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 2019.
- 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 current 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 (https://gems.lm.doe.gov/).

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Attachment A.1

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Abbreviations

CAWWT	Converted Advanced Wastewater Treatment
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FRL	Final Remediation Level
GMA	Great Miami Aquifer
Ohio EPA	Ohio Environmental Protection Agency
PRRS	Paddys Run Road Site
WSA	Waste Storage Area

Measurement Abbreviations

95% UCL	95% upper confidence limit
amsl	above mean sea level
ft	feet
gpm	gallons per minute
lb	pounds
µg/L	micrograms per liter
Mgal	million gallons

A.1.0 Operational Assessment

This attachment provides operational data for the South Field Module, the South Plume Module, and the Waste Storage Area (WSA) Module at the Fernald Preserve, Ohio, Site, including:

- Operational data for the 20 extraction wells pumping in 2020.
- Uranium concentrations trends for each extraction well compared to model-predicted concentration trends.
- Uranium concentrations at selected monitoring wells compared to model-predicted concentrations.
- Pounds of uranium removed from the aquifer.
- Estimates of the pounds of uranium remaining to be removed from the aquifer to complete the pumping stage of the aquifer remedy.

From July 1, 2014, through June 2018, extraction wells were operated to achieve a design pumping rate of 5,075 gallons per minute (gpm). The design pumping rate is the pumping rate used in the groundwater model to estimate cleanup times for the aquifer remedy. Beginning in July 2018, the design pumping rate was reduced to 4,975 gpm because of a decreased pumping rate from 200 to 100 gpm in extraction well RW-4 (Section A.1.8). Groundwater modeling predicted that the design pumping rate reduction would have no effect on the estimated cleanup times for the aquifer remedy. Figure A.1-1 depicts the locations of the extraction and former reinjection wells and identifies surrounding monitoring wells. Table A.1-1 provides summaries of gallons of water pumped, total uranium removed, and uranium removal indexes for 2020 and for the duration of the remedy to date (August 1993 through December 2020).

Information in this attachment is organized into the following subsections:

- Operational System Overview (Section A.1.1)
- Well field Shutdowns in 2020 (Section A.1.2)
- South Field Module (Section A.1.3)
- South Plume Module (Section A.1.4)
- WSA Module (Section A.1.5)
- Total Uranium Data (Section A.1.6)
- Total Uranium Data Discussion (Section A.1.7)
- Pumping Rates (Section A.1.8)
- Converted Advanced Wastewater Treatment (CAWWT) Capacity Reduction (Section A.1.9)

A.1.1 Operational System Overview

The current Operational Design for the groundwater remedy has been in effect since design changes were implemented on July 1, 2014. Under that design, modeling predictions indicate that the pumping stage of the aquifer remedy will be achieved by the following dates:

- 2022 for the South Plume and Southern South Field
- 2030 for the Northern South Field
- 2035 for the former WSA

Figure A.1-2 illustrates how the model predicts that the cleanup will progress. It should be noted that the model-predicted dates listed above and provided in Figure A.1-2 are 2 years later than the model-predicted cleanup times reported in the *Operational Design Adjustments-1, WSA Phase-II Groundwater Remediation Design, Fernald Preserve* (DOE 2014). The 2-year difference takes into account the 2 years that elapsed between the time the modeling exercise began and the operational changes defined by the modeling exercise were implemented.

Figure A.1-3 compares the monthly pounds of uranium removed from the aquifer in 2013 and 2020. In past years, the data has indicated that more uranium was being removed from the aquifer following the operational changes implemented in July 2014. The data for 2020 indicate that the mass of uranium being removed from the aquifer following the operational changes in July 2014 has decreased. The data further indicates that the pumping stage of the aquifer remedy will not be completed in the South Plume and Southern South Field by 2022 as the groundwater model predicted. Another optimization of the pumping system is needed. This is discussed further in Section A.1-7.

The current Operational Design is more aggressive than the previous design in that for the first 9 years the target system design pumping rate is 300 gpm higher. The current design is also more efficient because pumping is more concentrated where the pumping is needed and when it is needed. The strategy is to decrease design pumping rates as the remedy progresses.

The current, more-aggressive pumping rates require more maintenance 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 and successful well maintenance program to address this iron fouling. Extraction wells are treated with a chemical solution when operational parameters indicate that cleaning is warranted. As shown in the following table, considering the number of extraction wells decreased from 23 to 20, the number of chemical treatments has increased as a result of pumping at higher rates. The number of treatments was down in 2016, but 2016 was not a normal operating year due to an unplanned well field shutdown discussed in the 2016 Site Environmental Report (DOE 2017). The number of treatments was also down in 2018 and 2019. In 2018, it was due to the impact that the CAWWT construction project had on the availability of the backwash basin for wastewater generated by well treatment. In 2019, it was due to a construction project to replace the CAWWT backwash basin.

Year	Number of Extraction Wells	Number of Chemical Treatments
2020	20	43
2019	20	19[a]
2018	20	28[b]
2017	20	35
2016	20	22[c]
2015	20	41
2014	23/20[d]	32
2013	23	38

[a] Number of chemical treatments was affected by replacement of the CAWWT backwash basin.
[b] Number of chemical treatments was affected by the CAWWT construction project.
[c] Number of chemical treatments was affected by an extended unplanned shutdown (DOE 2017).
[d] The number of operating extraction wells was reduced in July 2014.

Although the well treatment program has been successful to date, over time the repeated chemical treatments are slowly corroding any metal that the chemicals come in contact with (e.g., cast iron pumps, bolts, cable connectors, and pipes). If this issue continues, more maintenance and pump replacements may be required in the future. The U.S. Department of Energy (DOE) purchased 12 new stainless-steel pumps in 2016 to help alleviate some of the maintenance challenges associated with operating the pumps continuously. Installation of the stainless steel pumps occurred as older pumps were removed for maintenance. As of 2020, all 12 of the pumps had been put into service, but, at the end of 2020, only 9 remained in service with 3 pumps removed for maintenance. Of the three stainless steel pumps removed for maintenance, two have been rebuilt and one is in the process of being rebuilt. Based on the recent maintenance history, the stainless-steel pumps have proven to last longer. DOE will continue to work with recognized well field maintenance experts to determine if the well maintenance program can be improved to extend the life of pumps. The issue of well maintenance will also be discussed in a DOE National Laboratory collaboration planned for 2021.

A.1.2 Well Field Shutdowns in 2020

The planned annual well field shutdown in 2020 lasted 29 days (June 15 to July 13, 2020). During the planned annual well field shutdown, extraction wells 1, 2, 3 and 4 continued to pump to maintain capture at the leading south edge of the uranium plume.

In addition to the annual planned well field shutdown, the well field is shut down whenever the Great Miