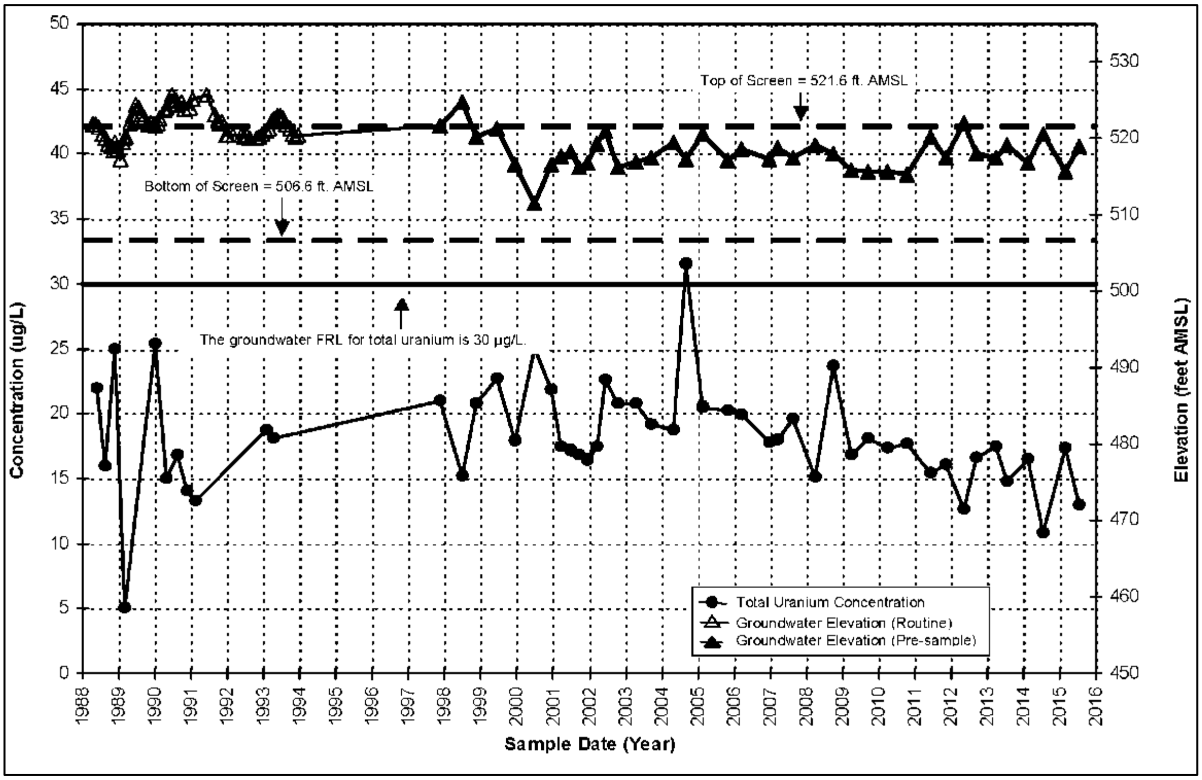

Figure A.2-30. Total Uranium Concentration Versus Time Plot for Monitoring Well 2008

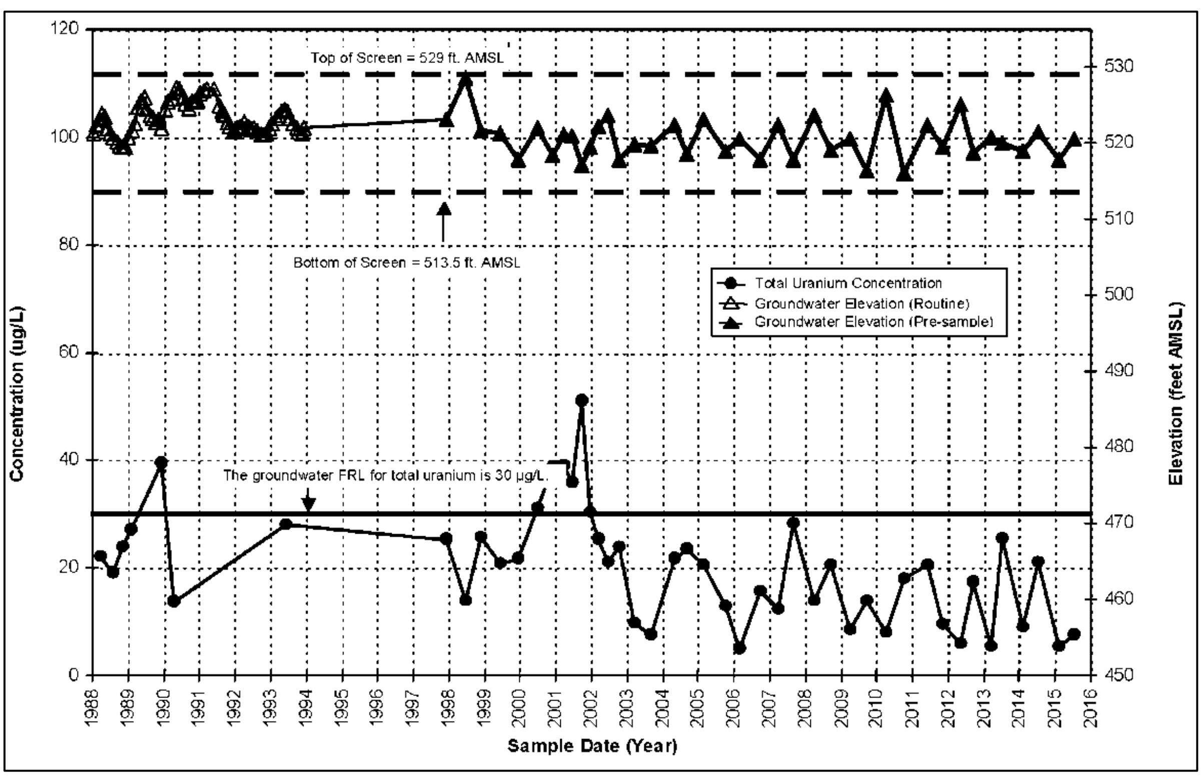

Figure A.2-31. Total Uranium Concentration Versus Time Plot for Monitoring Well 2009

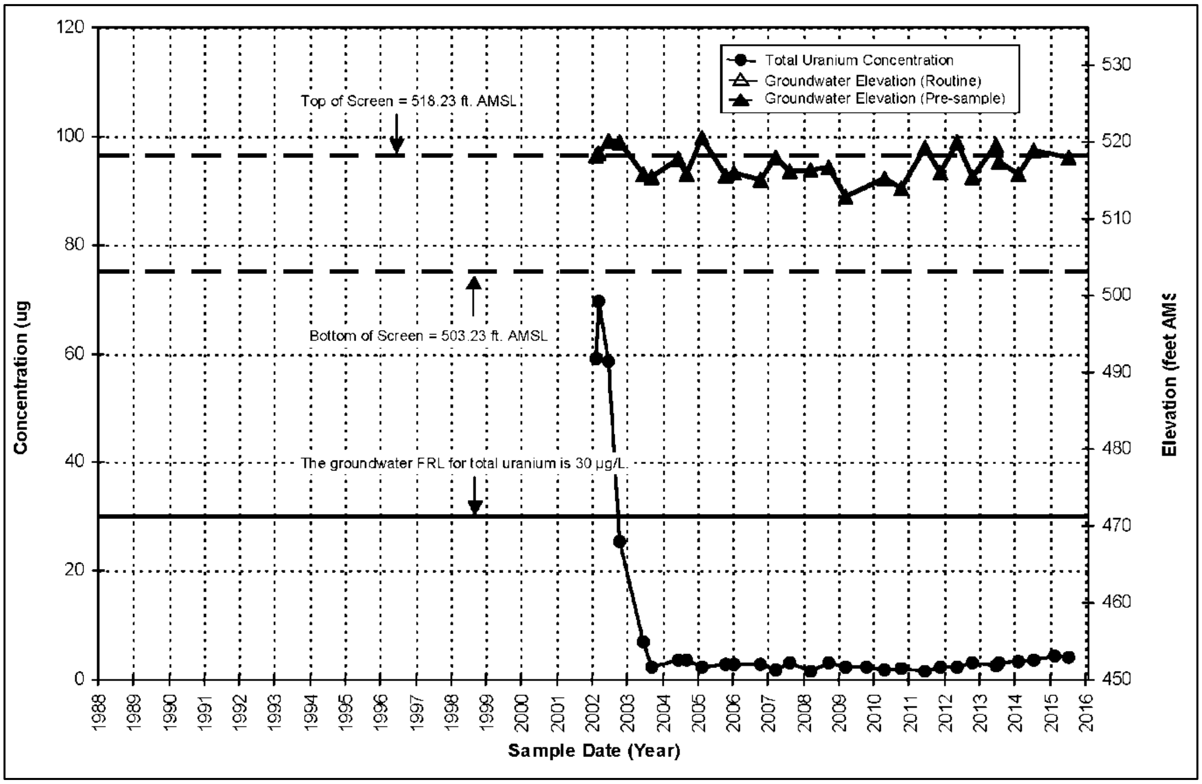

Figure A.2-32. Total Uranium Concentration Versus Time Plot for Monitoring Well 23118

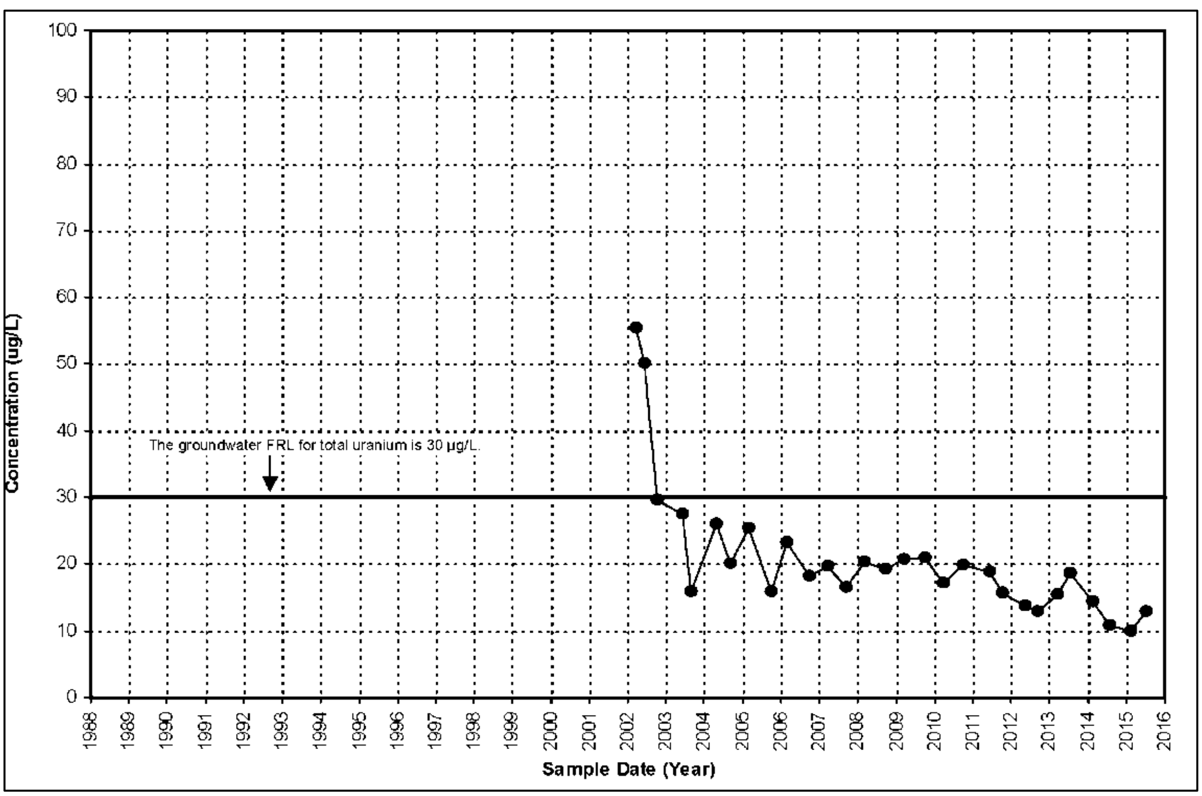

Figure A.2-33. Total Uranium Concentration Versus Time Plot for Monitoring Well 32768

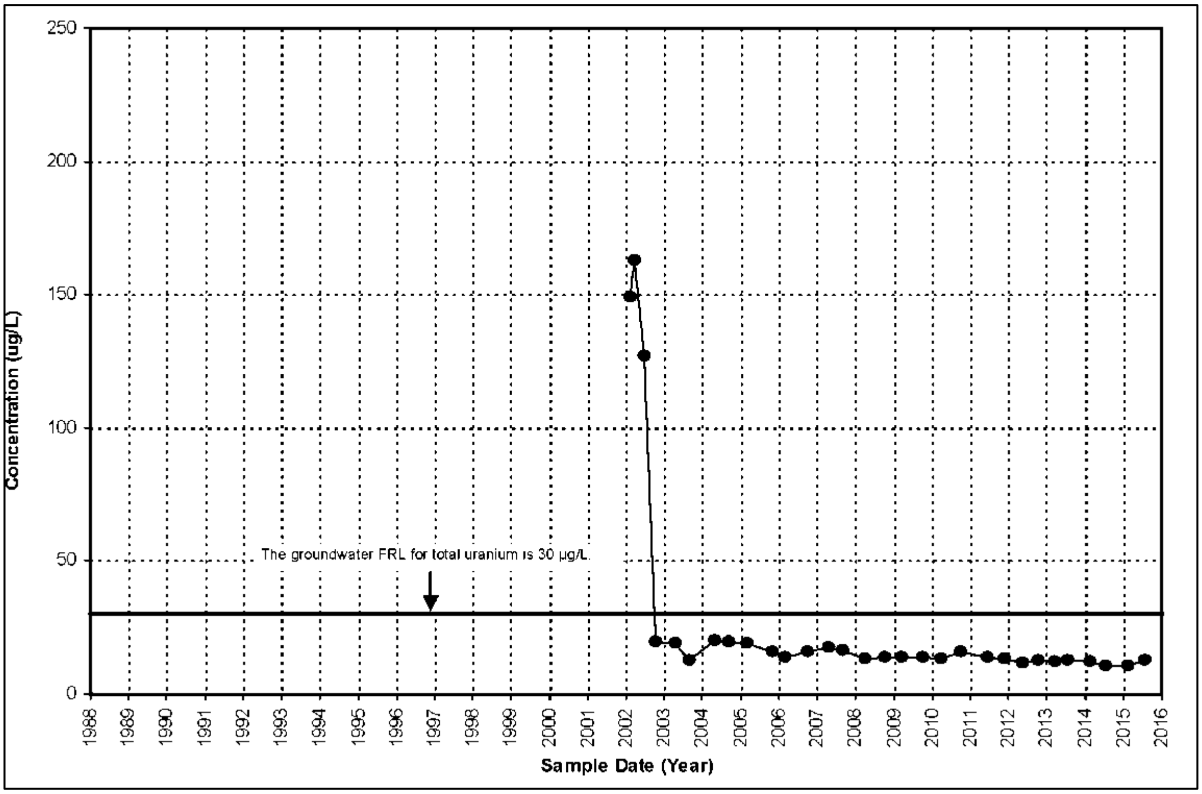

Figure A.2-34. Total Uranium Concentration Versus Time Plot for Monitoring Well 63116

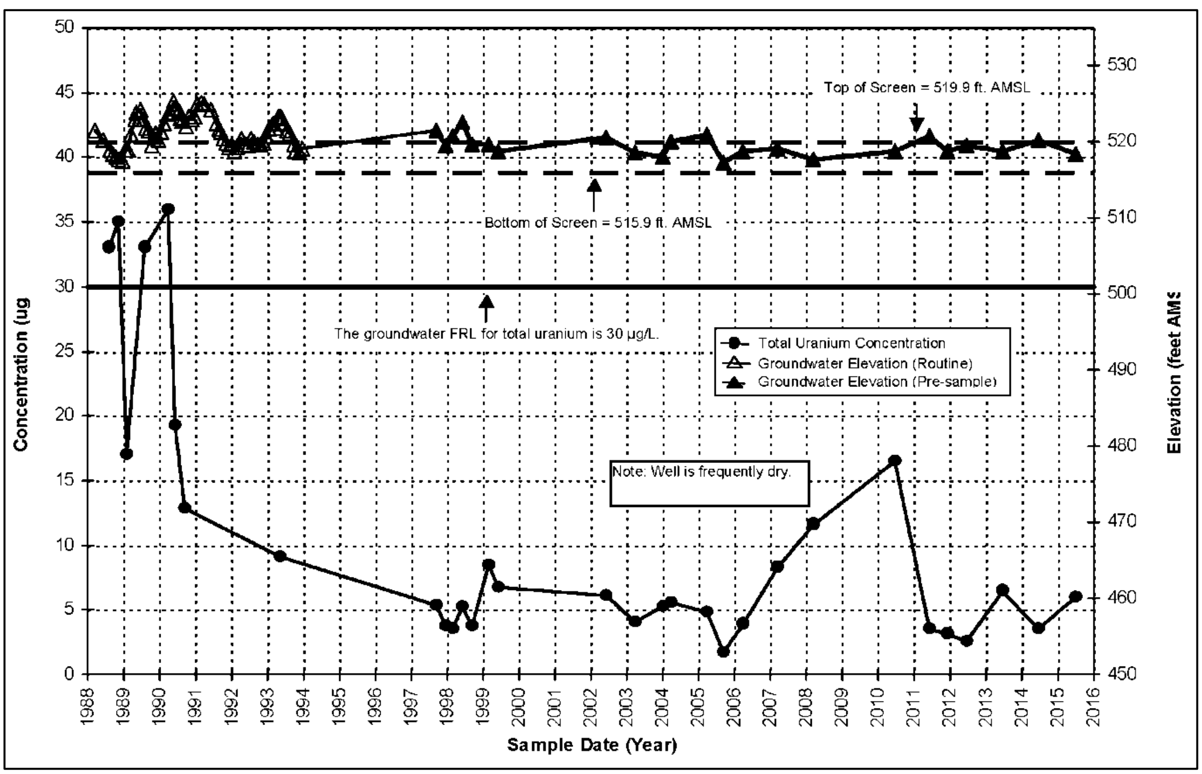

Figure A.2-35. Total Uranium Concentration Versus Time Plot for Monitoring Well 2014

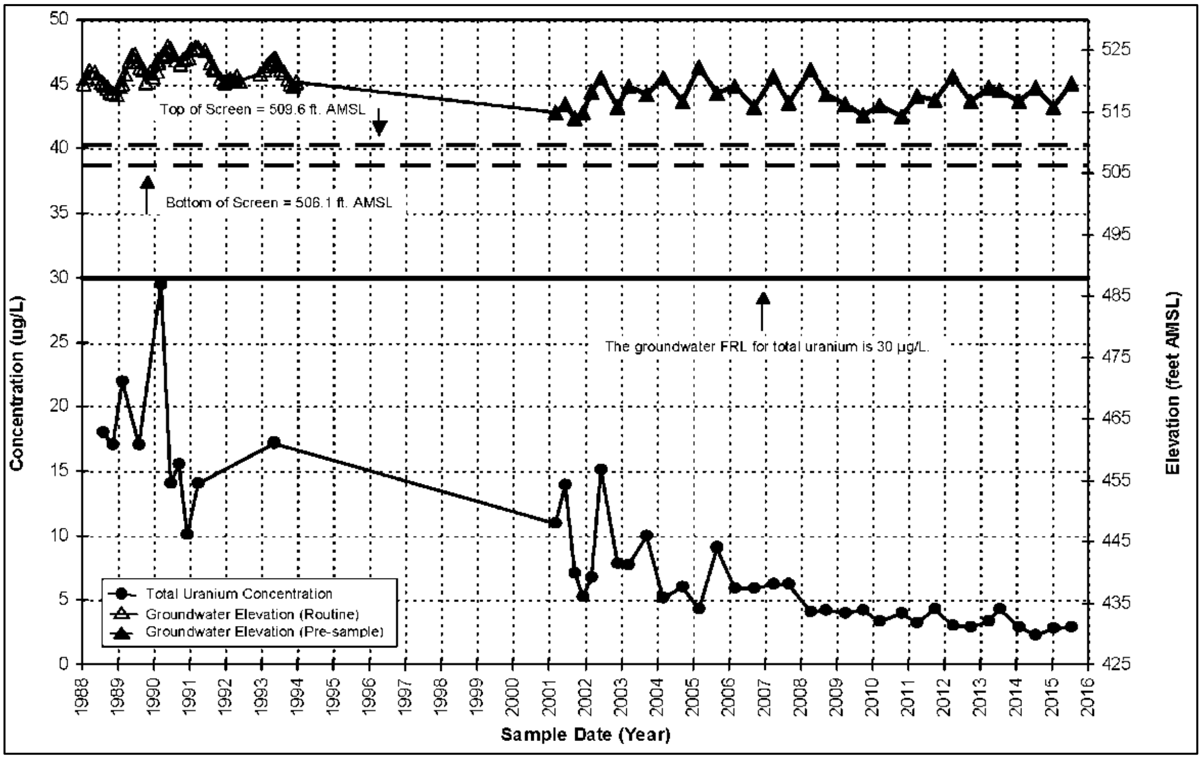

Figure A.2-36. Total Uranium Concentration Versus Time Plot for Monitoring Well 2016

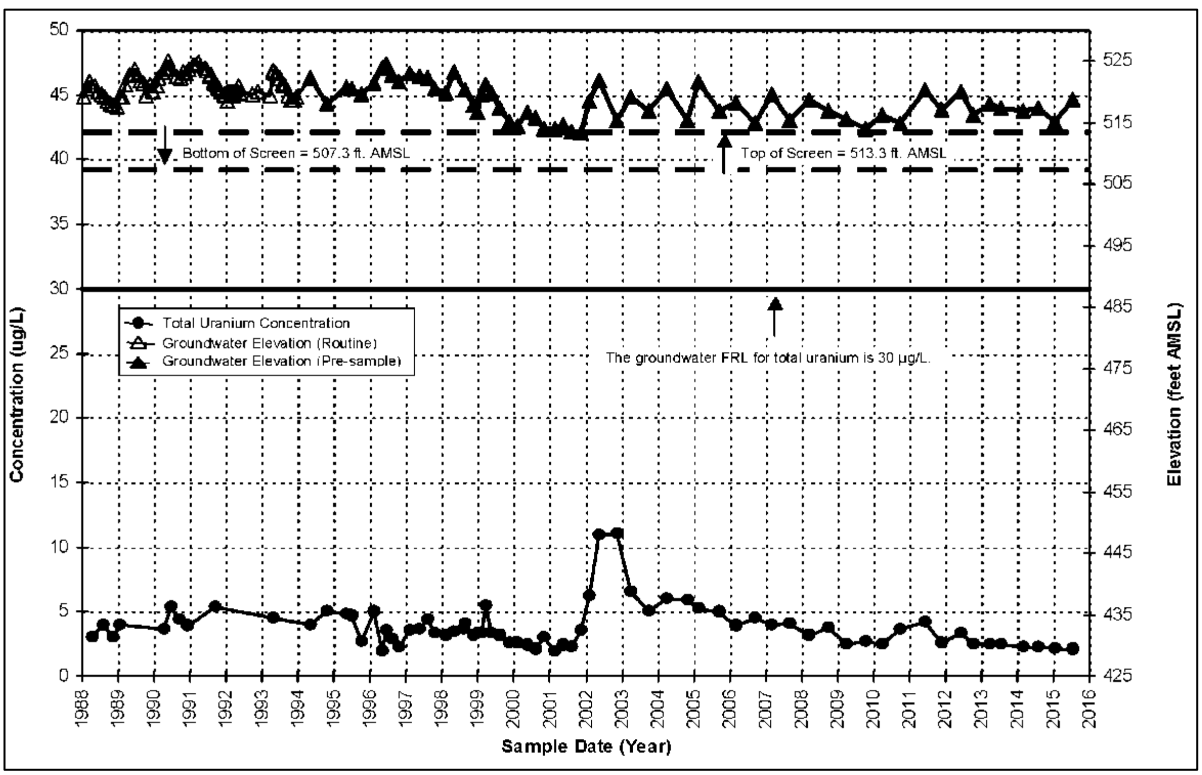

Figure A.2-37. Total Uranium Concentration Versus Time Plot for Monitoring Well 2017

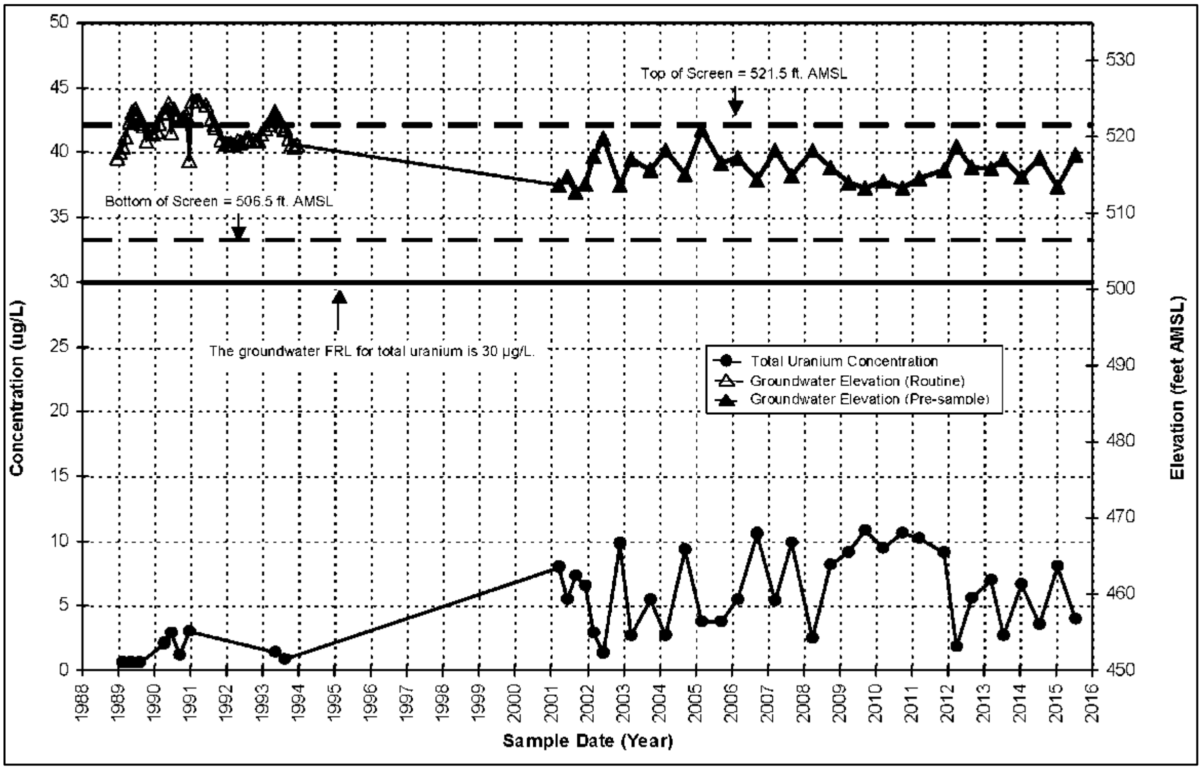

Figure A.2-38. Total Uranium Concentration Versus Time Plot for Monitoring Well 2048

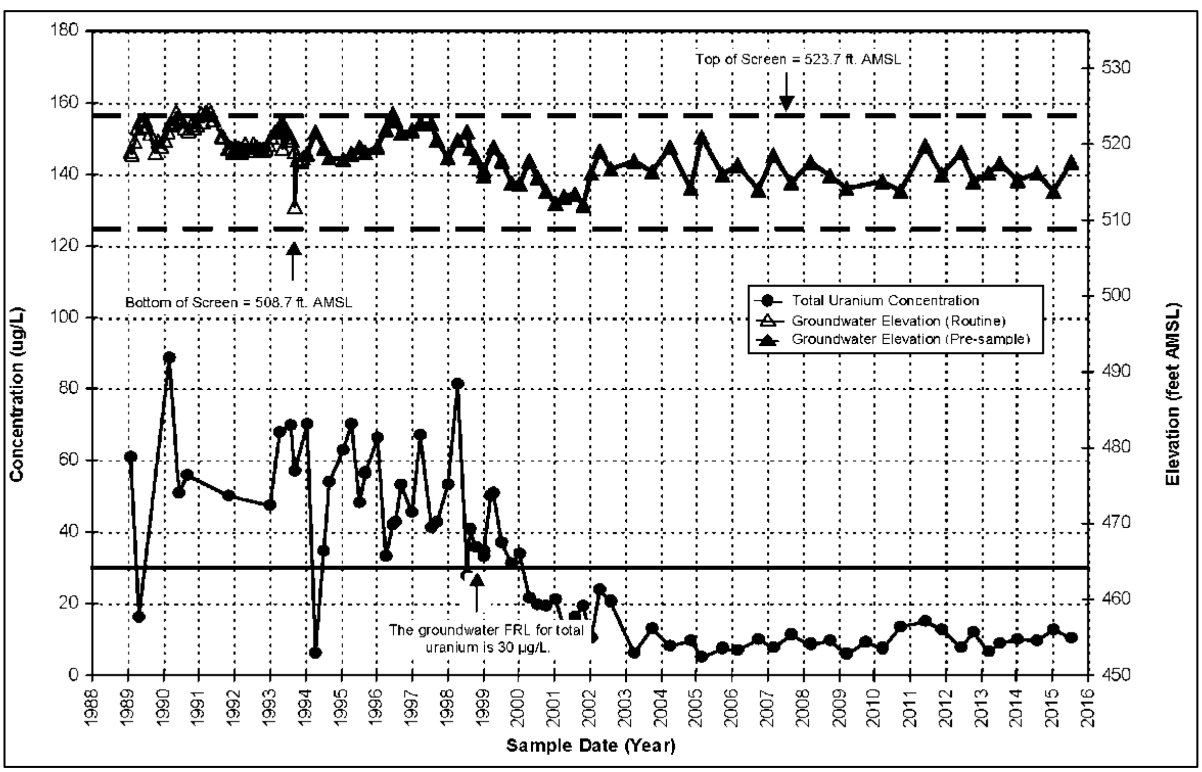

Figure A.2-39. Total Uranium Concentration Versus Time Plot for Monitoring Well 2106

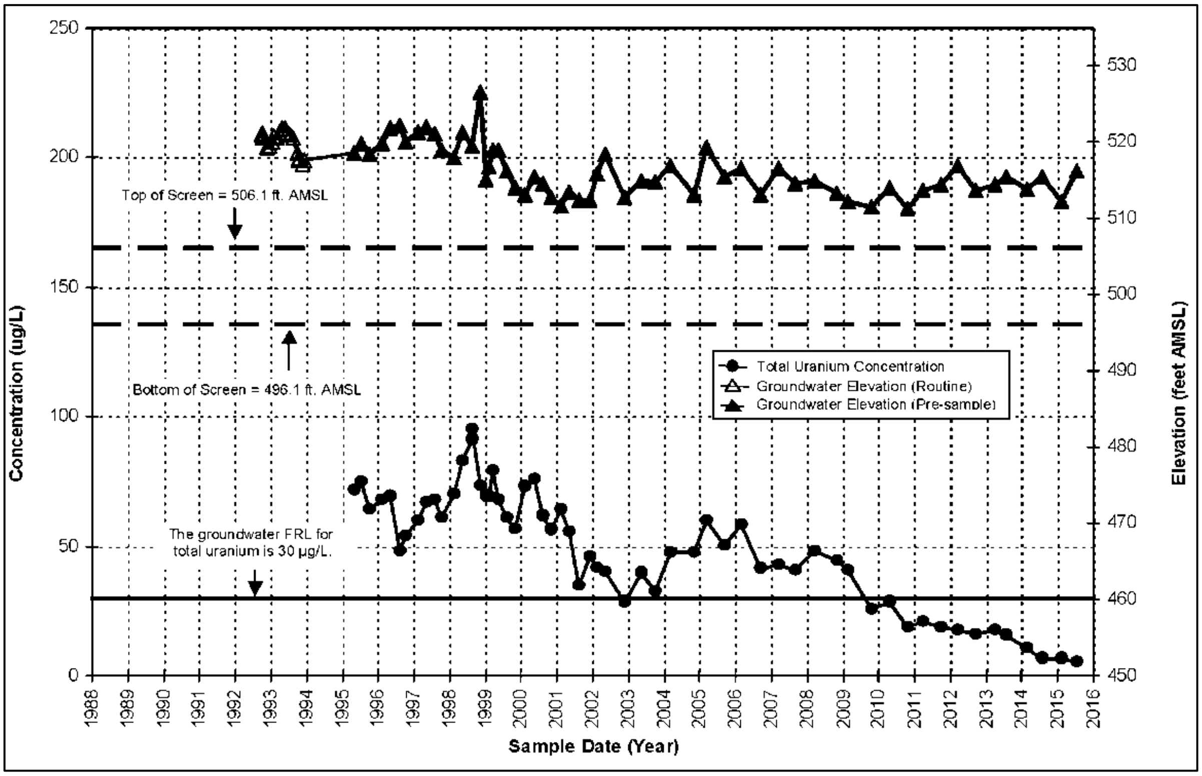

Figure A.2-40. Total Uranium Concentration Versus Time Plot for Monitoring Well 2166

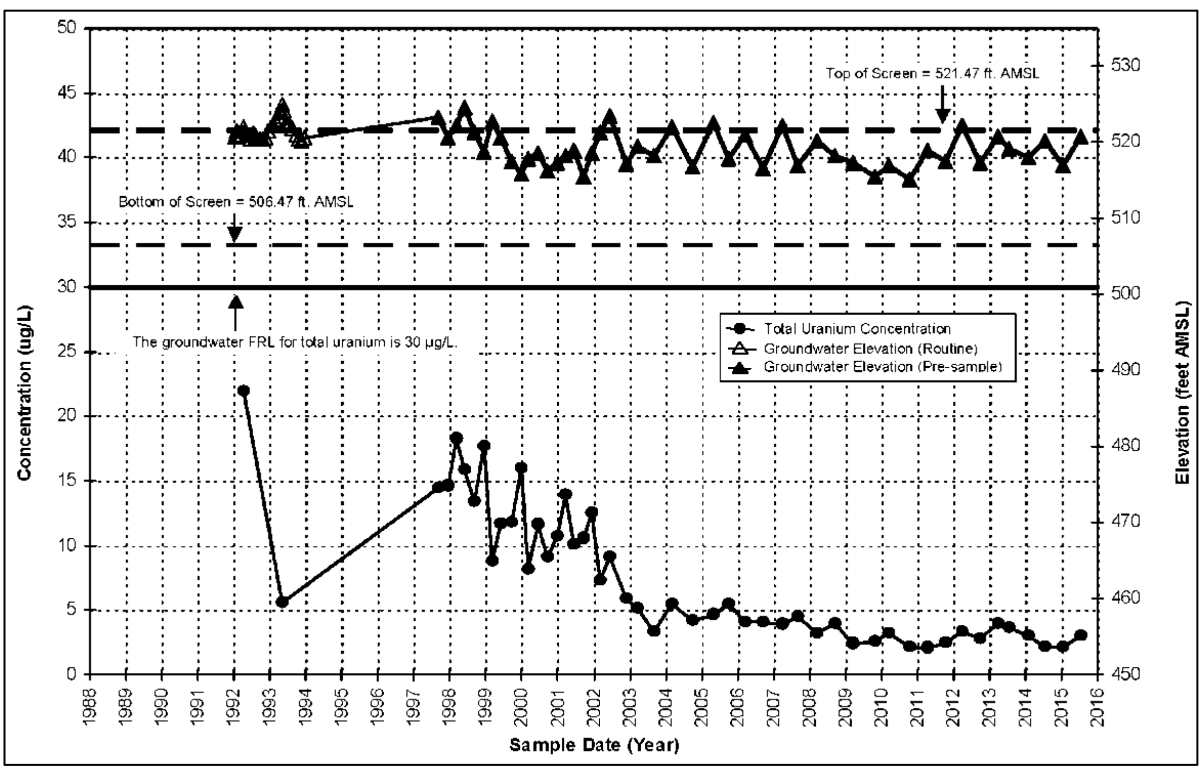

Figure A.2-41. Total Uranium Concentration Versus Time Plot for Monitoring Well 2402

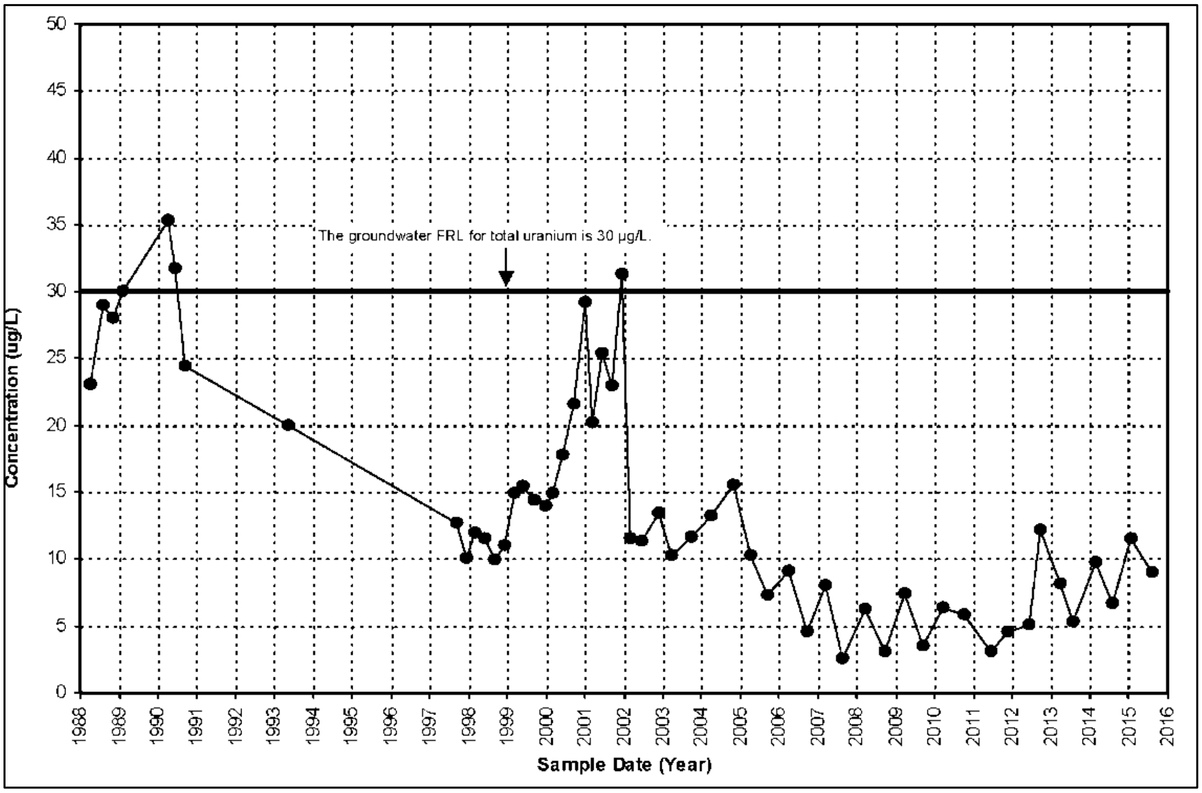

Figure A.2-42. Total Uranium Concentration Versus Time Plot for Monitoring Well 3014

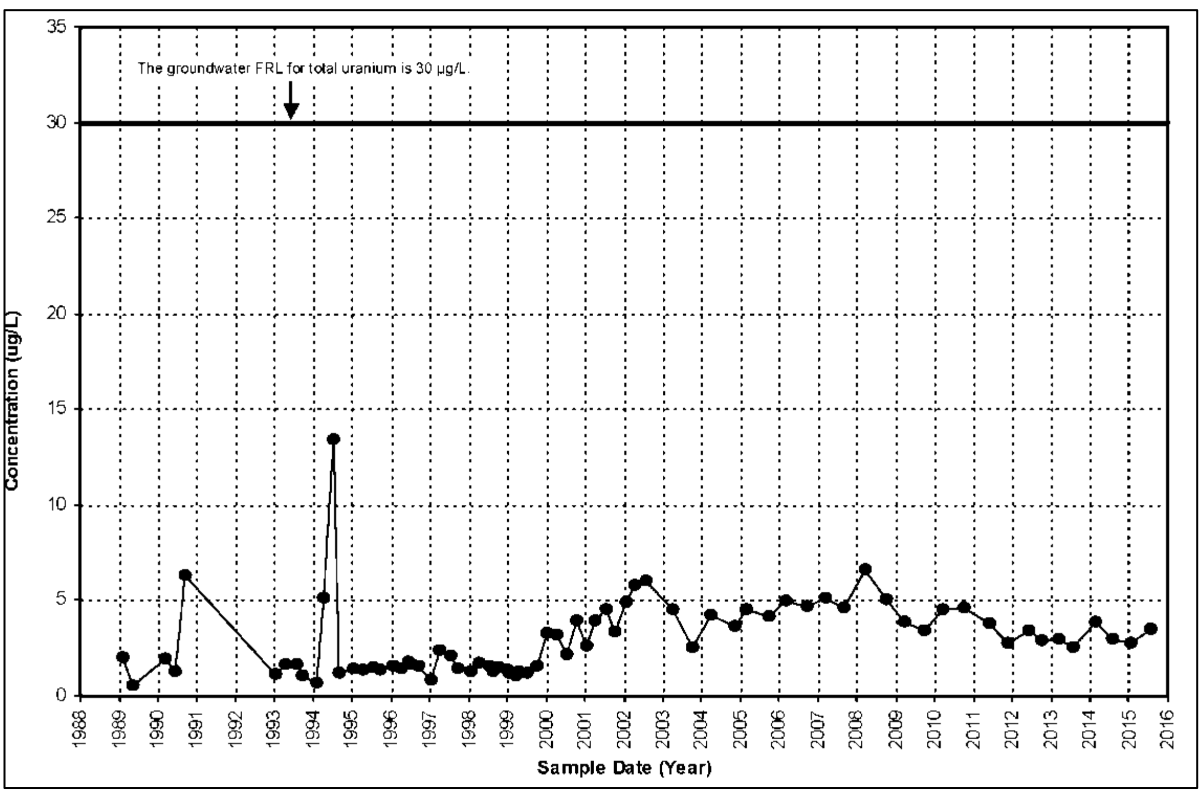

Figure A.2-43. Total Uranium Concentration Versus Time Plot for Monitoring Well 3106

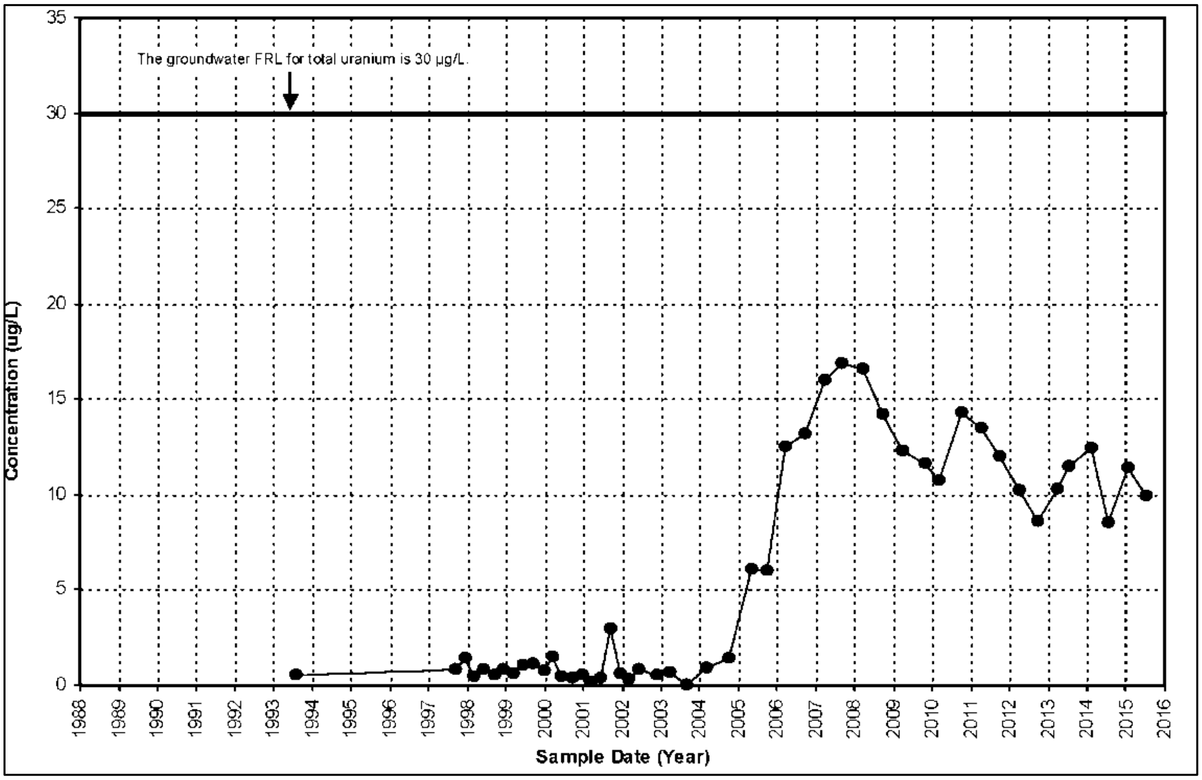

Figure A.2-44. Total Uranium Concentration Versus Time Plot for Monitoring Well 3402

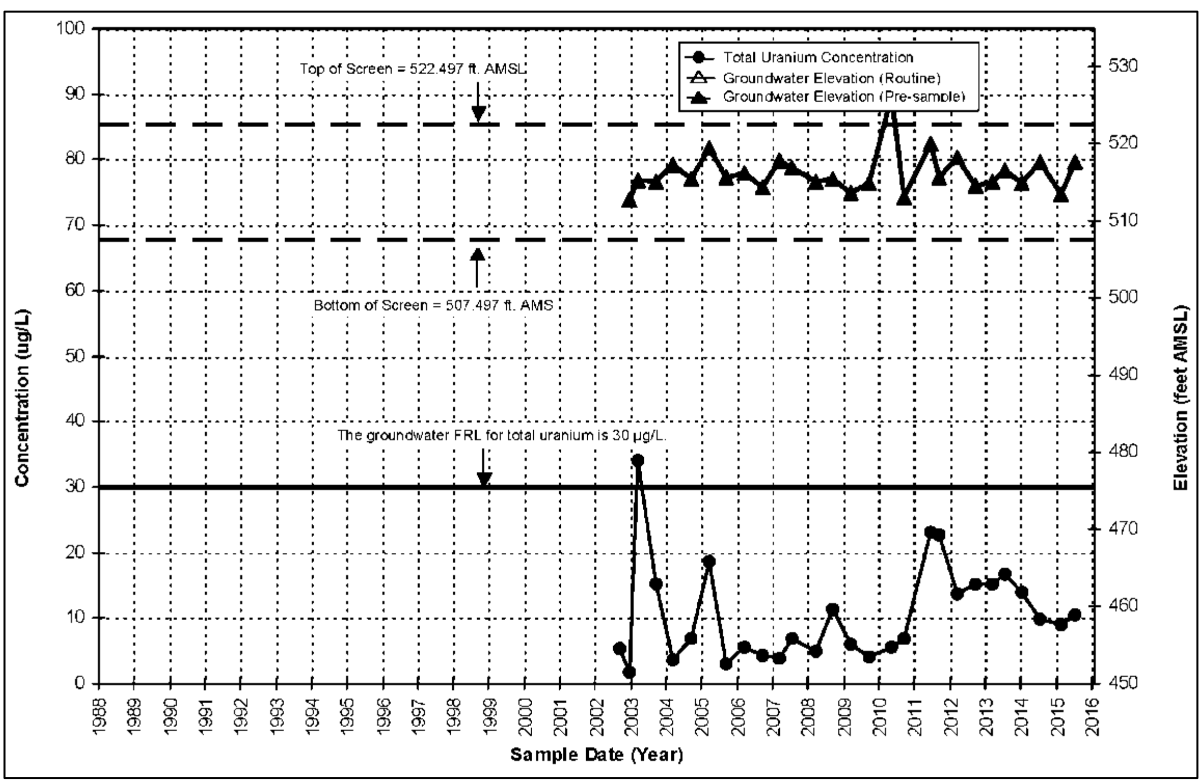

Figure A.2-45. Total Uranium Concentration Versus Time Plot for Monitoring Well 23272

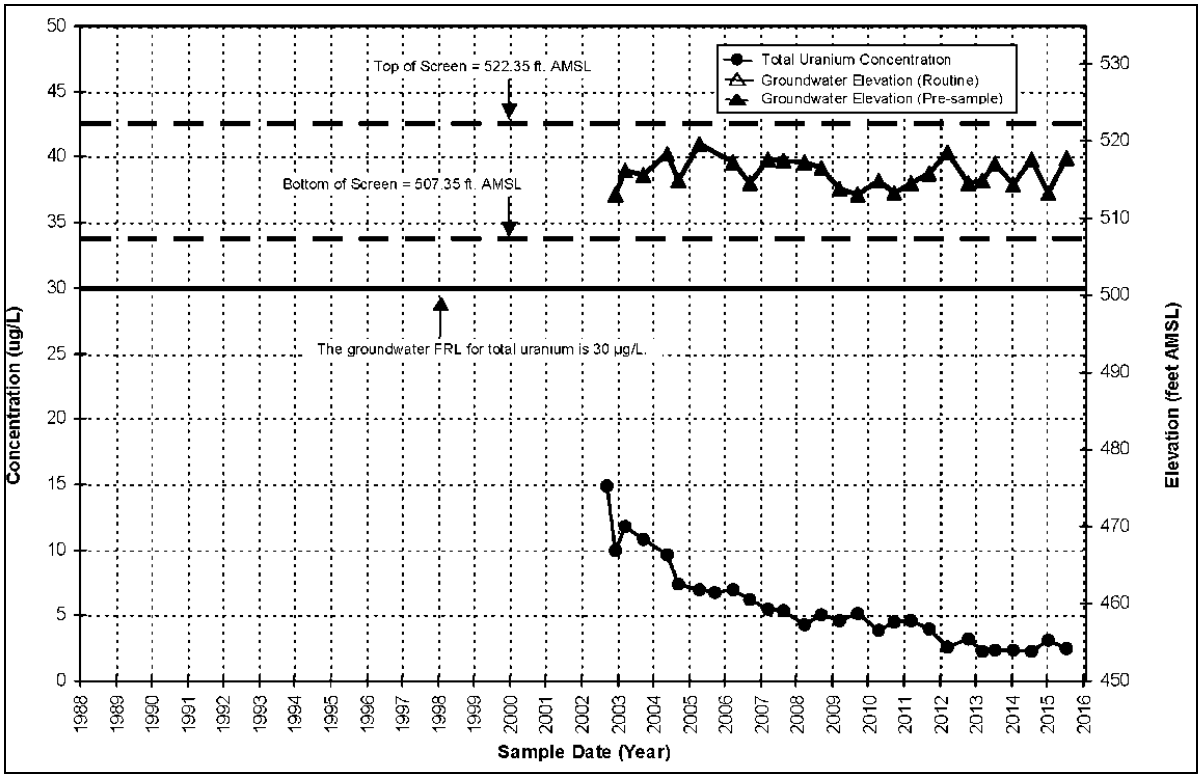

Figure A.2-46. Total Uranium Concentration Versus Time Plot for Monitoring Well 23277

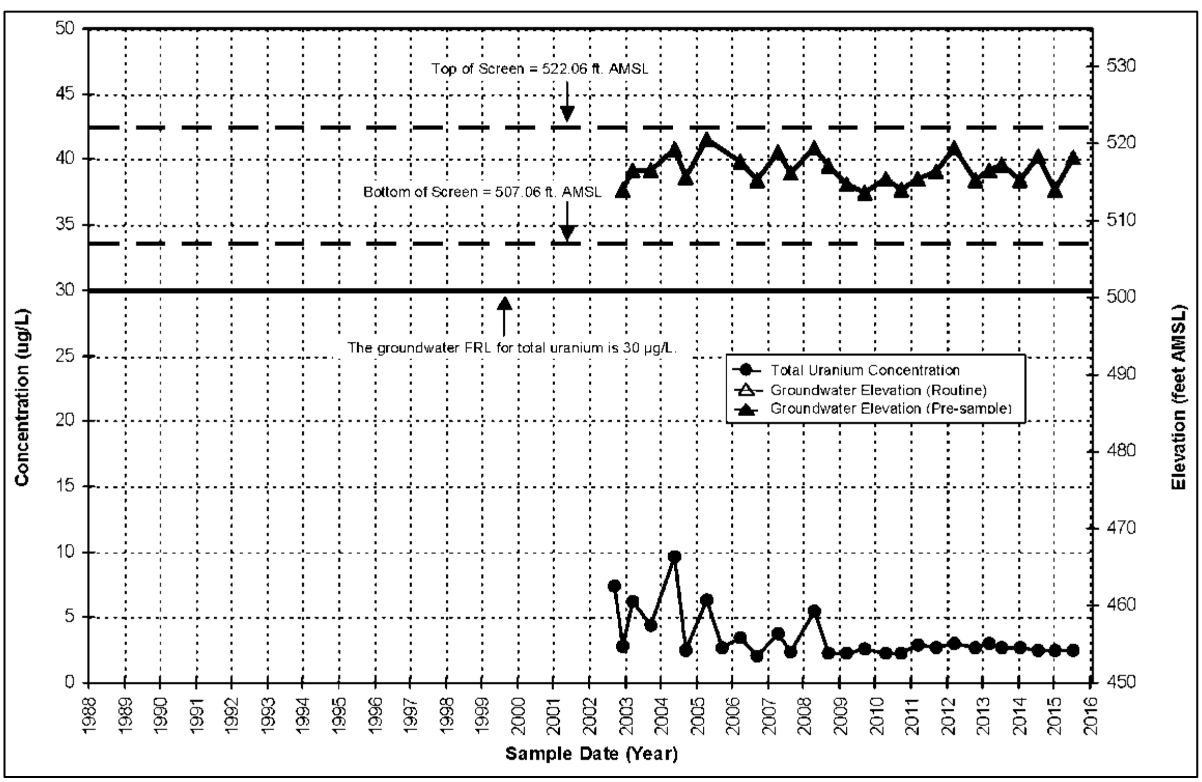

Figure A.2-47. Total Uranium Concentration Versus Time Plot for Monitoring Well 23279

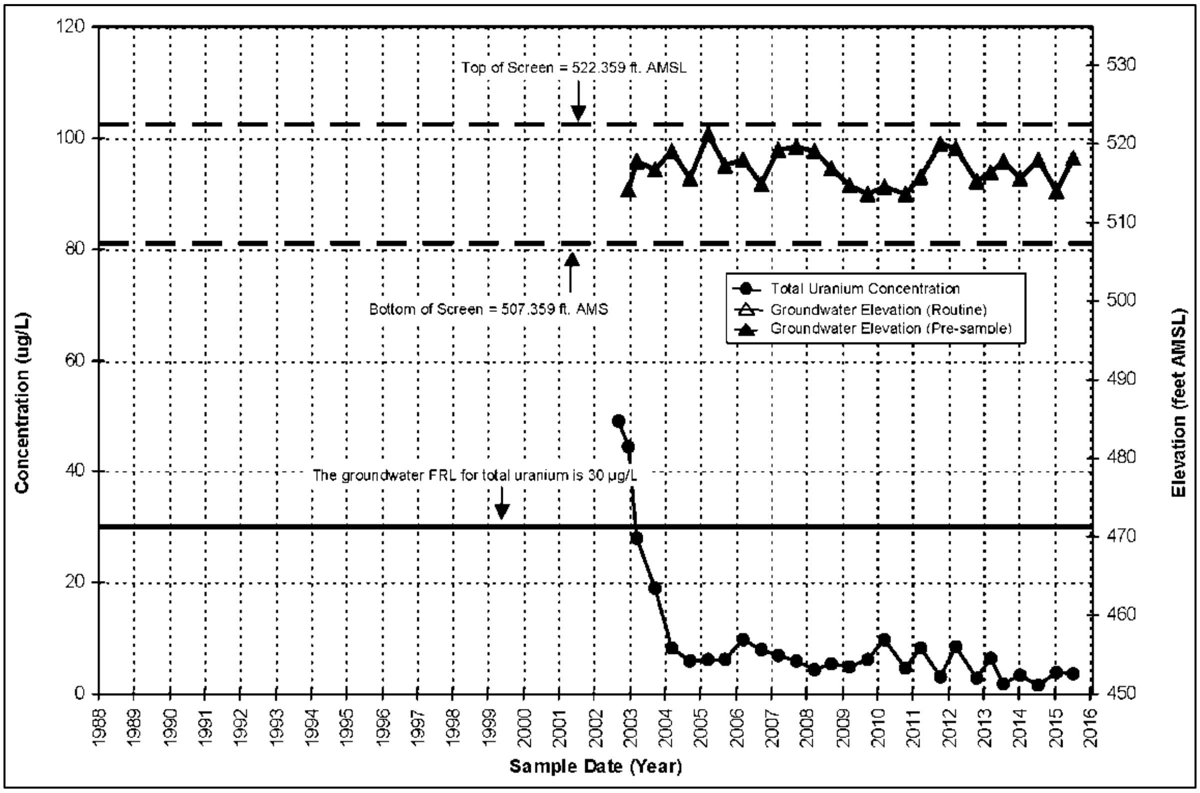

Figure A.2-48. Total Uranium Concentration Versus Time Plot for Monitoring Well 23282

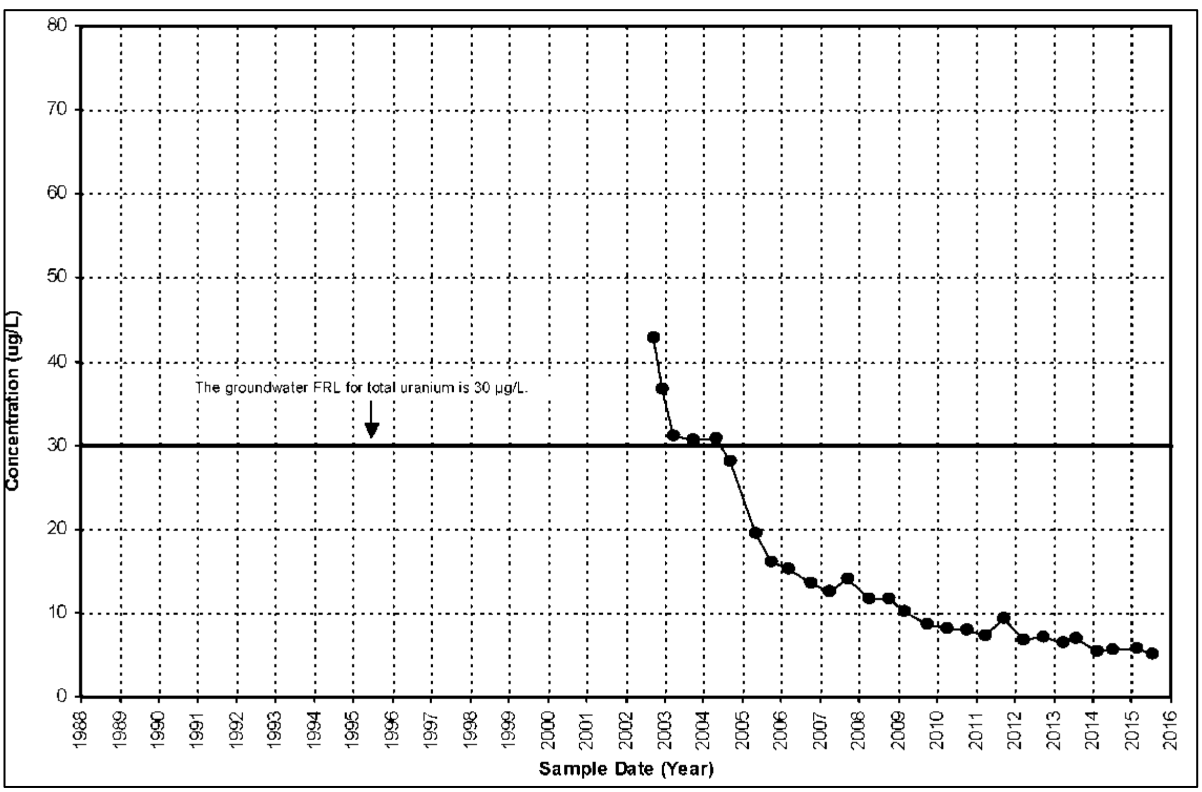

Figure A.2-49. Total Uranium Concentration Versus Time Plot for Monitoring Well 63284

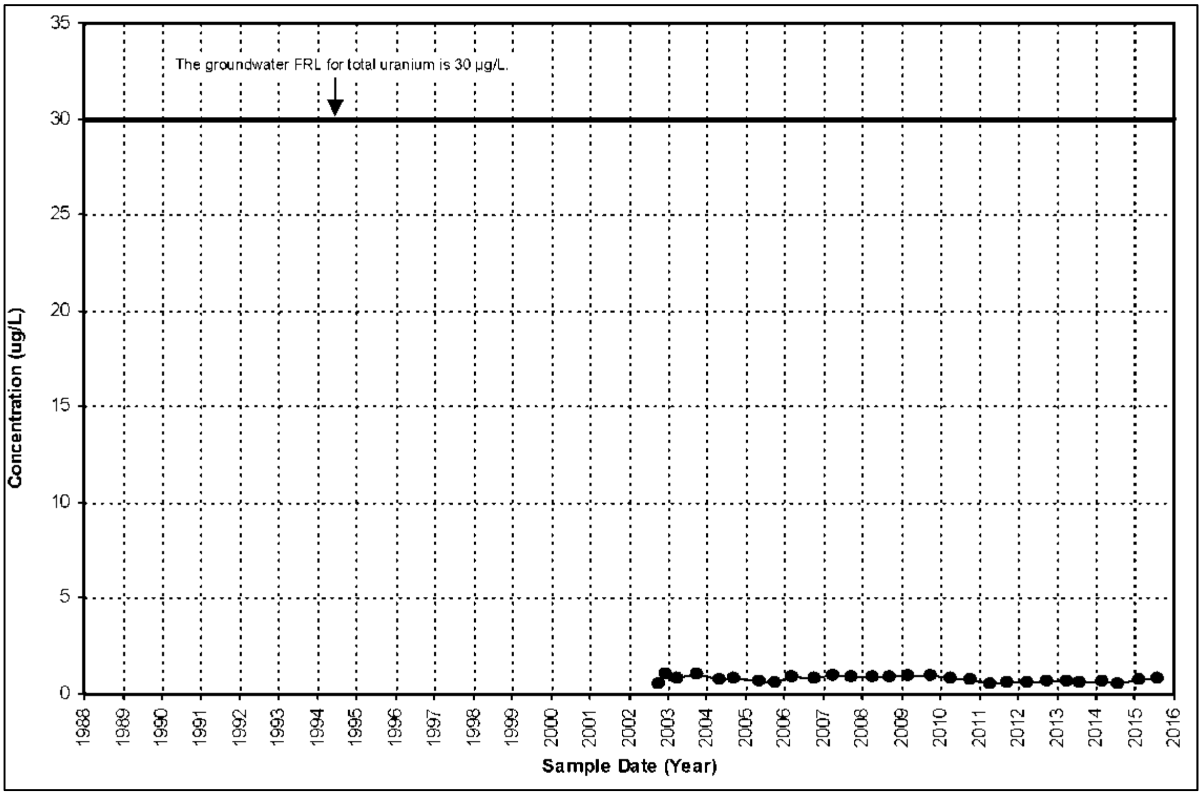

Figure A.2-50. Total Uranium Concentration Versus Time Plot for Monitoring Well 63286

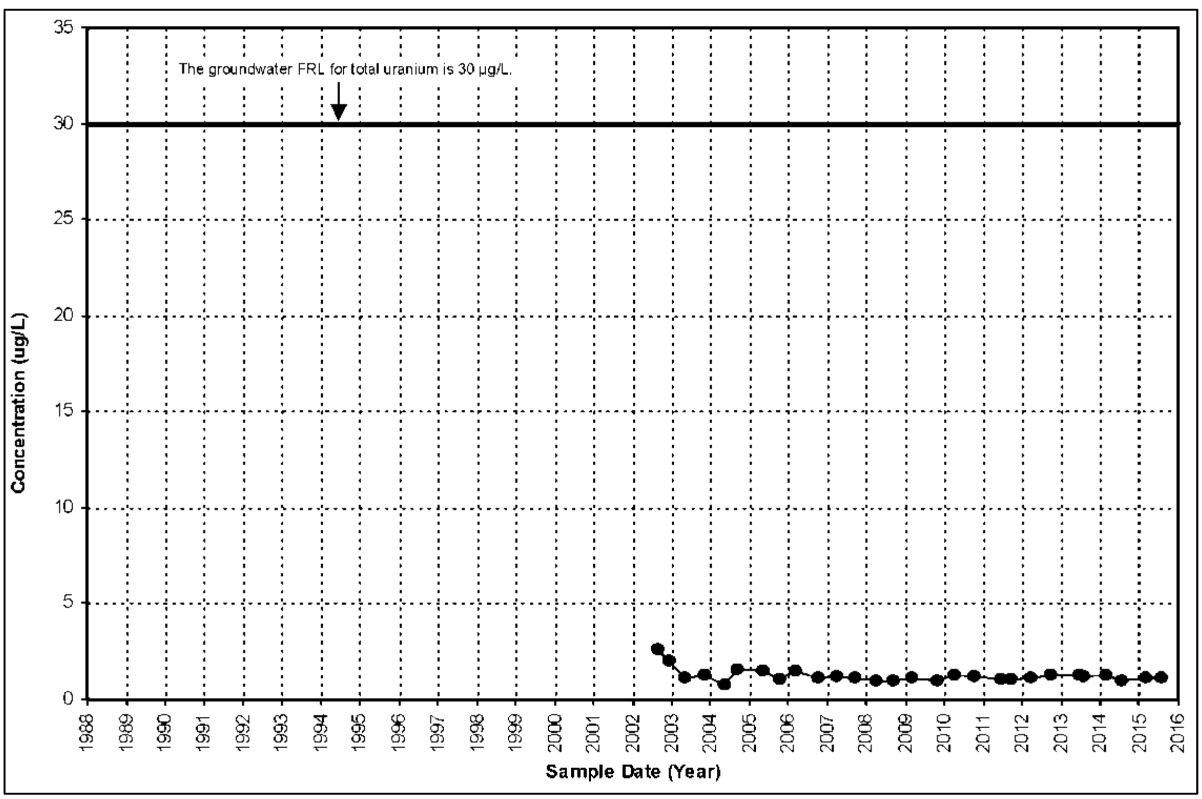

Figure A.2-51. Total Uranium Concentration Versus Time Plot for Monitoring Well 63289

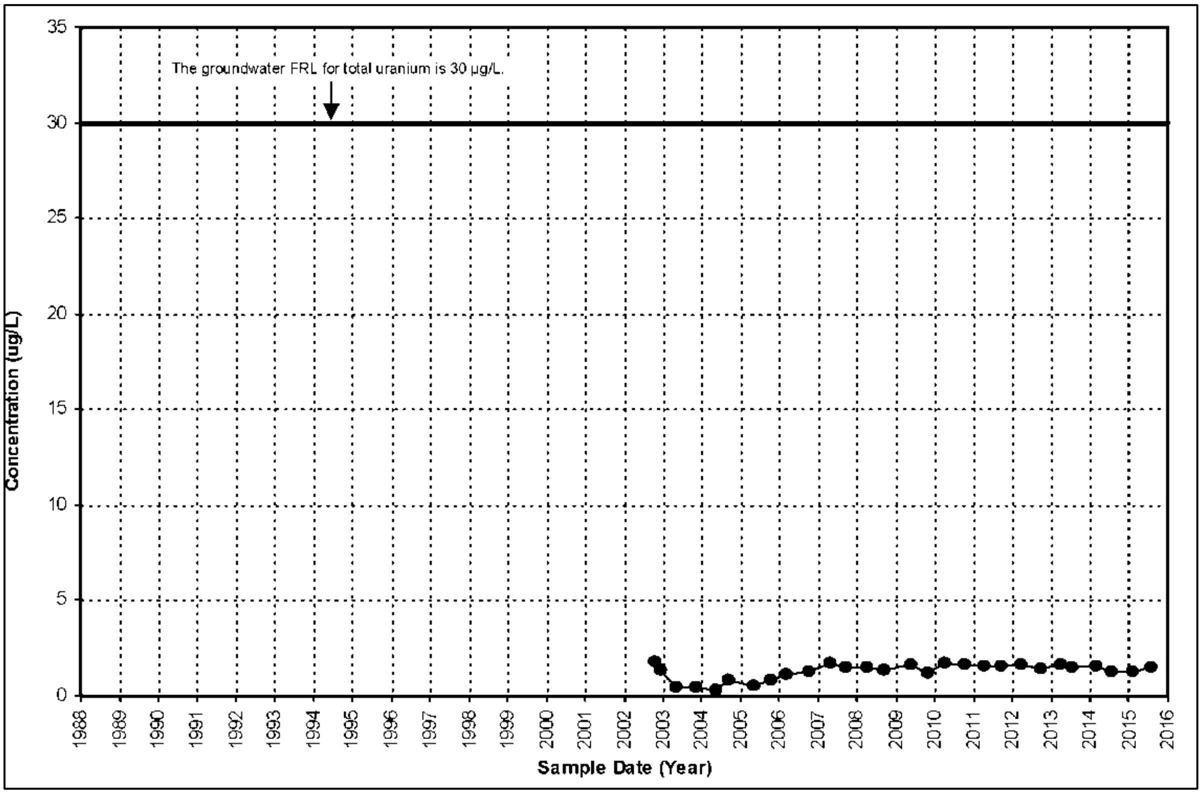

Figure A.2-52. Total Uranium Concentration Versus Time Plot for Monitoring Well 63290

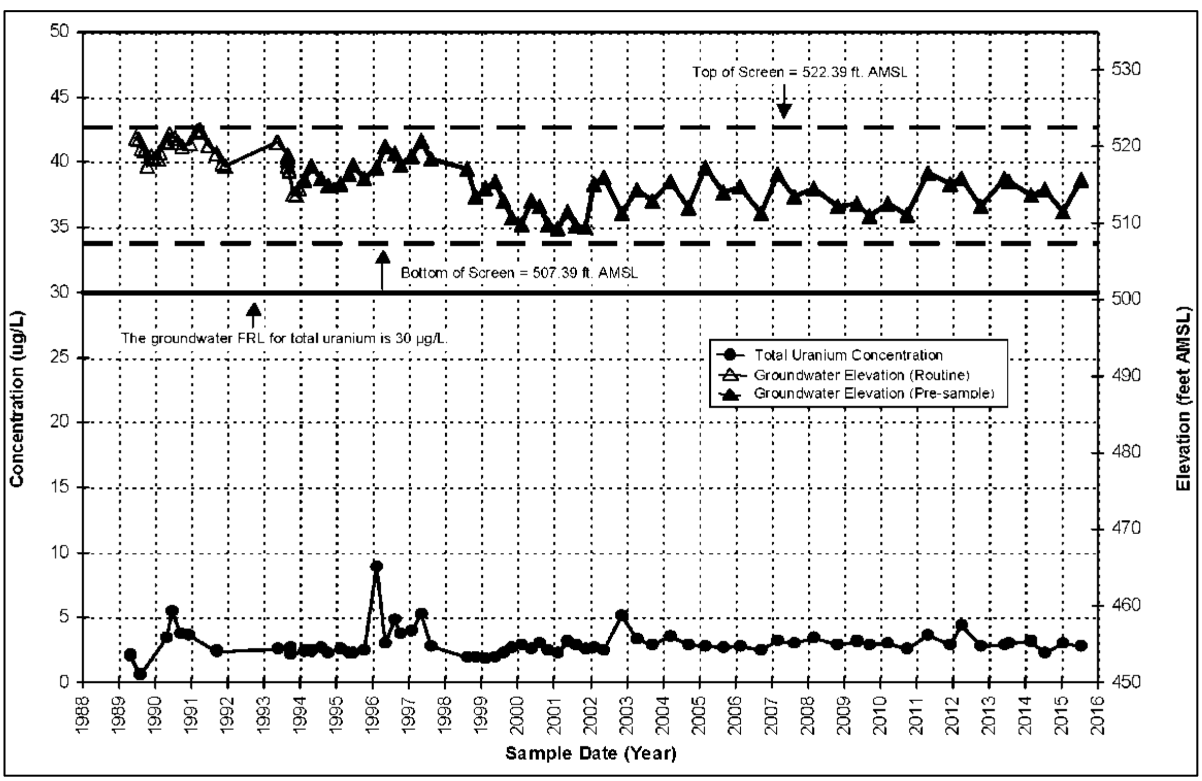

Figure A.2-53. Total Uranium Concentration Versus Time Plot for Monitoring Well 2002

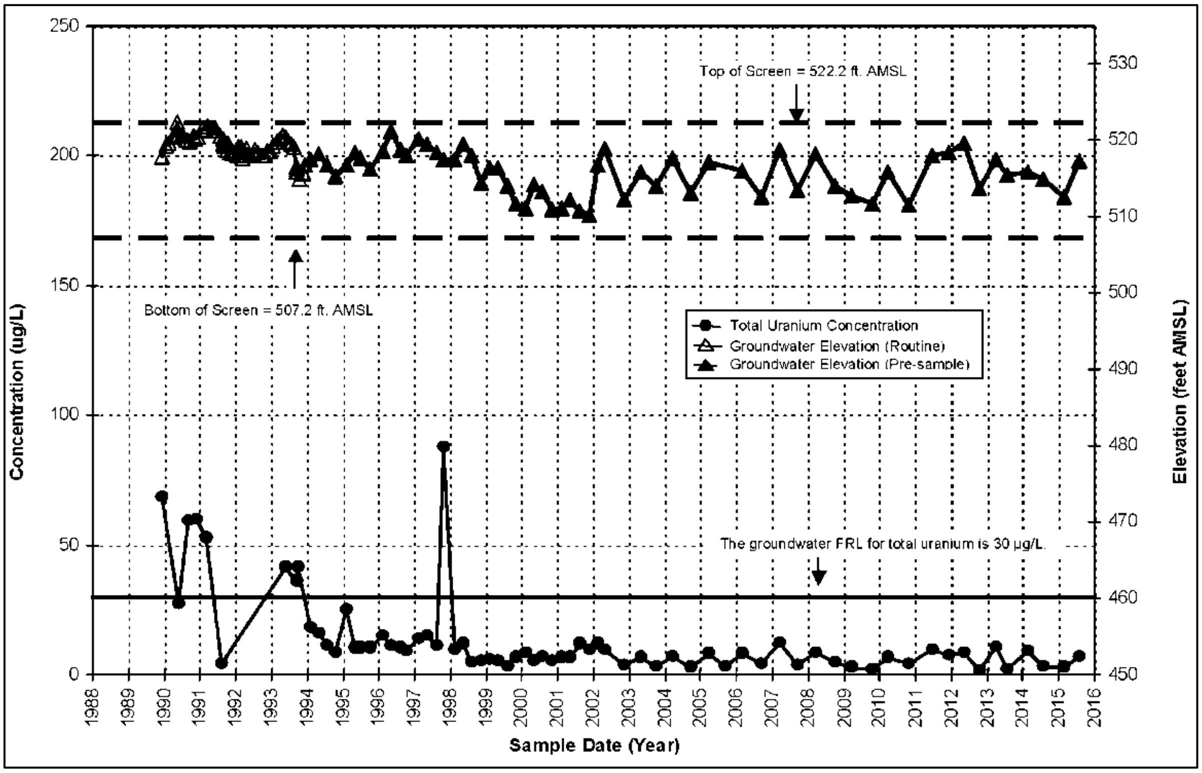

Figure A.2-54. Total Uranium Concentration Versus Time Plot for Monitoring Well 2125

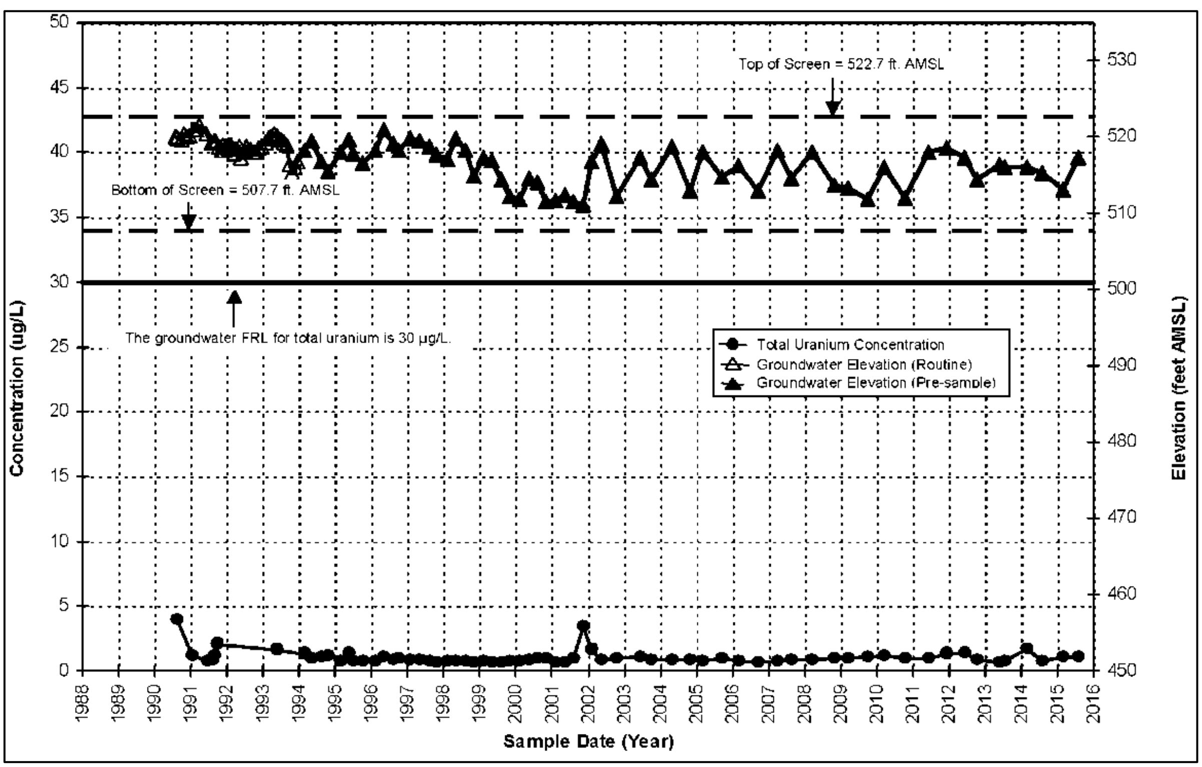

Figure A.2-55. Total Uranium Concentration Versus Time Plot for Monitoring Well 2396

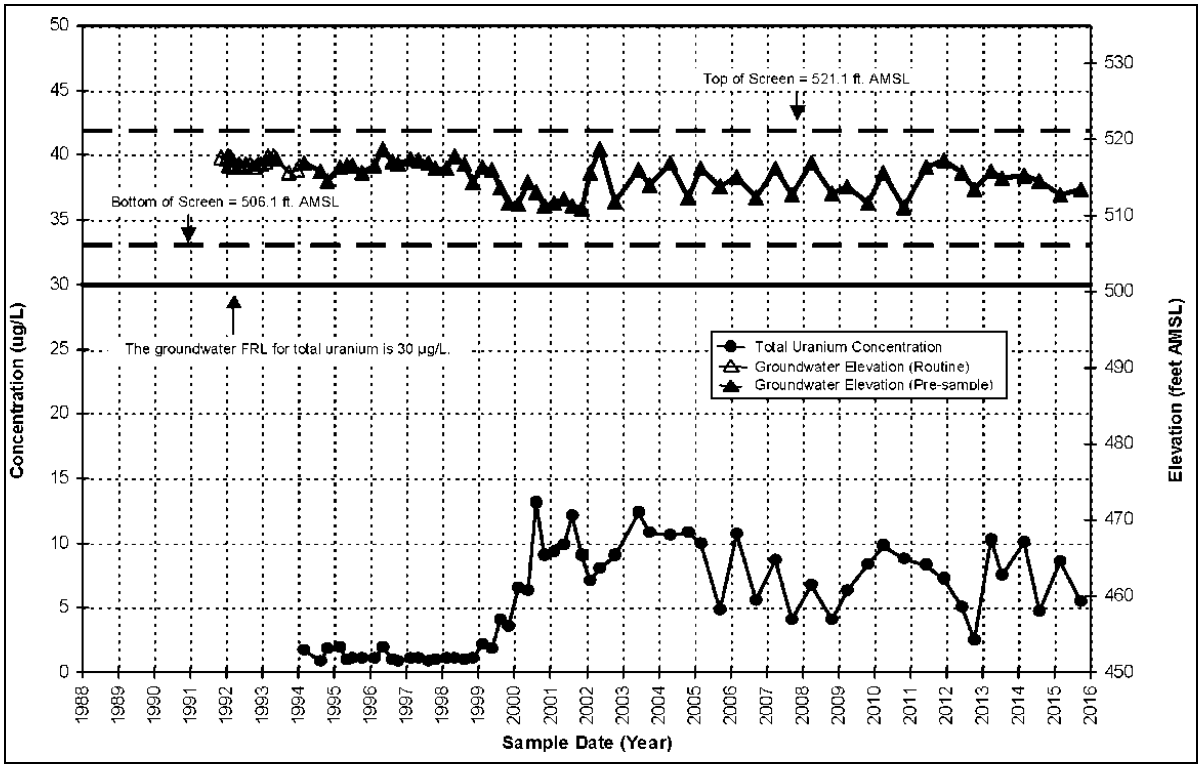

Figure A.2-56. Total Uranium Concentration Versus Time Plot for Monitoring Well 2553

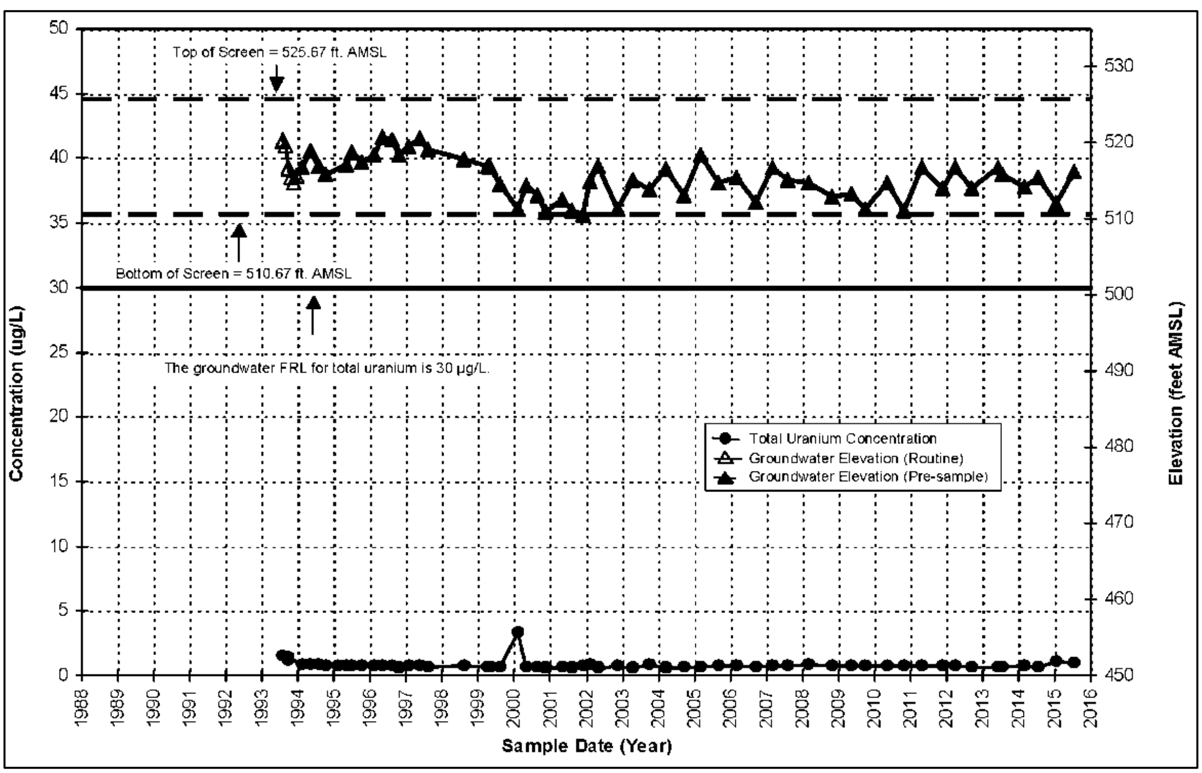

Figure A.2-57. Total Uranium Concentration Versus Time Plot for Monitoring Well 2897

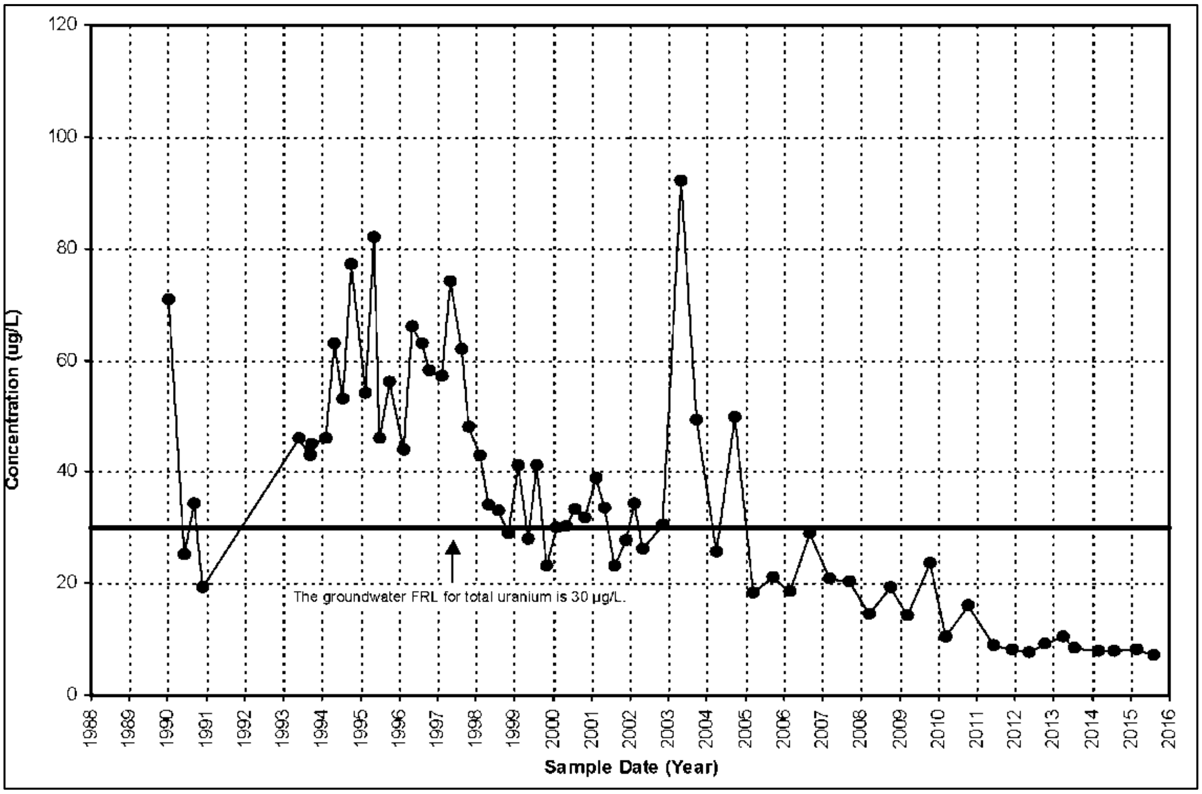

Figure A.2-58. Total Uranium Concentration Versus Time Plot for Monitoring Well 3125

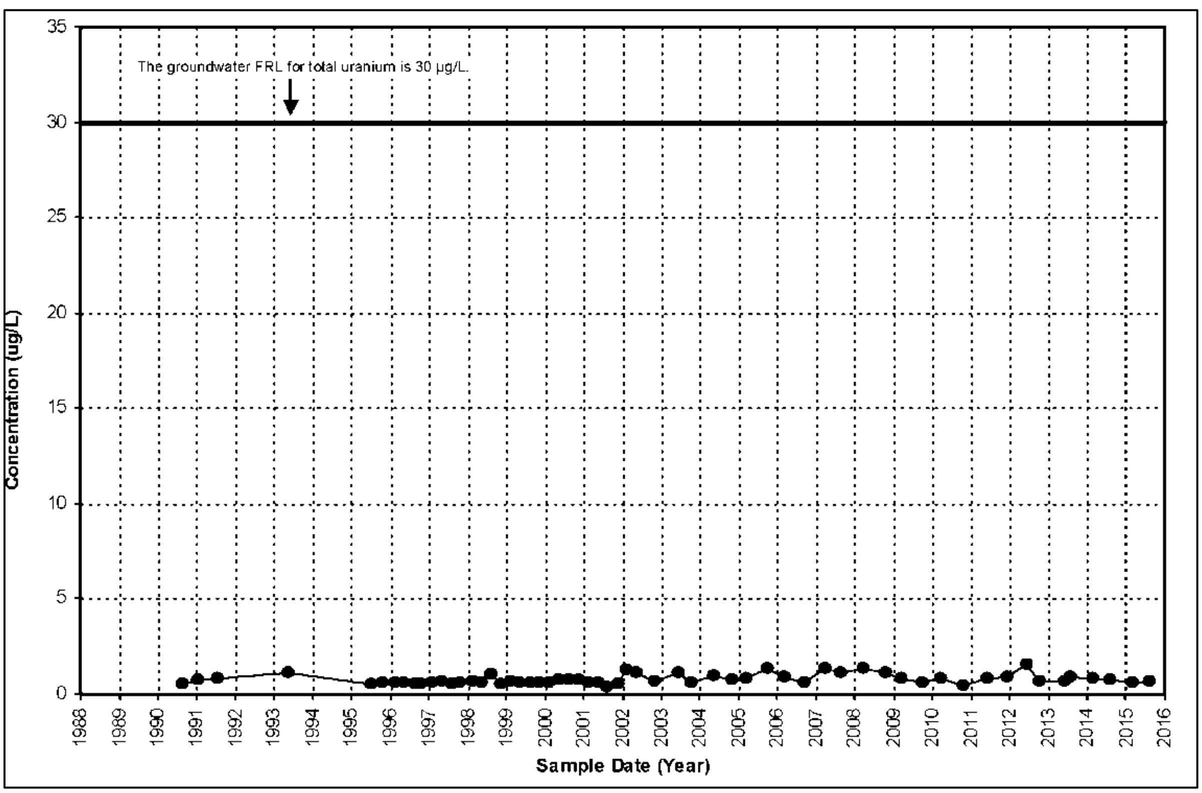

Figure A.2-59. Total Uranium Concentration Versus Time Plot for Monitoring Well 3396

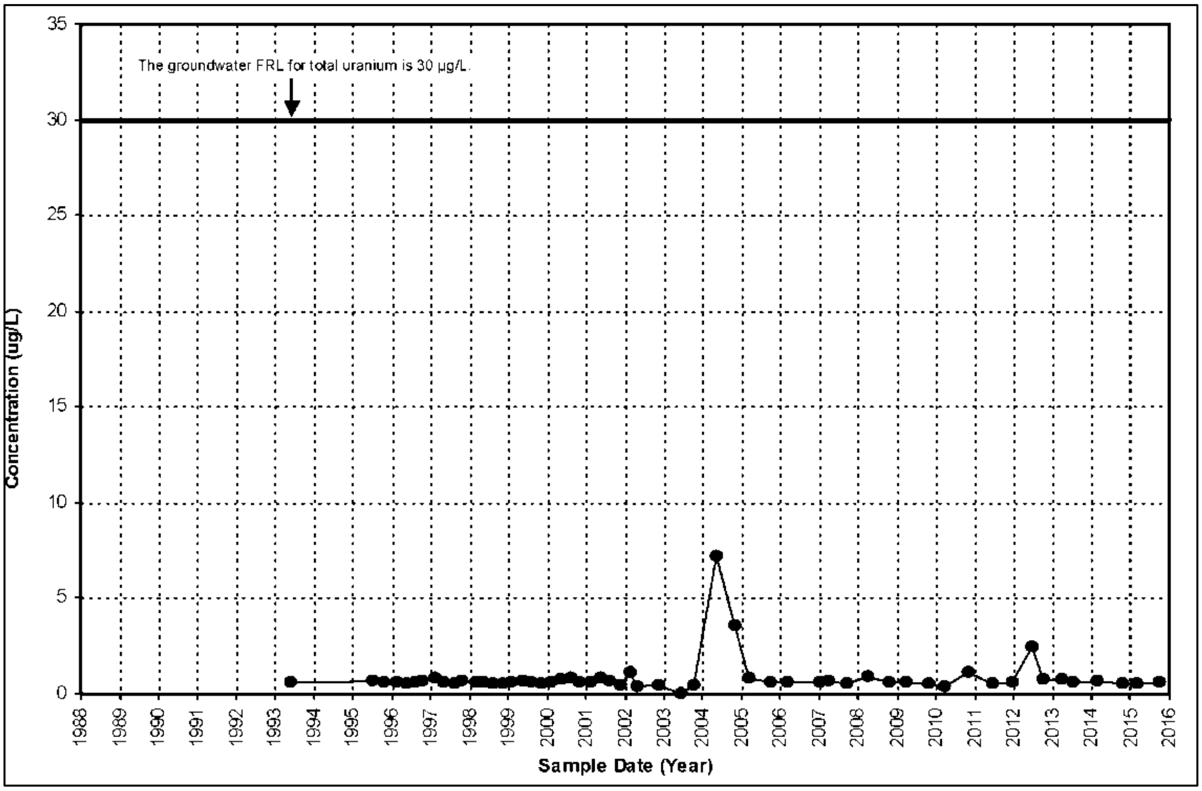

Figure A.2-60. Total Uranium Concentration Versus Time Plot for Monitoring Well 3552

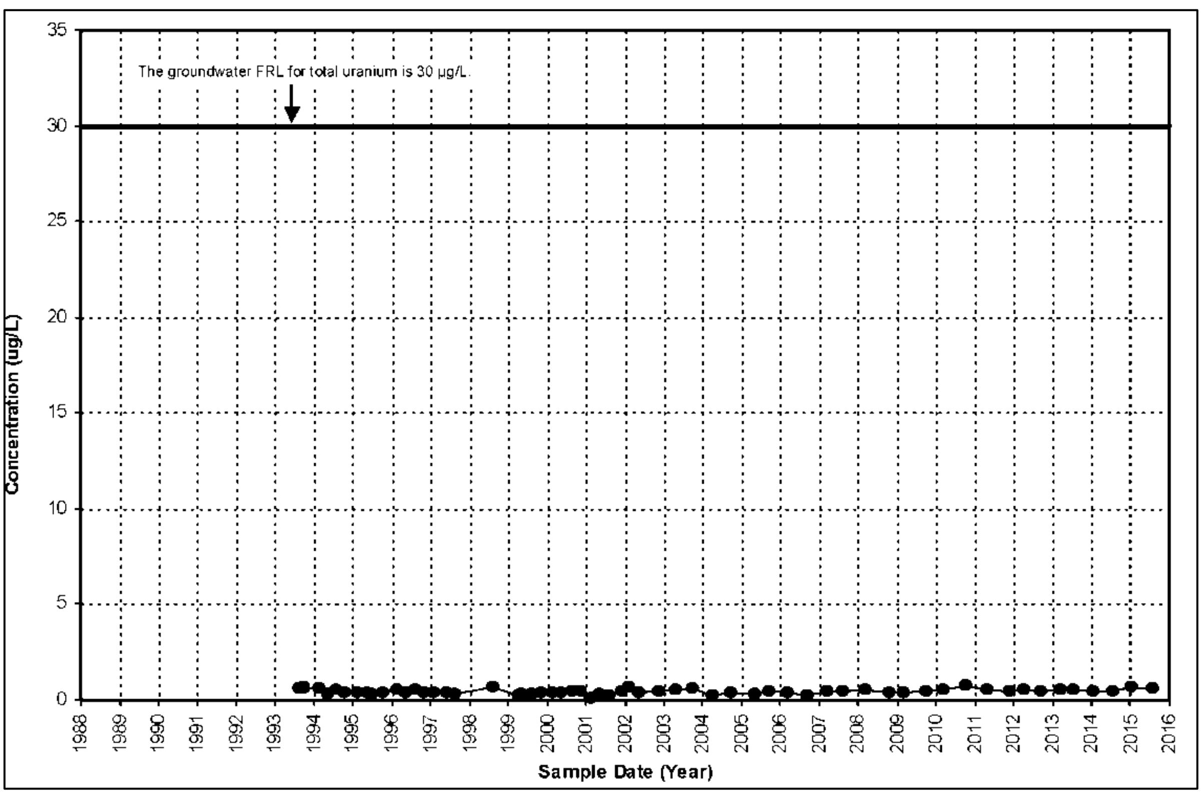

Figure A.2-61. Total Uranium Concentration Versus Time Plot for Monitoring Well 3897

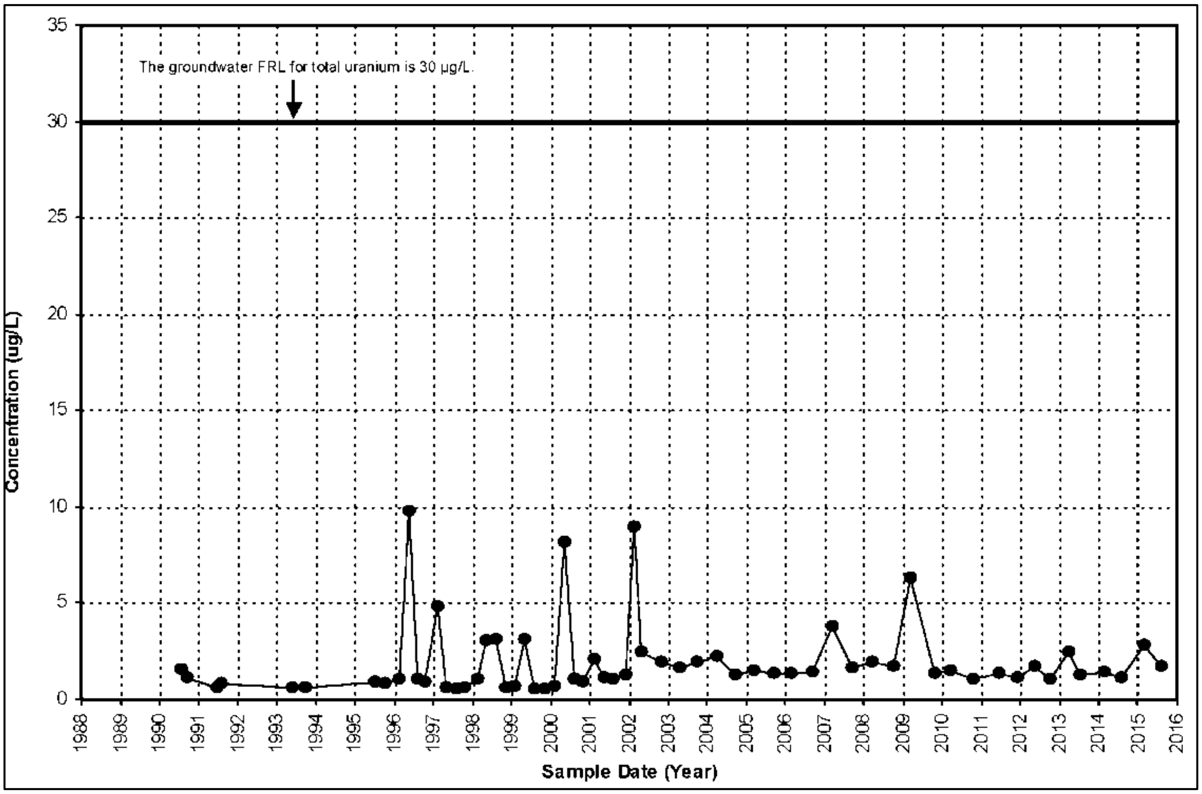

Figure A.2-62. Total Uranium Concentration Versus Time Plot for Monitoring Well 4125

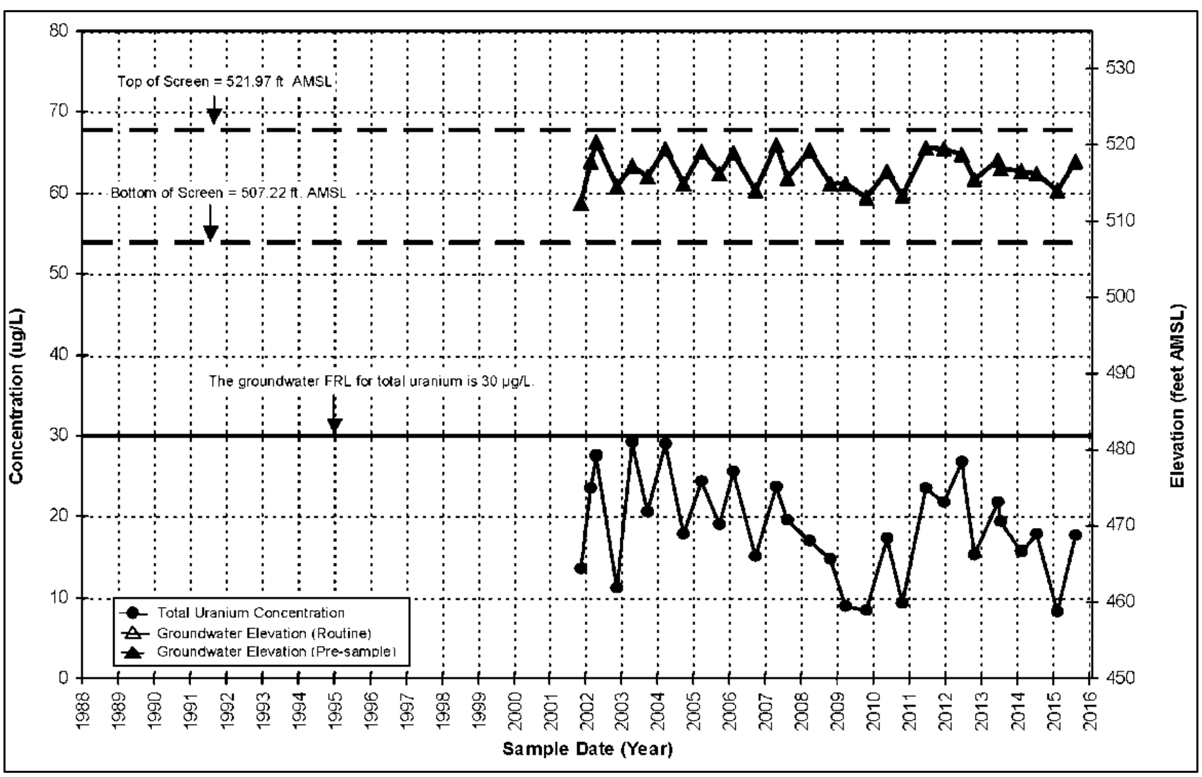

Figure A.2-63. Total Uranium Concentration Versus Time Plot for Monitoring Well 23064

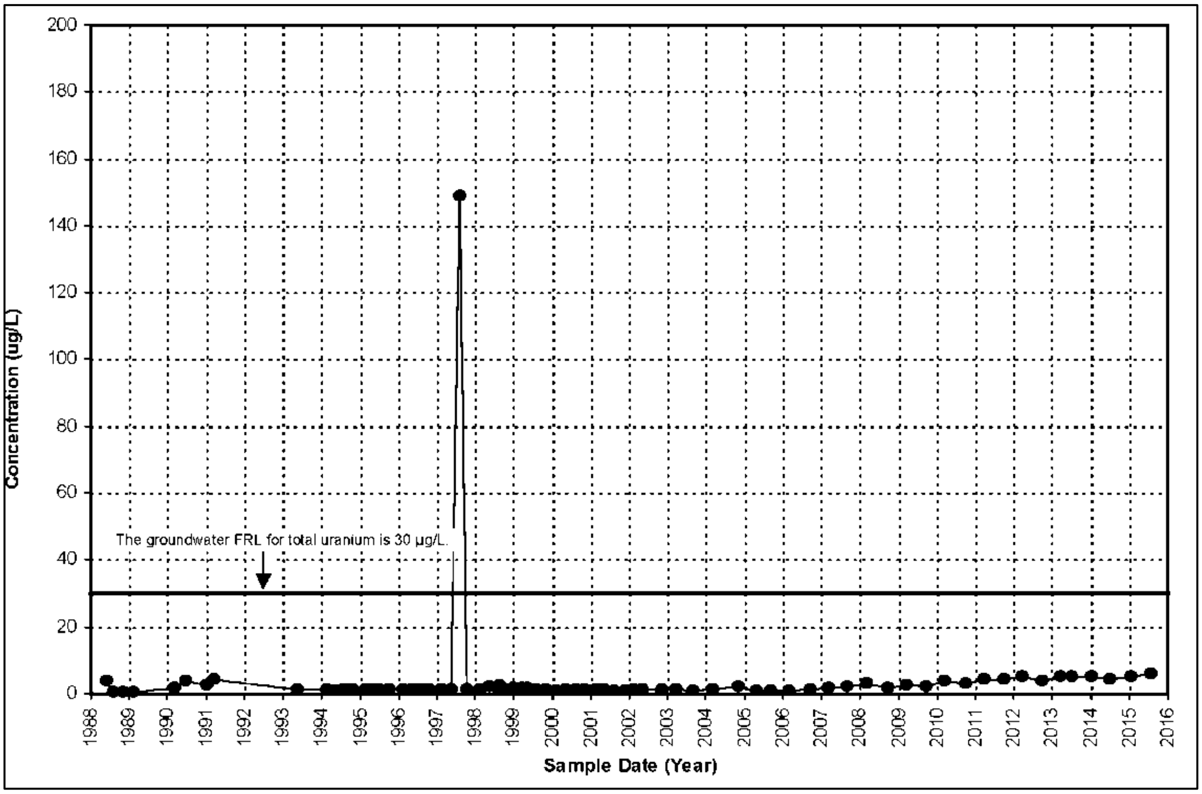

Figure A.2-64. Total Uranium Concentration Versus Time Plot for Monitoring Well 3015

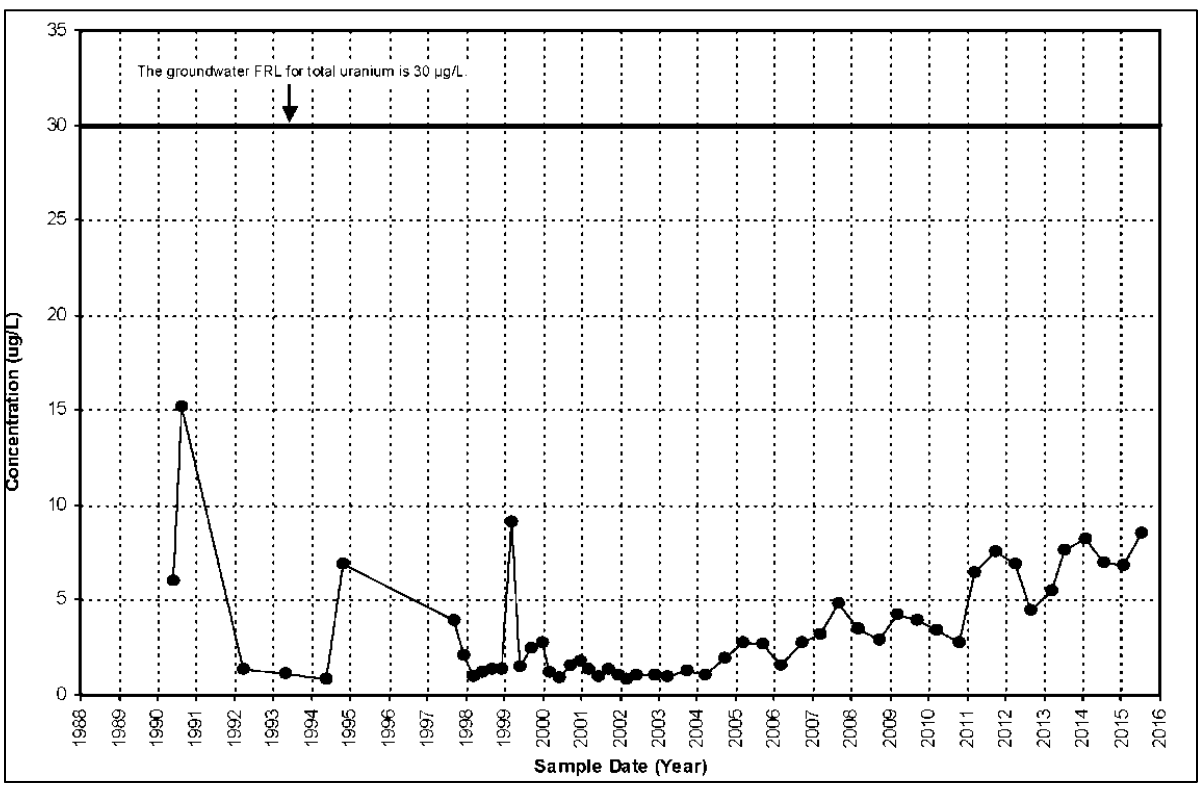

Figure A.2-65. Total Uranium Concentration Versus Time Plot for Monitoring Well 3045

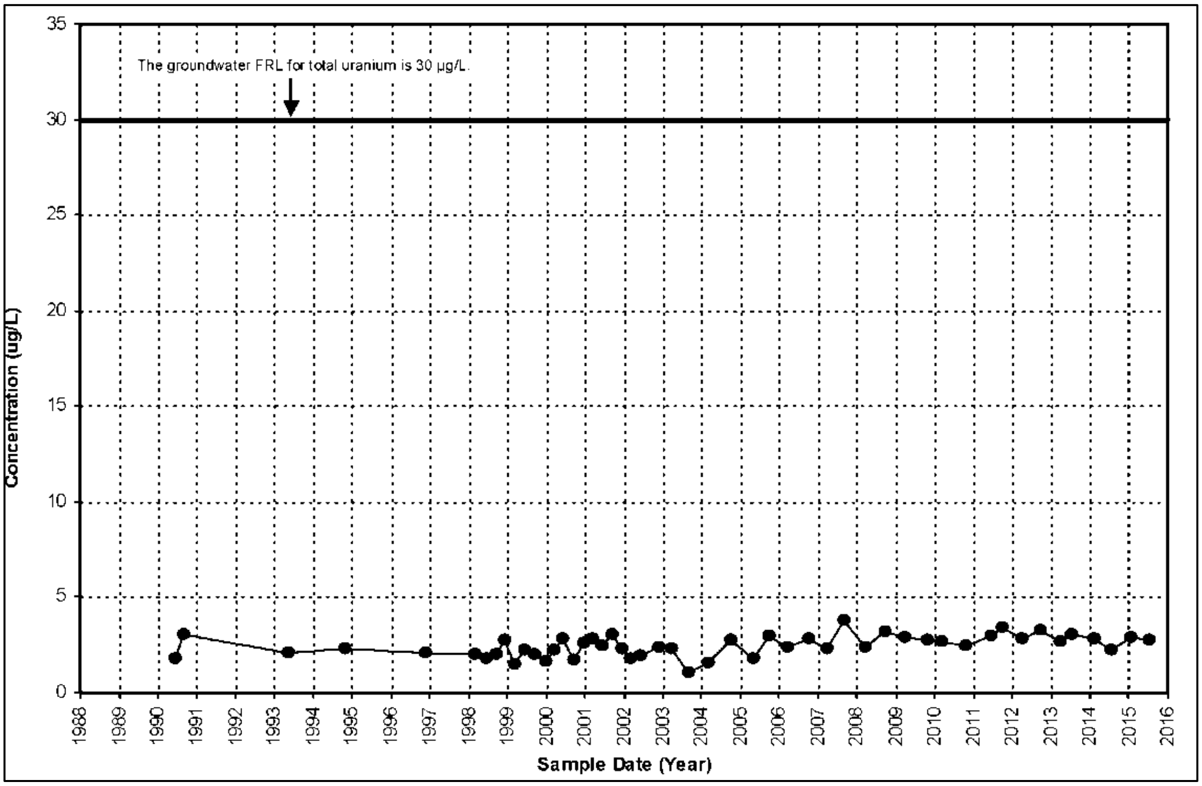

Figure A.2-66. Total Uranium Concentration Versus Time Plot for Monitoring Well 3046

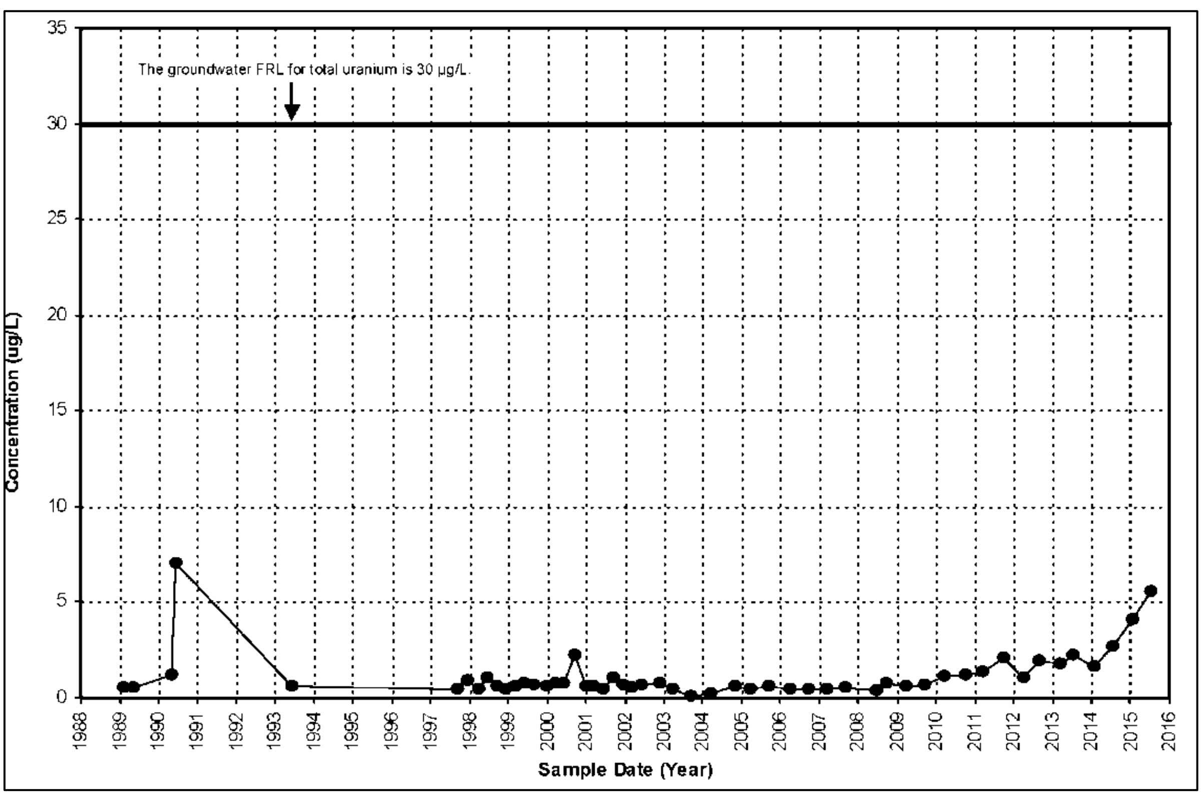

Figure A.2-67. Total Uranium Concentration Versus Time Plot for Monitoring Well 3049

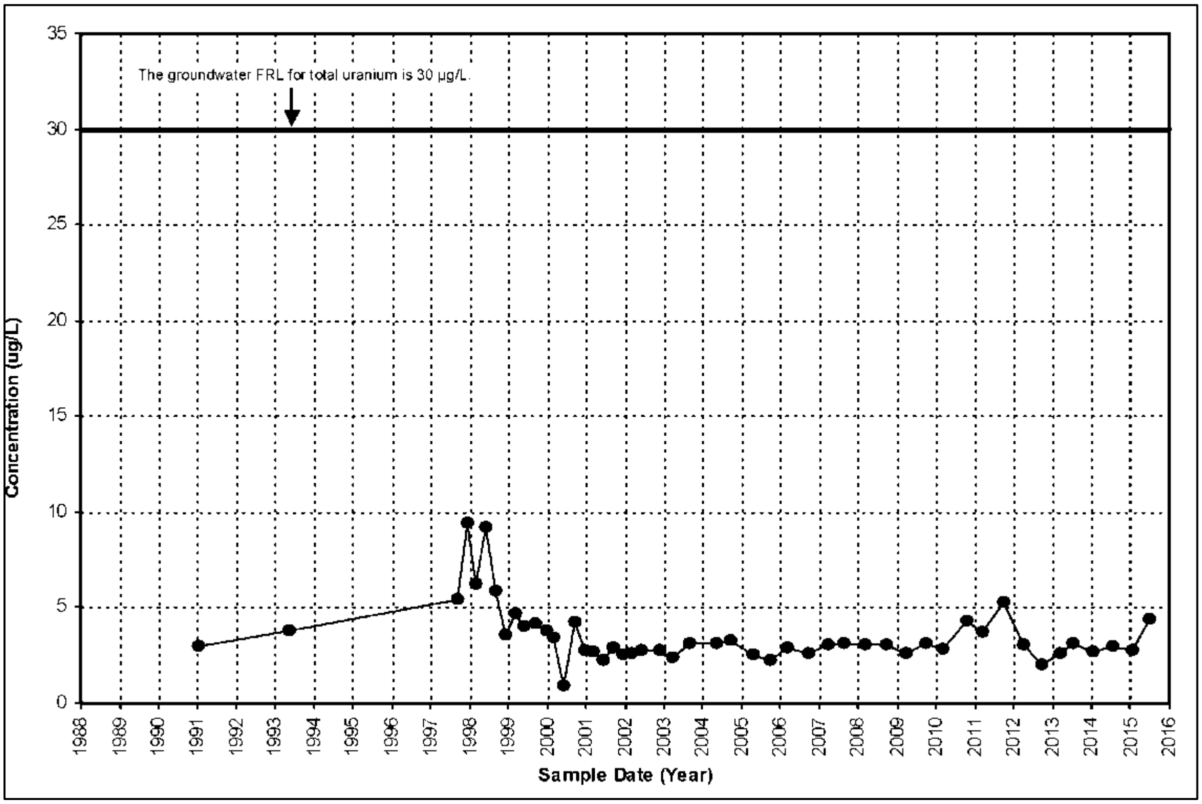

Figure A.2-68. Total Uranium Concentration Versus Time Plot for Monitoring Well 3385

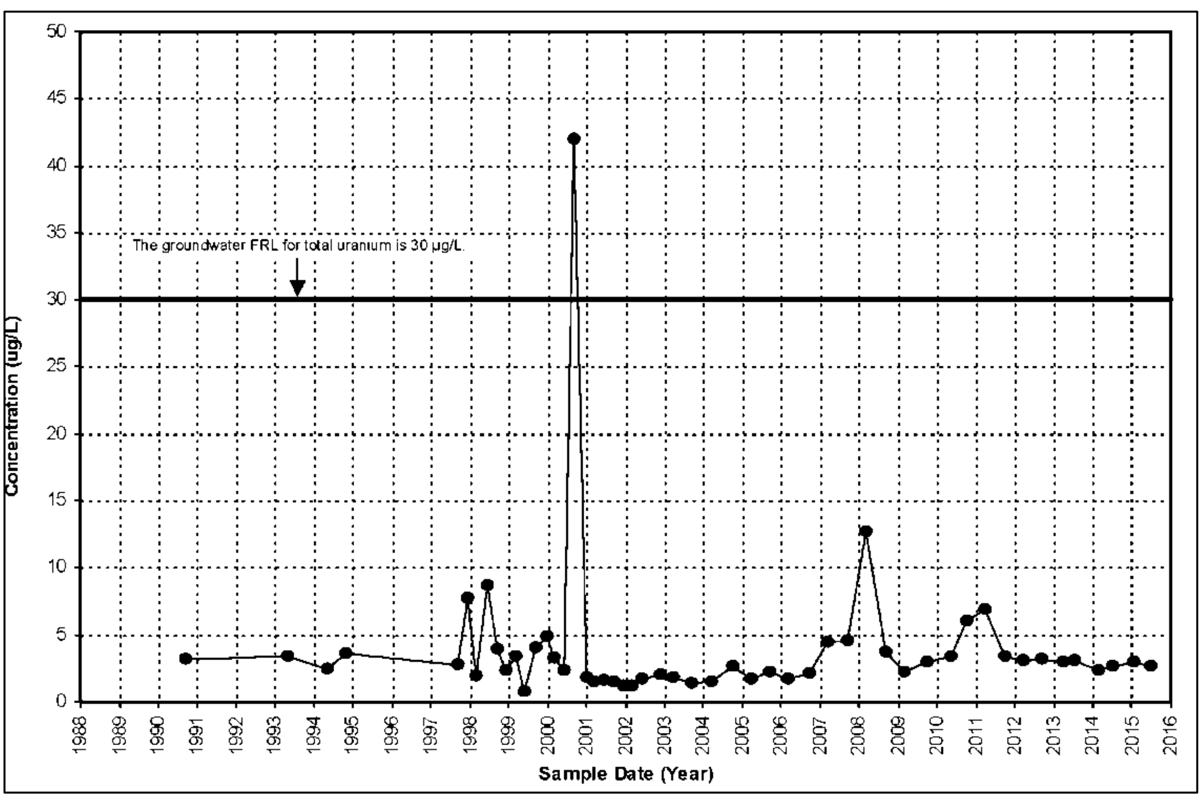

Figure A.2-69. Total Uranium Concentration Versus Time Plot for Monitoring Well 3387

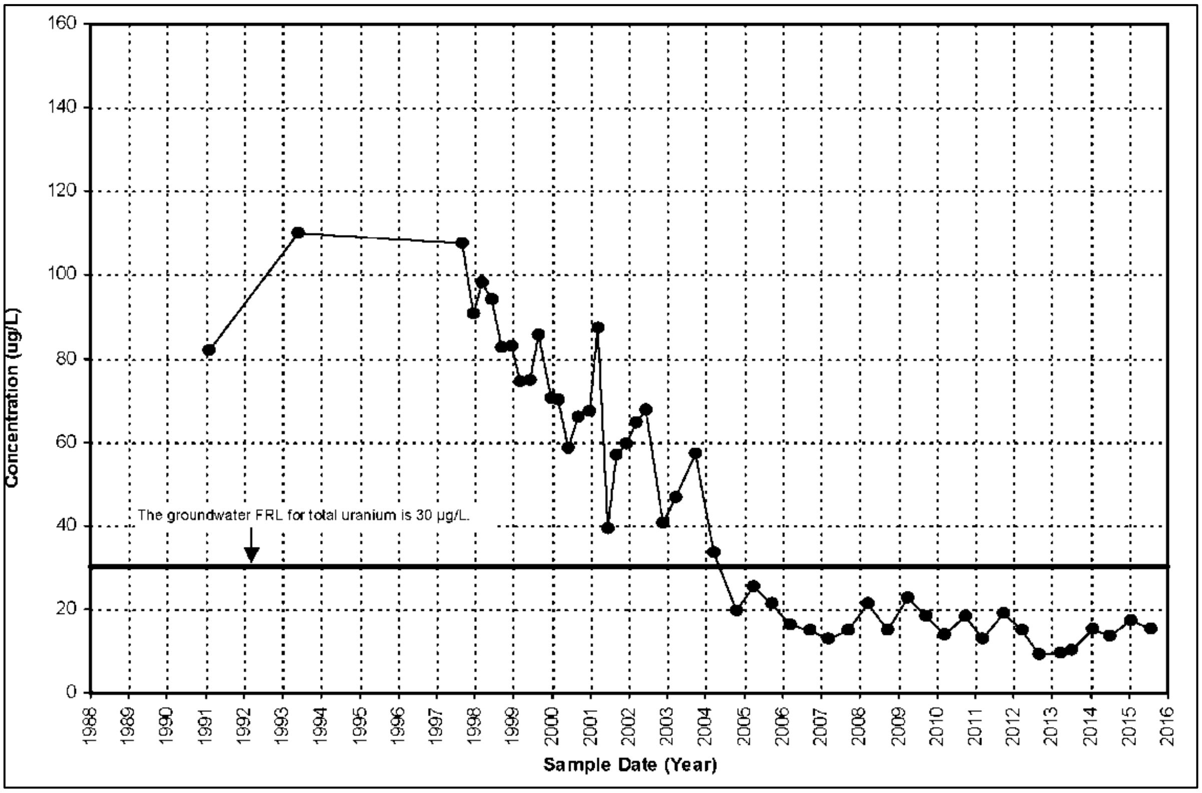

Figure A.2-70. Total Uranium Concentration Versus Time Plot for Monitoring Well 3390

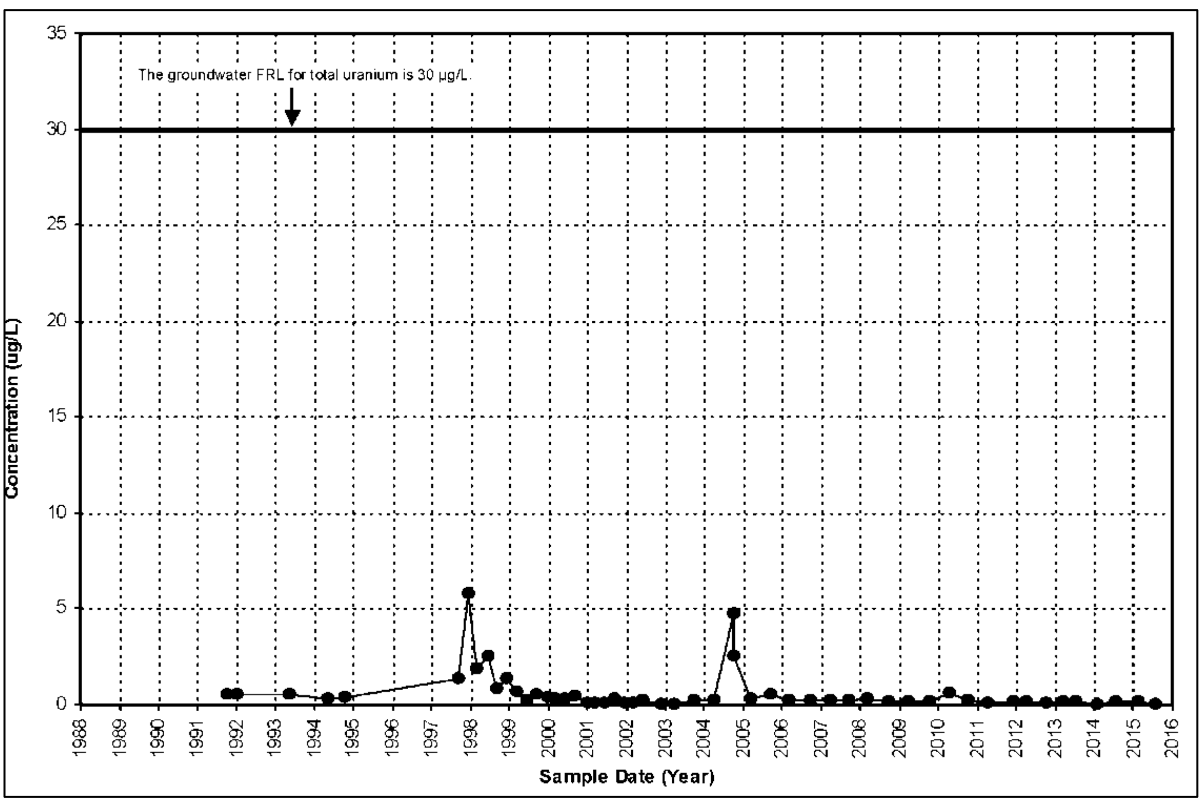

Figure A.2-71. Total Uranium Concentration Versus Time Plot for Monitoring Well 3397

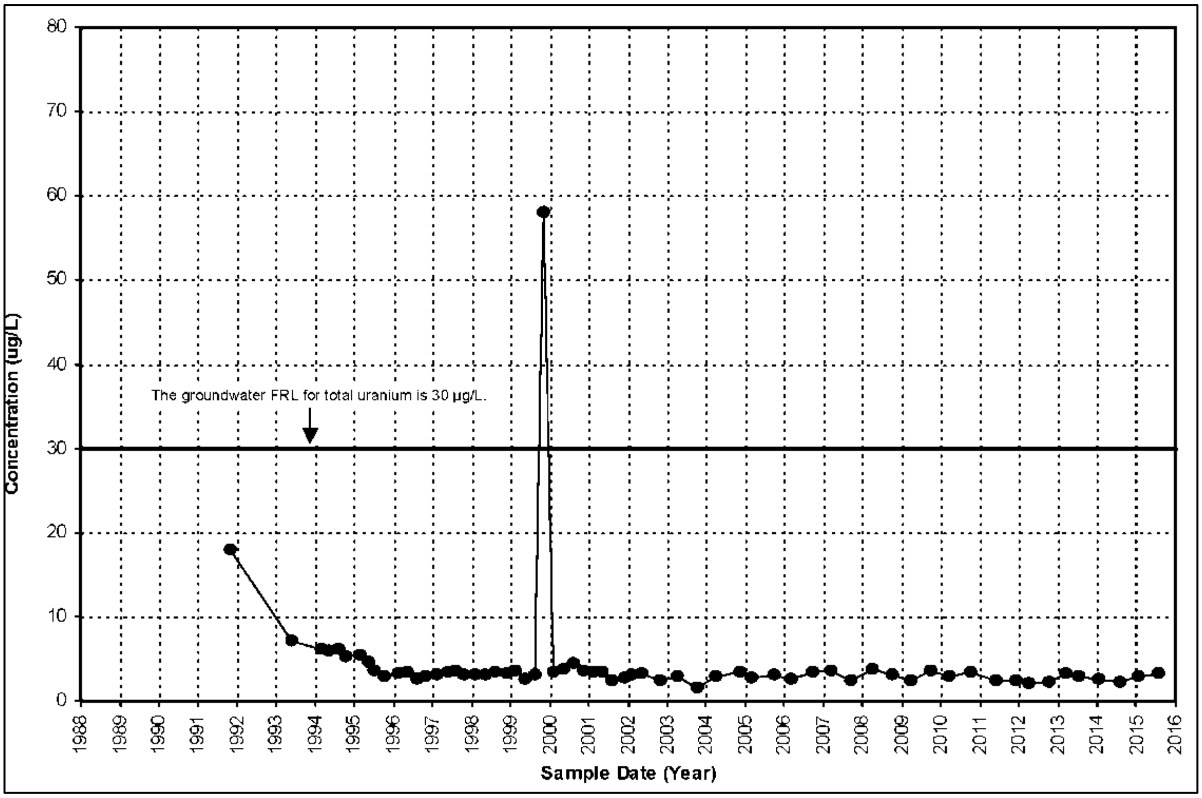

Figure A.2-72. Total Uranium Concentration Versus Time Plot for Monitoring Well 3550

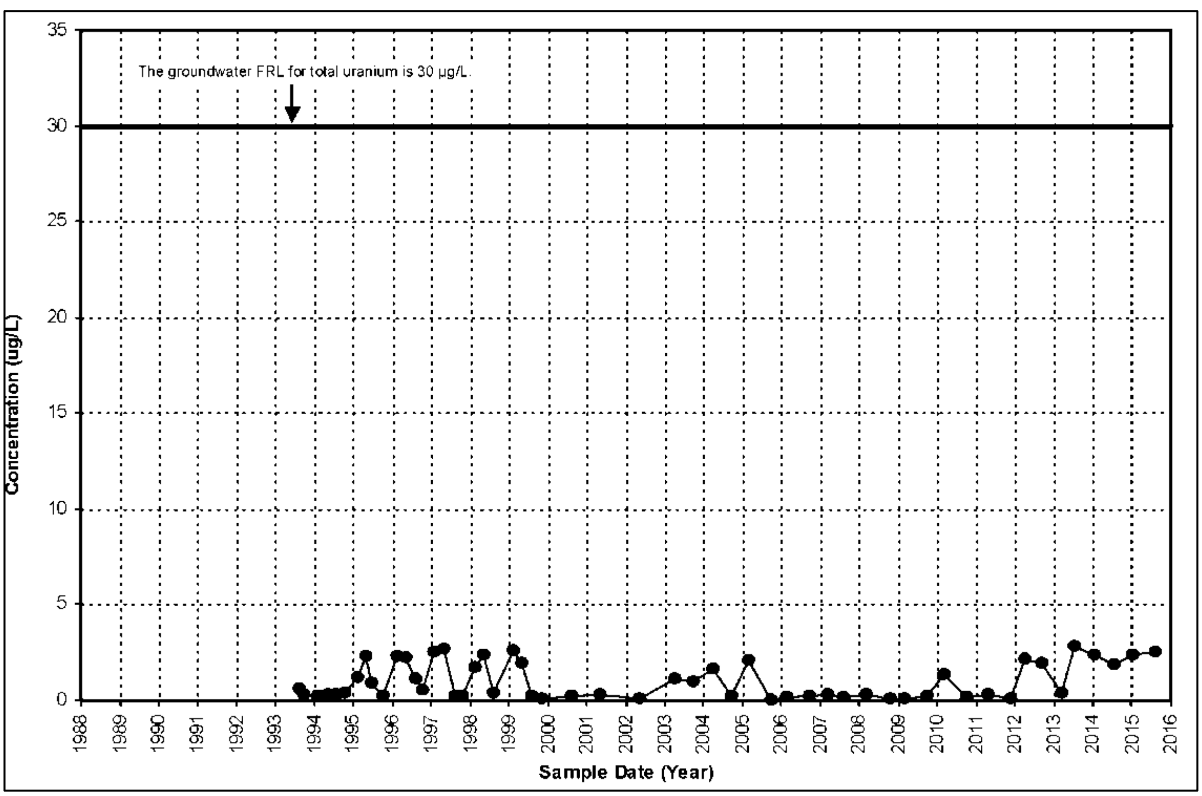

Figure A.2-73. Total Uranium Concentration Versus Time Plot for Monitoring Well 3880

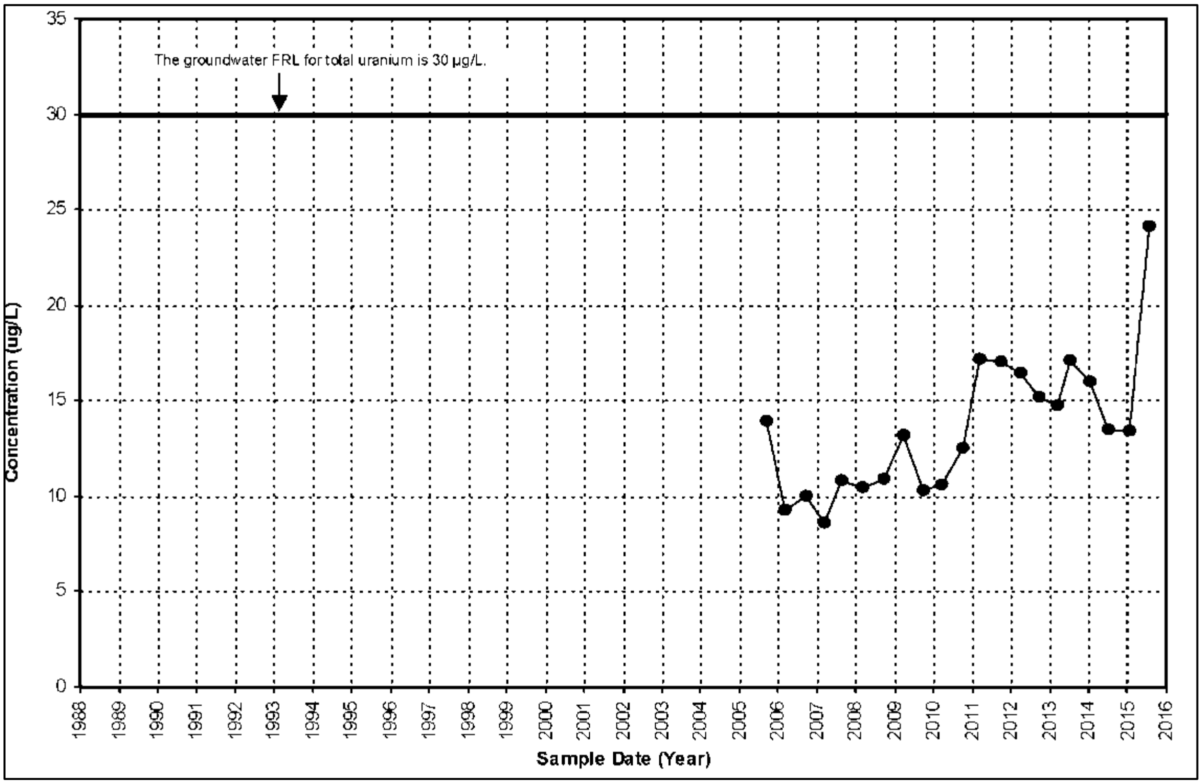

Figure A.2-74. Total Uranium Concentration Versus Time Plot for Monitoring Well 6015

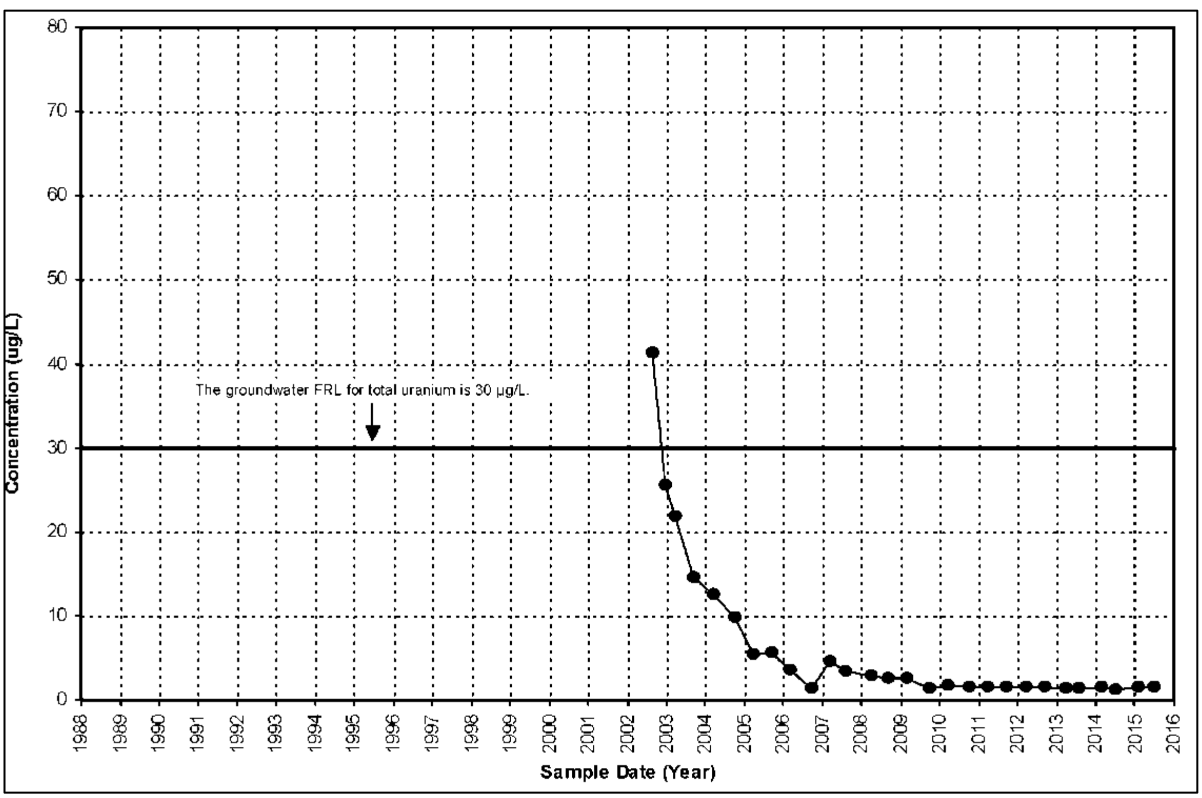

Figure A.2-75. Total Uranium Concentration Versus Time Plot for Monitoring Well 63283

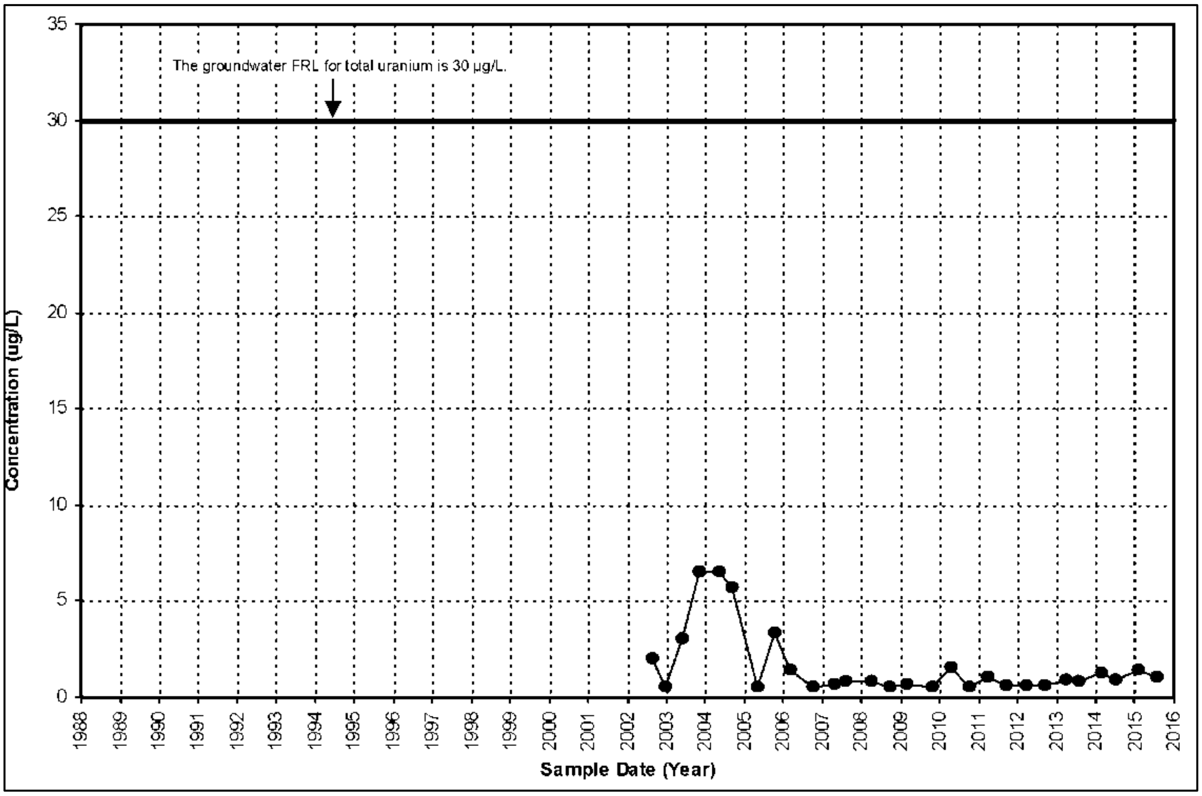

Figure A.2-76. Total Uranium Concentration Versus Time Plot for Monitoring Well 63292

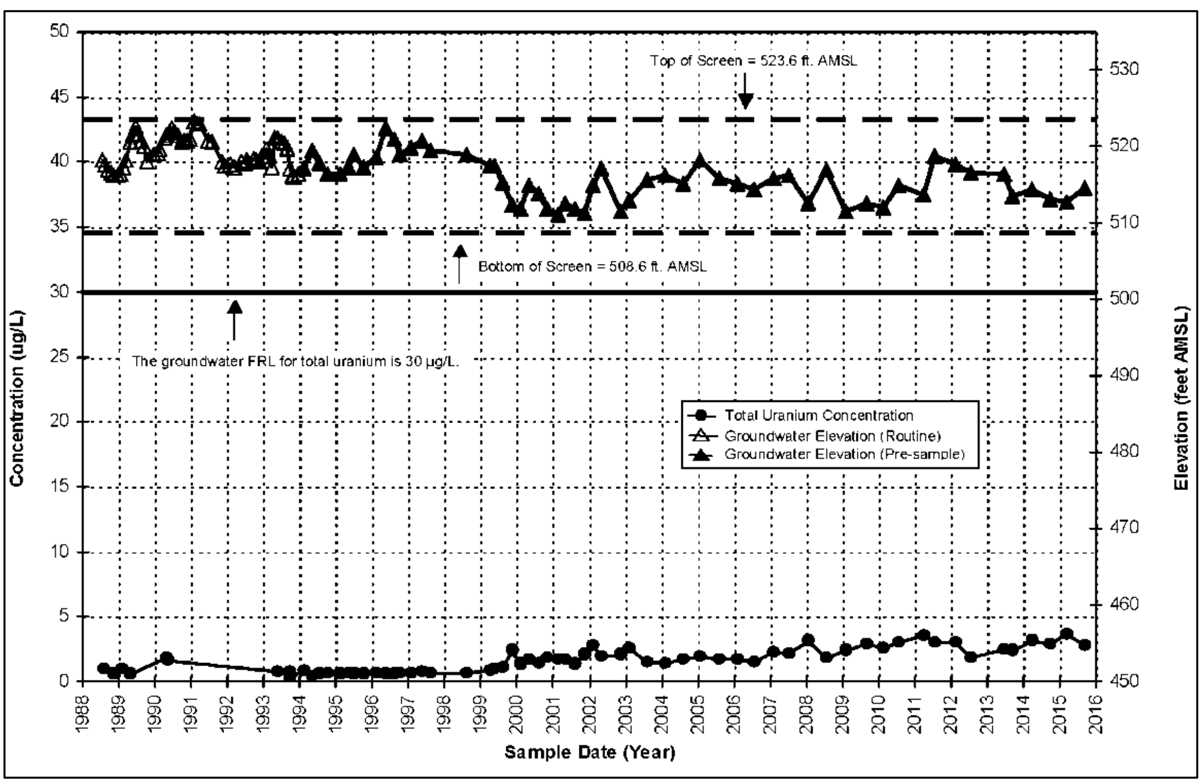

Figure A.2-77. Total Uranium Concentration Versus Time Plot for Monitoring Well 2093

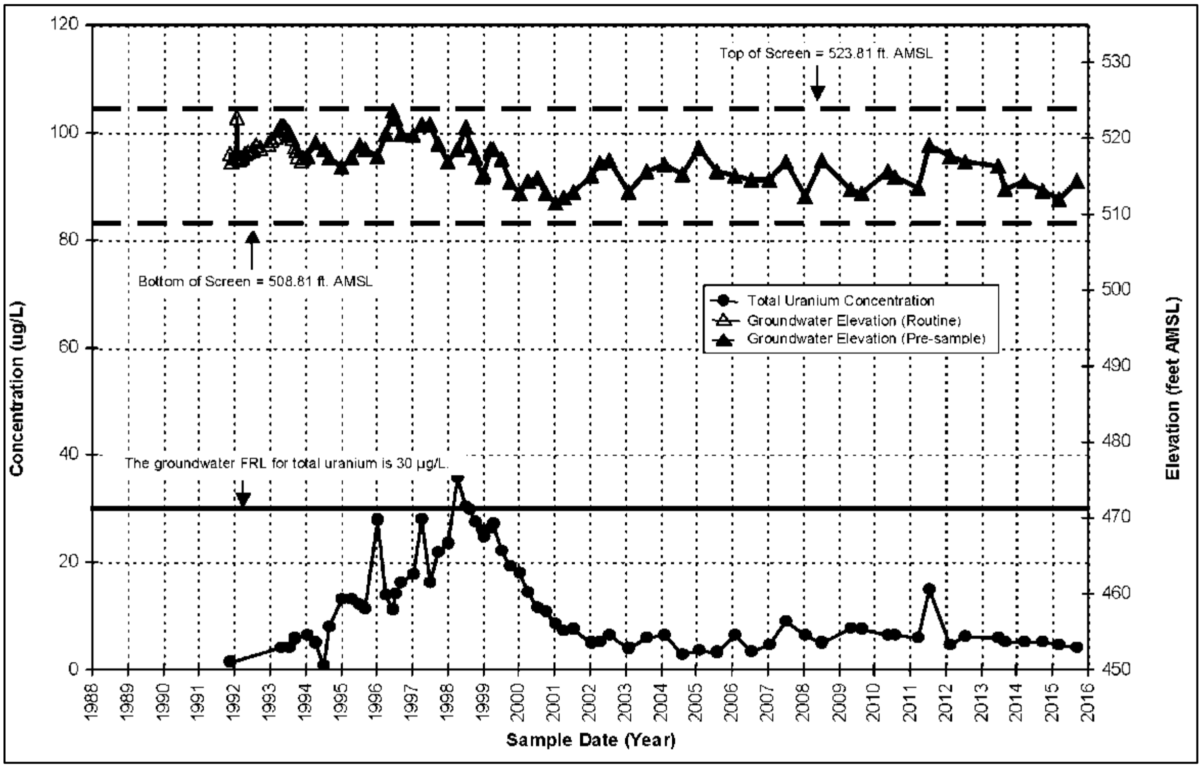

Figure A.2-78. Total Uranium Concentration Versus Time Plot for Monitoring Well 2398

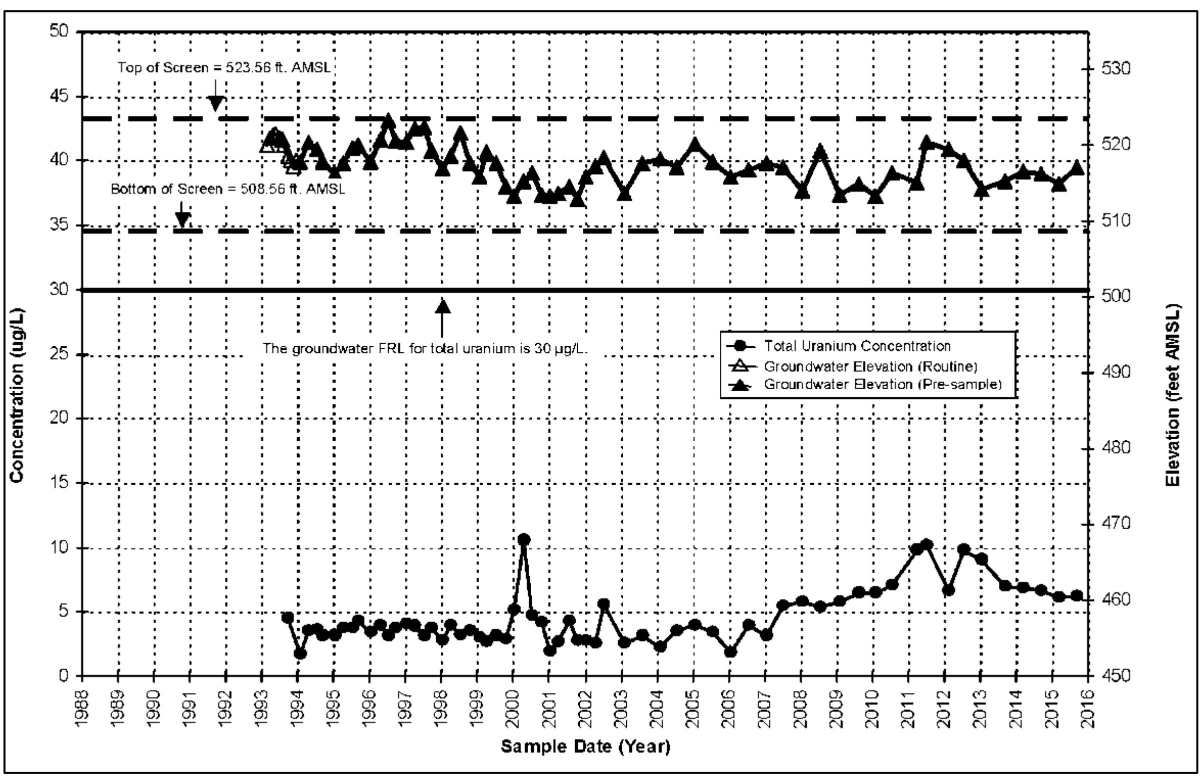

Figure A.2-79. Total Uranium Concentration Versus Time Plot for Monitoring Well 2431

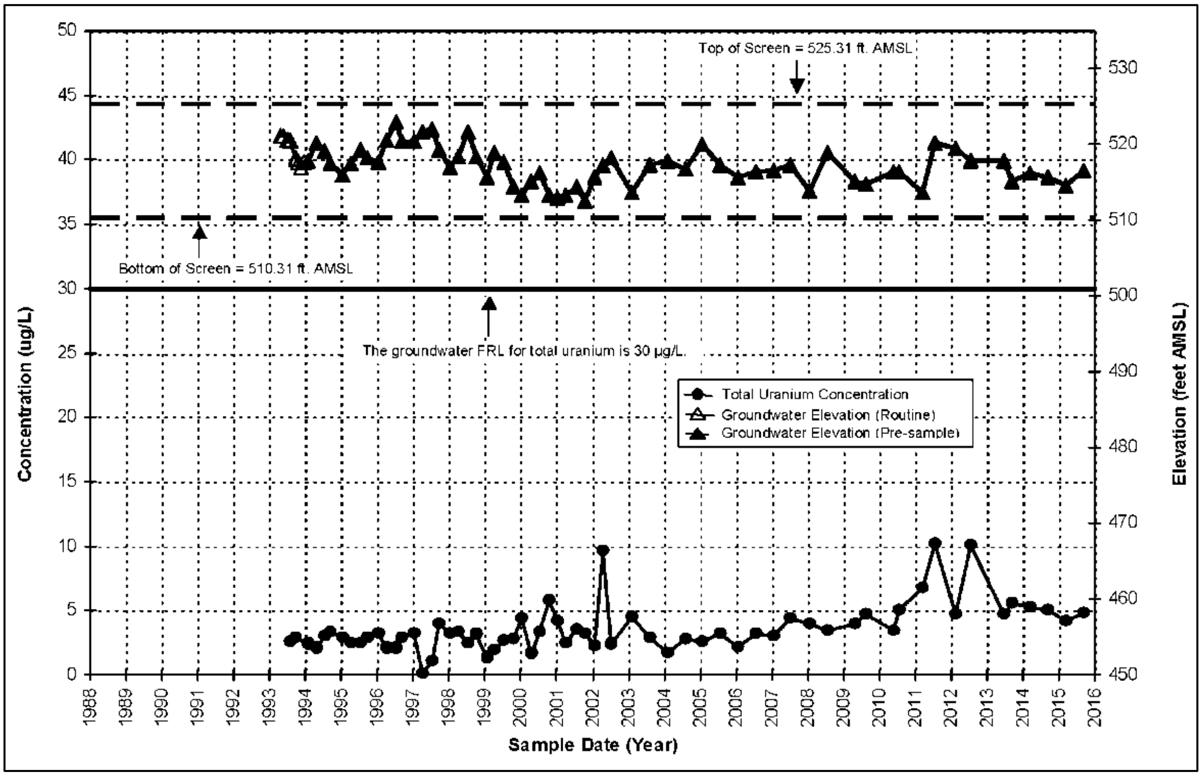

Figure A.2-80. Total Uranium Concentration Versus Time Plot for Monitoring Well 2432

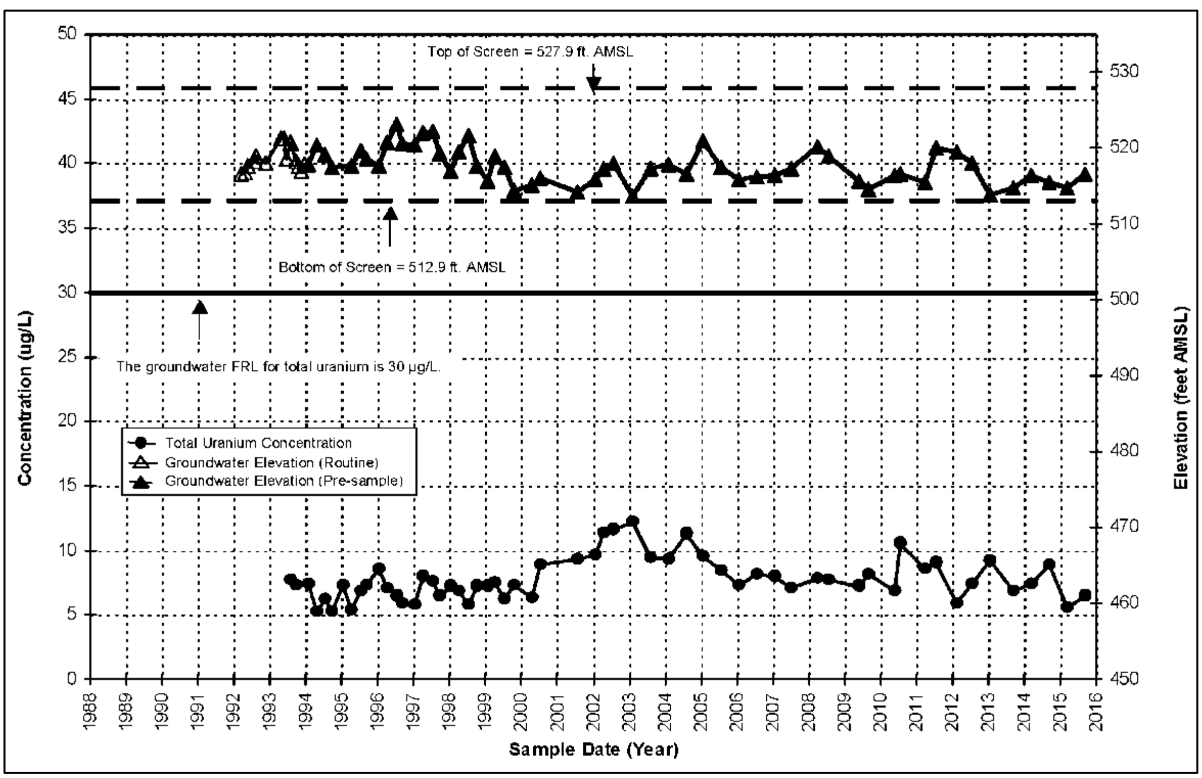

Figure A.2-81. Total Uranium Concentration Versus Time Plot for Monitoring Well 2733

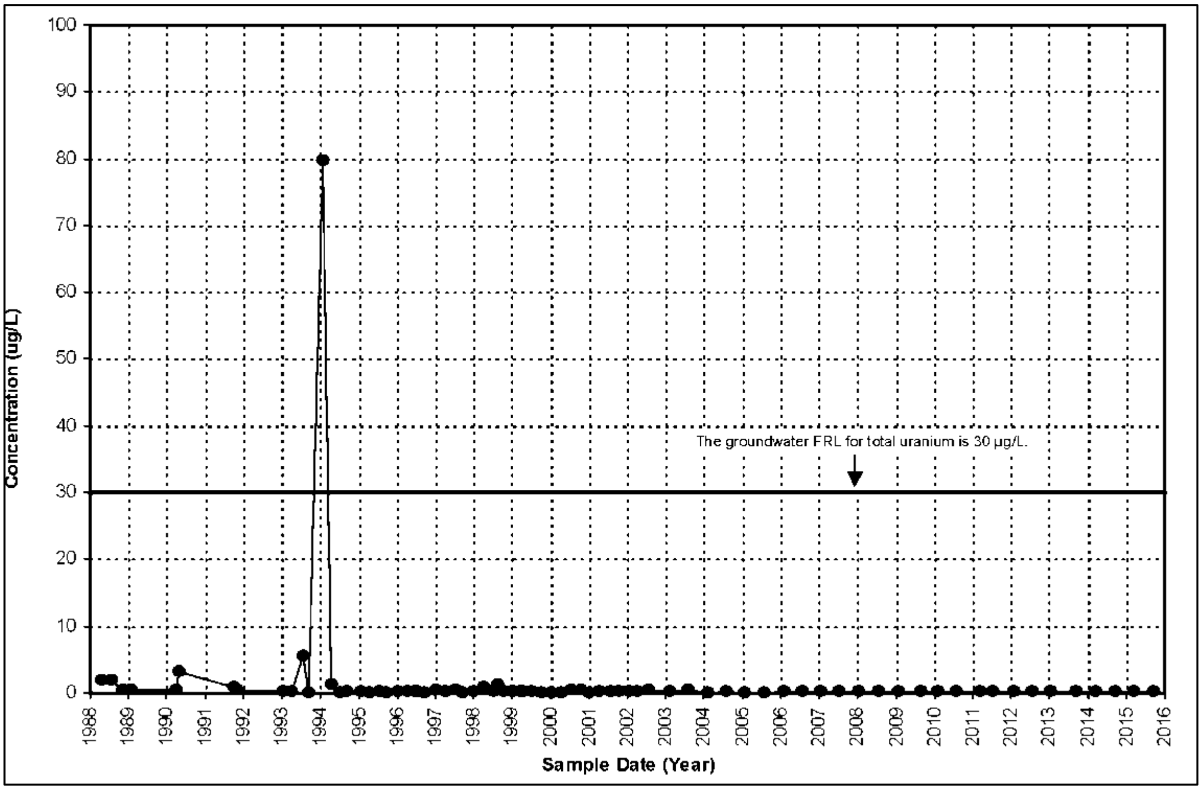

Figure A.2-82. Total Uranium Concentration Versus Time Plot for Monitoring Well 3070

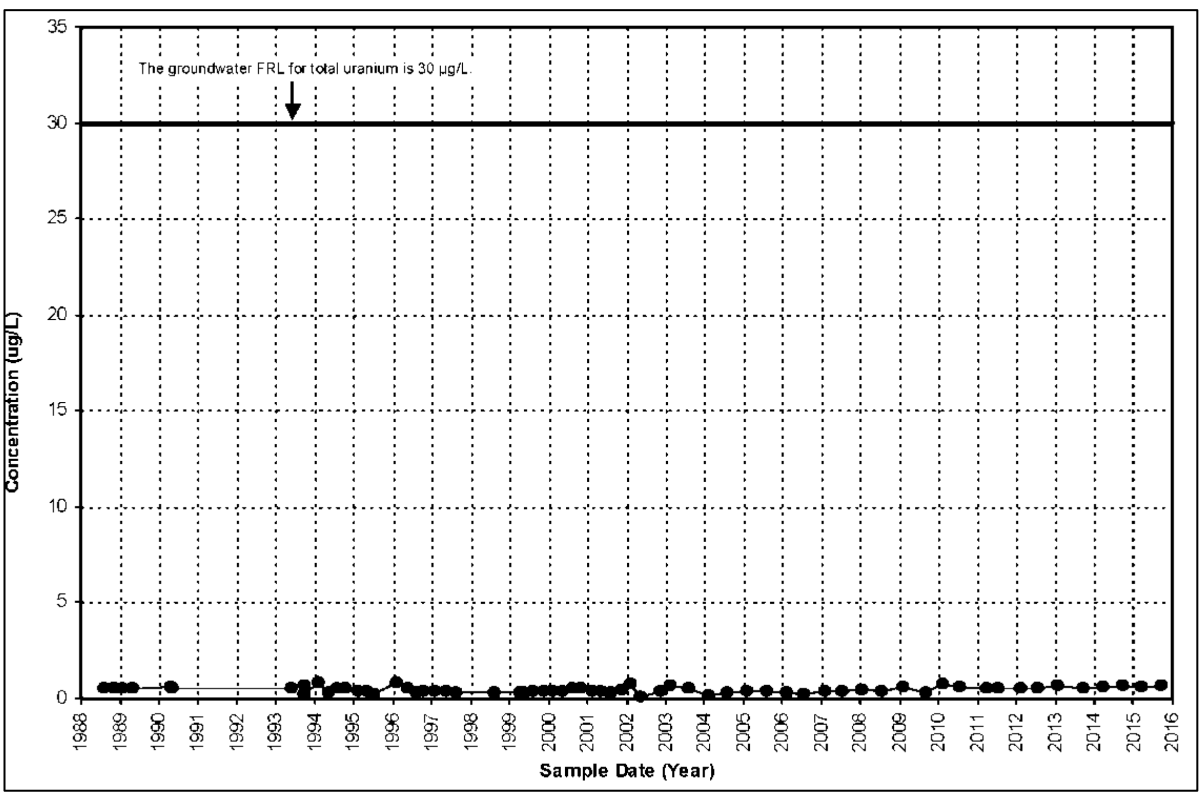

Figure A.2-83. Total Uranium Concentration Versus Time Plot for Monitoring Well 3093

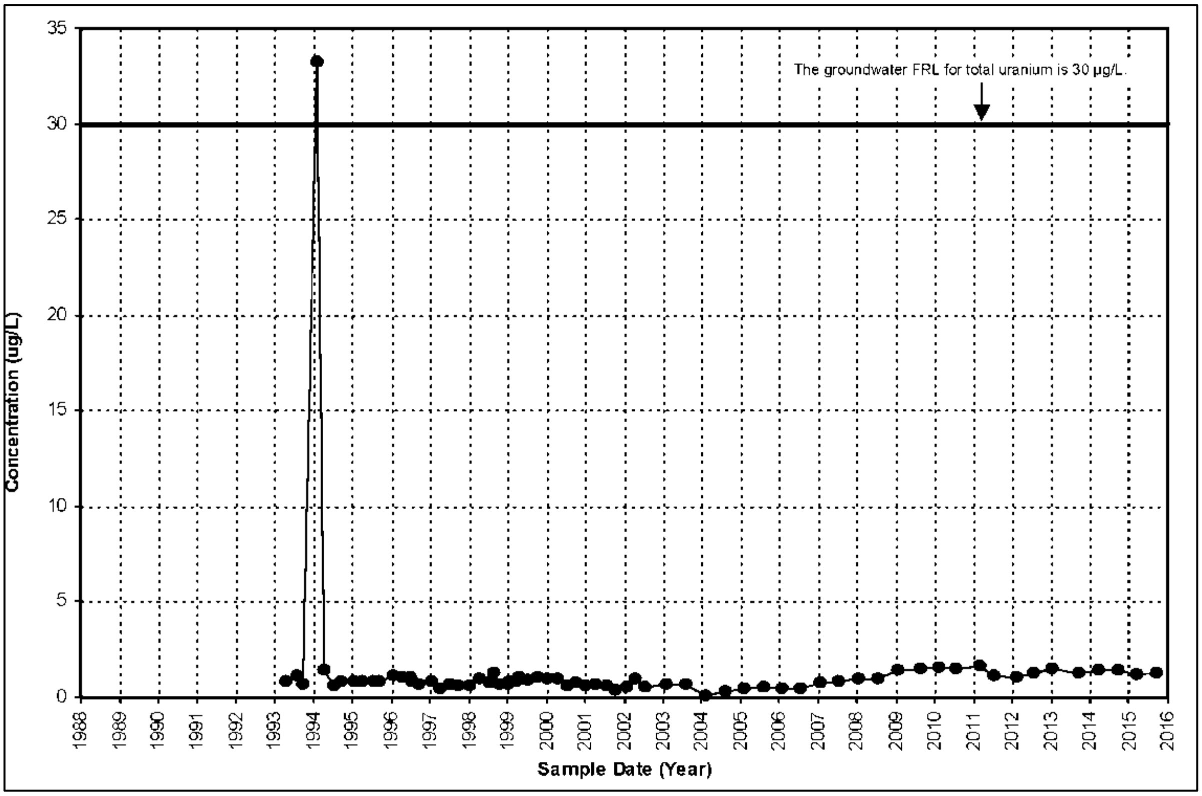

Figure A.2-84. Total Uranium Concentration Versus Time Plot for Monitoring Well 3398

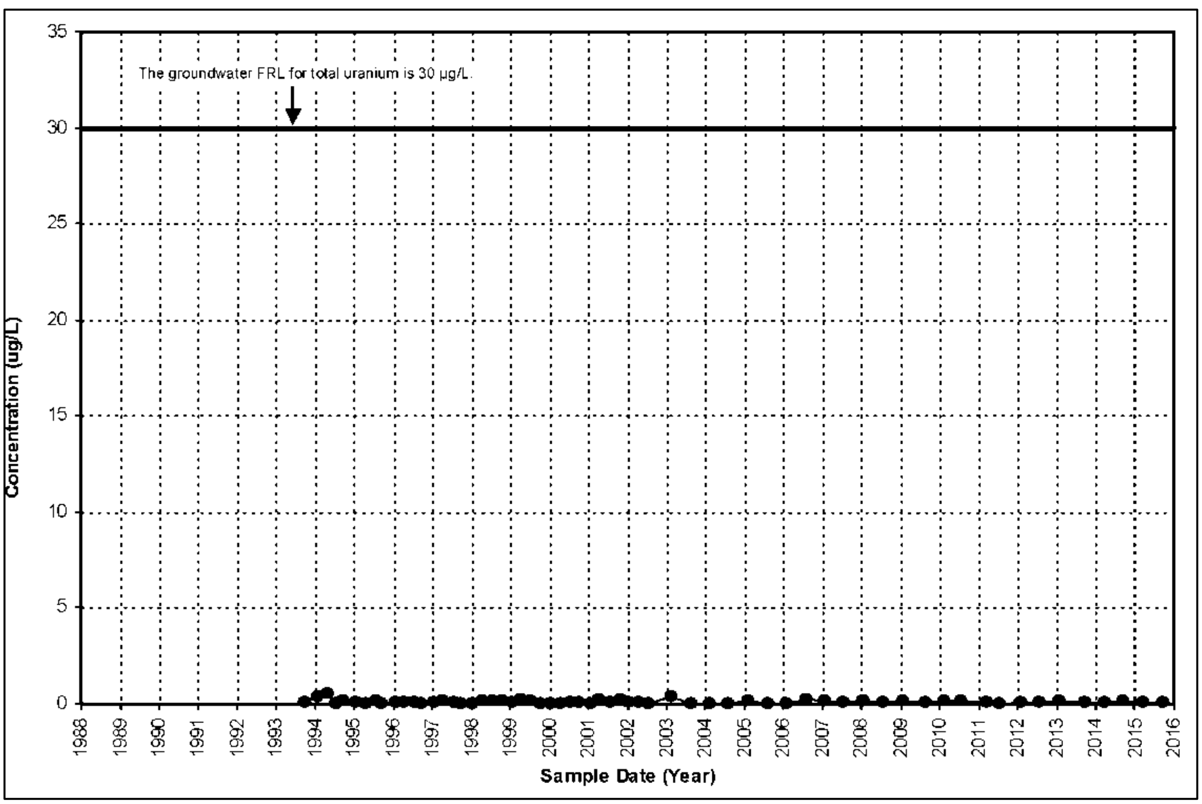

Figure A.2-85. Total Uranium Concentration Versus Time Plot for Monitoring Well 3424

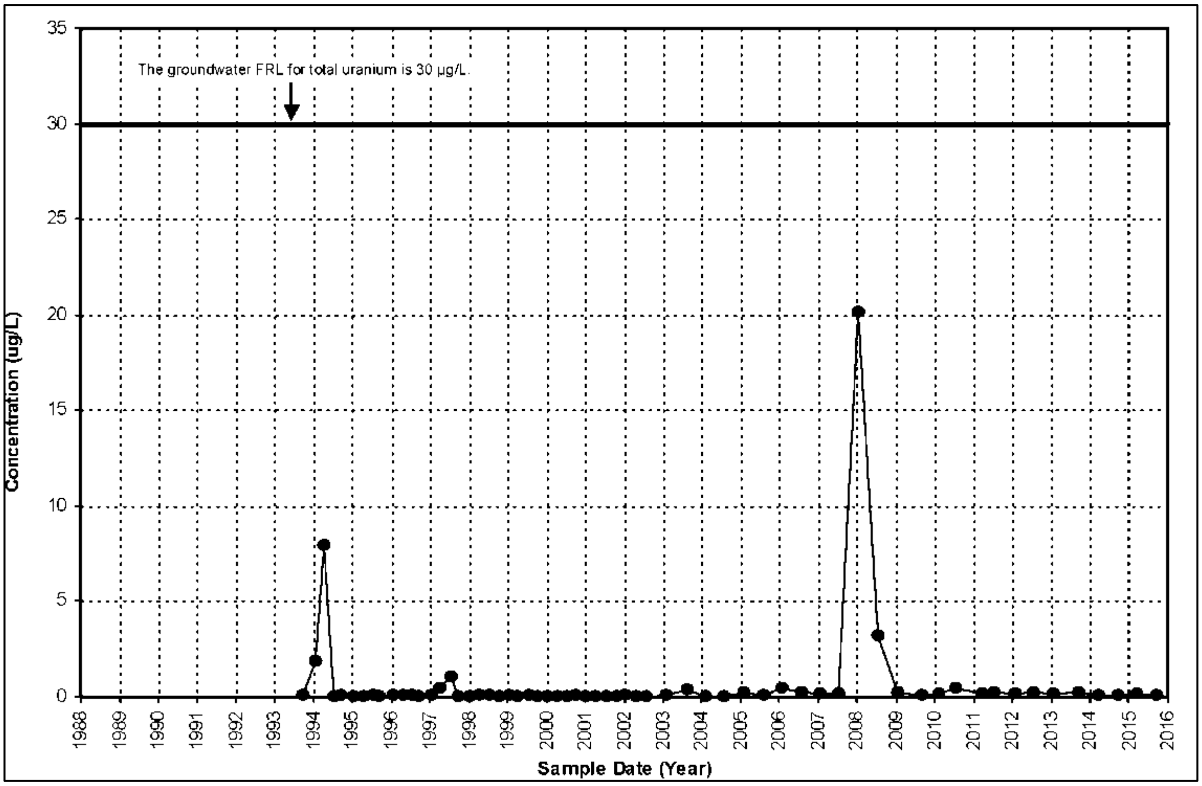

Figure A.2-86. Total Uranium Concentration Versus Time Plot for Monitoring Well 3426

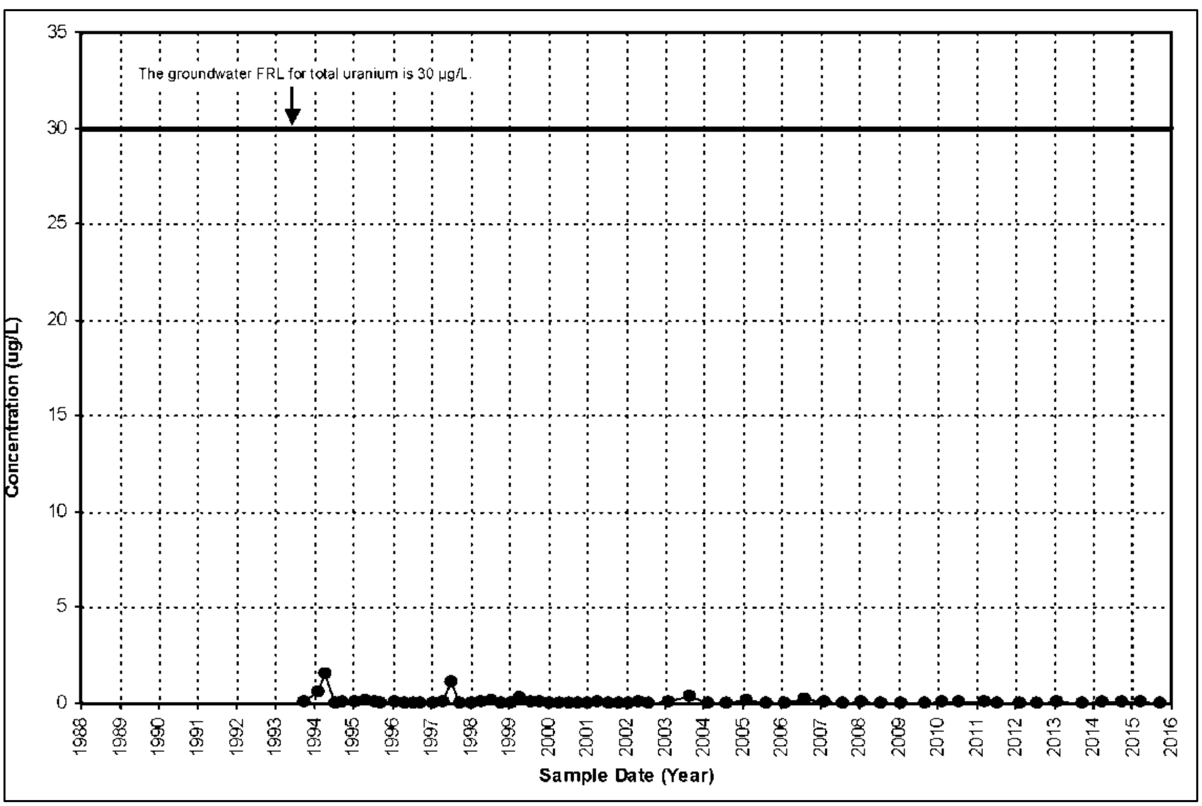

Figure A.2-87. Total Uranium Concentration Versus Time Plot for Monitoring Well 3429

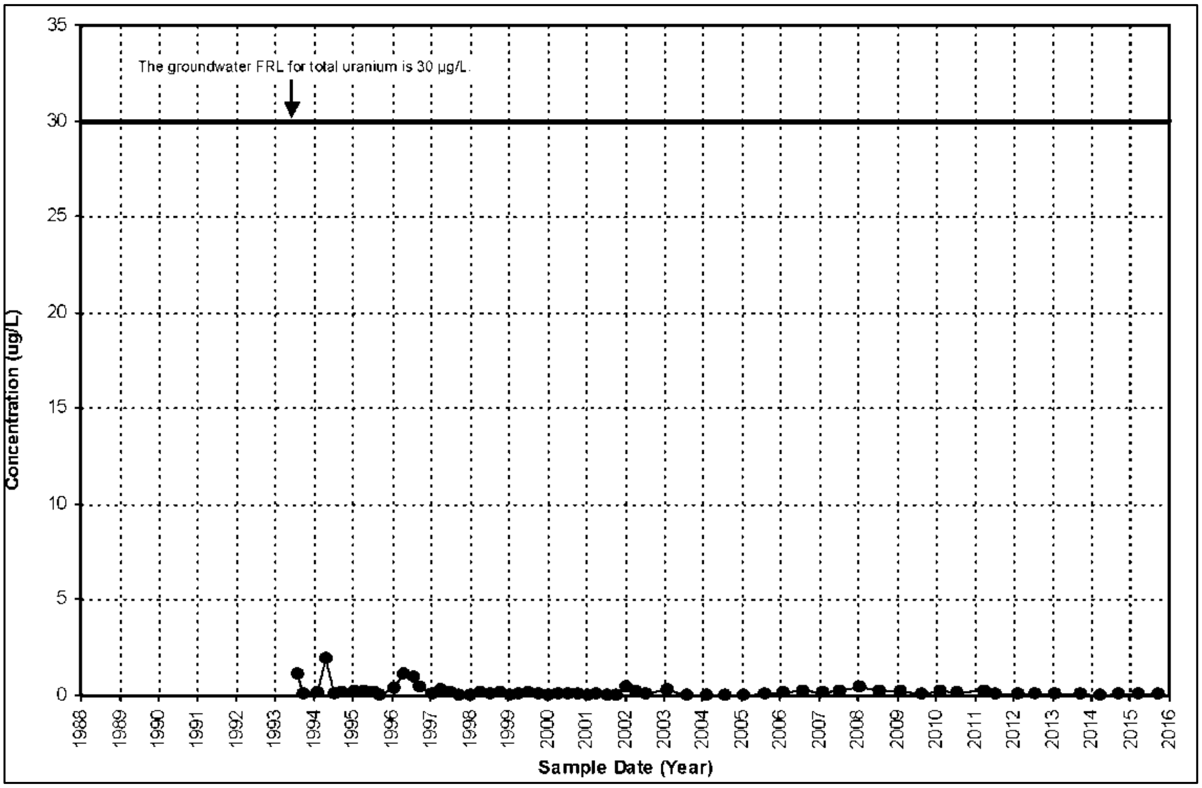

Figure A.2-88. Total Uranium Concentration Versus Time Plot for Monitoring Well 3431

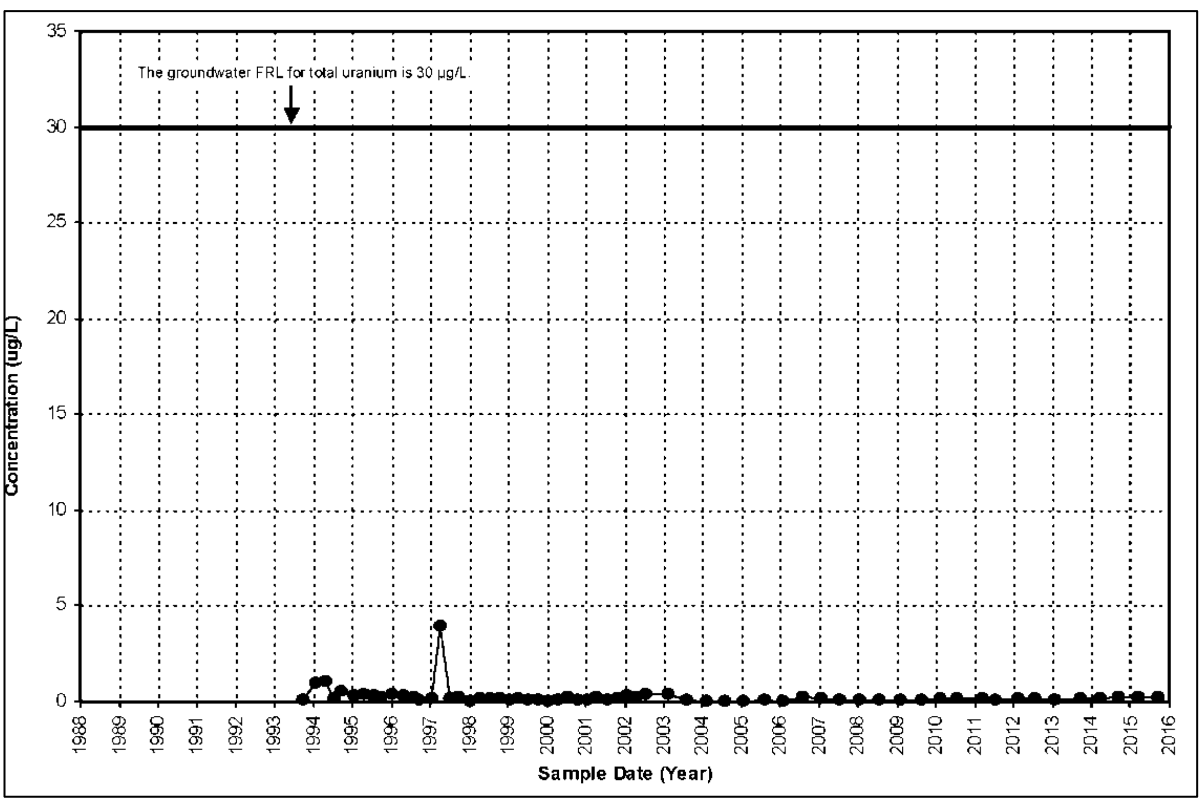

Figure A.2-89. Total Uranium Concentration Versus Time Plot for Monitoring Well 3432

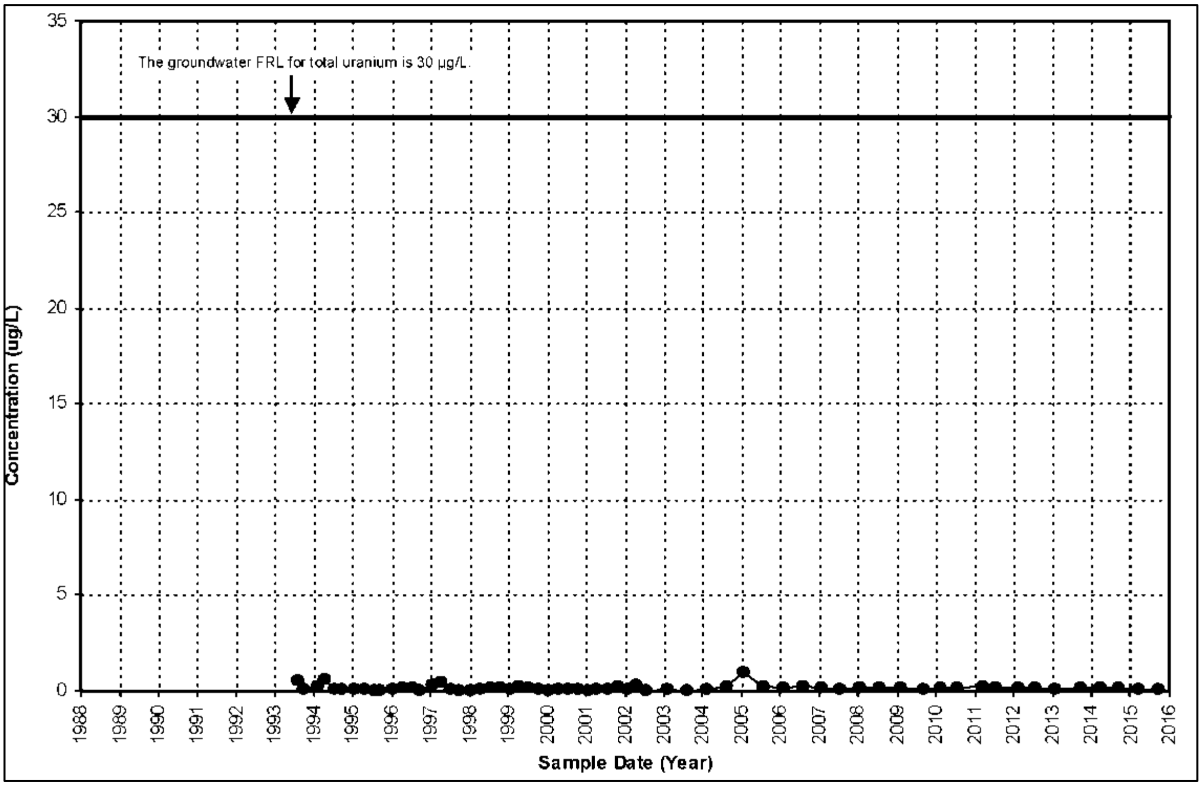

Figure A.2-90. Total Uranium Concentration Versus Time Plot for Monitoring Well 3733

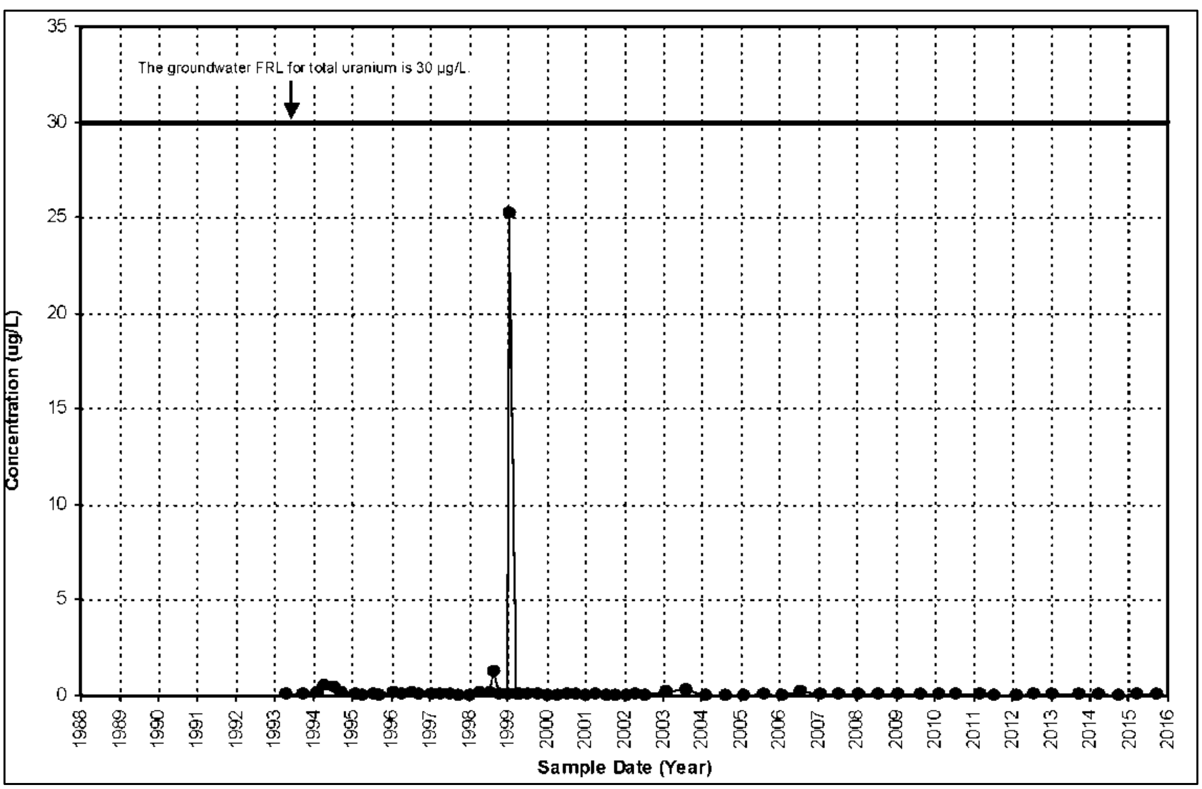

Figure A.2-91. Total Uranium Concentration Versus Time Plot for Monitoring Well 4398

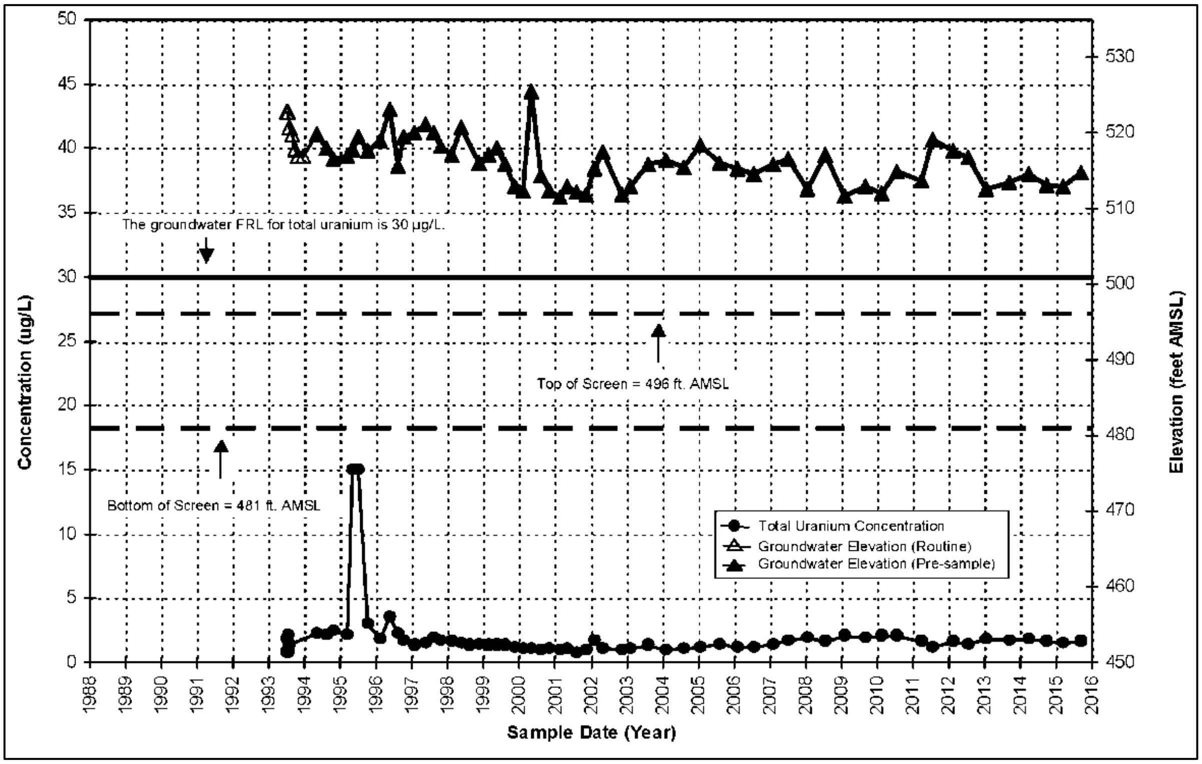

Figure A.2-92. Total Uranium Concentration Versus Time Plot for Monitoring Well 21063

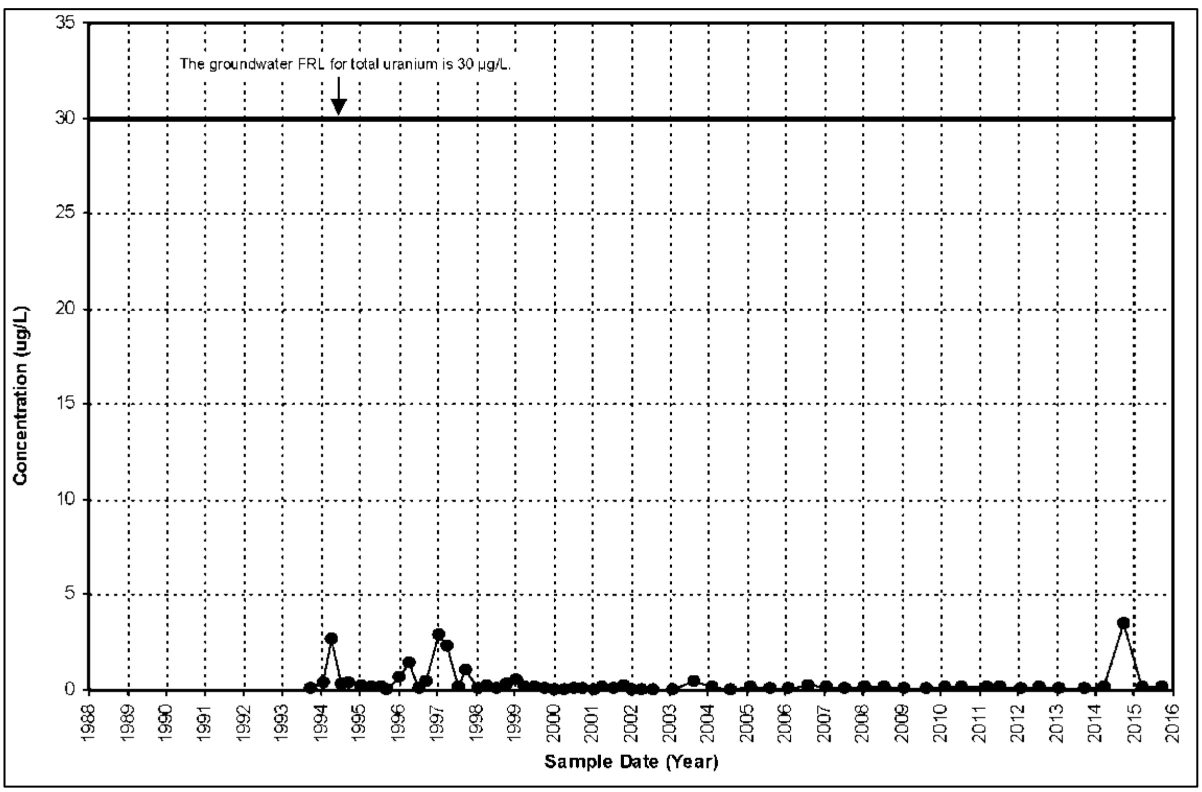

Figure A.2-93. Total Uranium Concentration Versus Time Plot for Monitoring Well 31217

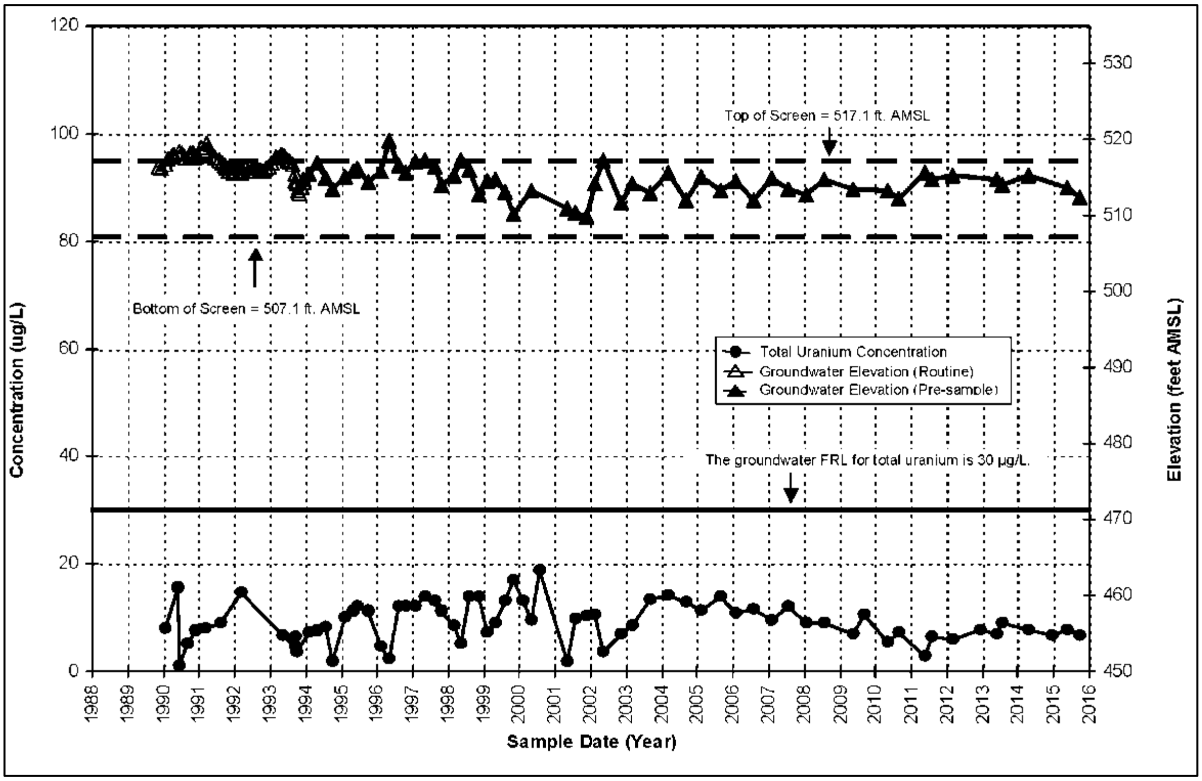

Figure A.2-94. Total Uranium Concentration Versus Time Plot for Monitoring Well 2128

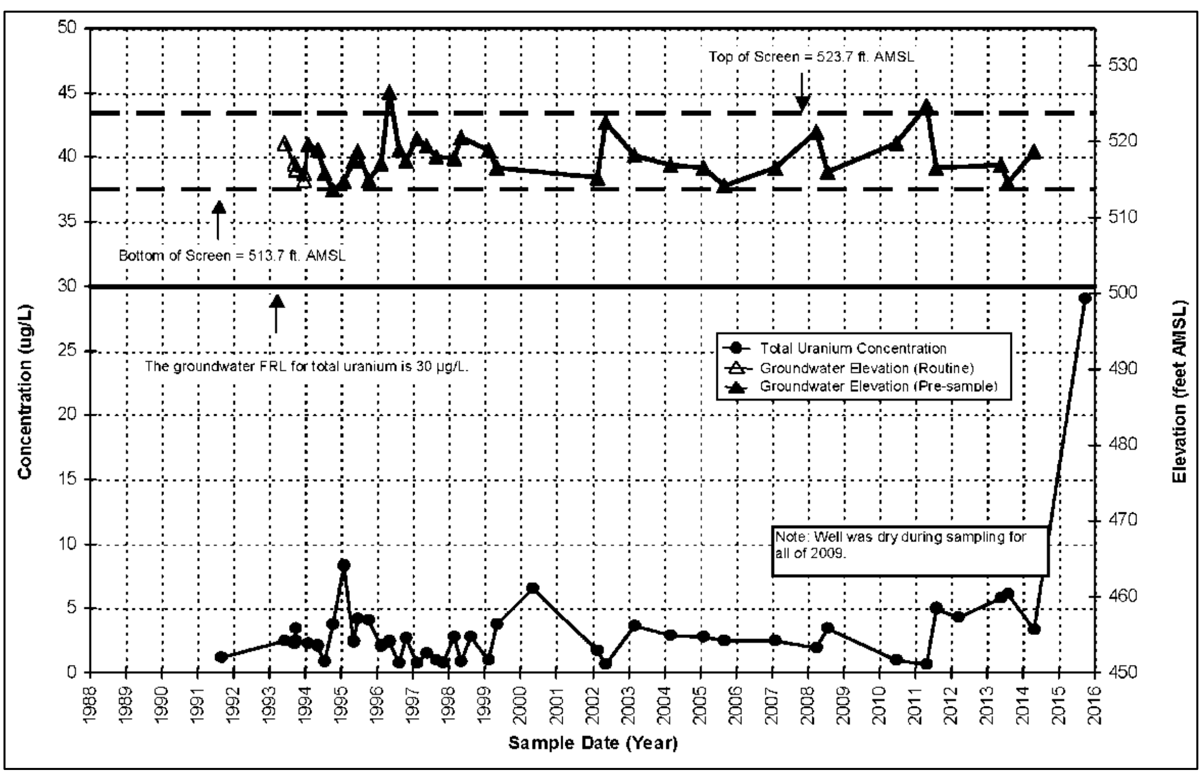

Figure A.2-95. Total Uranium Concentration Versus Time Plot for Monitoring Well 2625

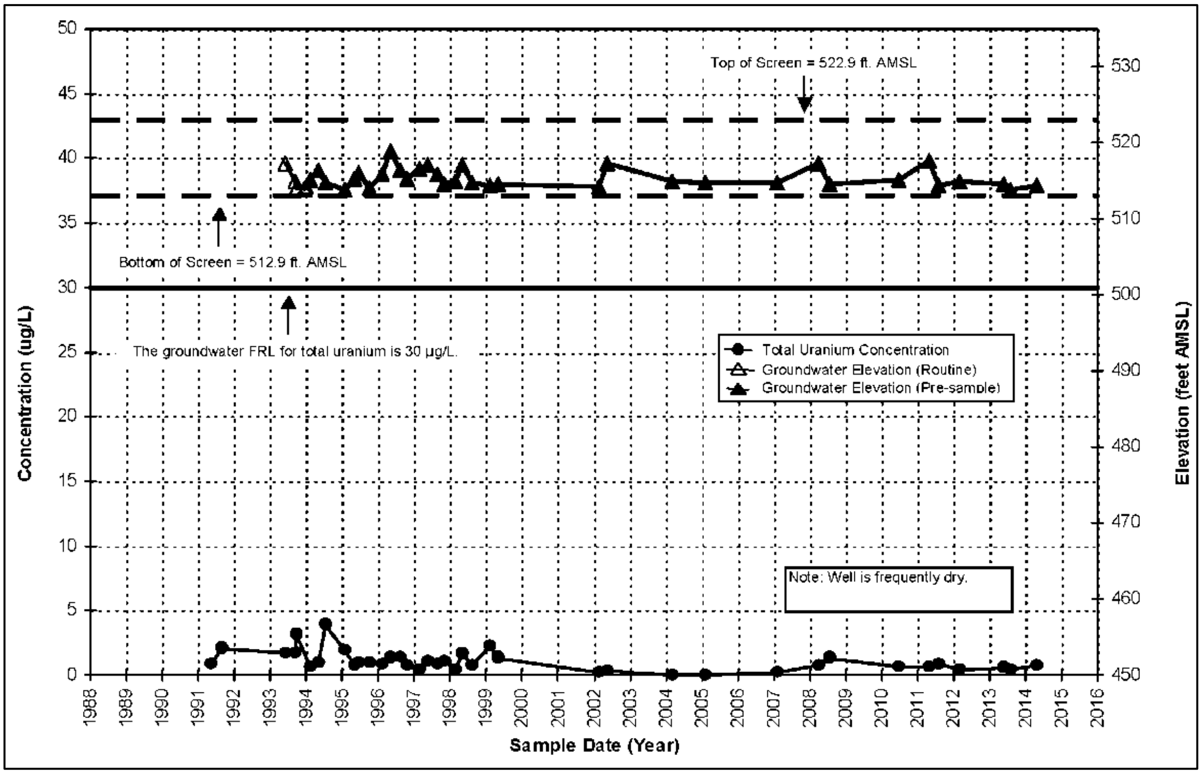

Figure A.2-96. Total Uranium Concentration Versus Time Plot for Monitoring Well 2636

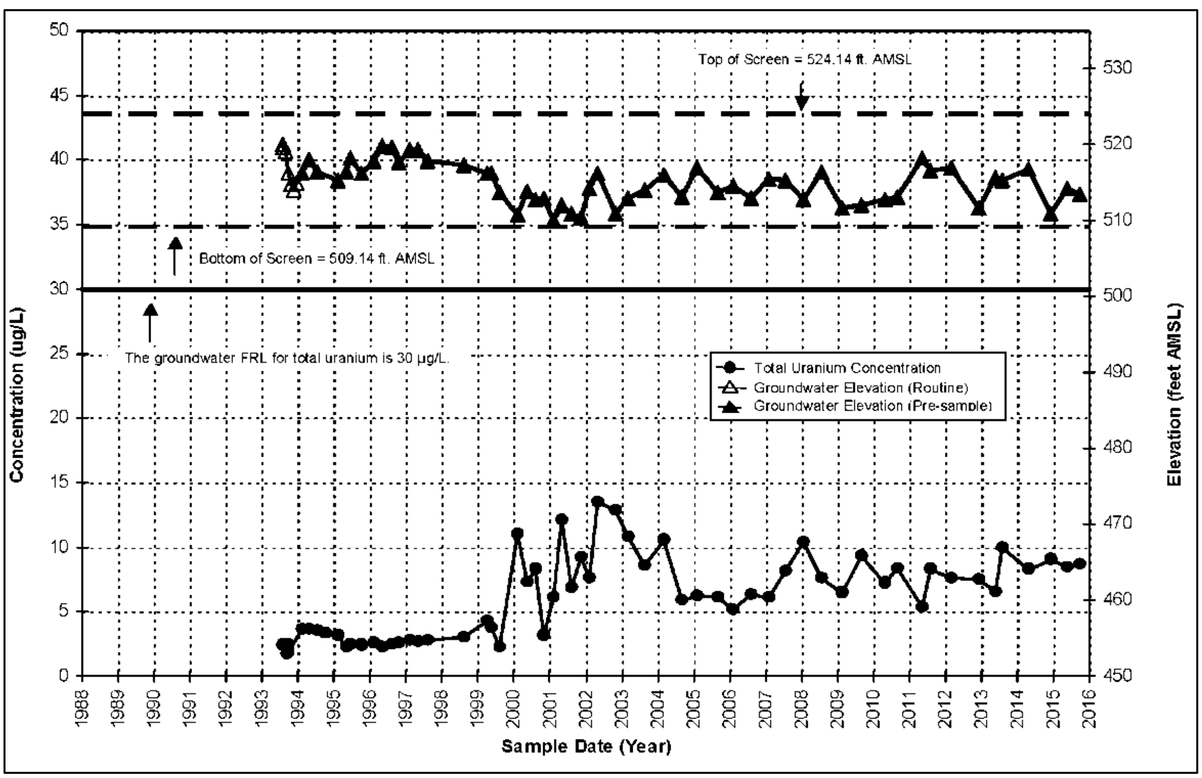

Figure A.2-97. Total Uranium Concentration Versus Time Plot for Monitoring Well 2898

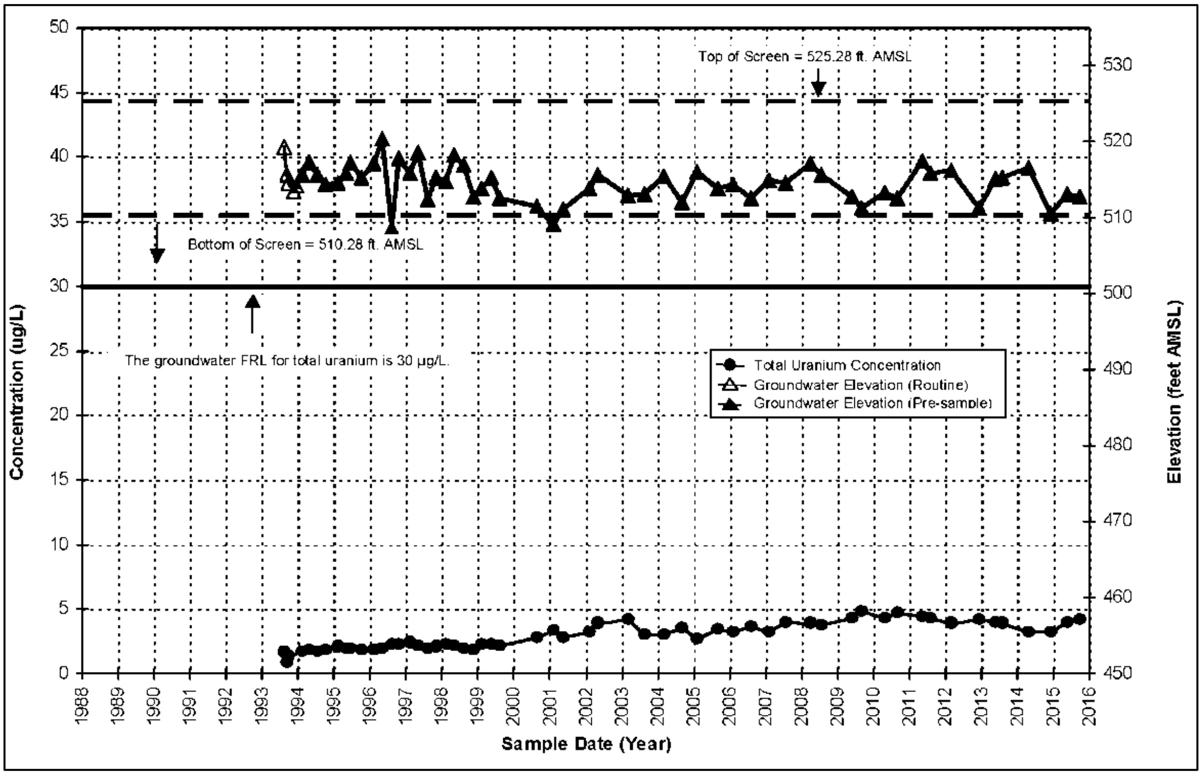

Figure A.2-98. Total Uranium Concentration Versus Time Plot for Monitoring Well 2899

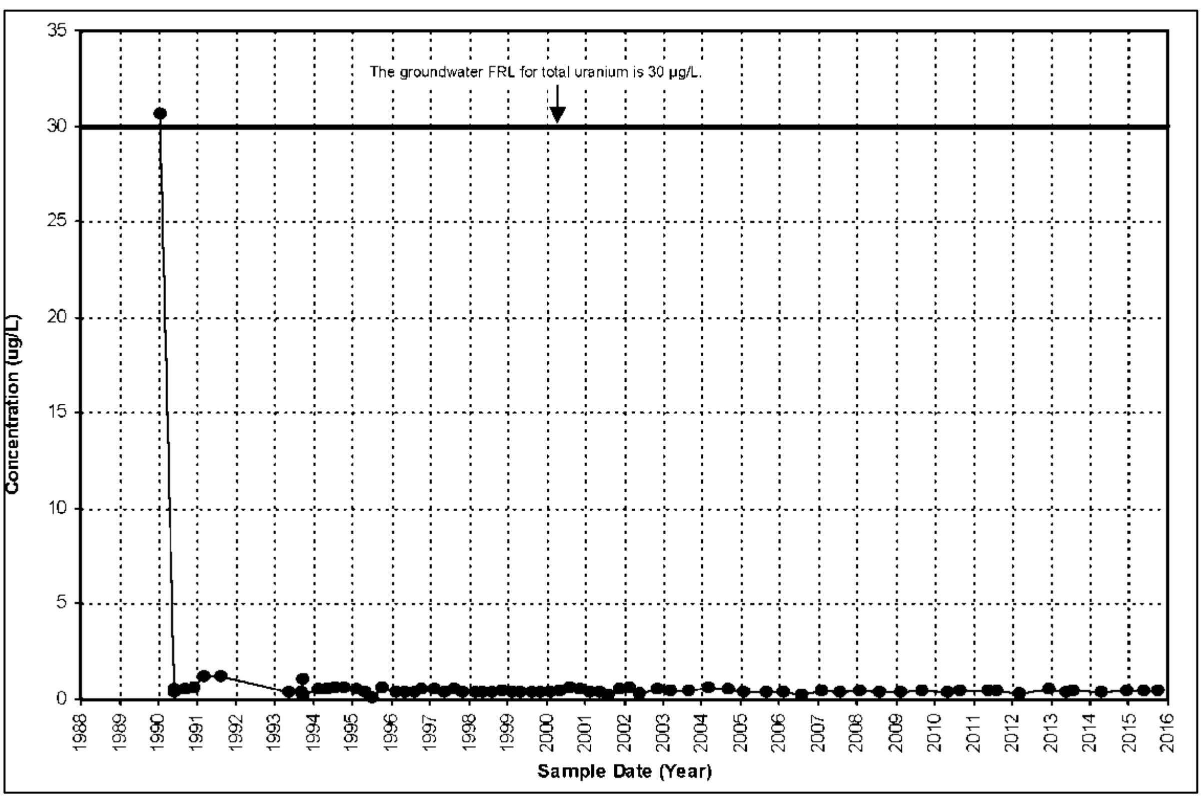

Figure A.2-99. Total Uranium Concentration Versus Time Plot for Monitoring Well 3128

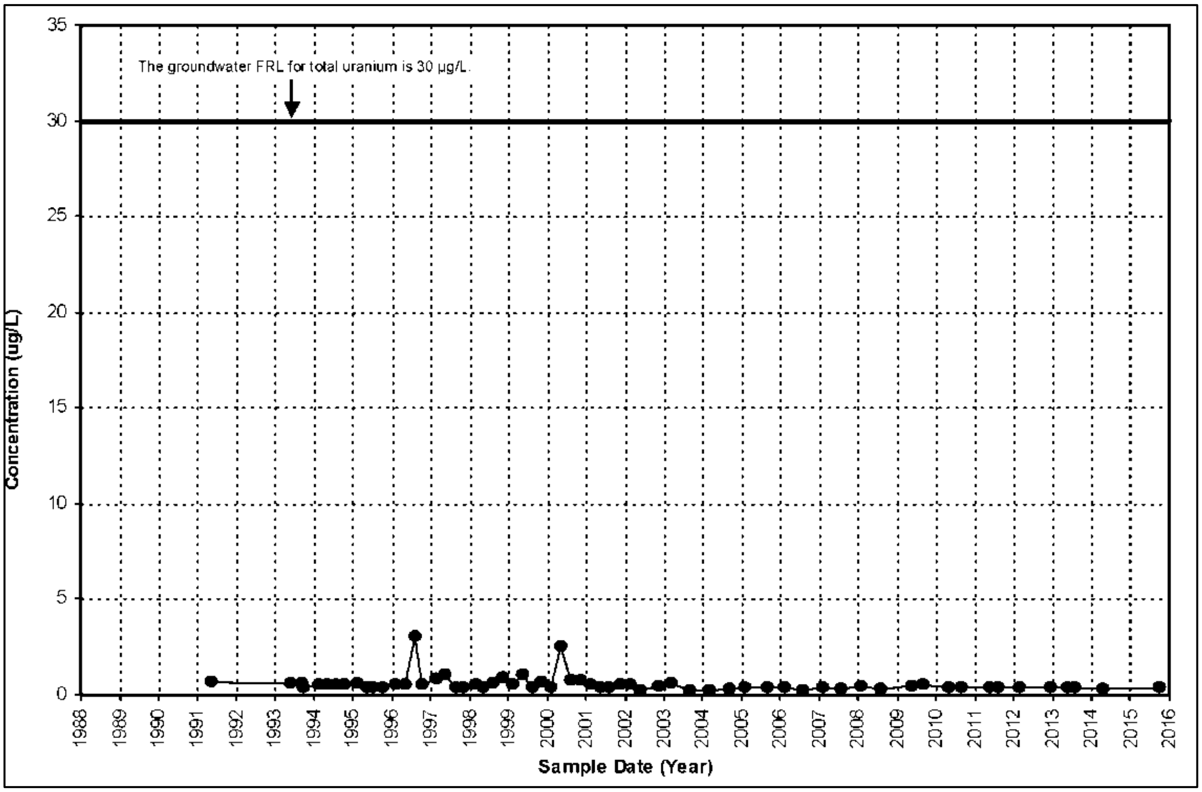

Figure A.2-100. Total Uranium Concentration Versus Time Plot for Monitoring Well 3636

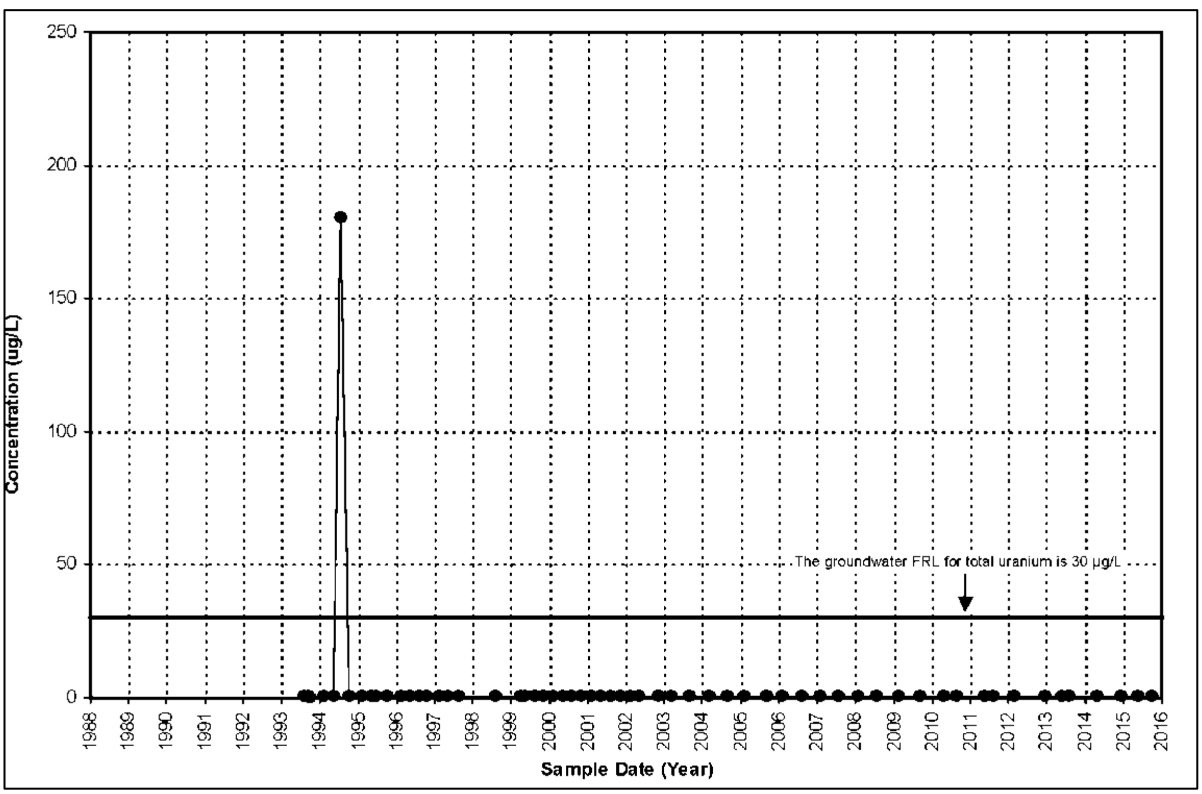

Figure A.2-101. Total Uranium Concentration Versus Time Plot for Monitoring Well 3898

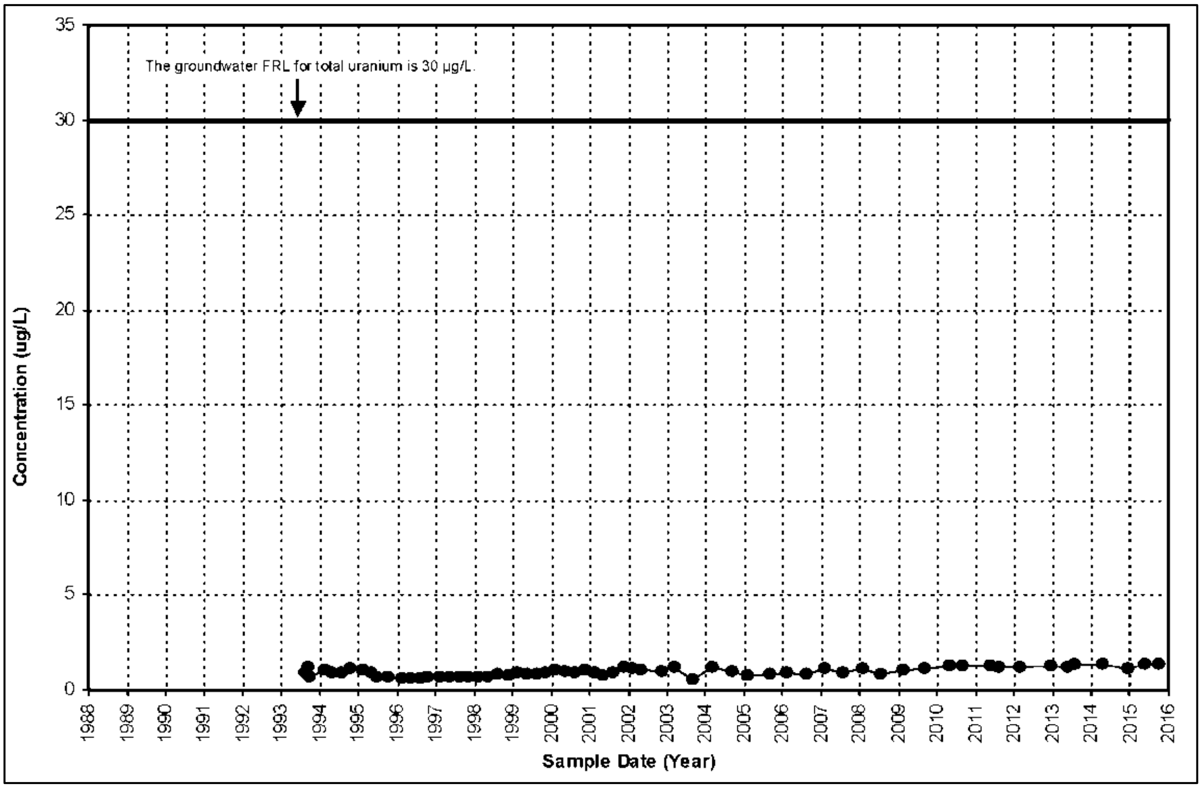

Figure A.2-102. Total Uranium Concentration Versus Time Plot for Monitoring Well 3899

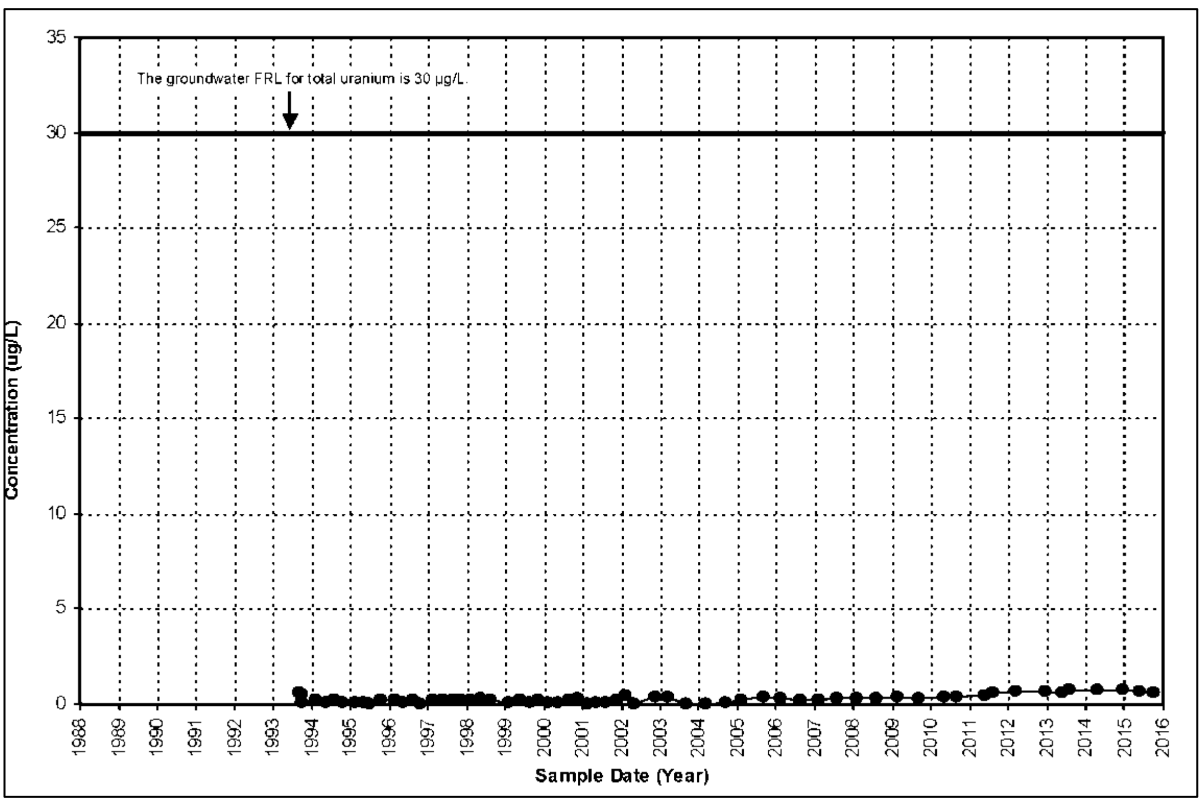

Figure A.2-103. Total Uranium Concentration Versus Time Plot for Monitoring Well 3900

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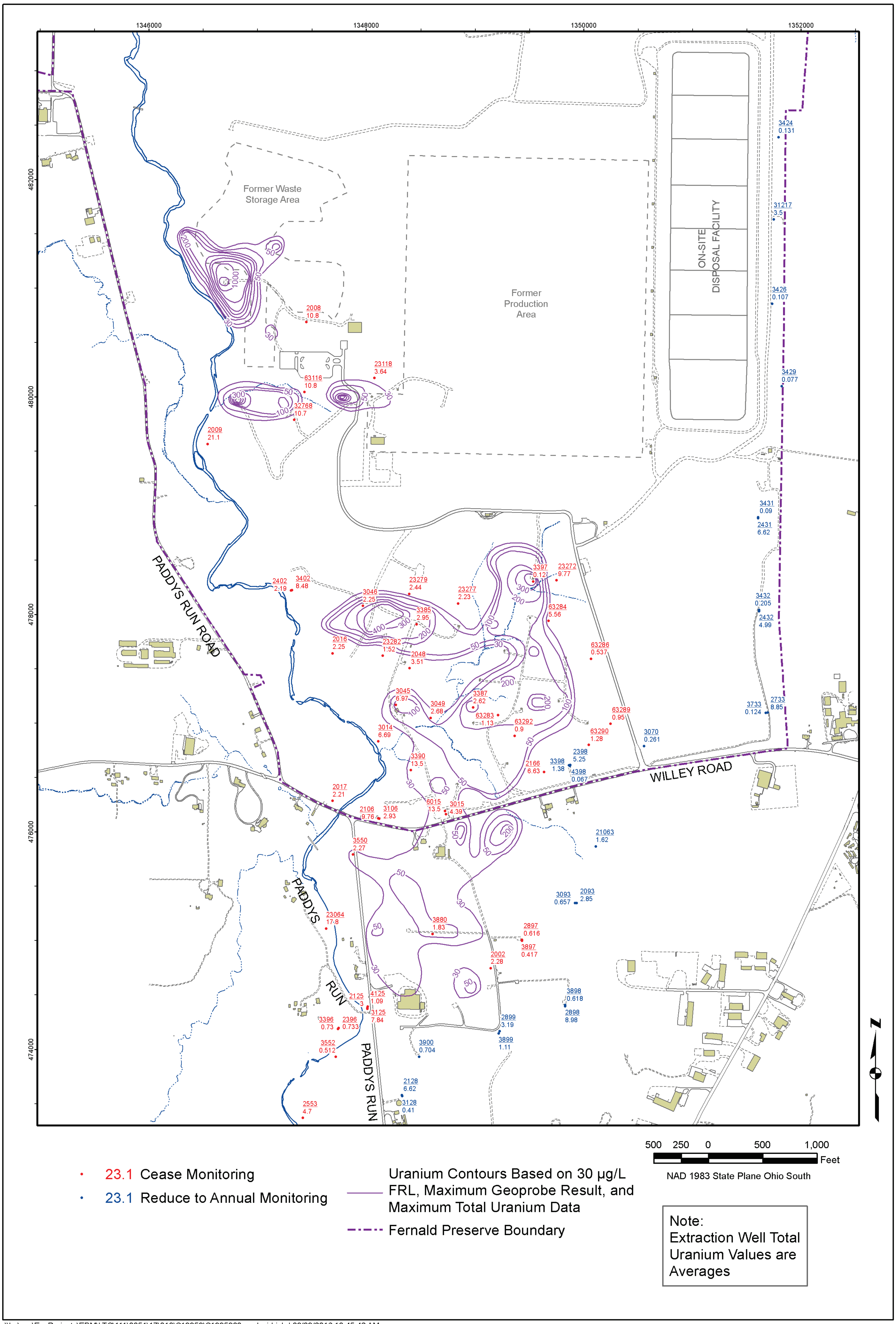

Figure A.2-104. Monitoring Wells Identified for Water Quality Monitoring Frequency Changes

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Attachment A.3

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Abbreviations

IEMP	Integrated Environmental Monitoring Plan
OSDF	On-Site Disposal Facility
VAM 3D	Variable Saturated Analysis Model in 3 Dimensions
WSA	Waste Storage Area

Measurement Abbreviations

ft	feet
gpm	gallons per minute
µg/L	micrograms per liter

A.3.0 Groundwater Elevations and Capture Assessment

A.3.1 Groundwater Elevations and Capture Assessment

Quarterly groundwater elevation maps for 2015 are provided in Figures A.3-1 through A.3-4. Each groundwater elevation map contains the following quarter-specific information:

- Groundwater elevation data
- Interpreted water table contours, capture zones, and flow divides
- Bedrock highs
- Model-predicted design particle track remediation footprint
- Extent of the maximum 30 micrograms per liter (µg/L) total uranium plume
- Number of wells in each module and the module-specific pumping rates during the time period in which the groundwater elevations were measured

Water levels in 2015 were measured as specified in the Integrated Environmental Monitoring Plan (IEMP), which is Attachment D of the *Comprehensive Legacy Management and Institutional Controls Plan* (DOE 2016). A total of 179 monitoring wells were available for measurement. During the second quarter of 2015, all 179 wells were targeted for water level measurements. During the other three quarters, 102 of the 179 available wells were targeted for measurement.

Quarter	Measurement Dates (2015)	Number of Days	Average Water Level (ft amsl)
1	January 26 to January 29	4	514.14
2	April 28 to April 29	2	516.05
3	July 13 to July 15	3	517.99
4	September 29 to October 1	3	515.52

ft amsl = feet above mean sea level

Fourteen monitoring wells and the uppermost sampling interval in 15 wells were dry or inaccessible. A summary is provided below.

Well	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
2014	Dry		Dry	Dry
2119				Inaccessible
2128	Dry			
2384	Dry	Dry	Dry	Dry
2544	Inaccessible	Inaccessible	Inaccessible	Dry
2545	Inaccessible	Inaccessible	Inaccessible	
2546		Inaccessible	Inaccessible	
2625	Inaccessible	Inaccessible	Inaccessible	Dry
2636	Inaccessible	Inaccessible	Inaccessible	Dry
2702	Inaccessible	Inaccessible	Inaccessible	
21064	Dry			
21192	Dry	Dry	Dry	Dry
21194	Inaccessible	Inaccessible		
22303	Dry			Dry
82369_C1	Dry			
82372_C1	Dry			
82433_C1		Dry		
83293_C1	Dry	Dry		Dry
83294_C1		Dry		
83295_C1	Dry	Dry		Dry
83296_C1		Dry		
83335_C1	Dry	Dry	Dry	Dry
83336_C1	Dry	Dry	Dry	Dry
83337_C1	Dry	Dry		Dry
83338_C1	Dry			
83339_C1	Dry			
83340_C1		Dry		
83341_C1	Dry	Dry	Dry	Dry
83346_C1	Dry			

Figures A.3-1 through A.3-4 show the 2015 quarterly groundwater elevation maps. These maps illustrate capture of the maximum total uranium plume using groundwater elevation contours derived from quarterly water level measurements and predicted capture. The predicted capture was based on particle tracks that were created using target system pumping rates defined in the new 2014 Operational Design. The pumping rates reported in Figures A.3-1 through A.3-4 are averages of the actual pumping rates during the measurement period.

The new 2014 Operational Design remediation footprint used in this report was constructed using reverse, non-retarded, particle path interpretations from the Variable Saturated Analysis Model in 3 Dimensions (VAM 3D) Zoom Groundwater Model. Figure A.3-5 shows the resulting particle tracks that were used to define the 2014 Operational Design remediation footprint. Model particles were seeded at each extraction well. The resulting particle tracks represent the individual path that each particle traveled over the time period modeled for the cleanup. The limits of most of the particle tracks are truncated because the particles reached the edge of the VAM 3D Zoom Groundwater Model domain.

The times of travel used to define the particle paths took into account the pumping changes that are predicted to occur when different portions of the uranium plume achieve cleanup goals. Three pumping stages were defined.

- Stage 1: Eight years of pumping 20 wells at a system rate of 5,075 gallons per minute (gpm).
- Stage 2: Eight years of pumping 10 wells at a system rate of 3,075 gpm.
- Stage 3: Five years of pumping 3 wells at a system rate of 1,100 gpm.

A groundwater flow divide between Paddys Run Outlet and the New Baltimore Outlet is not readily distinguishable. Groundwater flow diverges around the bedrock high that separates the Paddys Run Outlet from the New Baltimore Outlet, but without additional measurement locations in the New Baltimore Outlet, the location where flow is dividing is not apparent. However, additional measurement locations in the New Baltimore Outlet are not needed for capture assessment purposes.

During 2015, the flow direction in the vicinity of the On-Site Disposal Facility (OSDF) was generally northeast to south/southwest in the first, second, and third quarters, and more north to south in the fourth quarter. These flow directions are influenced by active pumping taking place for the groundwater remediation, which is predicted to last until 2035 (based on the new 2014 Operational Design and a July 2014 implementation). Prior to the start of pumping for the groundwater remediation, flow in the vicinity of the OSDF was generally west to east. It is anticipated that when pumping stops, flow direction in the vicinity of the OSDF will return to a generally west-to-east direction.

Figure A.3-6 shows cumulative annual precipitation levels for 2004 through 2015, as recorded at the Butler County Regional Airport. Cumulative precipitation in 2015 was 44.98 inches.

Average annual water table fluctuations and yearly ranges for 2006 through 2015 are as follows:

Year	Average Fluctuation (feet)	Fluctuation Range (feet)
2015	4.64	0.35 to 4.99
2014	5.14	1.21 to 6.35
2013	3.45	0.35 to 4.28
2012	4.70	1.1 to 6.79
2011	7.50	7.4 to 14.5
2010	3.78	0.06 to 12.1
2009	2.46	0.1 to 5.5
2008	5.70	1.0 to 10.46
2007	4.45	1.7 to 7.7
2006	3.40	2.0 to 7.1

Quarterly capture zone interpretations coupled with the particle track interpretations and contoured water table gradients indicate that the 30 µg/L total uranium plume was being captured in 2015.

A.3.2 Annual Planned Well Field Shutdown

The entire well field (excluding the South Plume recovery wells) was shut down from May 20 to June 22 as planned to allow water levels to recover to nonpumping elevations. Routine quarterly water level measurements were not collected in 2015 during the planned shutdown.

Uranium is bound to sediments in the unsaturated zone of the Great Miami Aquifer in former contamination source areas. This contamination will remain bound unless water levels in the aquifer rise and saturate the contaminated sediments, allowing the bound uranium to dissolve into the groundwater.

This presents a challenge to a pump-and-treat remedy, because pumping lowers the water level. In a pump-and-treat remedy, only the dissolved uranium is removed by the pumping action. Sorbed uranium in the vadose zone is not remediated. The concern is that once pumping ends, water levels will rise and provide a means for additional uranium to dissolve into the water, potentially raising dissolved contaminant levels above remediation goals. This process is referred to as "concentration rebound" and is a concern for pump-and-treat groundwater remedies. Planned annual well field shutdowns have been conducted since 2007 to allow water levels in the aquifer to rise as high as possible to saturate aquifer material that is not normally saturated. To achieve the highest water level rise possible, the well field shutdowns are planned to coincide with seasonal high water levels in the aquifer.

Water Level Results

Pressure transducers were installed in 11 groundwater monitoring wells (2045, 2046, 2649, 23274, 62433, 32763, 23118, 22301, 22302, 22303, and 63119) for the shutdown (Figure A.3-7). Water level measurements were recorded at the top of each hour.

The zero-hour transducer readings (midnight) were used to track water level changes in the transducer wells during the shutdown periods. The maximum water level rise at each transducer, measured during the shutdown period in 2015, is presented below.

Planned Shutdown: May 20 to June 22

Location	Midnight Prior to Shutdown 5/20/2015	Midnight Prior to Restart 6/22/2015	Water Level Rise (feet)
2045	515.50	518.07	2.57
2046	516.27	518.36	2.09
2649	517.90	520.14	2.24
23274	515.51	518.00	2.50
63119	516.15	518.21	2.06
22302	514.35	517.12	2.77
23118	516.62	518.59	1.98
22301	514.81	517.52	2.71
22303	514.93	516.93	2.01
32763	516.34	519.24	2.90
62433	513.61	517.39	3.78

The water level rise measurements indicate that during the shutdown, the water level rise ranged from 1.98 feet (ft) (well 23118) to 3.78 ft (well 62433).

Figure A.3-8 shows water levels versus precipitation from May 25, 2007, through January 4, 2016. Three wells are shown on the figure: well 2649 (former Waste Storage Area [WSA]), well 2046 (west side of South Field Area), and well 62433 (east side of South Field Area). The combination of the shutdown and seasonal water level rise in 2015 resulted in the following water level rises:

- 4.37 ft in the former WSA (monitoring well 2649)
- 4.99 ft in the west side of the South Field (monitoring well 2046)
- 7.01 ft in the east side of the South Field (monitoring well 62433)

Uranium Concentration Results

Uranium concentrations were measured in six groundwater monitoring wells (2045, 2046, 23274, 83124, 83294, and 83337 [Figure A.3-9]) before, during, and after the 2015 shutdown. The results of the 2015 IEMP first-half uranium sampling are used to represent uranium concentrations in the well before the shutdown. Groundwater samples collected in June represent concentrations during the shutdown. The results of the 2015 IEMP second-half uranium sampling are used to represent uranium concentrations in the well after the shutdown exercise was completed. The two shallowest channels (channels 1 and 2) of the Type-8 monitoring wells were sampled. Uranium concentration measurements at the six monitoring wells before, during, and after the 2015 shutdown are provided in Table A.3-1.

A comparison of pre-shutdown uranium concentrations to pre-startup uranium concentrations in the monitoring wells indicated that concentrations increased in five of the six wells during the shutdown. During the second half of the year, the channel with the highest uranium concentration (as measured during the first half of the year) is sampled if it is not dry. If the targeted channel is dry, the next deeper channel is sampled. No sample was collected from monitoring well 83124_C2, 83294_C1, and 83337_C1 in the second half of 2015.

As prescribed in the IEMP, uranium concentrations were also measured at the extraction wells before and daily for 4 days after the wells were restarted. The first water sample was collected after the well had been pumping for approximately 5 minutes. Results for the shutdown are provided in Table A.3-2.

The last column of Table A.3-2 provides the difference between the maximum uranium concentration measured after the wells were restarted and the average uranium concentration measured in the month prior to the shutdown at the extraction well. As the data indicate, uranium concentration changes were mixed. The largest increase in uranium concentration was measured in extraction well EW-15A (10.2 μg/L).

Extraction wells RW-6, EW-17A, EW-21A, and EW-25 underwent rehabilitation during the shutdown (Table A.3-2); therefore, uranium concentration data for those wells are not reported. During rehabilitation the well is shut down, liquid acid descalar and hydrochloric acid are placed in the well, and the well is surged to clean the screen and loosen up the formation around the well screen. The objective is to restore pumping efficiency. Extraction well RW-7 was not sampled during the shutdown because the pump, motor, and piping motor were being replaced.

A.3.3 Continued Transducer Monitoring

Although not required by the IEMP, pressure transducers installed in 2007 to support the first annual well field shutdown remain in the wells and continue to operate so that daily changes in water levels can be recorded on a continuous, routine basis at key points in the aquifer. The transducers are programmed to record a water level measurement at the top of each hour. Data from three of the six locations (former WSA [2649], east side of the South Field Area [2046], and west side of the South Field Area [62433]) are shown in Figure A.3-7 and are plotted in Figure A.3-8 along with precipitation data collected through January 4, 2016. The transducers will continue to record data to provide a more complete record of seasonal and short-term water table fluctuations and will continue to be used for planning the timing of future well field shutdowns.

A.3.4 References

DOE (U.S. Department of Energy), 2016. *Comprehensive Legacy Management and Institutional Controls Plan*, LMS/FER/S03496, Revision 9, Office of Legacy Management, January.

Table A.3-1. Uranium Concentrations at Monitoring Wells Before, During, and After the 2015 Wellfield Shutdown

Well	Easting	Northing	First Half 2015 Pre-Shutdown Concentrations		Pre-Start-Up Concentrations June 2015		Second Half 2015 Post-Shutdown Concentrations[a]	
			Date	Uranium (µg/L)	Date	Uranium (µg/L)	Date	Uranium (µg/L)
2045	1348291	477159	3/23/2015	77.4	6/16/2015	110.0	8/18/2015	88.4
2046	1347950	478088	1/22/2015	47.8	6/16/2015	33.7	7/7/2015	38.0
23274	1349406	478337	2/10/2015	120.0	6/16/2015	128.0	7/6/2015	109.0
83124_C1	1346826	479977	3/23/2015	143.0	6/17/2015	494.0	8/24/2015	507.0
83124_C2	1346826	479977	3/23/2015	39.9	6/17/2015	31.9	NS	NS
83294_C1	1349599	477190	DRY	DRY	6/16/2015	327.0	NS	NS
83294_C2	1349599	477190	5/7/2015	276.0	6/16/2015	306.0	11/1/2015	259.0
83337_C1	1346704	481052	DRY	DRY	6/17/2015	255.0	DRY	DRY
83337_C2	1346704	481052	5/11/2015	2.5	6/17/2015	145.0	10/13/2015	3.5

[a] NS = not sampled

Table A.3-2. Total Uranium Concentration at Extraction Wells During 2015 Well Field Shutdown

Extraction Well	May 4, 2015 Uranium Concentration (ug/L)	Total Uranium Concentration (ug/L) After Well Field Re-Start [a,b]							Maximum Post Re-Start Minus May 4, 2015 Concentration
		June 22, 2015	June 23, 2015	June 24, 2015	June 25, 2015	Minimum	Maximum	Range	
RW-1	15.6	15.3	15.1	15.2	14.9	14.9	15.3	0.4	-0.3
RW-2	14.7	17.0	17.0	17.3	17.0	17.0	17.3	0.3	2.6
RW-3	19.4	22.9	22.5	22.9	22.4	22.4	22.9	0.5	3.5
RW-4	2.9	3.1	3.2	3.5	2.4	2.4	3.5	1.1	0.6
RW-6	29.6	REHAB	REHAB	REHAB	REHAB	REHAB	REHAB	REHAB	REHAB
RW-7	25.6	REHAB	REHAB	REHAB	REHAB	REHAB	REHAB	REHAB	REHAB
EW-15A	26.0	36.2	33.8	31.3	34.8	31.3	36.2	4.9	10.2
EW-17A	12.8	REHAB	REHAB	REHAB	REHAB	REHAB	REHAB	REHAB	REHAB
EW-18	30.1	34.1	34.5	33.6	33.1	33.1	34.5	1.4	4.4
EW-19	16.1	16.2	17.7	19.3	18.2	16.2	19.3	3.1	3.2
EW-20	27.9	27.5	32.2	37.0	32.3	27.5	37.0	9.5	9.1
EW-21A	32.0	REHAB	REHAB	REHAB	REHAB	REHAB	REHAB	REHAB	REHAB
EW-22	25.0	32.2	29.8	29.9	28.8	28.8	32.2	3.4	7.2
EW-23	40.6	40.6	43.9	44.9	47.8	40.6	47.8	7.2	7.2
EW-24	31.1	31.8	34.3	32.7	32.7	31.8	34.3	2.5	3.2
EW-25	26.2	REHAB	REHAB	REHAB	REHAB	REHAB	REHAB	REHAB	REHAB
EW-26	21.6	34.6	30.2	32.8	28.1	28.1	34.6	6.5	13.0
EW-27	25.6	30.9	31.0	31.1	29.2	29.2	31.1	1.9	5.5
EW-30	22.4	29.5	31.2	29.5	28.6	28.6	31.2	2.6	8.8
EW-33	17.8	20.6	21.7	22.4	23.3	20.6	23.3	2.7	5.5

Shading indicates uranium concentration after well field re-start was greater than May 4 uranium concentration

[a] REHAB = Well offline during sampling event to undergo rehabilitation.

[b] Shutdown began on May 20, 2015 at 8:30 AM and ended on June 22, 2015 at 8:30 AM for a duration of 33 days

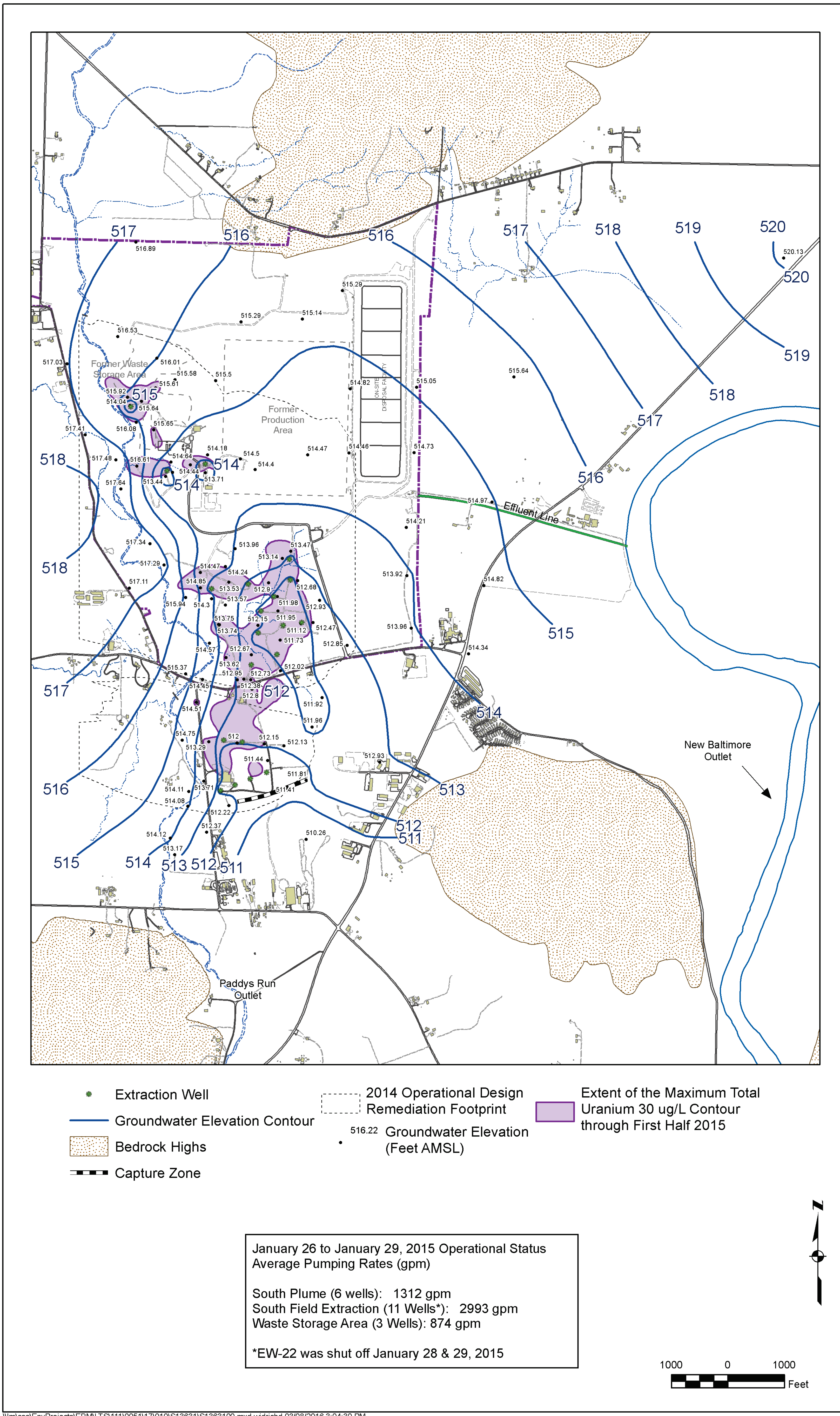

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Figure A.3-1. Routine Groundwater Elevation Map, First Quarter 2015 (January 26 through January 29, 2015)

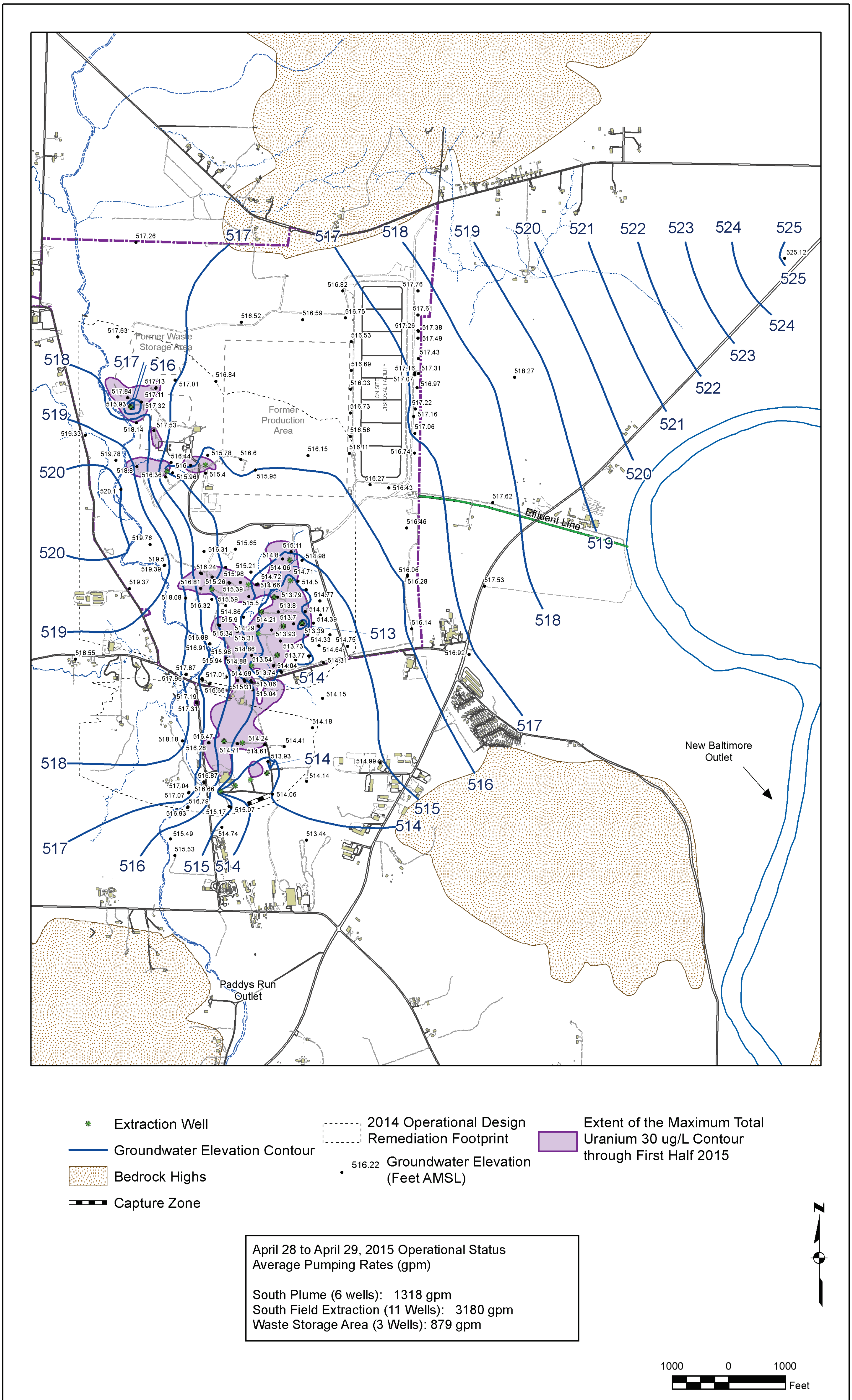

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Figure A.3-2. Routine Groundwater Elevation Map, Second Quarter 2015 (April 28 and April 29, 2015)

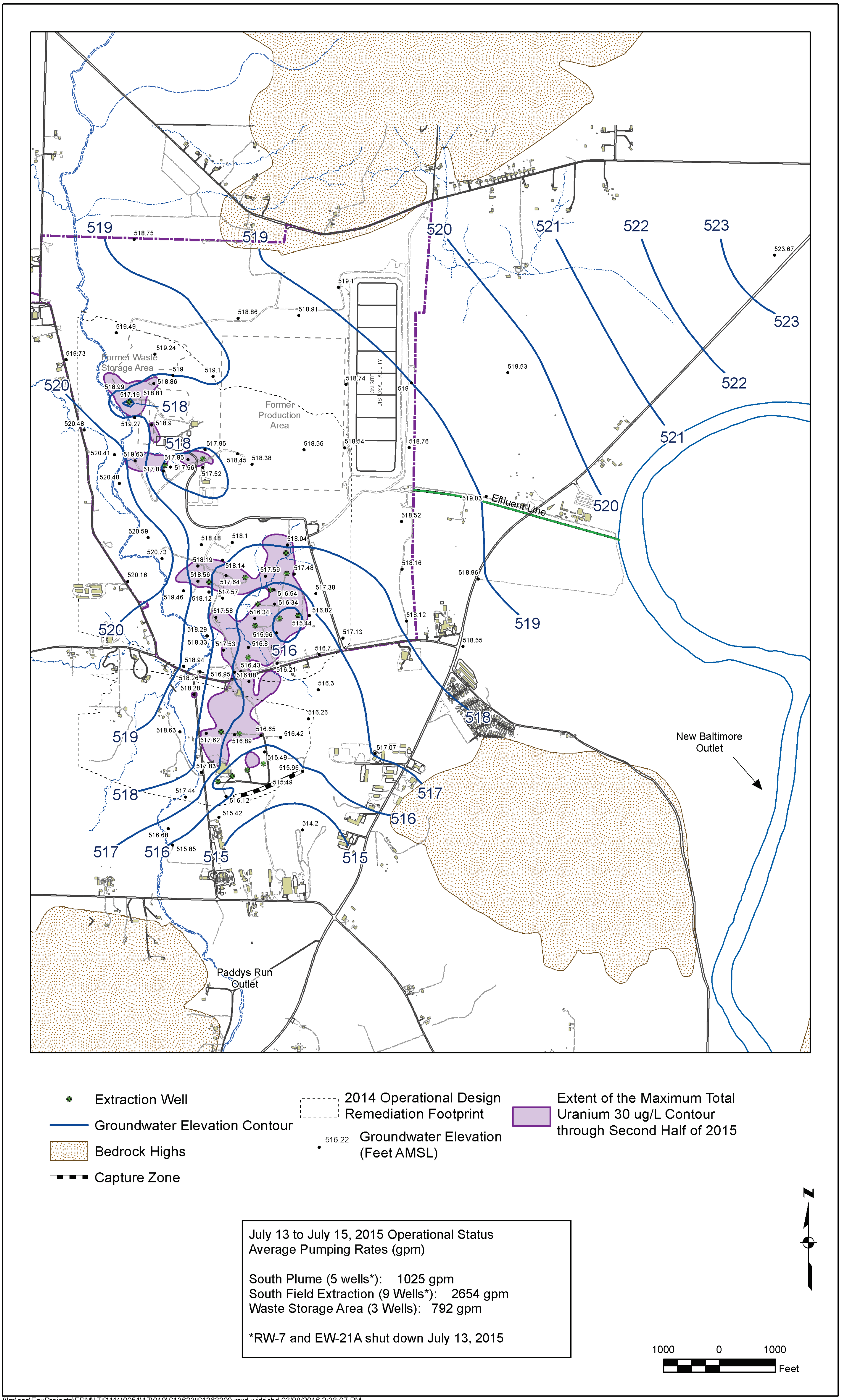

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Figure A.3-3. Routine Groundwater Elevation Map, Third Quarter 2015 (July 13 Through July 15, 2015)

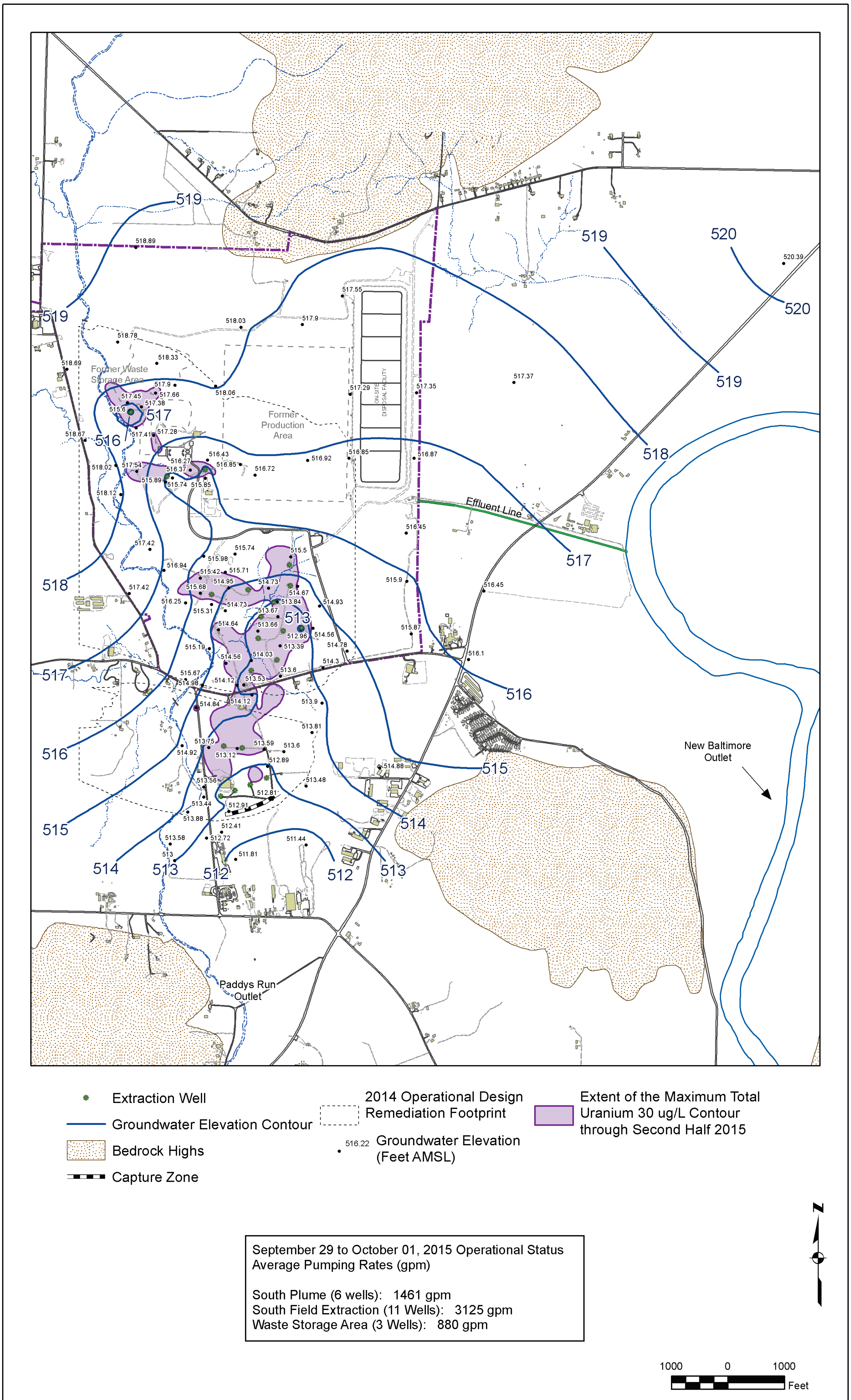

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Figure A.3-4. Routine Groundwater Elevation Map, Fourth Quarter 2015 (September 29 Through October 1, 2015)

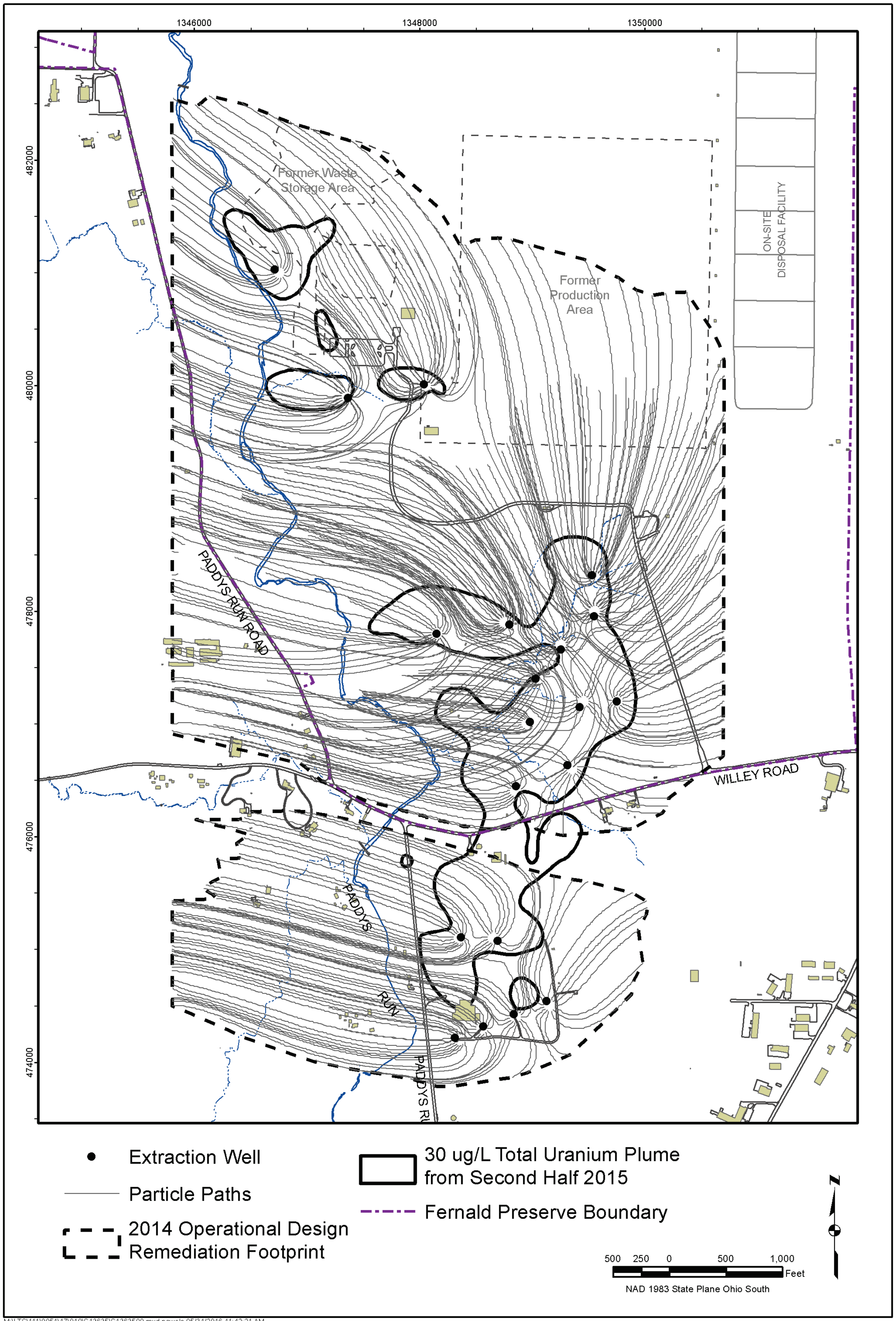

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Figure A.3-5. 2014 Operational Design Adjustment Remediation Footprint

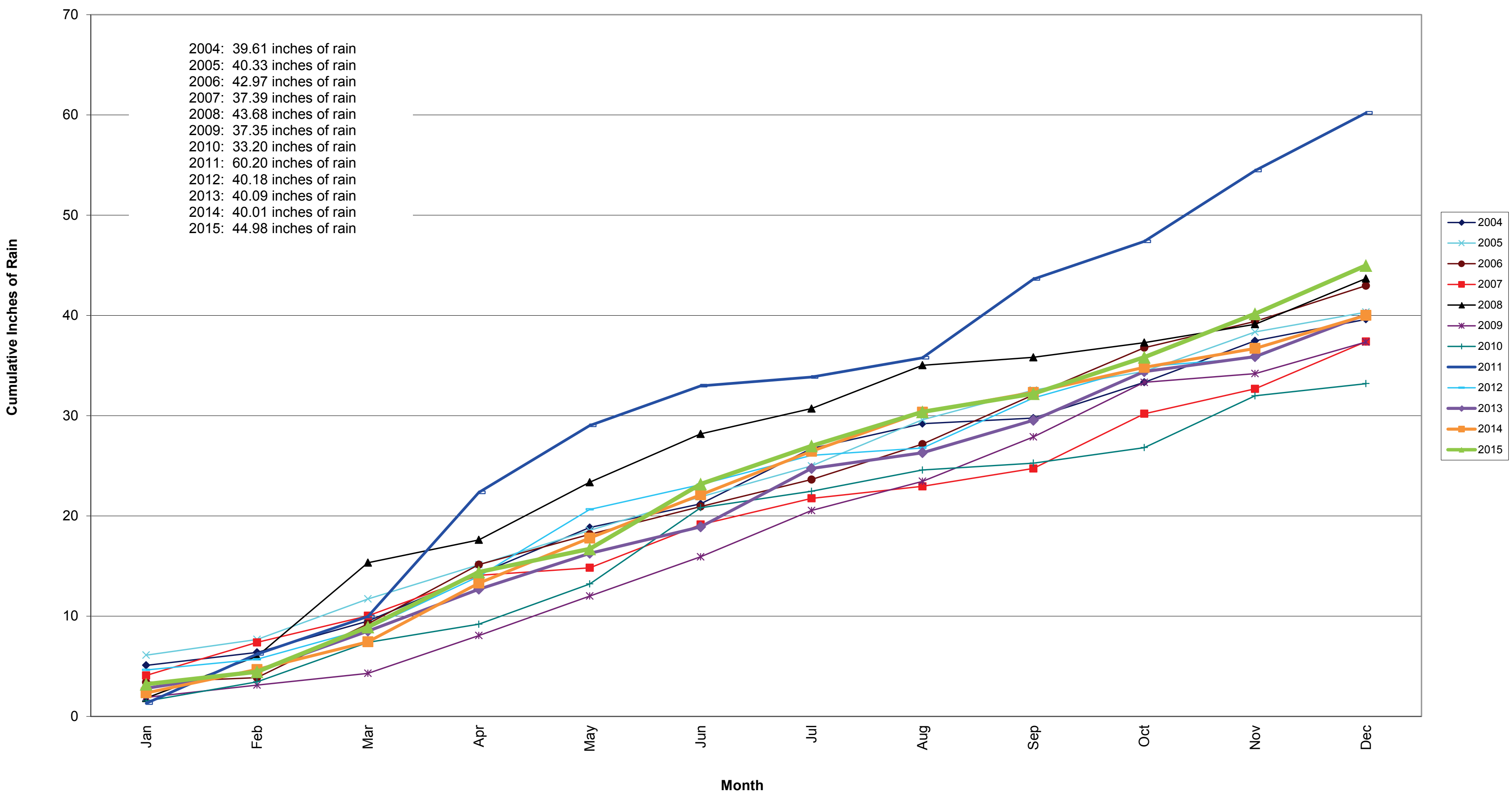

Figure A.3-6. Cumulative Annual Precipitation: 2004 through 2015 as Recorded at the Butler County Regional Airport

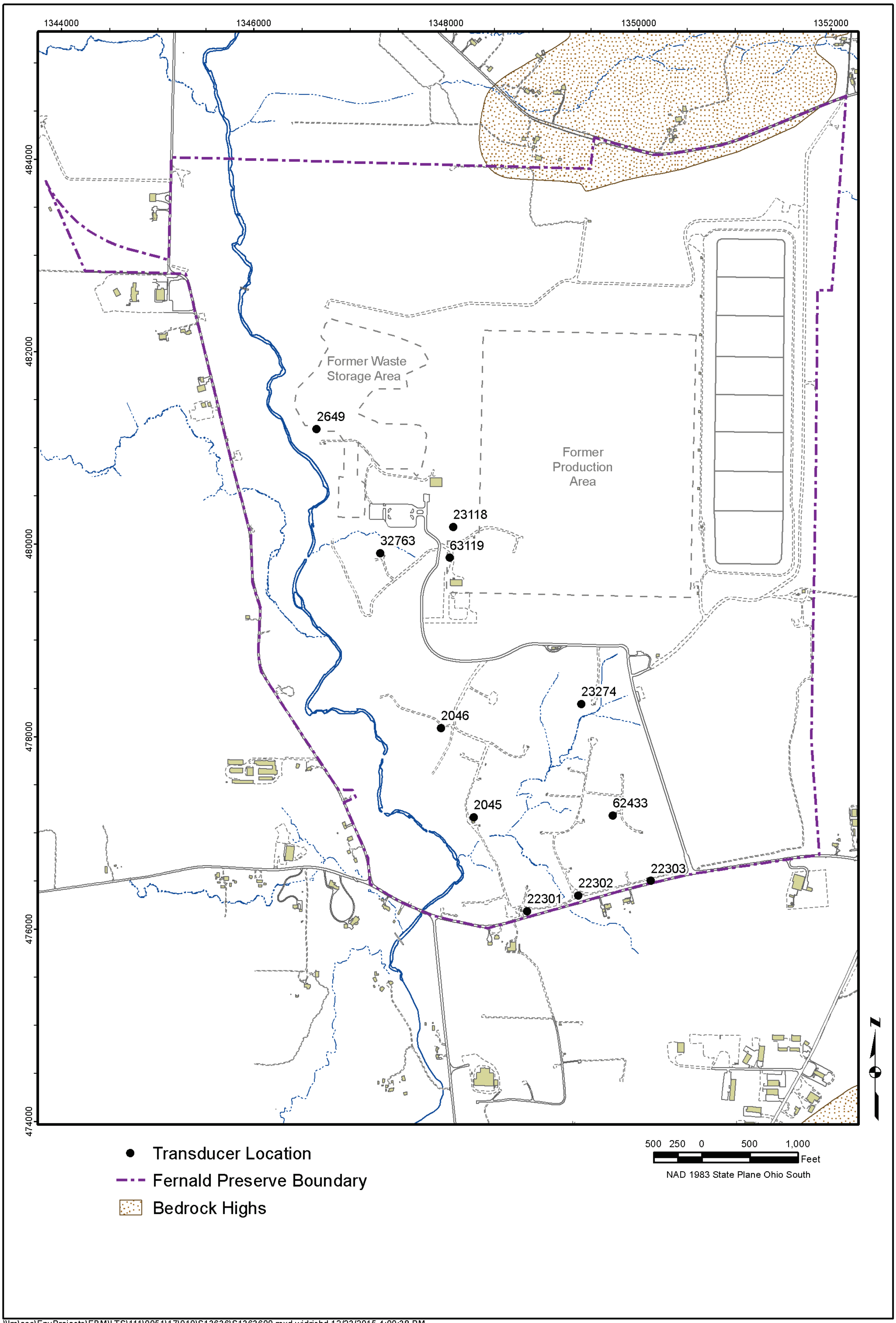

Figure A.3-7. Transducer Locations for the 2015 Operational Shutdown

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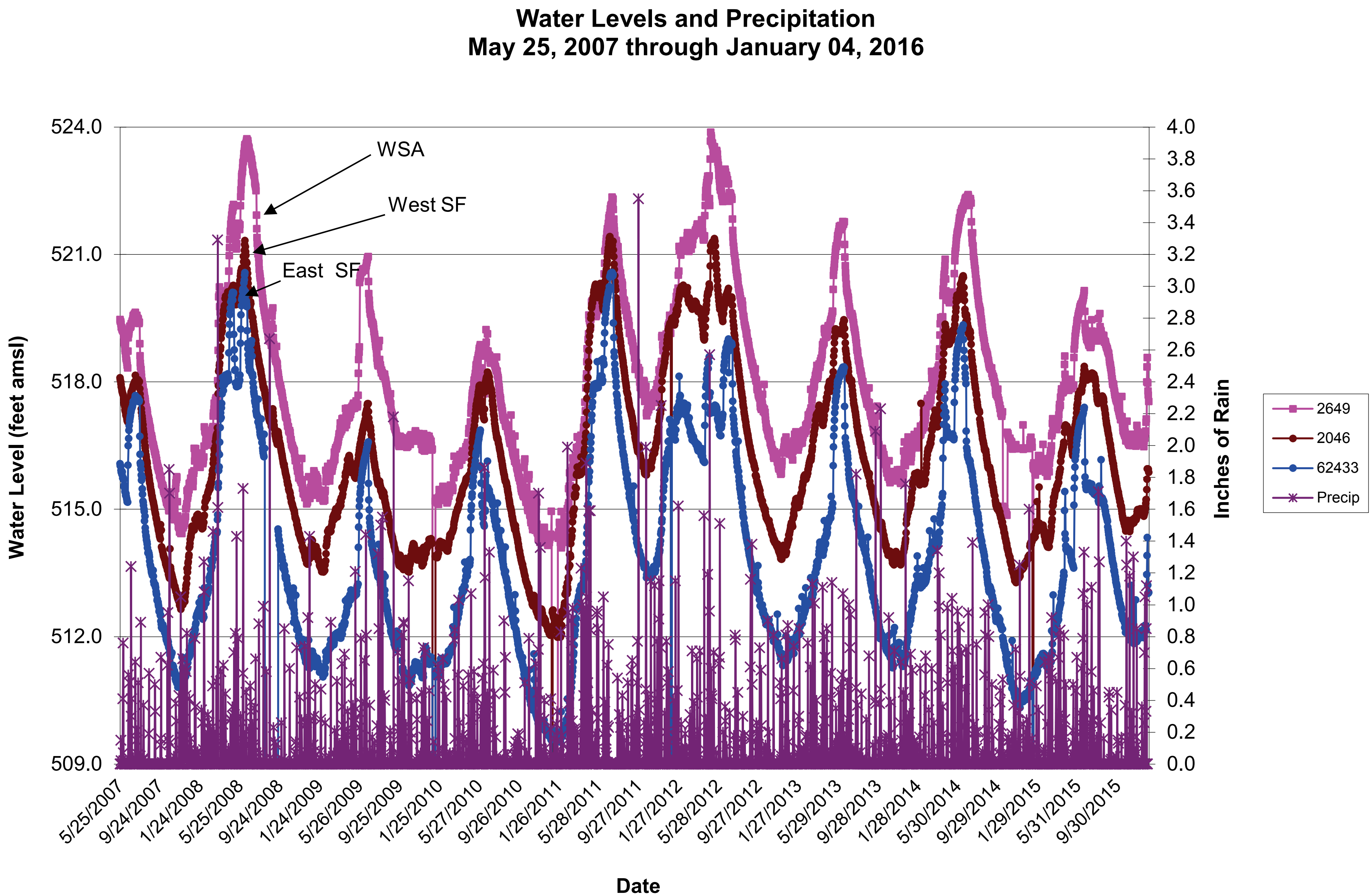

Figure A.3-8. Water Levels Versus Precipitation May 25, 2007, Through January 4, 2016

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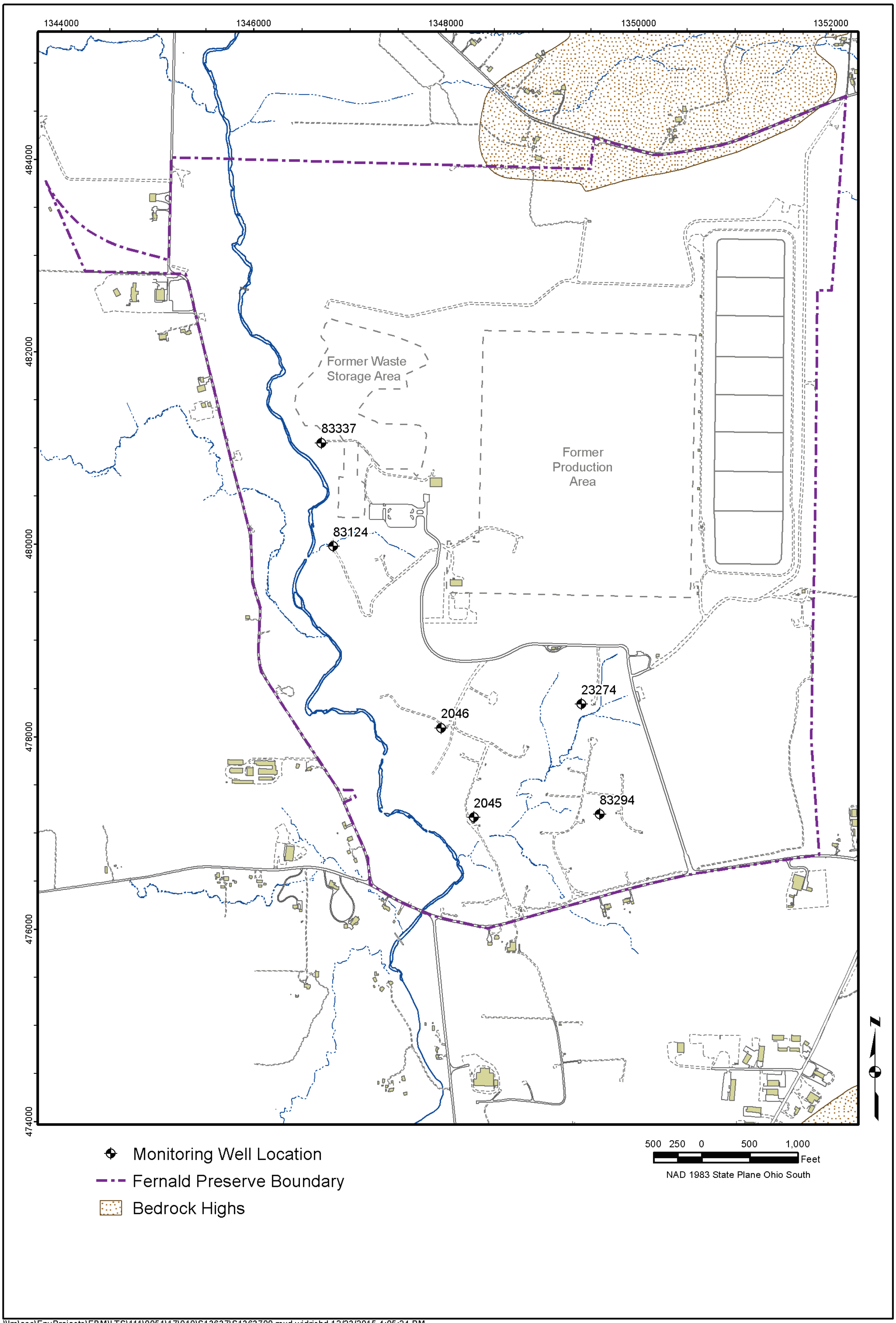

Figure A.3-9. Monitoring Well Locations for the 2015 Operational Shutdowns

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Abbreviations

DOE	U.S. Department of Energy
FRL	final remediation level
GMA	Great Miami Aquifer
IEMP	Integrated Environmental Monitoring Plan
LMICP	Legacy Management and Institutional Control Plan
Ohio EPA	Ohio Environmental Protection Agency
OSDF	On-Site Disposal Facility
PRRS	Paddys Run Road Site
VAM 3D	Variable Saturated Model in 3 Dimensions
WSA	Waste Storage Area

Measurement Abbreviations

µg/L	micrograms per liter
mg/L	milligrams per liter

A.4.0 Non-Uranium Final Remediation Level Results

This attachment evaluates non-uranium final remediation level (FRL) results for 2015 collected under the Integrated Environmental Monitoring Plan (IEMP), which is Attachment D of the *Comprehensive Legacy Management and Institutional Controls Plan* [LMICP (DOE 2016)]. The purpose of the evaluation is to:

- Identify 2015 non-uranium FRL exceedances (Section A.4.1).
- Determine the persistence of non-uranium FRL exceedances outside the new 2014 Operational Design remediation footprint (Section A.4.2).
- Describe the Groundwater Monitoring Program Assessment of Non-Uranium Parameters (Section A.4.3).
- Present conclusions (Section A.4.4).

A.4.1 Non-Uranium FRL Exceedances for 2015

Table A.4-1 shows the summary statistics and trend analysis for the 2015 non-uranium FRL exceedances from monitoring wells both inside and outside the 2014 Operational Design remediation footprint. As indicated in Table A.4-1, eight non-uranium FRL constituents had one or more FRL exceedances during 2015. Figure A.4-1 identifies the location of these FRL exceedances.

Figure A.4-1 shows that the non-uranium FRL exceedances in 2015 for monitoring wells were located in the former Waste Storage Area (WSA), along the eastern edge of the property boundary, and in the Paddys Run Road Site (PRRS) area. Those in the former WSA were within the 2014 Operational Design remediation footprint (DOE 2014). Those along the eastern property boundary and in the PRRS area were located outside the 2014 Operational Design remediation footprint. Specific discussion regarding exceedances and persistence outside the footprint is provided in Section A.4.2.

Table A.4-2 identifies all the locations and constituents that had non-uranium FRL exceedances since 1997. The first column in Table A.4-2 lists the groundwater FRL constituents monitored in 2015. The second column identifies the wells monitored that have had an exceedance since 1997 for each constituent. The third column identifies the associated aquifer zone monitored. The fourth column identifies the associated monitoring program for each well/constituent. The remaining columns show monitoring years that reflect a semiannual sampling frequency; a "1" denotes an exceedance for one of the two quarters and a "2" denotes an exceedance for both quarters. Table A.4-2 also indicates whether exceedances occurred inside or outside of the remediation footprint (shading indicates the well is located outside the footprint).

As specified in the IEMP, there were 13 non-uranium constituents monitored in 2015; 8 had exceedances. The following table summarizes the 2015 non-uranium monitoring information:

Constituent	2015 Monitoring Summary
Antimony	No exceedances
Arsenic	Exceedance in the PRRS area
Boron	No exceedances
Carbon Disulfide	No exceedances
Fluoride	No exceedances
Lead	Exceedance in the PRRS area
Manganese	Exceedances along the eastern site boundary and in the PRRS area
Molybdenum	Exceedances in former WSA wells
Nickel	Exceedance in the PRRS area
Nitrate + Nitrite as Nitrogen	Exceedances in former WSA wells
Technetium-99	Exceedances in former WSA wells
Trichloroethene	No exceedances
Zinc	Exceedance in the PRRS area

[a]PRRS = Paddys Run Road Site, WSA = Waste Storage Area

A.4.1.1 Non-Uranium Direct-Push Sampling Results for 2015

In 2015, five direct-push sampling locations in the former WSA were sampled for non-uranium constituents specified in the IEMP for the former WSA (locations 13374B, 13369B, 13463A, 13484, and 13485). These locations are identified in Attachment A.2, Figure A.2-5. Direct-push sampling results for 2015 are provided for locations 13374B, 13369B, 13463A, 13484, and 13485 in Tables A.2-1 through A.2-5, respectively. Non-uranium results are discussed below.

<u>Location 13374B</u>

Direct-push sampling results for location 13374B are provided in Table A.2-1. The location is identified in Figure A.2-3A.

This direct-push location was sampled previously in 2008 and 2013. The location sampled in 2008 was identified as 13374. The location sampled in 2013 was identified as 13374A. The location sampled in 2015 was identified as 13374B. Non-uranium concentrations from all sampling dates are provided below.

Constituent (Units)	Groundwater FRL	13374 (2008)	13374A (2013)	13374B (2015)
Technetium-99 (pCi/L)	94	NS	**514**	3.48
Nitrate + Nitrite as Nitrogen (mg/L)	11	NS	**375**	0.296
Manganese (mg/L)	0.90	NS	**2.49**	0.465
Molybdenum (mg/L)	0.10	NS	0.0457	0.0306
Nickel (mg/L)	0.10	NS	0.0358	0.00859

Bold indicates concentrations above FRL
FRL = final remediation level
NS = not sampled
mg/L = milligrams per liter
pCi/L = picocuries per liter

The data indicate that no non-uranium FRL exceedances were detected in 2015. As discussed in Attachment A.2, Section A.2.1.1, the 2015 sample was collected at an elevation that was lower in the water column than in previous years.

Location 13369B

Direct-push sampling results for location 13369B are provided in Table A.2-2. The location is identified in Figure A.2-3A.

This direct-push location was sampled previously in 2007 and 2013. The location sampled in 2007 was identified as 13369. The location sampled in 2013 was identified as 13369A. The location sampled in 2015 was identified as 13369B. Non-uranium concentrations from all sampling dates are provided below.

Constituent (Units)	Groundwater FRL	13369 (2007)	13369A (2013)	13369B (2015)
Technetium-99 (pCi/L)	94	1.91	3.67	6.53
Nitrate + Nitrite as Nitrogen (mg/L)	11	2.72	1.88	0.994
Manganese (mg/L)	0.90	**1.30**	**2.33**	**1.04**
Molybdenum (mg/L)	0.10	0.0231	**0.232**	0.0282
Nickel (mg/L)	0.10	0.0178	0.0231	0.00646

Bold indicates concentrations above FRL
FRL = final remediation level
mg/L = milligrams per liter
pCi/L = picocuries per liter

The data indicate that in 2007, 2013, and 2015 manganese exceeded the FRL, and in 2013, molybdenum exceeded the FRL. As discussed in Appendix A.2, Section 2.1.1, the 2015 sample was collected at an elevation that was lower in the water column than in previous years.

Location 13463A

Direct-push sampling results for location 13463A are provided in Table A.2-3. The location is identified in Figure A.2-3A.

This direct-push location was sampled previously in 2013. The location sampled in 2013 was identified as 13463. The location sampled in 2015 was identified as 13463A. Non-uranium concentrations from both sampling dates are provided below.

Constituent (Units)	Groundwater FRL	13463 (2013)	13463A (2015)
Technetium-99 (pCi/L)	94	8.73	**234**
Nitrate + Nitrite as Nitrogen (mg/L)	11	7.15	**69.5**
Manganese (mg/L)	0.90	.829	**1.02**
Molybdenum (mg/L)	0.10	**0.313**	**0.256**
Nickel (mg/L)	0.10	.0114	0.0144

Bold indicates concentrations above FRL
FRL = final remediation level
mg/L = milligrams per liter
pCi/L = picocuries per liter

The data indicate that molybdenum exceeded the FRL in 2013. In 2015, technetium-99, nitrate + nitrite as nitrogen, manganese, and molybdenum results exceeded the respective FRLs.

Location 13484
Direct-push sampling results for location 13484 are provided in Table A.2-4. The location is identified in Figure A.2-3A. The data indicate that no non-uranium FRL exceedances were detected in 2015.

Location 13485
Direct-push sampling results for location 13485 are provided in Table A.2-5. The location is identified in Figure A.2-3A. The data indicate that no non-uranium FRL exceedances were detected in 2015.

All of the direct-push sample results discussed above are located within the former WSA and within capture of the groundwater remediation system.

A.4.2 Evaluation of 2015 Non-Uranium FRL Exceedances Outside the 2014 Operational Design Remediation Footprint

This section presents an evaluation of the persistence of non-uranium FRL exceedances outside the 2014 Operational Design remediation footprint.

A.4.2.1 Background

The *Restoration Area Verification Sampling Program Summary Report* (DOE 1998) states that any FRL exceedance detected at the property boundary during routine monitoring outside the 10-year uranium-based restoration footprint (DOE 1997a) would also be evaluated for persistence. The evaluation would be performed using the same conservative data evaluation method approved in the *Restoration Area Verification Sampling Program Project-Specific Plan* (DOE 1997b) to determine if a change in the aquifer restoration remedy is required. This evaluation was expanded beginning with the *2000 Integrated Site Environmental Report* (DOE 2001) to include all non-uranium FRL exceedances detected outside of the 10-year uranium-based restoration footprint, not just those detected at the property boundary. In the *2003 Site Environmental Report* (DOE 2004), the 10-year uranium-based restoration footprint was replaced with a 10-year time-of-travel remediation footprint based on 2003 target pumping rates and using the Variable Saturated Model in 3 Dimensions (VAM 3D) Zoom Groundwater Model. The footprint was updated in 2005 to reflect capture during the time period modeled for the WSA (Phase II) remediation design. The footprint was updated once again in 2014 to reflect capture during the time period modeled for the 2014 Operational Adjustment Design (DOE 2014). The footprint for the 2014 Operational Adjustment Design is shown in Figure A.4-1.

Analytical data from samples collected immediately following an FRL exceedance are evaluated to determine if the exceedance is persistent. In accordance with the approved Restoration Area Verification Sampling Program Project-Specific Plan (DOE 1997b), if two or more consecutive sampling events following an FRL exceedance indicate that the concentration has decreased below the groundwater FRL, then the exceedance is not considered persistent. If an FRL exceedance outside the 2014 Operational Design remediation footprint is determined to not be persistent, then no additional action is required beyond the routine groundwater monitoring specified in the current IEMP. If an FRL exceedance is determined to be persistent, then the cause of the persistent exceedance will be identified and its effect 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.

A.4.2.2 Evaluation and Discussion

As reported last year, five possible persistent FRL exceedances were identified in 2014 requiring additional data to be collected through routine monitoring in 2015. The exceedances were for manganese in wells 22217 and 2733, and zinc in wells 2625, 22206, and 22200. The non-uranium FRL exceedances for 2015 along with the possible persistent exceedances identified in 2014 are addressed below.

Figure A.4-1 and the shaded portion of Table A.4-1 identify the 2015 non-uranium FRL exceedances outside the 2014 Operational Design remediation footprint. In 2015, five constituents had one or more FRL exceedance at three wells located outside the 2014 Operational Design remediation footprint:

- Arsenic at monitoring well 2625
- Lead at monitoring well 2625
- Manganese at monitoring wells 22204, 22217, and 2625
- Nickel at monitoring well 2625
- Zinc at monitoring well 2625

Table A.4-3 addresses possible persistent FRL exceedances that occur outside the 2014 Operational Design remediation footprint and includes the exceedances for 2015 listed in the bullets above, as well as those still being evaluated or deemed persistent from 2014. If the results of 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.4-3.

As shown in Table A.4-3, the FRL exceedance for manganese at monitoring well 22204 was identified as being persistent in 2015. The persistent manganese exceedance at monitoring well 22204 has been identified since 2004.

The following is a summary of results presented in Table A.4-3:

- The arsenic FRL exceedance in monitoring well 2625 detected in the second half of 2015 requires that additional data be collected through routine monitoring in 2016 to determine the persistence of the exceedance.
- The lead FRL exceedance in monitoring well 2625 detected in the second half of 2015 requires that additional data be collected through routine monitoring in 2016 to determine the persistence of the exceedance.
- The manganese FRL exceedance at monitoring well 22204 remains persistent in 2015.
- The manganese FRL exceedance at monitoring well 22217 requires that additional data be collected through routine monitoring in 2016 to determine the persistence of the exceedance.

- The manganese FRL exceedance at monitoring well 2625 in the second half of 2015 requires that additional data be collected through routine monitoring in 2016 to determine the persistence of the exceedance.
- The manganese FRL exceedance at monitoring well 2733 in the first half of 2014 was determined to be not persistent in 2015.
- The nickel FRL exceedance in monitoring well 2625 detected in the second half of 2015 requires that additional data be collected through routine monitoring in 2016 to determine the persistence of the exceedance.
- The zinc FRL exceedance at monitoring well 2625 requires that additional data be collected through routine monitoring in 2016 to determine the persistence of the exceedance.
- The zinc FRL exceedance at monitoring well 22206 in 2014 was determined to be not persistent in 2015.
- The zinc FRL exceedance at monitoring well 22200 in the second half of 2014 was determined to be not persistent in 2015.

Figures A.4-2 through A.4-11 present individual graphs of time versus concentration for the wells listed on Table A.4-3. Semiannual sampling results from On-Site Disposal Facility (OSDF) monitoring activities are included in the evaluation of property boundary wells. Therefore, some wells were sampled more than semiannually as reflected in Table A.4-3 and Figures A.4-2 through A.4-11.

The evaluation for persistence of non-uranium FRL exceedances in wells located outside the 2014 Operational Design remediation footprint in 2015 marks 19 years that an evaluation has been conducted as part of the IEMP. In the past, many exceedances identified as persistent became non-persistent in later years. Currently, the only persistent exceedance outside the remediation footprint appears to be manganese in monitoring well 22204.

Manganese was a process chemical used in the Former Production Area. The manganese groundwater FRL is 0.90 milligram per liter (mg/L) and is based on background values in the aquifer. Additional manganese data were collected from the Great Miami Aquifer (GMA) near the OSDF in 2008. Results were reported in the *Fernald Preserve 2008 Site Environmental Report* (DOE 2009). The purpose for collecting the additional data was to determine if manganese exceedances in the GMA near the OSDF indicate the presence of a localized plume. The additional data collected in 2008 indicated that the manganese exceedances were likely a background issue. Unconsolidated glaciofluvial aquifers in Ohio have relatively high manganese concentrations. Manganese is an impurity in shale, which is a major component of bedrock in the area. The background value upon which the groundwater FRL is based may not be representative of actual natural aquifer conditions. In past reports, biofouling has also been discussed as a possibility for the persistent manganese exceedance that was only seen at one monitoring well. At this time, no change to the aquifer remedy is planned to address the persistent manganese exceedance at monitoring well 22204.

A.4.3 Groundwater Monitoring Program Assessment for Non-Uranium Parameters

As discussed in Attachment A.2, the U.S. Department of Energy (DOE) plans to propose a monitoring change in the upcoming LMICP revision that will reduce the sampling frequency for uranium at several groundwater monitoring wells. Specifically, the sampling frequency will be reduced from semiannual to annual at the Property/Plume Boundary and the PRRS wells. Sampling at these wells also includes non-uranium constituents. This section presents the non-uranium concentration data for these wells.

As explained below, sampling at the Property/Plume Boundary wells is required to continue to address the Ohio Environmental Protection Agency (Ohio EPA) Director’s Findings and Orders (Ohio EPA 1993), and sampling at the PRRS wells is required to continue until the South Plume has been certified clean. However, the sampling frequency can be reduced, if warranted, through the IEMP revision process. Specifically:

- Section 3.2.2 of the IEMP: The September 10, 1993, Ohio EPA Director’s Findings and Orders required groundwater monitoring at the Fernald Preserve’s property boundary to satisfy Resource Conservation and Recovery Act facility groundwater monitoring requirements. The September 7, 2000, Director’s Findings and Orders (Ohio EPA 2000) superseded the 1993 Director’s Findings and Orders and specified that the site’s groundwater monitoring activities will be implemented in accordance with the IEMP. The revised language allows modification of the groundwater monitoring program as necessary via the IEMP revision process without issuance of a new order.
- Section 3.3 of the IEMP: Groundwater monitoring will continue south of the Administrative Boundary until certification of the off-property South Plume is complete. The monitoring will assess the nature of the 30 micrograms per liter (µg/L) total uranium plume south of the Administrative Boundary and the impact that pumping of the South Plume extraction wells has on the PRRS plume.

<u>Property/Plume Boundary Monitoring</u>

As defined in Section 3.6.1.4 of the IEMP, 25 monitoring wells are located along the eastern property boundary and leading edge of the offsite total uranium plume. The 25 wells are:

2093	3426	22204
2398	3429	22205
2431	3431	22208
2432	3432	22211
2733	3733	
3070	4398	22210 22214
3093	21063	31217
3398	22198	
3424	22199	

Figure A.4.12 shows the location of the 25 wells, which are sampled semiannually for the following constituents:

Property Plume Boundary Monitoring Table for FRL Exceedances, Semiannual Sampling Frequency

General Chemistry	Inorganic	Radionuclides and Uranium
Fluoride	Antimony Arsenic Lead Manganese Nickel Zinc	Total Uranium

Table A.4-4, presents a summary of the non-uranium data collected at the Property/Plume Boundary monitoring wells from 1988 through 2015. Column 1 identifies the monitoring well, column 2 lists the analytes, column 3 presents the FRL, column 4 lists the number of samples in which the analyte was detected, column 5 presents the number of samples, and column 6 presents the percent of samples in which each analyte was detected. Columns 7 through 10 present descriptive statistics (minimum value, maximum value, average, and standard deviation). The remaining columns report the number of FRL exceedances detected in the last 10 years and the trend of the data set. The trend is based on a Mann-Kendell test (95% confidence interval). A time-versus-concentration graph was prepared for any constituent data set listed on Table A.4-4 that had an FRL exceedance in the last 10 years or has an increasing concentration trend and is presented in Figures A.4-13 through A.4-74.

All 25 of these monitoring wells are located outside of the 2014 Operational Design Remediation Footprint shown in Figure A.4-1. For 19 years, DOE has evaluated all FRL exceedances at Property/Plume Boundary monitoring wells. No non-uranium plumes have been identified, and with the exception of manganese in monitoring well 22204, all of the exceedances have been nonpersistent. A discussion of this persistent exceedance is presented in Section A.4.2.2.

The data sets indicate that enough data have been collected at these wells to establish long-term concentration trends and show that no persistent FRL exceedances have been identified, with the exception of manganese in monitoring well 22204. Changing the sampling frequency from semiannual to annual for non-uranium constituents will continue to satisfy the monitoring objective of documenting if non-uranium conditions are changing at these locations over time.

<u>PRRS Monitoring</u>

Eleven monitoring wells are in the PRRS area:

2128	2899	3898
2625	2900	3899
2636	3128	3900
2898	3636	

The locations of the 11 wells are shown in Figure A.4.12. The 11 wells are sampled semiannually for the following constituents:

Property Plume Boundary Monitoring Table for FRL Exceedances and PRRS Constituents Semiannual Sampling Frequency

General Chemistry	Inorganic	Radionuclides and Uranium	Organic
Fluoride	Antimony	Total uranium	Benzene
Phosphorous	Arsenic		Ethylbenzene
	Lead		Isopropylbenzene
	Manganese		Toluene
	Nickel		Total xylenes
	Potassium		
	Sodium		
	Zinc		

Table A.4-5, presents a summary of the non-uranium data collected at the PRRS wells from 1988 through 2015. Column 1 identifies the monitoring well, column 2 lists the analytes, column 3 presents the FRL, column 4 presents the number of samples in which each analyte was detected, column 5 presents the number of samples, and column 6 presents the percent of samples in which each analyte was detected. Descriptive statistics (minimum value, maximum value, average, and standard deviation) are presented in Columns 7 through 10. The remaining columns report the number of FRL exceedances detected in the last 10 years and the trend of the data set. The trend is based on a Mann-Kendell test (95% confidence interval). A time-versus-concentration graph was prepared for any constituent data set listed on Table A.4-5 that had an FRL exceedance in the last 10 years or has an increasing concentration trend is presented in Figures A.4-75 through A.4-100.

As shown in Figures A.4-75 through A.4-80, analytical results were elevated for the groundwater sample collected from monitoring well 2625 on September 30, 2015. The laboratory results were validated through the standard validation process. There is reason to believe that the sample collected that day was not representative of aquifer conditions. The pre-sampling water measurement indicated that only 0.3 foot of water was present in the 2-inch diameter well. The well went dry during sampling, and the sample that was collected was very turbid. Also, the concentrations measured were very high compared to the historical concentration range for the well. The well was re-sampled on January 28, 2016, and a complete sample was collected. The sample was less turbid, and results were comparable with the historical range.

The data sets reviewed indicate that enough data have been collected at these wells to establish long-term concentration trends and show that no persistent FRL exceedances have been identified at these monitoring locations. Changing the sampling frequency from semiannual to annual for non-uranium constituents at these monitoring wells will continue to satisfy the monitoring objective of documenting if non-uranium conditions are changing at these locations over time.

DOE intends to propose changes to the IEMP groundwater monitoring program based on the data presented above in the upcoming 2017 revision of the LMICP. Specifically, the monitoring program frequency will be reduced at these monitoring wells from semiannual to annual. If approved by the U.S. Environmental Protection Agency, Ohio EPA, and stakeholders during the LMICP revision process, the monitoring changes would take effect on January 1, 2017, and be reflected in the 2017 LMICP.

A.4.4 Conclusions

From the information provided in this attachment, the following conclusions can be made:

- Non-uranium FRL exceedances that are occurring in the former WSA were taken into consideration for the 2014 Operational Design and are within capture of the groundwater remediation system.
- One persistent non-uranium FRL exceedance outside the 2014 Operational Design footprint was identified in 2014: manganese at monitoring well 22204. The exceedance for manganese is attributed to a background definition issue. A change in the design of the aquifer remedy to address the manganese exceedance is not being considered at this time.
- Additional routine data to be collected in 2016 are necessary to evaluate exceedances for manganese and zinc identified in Table A.4-3.

A.4.5 References

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DOE (U.S. Department of Energy), 2016. *Comprehensive Legacy Management and Institutional Controls Plan*, LMS/FER/S03496, Revision 9, Office of Legacy Management, January.

Ohio EPA (Ohio Environmental Protection Agency), 1993. *Ohio EPA Director's Findings and Orders*, Issued September 10, 1993.

Ohio EPA (Ohio Environmental Protection Agency), 2000. *Ohio EPA Director's Findings and Orders*, Issued September 10, 1993.

Table A.4-1. Summary Statistics and Trend Analysis for Non-Uranium Constituents with 2015 Results Above FRLs

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 2015[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,g]
Arsenic[h] (0.050 mg/L)	2625	33	2	1	0.00110	0.194	0.0169	0.0334	No Trend
Lead (0.015 mg/L)	2625	14	4	1	0.00015	0.349[h]	0.0332	0.0916	Up
Manganese (0.90 mg/L)									
	22204	49	44	4	0.418	3.01	1.39	0.462	No Trend
	22217	23	13	1	0.196	2.29	1.02	0.464	No Trend
	2625	14	2	1	0.001	6.88[h]	0.735	1.79	Up
Molybdenum (0.10 mg/L)	2649	31	31	2	0.178	1.26	0.510	0.246	No Trend
Nickel[h] (0.10 mg/L)	2625	14	1	1	0.0011	0.44	0.04	0.11	Up
Nitrate + Nitrite as Nitrogen (11 mg/L)[i]									
	2821	41	24	2	1.38	120	28.2	29.8	Up
	83338_C1	14	9	2	0.404	73.8	36.0	27.2	Up
	83338_C2	19	12	2	1.98	109	23.5	25.5	No Trend
	83340_C2	18	18	2	12.5	86.7	45.0	26.8	Down
	83340_C3	18	16	1	1.13	133	46.7	38.8	Down
Zinc (0.021 mg/L)					(mg/L)	(mg/L)	(mg/L)	(mg/L)	
	2625	13	9	1	0.00325	1.55[h]	0.163	0.420	Up
Technetium-99 (94 pCi/L)					(pCi/L)	(pCi/L)	(pCi/L)	(pCi/L)	
	2649	39	39	2	101	1660	582	451	No Trend
	83338_C1	14	9	2	10.1	321	161	124	Up
	83338_C2	19	12	1	7.12	587	143	133	No Trend
	83340_C1	15	15	2	115	817	267	173	Down

Notes: Shading indicates well is outside the 2014 Operational Design remediation footprint.
pCi/L = picocuries per liter
[a] From *Record of Decision for Remedial Actions at Operable Unit 5* (DOE 1996), Table 9-4.
[b] Based on samples from August 1997 through 2015.
[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 representative concentration is used for determining the summary statistics (minimum, maximum, average, and standard deviation) and Mann-Kendall test for trend.
[d] Rejected data qualified with an R 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] Mann-Kendall test for trend is performed using data from third quarter 1998 through 2015.
[h] Some data from the September 30, 2015, sampling round are not considered representative of aquifer conditions for monitoring well 2625: the water in the well was highly turbid and almost dry, with an insufficient sample volume for all of the constituents. Consequently, the monitoring well was resampled and analyzed on January 28, 2016. The results from this new sampling indicate that arsenic and nickel would not be FRL exceedances and would not be on the table if the January 28 sampling replaced the September 30 sampling. In addition, the FRL exceedances for lead, manganese, and zinc would be much lower: 0.349 mg/L (9/30/2015) vs. 0.0349 mg/L (1/28/2016) for lead; 6.88 mg/L (9/30/2015) vs. 0.969 mg/L (1/28/2016) for manganese; and 1.55 mg/L (9/30/2015) vs. 0.190 mg/L (1/28/2016) for zinc. The maximum concentrations for lead, manganese, and zinc would be 0.0425 mg/L, 1.05 mg/L, and 0.199 mg/L, respectively.
[i] FRL based upon nitrate from *Record of Decision for Remedial Actions at Operable Unit 5* (DOE 1996), Table 9–4.

Table A.4-2. Groundwater FRL Exceedances from 1997 Through 2015 Quarterly/Semiannually

Constituent	Well[a]	Aquifer Zone	Project[b]	1997	1998		1999		2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015	
				2[c]	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Antimony	22198	0	P/PB																									1	1											
	22199	0	P/PB																									1												
	22204	0	P/PB																									1												
	22205	0	P/PB																									1												
	22208	0	P/PB													1												1												
	2398	2	P/PB																				1																	
	2431	0	P/PB													1												1												
	2432	0	P/PB																				1					1												
	2636	4	PRRS														1		1				1						1			1								
	2733	0	P/PB																				1																	
	3070	2	P/PB																				1					1												
	31217	0	P/PB																									1												
	3398	2	P/PB																				1																	
	3424	0	P/PB																				1					1												
	3426	0	P/PB																				1																	
	3431	0	P/PB																									1												
	3432	0	P/PB																				1					1												
	4398	2	P/PB																				1					1												
Arsenic	2625	4	PRRS						1																															1[d]
	2636	4	PRRS	1	1		2						1				1												1											
	2898	4	PRRS						1																															
	2900	4	PRRS						1																															
Boron	2045	2	SF				1	1	1																															
	2049	2	SF	2		2	2	2	2	1				1																										
Carbon Disulfide	2649	1	WSA			1																																		
	3821	1	WSA					1										1																						
Fluoride	2431	0	P/PB			1																																		
Lead	22198	0	P/PB																										1											
	2431	0	P/PB						1																															
	2625	4	PRRS																													1	1		1					1
	3733	0	P/PB	1						1																														
Manganese	2010	1	WSA						1		1				1	1	1	1		1	1	1	1	1	1	1		1			1	1	1	1	2	1	1			
	22198	0	P/PB											1																										
	22201	0	OSDF																							1		1	1	1	2		1		1					
	22204	0	P/PB-OSDF												1			1	1	1	1	1	1	1	1	1	2	2	2	1	1	2	2	2	2	2	2	2	2	2
	22205	0	P/PB-OSDF																	1										1										
	22212	3	OSDF																													1								
	22214	0	P/PB-OSDF																													1								
	22215	3	OSDF																												1	1								
	22217	3	OSDF																								1		1	2		1	2	2	2		1		1	
	2431	0	P/PB		2																																			
	2432	0	P/PB							1		2	1		1																									
	2625	4	PRRS																																1					1
	2648	1	WSA	1		1		1	1		1		1					1	1		1																			
	2733	0	P/PB																																1					
	2898	4	PRRS										1				1																							
	2899	4	PRRS							1																														
	2900	4	PRRS							1																														
	3093	4	P/PB																								1													
	3821	1	WSA					1	1		1		1		1	1	1			1	1		1	1	1	1	1	1	1	1	1	1	1	1						
	83337_C1	1	WSA																						1	1														
	83337_C2	1	WSA																							1														
	83337_C3	1	WSA																							1		1												
	83338_C2	1	WSA																				1		1		1						1							
	83339_C1	1	WSA																				1		1	1														
	83339_C2	1	WSA																								1													
	83339_C3	1	WSA																						1							1								
	83341_C1	1	WSA																				1		1	1							1							
	83341_C2	1	WSA																				1	1							1				1					
	83346_C1	1	WSA																				1		1	1	1													
	83346_C2	1	WSA																				1	1		1	1													
Molybdenum	2649	1	WSA	1		1		1	1		1		1		1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1
Nickel	22198	0	P/PB					1																																
	2398	2	P/PB	1	2	2		2																																
	2625	4	PRRS																																					1[d]
	4398	2	P/PB				1																																	
	83346_C1	1	WSA																							1														
	83346_C2	1	WSA																							1	1													

Constituent	Well[a]	Aquifer Zone	Project[b]	1997	1998		1999		2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015	
				2[c]	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Nitrate + Nitrite, as Nitrogen	2648	1	WSA		1			1	1		1					1	1	1			1																			
	2649	1	WSA	1	1	1	1	1	1	1	2	2	2	1	1	1	1	1		1	1		1		1	1					1		1		1					
	2821	1	WSA					1							1				1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1
	3821	1	WSA							1										1				1			1	1	1	1	1	1								
	83338_C1	1	WSA																										1		1	1	1		1		1	1	1	1
	83338_C2	1	WSA																					1				1	1	1	1		1	1	1	1	1		1	1
	83338_C3	1	WSA																					1			1	1	1	1	1	1				1				
	83340_C1	1	WSA																				1		1	1	1		1		1	1	1	1	1		1	1		
	83340_C2	1	WSA																				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	83340_C3	1	WSA																				1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	
	83341_C1	1	WSA																				1										1	1	1					
	83341_C2	1	WSA																							1								1				1		
	83341_C3	1	WSA																				1			1														
Technetium-99	2648	1	WSA					1			2				1																									
	2649	1	WSA	1	1	1	1	1	1	1	2	2	2	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1
	2821	1	WSA					1						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	2	1				
	83338_C1	1	WSA																										1		1	1	1		1		1	1	1	1
	83338_C2	1	WSA																					1				1	1	1	1	1	1	1	1	1	1		1	
	83338_C3	1	WSA																					1			1	1	1	1	1			1	1	1				
	83340_C1	1	WSA																				1		1	1	1		1		1	1	1	1	1	1	1	1	1	1
	83340_C2	1	WSA																				1	1	1	1	1	1												
	83340_C3	1	WSA																				1	1	1	1	1	1				1		1						
Trichloroethene	2649	1	WSA			1		1	1		1		1		1	1	1	1	1	1	1		1			1	1				1	1	1	1	1	1				
	2821	1	WSA																				1	1		1	1	1	1	1	1	1	1	1	2					
Zinc	22198	0	P/PB-OSDF																										1											
	22199	0	P/PB												1																									
	22200	0	OSDF																										1		1					1		1		
	22204	0	P/PB-OSDF												1										1				1											
	22206	3	OSDF																																			1		
	22210	0	P/PB-OSDF																1		1						1													
	22212	3	OSDF																											1				1						
	22213	3	OSDF																											1										
	2398	2	P/PB		1																																			
	2431	0	P/PB			2			1																															
	2432	0	P/PB				1		1	1																														
	2625	4	PRRS																						1	1					1	1	1		1	1	1			1
	2636	4	PRRS																						1	1														
	2733	0	P/PB				1																												1					
	2900	4	PRRS							1							1							1																
	3128	4	PRRS																1																					
	3426	0	P/PB				1	1																																
	3429	0	P/PB				2																																	
	3431	0	P/PB										1																											
	3733	0	P/PB												1																									
	3899	4	PRRS								1																													

Note: Shading indicates well is outside the 2014 Operational Adjustment remediation footprint.

[a]A "1" denotes an excedance for one of the two quarters and a "2" denotes an exceedance for both quarters.

[b]WSA = Waste Storage Area

SF = South Field

P/PB = Property/Plume Boundary for FRL Exceedances

PRRS = Property/Plume Boundary for Paddys Run Road Site

OSDF = Property/Plume Boundary for On-site Disposal Facility

[c]Sampling for the IEMP was initiated in August 1997.

[d]Some data from the September 30, 2015, sampling round are not considered representative of aquifer conditions for monitoring well 2625: the water in the well was highly turbid and almost dry, with an insufficient sample volume for all of the constituents. Consequently, the monitoring well was resampled and analyzed on January 28, 2016. The results from this new sampling indicate that arsenic and nickel would not be FRL exceedances if the January 28 sampling replaced the September 30 sampling. In addition, nickel at monitoring well 2625 would not be on the table.

Table A.4-3. Summary of Persistence Evaluation of Non-Uranium FRL Exceedances Outside the 2014 Operational Design Remediation Footprint

Constituent	Monitoring Well	Pertinent 2014 Results[a]	2015 FRL Exceedance		Evaluation Results for 2015	Figure Number
			First Half	Second Half		
Arsenic	2625	NA	No	Yes	Additional Routine Data Required	A.4-2
Lead	2625	NA	No	Yes	Additional Routine Data Required	A.4-3
Manganese	22204[b]	**Persistent**	Yes	Yes	**Persistent**	A.4-4
	22217	Additional Routine Data Required	Yes	No	Additional Routine Data Required	A.4-5
	2625	NA	No	Yes	Additional Routine Data Required	A.4-6
	2733	Additional Routine Data Required	No	No	Not Persistent	A.4-7
Nickel	2625	NA	No	Yes	Additional Routine Data Required	A.4-8
Zinc	2625	Additional Routine Data Required	No	Yes	Additional Routine Data Required	A.4-9
	22206	Additional Routine Data Required	No	No	Not Persistent	A.4-10
	22200	Additional Routine Data Required	No.	No	Not Persistent	A.4-11

[a] NA = not applicable.
[b] Sampled more than twice in 2015 because it is also sampled for OSDF monitoring program.

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Table A.4-4. Summary Statistics for Property/Plume Boundary

Well	Analyte	FRL[a] (mg/L)	Number of Detected Samples[b,c,d]	Number of Samples[b,c,d]	Percent Detects	Minimum[b,c,d,e] (mg/L)	Maximum[b,c,d,e] (mg/L)	Average[b,c,d,e] (mg/L)	Standard Deviation[b,c,d,e] (mg/L)	Number of FRL Exceedances Starting January 1, 2006	Trend[b,c,d,e,f]
2093	Fluoride	4	34	39	87.2	0.0276	0.990	0.150	0.140		No Trend
	Antimony	0.0060	1	33	3.0	0.000064	0.0225	0.00138	0.00386		No Trend
	Arsenic	0.050	2	33	6.1	0.000216	0.0230	0.00260	0.00390		Up
	Lead	0.015	2	33	6.1	0.000004	0.00165	0.000594	0.000556		No Trend
	Manganese	0.90	33	33	100	0.00340	0.101	0.0231	0.0244		Up
	Nickel	0.10	23	33	69.7	0.000500	0.0145	0.00340	0.00340		No Trend
	Zinc	0.021	13	33	39.4	0.00100	0.0137	0.00360	0.00320		No Trend
2398	Fluoride	4	63	69	91.3	0.0500	0.900	0.180	0.180		Up
	Antimony	0.0060	4	63	6.3	0.000050	0.0304	0.00374	0.00676	1	Down
	Arsenic	0.050	8	63	12.7	0.000350	0.0180	0.00190	0.00220		Up
	Lead	0.015	10	62	16.1	0.000007	0.00775	0.000854	0.00106		No Trend
	Manganese	0.90	53	67	79.1	0.000390	0.438	0.0269	0.0593		Down
	Nickel	0.10	49	63	77.8	0.00238	0.791	0.0600	0.117		No Trend
	Zinc	0.021	24	62	38.7	0.00100	0.0304	0.00560	0.00490		No Trend
2431	Fluoride	4	52	62	83.9	0.0150	12.3	0.400	1.55		No Trend
	Antimony	0.0060	3	62	4.8	0.000086	0.0304	0.00330	0.00665	1	Down
	Arsenic	0.050	14	62	22.6	0.000325	0.0284	0.00340	0.00480		Up
	Lead	0.015	10	62	16.1	0.000031	0.0157	0.00131	0.00260		No Trend
	Manganese	0.90	62	62	100	0.237	5.52	0.623	0.720		No Trend
	Nickel	0.10	20	62	32.3	0.000250	0.0280	0.00350	0.00470		Down
	Zinc	0.021	21	62	33.9	0.00100	0.0917	0.00860	0.0154		Down
2432	Fluoride	4	58	63	92.1	0.0150	1.20	0.210	0.220		Down
	Antimony	0.0060	6	63	9.5	0.000095	0.0304	0.00357	0.00691	2	Down
	Arsenic	0.050	14	63	22.2	0.000350	0.0300	0.00290	0.00420		Up
	Lead	0.015	9	63	14.3	0.000015	0.0146	0.00122	0.00223		No Trend
	Manganese	0.90	63	63	100	0.330	2.29	0.563	0.299		Up
	Nickel	0.10	13	63	20.6	0.000160	0.0552	0.00400	0.00790		Down
	Zinc	0.021	16	63	25.4	0.000800	0.114	0.00800	0.0174		Down
2733	Fluoride	4	53	57	93.0	0.0276	1.20	0.220	0.210		Down
	Antimony	0.0060	3	57	5.3	0.000050	0.0304	0.00355	0.00655	1	Down
	Arsenic	0.050	4	57	7.0	0.000325	0.0229	0.00210	0.00320		Up
	Lead	0.015	9	57	15.8	0.000035	0.0243	0.00140	0.00335		No Trend
	Manganese	0.90	52	57	91.2	0.00585	1.27	0.172	0.256	1	Down
	Nickel	0.10	20	57	35.1	0.000500	0.0556	0.00510	0.0089		Down
	Zinc	0.021	20	56	35.7	0.001	0.152	0.0101	0.0217	1	Down
3070	Fluoride	4	62	74	83.8	0.0150	0.800	0.170	0.130		No Trend
	Antimony	0.0060	6	65	9.2	0.000050	0.0304	0.00408	0.00692	2	Down
	Arsenic	0.050	11	65	16.9	0.000350	0.0283	0.00240	0.00370		Up
	Lead	0.015	8	65	12.3	0.000008	0.00470	0.000782	0.000807		No Trend
	Manganese	0.90	67	68	98.5	0.185	0.529	0.373	0.086		Up
	Nickel	0.10	17	65	26.2	0.000160	0.0155	0.00280	0.00280		Down
	Zinc	0.021	15	65	23.1	0.000750	0.0894	0.00580	0.0115		Down
3093	Fluoride	4	35	39	89.7	0.0276	0.780	0.170	0.110		No Trend
	Antimony	0.0060	1	33	3.0	0.000030	0.0225	0.00139	0.00386		No Trend
	Arsenic	0.050	8	33	24.2	0.000234	0.0229	0.00310	0.00390		Up
	Lead	0.015	2	33	6.1	0.000004	0.00165	0.000600	0.000552		No Trend
	Manganese	0.90	33	33	100	0.0763	2.38	0.405	0.377	1	Up
	Nickel	0.10	13	33	39.4	0.000125	0.0102	0.00170	0.00240		No Trend
	Zinc	0.021	12	33	36.4	0.000120	0.0181	0.00350	0.00350		No Trend
3398	Fluoride	4	61	68	89.7	0.0276	0.900	0.190	0.170		Up
	Antimony	0.0060	3	64	4.7	0.000040	0.0304	0.00358	0.00668	1	Down
	Arsenic	0.050	7	64	10.9	0.000037	0.0236	0.00230	0.00350		Up
	Lead	0.015	7	64	10.9	0.000005	0.00531	0.000750	0.000782		No Trend
	Manganese	0.90	66	67	98.5	0.196	0.539	0.343	0.065		Up
	Nickel	0.10	11	64	17.2	0.000160	0.0264	0.00300	0.00440		Down
	Zinc	0.021	13	63	20.6	0.000550	0.0568	0.00440	0.00740		Down
3424	Fluoride	4	62	62	100	0.280	1.80	0.530	0.290		No Trend
	Antimony	0.0060	5	62	8.1	0.000050	0.0304	0.00323	0.00616	2	Down
	Arsenic	0.050	5	62	8.1	0.000325	0.0239	0.00200	0.00300		Up
	Lead	0.015	4	62	6.5	0.000005	0.00567	0.000741	0.000812		No Trend
	Manganese	0.90	61	62	98.4	0.0875	0.190	0.133	0.017		No Trend
	Nickel	0.10	9	62	14.5	0.000160	0.00900	0.00230	0.00240		Down
	Zinc	0.021	12	62	19.4	0.000500	0.0247	0.00330	0.00340		Down
3426	Fluoride	4	60	62	96.8	0.100	1.10	0.280	0.210		Down
	Antimony	0.0060	3	62	4.8	0.000086	0.0304	0.00317	0.00622	1	Down
	Arsenic	0.050	3	62	4.8	0.000088	0.0251	0.00240	0.00370		Up
	Lead	0.015	8	62	12.9	0.000007	0.00541	0.000821	0.000859		No Trend
	Manganese	0.90	61	62	98.4	0.0588	0.465	0.131	0.074		Up
	Nickel	0.10	10	62	16.1	0.000040	0.00950	0.00220	0.00230		Down
	Zinc	0.021	16	61	26.2	0.000850	0.0699	0.00660	0.0106		Down
3429	Fluoride	4	58	62	93.5	0.0900	0.900	0.230	0.130		Up
	Antimony	0.0060	1	62	1.6	0.000038	0.0304	0.00309	0.00626		Down
	Arsenic	0.050	3	62	4.8	0.000037	0.0183	0.00200	0.00240		Up
	Lead	0.015	6	62	9.7	0.000005	0.00380	0.000747	0.000685		No Trend
	Manganese	0.90	61	62	98.4	0.0565	0.525	0.213	0.053		Up
	Nickel	0.10	7	62	11.3	0.000030	0.00950	0.00210	0.00240		Down
	Zinc	0.021	15	62	24.2	0.000650	1.11	0.0221	0.140		Down

Table A.4-4 (continued). Summary Statistics for Property/Plume Boundary

Well	Analyte	FRL[a] (mg/L)	Number of Detected Samples[b,c,d]	Number of Samples[b,c,d]	Percent Detects	Minimum[b,c,d,e] (mg/L)	Maximum[b,c,d,e] (mg/L)	Average[b,c,d,e] (mg/L)	Standard Deviation[b,c,d,e] (mg/L)	Number of FRL Exceedances Starting January 1, 2006	Trend[b,c,d,e,f]
3431	Fluoride	4	57	63	90.5	0.0150	0.800	0.190	0.140		No Trend
	Antimony	0.0060	2	63	3.2	0.000026	0.0304	0.00328	0.00631	1	Down
	Arsenic	0.050	5	63	7.9	0.000325	0.0275	0.00210	0.00340		Up
	Lead	0.015	12	63	19.0	0.000005	0.0112	0.00121	0.00198		Down
	Manganese	0.90	63	63	100	0.297	0.982	0.440	0.112		Up
	Nickel	0.10	11	63	17.5	0.000160	0.0131	0.00240	0.00270		Down
	Zinc	0.021	15	62	24.2	0.000550	0.124	0.00650	0.0160		Down
3432	Fluoride	4	56	62	90.3	0.0150	1.00	0.190	0.180		No Trend
	Antimony	0.0060	3	62	4.8	0.000040	0.0304	0.00319	0.00618	2	Down
	Arsenic	0.050	12	62	19.4	0.000147	0.0205	0.00230	0.00250		Up
	Lead	0.015	7	62	11.3	0.000005	0.00399	0.000708	0.000694		No Trend
	Manganese	0.90	62	62	100	0.239	0.771	0.431	0.091		Up
	Nickel	0.10	10	62	16.1	0.000160	0.00880	0.00210	0.00220		Down
	Zinc	0.021	15	61	24.6	0.00100	0.0190	0.00450	0.00380		Down
3733	Fluoride	4	53	63	84.1	0.0150	0.800	0.170	0.150		No Trend
	Antimony	0.0060	2	63	3.2	0.000050	0.0304	0.00324	0.00627		Down
	Arsenic	0.050	19	63	30.2	0.000375	0.0303	0.00260	0.00370		Up
	Lead	0.015	8	63	12.7	0.000005	0.201	0.00462	0.0255		No Trend
	Manganese	0.90	62	63	98.4	0.186	0.474	0.369	0.051		Up
	Nickel	0.10	10	63	15.9	0.000125	0.0105	0.00270	0.00300		Down
	Zinc	0.021	11	62	17.7	0.000325	0.0215	0.00390	0.00410		Down
4398	Fluoride	4	58	66	87.9	0.0500	0.900	0.180	0.170		No Trend
	Antimony	0.0060	5	63	7.9	0.000050	0.0304	0.00361	0.00664	2	Down
	Arsenic	0.050	28	63	44.4	0.000350	0.0316	0.00330	0.00400		No Trend
	Lead	0.015	5	63	7.9	0.000005	0.00523	0.000742	0.000800		No Trend
	Manganese	0.90	65	66	98.5	0.0317	0.709	0.450	0.124		Down
	Nickel	0.10	14	63	22.2	0.000160	0.101	0.00420	0.0127		Down
	Zinc	0.021	19	62	30.6	0.000550	0.0495	0.00510	0.00690		Down
21063	Fluoride	4	27	31	87.1	0.0276	0.200	0.130	0.030		No Trend
	Antimony	0.0060	1	31	3.2	0.000044	0.0225	0.00150	0.00401		No Trend
	Arsenic	0.050	3	31	9.7	0.000350	0.0185	0.00250	0.00320		Up
	Lead	0.015	1	31	3.2	0.000004	0.00165	0.000621	0.000563		No Trend
	Manganese	0.90	31	31	100	0.224	0.416	0.307	0.040		Up
	Nickel	0.10	8	31	25.8	0.000150	0.00950	0.00140	0.00180		No Trend
	Zinc	0.021	10	31	32.3	0.000284	0.0169	0.00300	0.00330		No Trend
22198	Fluoride	4	46	47	97.9	0.212	0.853	0.360	0.090		No Trend
	Antimony	0.0060	2	47	4.3	0.000032	0.0334	0.00155	0.00491	2	No Trend
	Arsenic	0.050	8	70	11.4	0.000113	0.0372	0.00350	0.00660		Up
	Lead	0.015	7	47	14.9	0.000007	0.0260	0.00145	0.00415	1	No Trend
	Manganese	0.90	69	70	98.6	0.174	1.09	0.494	0.175		No Trend
	Nickel	0.10	19	70	27.1	0.000250	0.130	0.00390	0.0156		Down
	Zinc	0.021	23	70	32.9	0.000500	0.0474	0.00430	0.00620	1	No Trend
22199	Fluoride	4	26	26	100	0.172	0.426	0.340	0.050		No Trend
	Antimony	0.0060	1	26	3.8	0.000140	0.00883	0.00114	0.00190	1	No Trend
	Arsenic	0.050	7	49	14.3	0.000350	0.0429	0.00490	0.00840		Up
	Lead	0.015	3	26	11.5	0.000092	0.00497	0.000801	0.00101		No Trend
	Manganese	0.90	48	49	98.0	0.0915	0.791	0.277	0.129		Down
	Nickel	0.10	6	49	12.2	0.000395	0.00660	0.00110	0.00130		No Trend
	Zinc	0.021	28	49	57.1	0.00100	0.0255	0.00550	0.00450		Down
22204	Fluoride	4	26	26	100	0.0600	0.441	0.280	0.060		Up
	Antimony	0.0060	2	26	7.7	0.000140	0.00867	0.00108	0.00176	1	No Trend
	Arsenic	0.050	7	49	14.3	0.000350	0.0382	0.00500	0.00820		Up
	Lead	0.015	3	26	11.5	0.000025	0.00592	0.000857	0.00117		No Trend
	Manganese	0.90	48	49	98.0	0.418	3.01	1.39	0.46	42	No Trend
	Nickel	0.10	13	49	26.5	0.000395	0.0127	0.00170	0.00240		No Trend
	Zinc	0.021	34	49	69.4	0.00100	0.0405	0.00890	0.00790	2	Down
22205	Fluoride	4	26	26	100	0.135	0.356	0.250	0.040		No Trend
	Antimony	0.0060	1	26	3.8	0.000140	0.00973	0.00110	0.00190	1	No Trend
	Arsenic	0.050	5	49	10.2	0.000350	0.0344	0.00500	0.00820		Up
	Lead	0.015	2	26	7.7	0.000025	0.00516	0.000800	0.00105		No Trend
	Manganese	0.90	48	49	98.0	0.184	1.10	0.602	0.172	2	Down
	Nickel	0.10	12	49	24.5	0.000395	0.0135	0.00160	0.00230		No Trend
	Zinc	0.021	26	49	53.1	0.00100	0.0178	0.00510	0.00420		Up
22208	Fluoride	4	26	26	100	0.0690	0.254	0.180	0.040		No Trend
	Antimony	0.0060	2	26	7.7	0.000140	0.0109	0.00129	0.00232	1	No Trend
	Arsenic	0.050	6	49	12.2	0.000350	0.0390	0.00550	0.00840		No Trend
	Lead	0.015	2	26	7.7	0.000025	0.00529	0.000808	0.00107		No Trend
	Manganese	0.90	48	49	98.0	0.000425	0.548	0.398	0.0833		Up
	Nickel	0.10	8	49	16.3	0.000150	0.00690	0.00110	0.00130		No Trend
	Zinc	0.021	21	49	42.9	0.00100	0.0143	0.00380	0.00290		No Trend

Well	Analyte	FRL[a] (mg/L)	Number of Detected Samples[b,c,d]	Number of Samples[b,c,d]	Percent Detects	Minimum[b,c,d,e] (mg/L)	Maximum[b,c,d,e] (mg/L)	Average[b,c,d,e] (mg/L)	Standard Deviation[b,c,d,e] (mg/L)	Number of FRL Exceedances Starting January 1, 2006	Trend[b,c,d,e,f]
22210	Fluoride	4	22	22	100	0.270	0.487	0.360	0.070		Down
	Antimony	0.0060	1	22	4.5	0.000140	0.00481	0.000840	0.00103		No Trend
	Arsenic	0.050	7	45	15.6	0.000750	0.0381	0.00540	0.00870		No Trend
	Lead	0.015	2	22	9.1	0.000250	0.00472	0.000880	0.00103		No Trend
	Manganese	0.90	45	45	100	0.0735	0.420	0.209	0.087		No Trend
	Nickel	0.10	37	45	82.2	0.000750	0.00990	0.00330	0.00230		No Trend
	Zinc	0.021	36	45	80.0	0.00165	0.0244	0.00900	0.00590	3	Down
22211	Fluoride	4	22	22	100	0.0790	0.280	0.140	0.040		No Trend
	Antimony	0.0060	1	22	4.5	0.000140	0.00383	0.000780	0.000850		No Trend
	Arsenic	0.050	8	45	17.8	0.000750	0.0323	0.00520	0.00710		No Trend
	Lead	0.015	1	22	4.5	0.000025	0.00578	0.000909	0.00123		No Trend
	Manganese	0.90	45	45	100	0.178	0.680	0.448	0.119		No Trend
	Nickel	0.10	5	45	11.1	0.000500	0.00520	0.00100	0.00080		No Trend
	Zinc	0.021	19	45	42.2	0.00100	0.0209	0.00400	0.00420		No Trend
22214	Fluoride	4	22	22	100	0.0620	0.221	0.170	0.030		No Trend
	Antimony	0.0060	0	22	0	0.000140	0.00515	0.000900	0.00109		No Trend
	Arsenic	0.050	9	45	20.0	0.000750	0.0457	0.00590	0.00940		No Trend
	Lead	0.015	3	22	13.6	0.000180	0.00531	0.000910	0.00113		No Trend
	Manganese	0.90	45	45	100	0.189	0.972	0.392	0.180	1	Down
	Nickel	0.10	5	45	11.1	0.000500	0.00630	0.00100	0.00090		No Trend
	Zinc	0.021	15	45	33.3	0.00100	0.0104	0.00330	0.00260		No Trend
31217	Fluoride	4	56	62	90.3	0.0750	1.70	0.290	0.330		No Trend
	Antimony	0.0060	3	62	4.8	0.000050	0.0304	0.00315	0.00615	1	Down
	Arsenic	0.050	3	62	4.8	0.000037	0.0259	0.00220	0.00330		Up
	Lead	0.015	4	62	6.5	0.000005	0.0200	0.00102	0.00256		No Trend
	Manganese	0.90	61	62	98.4	0.00320	0.258	0.181	0.054		Down
	Nickel	0.10	13	62	21.0	0.000035	0.0118	0.00260	0.00280		Down
	Zinc	0.021	12	61	19.7	0.000850	0.0164	0.00390	0.00340		Down

Shading indicates that the analyte had either an FRL exceedance or an upward trend.

[a]FRL = final remediation level. FRL is from the *Record of Decision for Remedial Actions at Operable Unit 5* (DOE 1996), Table 9-4.

[b]The data are based on unfiltered samples from the Operable Unit 5 Remedial Investigation/Feasibility Study data set (1988 through 1993) and 1994 through 2015 groundwater data (unfiltered and filtered for 2001 through 2015).

[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 to determine the summary statistics (minimum, maximum, average, standard deviation and Mann-Kendall test for trend).

[d]Rejected data qualified with an "R" were not included in this count or summary statistics.

[e]Where concentrations are below the detection limit each result used in the summary statistics is set at half the detection limit.

[f]Mann-Kendall test for trend is performed using data from third quarter 1998 through 2015.

Table A.4-5. Summary Statistics for Property/Plume Boundary and PRRS

Well	Analyte	FRL[a,b]	Number of Detected Samples[c,d,e]	Number of Samples[c,d,e]	Percent Detects	Minimum[c,d,e,f]	Maximum[c,d,e,f]	Average[c,d,e,f]	Standard Deviation[c,d,e,f]	Exceedances Starting January 1, 2006	Trend[c,d,e,f,g]
2128	Fluoride (mg/L)	4	37	37	100	0.104	1.85	0.260	0.270		Down
	Phosphorus (mg/L)	NA	67	72	93.1	0.0250	16.2	1.36	2.33		Down
	Antimony (mg/L)	0.0060	0	31	0	0.000140	0.0225	0.00282	0.00536		No Trend
	Arsenic (mg/L)	0.050	64	246	26.0	0.000195	0.188	0.0111	0.0203		Down
	Lead (mg/L)	0.015	6	31	19.4	0.000025	0.0325	0.00263	0.00608		Down
	Manganese (mg/L)	0.90	22	31	71.0	0.00100	5.39	0.466	1.26		Down
	Nickel (mg/L)	0.10	12	31	38.7	0.000500	0.0730	0.00600	0.0143		Down
	Potassium (mg/L)	NA	62	64	96.9	0.830	18.0	3.28	3.24		Down
	Sodium (mg/L)	NA	64	64	100	12.3	75.2	34.1	11.3		Down
	Zinc (mg/L)	0.021	15	30	50.0	0.00100	0.154	0.0169	0.0375		Down
	Benzene (ug/L)	5.0	0	66	0	0.025	5.00	0.910	1.45		Down
	Ethylbenzene (ug/L)	NA	1	66	1.5	0.025	5.00	1.77	2.15		Down
	Isopropylbenzene (ug/L)	NA	0	53	0	0.025	5.00	1.62	2.08		Down
	Toluene (ug/L)	NA	1	66	1.5	0.025	5.00	1.67	2.08		Down
	Total Xylenes (ug/L)	NA	1	66	1.5	0.025	5.00	1.71	2.06		Down
2625	Fluoride (mg/L)	4	14	14	100	0.0840	0.283	0.210	0.050		No Trend
	Phosphorus (mg/L)	NA	37	39	94.9	0.307	18.6	3.84	3.83		Up
	Antimony (mg/L)	0.0060	1	18	5.6	0.000140	0.0225	0.00450	0.00751		Down
	Arsenic (mg/L)	0.050	128	216	59.3	0.00110	0.194	0.0127	0.0156	1	Down
	Lead (mg/L)	0.015	12	18	66.7	0.000150	0.349	0.0270	0.0810	4	Up
	Manganese (mg/L)	0.90	17	18	94.4	0.00100	6.88	0.673	1.58	2	No Trend
	Nickel (mg/L)	0.10	12	18	66.7	0.00110	0.440	0.0361	0.102	1	Up
	Potassium (mg/L)	NA	37	41	90.2	0.640	38.8	4.39	5.90		No Trend
	Sodium (mg/L)	NA	41	41	100	13.1	61.4	31.3	9.6		Down
	Zinc (mg/L)	0.021	13	17	76.5	0.00325	1.55	0.133	0.368	9	Up
	Benzene (ug/L)	5.0	0	39	0	0.025	5.00	1.25	1.82		Down
	Ethylbenzene (ug/L)	NA	0	39	0	0.025	5.00	1.90	2.23		Down
	Isopropylbenzene (ug/L)	NA	0	32	0	0.025	5.00	1.29	1.86		Down
	Toluene (ug/L)	NA	0	39	0	0.025	5.00	1.73	2.12		Down
	Total Xylenes (ug/L)	NA	0	39	0	0.025	5.00	1.83	2.13		Down
2636	Fluoride (mg/L)	4	10	13	76.9	0.0276	0.200	0.0800	0.0400		No Trend
	Phosphorus (mg/L)	NA	36	37	97.3	9.60	170	83.9	42.9		No Trend
	Antimony (mg/L)	0.0060	11	16	68.8	0.00150	0.0266	0.00895	0.00790	4	Down
	Arsenic (mg/L)	0.050	146	185	78.9	0.0100	0.0939	0.0440	0.0185	1	Down
	Lead (mg/L)	0.015	9	16	56.2	0.000130	0.00550	0.00171	0.00127		No Trend
	Manganese (mg/L)	0.90	14	16	87.5	0.00100	0.478	0.135	0.136		No Trend
	Nickel (mg/L)	0.10	16	16	100	0.00390	0.0936	0.0227	0.0212		No Trend
	Potassium (mg/L)	NA	37	37	100	4.60	218	63.5	51.0		Down
	Sodium (mg/L)	NA	37	37	100	19.1	148	52.0	26.6		Down
	Zinc (mg/L)	0.021	11	16	68.8	0.00254	0.0238	0.0125	0.0055	2	No Trend
	Benzene (ug/L)	5.0	0	36	0	0.025	5.00	1.32	1.87		Down
	Ethylbenzene (ug/L)	NA	0	36	0	0.025	5.00	2.01	2.28		Down
	Isopropylbenzene (ug/L)	NA	0	29	0	0.025	5.00	1.36	1.94		Down
	Toluene (ug/L)	NA	0	36	0	0.025	5.00	2.02	2.20		Down
	Total Xylenes (ug/L)	NA	0	36	0	0.025	5.00	2.02	2.22		Down
2898	Fluoride (mg/L)	4	29	33	87.9	0.0276	0.243	0.130	0.040		No Trend
	Phosphorus (mg/L)	NA	19	64	29.7	0.00500	9.95	0.243	1.26		Down
	Antimony (mg/L)	0.0060	0	36	0	0.000140	0.0225	0.00241	0.00553		No Trend
	Arsenic (mg/L)	0.050	11	63	17.5	0.000147	0.0820	0.00420	0.0110		Up
	Lead (mg/L)	0.015	4	36	11.1	0.000025	0.00165	0.000686	0.000566		No Trend
	Manganese (mg/L)	0.90	36	36	100	0.117	1.44	0.517	0.258		No Trend
	Nickel (mg/L)	0.10	28	36	77.8	0.000500	0.0158	0.00460	0.00380		Down
	Potassium (mg/L)	NA	61	64	95.3	1.11	9.64	4.40	1.20		Up
	Sodium (mg/L)	NA	63	64	98.4	4.94	31.0	19.7	4.9		Up
	Zinc (mg/L)	0.021	15	36	41.7	0.000100	0.0156	0.00510	0.00400		Down
	Benzene (ug/L)	5.0	0	61	0	0.025	5.00	0.870	1.41		Down
	Ethylbenzene (ug/L)	NA	0	61	0	0.025	5.00	1.96	2.23		Down
	Isopropylbenzene (ug/L)	NA	0	54	0	0.025	5.00	1.68	2.11		Down
	Toluene (ug/L)	NA	4	61	6.6	0.025	5.00	1.61	2.07		Down
	Total Xylenes (ug/L)	NA	1	61	1.6	0.025	5.00	1.89	2.14		Down
2899	Fluoride (mg/L)	4	28	32	87.5	0.0165	0.275	0.130	0.050		No Trend
	Phosphorus (mg/L)	NA	16	55	29.1	0.00500	0.831	0.0580	0.115		No Trend
	Antimony (mg/L)	0.0060	0	35	0	0.000025	0.0225	0.00189	0.00438		No Trend
	Arsenic (mg/L)	0.050	6	56	10.7	0.000320	0.0283	0.00230	0.00390		Up
	Lead (mg/L)	0.015	4	35	11.4	0.000021	0.00165	0.000557	0.000508		No Trend
	Manganese (mg/L)	0.90	35	35	100	0.0327	1.72	0.167	0.280		Down
	Nickel (mg/L)	0.10	29	35	82.9	0.000750	0.0140	0.00510	0.00340		Down
	Potassium (mg/L)	NA	54	56	96.4	1.36	8.85	4.10	0.95		Up
	Sodium (mg/L)	NA	56	56	100	11.2	25.1	18.0	3.5		Up
	Zinc (mg/L)	0.021	14	34	41.2	0.000850	0.0300	0.00450	0.00530		Down
	Benzene (ug/L)	5.0	0	54	0	0.025	5.00	0.840	1.38		Down
	Ethylbenzene (ug/L)	NA	2	54	3.7	0.025	5.00	1.46	2.02		Down
	Isopropylbenzene (ug/L)	NA	0	48	0	0.025	5.00	1.35	1.93		Down
	Toluene (ug/L)	NA	3	54	5.6	0.025	5.00	1.34	1.91		Down
	Total Xylenes (ug/L)	NA	1	54	1.9	0.025	5.00	1.68	2.03		Down
3128	Fluoride (mg/L)	4	36	36	100	0.0700	0.350	0.160	0.050		Down
	Phosphorus (mg/L)	NA	31	73	42.5	0.0050	13.0	0.231	1.52		No Trend
	Antimony (mg/L)	0.0060	1	31	3.2	0.000140	0.0720	0.00439	0.0132		No Trend
	Arsenic (mg/L)	0.050	19	66	28.8	0.000400	0.234	0.00710	0.0288		No Trend
	Lead (mg/L)	0.015	4	31	12.9	0.000025	0.295	0.0103	0.0528		No Trend
	Manganese (mg/L)	0.90	31	31	100	0.205	0.393	0.263	0.040		Down
	Nickel (mg/L)	0.10	9	31	29.0	0.000395	0.547	0.0197	0.0979		Down
	Potassium (mg/L)	NA	62	66	93.9	1.08	3.70	1.92	0.63		Down
	Sodium (mg/L)	NA	66	66	100	3.52	13.4	5.60	2.54		Down
	Zinc (mg/L)	0.021	17	30	56.7	0.00100	0.126	0.0100	0.0229	1	Down
	Benzene (ug/L)	5.0	0	67	0	0.025	5.00	0.900	1.44		Down
	Ethylbenzene (ug/L)	NA	0	67	0	0.025	5.00	1.96	2.22		Down
	Isopropylbenzene (ug/L)	NA	0	55	0	0.025	5.00	1.74	2.13		Down
	Toluene (ug/L)	NA	2	67	3.0	0.025	5.00	1.80	2.13		Down
	Total Xylenes (ug/L)	NA	0	67	0	0.025	5.00	1.97	2.16		Down

Table A.4-5 (continued). Summary Statistics for Property/Plume Boundary and PRRS

Well	Analyte	FRL[a,b]	Number of Detected Samples[c,d,e]	Number of Samples[c,d,e]	Percent Detects	Minimum[c,d,e,f]	Maximum[c,d,e,f]	Average[c,d,e,f]	Standard Deviation[c,d,e,f]	Exceedances Starting January 1, 2006	Trend[c,d,e,f,g]
3636	Fluoride (mg/L)	4	23	25	92.0	0.0276	0.314	0.150	0.050		No Trend
	Phosphorus (mg/L)	NA	24	62	38.7	0.0091	1.10	0.0690	0.141		Down
	Antimony (mg/L)	0.0060	0	28	0	0.000140	0.0225	0.00295	0.00618		No Trend
	Arsenic (mg/L)	0.050	17	63	27.0	0.000500	0.0233	0.00280	0.00370		Up
	Lead (mg/L)	0.015	3	28	10.7	0.000025	0.00480	0.000961	0.00101		No Trend
	Manganese (mg/L)	0.90	28	28	100	0.211	0.344	0.274	0.032		No Trend
	Nickel (mg/L)	0.10	5	28	17.9	0.000245	0.0100	0.00210	0.00290		Down
	Potassium (mg/L)	NA	59	62	95.2	1.09	4.24	2.15	0.55		Down
	Sodium (mg/L)	NA	62	62	100	3.14	13.0	5.78	2.73		Down
	Zinc (mg/L)	0.021	8	27	29.6	0.000800	0.119	0.00790	0.0229		No Trend
	Benzene (ug/L)	5.0	0	61	0	0.025	5.00	0.950	1.50		Down
	Ethylbenzene (ug/L)	NA	0	61	0	0.025	5.00	2.16	2.26		Down
	Isopropylbenzene (ug/L)	NA	0	53	0	0.025	5.00	1.80	2.15		Down
	Toluene (ug/L)	NA	3	61	4.9	0.025	6.50	2.24	2.28		Down
	Total Xylenes (ug/L)	NA	0	61	0	0.025	15.0	2.29	2.73		Down
3898	Fluoride (mg/L)	4	29	32	90.6	0.0276	0.227	0.140	0.040		No Trend
	Phosphorus (mg/L)	NA	30	62	48.4	0.0075	1.24	0.0980	0.168		No Trend
	Antimony (mg/L)	0.0060	0	35	0	0.000025	0.0225	0.00185	0.00445		No Trend
	Arsenic (mg/L)	0.050	27	63	42.9	0.000500	0.0434	0.00430	0.00640		Up
	Lead (mg/L)	0.015	3	35	8.6	0.000011	0.00165	0.000602	0.000535		No Trend
	Manganese (mg/L)	0.90	35	35	100	0.225	0.553	0.360	0.081		Up
	Nickel (mg/L)	0.10	17	35	48.6	0.000150	0.00950	0.00200	0.00200		No Trend
	Potassium (mg/L)	NA	59	63	93.7	0.610	4.09	2.63	0.72		Up
	Sodium (mg/L)	NA	62	63	98.4	7.29	28.8	12.4	5.7		Up
	Zinc (mg/L)	0.021	10	34	29.4	0.000100	0.0191	0.00360	0.00390		No Trend
	Benzene (ug/L)	5.0	0	61	0	0.025	5.00	0.800	1.30		Down
	Ethylbenzene (ug/L)	NA	0	61	0	0.025	5.00	1.96	2.23		Down
	Isopropylbenzene (ug/L)	NA	0	55	0	0.025	5.00	1.74	2.13		Down
	Toluene (ug/L)	NA	3	61	4.9	0.025	5.00	1.91	2.14		Down
	Total Xylenes (ug/L)	NA	0	61	0	0.025	5.00	1.89	2.14		Down
3899	Fluoride (mg/L)	4	31	33	93.9	0.0500	0.254	0.150	0.040		No Trend
	Phosphorus (mg/L)	NA	23	63	36.5	0.0050	1.86	0.114	0.266		Down
	Antimony (mg/L)	0.0060	0	36	0	0.000025	0.0225	0.00242	0.00553		No Trend
	Arsenic (mg/L)	0.050	8	64	12.5	0.000147	0.0307	0.00270	0.00450		Up
	Lead (mg/L)	0.015	3	36	8.3	0.000025	0.00240	0.000639	0.000598		No Trend
	Manganese (mg/L)	0.90	36	36	100	0.174	0.893	0.349	0.146		Up
	Nickel (mg/L)	0.10	23	36	63.9	0.000155	0.0360	0.00460	0.00760		No Trend
	Potassium (mg/L)	NA	61	64	95.3	0.875	4.54	2.72	0.72		Up
	Sodium (mg/L)	NA	64	64	100	6.24	43.6	12.7	9.4		Up
	Zinc (mg/L)	0.021	11	36	30.6	0.000100	0.0347	0.00420	0.00590		No Trend
	Benzene (ug/L)	5.0	0	62	0	0.025	5.00	0.860	1.40		Down
	Ethylbenzene (ug/L)	NA	0	62	0	0.025	5.00	2.01	2.25		Down
	Isopropylbenzene (ug/L)	NA	0	55	0	0.025	5.00	1.74	2.13		Down
	Toluene (ug/L)	NA	2	62	3.2	0.025	8.00	1.89	2.25		Down
	Total Xylenes (ug/L)	NA	0	62	0	0.025	5.00	1.94	2.16		Down
3900	Fluoride (mg/L)	4	31	33	93.9	0.0570	0.289	0.160	0.040		No Trend
	Phosphorus (mg/L)	NA	16	64	25.0	0.0050	1.38	0.0870	0.230		Down
	Antimony (mg/L)	0.0060	0	35	0	0.000025	0.0225	0.00188	0.00440		No Trend
	Arsenic (mg/L)	0.050	18	64	28.1	0.000375	0.0208	0.00280	0.00320		No Trend
	Lead (mg/L)	0.015	5	35	14.3	0.000075	0.00290	0.000686	0.000640		No Trend
	Manganese (mg/L)	0.90	35	35	100	0.219	0.371	0.288	0.040		Up
	Nickel (mg/L)	0.10	10	35	28.6	0.000275	0.00950	0.00160	0.00210		Down
	Potassium (mg/L)	NA	58	64	90.6	0.975	3.19	1.71	0.38		Down
	Sodium (mg/L)	NA	63	64	98.4	3.13	10.8	4.81	1.75		Down
	Zinc (mg/L)	0.021	11	34	32.4	0.000440	0.0191	0.00400	0.00410		Down
	Benzene (ug/L)	5.0	0	62	0	0.025	5.00	0.860	1.40		Down
	Ethylbenzene (ug/L)	NA	0	62	0	0.025	5.00	2.01	2.25		Down
	Isopropylbenzene (ug/L)	NA	0	55	0	0.025	5.00	1.74	2.13		Down
	Toluene (ug/L)	NA	5	62	8.1	0.025	13.0	2.17	2.57		Down
	Total Xylenes (ug/L)	NA	1	62	1.6	0.025	5.00	2.02	2.18		Down

Shading indicates that the analyte had either an FRL exceedance or an upward trend.

[a]From *Record of Decision for Remedial Actions at Operable Unit 5* (DOE 1996), Table 9-4.

[b]NA = not applicable

[c]The data are based on unfiltered samples from the Operable Unit 5 Remedial Investigation/Feasibility Study data set (1988 through 1993) and 1994 through 2015 groundwater data (unfiltered and filtered for 2001 through 2015).

[d]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, standard deviation and Mann-Kendall test for trend).

[e]Rejected data qualified with an "R" were not included in this count or summary statistics.

[f]Where concentrations are below the detection limit each result used in the summary statistics is set at half the detection limit.

[g]Mann-Kendall test for trend is performed using data from third quarter 1998 through 2015.

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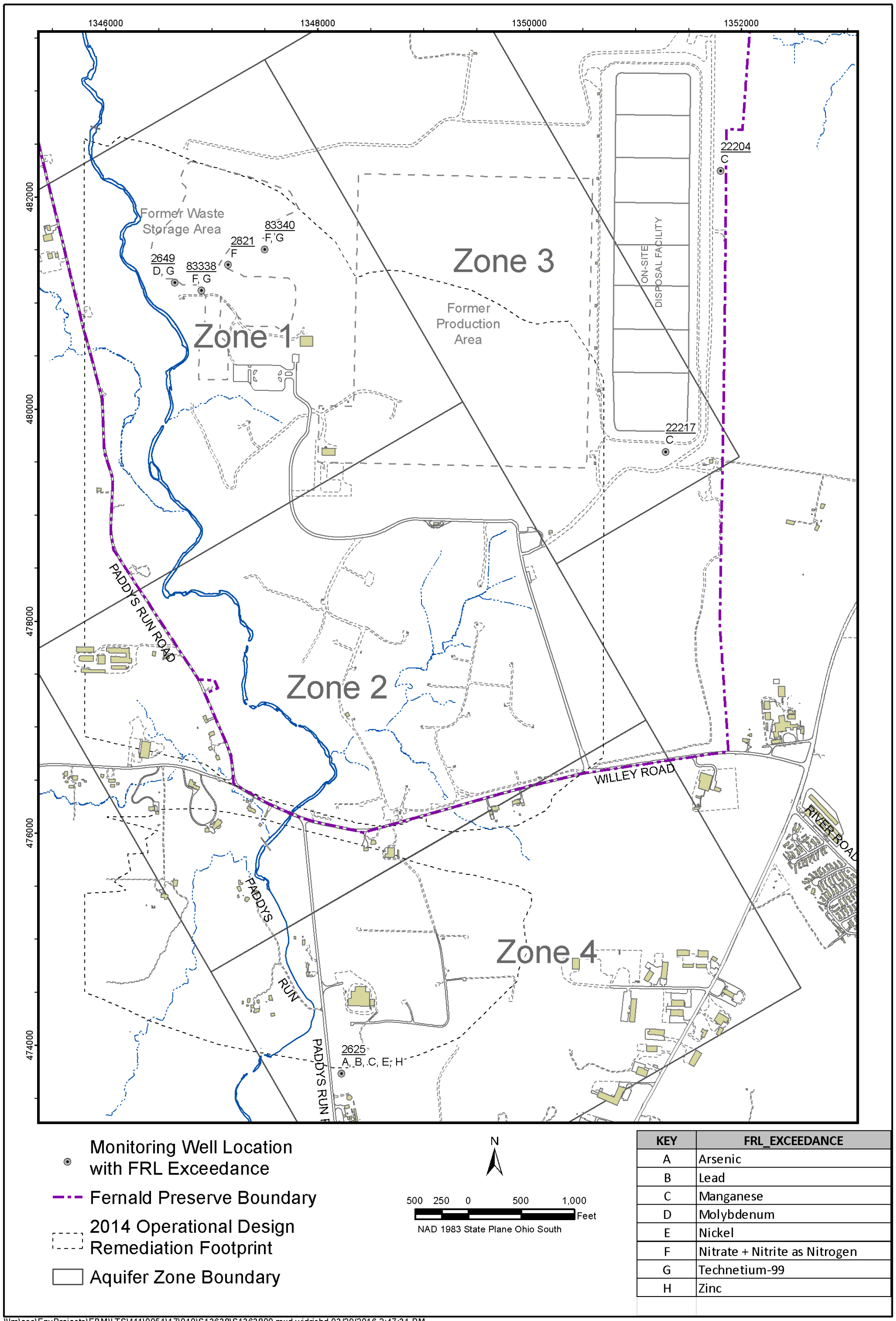

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Figure A.4-1. Non-Uranium Constituents with 2015 Results Above FRLs

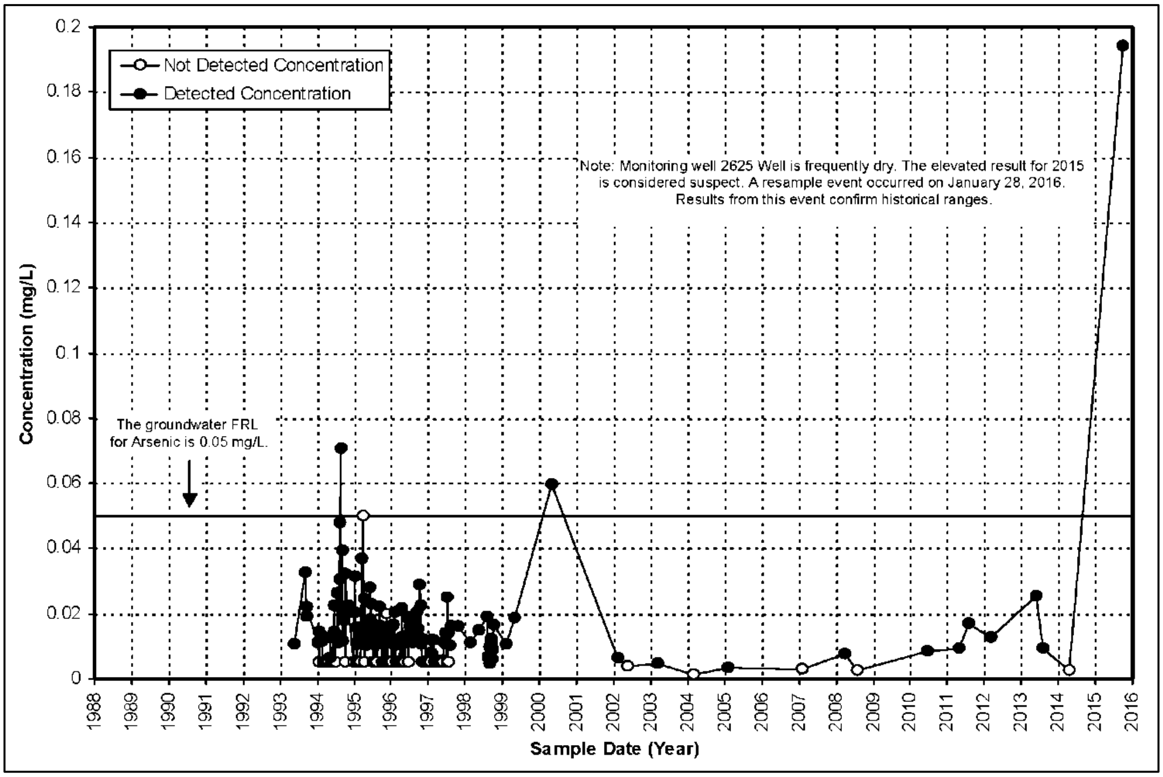

Figure A.4-2. Arsenic Concentration Versus Time Plot for Monitoring Well 2625

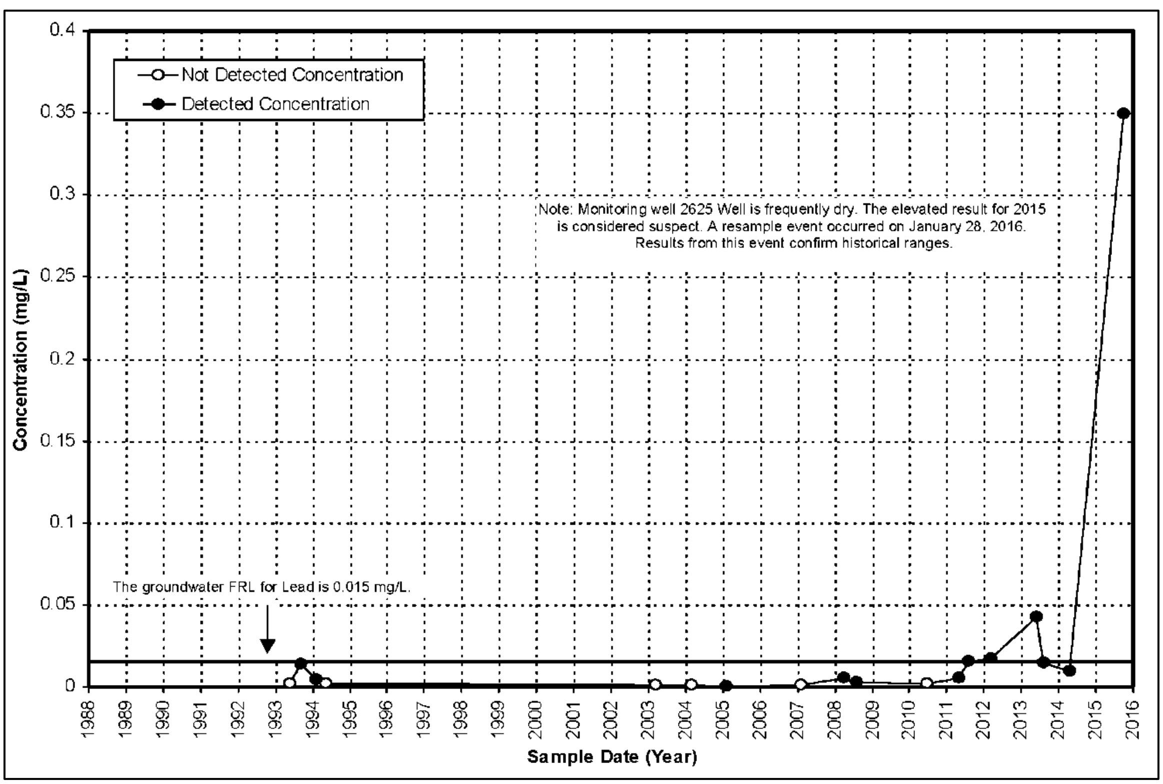

Figure A.4-3. Lead Concentration Versus Time Plot for Monitoring Well 2625

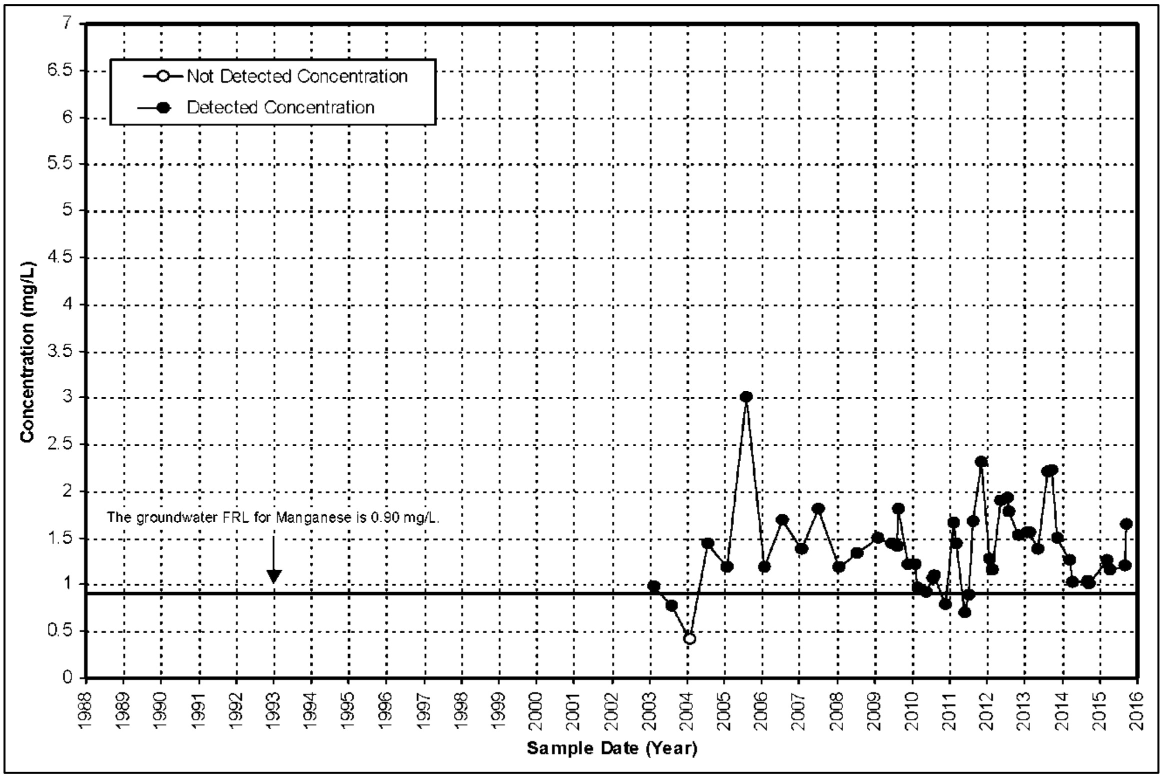

Figure A.4-4. Manganese Concentration Versus Time Plot for Monitoring Well 22204

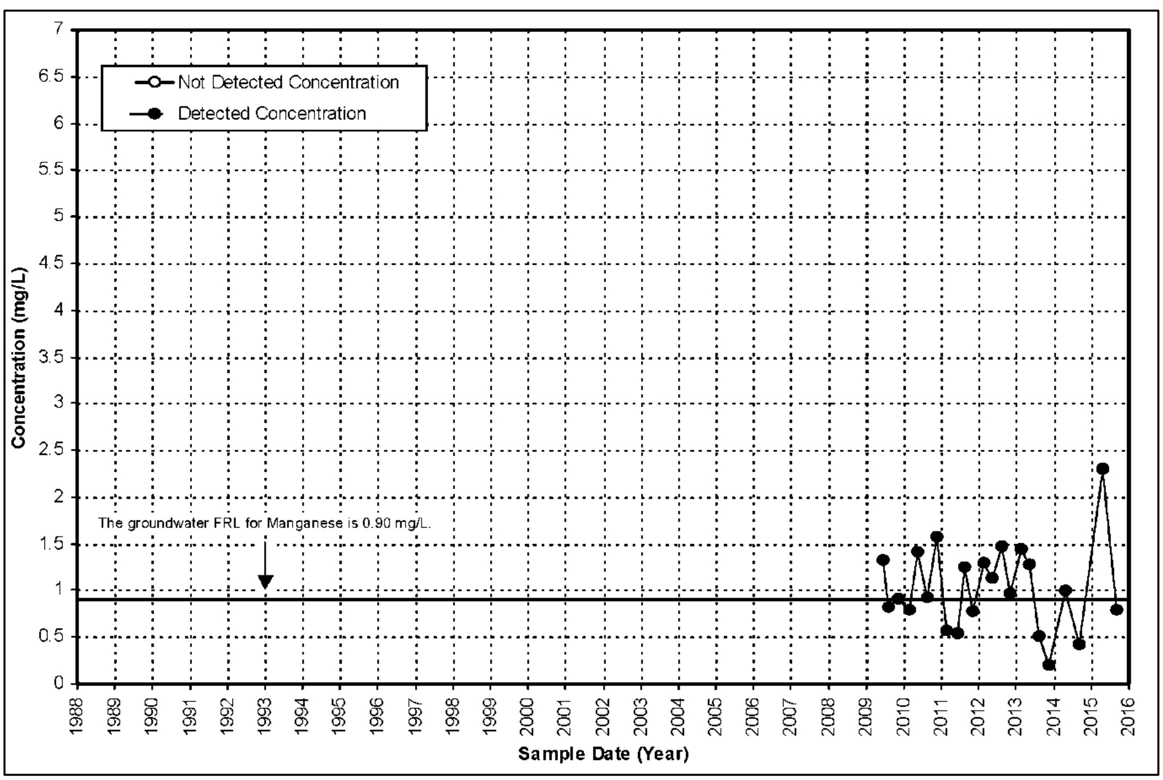

Figure A.4-5. Manganese Concentration Versus Time Plot for Monitoring Well 22217

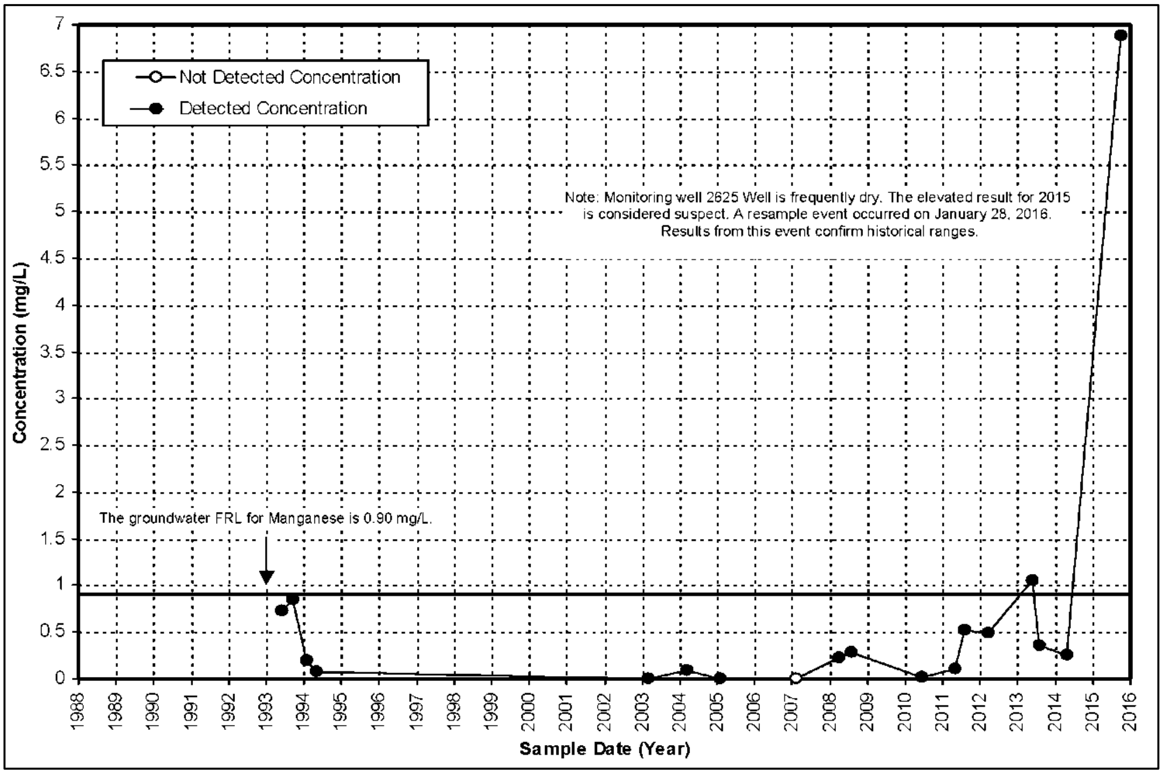

Figure A.4-6. Manganese Concentration Versus Time Plot for Monitoring Well 2625

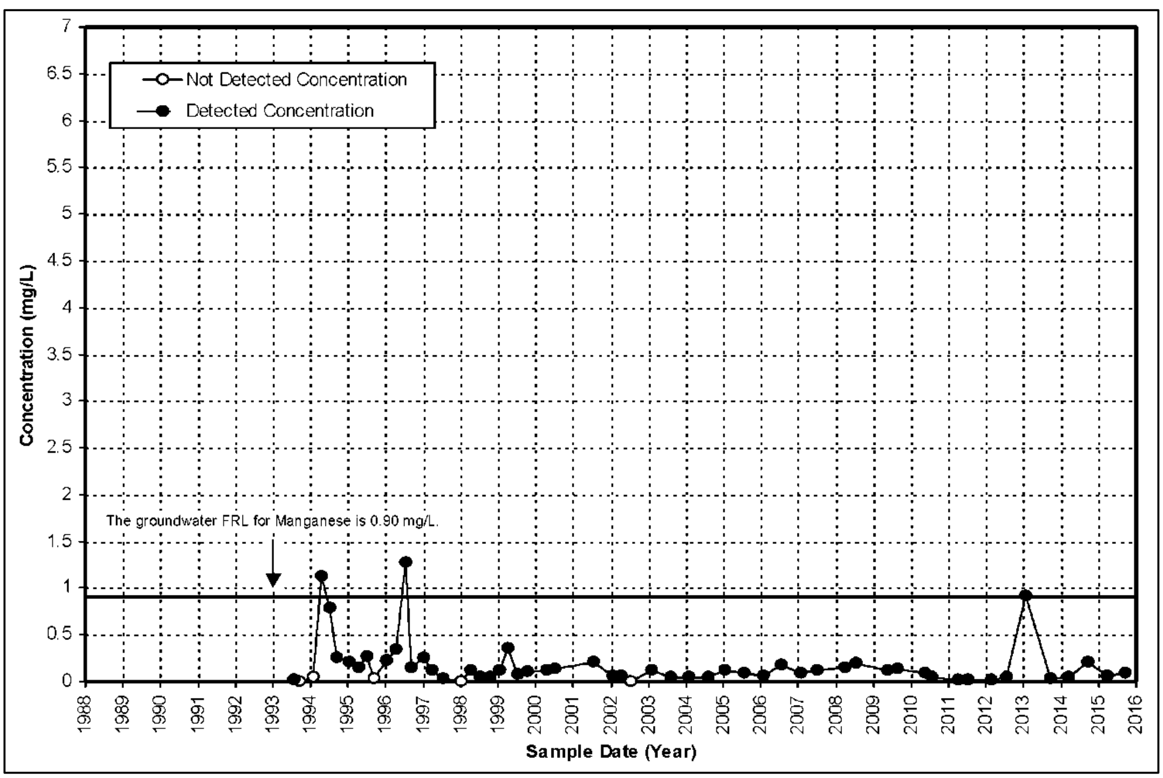

Figure A.4-7. Manganese Concentration Versus Time Plot for Monitoring Well 2733

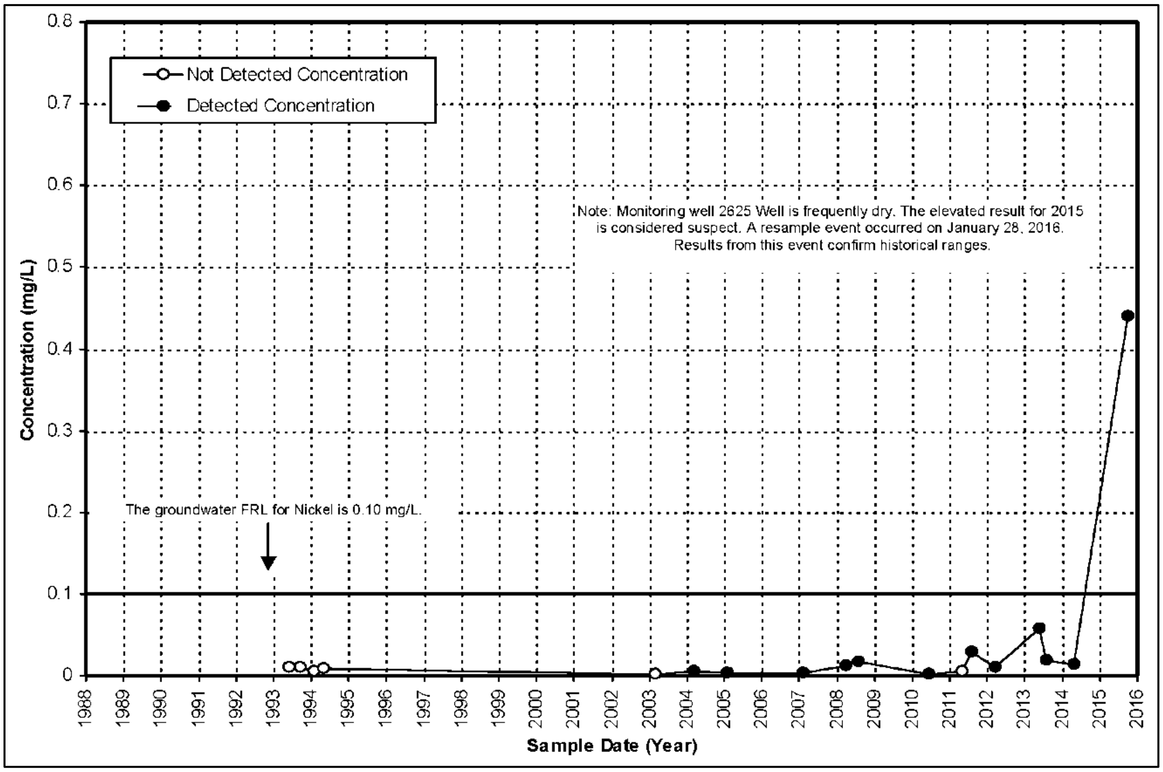

Figure A.4-8. Nickel Concentration Versus Time Plot for Monitoring Well 2625

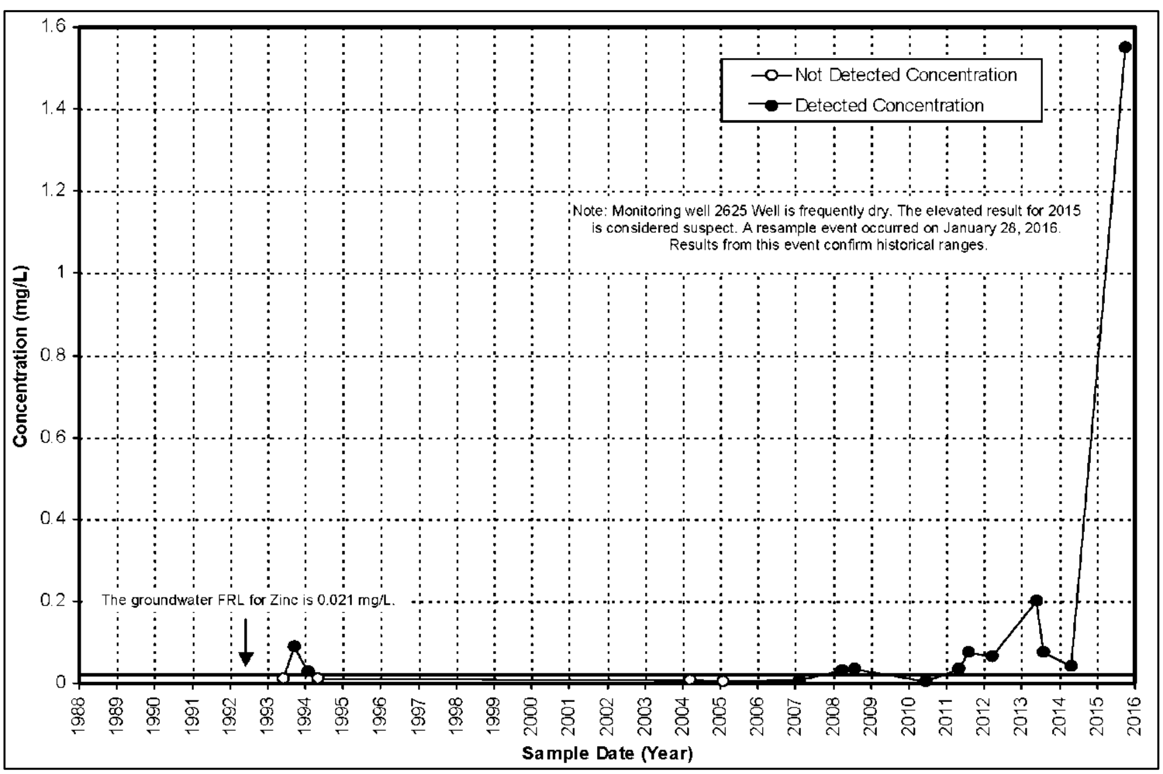

Figure A.4-9. Zinc Concentration Versus Time Plot for Monitoring Well 2625

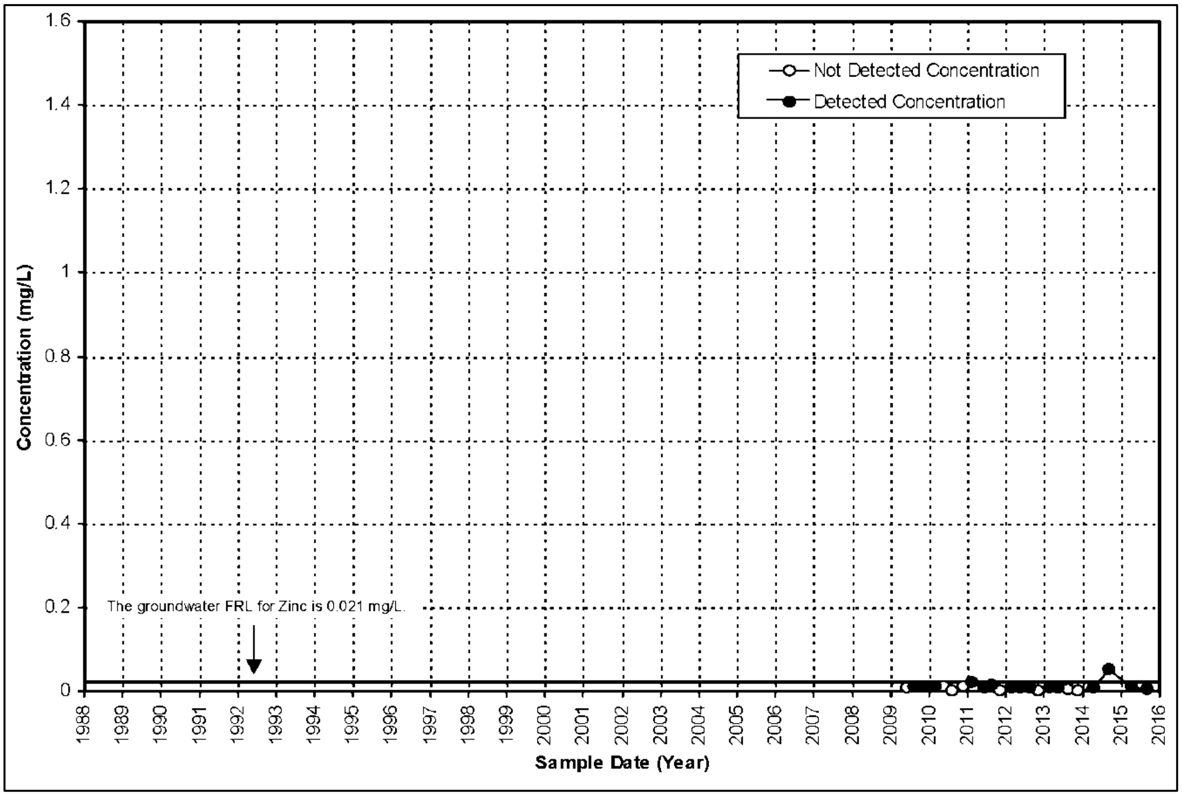

Figure A.4-10. Zinc Concentration Versus Time Plot for Monitoring Well 22206

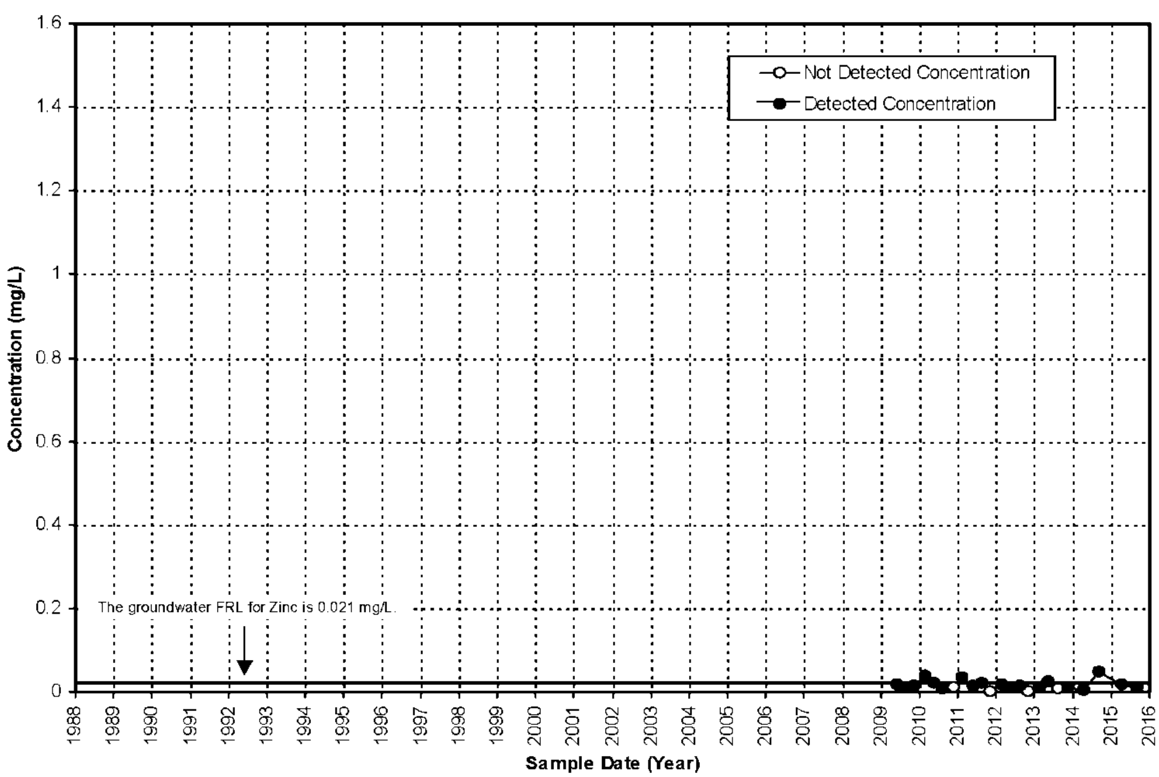

Figure A.4-11. Zinc Concentration Versus Time Plot for Monitoring Well 22200

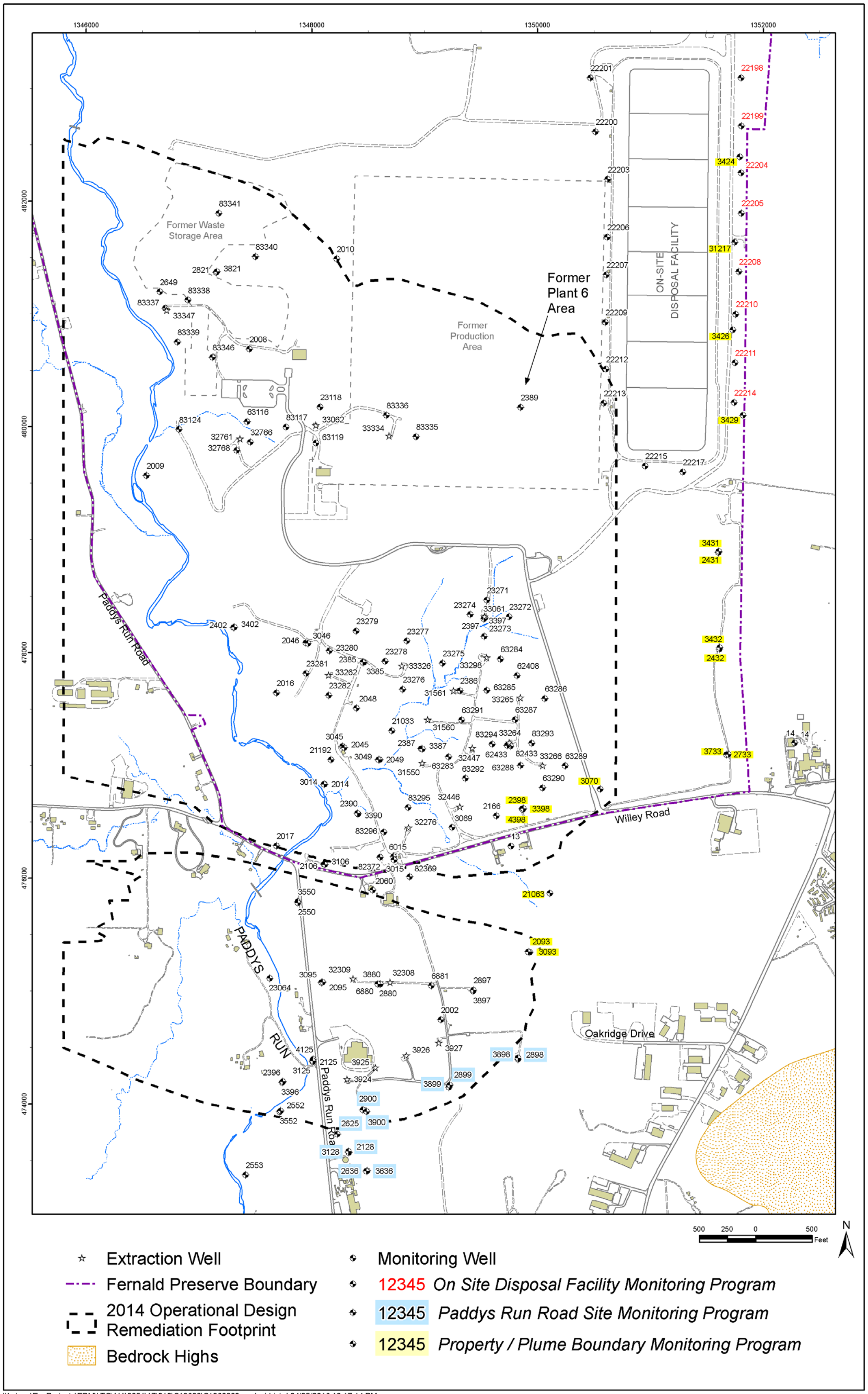

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Figure A.4-12. Location of Property/Plume Boundary and PRRS Monitoring Wells

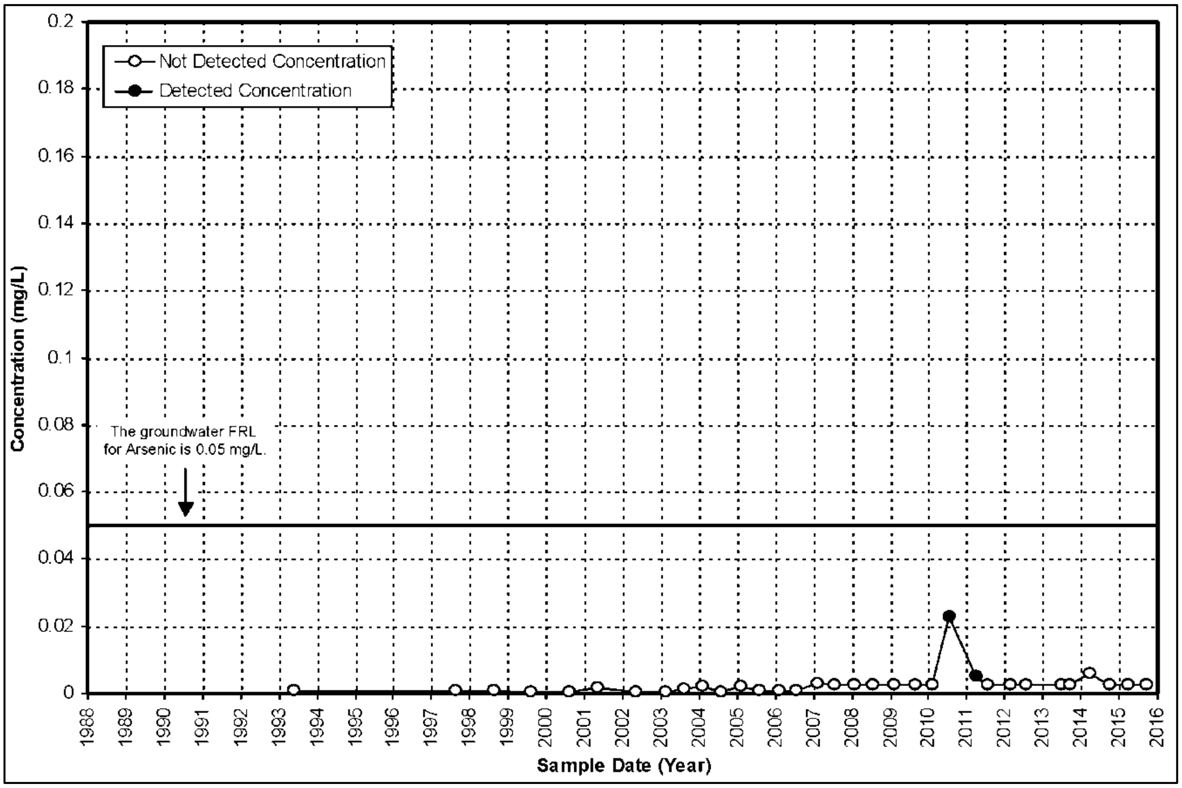


Figure A.4-13. Arsenic Concentration Versus Time Plot for Monitoring Well 2093

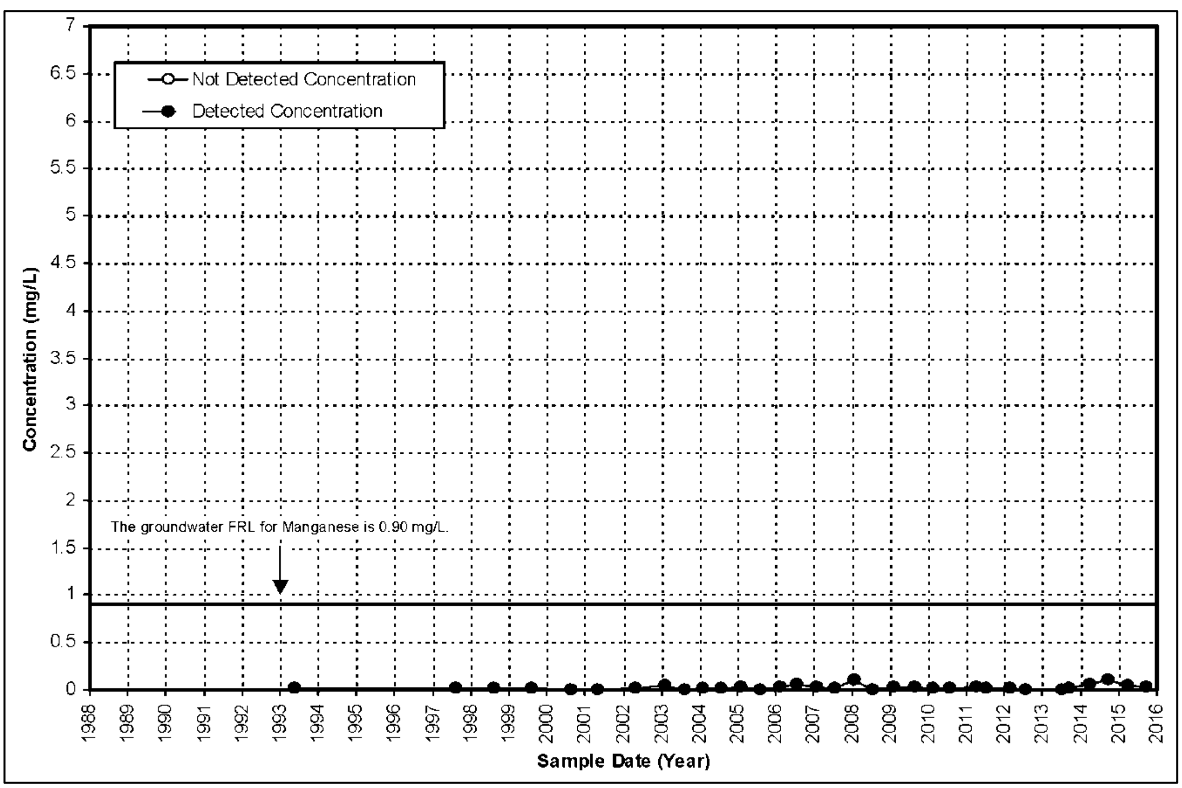


Figure A.4-14. Manganese Concentration Versus Time Plot for Monitoring Well 2093

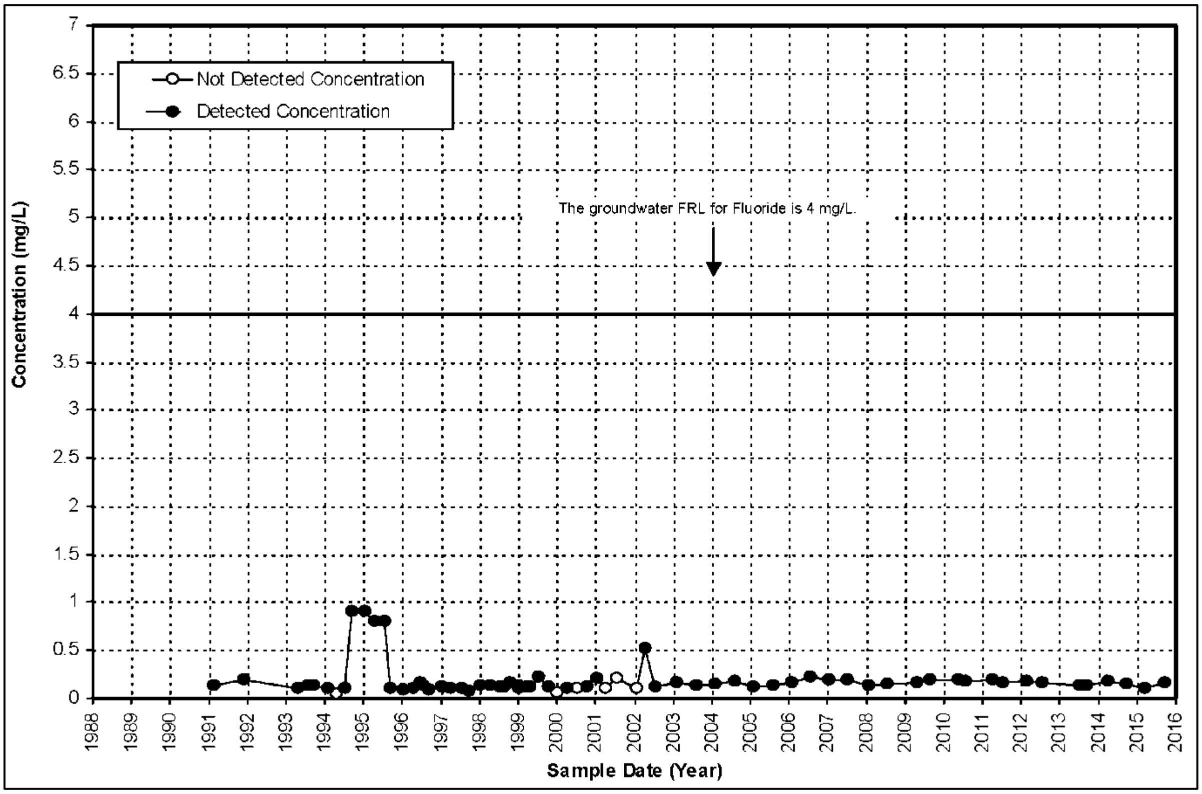


Figure A.4-15. Fluoride Concentration Versus Time Plot for Monitoring Well 2398

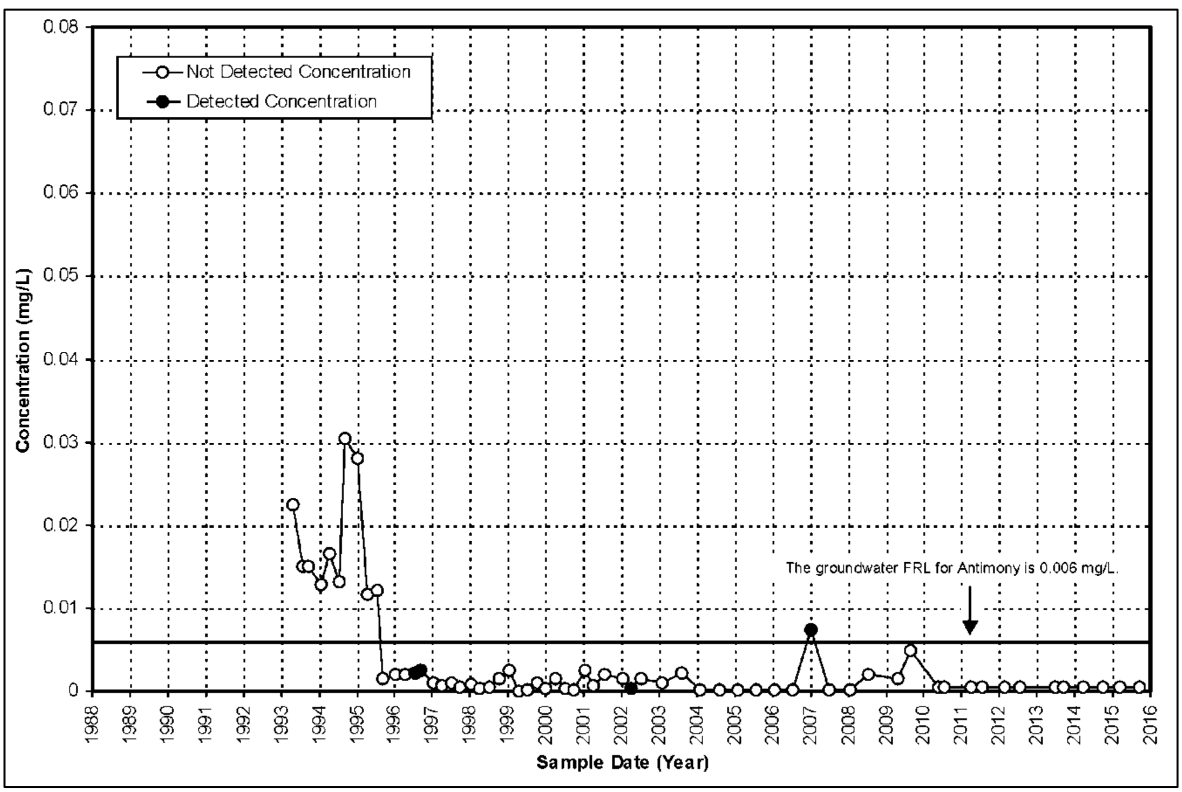


Figure A.4-16. Antimony Concentration Versus Time Plot for Monitoring Well 2398

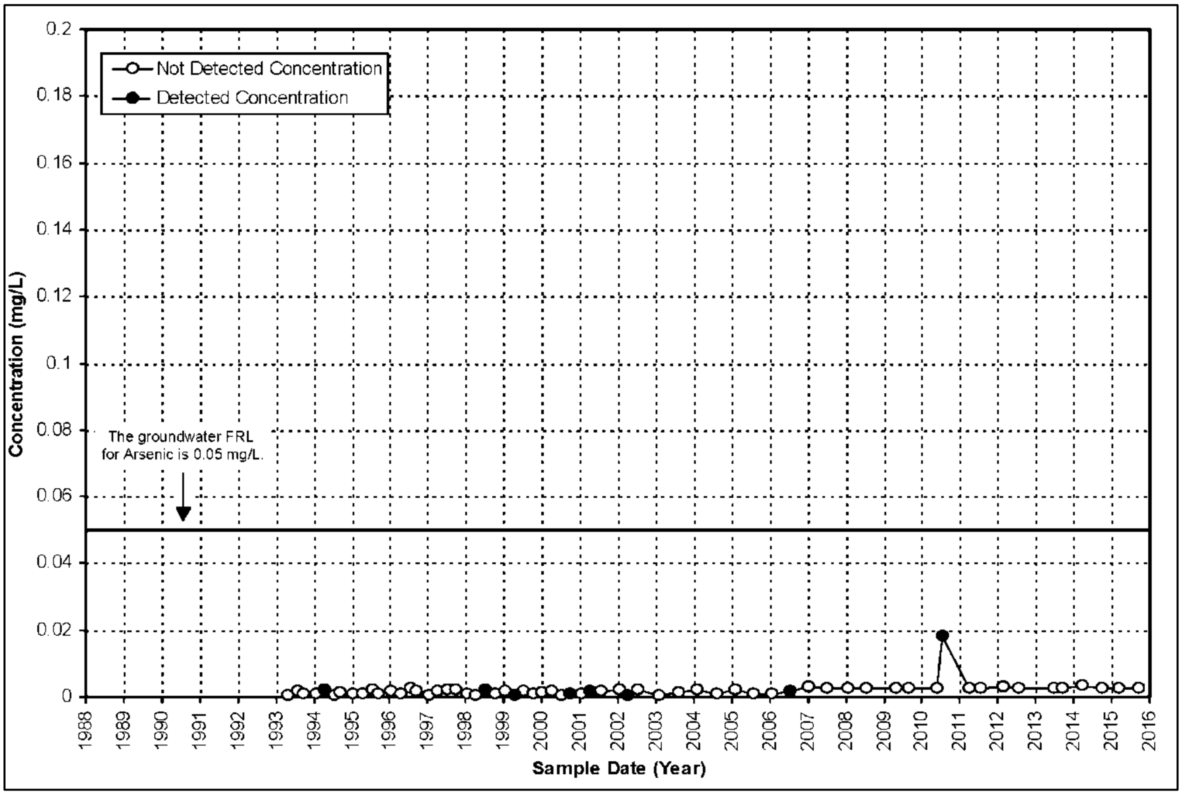


Figure A.4-17. Arsenic Concentration Versus Time Plot for Monitoring Well 2398

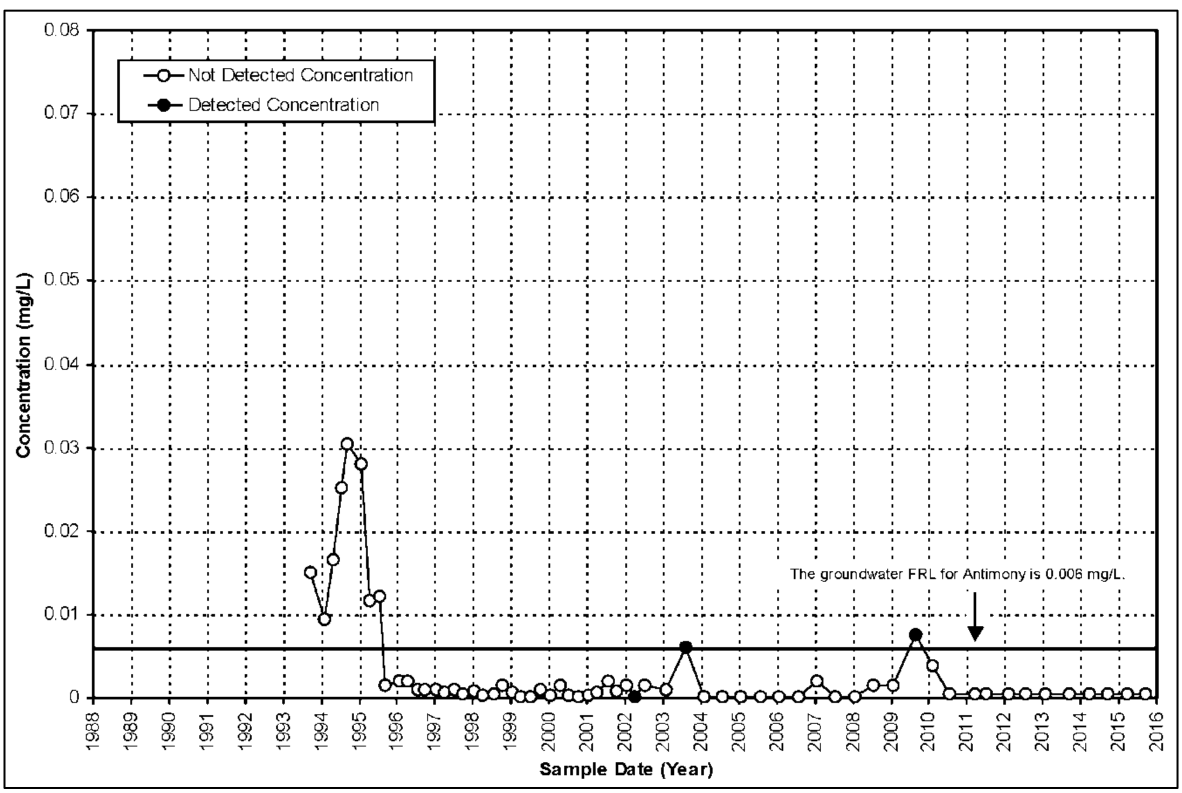


Figure A.4-18. Antimony Concentration Versus Time Plot for Monitoring Well 2431

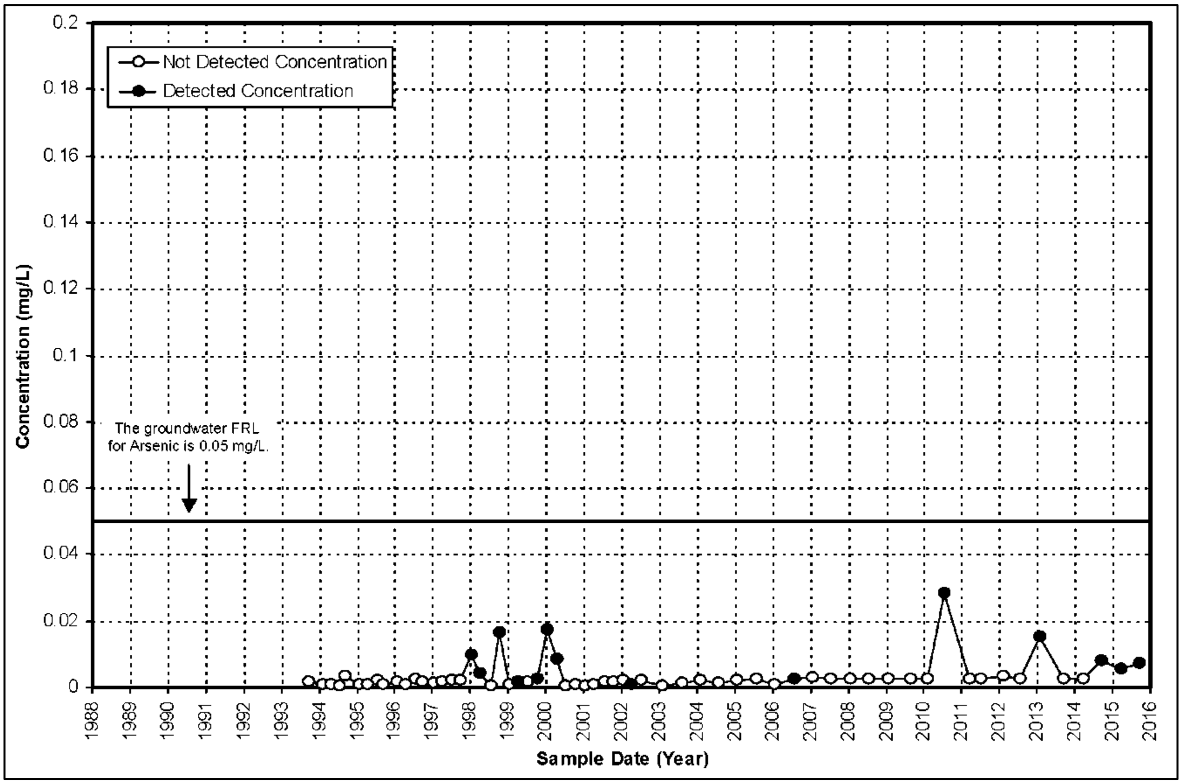


Figure A.4-19. Arsenic Concentration Versus Time Plot for Monitoring Well 2431

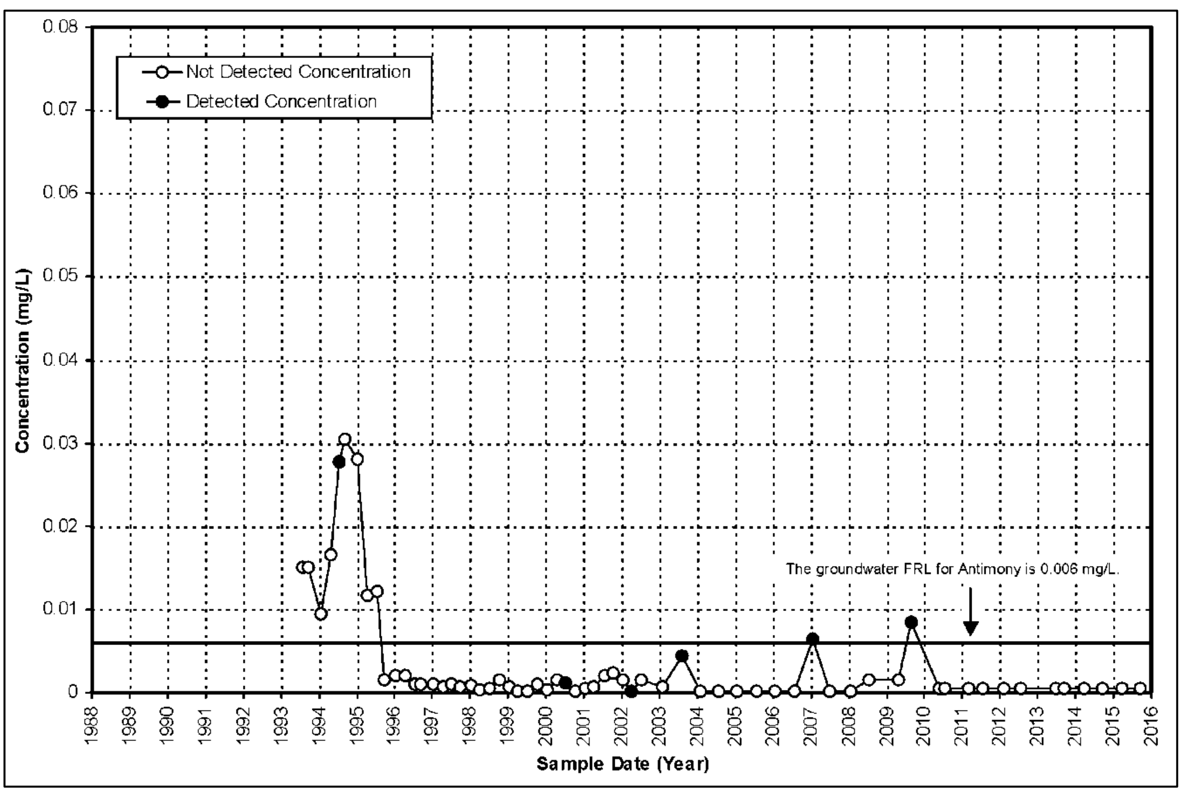


Figure A.4-20. Antimony Concentration Versus Time Plot for Monitoring Well 2432

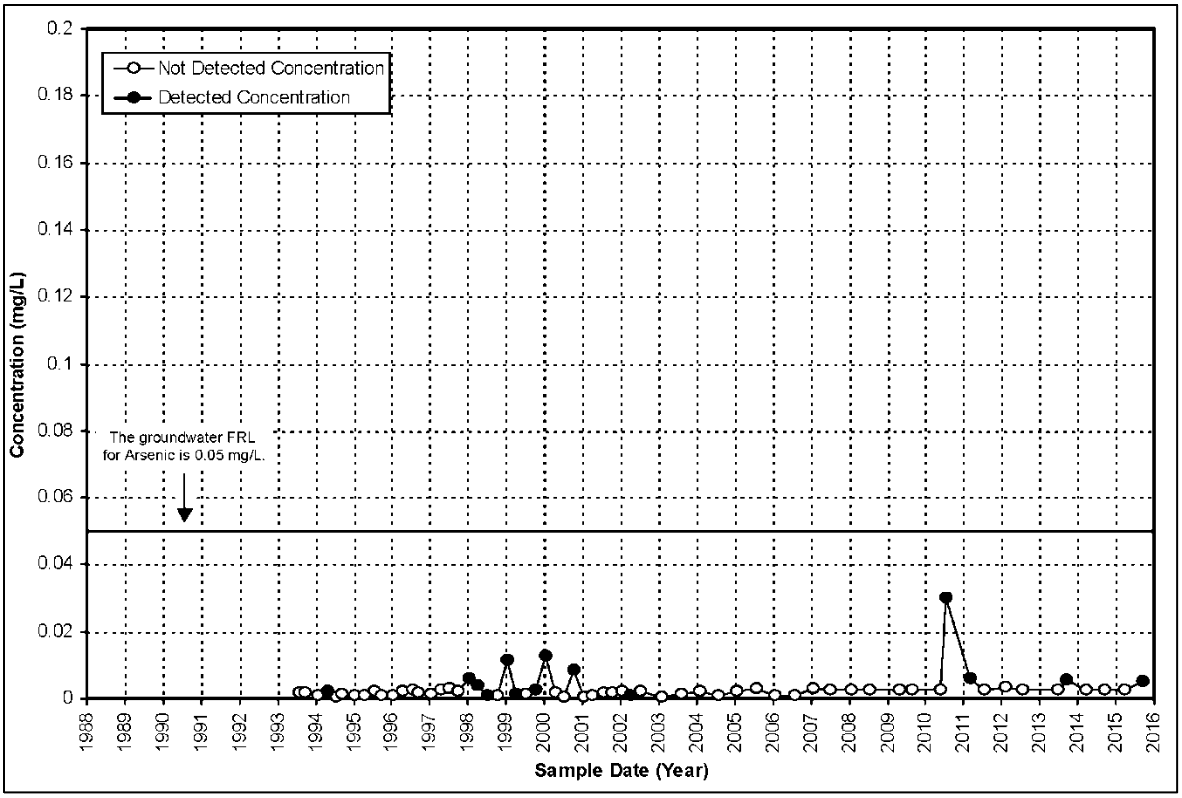


Figure A.4-21. Arsenic Concentration Versus Time Plot for Monitoring Well 2432

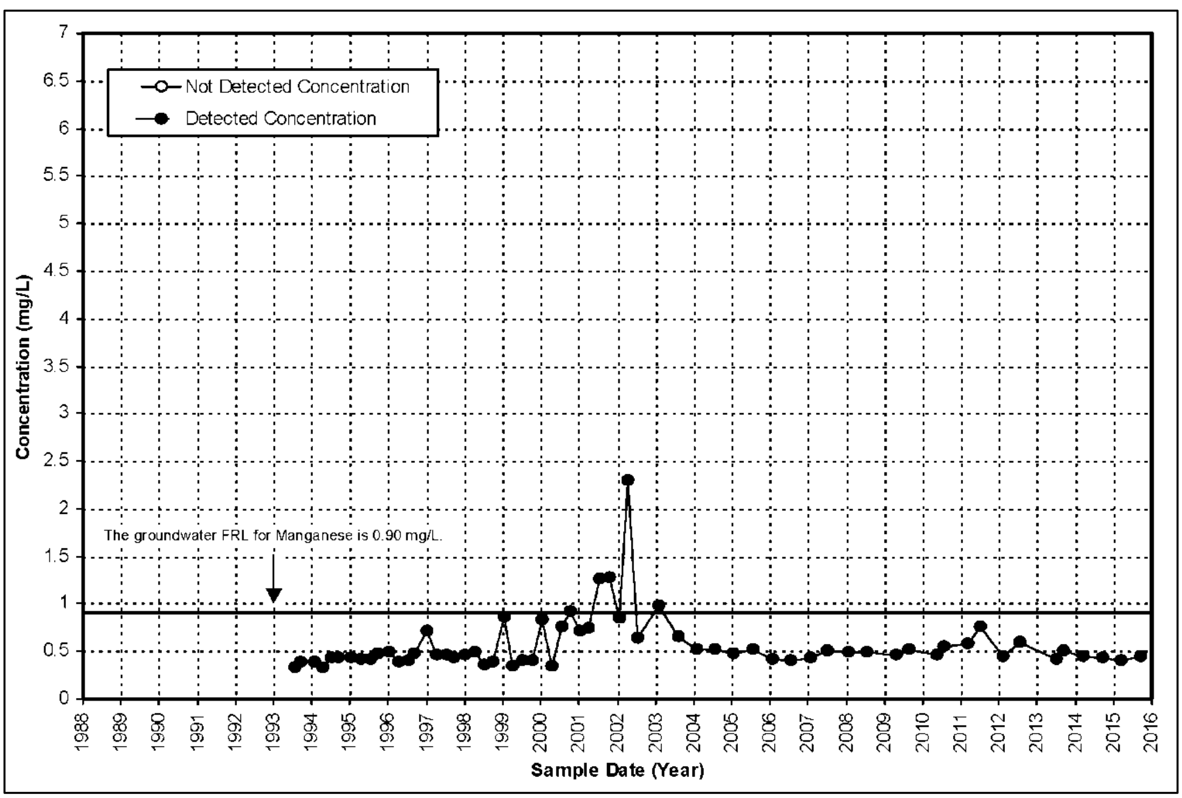


Figure A.4-22. Manganese Concentration Versus Time Plot for Monitoring Well 2432

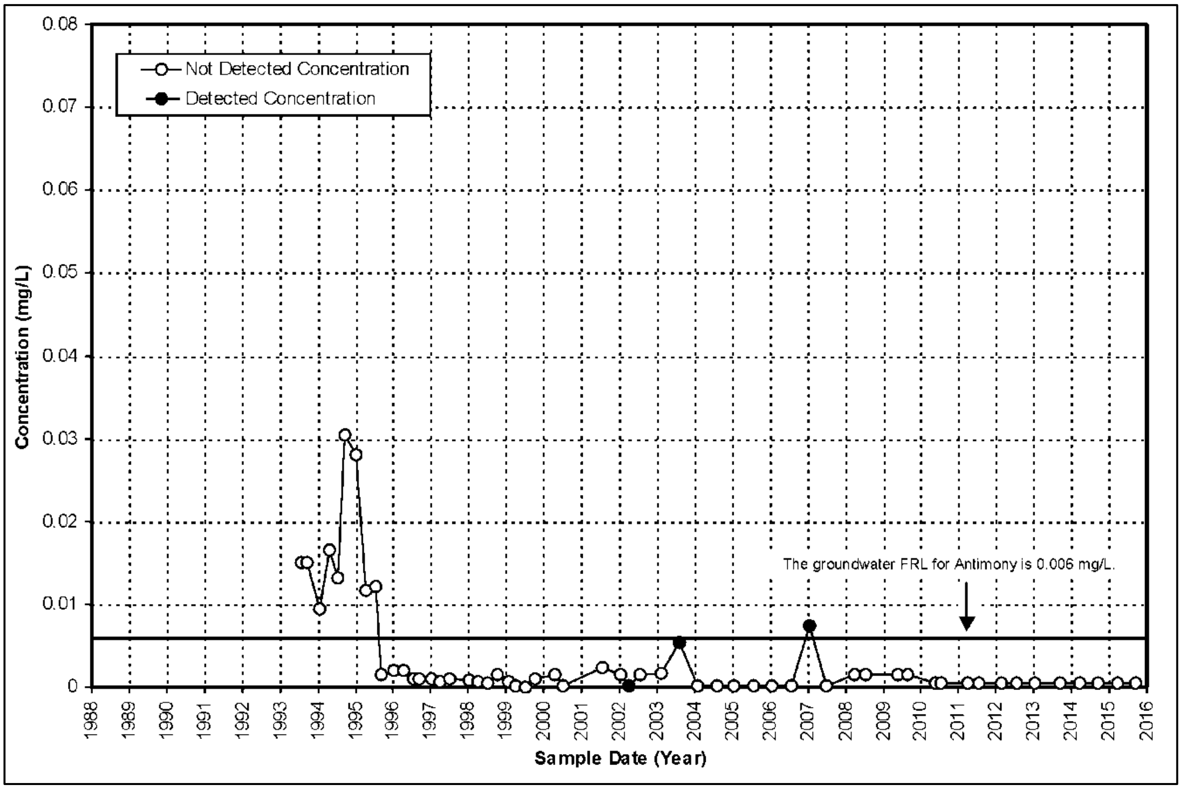


Figure A.4-23. Antimony Concentration Versus Time Plot for Monitoring Well 2733

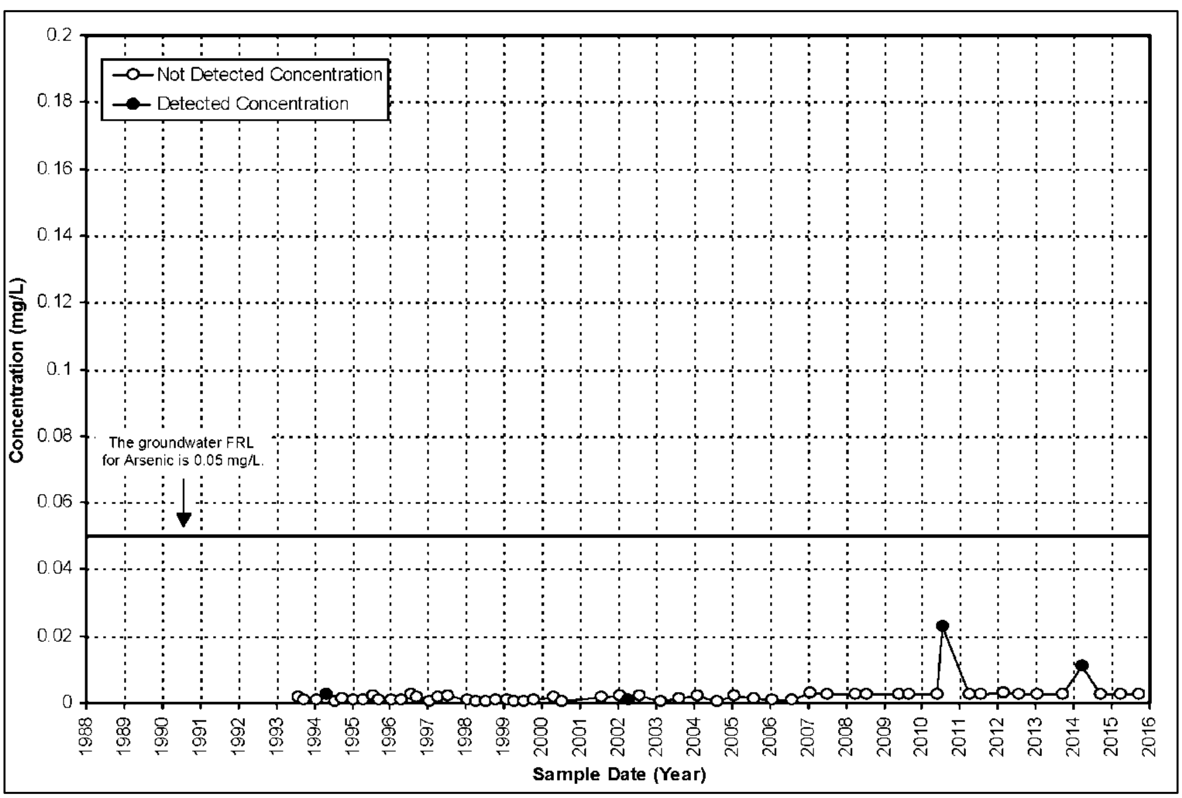


Figure A.4-24. Arsenic Concentration Versus Time Plot for Monitoring Well 2733

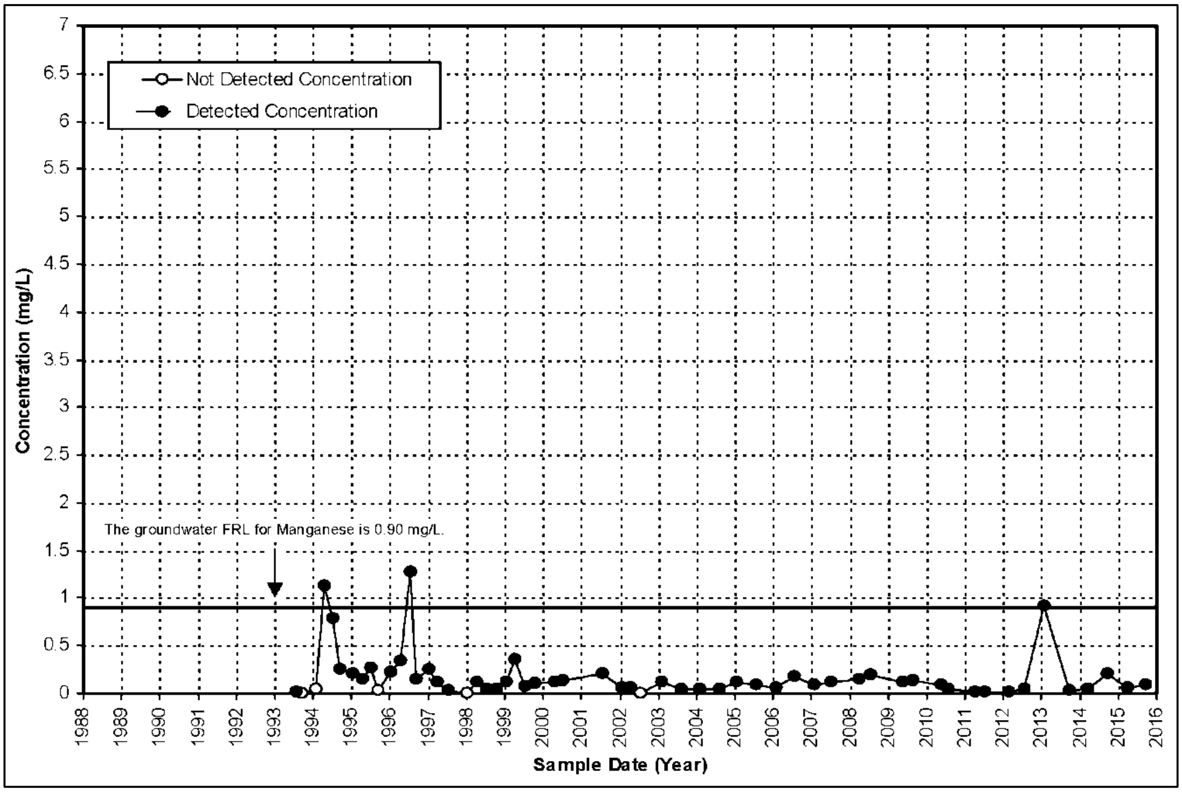


Figure A.4-25. Manganese Concentration Versus Time Plot for Monitoring Well 2733

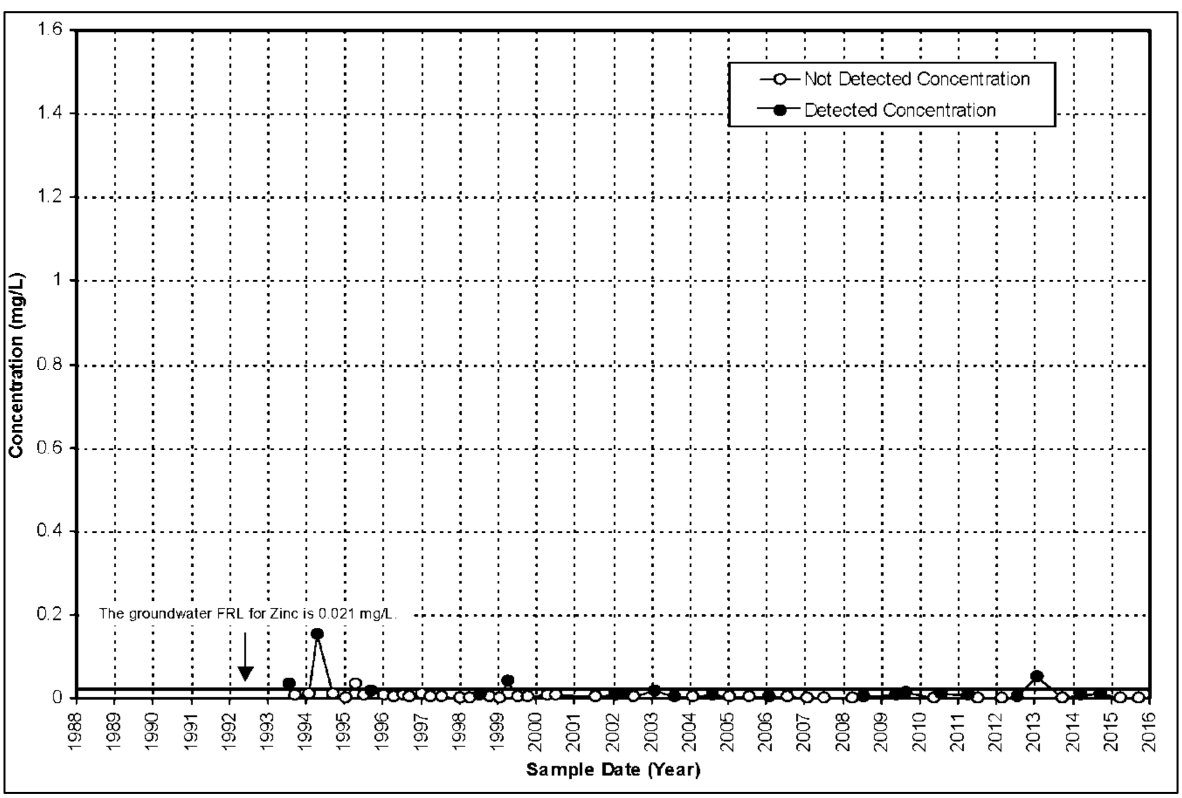


Figure A.4-26. Zinc Concentration Versus Time Plot for Monitoring Well 2733

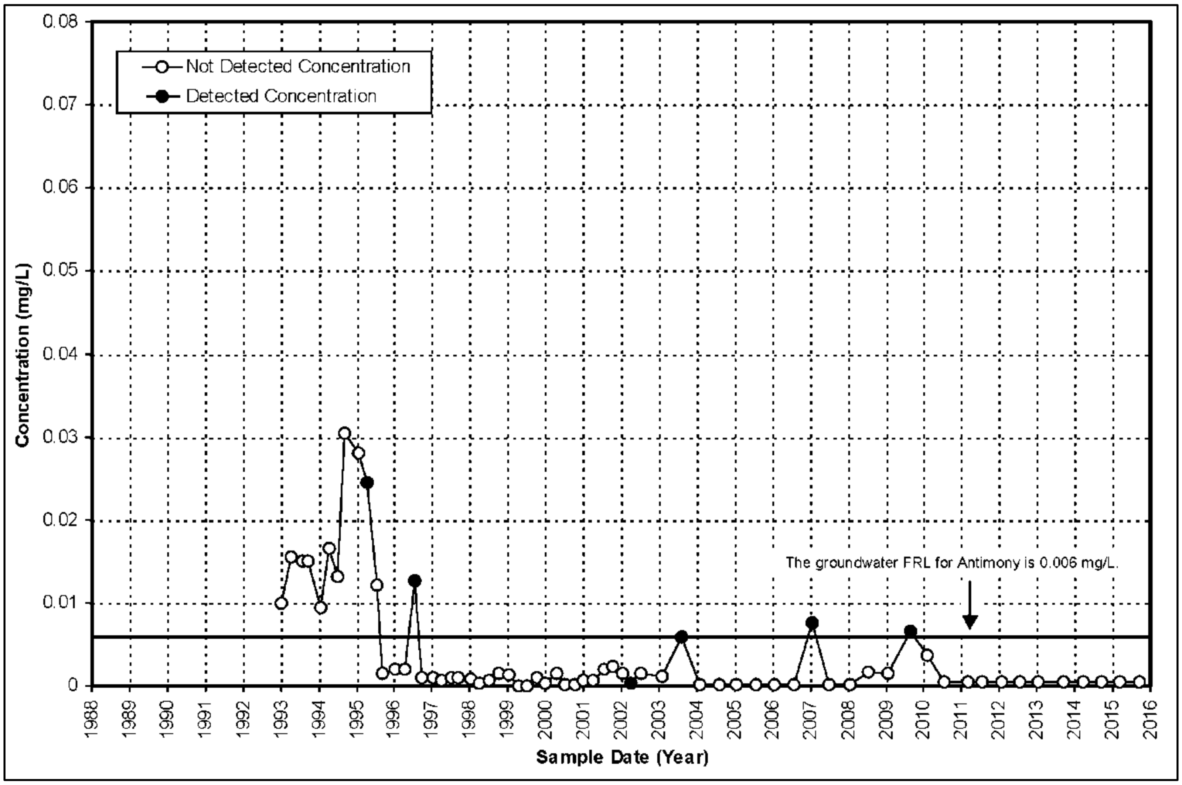


Figure A.4-27. Antimony Concentration Versus Time Plot for Monitoring Well 3070

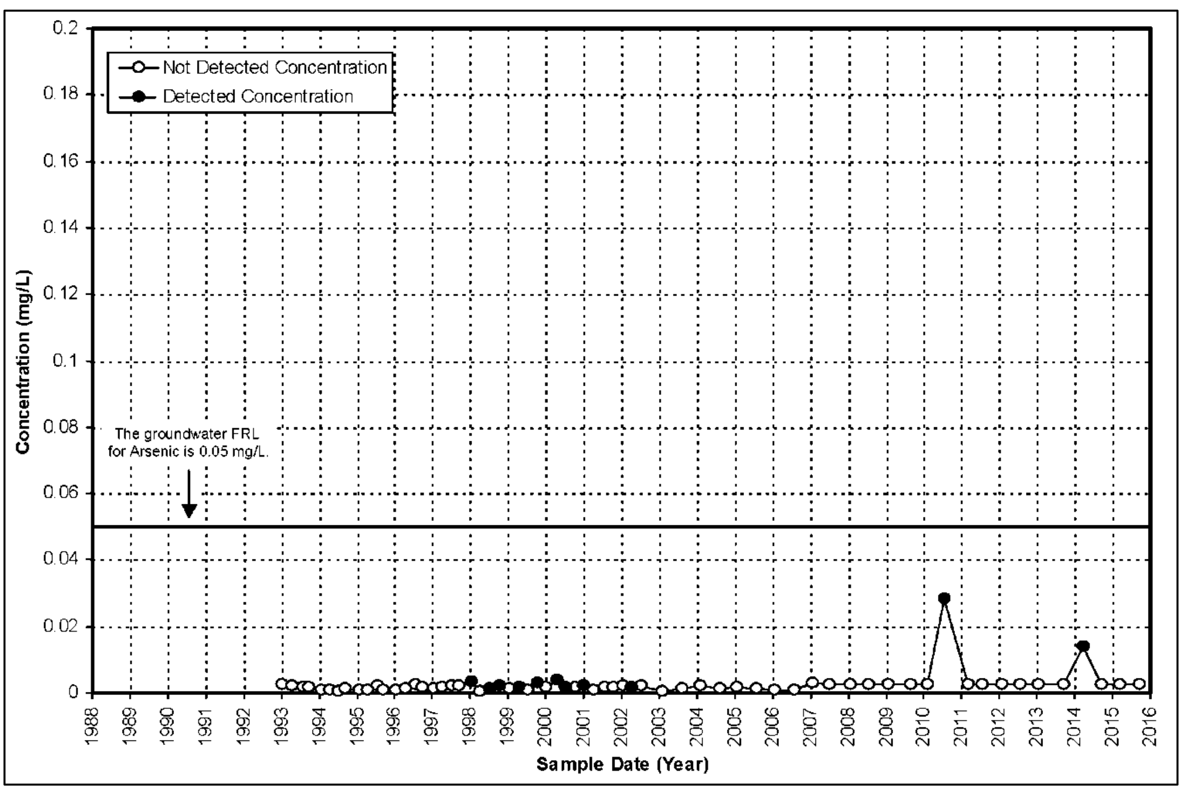


Figure A.4-28. Arsenic Concentration Versus Time Plot for Monitoring Well 3070

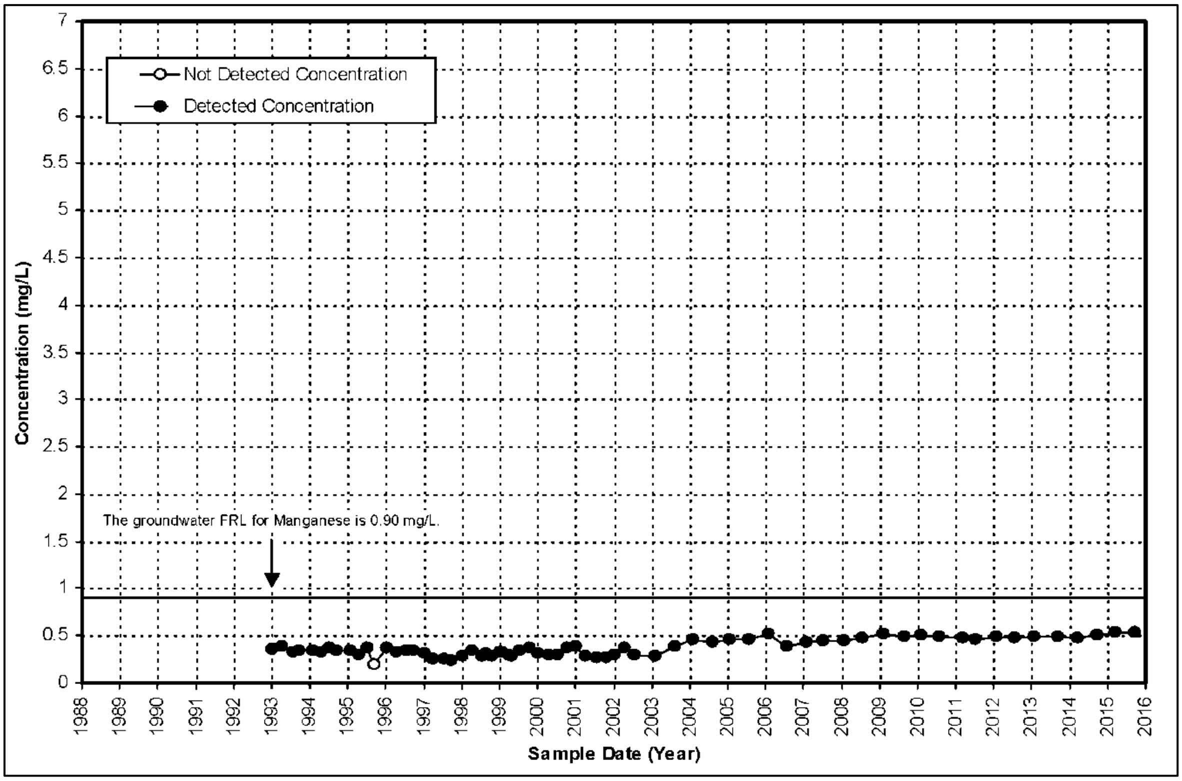


Figure A.4-29. Manganese Concentration Versus Time Plot for Monitoring Well 3070

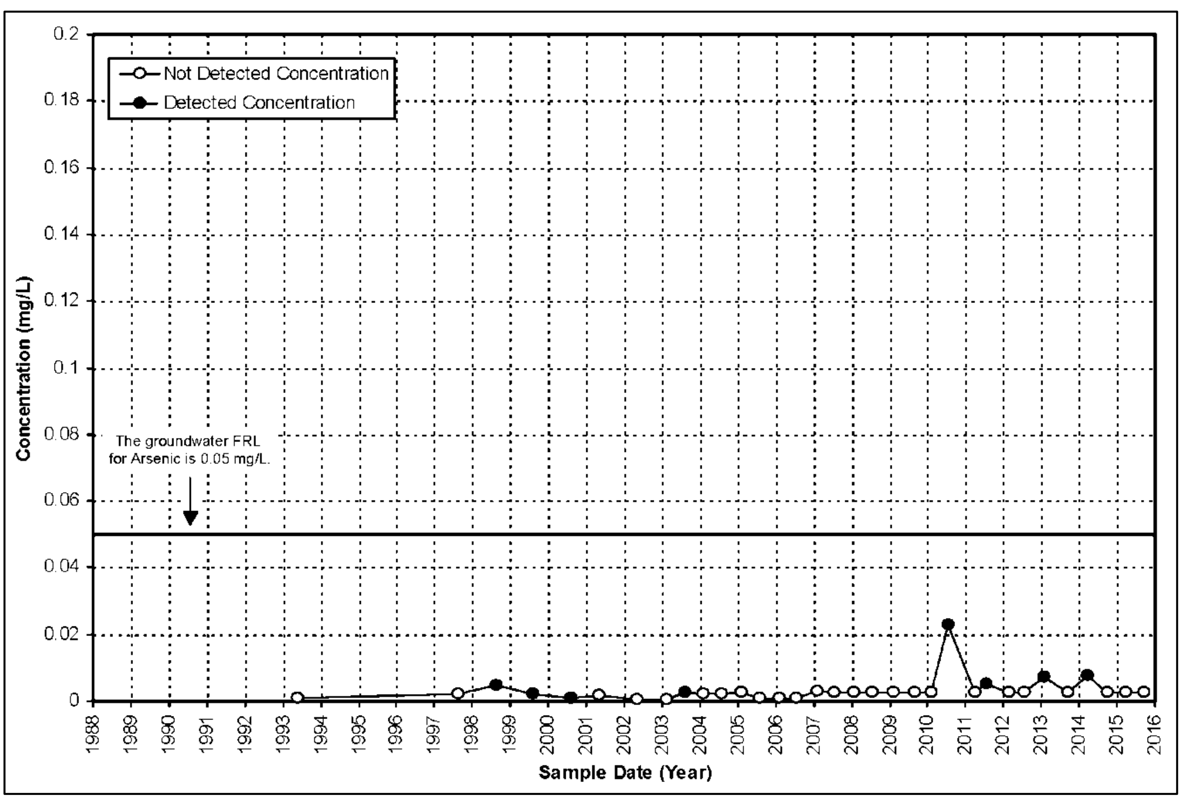


Figure A.4-30. Arsenic Concentration Versus Time Plot for Monitoring Well 3093

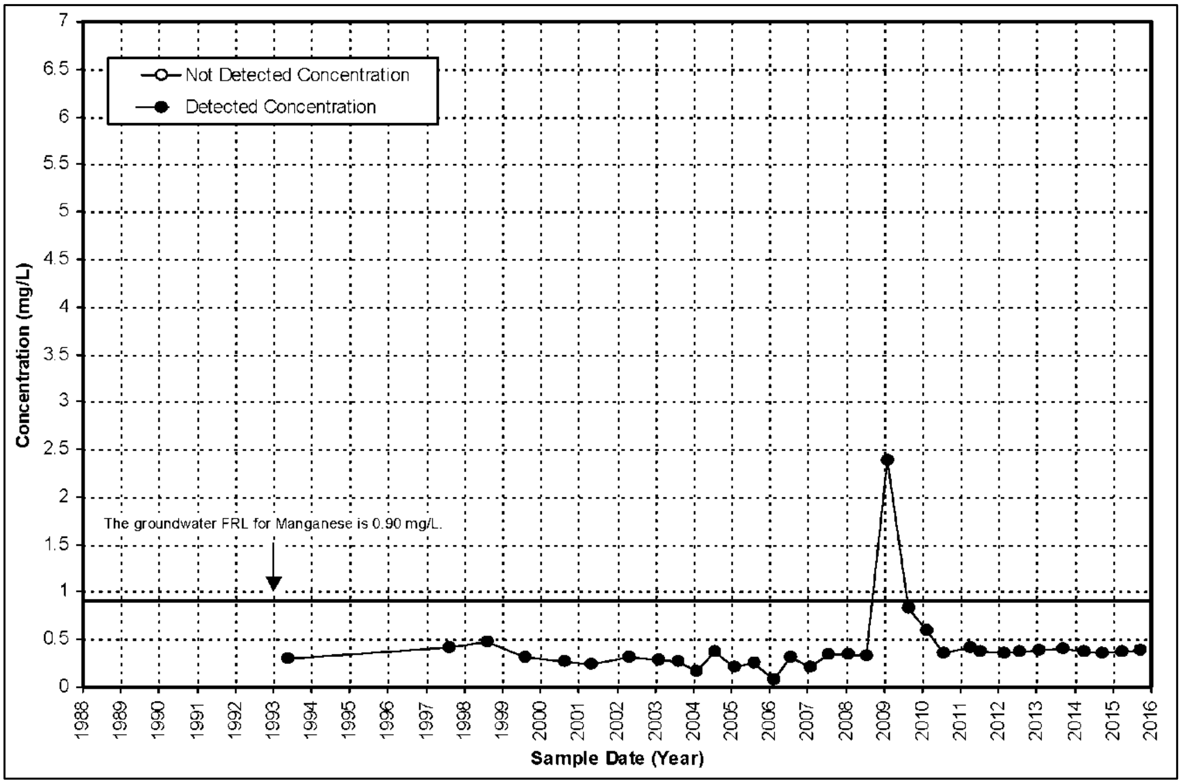


Figure A.4-31. Manganese Concentration Versus Time Plot for Monitoring Well 3093

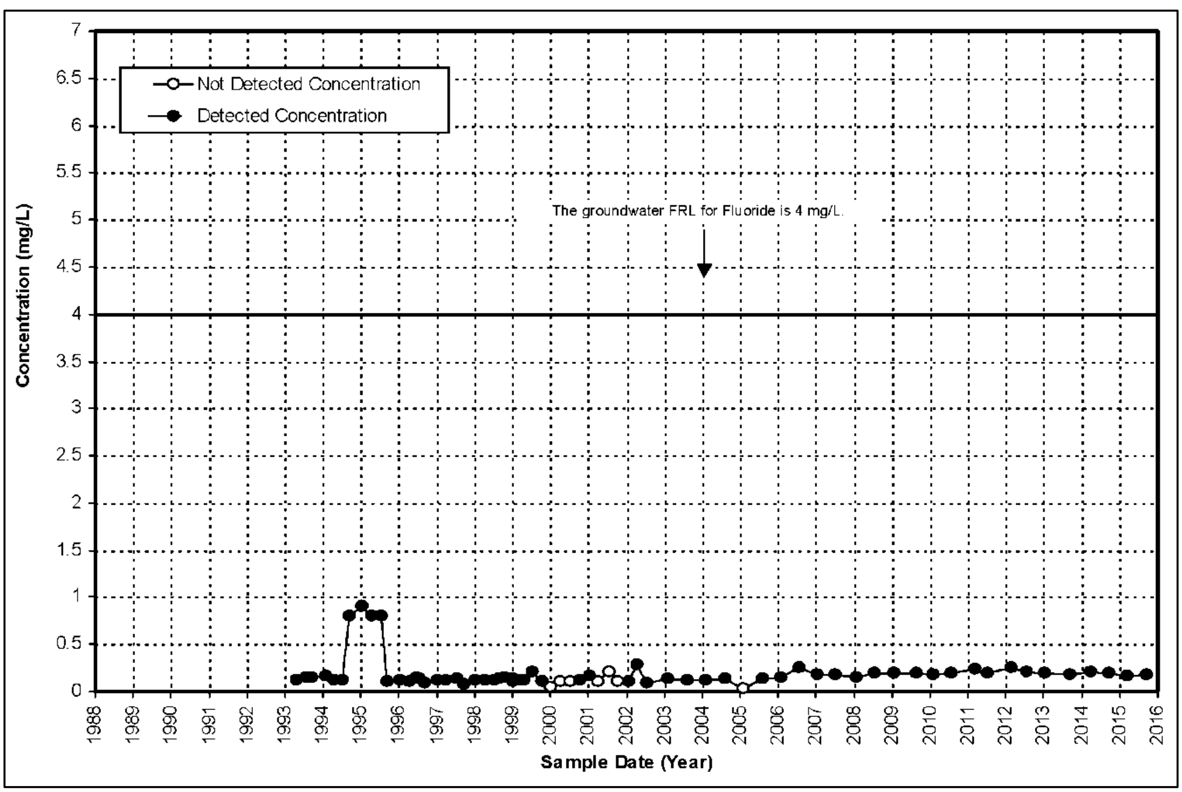


Figure A.4-32. Fluoride Concentration Versus Time Plot for Monitoring Well 3398

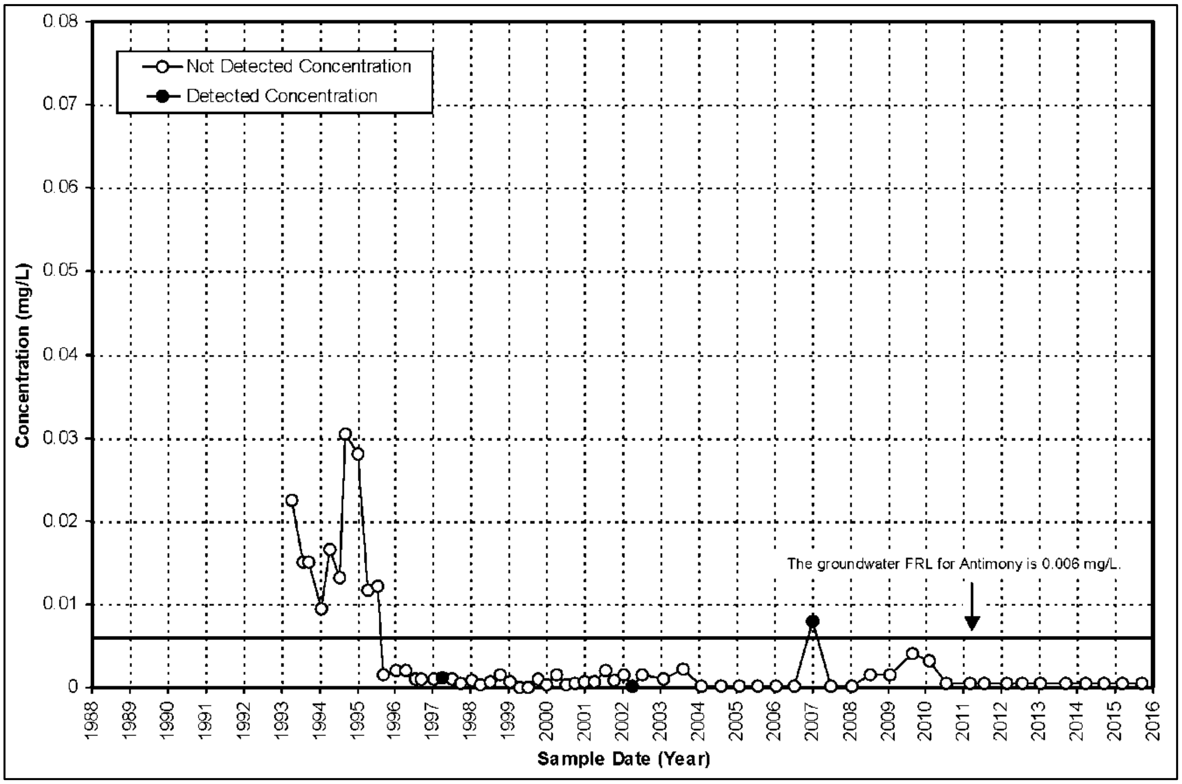


Figure A.4-33. Antimony Concentration Versus Time Plot for Monitoring Well 3398

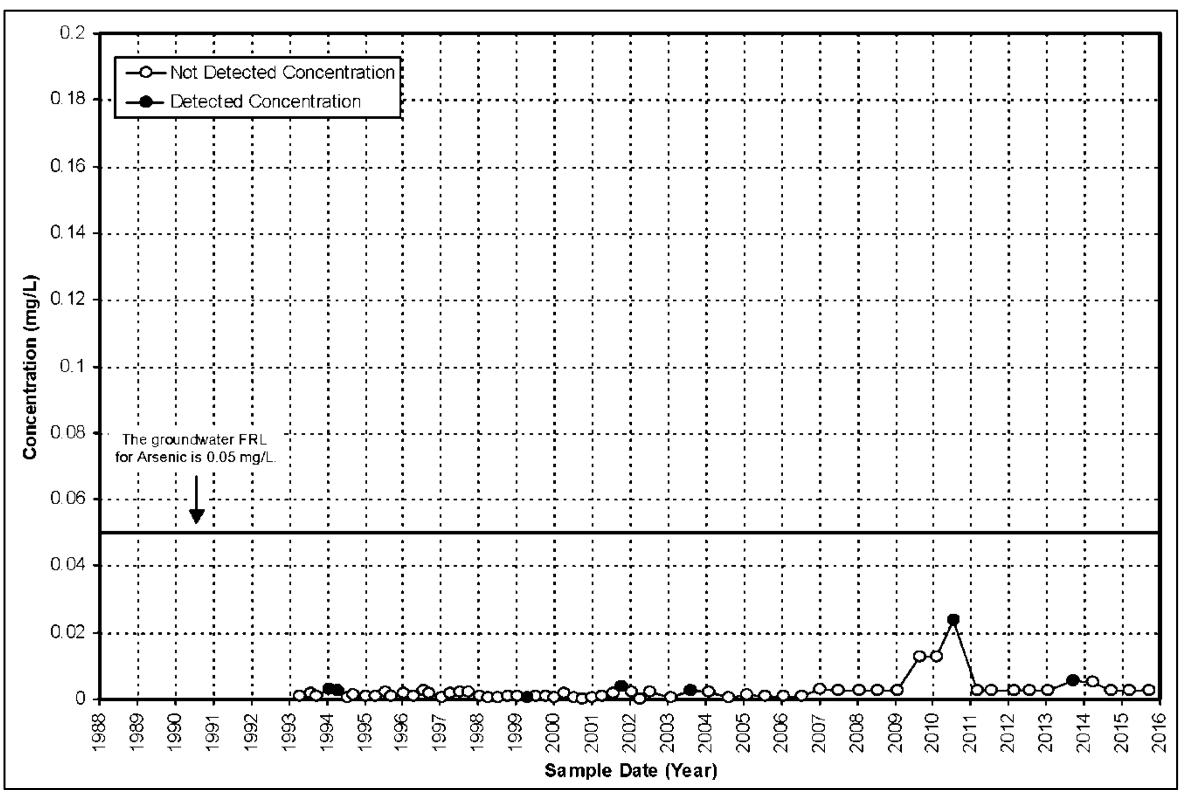


Figure A.4-34. Arsenic Concentration Versus Time Plot for Monitoring Well 3398

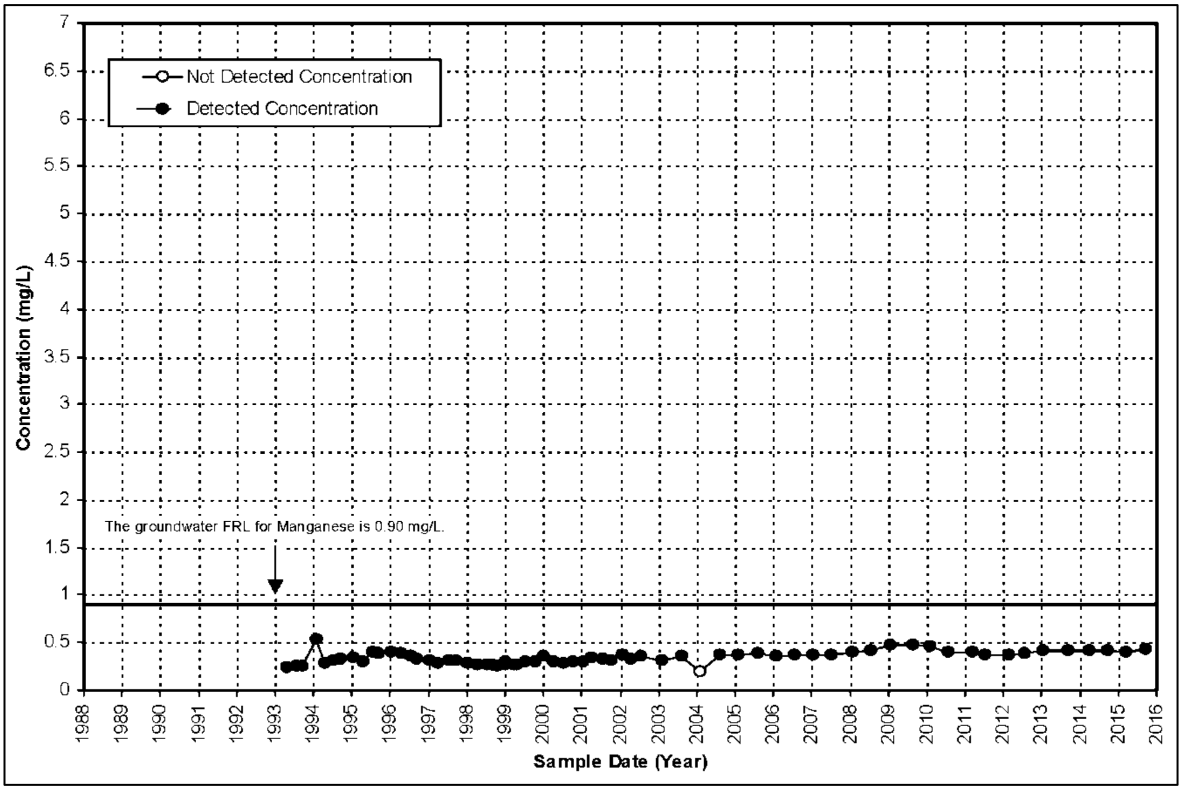


Figure A.4-35. Manganese Concentration Versus Time Plot for Monitoring Well 3398

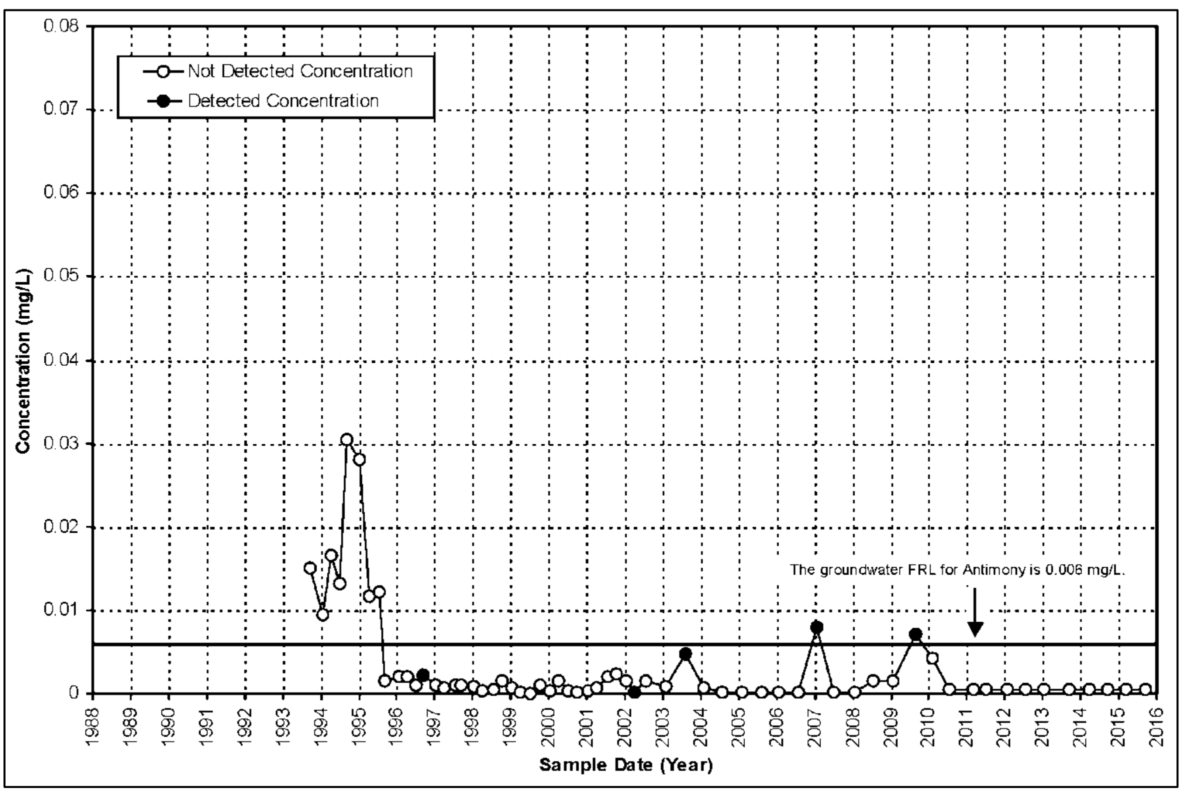


Figure A.4-36. Antimony Concentration Versus Time Plot for Monitoring Well 3424

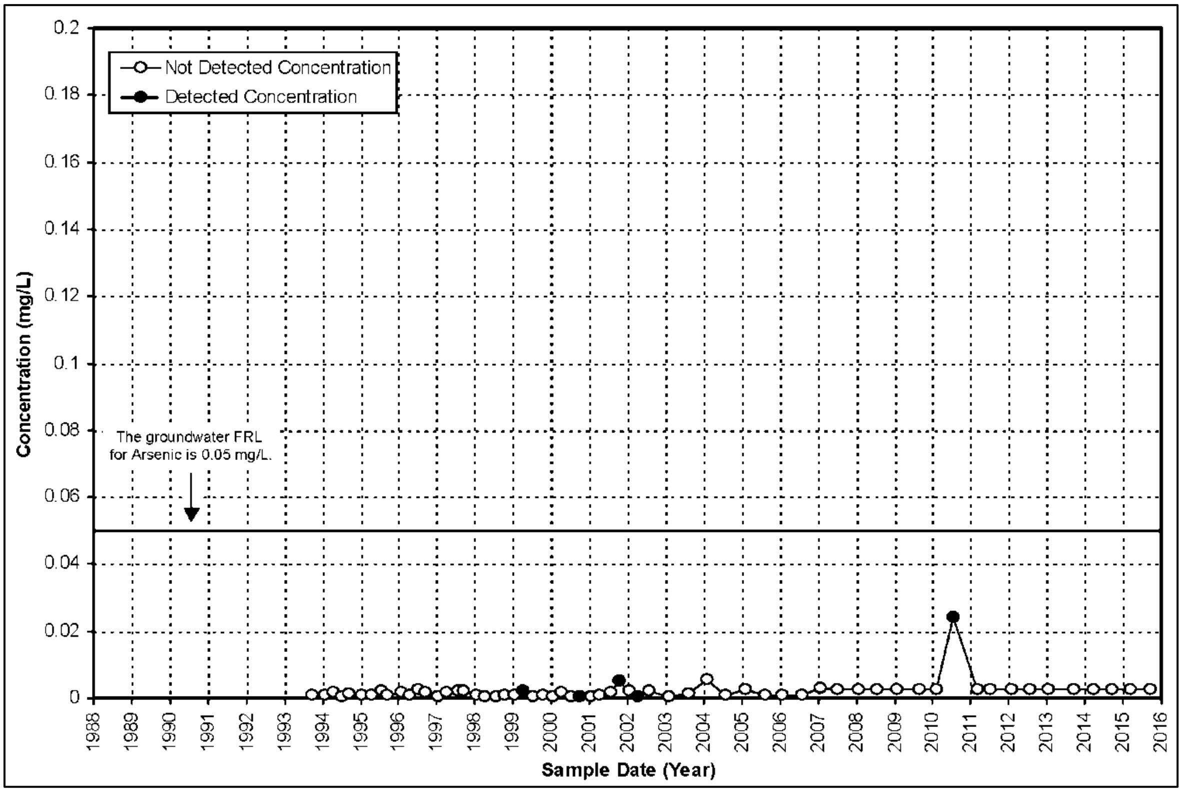


Figure A.4-37. Arsenic Concentration Versus Time Plot for Monitoring Well 3424

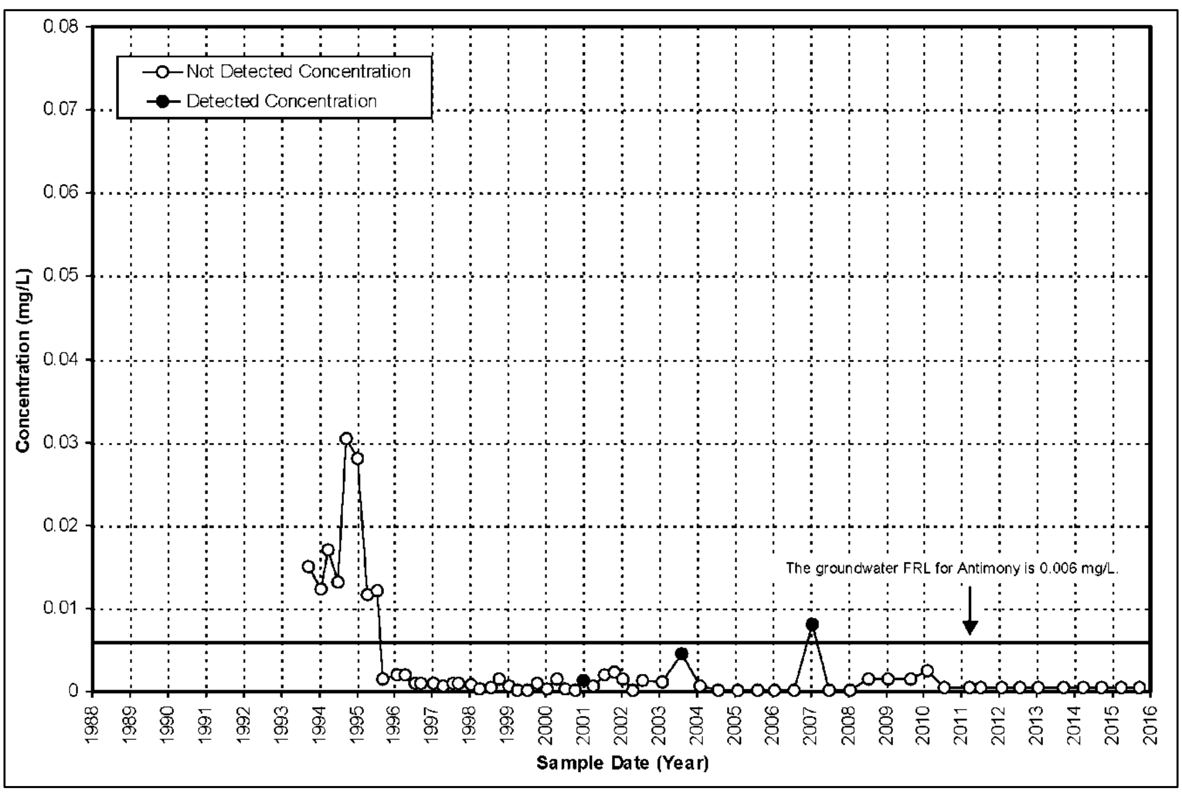


Figure A.4-38. Antimony Concentration Versus Time Plot for Monitoring Well 3426

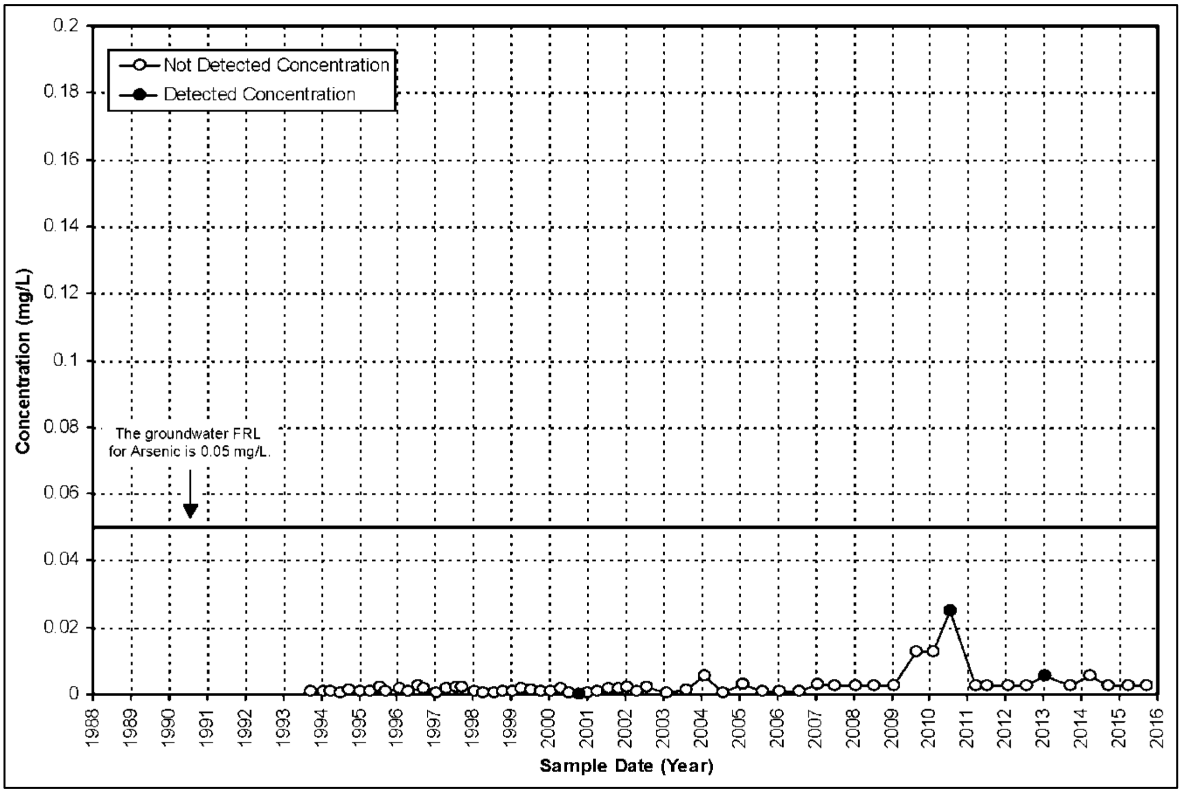


Figure A.4-39. Arsenic Concentration Versus Time Plot for Monitoring Well 3426

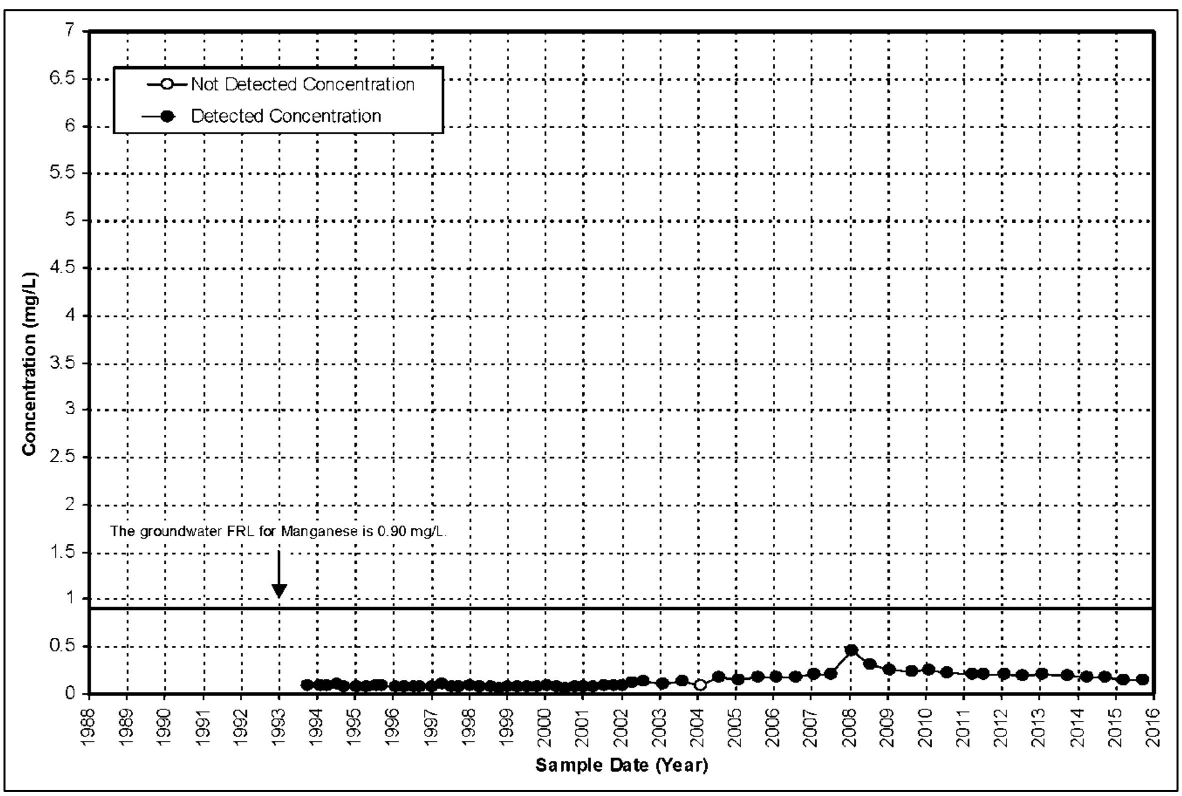


Figure A.4-40. Manganese Concentration Versus Time Plot for Monitoring Well 3426

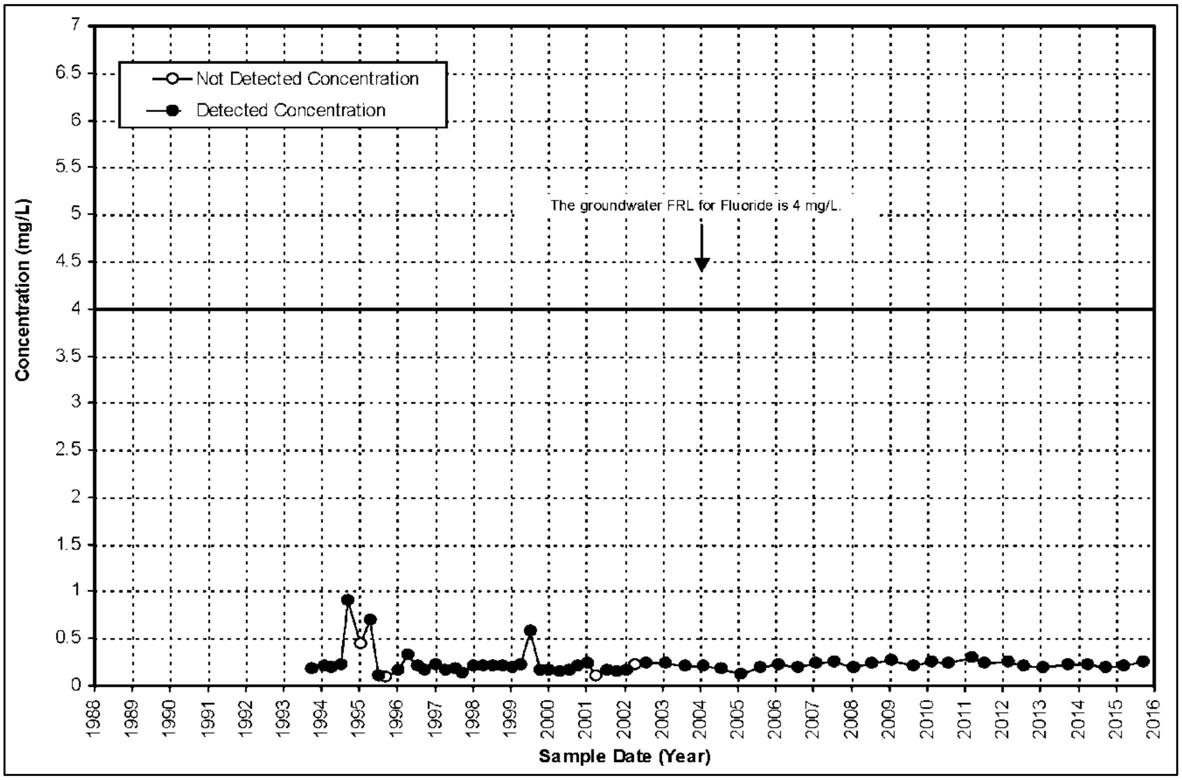


Figure A.4-41. Fluoride Concentration Versus Time Plot for Monitoring Well 3429

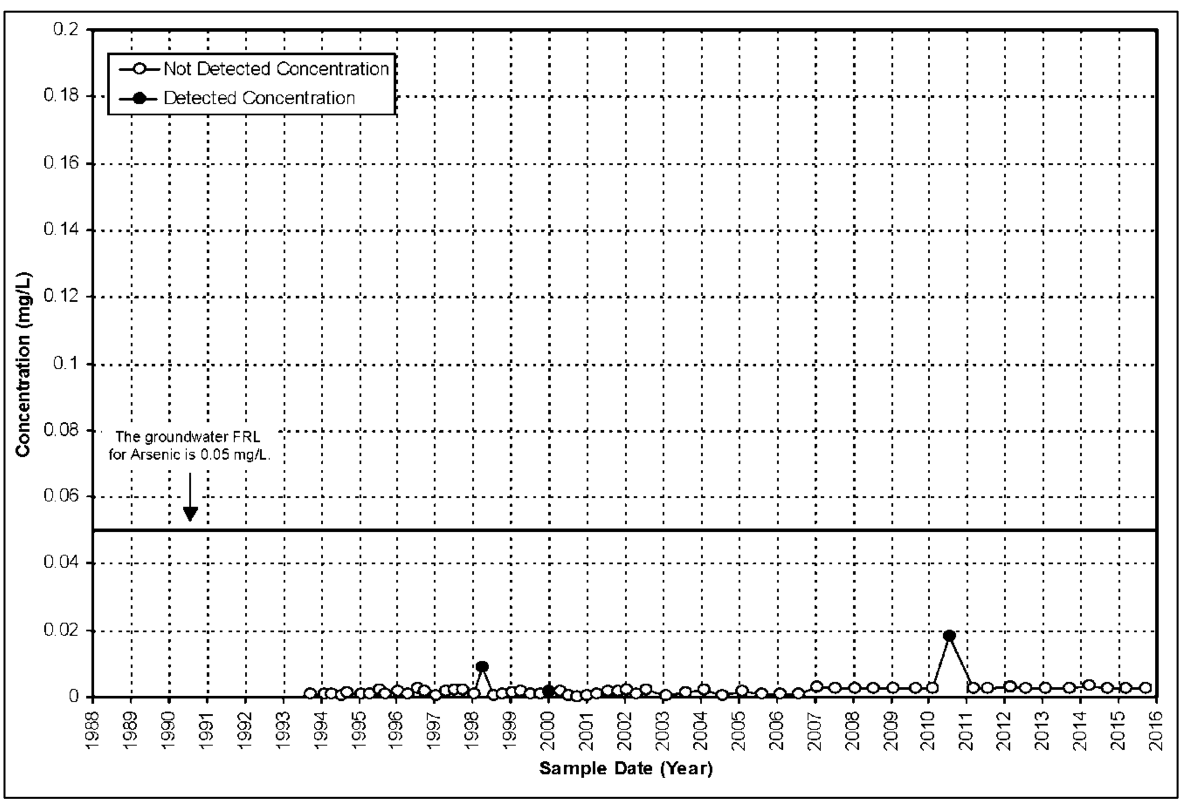


Figure A.4-42. Arsenic Concentration Versus Time Plot for Monitoring Well 3429

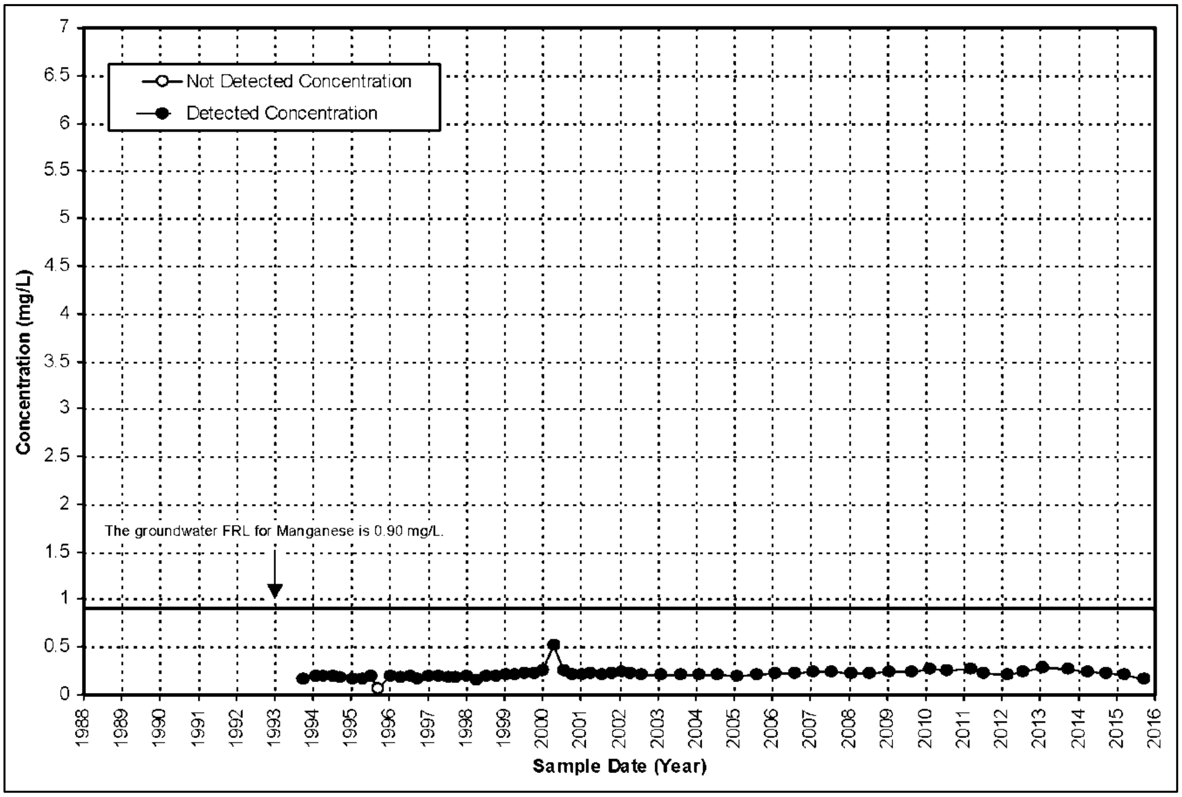


Figure A.4-43. Manganese Concentration Versus Time Plot for Monitoring Well 3429

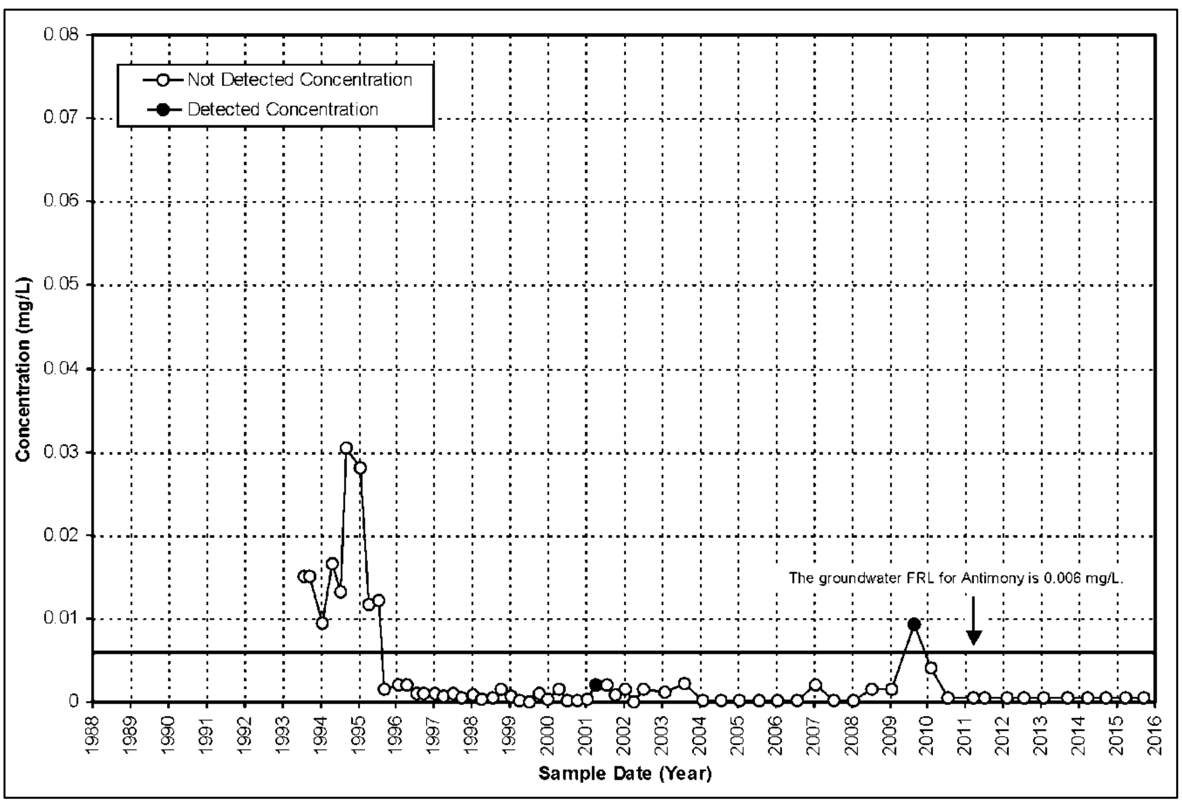


Figure A.4-44. Antimony Concentration Versus Time Plot for Monitoring Well 3431

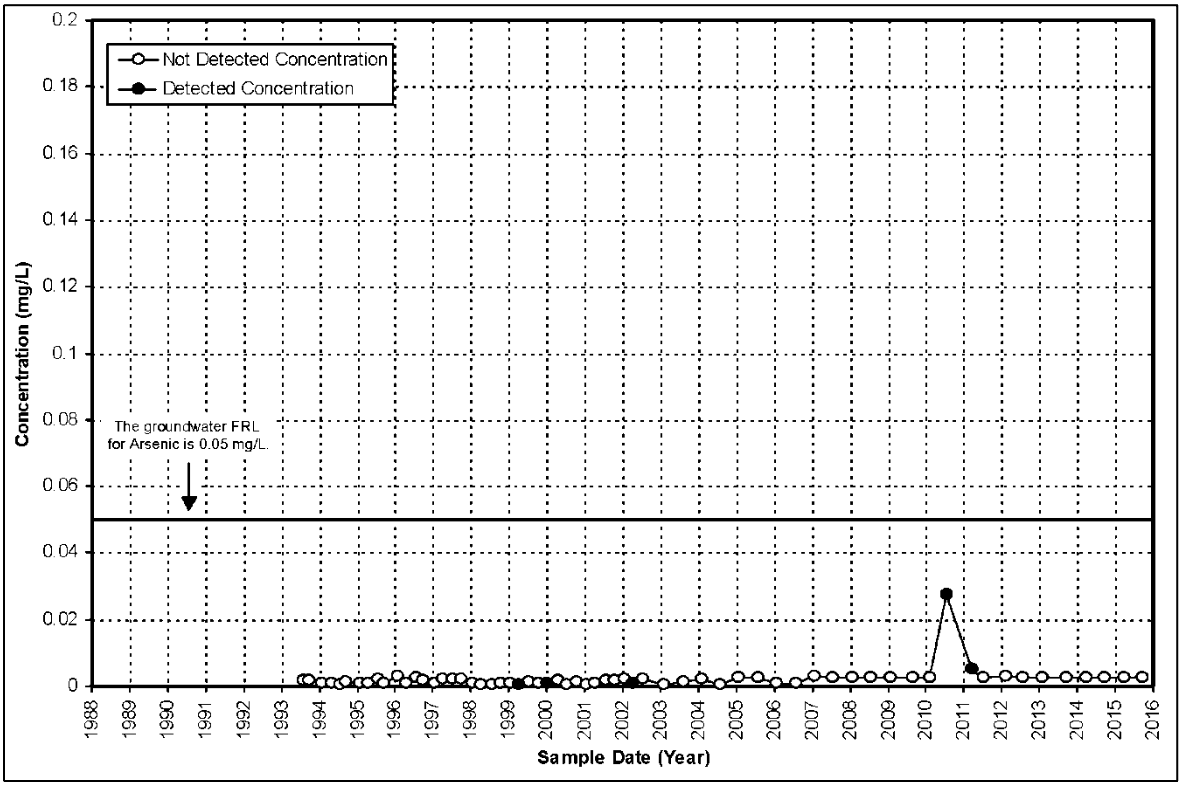


Figure A.4-45. Arsenic Concentration Versus Time Plot for Monitoring Well 3431

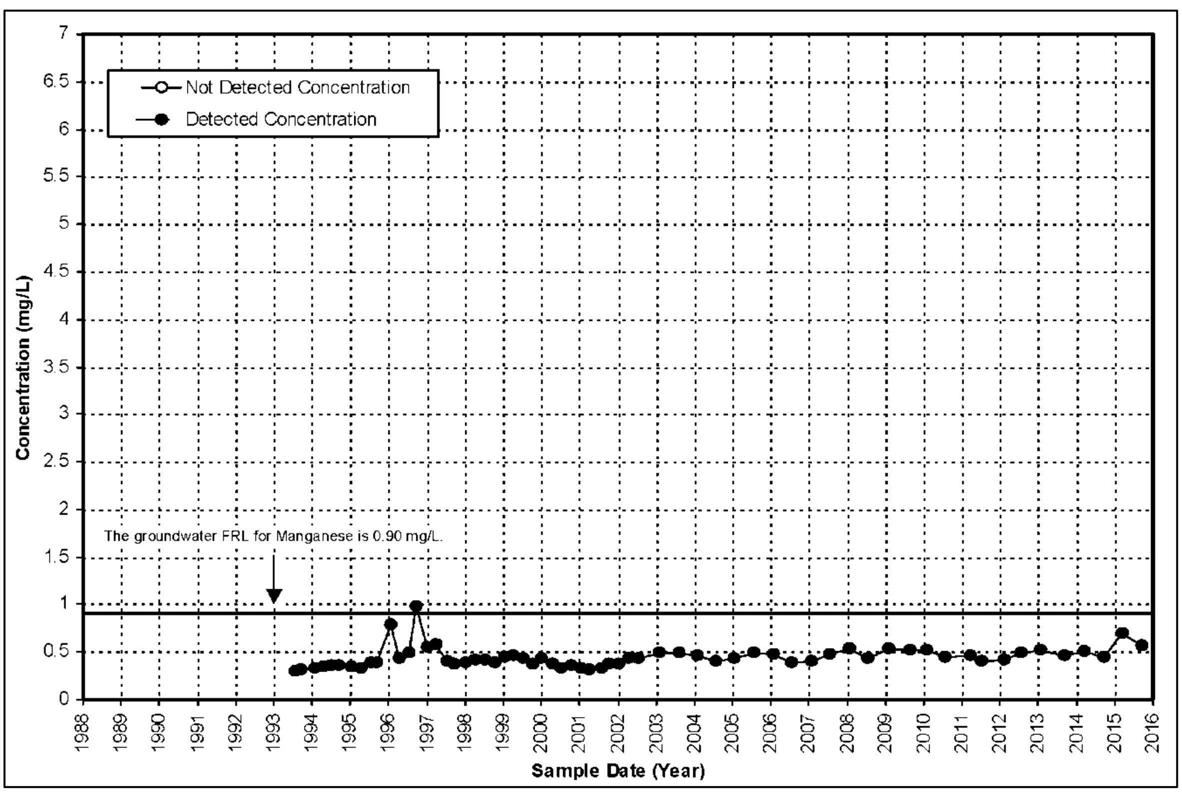


Figure A.4-46. Manganese Concentration Versus Time Plot for Monitoring Well 3431

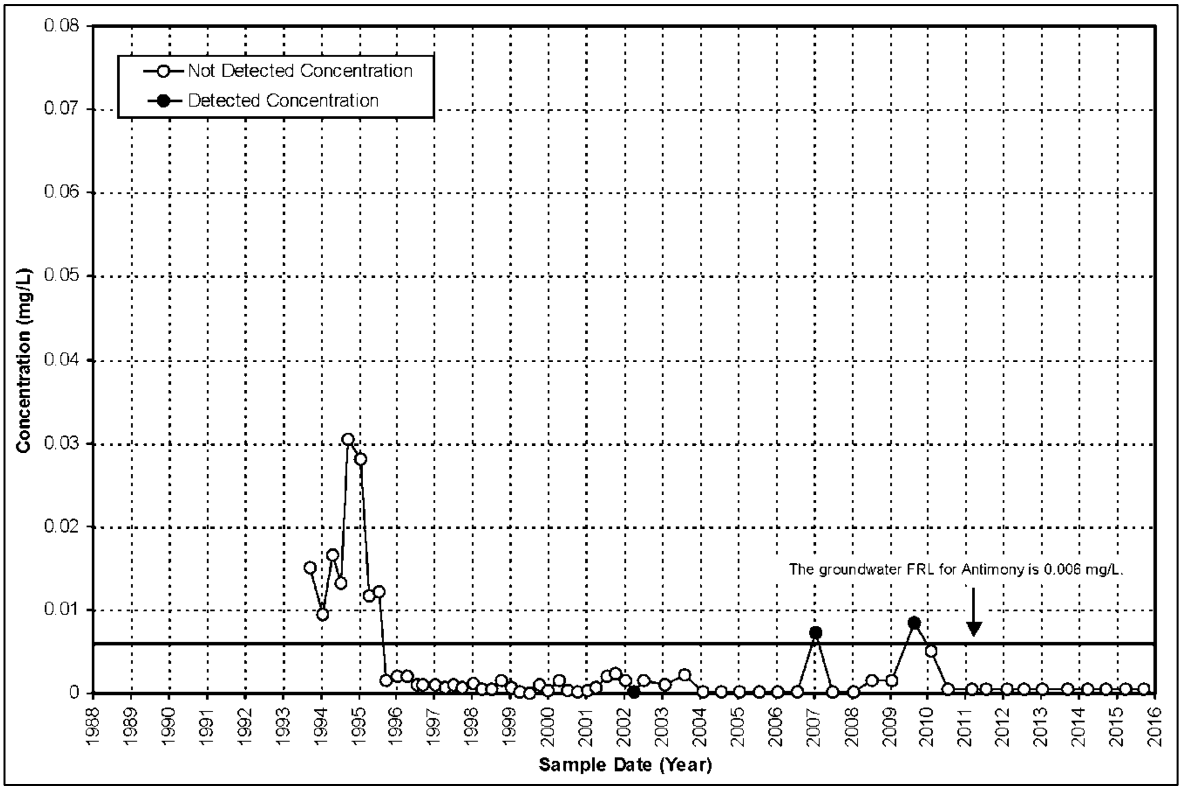


Figure A.4-47. Antimony Concentration Versus Time Plot for Monitoring Well 3432

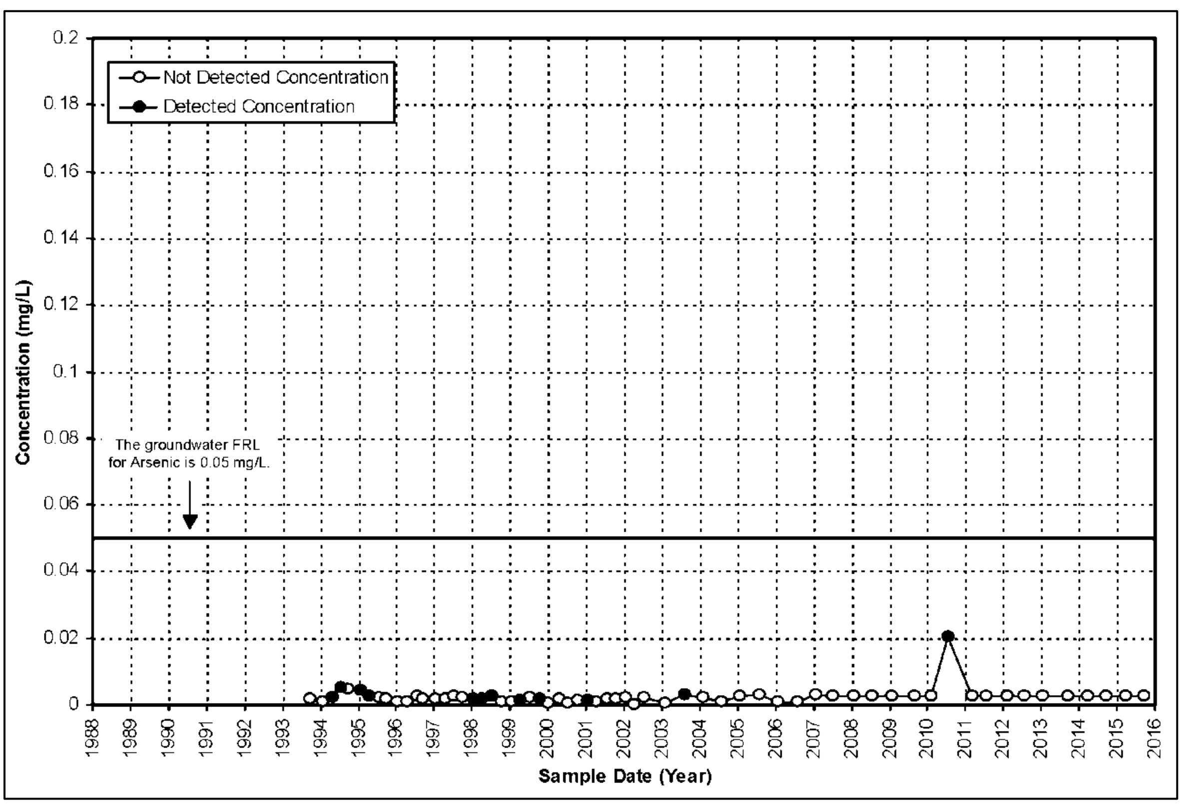


Figure A.4-48. Arsenic Concentration Versus Time Plot for Monitoring Well 3432

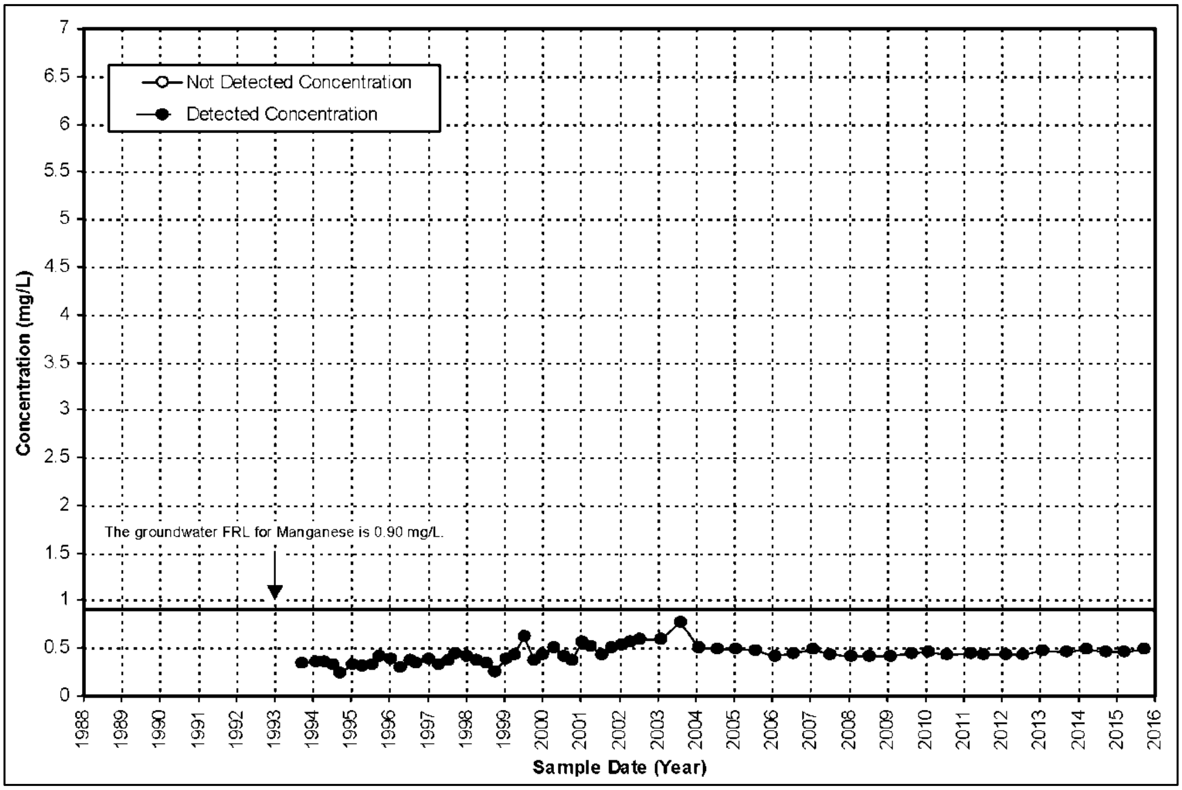
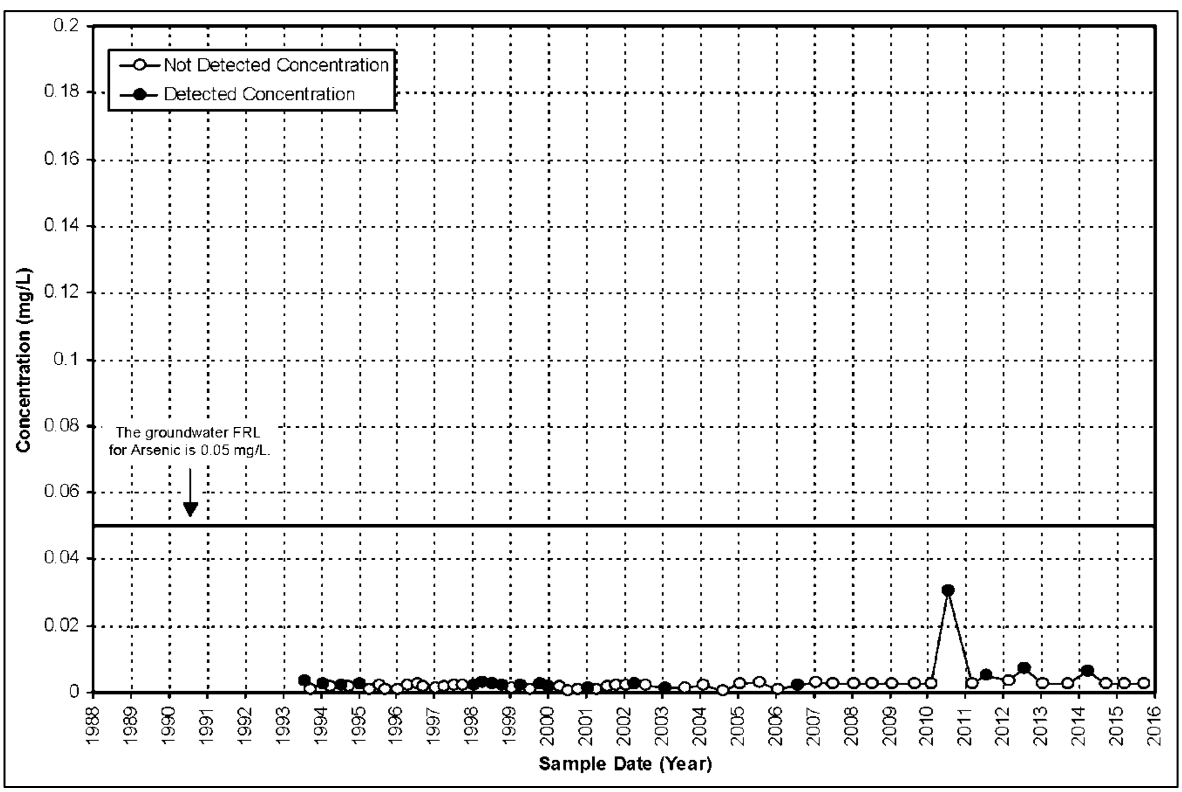


Figure A.4-49. Manganese Concentration Versus Time Plot for Monitoring Well 3432



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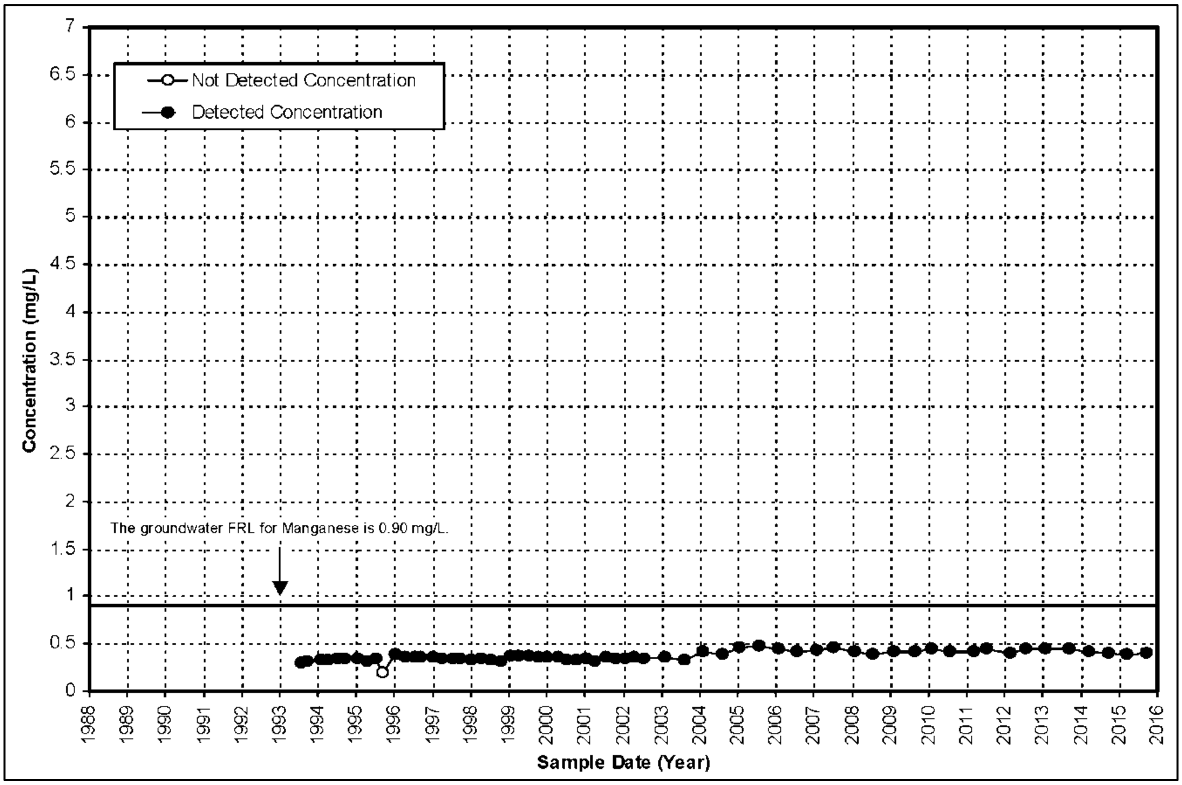
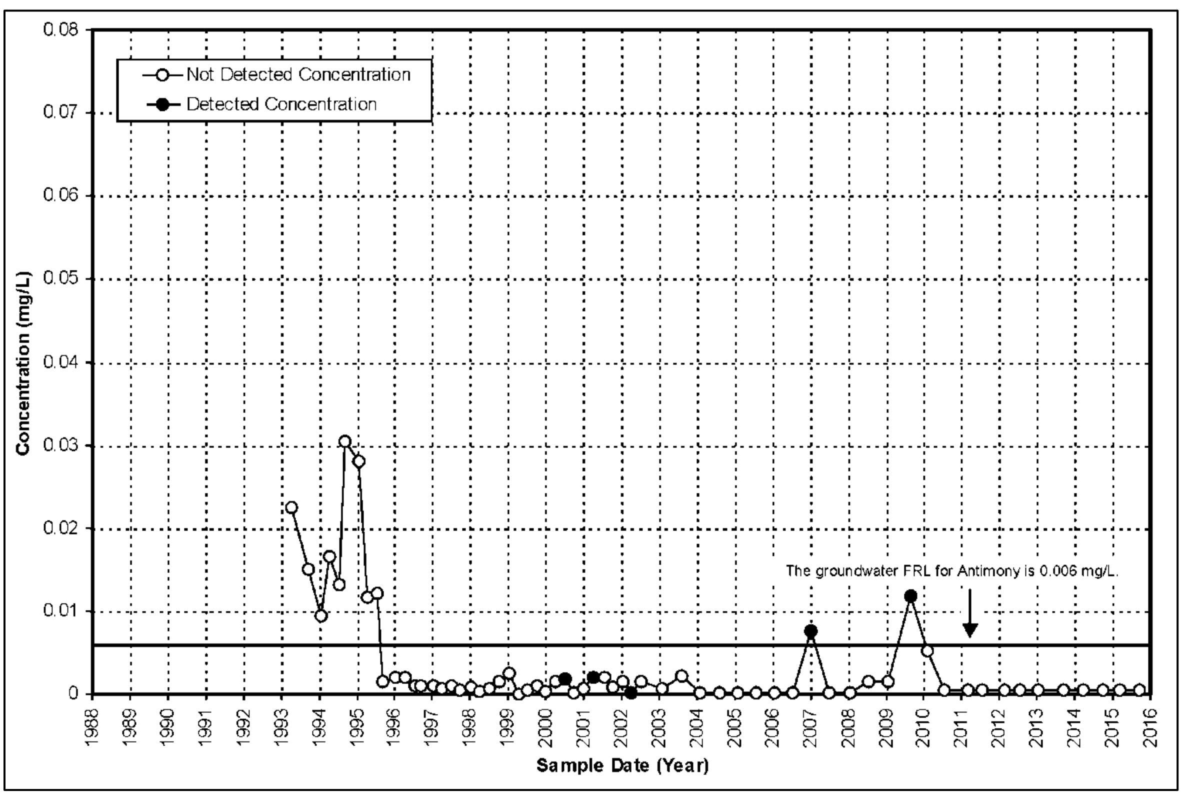


Figure A.4-51. Manganese Concentration Versus Time Plot for Monitoring Well 3733



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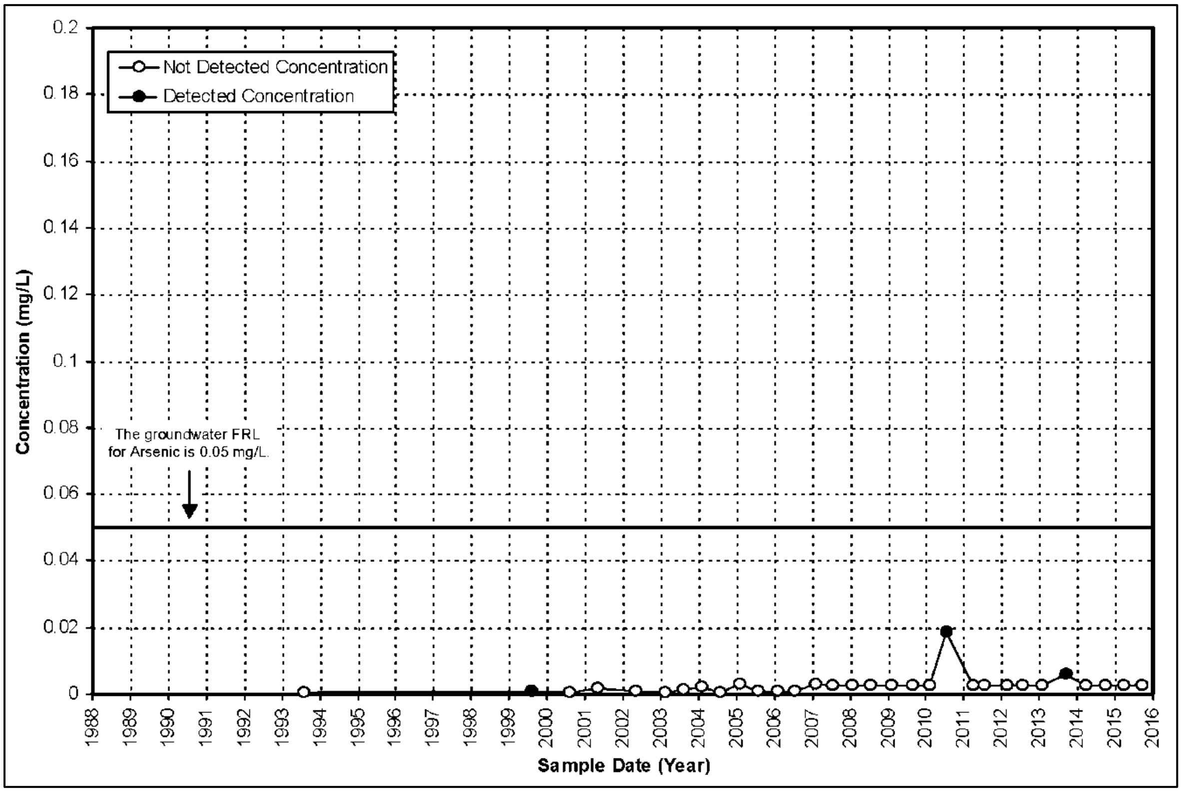


Figure A.4-53. Arsenic Concentration Versus Time Plot for Monitoring Well 21063

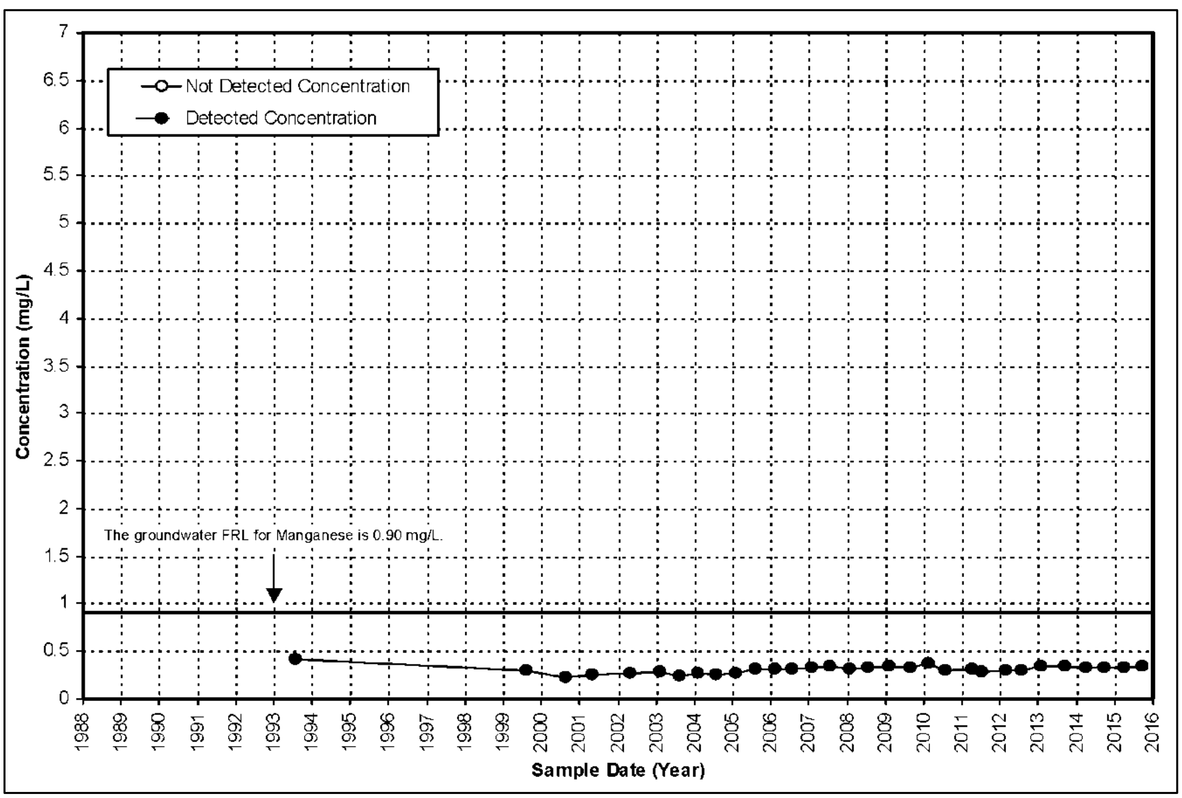
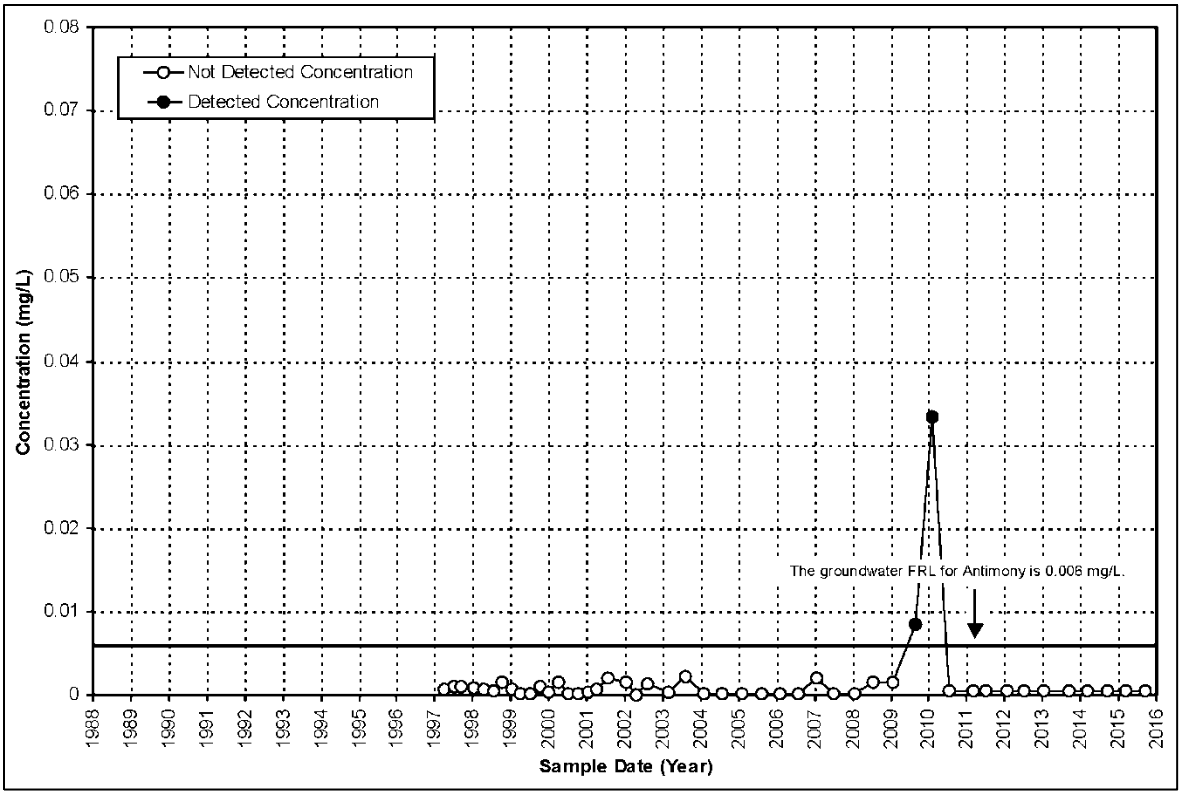


Figure A.4-54. Manganese Concentration Versus Time Plot for Monitoring Well 21063



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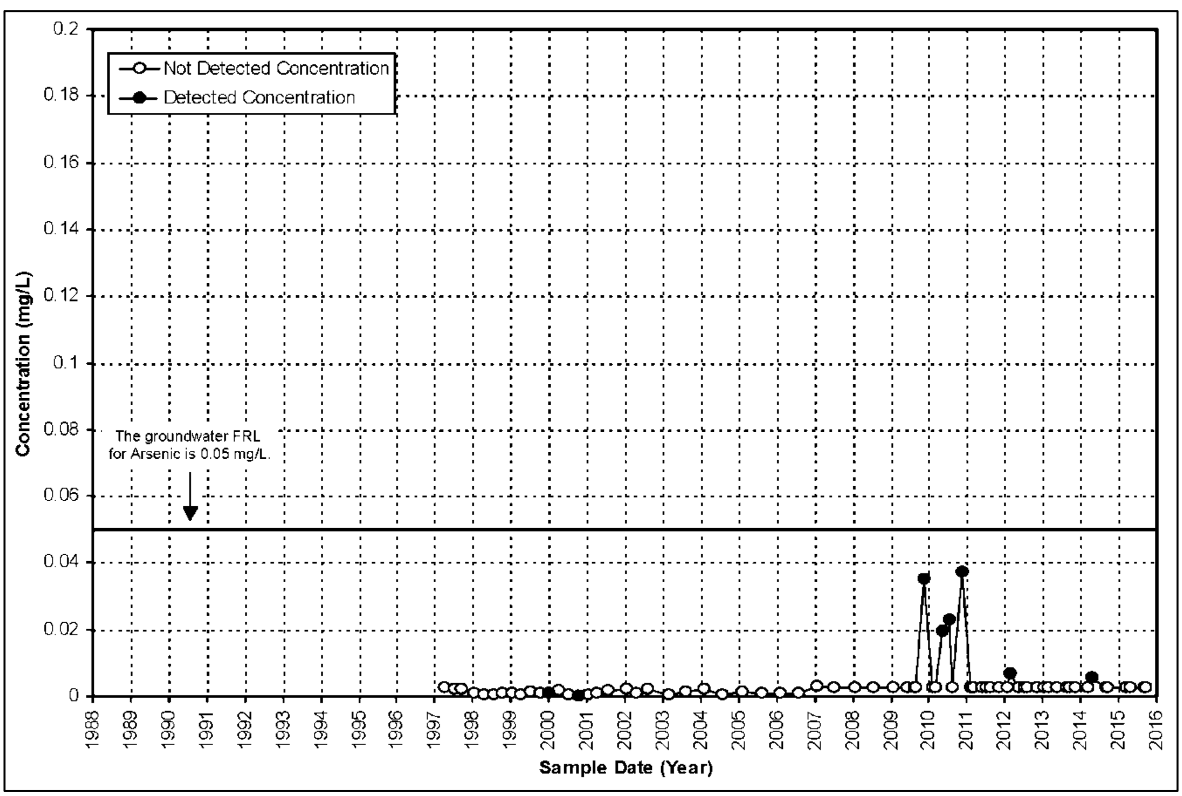
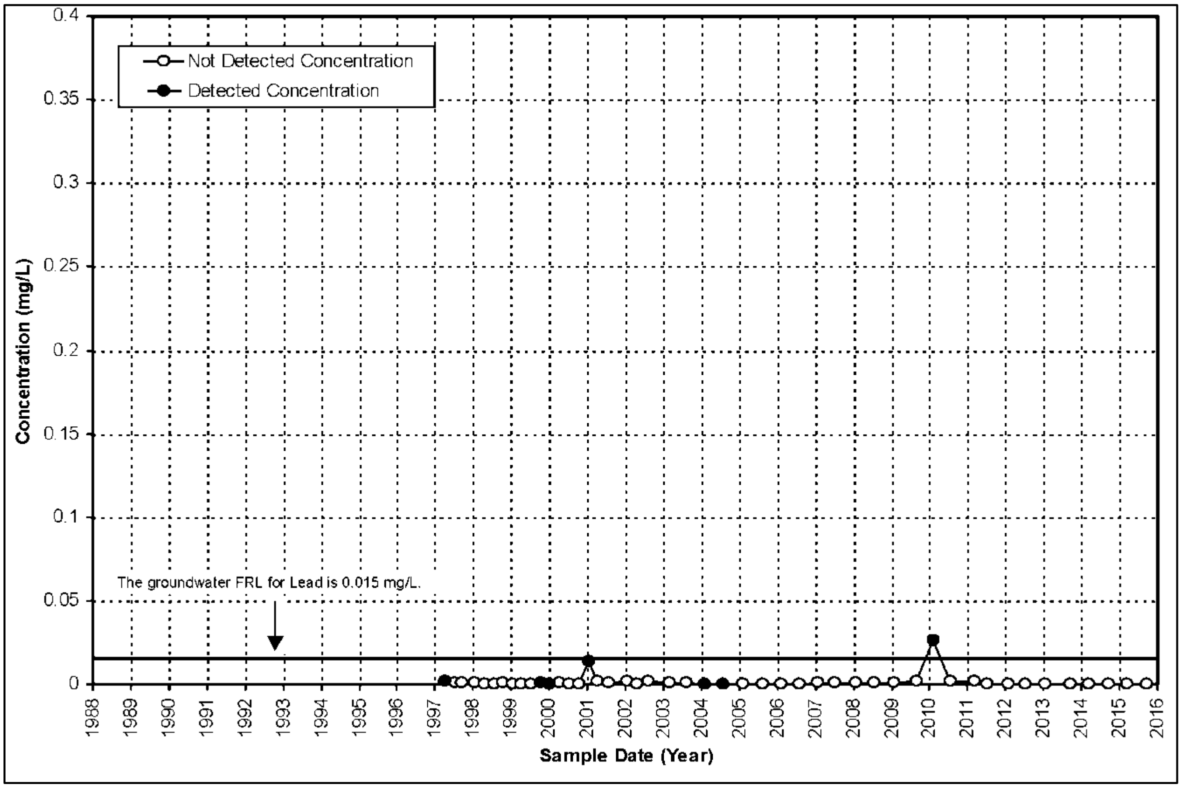


Figure A.4-56. Arsenic Concentration Versus Time Plot for Monitoring Well 22198



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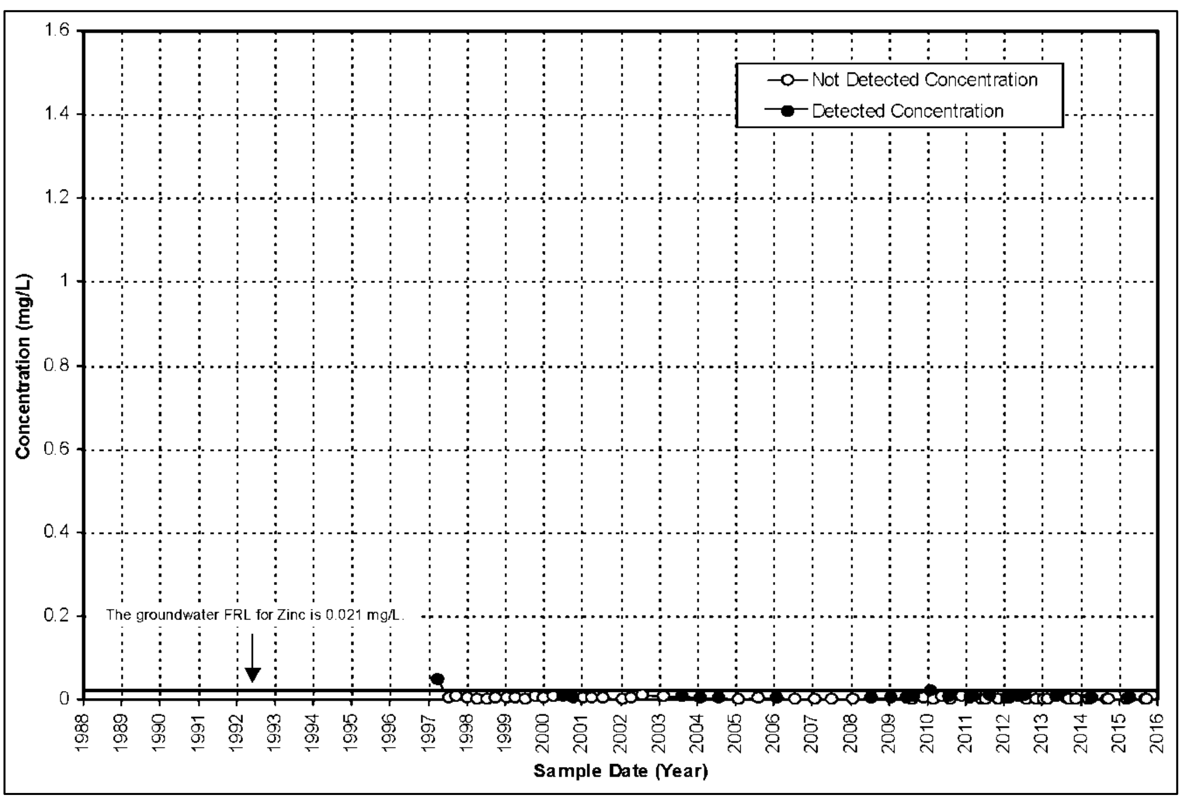

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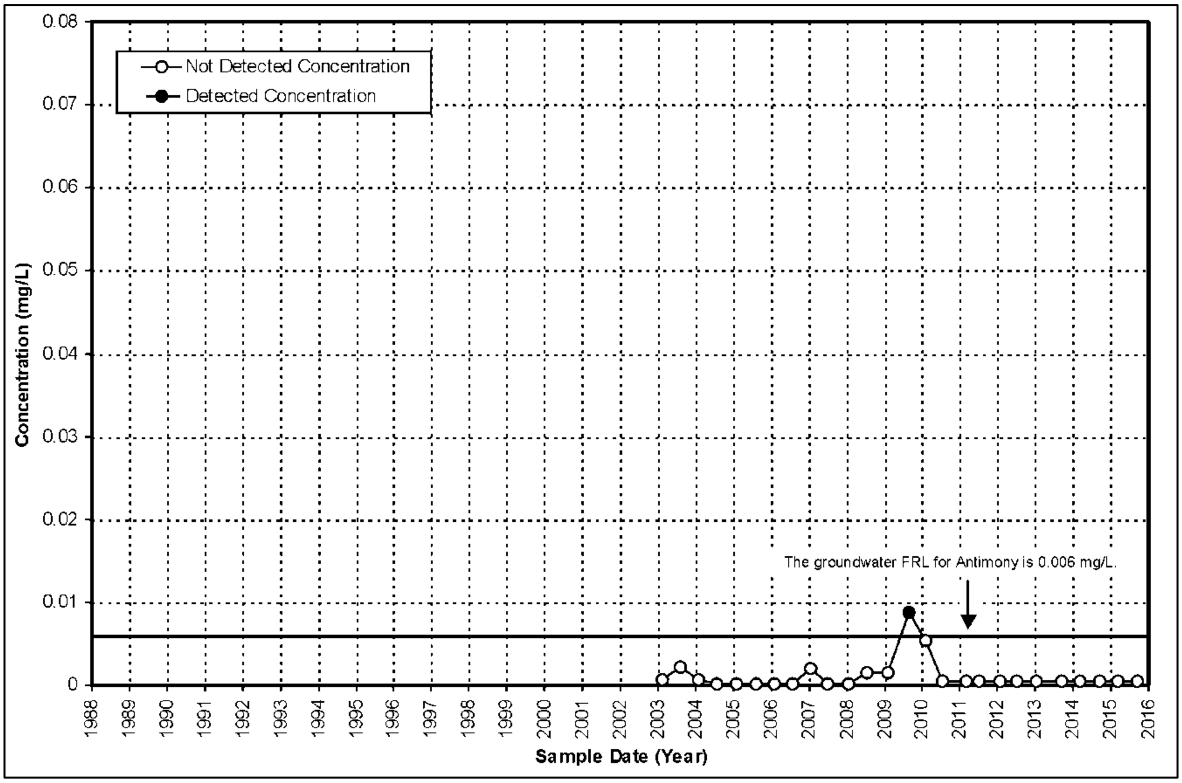

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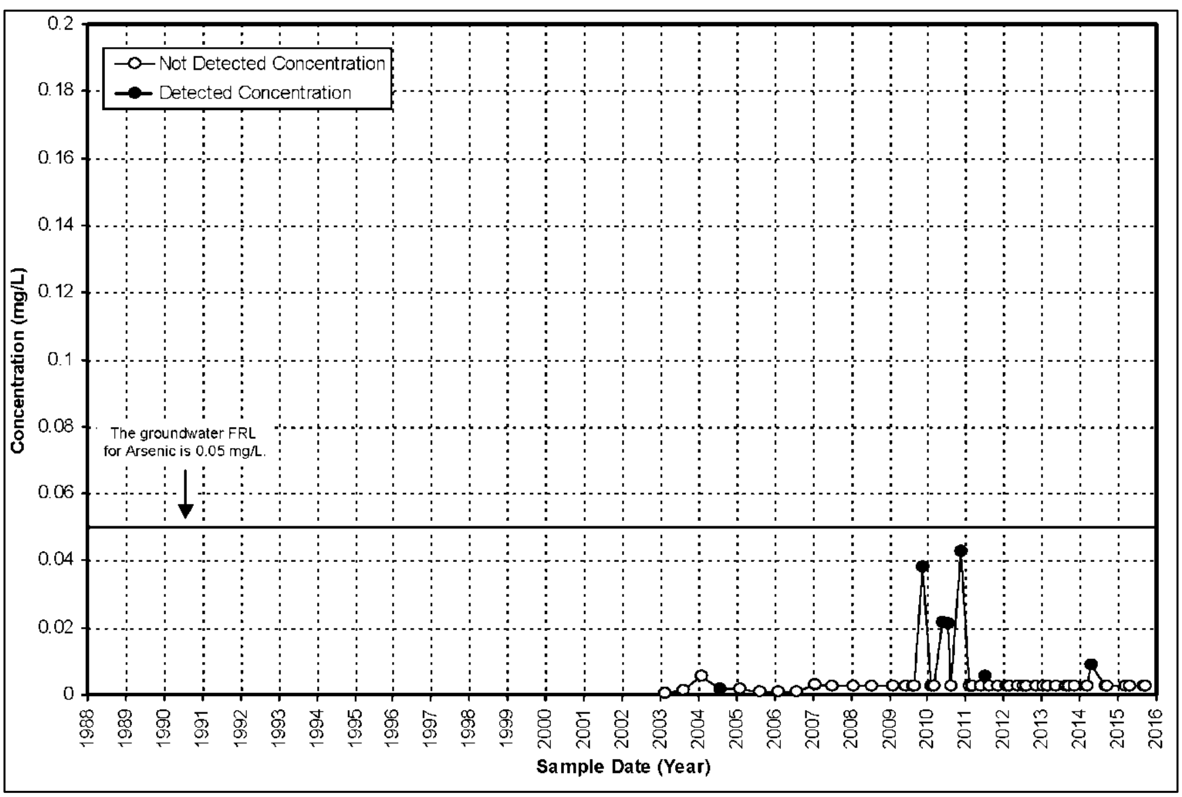

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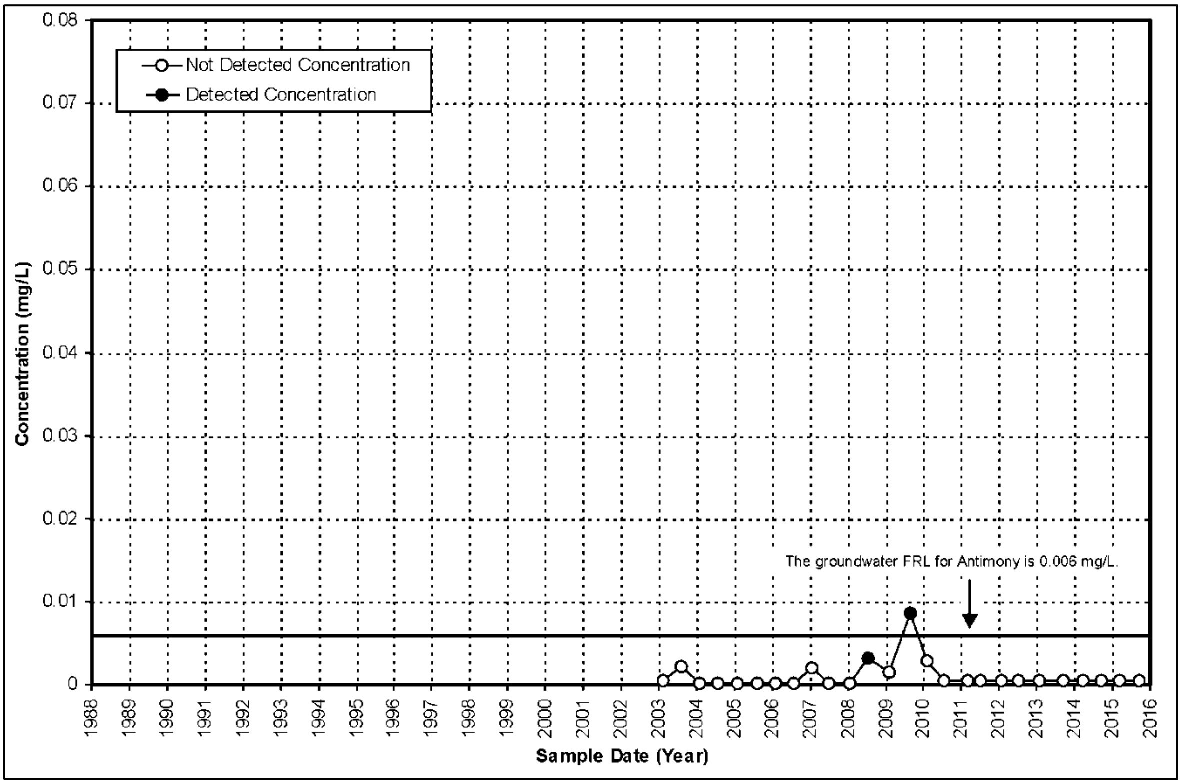

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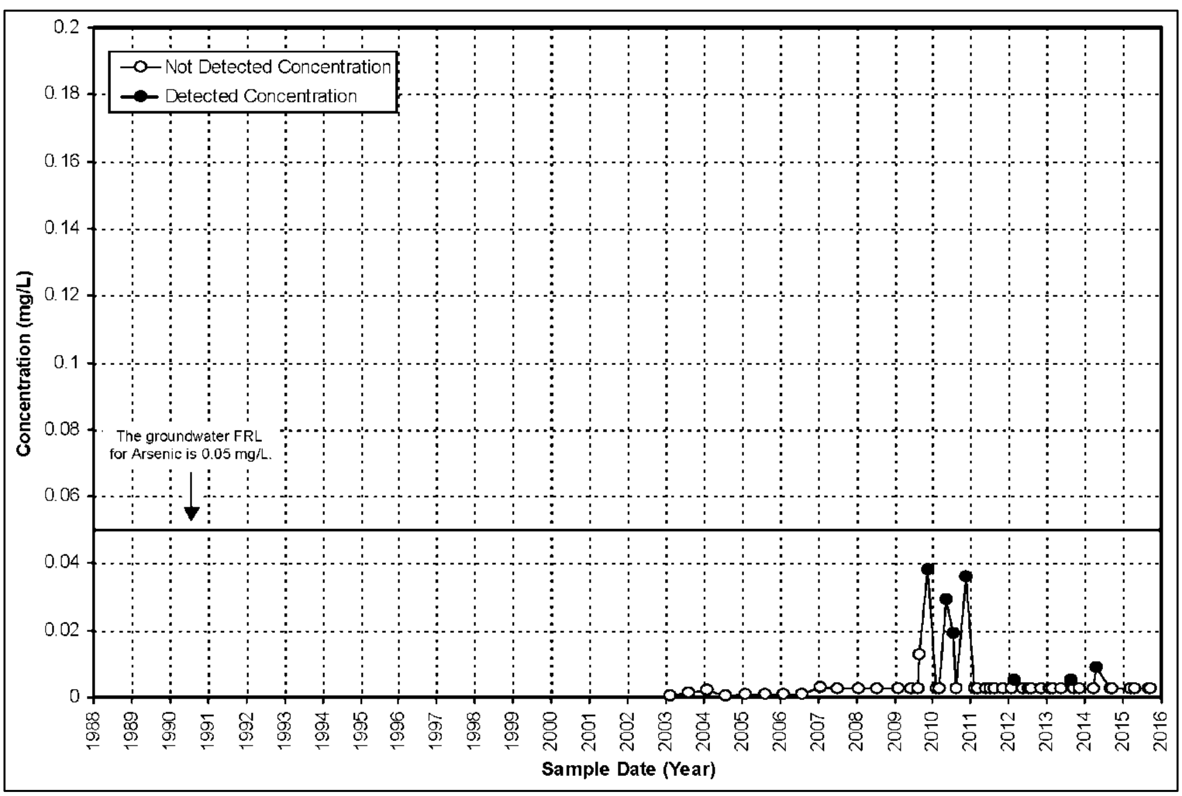

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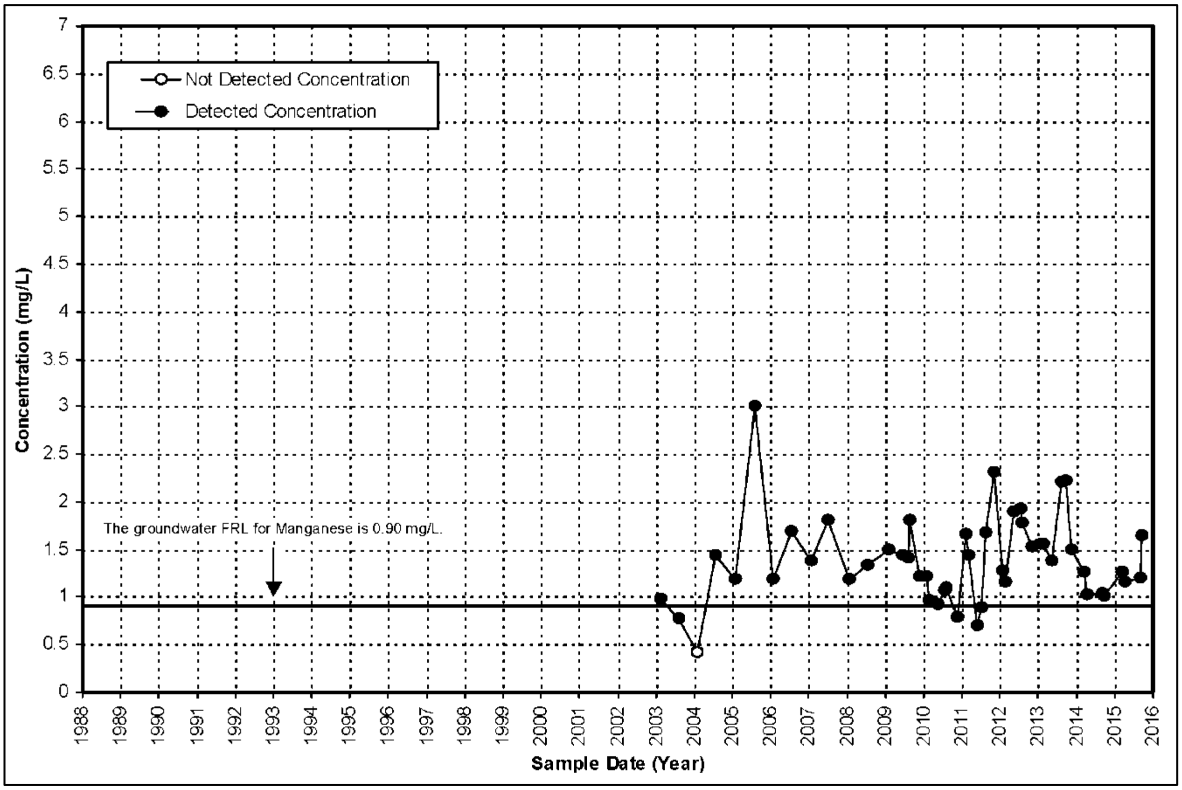

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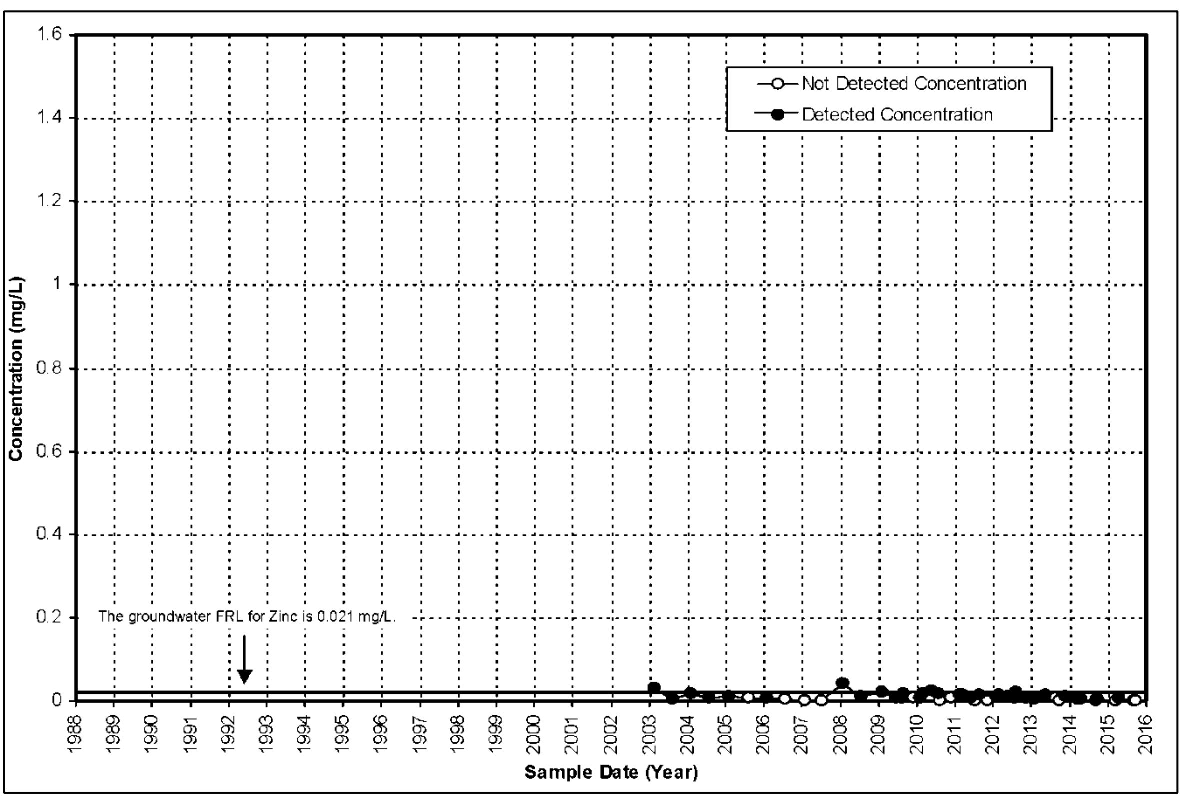

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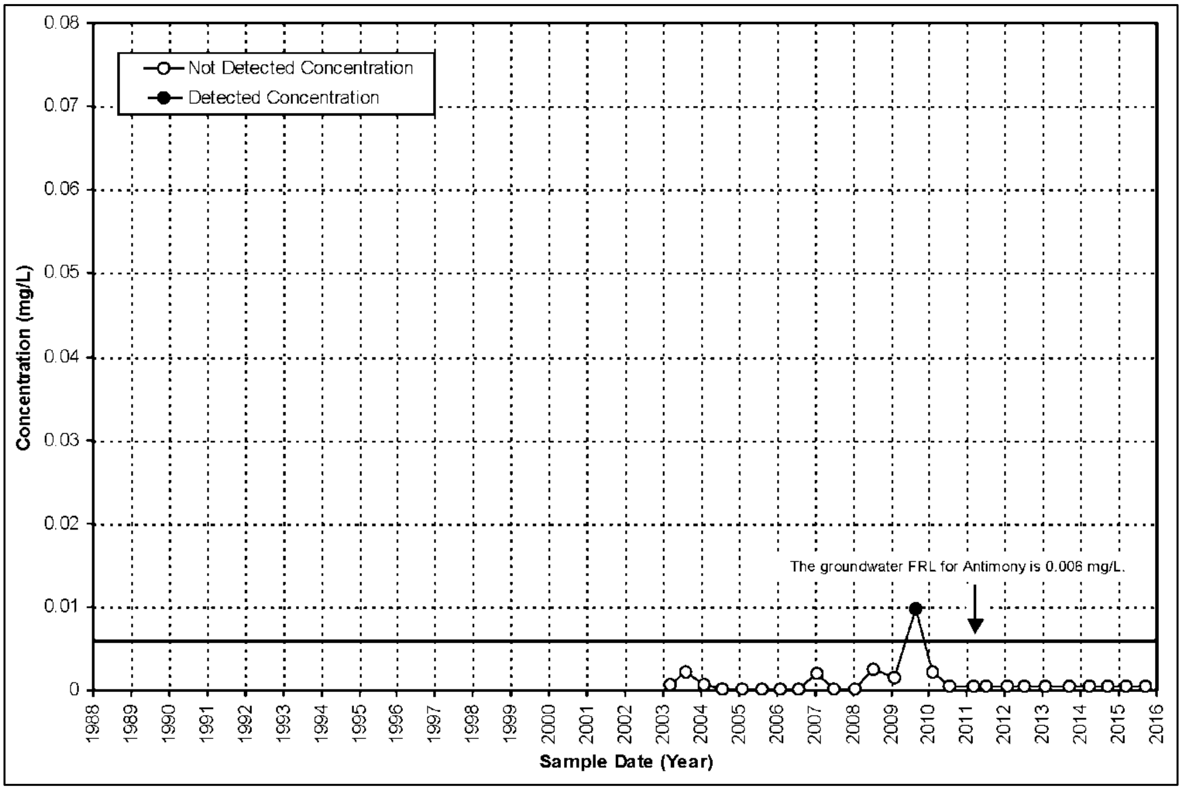

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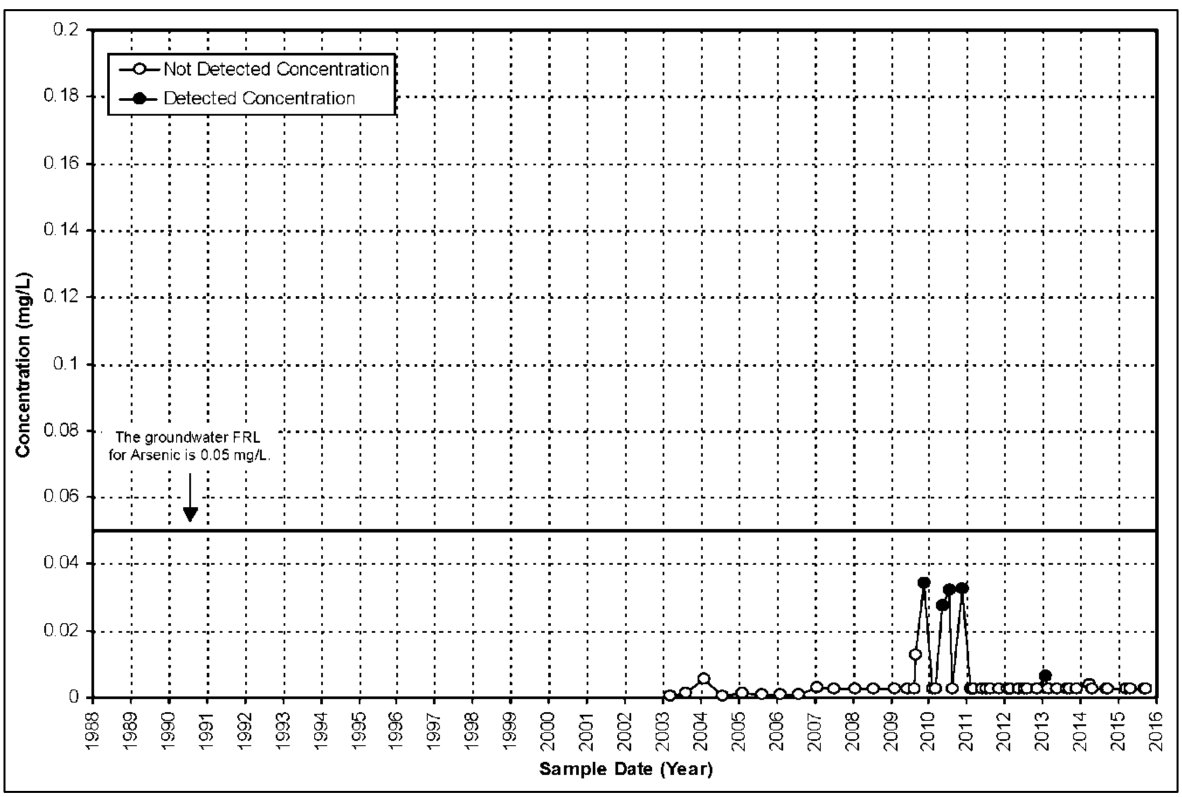

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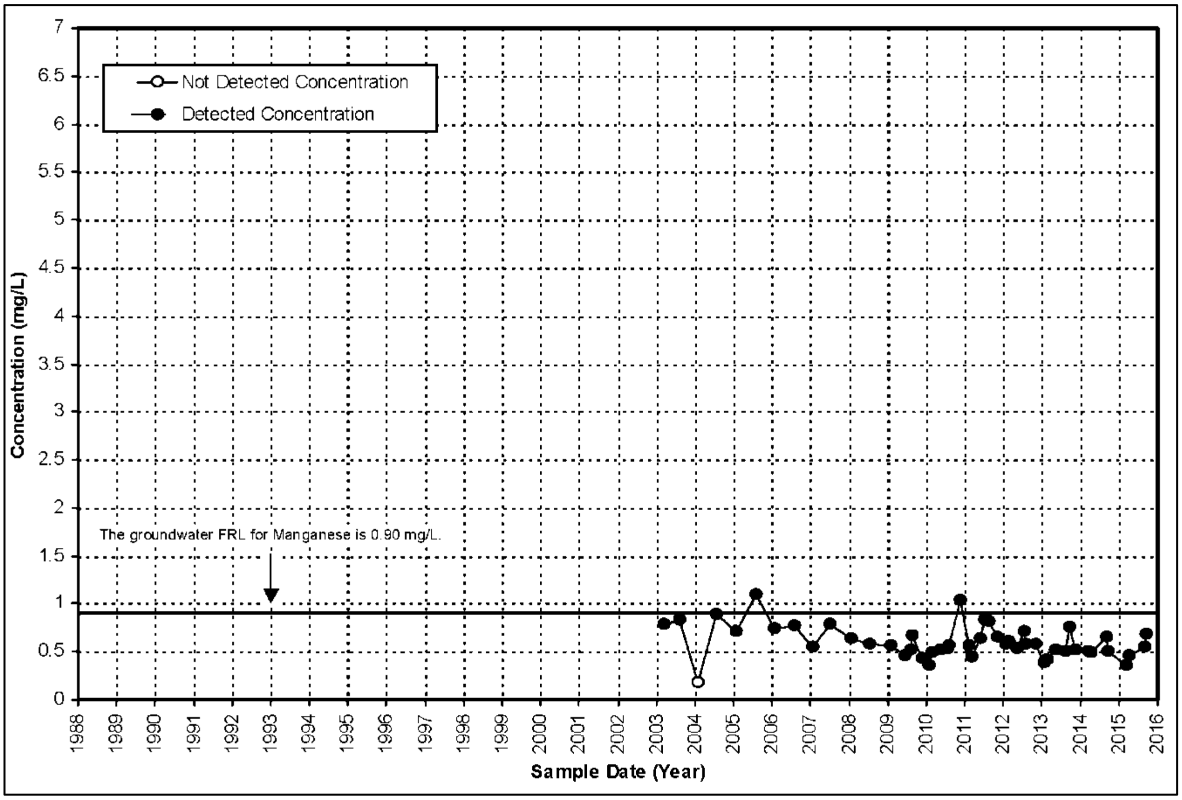

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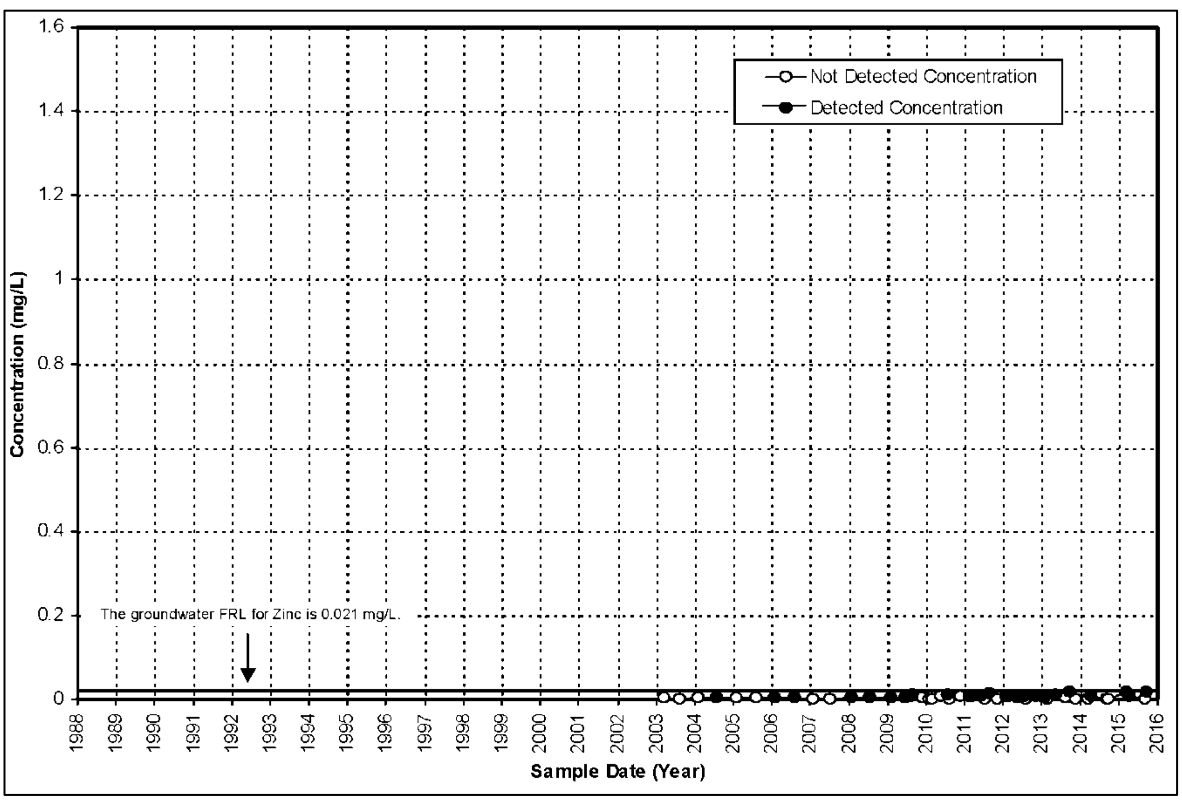


Figure A.4-68. Zinc Concentration Versus Time Plot for Monitoring Well 22205

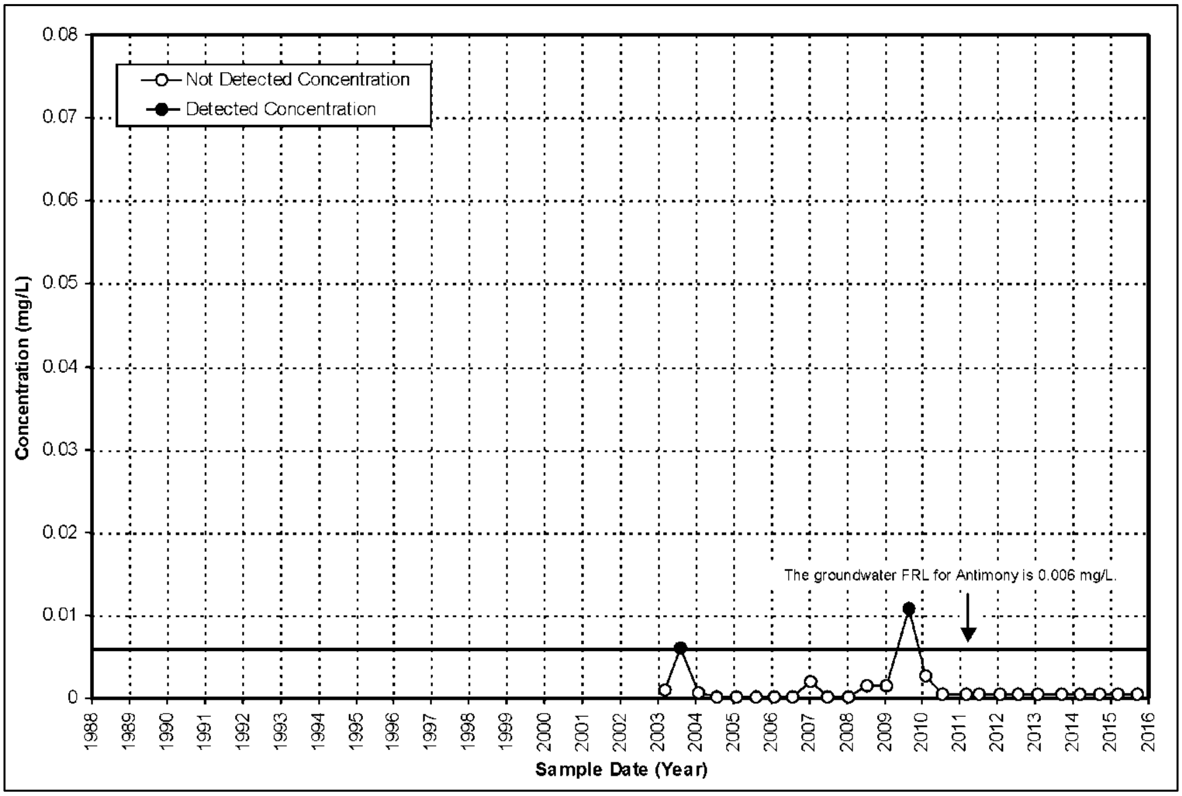
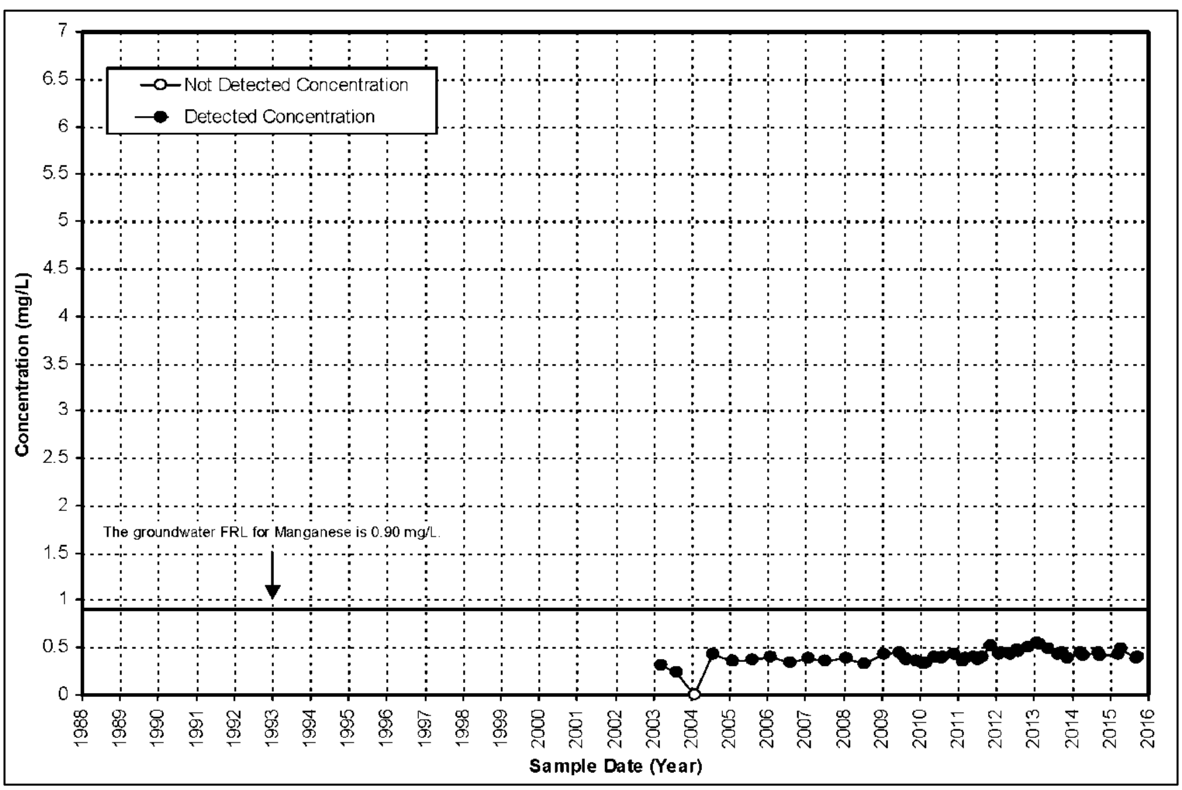


Figure A.4-69. Antimony Concentration Versus Time Plot for Monitoring Well 22208



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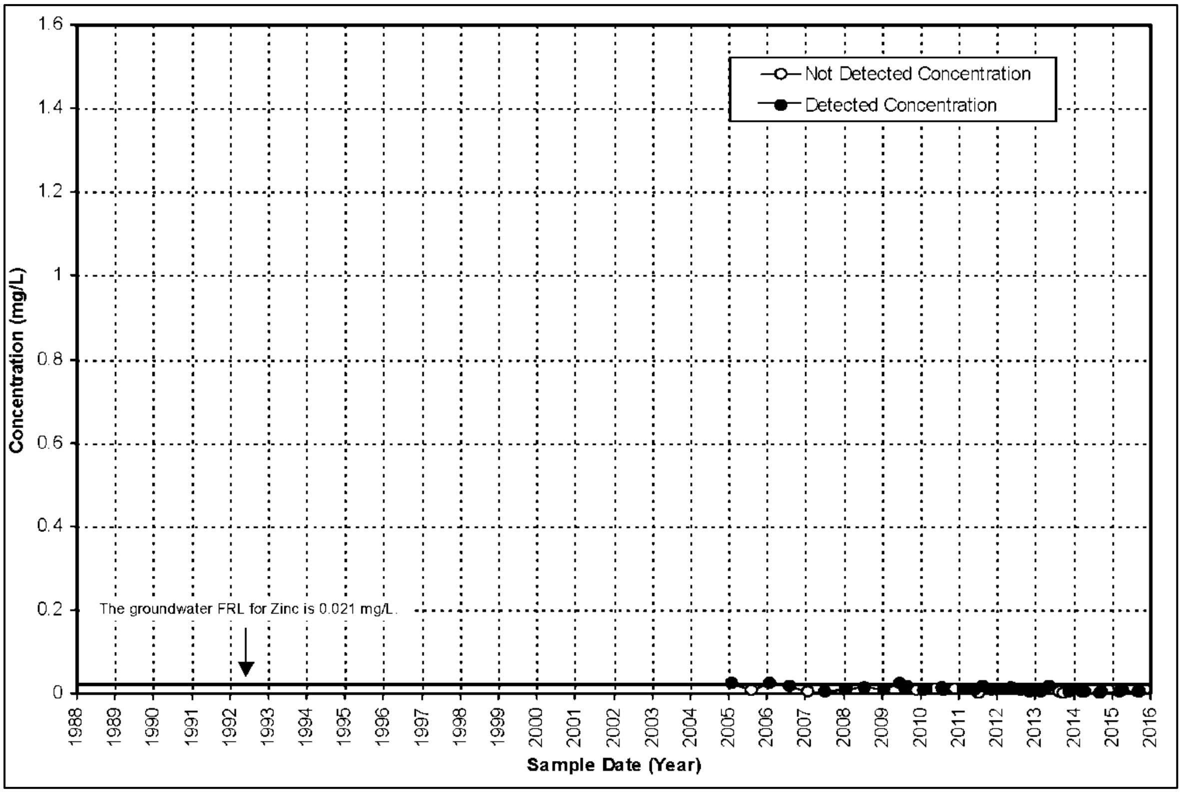

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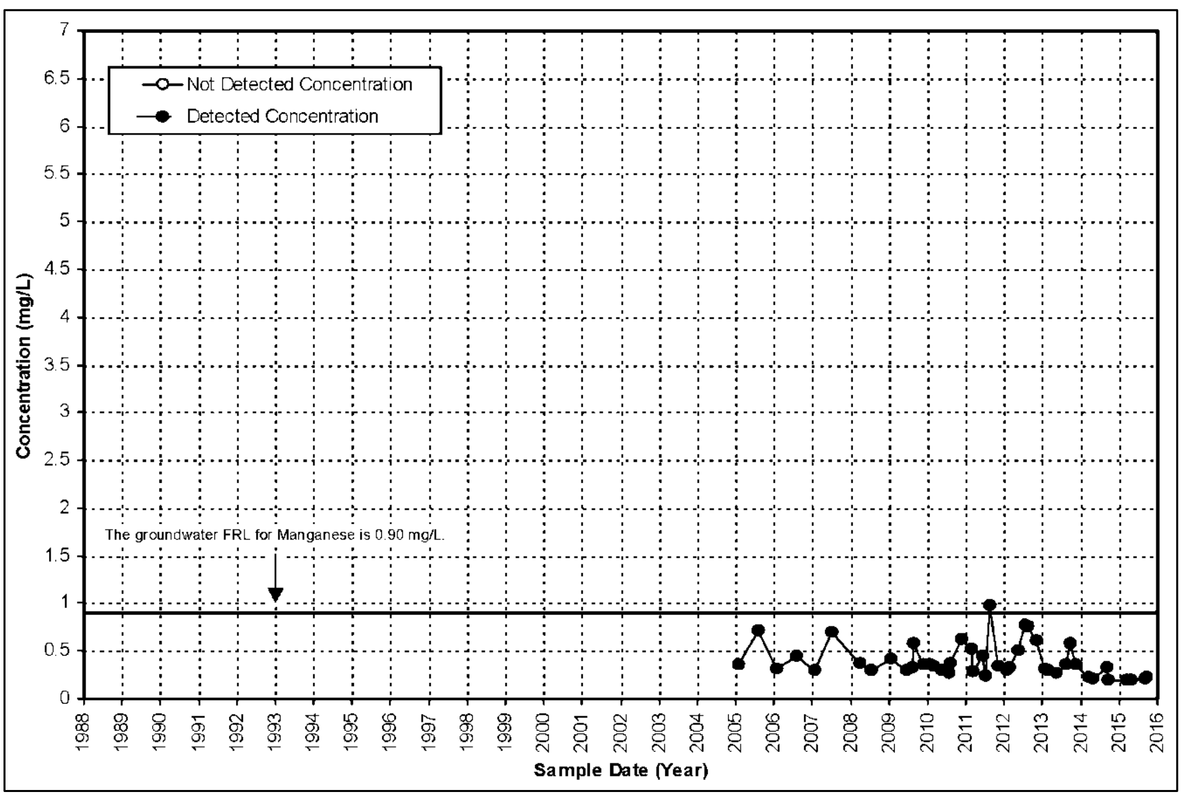

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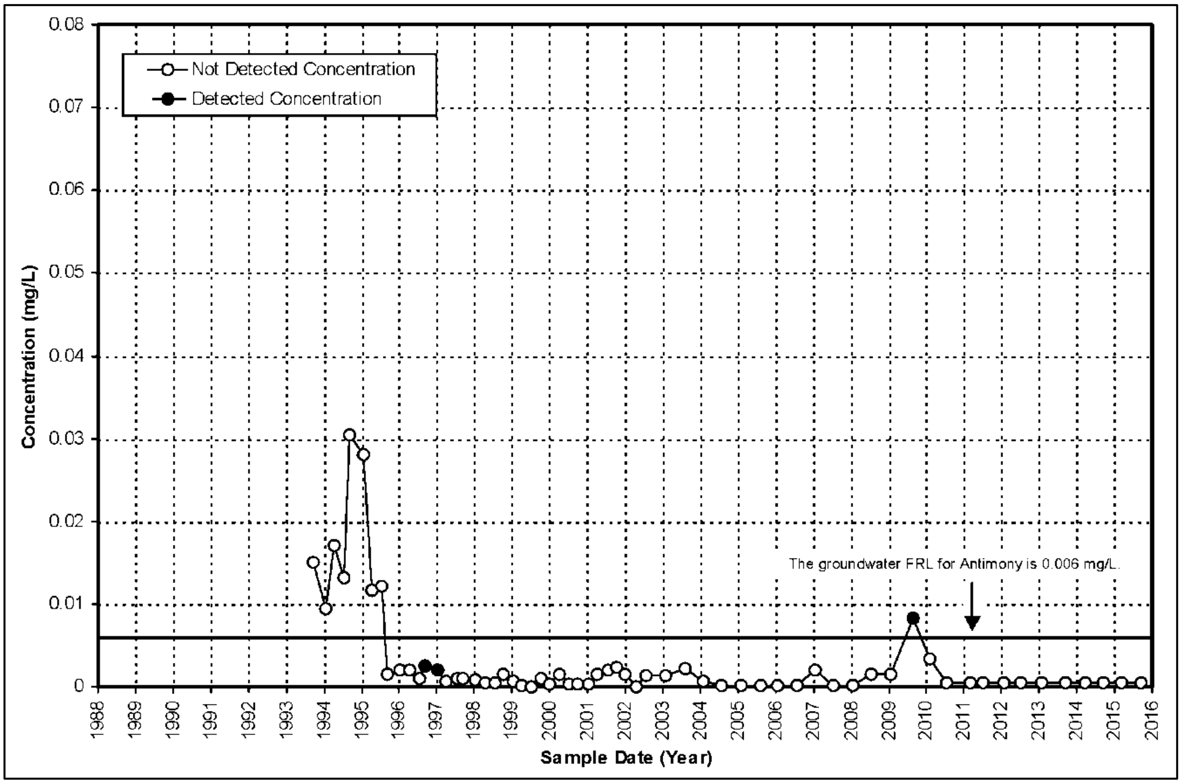

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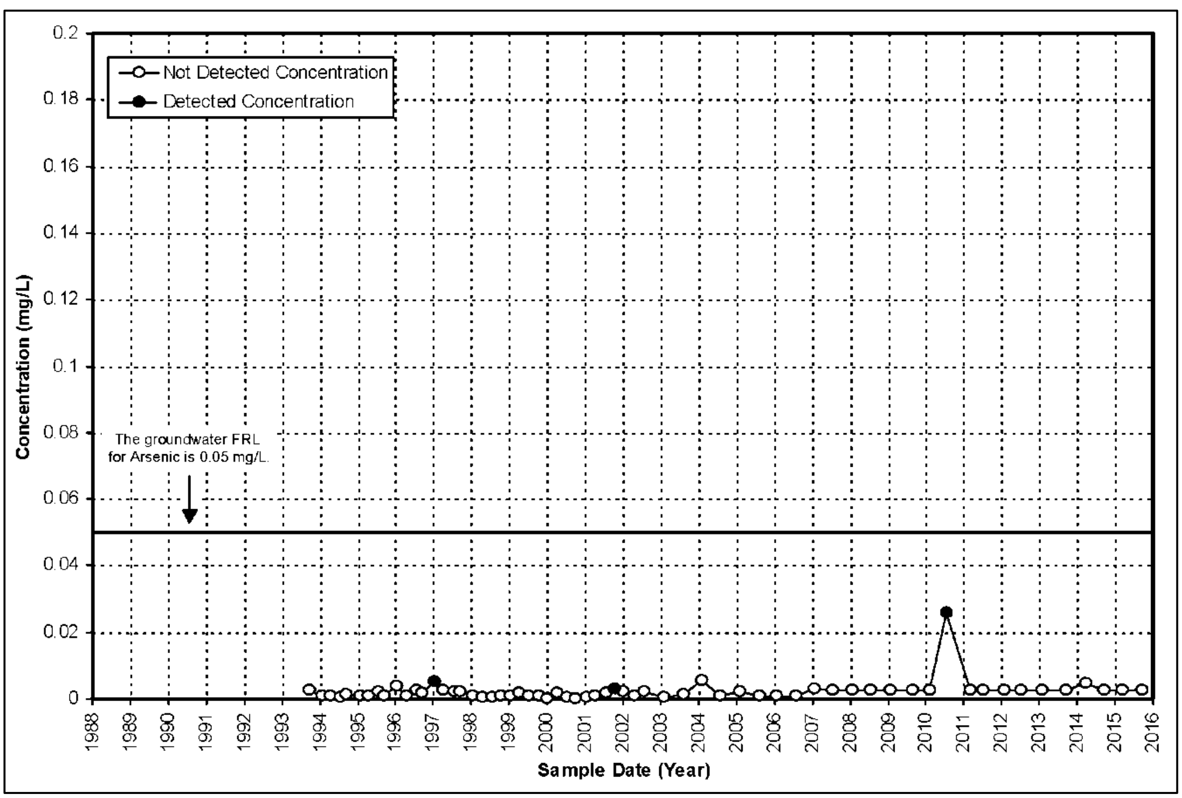

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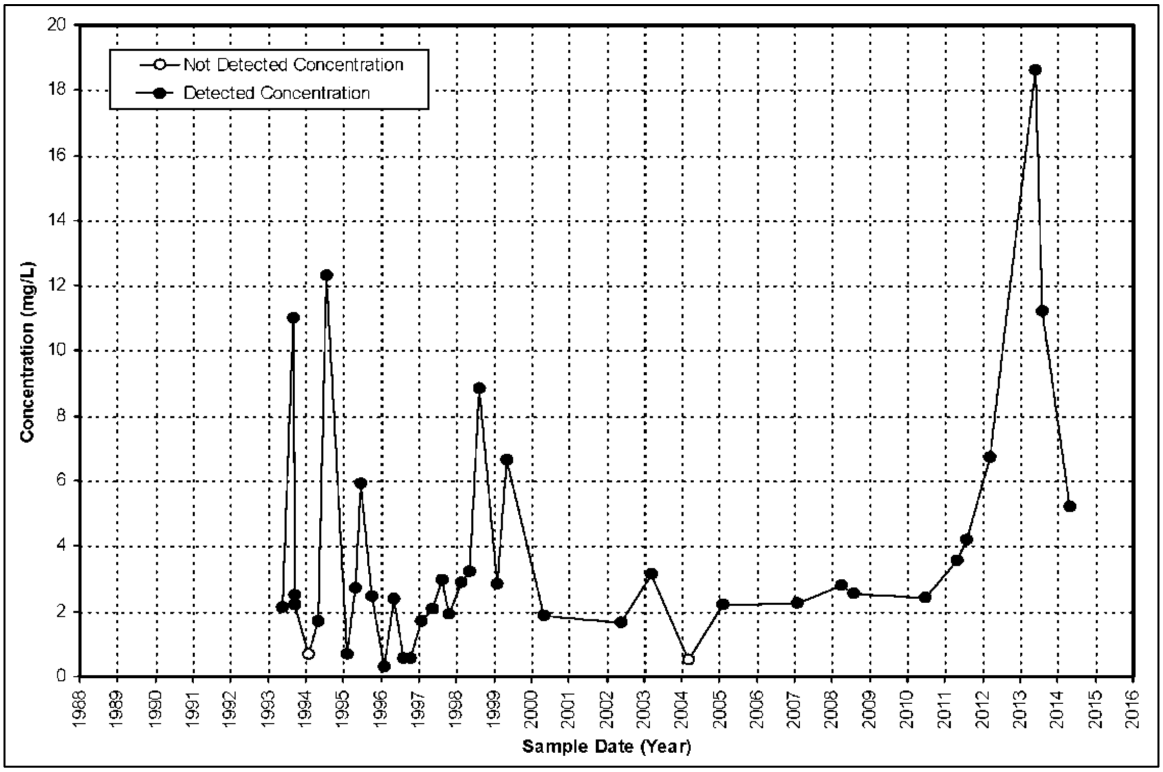

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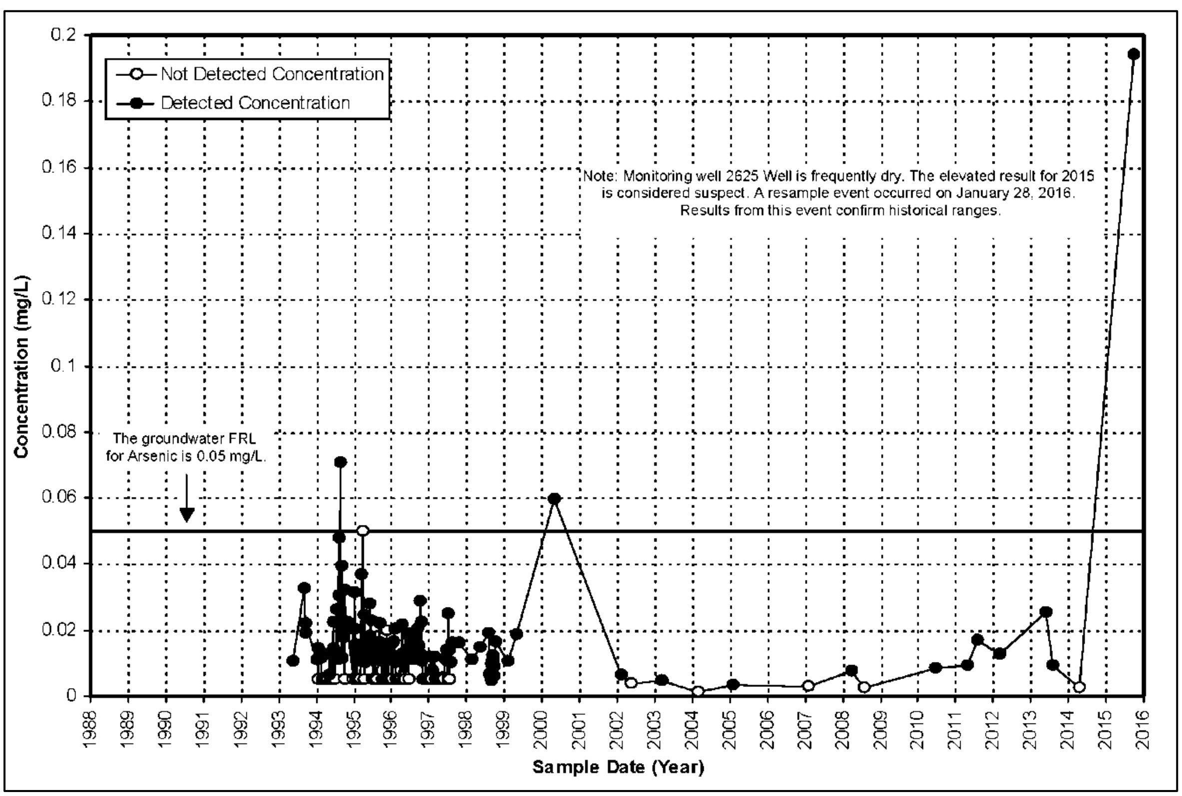

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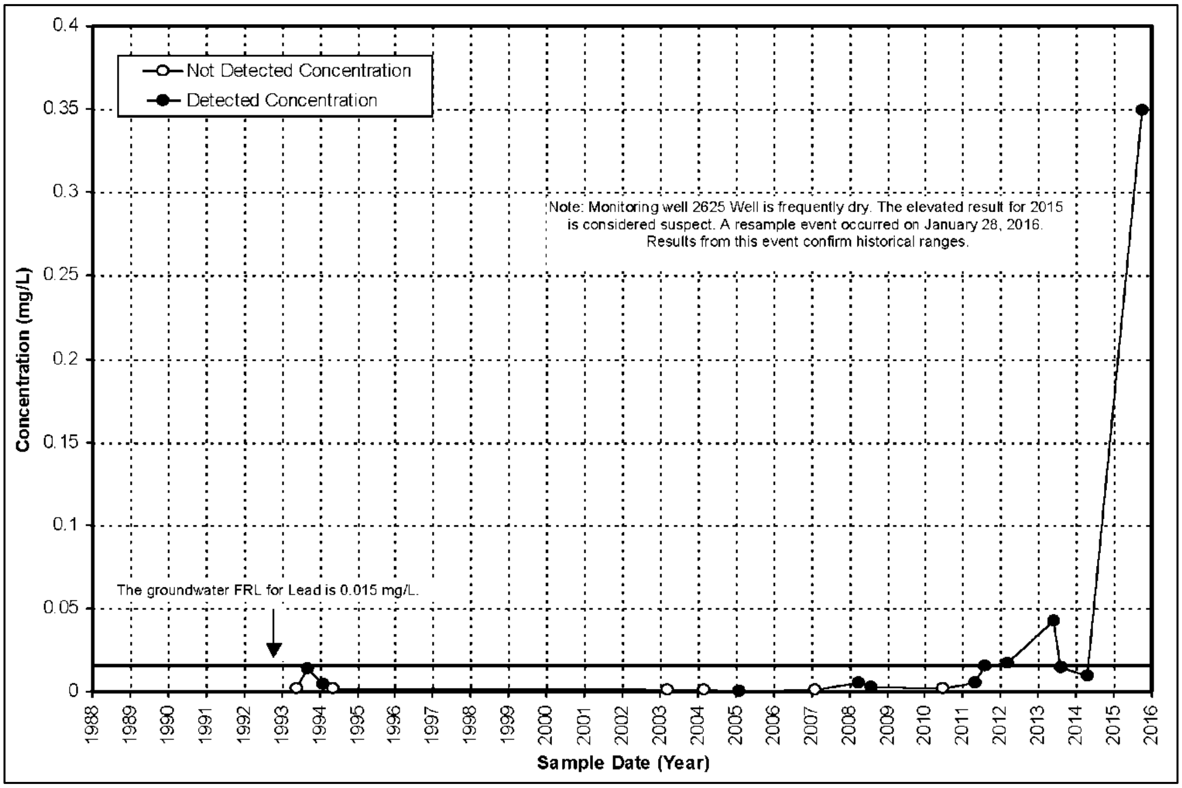

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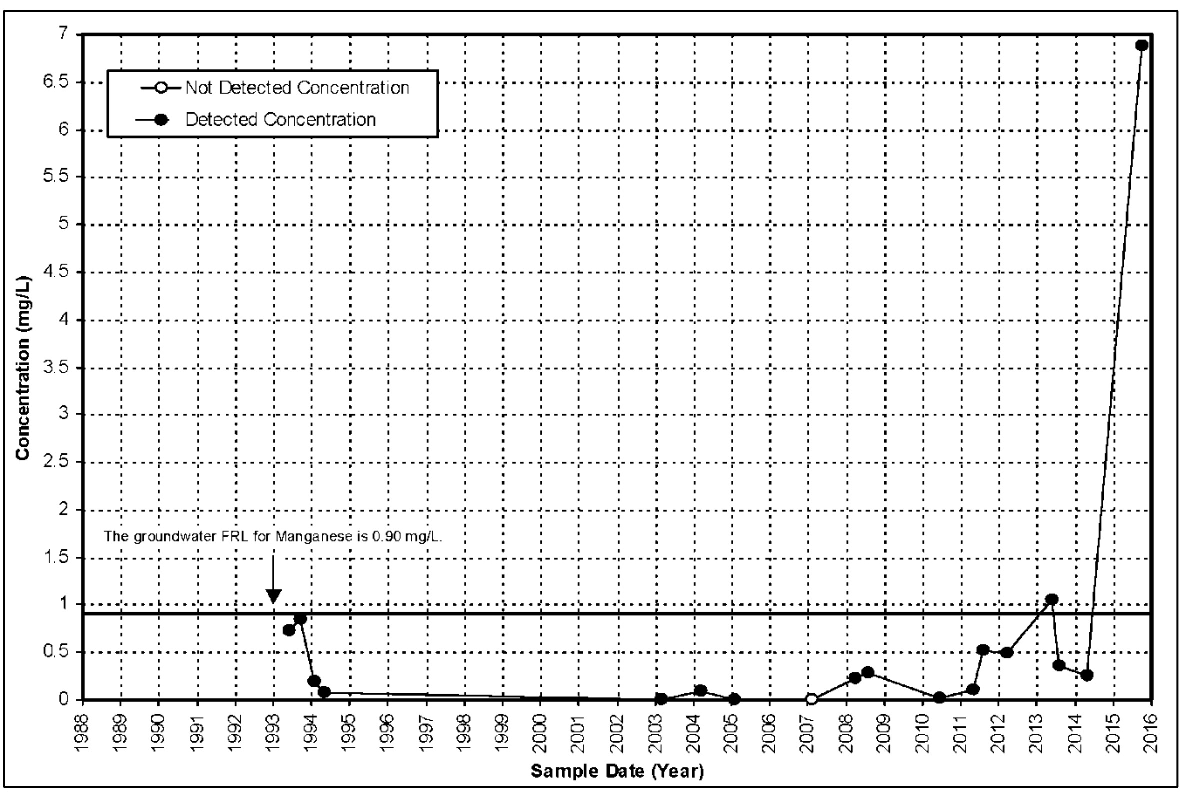

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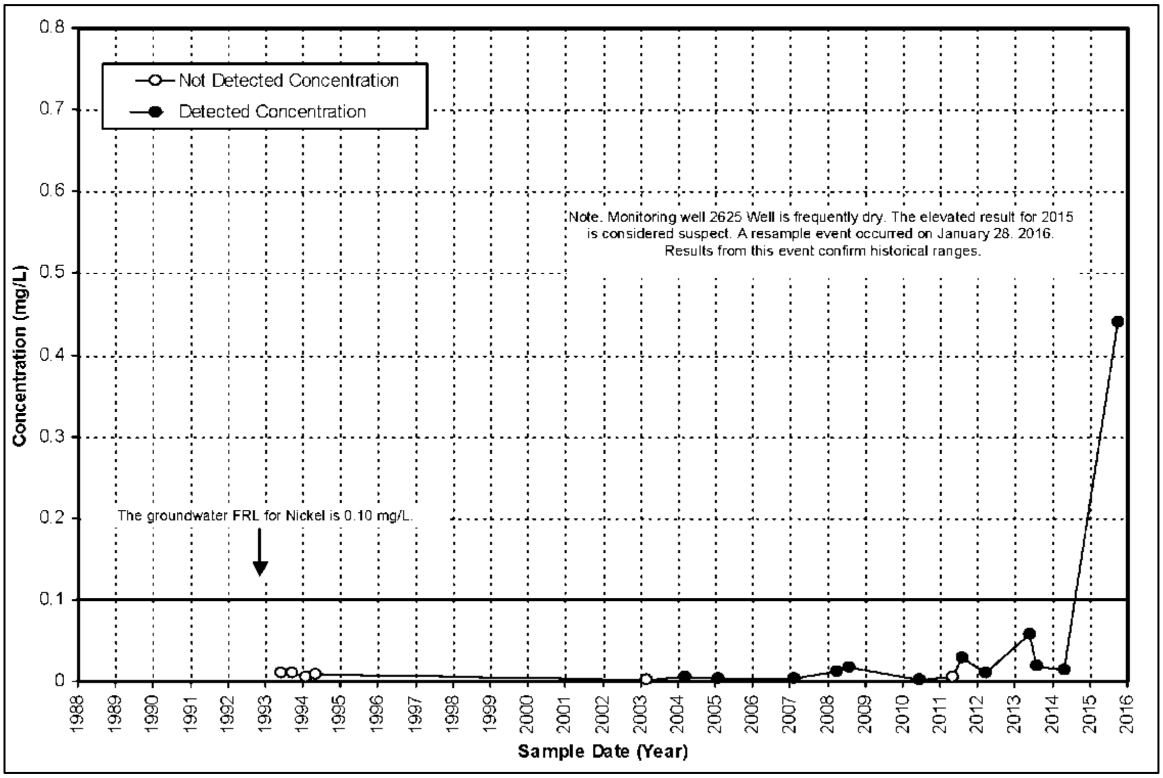

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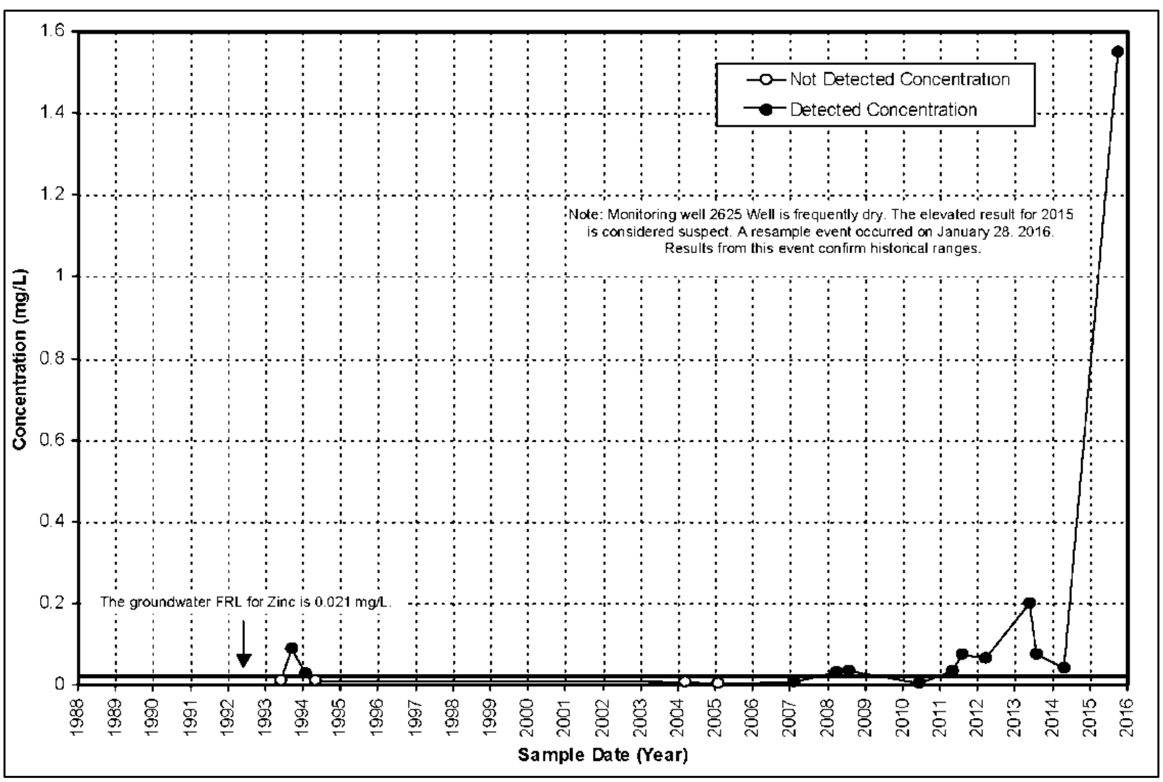

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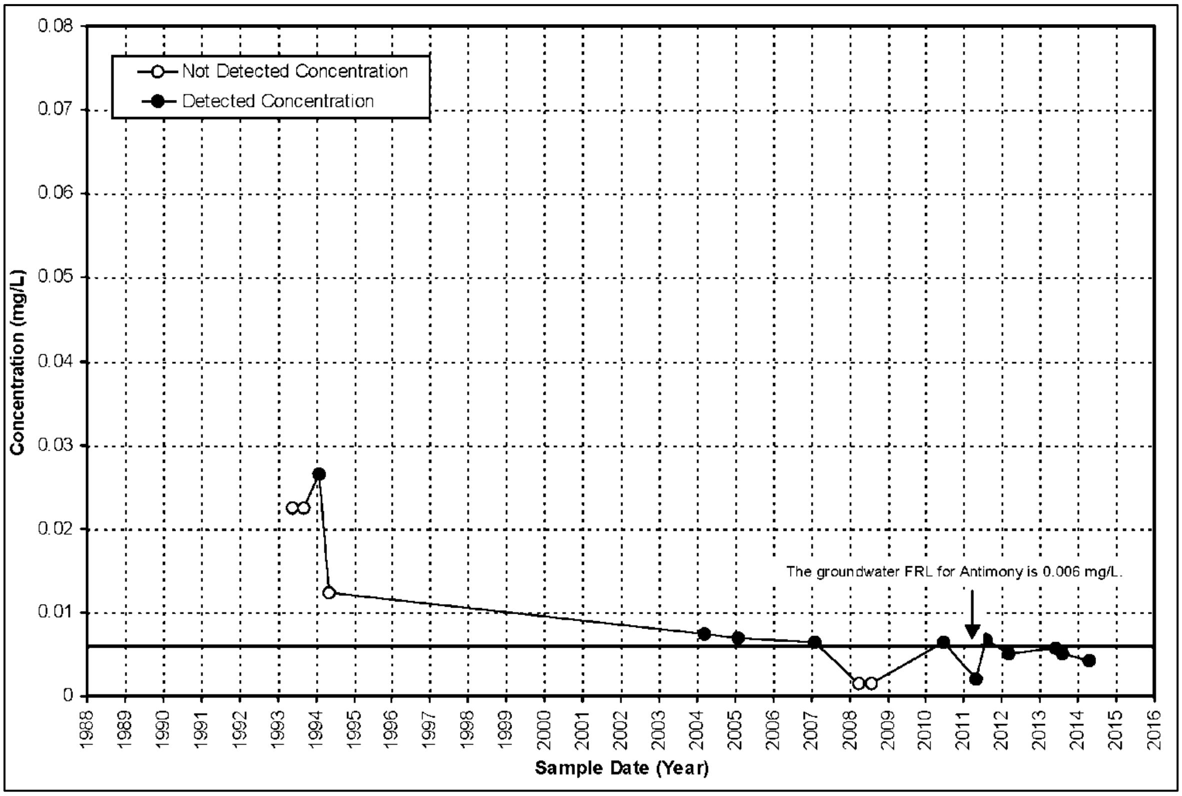


Figure A.4-81. Antimony Concentration Versus Time Plot for Monitoring Well 2636

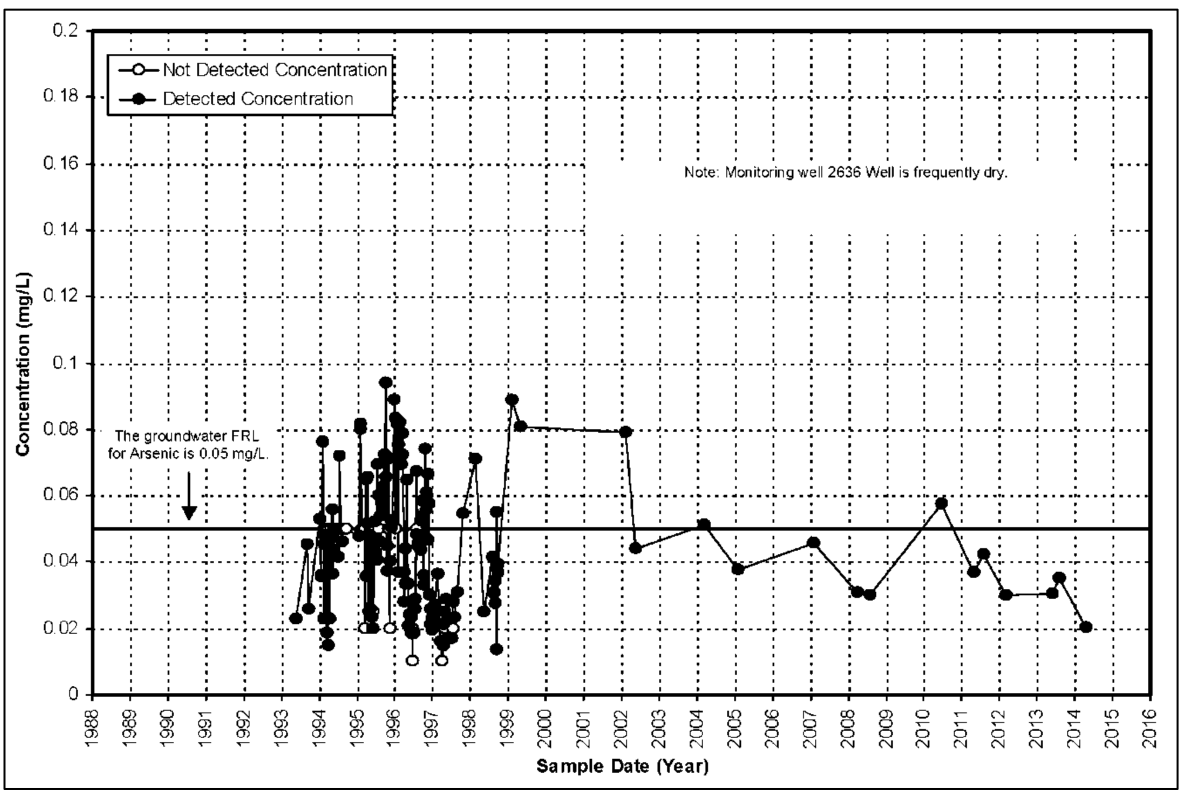


Figure A.4-82. Arsenic Concentration Versus Time Plot for Monitoring Well 2636

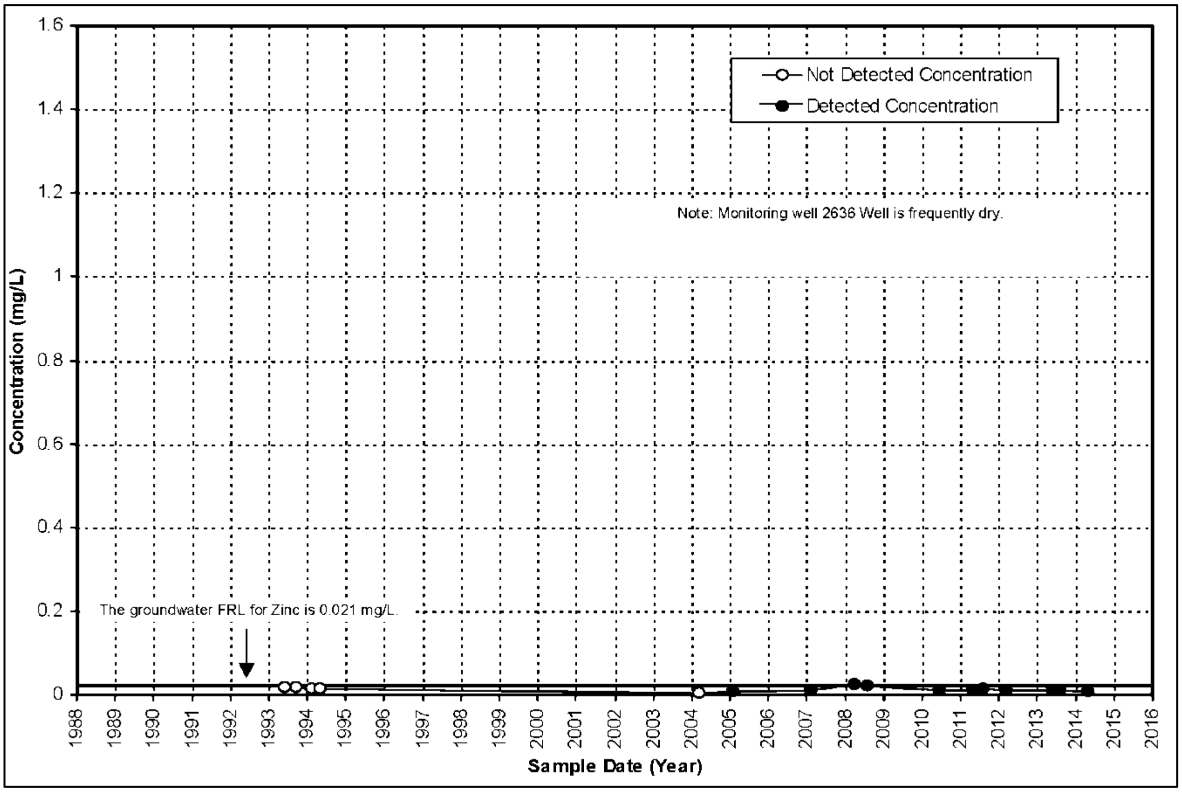


Figure A.4-83. Zinc Concentration Versus Time Plot for Monitoring Well 2636

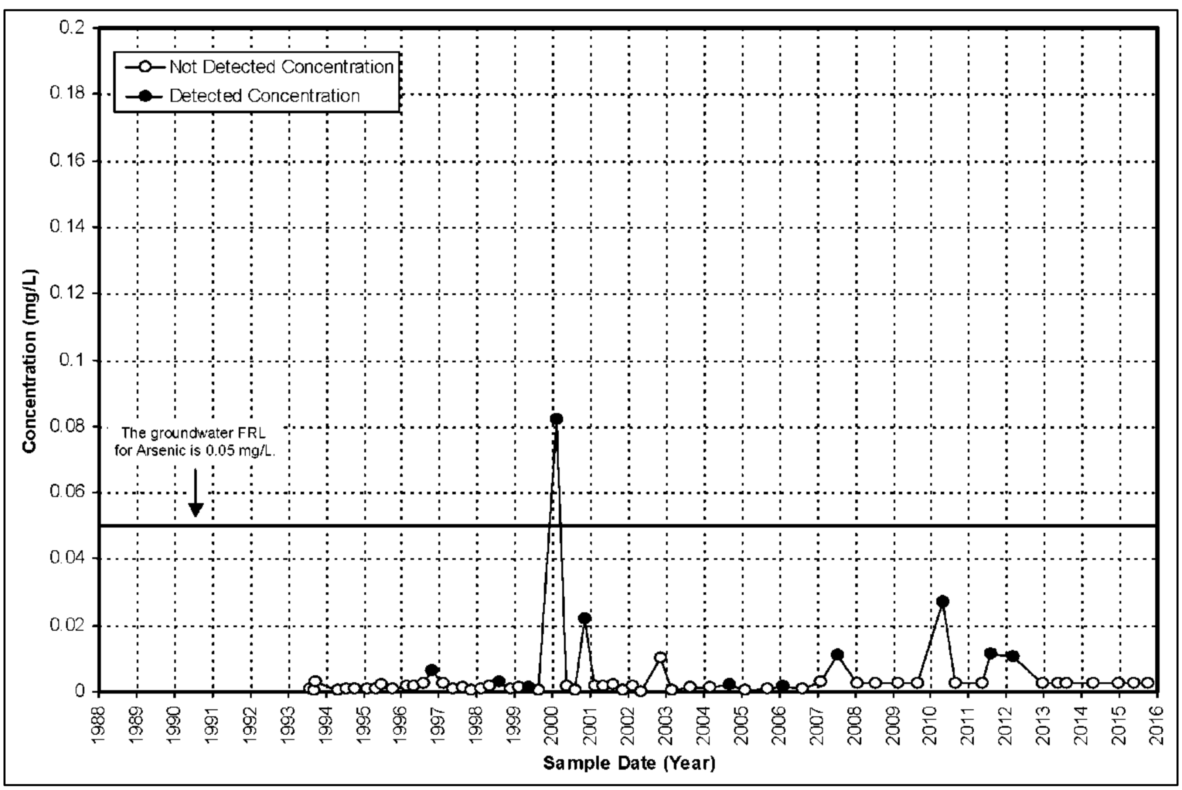


Figure A.4-84. Arsenic Concentration Versus Time Plot for Monitoring Well 2898

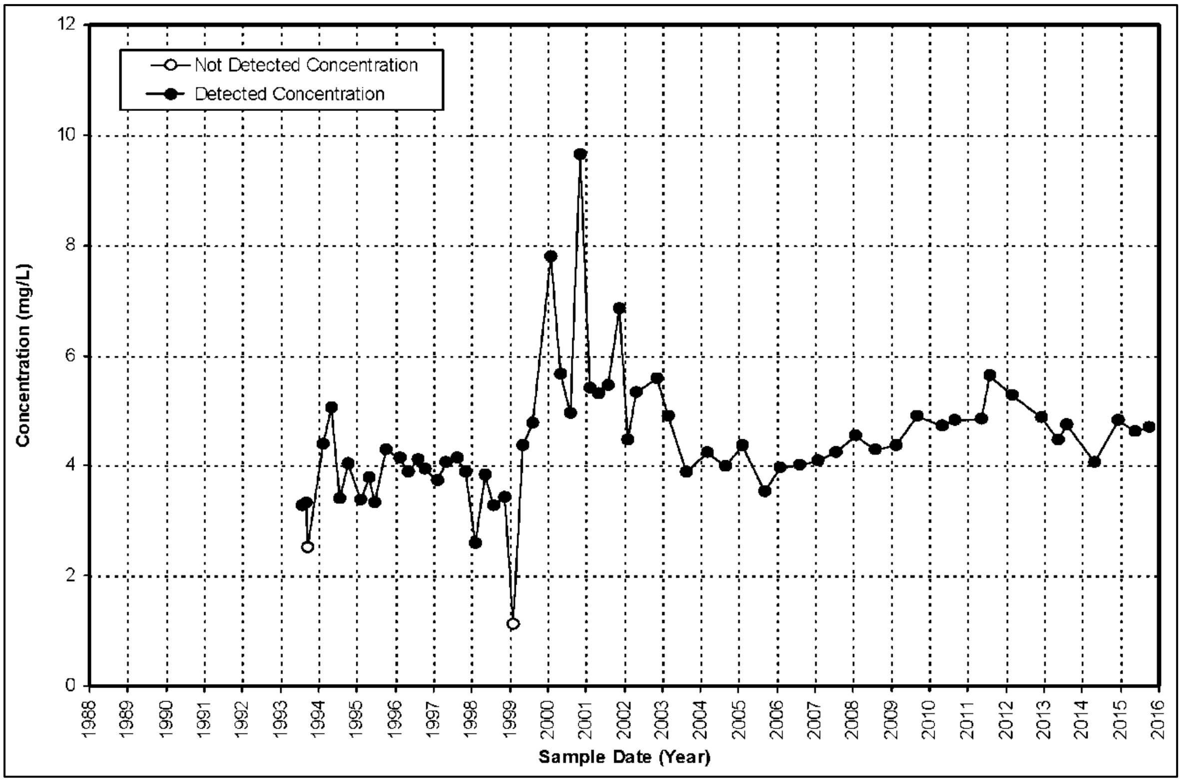


Figure A.4-85. Potassium Concentration Versus Time Plot for Monitoring Well 2898

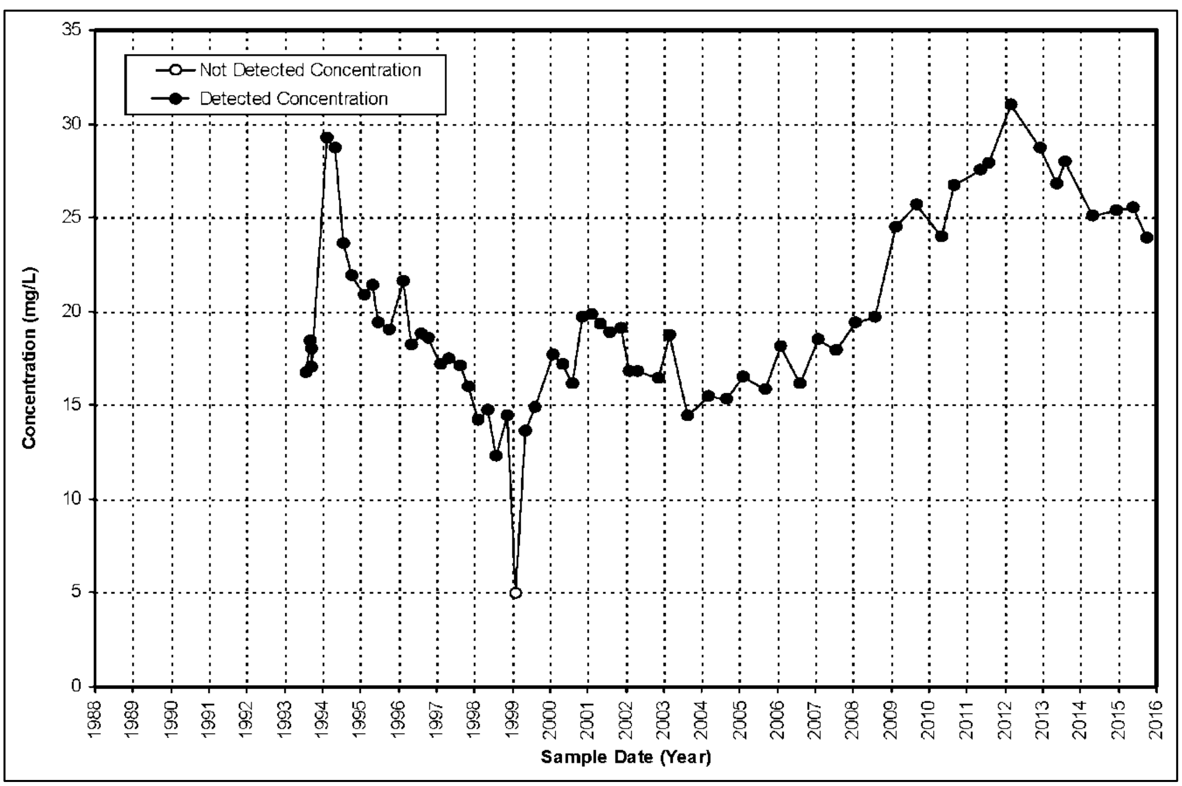


Figure A.4-86. Sodium Concentration Versus Time Plot for Monitoring Well 2898

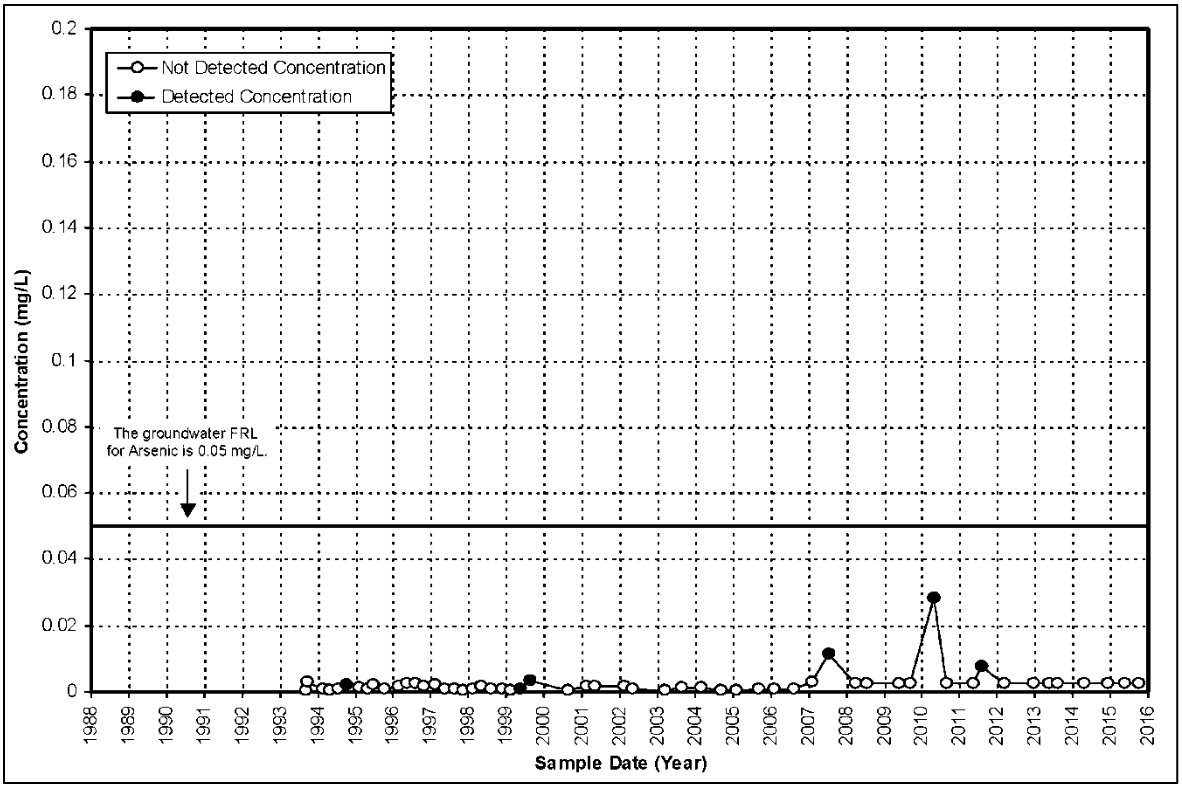
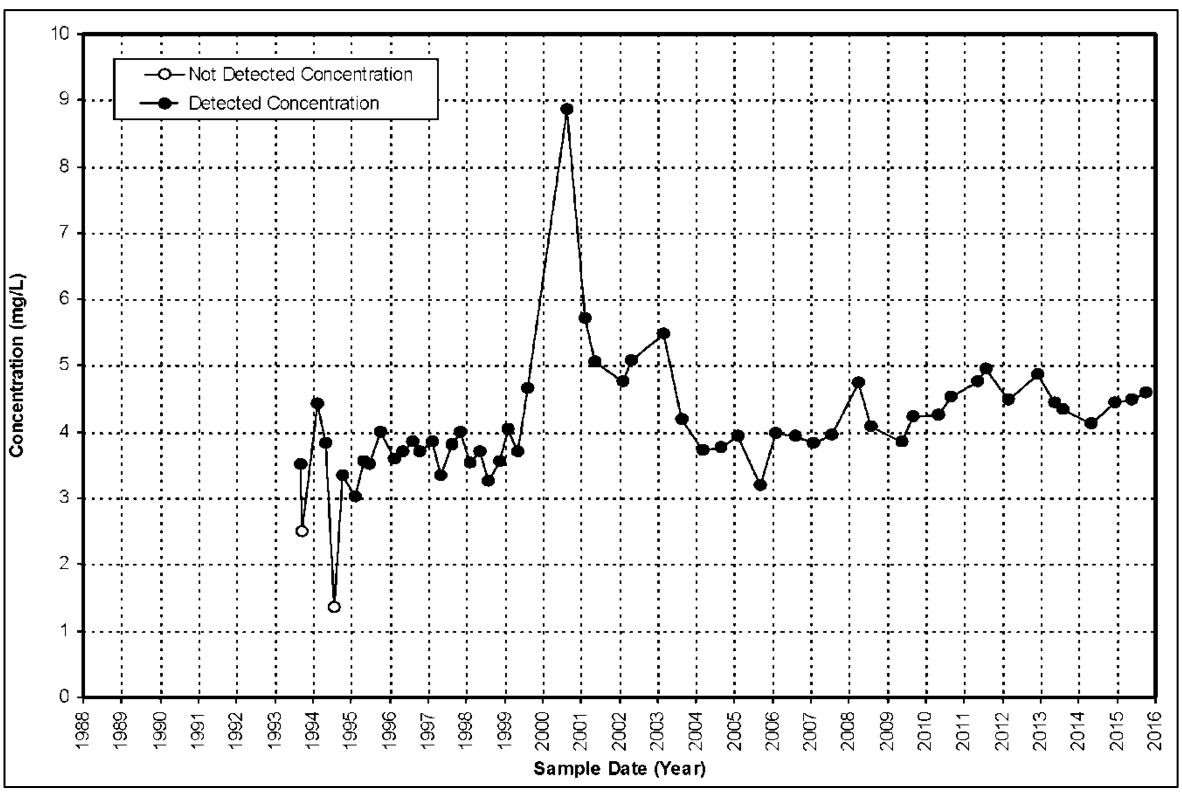


Figure A.4-87. Arsenic Concentration Versus Time Plot for Monitoring Well 2899



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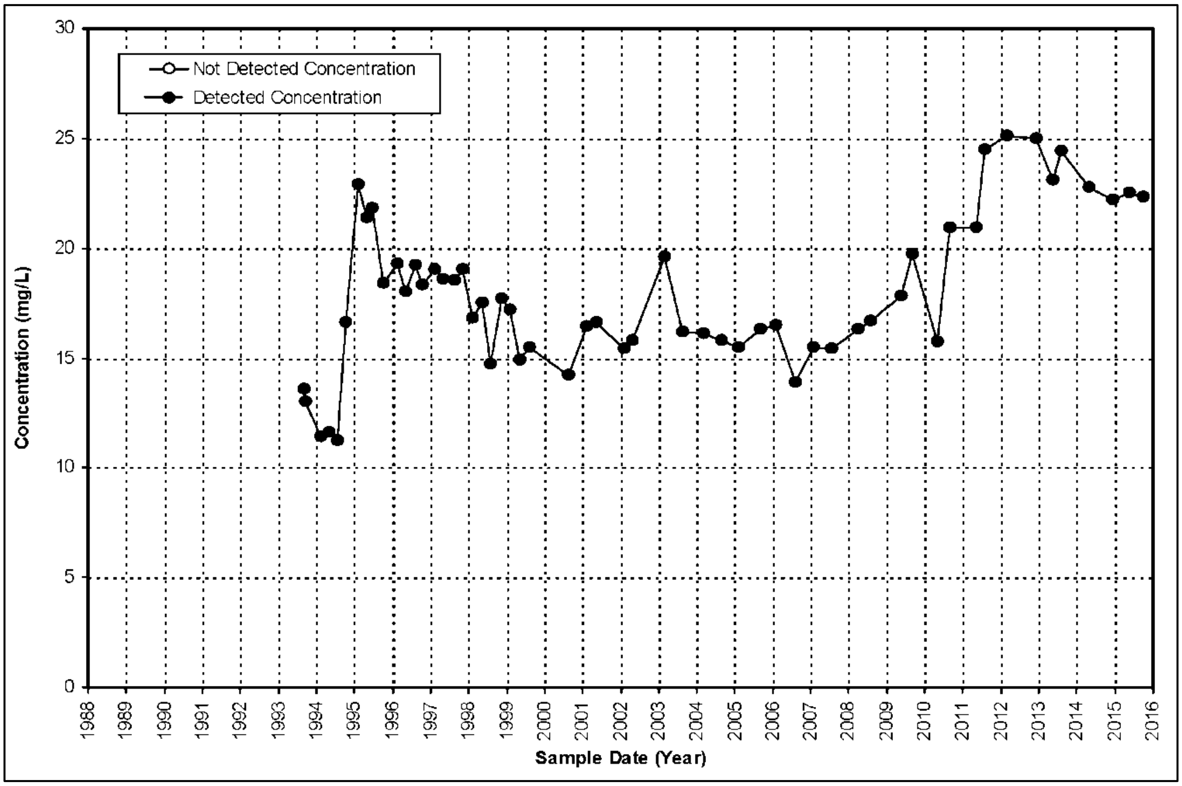

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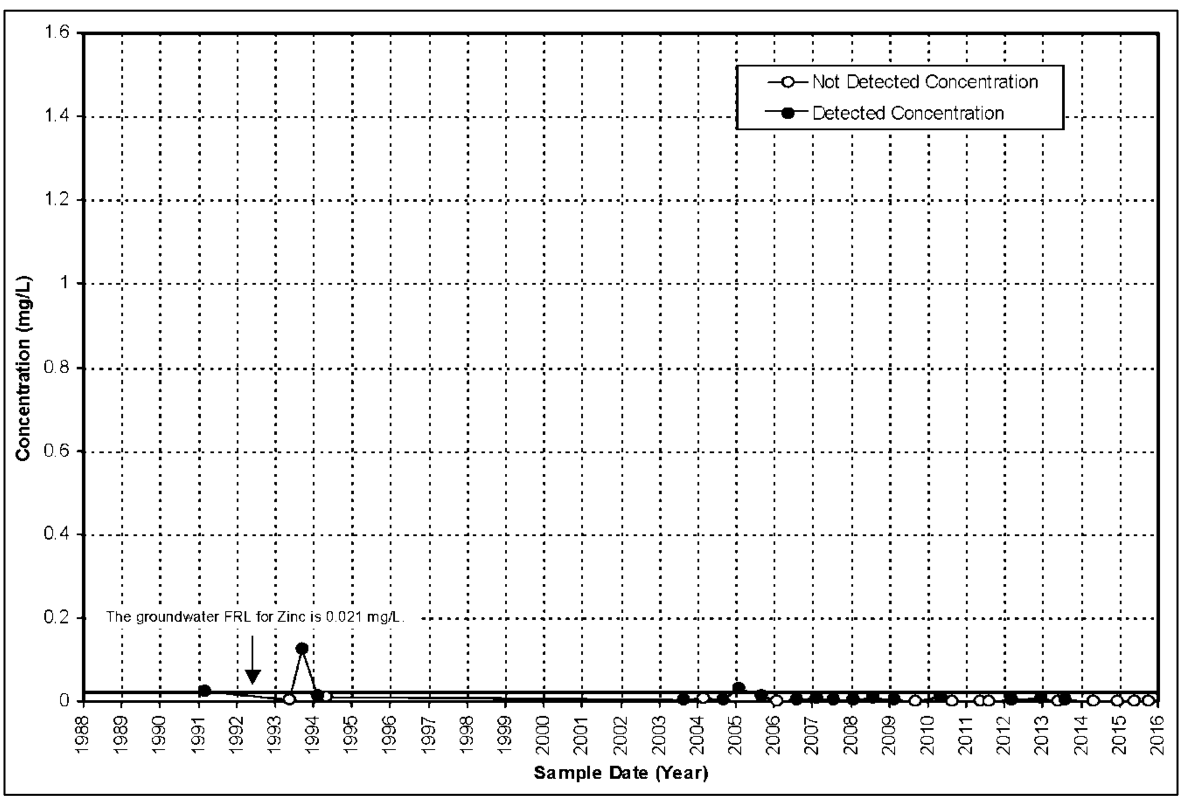

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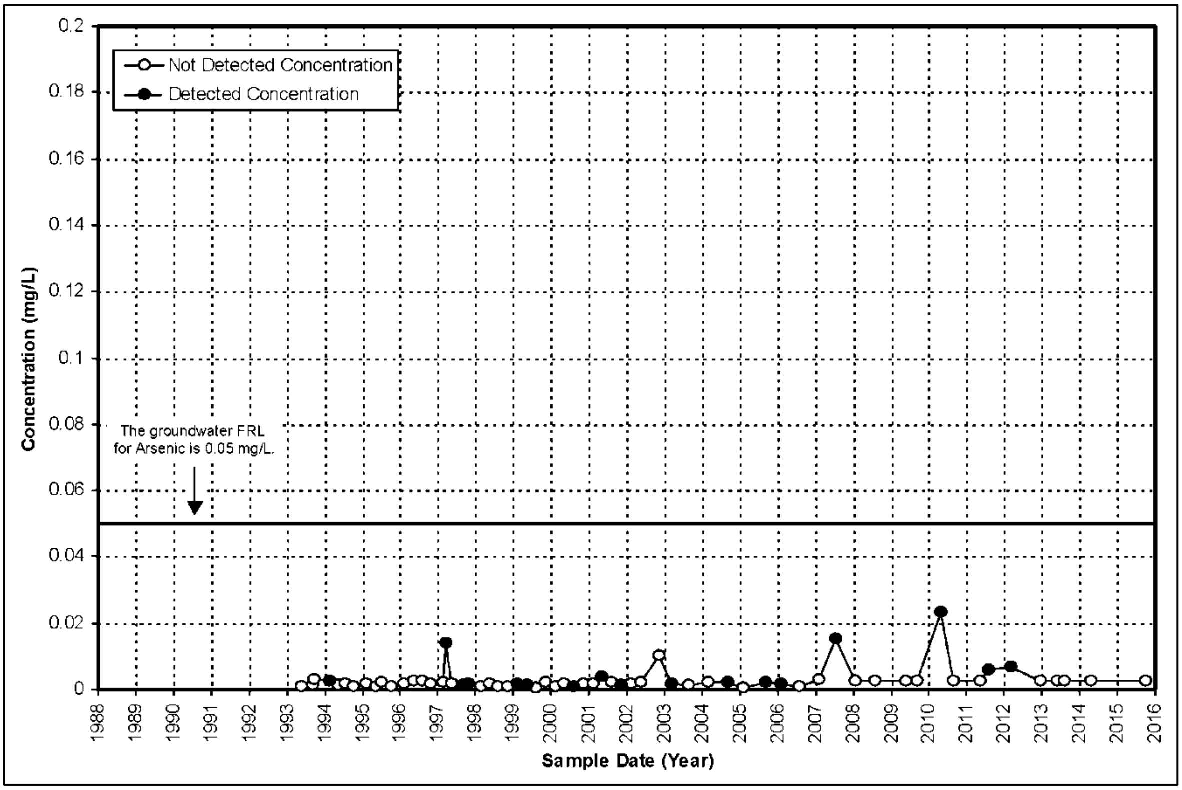

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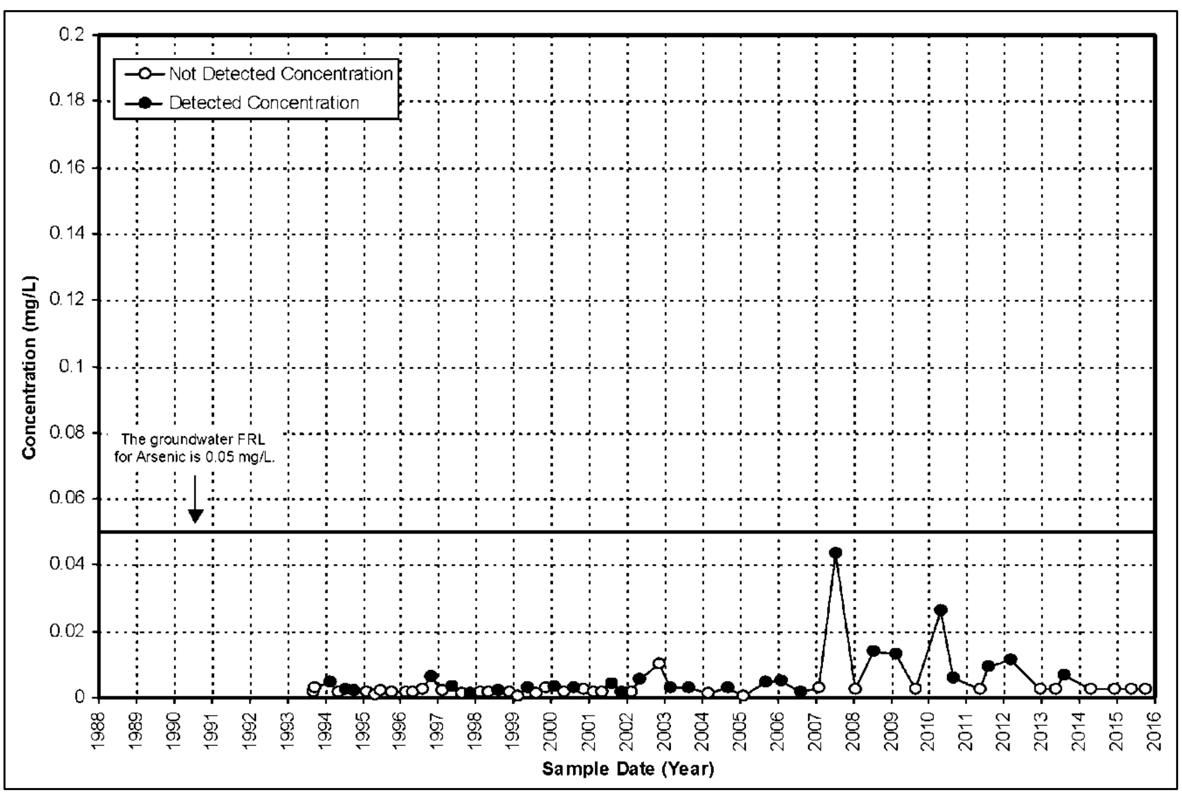
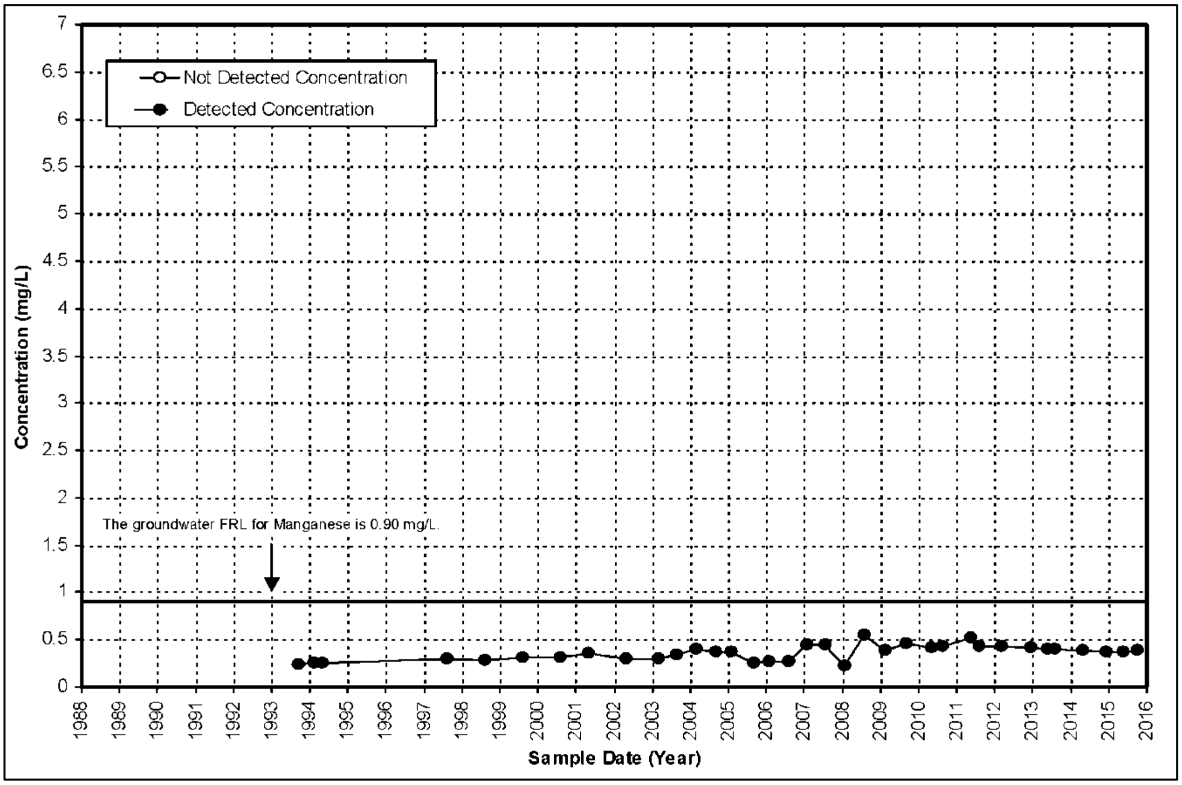


Figure A.4-92. Arsenic Concentration Versus Time Plot for Monitoring Well 3898



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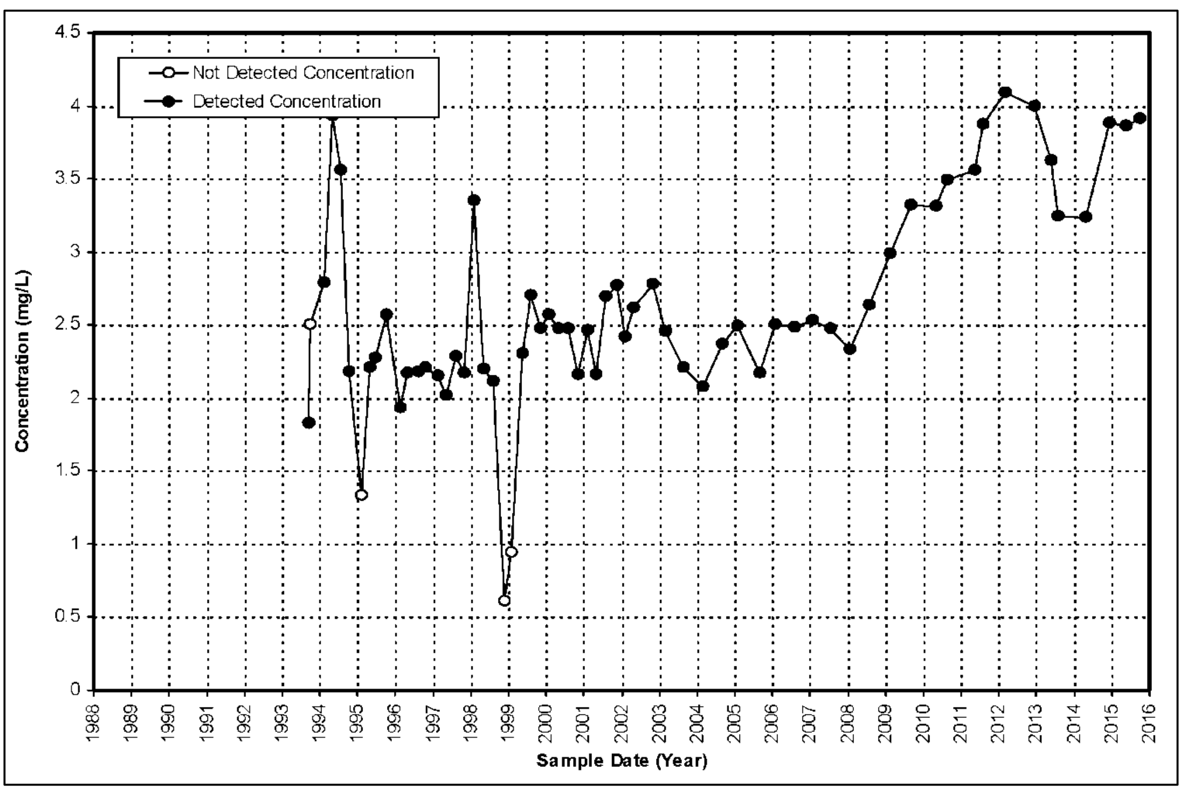

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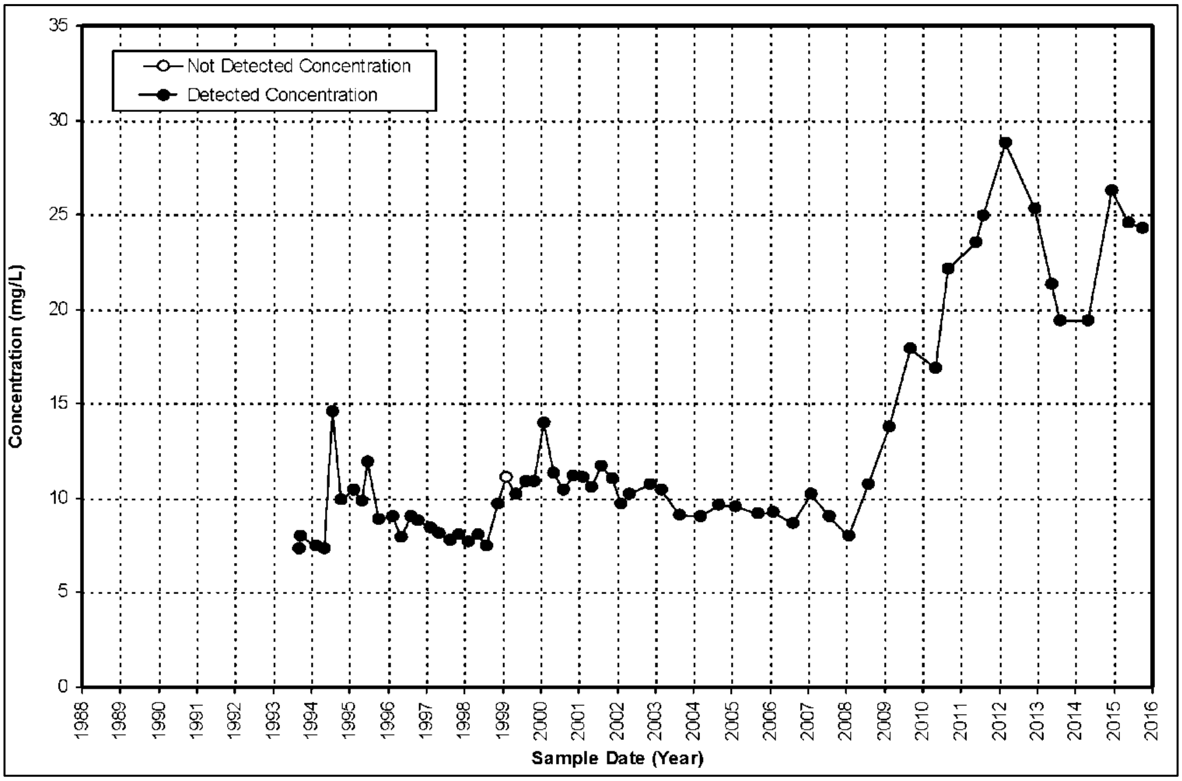

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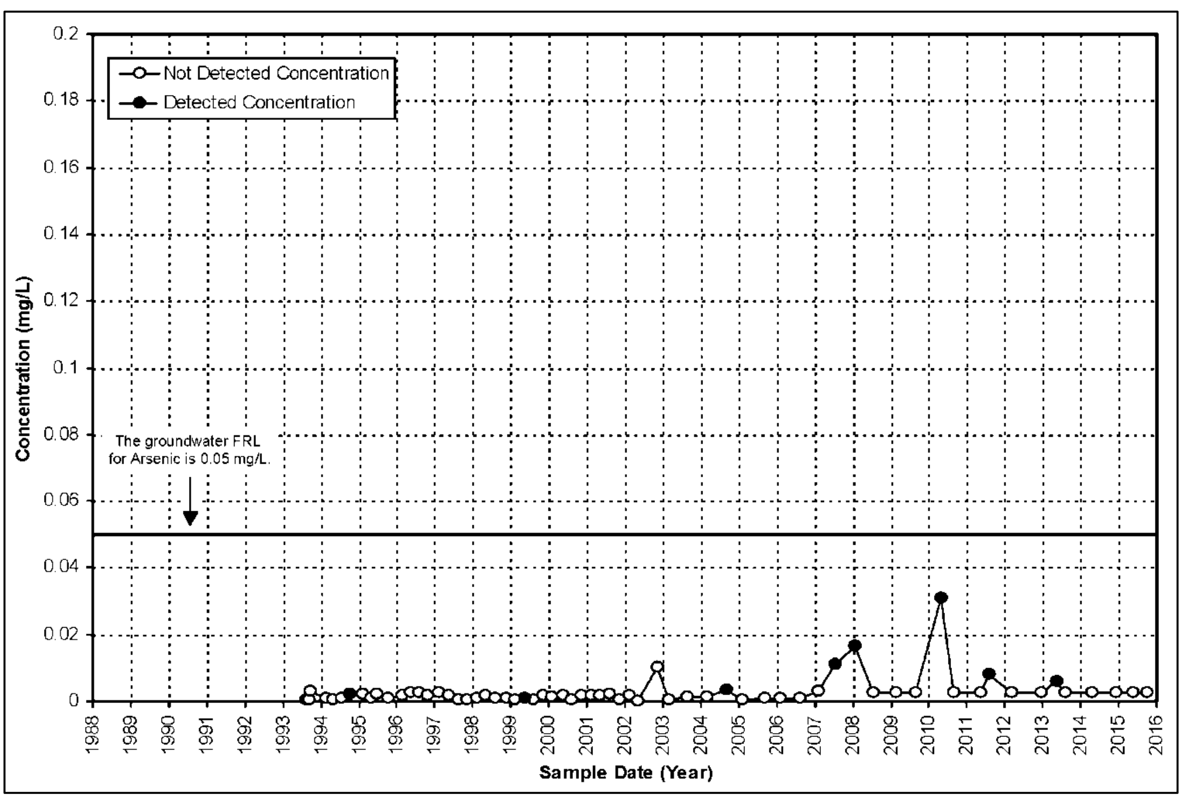

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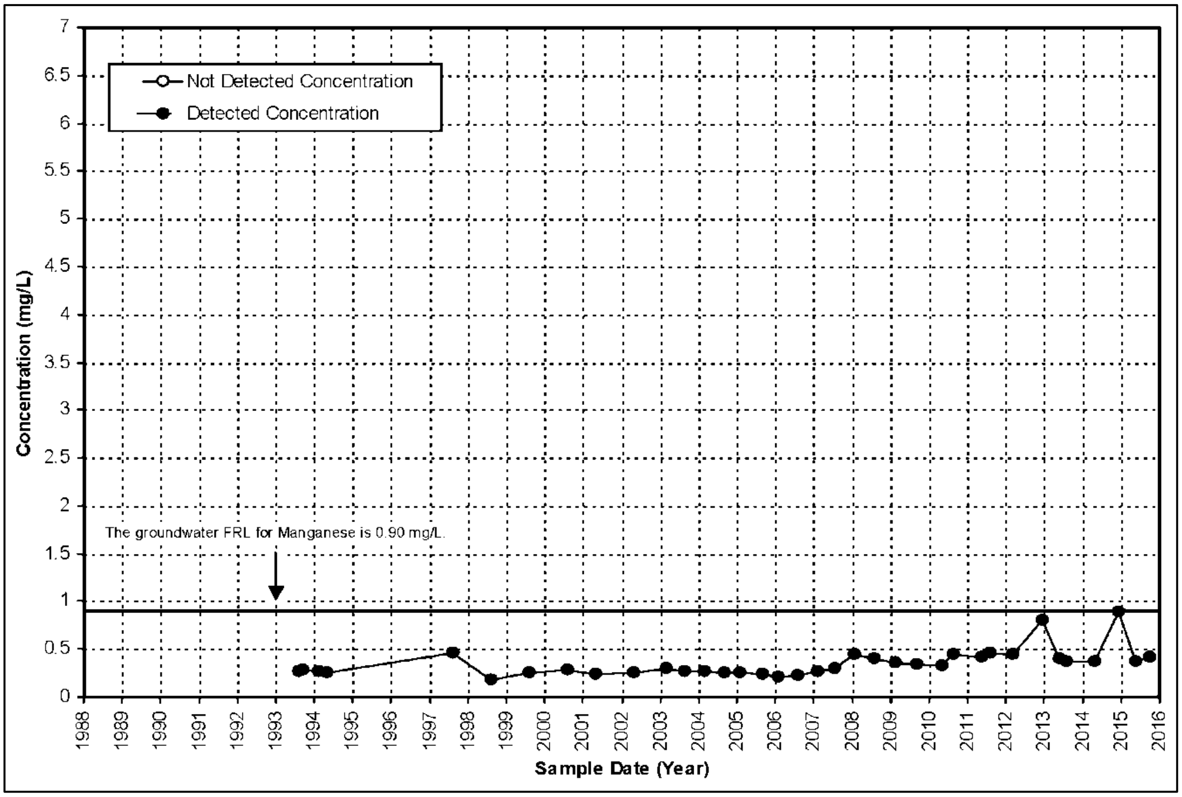


Figure A.4-97. Manganese Concentration Versus Time Plot for Monitoring Well 3899

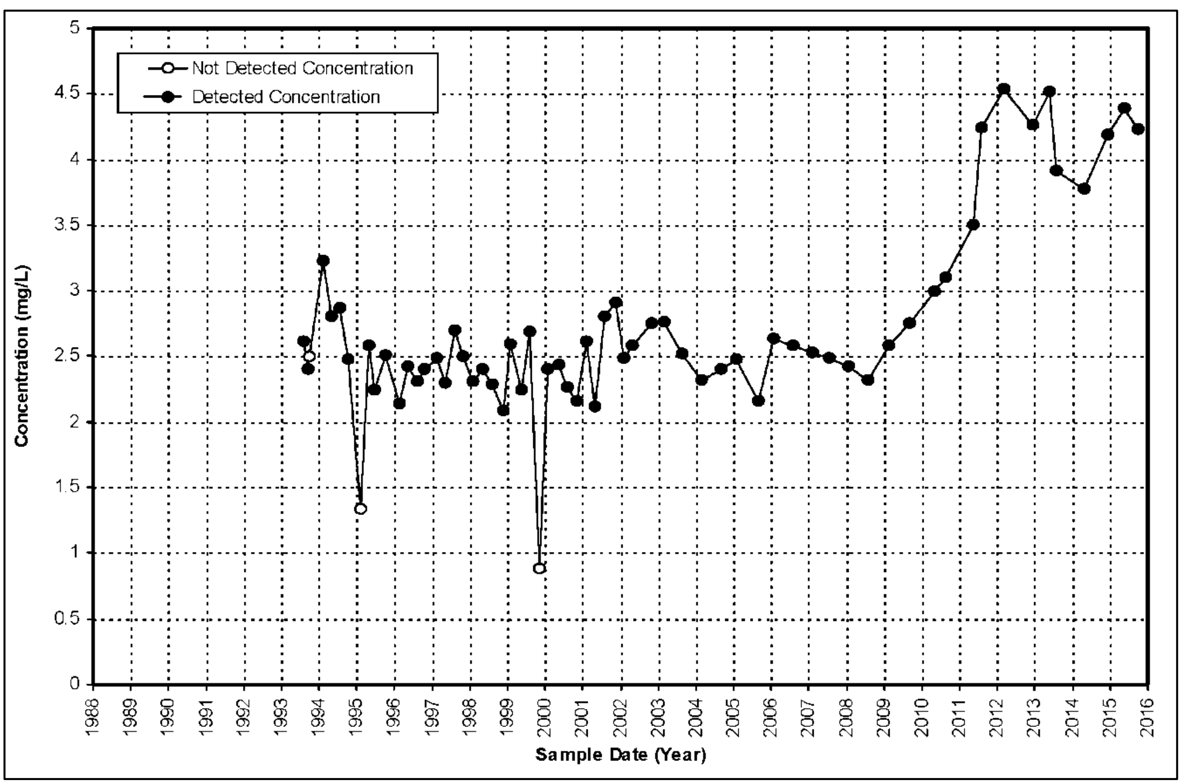
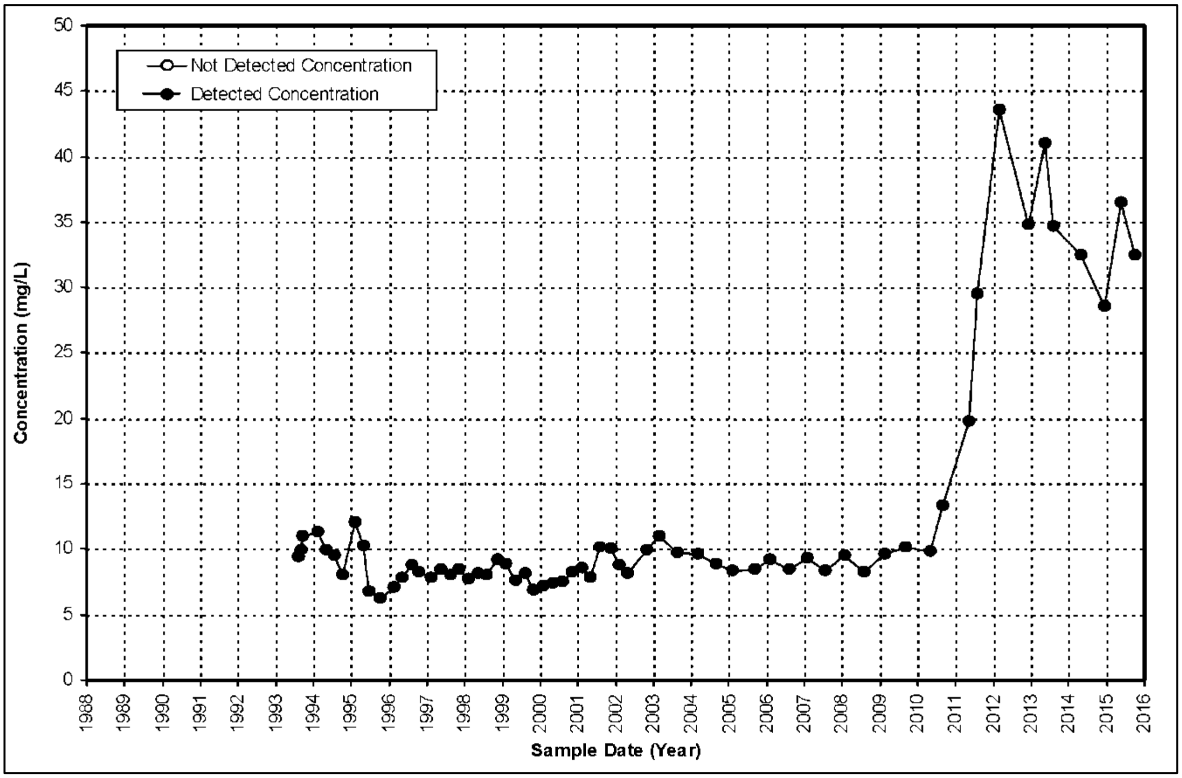


Figure A.4-98. Potassium Concentration Versus Time Plot for Monitoring Well 3899



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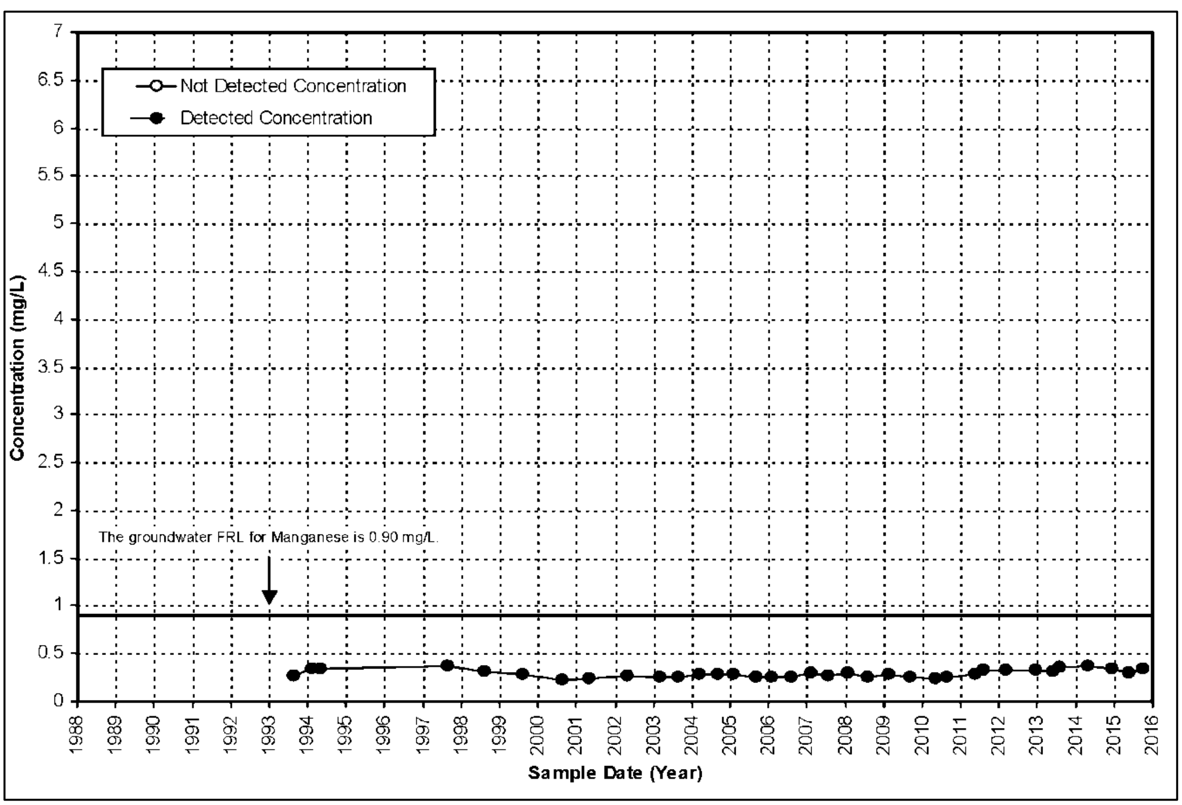

Figure A.4-100. Manganese Concentration Versus Time Plot for Monitoring Well 3900

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Attachment A.5

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Abbreviations

$CaCO_3$	calcium carbonate
CAWWT	Converted Advanced Wastewater Treatment Facility
CUSUM	Shewhart-cumulative sum
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
GMA	Great Miami Aquifer
GWLMP	Groundwater/Leak Detection and Leachate Monitoring Plan
HTW	horizontal till well
LCS	leachate collection system
LDS	leak detection system
OAC	Ohio Administrative Code
Ohio EPA	Ohio Environmental Protection Agency
OSDF	On-Site Disposal Facility
OU5 RI/FS	Operable Unit 5 Remedial Investigation/Feasibility Study
PCB	polychlorinated biphenyl
RLCS	redundant leachate collection system
SCL	Shewhart control limit
TDS	total dissolved solids
TOX	total organic halogen

Measurement Abbreviations

ft	feet
gpad	gallons per acre per day [(gallons/day)/acre]
mL/minute	milliliters per minute
pCi/L	picocuries per liter

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A.5.0 On-Site Disposal Facility Monitoring Results

This attachment provides results for the On-Site Disposal Facility (OSDF) leak detection and leachate monitoring program for 2015. Monitoring and sampling were conducted in accordance with the *Comprehensive Legacy Management and Institutional Controls Plan*, Attachment C "Groundwater/Leak Detection and Leachate Monitoring Plan" (GWLMP) (DOE 2016). The objective of the GWLMP is to meet regulatory requirements for groundwater detection monitoring in the Great Miami Aquifer (GMA) and perched groundwater system and to provide leachate monitoring information.

Facility Description

The OSDF is situated in the northeast area of the Fernald Preserve. It has a capacity of 2.96 million cubic yards (2.26 million cubic meters) and a maximum height of approximately 65 feet (ft) (20 meters). A security fence surrounds the OSDF and defines a footprint that occupies approximately 98 acres. The facility consists of eight individual cells. All eight cells were 100 percent full and capped by October 2006.

Protection of the GMA and the overlying perched groundwater system includes the following measures for each of the eight cells (refer to Figure A.5-1 for a cross section of the liner system):

- Leachate collection system (LCS)
- Leak detection system (LDS)
- Multilayer composite liner system
- Multilayer composite cap system

The LCS consists of a gravel layer installed beneath the encapsulated waste to collect rainwater that came in contact with the waste during cell construction and additional moisture that is draining from the waste following capping. The LDS is located beneath both the LCS and the primary geosynthetic liner system and provides a mechanism for collecting and monitoring leakage through the primary liner layer of the OSDF prior to any releases to the environment. Both systems drain to the west and extend beyond the synthetic liner systems into valve houses, where leachate becomes accessible for monitoring.

The base of each cell liner also slopes toward the centerline of the cell, and the centerline of the base is sloped toward the west. Leachate moving along the top of a liner would first travel toward the centerline and then west along the centerline to be drained from the cell via piping at the penetration box, which is the lowest elevation point of the cell.

Each cell is monitored below the penetration box with a horizontal till well (HTW), which represents the first monitoring point for a release from a cell. HTWs provide monitoring of the perched groundwater quality beneath the point where the LCS and LDS pipes exit the liner system. The GMA is monitored via both an upgradient and a downgradient monitoring well for each cell. Figure A.5-2 identifies the well locations associated with the OSDF. Table A.5-1 identifies specific dates for the following cell activities:

- Sample initiation for each monitoring horizon
- Waste placement initiation

- LDS volume measurement initiation
- Cap geomembrane layer completion
- Cap completion (through seeding)

A construction quality assurance/quality control program was executed for each cell of the OSDF. The synthetic liners and caps of each cell were inspected and tested for defects at the time of installation. Given the attention to quality assurance/quality control during the installation of the OSDF liner system, it is doubtful that a breach in the liner would have gone unnoticed, but it is possible that a breach could develop. Such a breach would provide a potential pathway for leachate migration, but adequate hydraulic head is needed to drive leachate through the breach and clay liner into the underlying horizon.

The GWLMP summarizes the principal geologic, hydrogeologic, and subsurface contaminant conditions in the OSDF area that had a direct bearing on the development of the monitoring program for the OSDF facility. As discussed in the GWLMP, the conceptual flow-path/migration pathway for a leak from the facility involves understanding:

- How each cell was constructed and how a cell transmits leachate from the facility.
- The impact of hydraulic head within the facility in the LDS and the design action leakage rate.
- Nature, thickness, and hydraulic conductivity of glacial clay beneath the facility.
- Residual soil contamination beneath the facility and its possible impact to HTW water quality results.
- Groundwater model evaluations of transport times and modeled flow-paths for use in placing monitoring wells for the monitoring network in the GMA.
- Modeled breakthrough travel times through the glacial clay for uranium (the main contaminant of concern) and for technetium-99 (the most mobile contaminant).

<u>Information Organization</u>

The 2015 OSDF leak detection and leachate monitoring information is organized in the following sections:

- Flow and Hydraulic Performance (Section A.5.1)
- Water Quality: Data Presentations/Evaluations (Section A.5.2)
- Cell Cap Inspections (Section A.5.3)
- Water Quality Monitoring Changes (Section A.5.4)
- Additional Assessment of the OSDF Groundwater/Leak Detection and Leachate Monitoring Program (Section A.5.5)
- Inspection of LCS and LDS lines (Section A.5.6)
- Summary of Overall Performance/Findings and Recommendations (Section A.5.7)

Subattachments A.5.1 through A.5.8 provide cell-specific information for Cells 1 through 8.

A.5.1 Flow and Hydraulic Performance

A.5.1.1 Overall LCS Volumes

In 2015, leachate volumes pumped from the LCS tanks were measured by readings recorded from capacitance probes installed in each primary containment vessel. The probes are attached through a remote control unit to the Converted Advanced Wastewater Treatment Facility (CAWWT) control room, where water levels are converted automatically to volumes based on the tank manufacturer's design specifications for the tanks.

If communication to the CAWWT is not functioning properly, tanks are pumped manually when the level reaches 40 percent full or 0.9 ft of leachate in the tank. Volumes pumped are recorded manually on the leachate round sheet. Volumes in the tank are based on levels in the tank and are calculated using the formula provided by the tank manufacturer.

Leachate volumes have been measured since waste placement began. Figure A.5-3 is a graph showing monthly leachate volumes from October 2006 through December 2015. Figure A.5-4 is a graph that shows the annual leachate volume from 2007 through 2015. The data collected in 2015 indicate that 130,378 gallons of leachate were collected and pumped to the CAWWT Backwash Basin for subsequent treatment at the CAWWT. The total volume measured in 2015 represents a 6.2% decrease from the total volume measured in 2014 (138,949 gallons). The volume of precipitation that fell on the OSDF in 2015 was approximately 66.1 million gallons (44.98 inches of rain over 54.1 acres). The facility cap was designed to inhibit rainwater from infiltrating into the OSDF. Leachate collected in 2015 represents approximately 0.2% of the precipitation that fell on the OSDF in 2015, indicating that the cap is performing as designed to reduce infiltration.

The GWLMP identifies that trend analysis of the LCS flow-monitoring measurements will be conducted for capped cells to provide an indication of changes in system performance. Monthly accumulation volumes for Cells 1 through 8 are plotted and provided in Subattachments A.5.1 through A.5.8. The semilog plots indicate that leachate volumes from the capped cells continue to decline over time, but the rate of decline is decreasing. The overall monthly facility leachate flow declined by 1,402 gallons or approximately 2% (65,938 gallons for January–June 2015 versus 64,536 gallons for July–December 2015). Comparing this rate with the 5% decline observed between the first and second half of 2015 demonstrates how this rate of decline continues to decrease. This is best illustrated by the trend line in Figure A.5-4.

A.5.1.2 LDS Accumulation Rates and Volumes

Quantitative measurement of the volumes accumulating in and pumped from the LDS tanks was initiated according to the various dates in Table A.5-1. These measurements were taken using the same methodology as described above for the LCS. These data are used to determine both accumulation rates (in gallons per acre per day [gpad]) and accumulation volumes (in gallons) for each cell's LDS.

The GWLMP states that trend analysis of the LDS flow monitoring measurements will be conducted for capped cells to provide an indication of changes in system performance. Monthly accumulation volumes for Cells 1 through 8 are provided and graphically displayed in Subattachments A.5.1 through A.5.8. The graphs indicate that overall LDS flows are declining.

Capacitance probe readings indicated that LDS tanks 2, 3, and 5 were dry during all four quarters of 2015. The LDS of Cell 4 was dry during the first three quarters of 2015. The capacitance probes can measure within hundredths of a foot of water in the bottom of the tank. Although water may register via the probes, there may not be enough water present to physically obtain a sample. This was the case in 2015 for the LDS in Cells 1, 2, 3, 4, and 5. Because the water volume was insufficient for sampling, the LDSs in Cells 1 through 5 were considered to be dry all year.

The *On-site Disposal Facility Final Design Calculation Package* (DOE 1997) defines an initial response leakage rate for individual cells of 20 gpad. The 2015 maximum LDS accumulation rates and the percent of the initial response leakage rate for each cell are as follows:

Cell	Maximum LDS Accumulation Rate Capacitance Probe Measurements (gpad)	Percent of Initial Response Leakage Rate
1	0.05	0.2
2	0.00	0.0
3	0.00	0.0
4	0.03	0.1
5	0.00	0.0
6	0.23	1.1
7	0.02	0.1
8	0.01	0.1

These LDS accumulation rates indicate that the liner systems for the cells are performing well within the specifications outlined in the approved OSDF design. The initial response leakage rate of 20 gpad is an administrative criterion for commencing an investigation into the possibility that the cell is not performing as designed. It is one-tenth of the design criterion of 200 gpad. Because all of the cells are closed and capped, it is expected that LDS accumulation rates will continue to diminish over time. Rates will continue to be closely tracked to document that the primary liner systems continue to perform as designed.

A.5.1.3 Liner Efficiencies

Cell-specific apparent liner hydraulic efficiencies are calculated using the following equation:

$$\text{Hydraulic efficiency} = [1 - (\text{Volume}_{\text{LDS}}/\text{Volume}_{\text{LCS}})] \times 100$$

Apparent liner hydraulic efficiency is a measure of how a cell's liner is performing. The above equation considers *all* the LDS volume to be leakage through the primary liner, which is a conservative measure. In the *Report on the 1995 Workshop on Geosynthetic Clay Liners* (EPA 1996), several sources of flow from leak detection layers are identified. These sources include:

- Top liner leakage
- Construction water and compression water

- Consolidation water
- Water from groundwater infiltration

Quarterly apparent liner efficiencies were consistently greater than 99% for Cells 1 through 8 throughout 2015 with the exception the third and fourth quarter in Cell 6, with an apparent liner efficiency of 98.25% and 98.35%, respectively. Quarterly apparent liner efficiencies (in percent) are provided below.

Apparent Liner Efficiency (percent), Quarterly for 2015

Quarter	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
First	99.79	100.00	100.00	100.00	100.00	99.58	99.93	100.00
Second	99.84	99.98	100.00	100.00	100.00	99.49	100.00	99.91
Third	99.98	99.98	100.00	99.97	100.00	98.25	99.87	99.98
Fourth	100.00	100.00	100.00	99.84	99.98	99.35	100.00	99.94

A.5.1.4 HTW Water Yields

HTW water yields are monitored at each cell to document trends in perched-water purge volumes. In 2015, the HTWs were purged twice (April and September). Average purge water yields from the HTWs ranged from 0 gallons beneath Cell 8 to 1,050 gallons beneath Cell 5. The HTW water yields will continue to be tracked and factored into the OSDF leak detection evaluation, where appropriate. The water-yield graphs are provided in each cell's subattachment and are updated with purge volume data collected prior to each sampling event.

A.5.2 Water Quality: Data Presentations/Evaluations

The water quality and data presentations/evaluations presented in this report consist of the following:

- Semiannual Monitoring Summary Statistics (Section A.5.2.1)
- Concentration Plots (Section A.5.2.2)
  - LCS, LDS, and HTW of each cell
  - HTW and GMA wells of each cell
- Control Charts (Section A.5.2.3)
- Annual LCS Monitoring Results (Section A.5.2.4)
- Additional LDS Monitoring (Section A.5.2.5)
- Bivariate Plots for Each Cell (Section A.5.2.6)
- Summary of Upward Concentration Trends in the HTW and GMA Wells (Section A.5.2.7)

A.5.2.1 Semiannual Monitoring Summary Statistics

Until 2014, quarterly water quality monitoring occurred in the LCS, LDS, HTW, and GMA wells of each cell for the purpose of determining if the OSDF is operating as designed. With U.S. Environmental Protection Agency (EPA) and Ohio Environmental Protection Agency (Ohio EPA) concurrence, the U.S. Department of Energy (DOE) changed from a quarterly sampling frequency to a semiannual sampling frequency at the start of 2014. Water quality within each cell is sampled in the LCS and LDS. Water quality beneath each cell is sampled in the HTW and GMA wells. Concentrations-versus-time plots, bivariate plots, and control charts are used to help interpret and present results.

In 2015, 24 parameters were sampled semiannually in the LCS, LDS, and GMA wells of each cell (total alkalinity as calcium carbonate [$CaCO_3$], chloride, chromium, nitrate + nitrite as nitrogen, total dissolved solids [TDS], total organic carbon, total organic halogens, sulfate, arsenic, barium, boron, calcium, cobalt, copper, iron, lithium, magnesium, manganese, nickel, potassium, selenium, sodium, zinc, and total uranium). HTWs in all cells were sampled semiannually for arsenic, total uranium, sodium, and sulfate. In addition, the LCS, LDS, and GMA wells of Cell 8 were sampled semiannually for technetium-99. Summary statistics for all of the parameters monitored semiannually are provided in Subattachments A.5.1 to A.5.8 (Tables A.5.1-1 through A.5.8-1). The information provided in each summary table is based on a standardized quarterly sampling frequency.

The process used for conducting the summary statistics is illustrated in Figure A.5-5. Table A.5-2 lists the rules that are used to report the data provided on Tables A.5.1-1 to A.5.8-1 in each subattachment. For analytical results below the detection limit, one-half the detection limit was used in calculations of the average, standard deviation, distribution, trend, serial correlation, and outliers. One objective of conducting the summary statistics is to identify the parameters that meet the requirements for control charts (i.e., greater than eight samples, normal or lognormal distribution, no trend, and no serial correlation).

Data used in the summary statistics were "quarterized" (i.e., normalized to quarterly data). The rationale behind this is that during different time periods, data were collected at varying time intervals. For example, from October 30, 1997, through December 8, 1997, 15 samples were collected for total uranium from HTW 12338. In all of 1998, only 4 were collected; in 1999 there were 7; in 2000 there were 6; and 4 each were collected in 2001 through 2003. So, in a 5- to 6-week period in 1997, nearly as much data were collected as were collected from 1998 to 2000. Without normalizing the data, the time periods with more sampling activity would carry more weight, and, therefore, with respect to the calculations, be considered more important. Additionally, sampling the same well at too short of an interval (often just one day apart in 1997) also violated the statistical assumption of independence. Well data that are collected too closely in time are serially correlated and can distort the statistics underlying the control charts. Even with quarterly sampling, there is often an issue with serial correlation.

ChemStat, Version 6.3, (a Starpoint Software program) was used to conduct the statistics. ChemStat software is used to perform the statistical analysis of groundwater monitoring data at Resource Conservation and Recovery Act facilities. The website for the software is www.pointstar.com.

Data set distributions were checked using the Shapiro Wilk Test (95% confidence interval) for data sets with fewer than 50 samples and the Shapiro-Francia Test (95% confidence interval) for data sets with 50 samples or more. The Mann-Kendall test for trend (95% confidence interval) was used to determine the presence of either an upward or downward concentration trend over time. The rank Von Neumann test (confidence interval of 99%) was used to check for serial correlation.

A.5.2.2 Concentration Plots

Concentration plots for the 24 parameters monitored semiannually in the LCS and LDS and the 4 parameters monitored semiannually in the HTW of each cell in 2015 are presented in Subattachments A.5.1 to A.5.8. The plots are presented with a common *y*-scale based on the parameter. Outliers identified in Subattachments A.5.1 through A.5.8 in Tables A.5.1-1 through A.5.8-1 are not plotted on the concentration plots.

A.5.2.3 Control Charts

Intrawell control charts employ historical measurements from a compliance point as background. The *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities—Unified Guidance* (EPA 2009) defines the process of creating a Shewhart-cumulative sum (CUSUM) control chart works as follows. Appropriate background data are used to define a baseline for the well. The baseline parameters for the chart, estimates of the mean, and standard deviation are obtained from the background data. These baseline measurements characterize the expected background concentrations at the monitoring point. As future concentrations are measured, the baseline parameters are used to standardize the newly gathered data. After these measurements are standardized and plotted, a control chart is declared "out of control" if future concentrations exceed the baseline control limit. This is indicated on the control chart when either the Shewhart or CUSUM plot traces begin to exceed a control limit. The limit is based on the rationale that if the monitoring point remains unchanged from the baseline condition, new standardized observations should not deviate substantially from the baseline mean. If a change occurs, the standardized values will deviate significantly from the baseline and tend to exceed the control limit.

A minimum of eight samples are recommended for use in ChemStat software to define the baseline for a control chart. Therefore, only sample sets with greater than or equal to eight samples were selected for control charts. By default, the ChemStat software plots both a CUSUM control limit (h) and a Shewhart control limit (SCL) on the control chart. The software recommends a value of 5 for the CUSUM control limit (h) and a value of 4.5 for the SCL control limit.

EPA Unified Guidance (EPA 2009) suggests that to simplify the interpretation of the control chart, an out-of-control condition should be based on the CUSUM (h) limit alone. Plotting the SCL limit is not needed. However, the ChemStat software, by default, plots both the SCL and CUSUM control limit (h) on the charts. To address this issue, the SCL limit was defined as 5 to equal the recommended CUSUM control limit (h). This combined limit is identified as hCL on the control charts. For interpretation purposes, the hCL will be regarded as the CUSUM control limit (h).

One hundred and two Shewhart-CUSUM control charts were prepared in 2015 and are presented in Subattachments A.5.1 through A.5.8 for parameters monitored semiannually in the HTW and GMA wells in 2015 and had data sets that achieved control chart criteria (i.e., more than eight samples, normal or lognormal distribution, no trend, and no serial correlation). In 2012, 78 control charts were prepared. In 2013, 127 control charts were prepared. In 2014, 121 control charts were prepared.

Of the 102 control charts presented, 99 (97%) exhibit "in control" conditions, and 3 (3%) exhibit "not in control" conditions. The 3 "not in control" conditions were as follows:

- Cell 4 (arsenic in HTW 12341)
- Cell 5 (TDS in monitoring well 22208)
- Cell 8 (chromium in monitoring well 22217)

A.5.2.4 Annual LCS Monitoring Results

Once a year, the LCS of each cell is sampled for an abbreviated list of Appendix I parameters and polychlorinated biphenols (PCBs) listed in *Ohio Administrative Cod*e (OAC) 3745-27-10. A summary of the results for each cell is provided in Subattachments A.5.1 through A.5.8 (Tables A.5.1-2 through A.5.8-2).

- One new Appendix I or PCB parameter (beryllium) was detected in the LCS of Cell 4 in 2015. Detection of beryllium in the LCS of Cell 4 in 2016 will trigger sampling for beryllium in the LDS of Cell 4 during the subsequent sampling event.
- In 2014, lead was detected for the first time in the LCS of Cell 8. Lead was not detected in the LCS of Cell 8 in 2015.
- Cadmium was detected for the first time in the LCS of Cell 6 in 2013. Cadmium was not detected in the LCS of Cell 6 in 2014 or 2015.

A.5.2.5 Additional LDS Monitoring

As stated in Appendix B of the GWLMP (DOE 2016) "two consecutive detects in a cell's LCS will trigger sampling in the cell's LDS during the next scheduled sampling round." In Cells 3, 7, and 8, additional sampling is taking place in the LDS. A summary and status of the additional LDS sampling is provided below.

- **Ammonia in Cell 3:** First detected in the LCS of Cell 3 in 2009, a consecutive detect was made in 2010. Ammonia is therefore being sampled for in the LDS of Cell 3. The LDS of Cell 3 has been dry since 2011. Ammonia was detected in the LCS of Cell 3 from 2011 through 2014, but it was not detected in 2015.
- **1,1-Dichloroethene in Cell 7:** First detected in the LCS of Cell 7 in 2009, a consecutive detect was made in 2010. It was detected in the LCS of Cell 7 in 2011 but not from 2012 through 2015. Sampled for twice in the LDS of Cell 7 in 2011, it was not detected. The LDS was dry in 2012 and 2013. In 2014 and 2015, the LDS was sampled twice, and 1,1-dichloroethene was not detected in either year.
- **1,1-Dichloroethene in Cell 8:** First detected in the LCS of Cell 8 in 2009, a consecutive detect was made in 2010. It was detected in the LCS of Cell 8 in 2011 but not from 2012

through 2015. Sampled for twice in the LDS of Cell 8 in 2011, it was not detected. Sampled for once in the LDS in 2012 (LDS of Cell 8 was dry for three of the four quarters in 2012) it was not detected. It was not detected in the LDS in 2013, 2014, or 2015.

- **Cadmium in Cell 8:** First detected in the LCS of Cell 8 in 2011, consecutive detect made in 2012. Cadmium was not detected in either the LCS or the LDS of Cell 8 in 2013, 2014, or 2015.

A.5.2.6 Bivariate Plots for Each Cell

Bivariate plots are used in an Alternate Source Determination capacity to show that water quality changes observed beneath the facility in HTW and GMA wells are not attributed to facility performance. Sodium and total uranium were selected because this combination provides a good distinction between LCS, LDS, and HTW. This combination was discovered during the Common Ion Study (DOE 2008a). Although the sodium-uranium bivariate plot for Cell 8 provides a distinction between the LDS and HTW, the separation shown between the LDS and HTW is not as distinct as it is for the other seven cells; therefore, a sulfate-uranium bivariate plot is also provided for Cell 8. Other combinations may be added if deemed appropriate.

Bivariate plots for uranium-sodium are presented for each cell in Subattachments A.5.1 through A.5.8. The bivariate plots illustrate the concentration signatures for total uranium and sodium in each monitoring horizon. Distinct clustering of horizon concentrations indicates that the fluids in the different horizons are not mixing. In response to an Ohio EPA comment on the *Fernald Preserve 2009 Site Environmental Report* (DOE 2010) (Ohio EPA Comment Number 35) the closest points between monitoring horizons are dated.

An additional bivariate plot for uranium–sulfate is presented for Cell 8 in Subattachment A.5.8. The additional uranium-sulfate bivariate plot provides supporting information concerning the water chemistry signatures that are present in the LDS and HTW of Cell 8; specifically, that they are separate and distinct.

The bivariate plots for 2015 continue to support the interpretation that chemical signatures for the different monitoring horizons are separate and distinct, indicating that mixing between the horizons is not occurring; therefore, upward concentration trends measured beneath the cells in 2015 (HTW and/or GMA wells) are attributed to fluctuating ambient concentrations beneath the cell that are not related to cell performance.

A.5.2.7 Upward Concentration Trends in the HTW and GMA Wells

The HTW is located beneath the liner penetration box of each cell by design. This area of the liner penetration box is considered to be potentially the weakest point in the cell design. If a leak were to develop, it should be detected beneath the liner penetration box first. Therefore, the water quality in the HTW represents the first line of evidence that a potential leak from the cell might be occurring. A leak would be indicated by an increasing concentration trend in the HTW.

GMA monitoring wells are positioned (and identified) for pre-aquifer-remediation flow conditions defined in the Operable Unit 5 Remedial Investigation/Feasibility Study (OU5 RI/FS) Report. Water level data reported in the OU5 RI/FS Report indicate that prior to the start of pumping for the groundwater remediation, groundwater flow directions in the vicinity of the OSDF were generally from west to east.

Groundwater flow beneath the OSDF is currently being influenced by active pumping taking place for the groundwater remediation southwest of the OSDF. Water beneath the OSDF is generally moving in response to this pumping from northeast to southwest. When pumping for the groundwater remedy stops, groundwater flow in the vicinity of the OSDF should once again return to a direction that is generally from west to east. Upward trends are therefore being tracked in all GMA wells at this time.

An increasing concentration trend in a GMA monitoring well could be attributed to a possible leak from the OSDF. In addition, increasing concentration trends in the HTW or GMA wells could also be caused by fluctuating ambient concentrations beneath the cells not connected to the operation of the facility.

As presented in Subattachments A.5.1 through A.5.8, several parameter data sets have upward concentration trends beneath the OSDF (i.e., HTW and GMA wells). Bivariate plots (uranium-sodium and uranium-sulfate) indicate separate and distinct chemical signatures for the LCS, LDS, and HTW of all eight cells. This indicates that water is not mixing from inside the facility to outside the facility, leading to the conclusion that the facility is not leaking. Therefore, concentration increases observed in the GMA wells are attributed to fluctuating ambient concentrations beneath the cells, and not to cell performance. Additional information is provided in Subattachments A.5.1 through A.5.8.

A.5.3 Cell Cap Inspections

OSDF cell cap inspections are conducted quarterly. Quarterly inspection includes the toe of the side slopes, the drainage features around the base of the cell cap, and the fence line. A complete inspection of the cell cap is conducted annually. The inspection team typically includes representatives from Ohio EPA, Ohio Department of Health, and the site contractor. Issues identified during inspections typically include small erosion rills, rocks that surface as topsoil settles, animal burrows and digging, small areas that require reseeding, and the presence of woody vegetation, thistle, or other noxious species.

The issues are addressed as follows:

- Erosion rills are repaired if they exceed 3 inches wide by 6 inches deep.
- Rocks that surface are removed, especially if they will interfere with mowing activities or may be a source location for erosion.
- Animal burrows and holes are filled in and reseeded, if necessary.
- Areas that require reseeding are seeded and covered with jute matting to help prevent erosion of the seed.
- Woody vegetation is removed and herbicide is applied to the noxious weeds.

Following each inspection, a report is submitted to the agencies documenting the inspection and issues and stating how issues will be addressed. These reports are available to the public on the Fernald Preserve website http://www.lm.doe.gov/fernald/sites.aspx. In 2015, inspections were conducted in March, June, September, and December. In 2015, there were no visual signs that the integrity of the cap had been compromised in any way.

A.5.4 Water Quality Monitoring Changes

DOE completed a parameter selection process in 2011 that had been ongoing for several years. Established in consultation with the Ohio EPA in 2005 and 2006, the objective of the process was to identify the Appendix I and PCB parameters detected in the LCS that would provide the most promise for detecting a leak from the facility and therefore warrant more frequent and robust monitoring. A description of the process and the results of the process were documented in the *Fernald Preserve 2011 Site Environmental Report* (DOE 2012).

The process can be briefly described as a statistical screening procedure that was applied to each cell. The 24 parameters selected by the process were parameters that had been most detected in the LCS at concentrations large enough to be measured beneath the facility should a leak in the facility ever occur. Specifically:

- Parameters had been detected at least 25 percent of the time in the LCS.
- Parameters were shown statistically to have a mean concentration in the LCS that is larger than the mean concentration of the pre-design or background data sets.

Results from the parameter selection process for LCS data from Cells 1, 2, and 3 were reported in the *Fernald Preserve 2007 Site Environmental Report* (DOE 2008b). Six additional parameters were identified for more frequent and robust monitoring (arsenic, cobalt, nickel, selenium, TDS, and zinc). Quarterly sampling for these six additional parameters in the LCS, LDS, HTW, and GMA wells of each cell began in 2009.

Results from the parameter selection process for LCS data from Cells 4 and 5 were presented in the *Fernald Preserve 2009 Site Environmental Report* (DOE 2010). Eight additional parameters were identified for more frequent and robust monitoring (total alkalinity as $CaCO_3$, chloride, nitrate + nitrite as nitrogen, barium, calcium, copper, magnesium, and potassium). Quarterly sampling for these eight additional parameters in the LCS, LDS, HTW, and GMA wells of each cell began in 2011. Vanadium was also identified for quarterly sampling in the LCS, LDS, and GMA wells of Cell 5, and technetium-99 was identified for quarterly sampling in the LCS, LDS, and GMA wells of Cell 8. As reported in the *Fernald Preserve 2012 Site Environmental Report* (DOE 2013), sampling for vanadium ended in the LCS, LDS, and GMA of Cell 5 beginning in 2013.

Results from the parameter selection process for LCS data from Cell 6 were presented in the *Fernald Preserve 2010 Site Environmental Report* (DOE 2011). No new parameters were identified for quarterly monitoring.

Results from the parameter selection process for Cells 7 and 8 were presented in the *Fernald Preserve 2011 Site Environmental Report* (DOE 2012). One additional parameter (chromium) was identified for quarterly monitoring. Quarterly monitoring for chromium in the LCS, LDS, and GMA wells of each cell began in 2013.

The resulting quarterly sampling list was as follows:

Quarterly Sampling in the LCS, LDS, and GMA of each Cell

Total alkalinity as $CaCO_3$	Barium	Manganese
Chloride	Boron	Nickel
Nitrate + nitrite as nitrogen	Calcium	Potassium
Total Dissolved Solids	Cobalt	Selenium
Total organic carbon	Copper	Sodium
Total organic halogen	Iron	Zinc
Sulfate	Lithium	Total uranium
Arsenic	Magnesium	Chromium

Additional, cell-specific sampling included:

- Quarterly sampling for vanadium in the LCS, LDS, and GMA wells of Cell 5.
- Quarterly sampling for technetium-99 in the LCS, LDS, and GMA wells of Cell 8.

A.5.4.1 Monitoring Changes Implemented in 2011

Beginning in the second quarter of 2011, DOE implemented the following monitoring changes:

- For 1 year, tritium was added to the quarterly sampling list for all four horizons of all eight cells.
- The quarterly sampling list for the HTW of each cell was reduced to tritium, total uranium, arsenic, and sodium. Sodium was retained to support the preparation of bivariate plots.

These changes stemmed from an informal proposal made to DOE by Ohio EPA in February 2011 via email.

Tritium sampling was conducted from the second quarter of 2012 to the first quarter of 2013. The results indicate that tritium was only detected in the LCS of Cell 8. The August 4, 2011, sample from the Cell 8 LCS (12345C) had a concentration of 373 picocuries per liter (pCi/L), with a "J" validation qualifier indicating that the concentration was estimated. The February 27, 2012, sample from the Cell 8 LCS (12345C) also had a concentration of 373 pCi/L with a "J" validation qualifier indicating that the concentration was estimated.

Based on the lack of detections made, DOE discontinued sampling for tritium. Quarterly sampling in the HTW continued for total uranium, arsenic, sodium, and sulfate. Arsenic is included at the request of Ohio EPA, and total uranium, sodium, and sulfate are included to provide data for bivariate plots.

A.5.4.2 Monitoring Changes Implemented in 2014

Beginning in 2014:

- The sampling frequency was changed from quarterly to semiannually.
- Vanadium was removed from the semiannual monitoring list for Cell 5.

<u>Sampling Frequency Change</u>
Ohio Solid Waste Regulations (OAC 3745-27-10) allow for a semiannual sampling frequency for detection monitoring after the first year of sampling. At the request of Ohio EPA, sampling had remained on a quarterly frequency through 2013. With EPA and Ohio EPA concurrence, DOE changed from a quarterly sampling frequency to a semiannual sampling frequency at the end of 2013. The supporting argument for the change can be found in the *Fernald Preserve 2012 Site Environmental Report* (DOE 2013).

<u>Vanadium in Cell 5</u>
In 2009, vanadium was identified for quarterly monitoring in Cell 5 only based on the outcome of the parameter selection process that was being conducted at the time. It was discovered in 2013 that the designation was a mistake. The parameter selection process that was conducted for Cell 5 required a detection rate of at least 25%. Vanadium in the Cell 5 LCS had a detection rate of only 21% (see Table A.5.5-4 in the *Fernald Preserve 2009 Site Environmental Report* [DOE 2010]). A review of the data collected through 2012 indicated that vanadium still only had a detection rate of 21.7% in the LCS (Table A.5.5-1). Vanadium has never been detected in the LDS or HTW of Cell 5. With EPA and Ohio EPA concurrence, vanadium was dropped from the quarterly monitoring list for Cell 5 beginning January 1, 2014. It continues to be sampled annually in the LCS.

A.5.5 Additional Assessment of the OSDF Groundwater/Leak Detection and Leachate Monitoring Program

In 2015, DOE, EPA, and Ohio EPA held several discussions concerning the OSDF Groundwater/Leak Detection and Leachate Monitoring Program. The discussions involved the following:

- The results of an independent assessment of the parameter selection process for the alternate sampling list of 24 constituents completed by a recognized statistical expert in the field of environmental studies. The assessment concluded that only 12 of the 24 parameters should remain in the monitoring program. Section A.5.5.1 provides further discussion.
- Low flow rates in the LDS, coupled with the sampling logistics involved with the geometry of the collection tanks in the valve houses, create opportunities for sample degassing due to prolonged contact of a water sample with the atmosphere and the collection of stagnant samples due to incomplete tank pump-outs. The samples being analyzed from the LDS may not accurately represent the chemistry of the facility leachate and could lead to future false positive and negative indications of a leak from the facility. Section A.5.5.2 provides further discussion.
- An additional geochemical assessment concluded that sample degassing and oxidation of the samples collected from the LDS collection tanks were not large enough to adversely impact the continued use of bivariate plots. The use of bivariate plots should continue in order to

demonstrate chemical independence between the LCS, LDS, and HTW. Section A.5.5.3 provides further discussion.

A.5.5.1 Independent Assessment of the Monitoring Parameter Selection Process

The controlling document for leak detection and leachate monitoring at the OSDF is the *Groundwater/Leak Detection and Leachate Monitoring Plan* (Attachment C of the 2016 LMICP [DOE 2016]). As presented in the plan, Ohio Solid Waste Regulations (OAC 3745-27-19(M)(5)) require collection and analysis of leachate annually for Appendix I constituents and PCBs listed in OAC 3745-27-10. Ohio Solid Waste regulations OAC 3745-27-10(D)(2) and (3) allow for the selection of an alternate list of constituents to monitor in lieu of some or all of the constituents listed in Appendix I of OAC 3745-27-10.

As discussed in Section A.5.4, DOE completed a parameter selection process in 2011 that had been ongoing for several years. The parameter selection process was established in consultation with EPA and Ohio EPA to select an alternate list of constituents to monitor; it relied heavily on the use of statistics to select the most useful constituents. The parameter selection process resulted in an alternate list of 24 constituents specific to the OSDF.

As a final step to conclude the parameter selection process, DOE obtained the services of a recognized expert in the field of statistics to conduct an independent assessment of the parameter selection process that was used. Dr. Kirk Cameron performed the assessment in 2014 (MacStat Consulting 2014) and presented the results to DOE, EPA, and Ohio EPA on April 15, 2015, at the Fernald site.

The selected parameter list was assessed to reduce the potential for false positive or false negative conclusions concerning the interpretation of the data sets. The independent assessment concluded that 12 of the 24 constituents on the Fernald alternate sampling list for the OSDF should be eliminated from the sampling effort. As explained in the report, the 12 parameters proposed for elimination either added no value to the monitoring effort or increased the potential for a false positive or false negative conclusion based on the statistics being applied to evaluate the data sets. The 12 monitoring constituents that should remain in the OSDF sampling program are total uranium, boron, total organic halogen (TOX), sulfate, lithium, selenium, TDS, calcium, magnesium, nitrate + nitrite as nitrogen, potassium, and technetium-99.

A.5.5.2 Low Flow Rates in the LDS

Accumulation rates reported for the LDS over the past several years demonstrate that the OSDF is operating as designed. Flows are very low, are decreasing and, in some cells, have stopped altogether.

Leachate volumes pumped from the LDS tanks are measured by recorded readings from capacitance probes installed in each LDS tank. The probes are attached through a remote control unit to the CAWWT control room, where water levels are converted automatically to volumes based on the tank manufacturer's design specifications for the tanks.

As stated in Section A.1.2, the LDS in Cells 1, 2, 3, 4 and 5 were considered to be dry all year. Figure A.5-6 shows the maximum LDS accumulation rate between 2006 and 2015. The accumulation rate reported is the maximum accumulation rate reported for that year by any of the individual eight cells. As shown in Figure A.5-6, the maximum accumulation rate for any cell has decreased from 13.08 gpad in 2006 (Cell 7) to 0.23 gpad in 2015 (Cell 6).

In 2015, the maximum LDS accumulation rate was 0.23 gpad in Cell 6. This accumulation rate is 1.1% of the 20 gpad initial response leakage rate. An accumulation rate of 0.23 gpad from the 6.4-acre cell equals a total volumetric flow rate of 3.9 milliliters per minute (mL/min). As noted by Ohio EPA, a minimum flow of 100 mL/minute is generally accepted as necessary to obtain a representative low-flow groundwater sample from a monitoring well. A flow rate as low as 3.9 mL/min is not laminar, and the sample being slowly collected is susceptible to sample bias due to aeration and oxidation.

On July 22, 2015, Ohio EPA participated in an onsite tour of an OSDF valve house for the purpose of reviewing the logistics involved in the collection of a water sample from an LDS. Upon inspection of the valve house, Ohio EPA made the following observations:

- Water is not being constantly replenished through the LDS collection tank, and the sample being bailed from the tank is representative of these stagnant conditions.
- A sample degassing potential is present because the low flow prolongs contact of a water sample with the atmosphere.
- Reduction-oxidation (redox) sensitive metals in the water could oxidize from the prolonged contact of the water with the atmosphere. Iron precipitates were observed in the interior of the collection tanks.
- Carbon dioxide could degas from the sample and affect the representativeness of other parameters (e.g., calcium and magnesium). A white precipitate, presumably calcite, was observed on the floor and lower walls of the collection tank.
- Ammonia in the sample could oxidize.

The observations noted above could at times bias analytical results high for certain constituents and other times bias results low for certain constituents. If the LDS dries up completely, no sample can be collected, and no leachate quality determination can be made.

Because of the low flows and the exposure of the sample to the atmosphere, it is uncertain if an LDS sample periodically collected from a valve house tank truly represents the composition of an LDS sample from within the facility. Collecting water quality samples from the LDS and using the data to statistically demonstrate that the facility is operating as designed does not appear be the best approach for complying with Ohio Solid Waste Regulations (OAC 3745-27-19(M)(5)) for the OSDF. As stated in the current *Groundwater/Leak Detection and Leak Detection Monitoring Plan*, monitoring leachate accumulation rates from the LDS (against the Action Leakage Rate and Initial Response Leakage Rate) is a much better approach.

A.5.5.3 Additional Geochemical Assessment of Continued Use of Bivariate Plots

In light of the water quality sampling observations noted for the LDS (e.g., low flow, stagnant samples), the question was raised concerning the continued value of using uranium-sodium and uranium-sulfate bivariate plots to demonstrate that the water chemistry of the LCS, LDS, and HTW are separate and distinct and, therefore, not mixing. The use of bivariate plots at Fernald for this purpose originated from a common-ion study that was conducted as part of the alternate parameter selection process (DOE 2008a). The same geochemist who developed the 2008 Common-Ion Study, Dr. Richard Abitz, was asked to update the analysis with data collected between 2008 and 2014 and determine if continued use of the bivariate plots was still warranted. Preliminary evaluation results indicate that the bivariate diagram method continues to be a valuable method for assessing whether the monitoring zones are mixing (Geochemical Consultants 2016). DOE plans to issue the geochemical assessment report for review later in 2016.

In addition to confirming that the bivariate plots are still a valid interpretation method, the study provided additional preliminary results:

- The data set shows evidence for manganese oxidation in the LDS; therefore, manganese is no longer a useful monitoring parameter.
- Increasing concentrations for the mobile ions (e.g., boron and sulfate) indicate evaporation of the leachate in the LDS tanks or concentration of the ions in the pore fluid of the source materials due to longer residence time as the rate of leachate removal decreases.
- Removal of manganese by oxidation of the leachate is most likely occurring in the LDS along the flow path and within the collection tank due to the low fluid volumes seeping into the pipes and slower flow rates in the tanks.
- Sodium and uranium are the best chemical indicators to evaluate migration of leachate between the monitoring horizons.

A.5.5.4 Proposed Changes to the Groundwater/Leak Detection and Leachate Monitoring Program

DOE proposes to modify the GWLMP via the annual review and revision process later in 2016 based on the following:

- Results of the independent assessment conducted by Dr. Cameron (MacStat Consulting 2014).
- Current understanding of LDS sampling challenges.
- Recognition that measuring flow from the LDS is a much better method than analyzing water quality samples for demonstrating that the facility is operating as designed.
- Preliminary findings of Dr. Abitz's (Geochemical Consultants, Inc. 2016) assessment indicating that uranium-sodium bivariate plots remain effective in spite of the LDS sampling challenges.

If the proposed changes are approved by EPA, Ohio EPA, and stakeholders during the LMICP review and approval process, the proposed monitoring changes would become effective January 1, 2017. A summary of the proposed monitoring is provided below:

- Change sampling in the LCS, LDS, and HTW to uranium, sodium, sulfate, and boron. The semiannual sampling frequency would remain the same.
- Discontinue annual sampling for the reduced list of Appendix I and PCB constituents in the LCS.

- Reduce the sampling parameter list for GMA wells from 24 parameters to the following 13 parameters: total uranium, boron, TOX, sulfate, lithium, selenium, TDS, calcium, magnesium, nitrate + nitrite as nitrogen, potassium, technetium-99, and sodium. The semiannual sampling frequency would remain the same.
- Track accumulation rates in the LDS collection tank against a new lower rate of 2.0 gpad as discussed below.

A.5.5.5 Basis for a Lower Leakage Rate Metric of 2.0 gpad

During several discussions with EPA and Ohio EPA in 2015, a concern was presented that if the scope of the water quality sampling effort was decreased as proposed, the 20 gpad initial response leakage rate may not be low enough to provide for a timely alert to increasing flow conditions within the LDS. A lower flow rate metric would be more responsive to changes in the low flow rate environment that currently exists in the LDS. A lower rate of 2.0 gpad was briefly discussed, and the question was raised as to whether an even lower rate than 2.0 gpad is warranted.

By design, monitoring flow from the LDS is the main indicator of whether or not the facility is operating as designed. Two LDS flow criteria are currently established for the facility in the LMICP, specifically:

- 200 gpad Action Leakage Rate
- 20 gpad Initial Response Leakage Rate

As shown in Figure A.5-6, the maximum LDS accumulation rate has been below 1.00 gpad since 2009. If the facility is operating as designed, accumulation rates in the LDS are not expected to increase, but slight increases from year to year are still observed. For example in 2014, Cell 6 (6.4 acres) had the maximum LDS accumulation rate for the facility of 0.06 gpad (1 mL/min). In 2015, Cell 6 again had the maximum LDS accumulation rate for the facility 0.23 gpad (3.9 mL/min). This is an increase of approximately 290 percent, yet it is an accumulation rate that is still well below the initial response leakage rate of 20 gpad. The table below lists the LDS maximum accumulation rates in various units from 2008 to 2015. Note that the area of Cells 1 through 7 is 6.4 acres and Cell 8 is 9.3 acres. As indicated below, maximum flows in the LDS since 2008 have been well below 100 mL/minute.

Maximum LDS Accumulation Rates

Year	Accumulation Rate (gpad)	Cell	Area of Cell (Acres)	Gallons Per Day (gpd)	Gallons Per Minute (gpm)	Milliliters Per Minute (mL/min)
2008	1.36	5	6.4	8.70	6.04×10^{-3}	22.9
2009	0.48	5	6.4	3.1	2.1×10^{-3}	8.1
2010	0.21	6	6.4	1.3	9.3×10^{-4}	3.5
2011	0.38	8	9.3	3.5	2.4×10^{-3}	9.3
2012	0.10	6	6.4	0.64	4.4×10^{-4}	1.7
2013	0.07	6	6.4	0.4	3×10^{-4}	1
2014	0.06	6	6.4	0.4	3×10^{-4}	1
2015	0.23	6	6.4	1.5	1.0×10^{-3}	3.9

For comparison, the action leakage rate, the initial response leakage rate, and the proposed lower rate of 2.0 gpad are provided below in various units. As noted above, the area of Cells 1 through 7 is 6.4 acres and Cell 8 is 9.3 acres.

Comparison of Established Rates and Proposed Rates

Rate	Gallons Per Day Per Acre (gpad)	Cell	Gallons Per Day (gpd)	Gallons Per Minute (gpm)	Milliliters Per Minute (mL/min)
Action Leakage Rate	200	1 through 7	1,300	0.89	3,400
Action Leakage Rate	200	8	1,900	1.3	4,900
Initial Response Leakage Rate	20	1 through 7	130	0.089	340
Initial Response Leakage Rate	20	8	190	0.13	490
Proposed Lower Rate	2	1 through 7	13	0.0089	34
Proposed Lower Rate	2	8	19	0.013	49

Leakage rates are calculated from the volume of fluid inside the LDS tanks. The manufacturer of the tanks provides a third-order polynomial equation for estimating the volume of fluid inside each of the tanks:

$$V = -5.76(A)^3 + 26.126(A)^2 + 91.086(A) - 8$$

where:

V = volume of water inside the LDS tank in gallons
A = water level in feet.

This calculation is used to determine the volume of water in the tank based on the interior contour of the collection tank and uses water depth as the independent variable. Unfortunately, the interior contour of the tank is not a perfect cylinder. This complicated contour results in errors (variability) when water volumes are small. At low levels (1.0 inch of water in the tank), the polynomial equation has enough variability to result in a negative volume. The table below provides the relationship between the height of water in the collection tank and the calculated volume of water present in the tank based on the equation.

Height of Water in Tank (inches)	Volume of Water in Tank (gallons)
1.0	−0.23
1.1	0.56
2.6	13

As shown in the table, the volume calculation goes from a negative volume of −0.23 gallon to a positive volume of 0.56 gallon between 1.0 inch and 1.1 inches of water in the LDS tank (i.e., a change of one tenth of an inch). Low water heights within the tank push the limits of the data interpretation (e.g., just bumping the tank could cause the water surface to undulate a tenth of an inch). The table also shows that a volume of 13 gallons of water in the tank, the daily volume of water for Cells 1 through 7 at the proposed rate of 2 gpad, would correlate to a height of water in the tank equal to 2.6 inches.

With a lower action rate of no less than 2.0 gpad, the rate of volume change determination in the tank should be just above the range of measurement variability discussed above. Therefore, DOE plans to propose that the new lower accumulation rate metric for the LDS should be no lower than 2.0 gpad. Actions associated with the new lower proposed limit will be detailed in the upcoming revision to the LMICP and presented to the EPA, Ohio EPA, and stakeholders for review and approval.

A.5.6 LCS and LDS Camera Inspection

The LMICP, Attachment C, "Groundwater/Leak Detection and Leachate Monitoring Plan," contains the requirement of a 5-year frequency for inspection of the LCS and LDS piping. A camera survey of LCS, redundant LCS (RLCS), and LDS lines was conducted in the summer of 2015. The previous camera survey was completed in 2010 and revealed notable accumulation of construction pipe bed gravel and scale. Based on the results of that survey, a cleaning of all lines was performed in 2011.

The lines were surveyed with a camera in late 2015, and the initial recommendation was that no cleaning of the lines was necessary. This recommendation was based on the absence or minimal presence of both gravel and scale that had been identified and cleaned in the previous (2010) camera survey. The OSDF engineer of record, Geosyntec Consultants, Inc., reviewed the camera survey results and concluded that the facility conditions are stable and the camera survey interval could be extended (Geosyntec 2015). This conclusion is based on the observations that no significant additional scale or infiltration of the pipes by gravel was observed, and that no change in pipe integrity or signs of structural impacts (i.e., crushing or ovality) was observed. Geosyntec calculated the primary soil consolidation as 95% complete after 8.4 years, indicating that pipe slopes should not change significantly.

The conclusion reached from analysis of the 2015 camera survey is that monitoring of the LCS and LDS pipe networks will be extended to 10 years, and the next camera survey will be performed in 2025. It is expected that the pipe networks will maintain their designed integrity, as post-construction settling is mostly complete. Accumulation of gravel and scale is expected to lessen as leachate accumulation tapers off.

A.5.7 Summary of Overall Performance/Findings and Recommendations

Based on LCS and LDS flow data, engineered drainage features within the OSDF continue to perform as designed. Separate and distinct chemical signatures for total uranium and sodium in the LCS, LDS, and HTW of each cell (and total uranium and sulfate in Cell 8) indicate that waters from the different horizons are not mixing, and therefore it can be inferred that the primary and secondary liners are not leaking. Water quality constituent concentration increases noted in the HTW and GMA wells are attributed to fluctuating ambient concentrations beneath the OSDF and not to OSDF performance.

Specific findings:

- LCS volumes continue to diminish with time. Total facility leachate volume in 2015 was 6.2% less than in 2014 (approximately 130,378 gallons compared to 138,949 gallons).
- There was not enough water in the LDS of Cells 1, 2, 3, 4, and 5 during 2015 to collect a water sample.
- The largest LDS maximum accumulation rate recorded in 2015 was 0.23 gpad in Cell 6, approximately 1.1% of the initial response leakage rate of 20 gpad.
- LDS accumulation rates indicate that the liner systems are performing well within the specification outlined in the approved cell design.
- Quarterly apparent liner efficiencies were consistently greater than 99% for Cells 1 through 8 throughout 2015, with the exception of Cell 6 in the third and fourth quarter of 2015 (98.25% and 98.35%, respectively).
- Bivariate plots continue to illustrate that the water chemistries in the LCS, LDS, and HTW of each cell are distinct and separate, indicating that waters from the different horizons are not mixing. Therefore, upward concentration trends beneath the cells (i.e., HTWs and GMA wells) are attributed to fluctuating ambient concentrations beneath the cell and not to cell performance.
- In 2015, 102 data sets met the criteria for control Shewhart-CUSUM control charts. Of the 102 control charts presented for 2015, 99 (97%) exhibited "in control" conditions, and 3 (3%) exhibited "not in control" conditions.
- Annual LCS sampling for Appendix I and PCB parameters led to the following results:
  - One new Appendix I or PCB parameter (beryllium) was detected in the LCS of Cell 4. Detection of beryllium in the LCS of Cell 4 in 2016 will trigger sampling for beryllium in the LDS of Cell 4 during the subsequent sampling event.
  - In 2014, lead was detected for the first time in the LCS of Cell 8. Lead was not detected in the LCS of Cell 8 in 2015.
  - Cadmium was detected for the first time in the LCS of Cell 6 in 2013. Cadmium was not detected in the LCS of Cell 6 in 2014 or 2015.
- In 2015, quarterly physical inspections of the OSDF revealed no visual signs that the integrity of the OSDF cap had been compromised.
- Data support modifying the *Groundwater/Leak Detection and Leachate Monitoring Plan* via the 2016 LMICP review and approval process.
- Camera survey results of the LCS and LDS lines indicate that facility conditions are stable and the monitoring interval by camera survey could be extended.

A.5.8 References

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Table A.5-1. OSDF Initiation and Completion Dates

Cell	Sample Initiation per Horizon[a]	Waste Placement Initiation	LDS Volume Measurement Initiation[b]	Cap Geomembrane Layer Completion[c]	Cap Completion[d]
1	LCS: February 17, 1998 LDS: February 18, 1998 HTW: October 30, 1997 GMA-U: March 31, 1997 GMA-D: March 31, 1997	December 23, 1997	May 1999	August 17, 2001	December 20, 2001
2	LCS: November 23, 1998 LDS: December 14, 1998 HTW: June 29, 1998 GMA-U: June 30, 1997 GMA-D: June 25, 1997	November 12, 1998	May 1999	July 17, 2003	November 12, 2003
3	LCS: October 13, 1999 LDS: August 26, 2002 HTW: July 28, 1998 GMA-U: August 24, 1998 GMA-D: August 24 1998	October 26, 1999	October 1999	July 16, 2004	September 20, 2004
4	LCS: November 4, 2002 LDS: November 4, 2002 HTW: February 26, 2002 GMA-U: November 6, 2001 GMA-D: November 5, 2001	November 08, 2002	November 2002	December 18, 2004	April 29, 2005
5	LCS: November 4, 2002 LDS: November 4, 2002 HTW: February 26, 2002 GMA-U: November 6, 2001 GMA-D: November 5, 2001	November 19, 2002	November 2002	June 22, 2005	August 29, 2005
6	LCS: October 27, 2003 LDS: October 27, 2003 HTW: March 14, 2003 GMA-U: December 16, 2002 GMA-D: December 16, 2002	November 18, 2003	January 2004	October 28, 2005	January 12, 2006

Table A.5-1 (continued). OSDF Initiation and Completion Dates

Cell	Sample Initiation per Horizon[a]	Waste Placement Initiation	LDS Volume Measurement Initiation[b]	Cap Geomembrane Layer Completion[c]	Cap Comp
7	LCS: September 2, 2004 LDS: September 2, 2004 HTW: February 24, 2004 GMA-U: January 21, 2004 GMA-D: January 21, 2004	September 9, 2004	September 2004	July 2006	October 25
8	LCS: October 18, 2004 LDS: October 18, 2004 HTW: May 19, 2004 GMA-U: March 31, 2004 GMA-D: March 31, 2004 GMA-SW: August 22, 2005 GMA-SE: August 22, 2005	December 2, 2004	December 2004	September 24, 2006	October 25

[a]LCS = leachate collection system; LDS = leak detection system; HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; GMA-D = downgradient Great Miami Aquifer; GMA-SW = southwest Great Miami Aquifer; and GMA-SE = southeast Great Miami Aquifer
[b]Prior to 1999, overall LDS volumes were measured. From 1999 on, LDS volumes were measured by cell.
[c]The cap geomembrane layer is made of high density polyethylene.
[d]Cap completion includes seeding.

Table A.5-2. Rules for Summary Statistics for Cells 1 Through 8

Rules	No. of Detected Samples	Total No. of Samples	Percent of Detects	Min[a,b]	Max[a,b]	Average	Std. Dev.	Distribution Type	Trend	Serial Correlation	Outliers
Include outliers	Yes	Yes	Yes	No	No	No	No	No	No	No	
Only one result	Yes	Yes	Yes	report "NA"	report value	report "Insuff"	report "Insuff"	report "Insuff"	report "Insuff"	report "Insuff"	
Only two results	Yes	Yes	Yes	report value	report value	report "Insuff"	report "Insuff"	report "Insuff"	report "Insuff"	report "Insuff"	
All non-detects	Yes	Yes	Yes	report "ND"	report "NA"	report "Insuff"	report "Insuff"	report "Insuff"	report "Insuff"	report "Insuff"	
Other rules						Need 3 detections otherwise report "Insuff"	Need 4 detections otherwise report "Insuff"	Need at least 3 samples to report distriburtion	Need at least 4 samples to report trend	Need at least 6 samples to report serial correlation	Need at least 4 samples to report outliers
Other rules						If distribution is "Lognormal," substitute "LogMean"					
Other rules						If distribution is "Undefined," substitute "Median"					

[a]NA=not applicable; ND=not detected

[b]If reported value is a nondetected result, report ND.

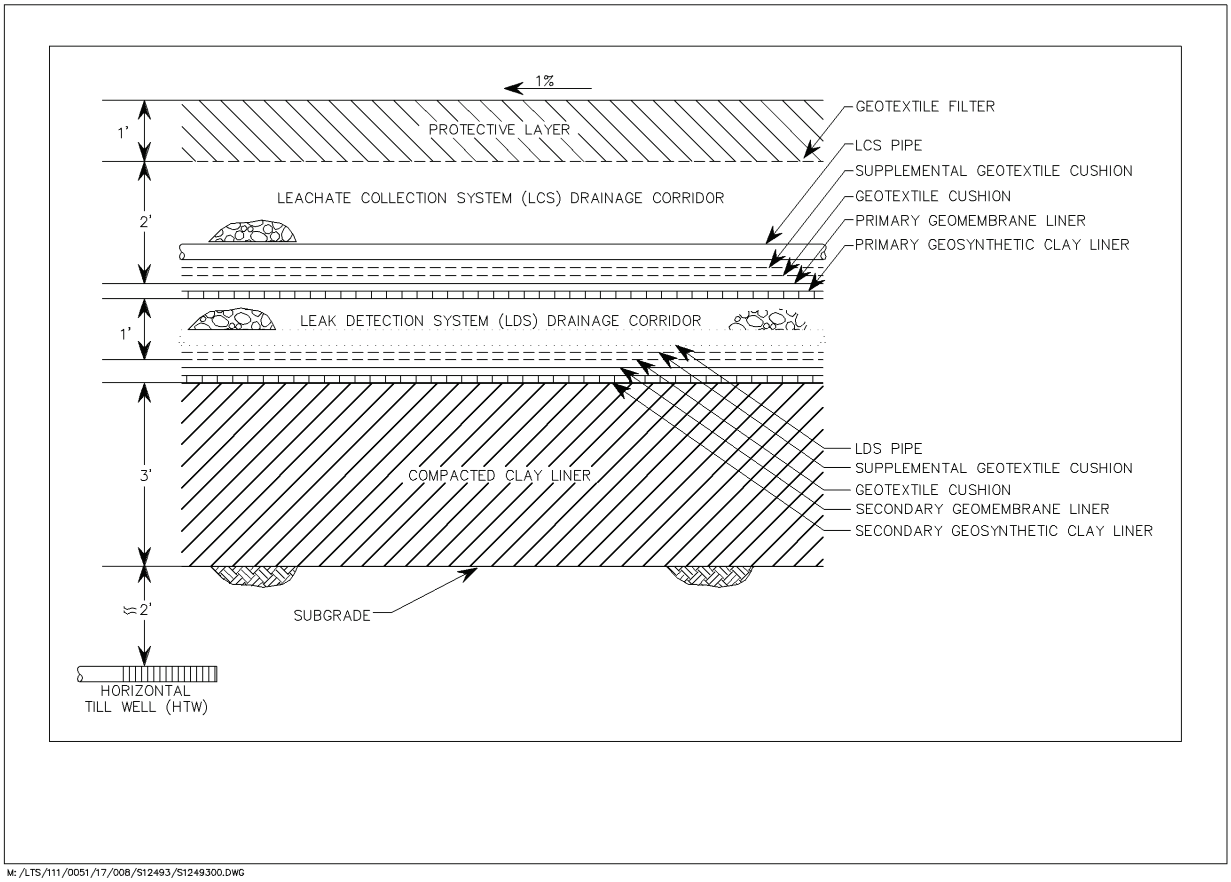

Figure A.5-1. On-Site Disposal Facility Liner System with HTW at the Drainage Corridor

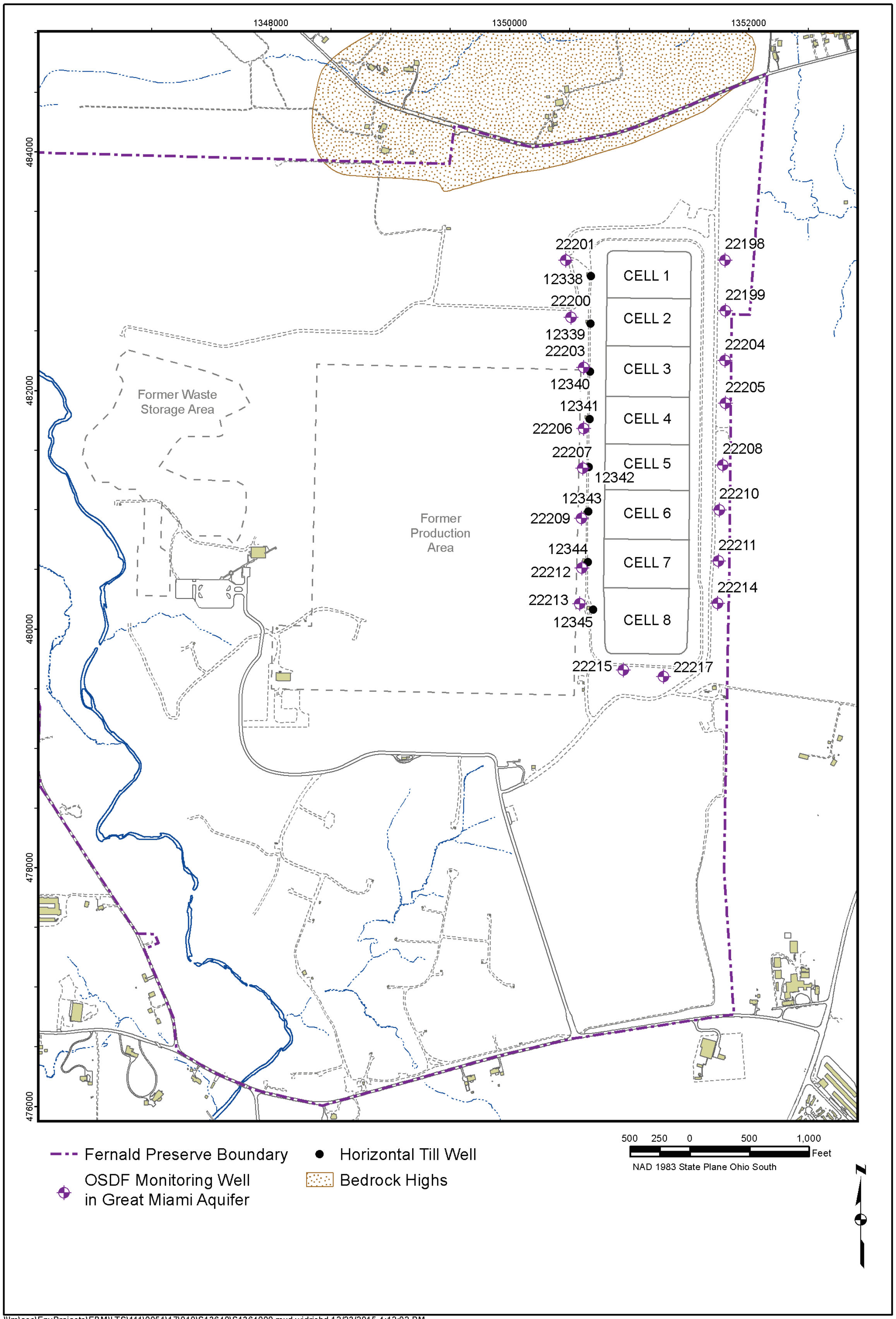

Figure A.5-2. OSDF Footprint and Monitoring Well Locations

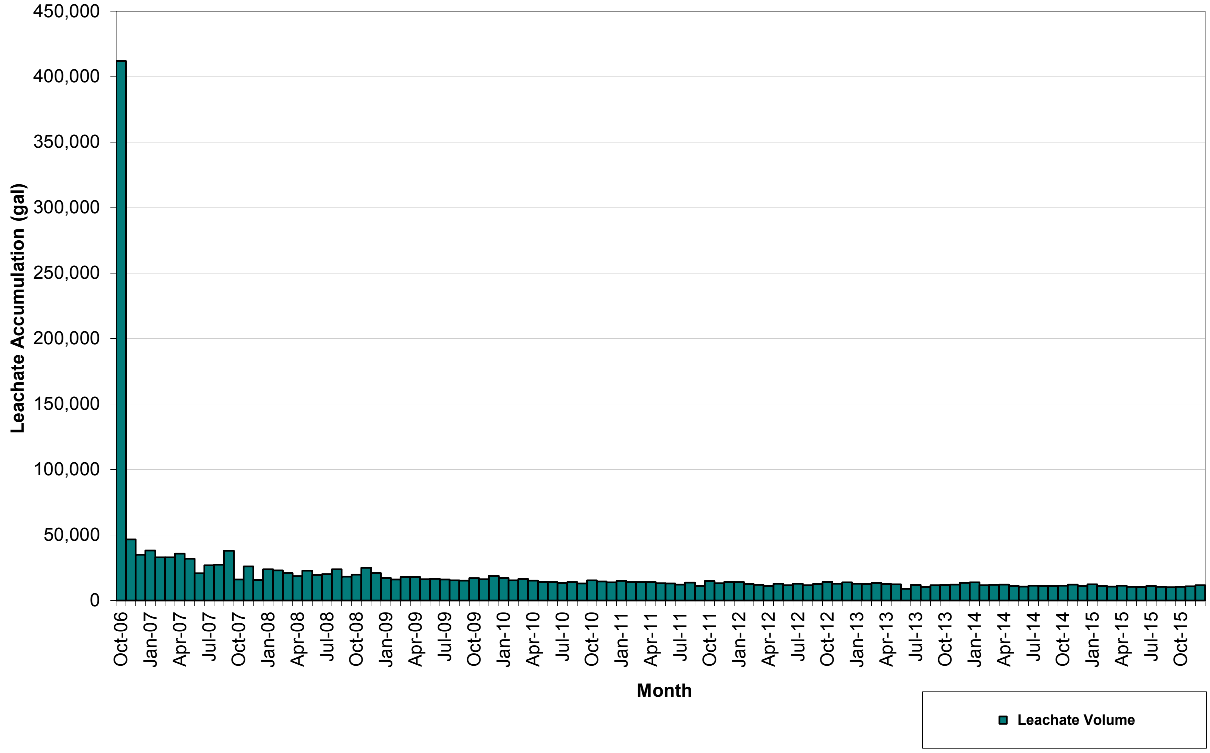

Figure A.5-3. OSDF Monthly LCS Flow (October 2006 Through December 2015)

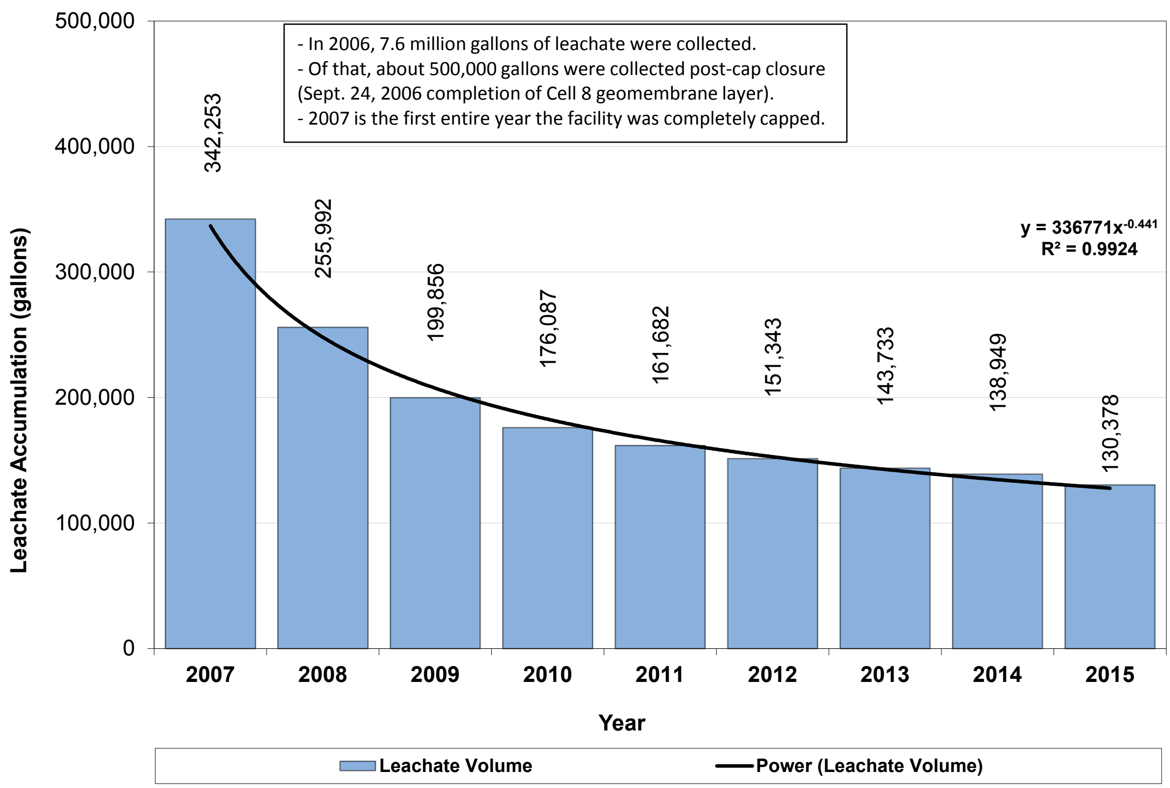

Figure A.5-4. OSDF Annual LCS Flow (2007 Through 2015)

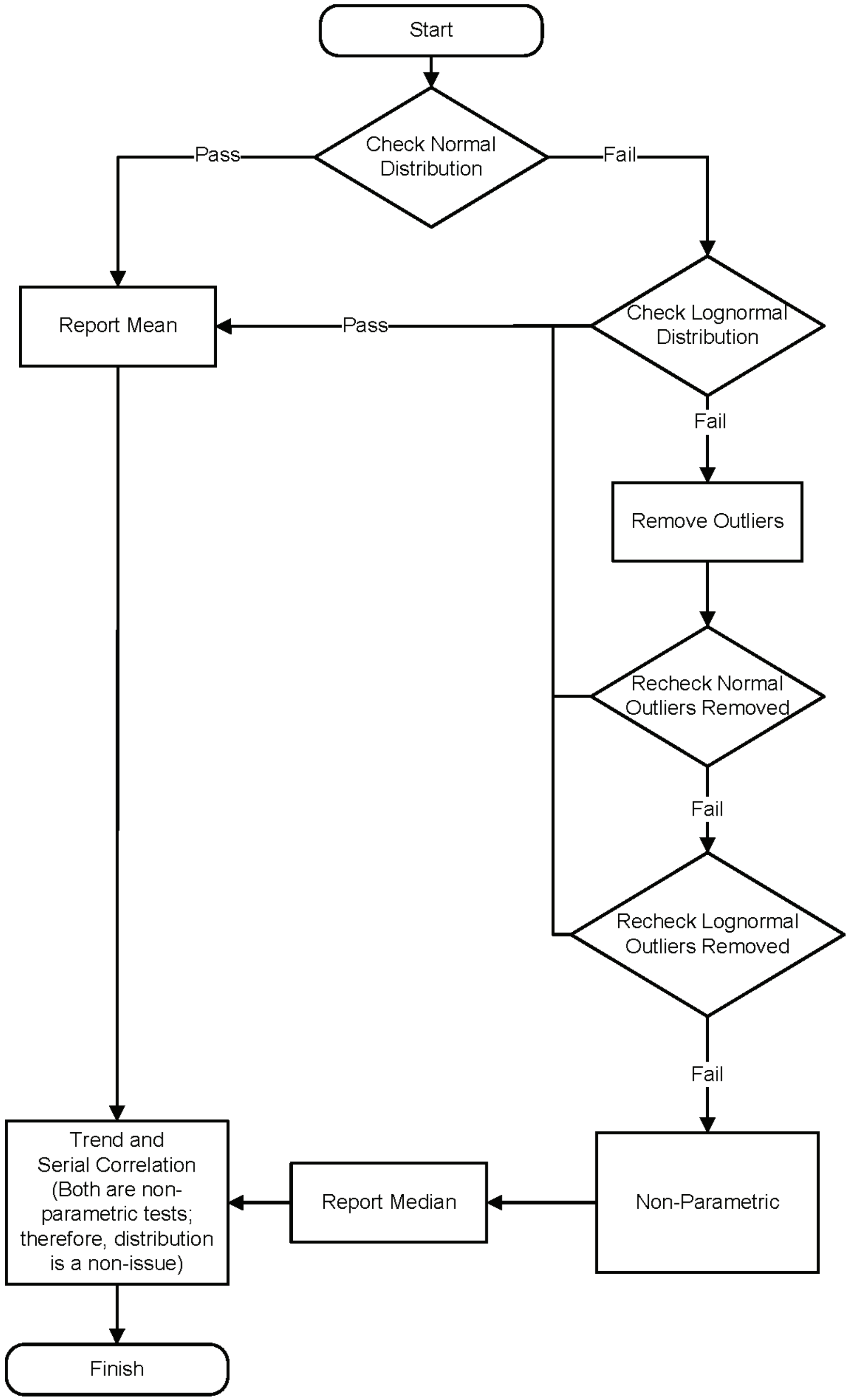

Figure A.5-5. OSDF Statistical Evaluation Process

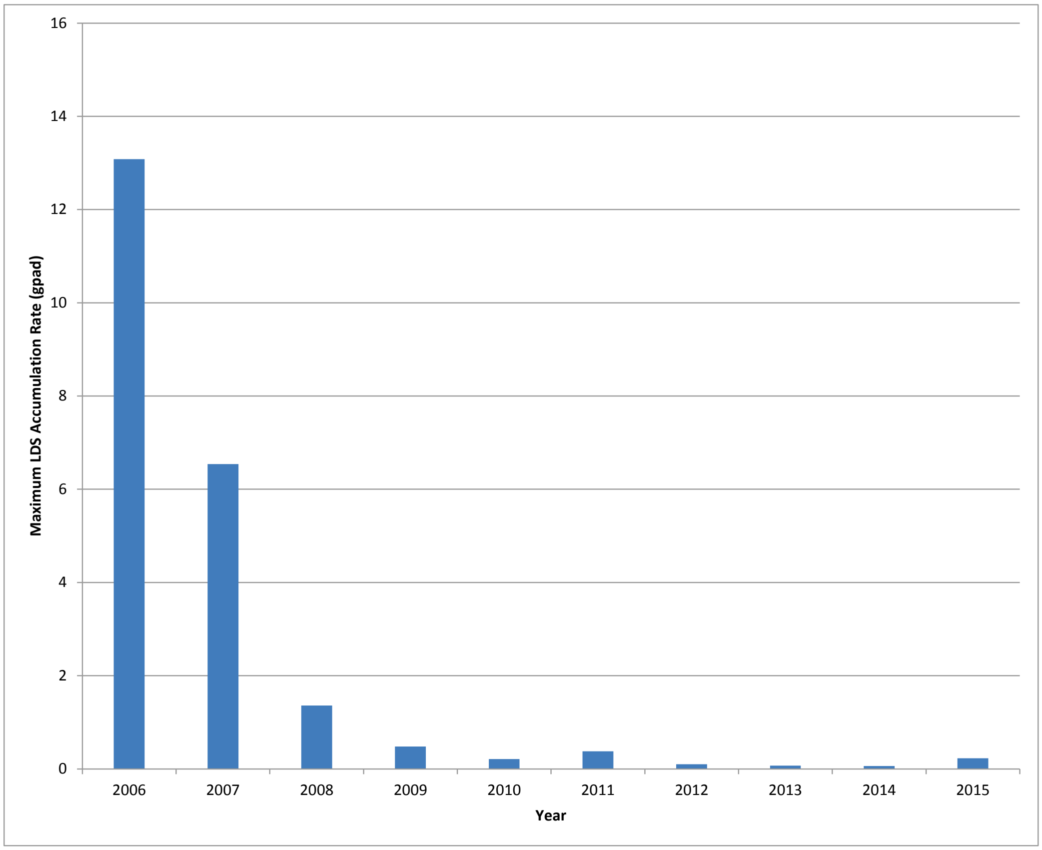

Figure A.5-6. Maximum LDS Accumulation Rate Between 2006 and 2015

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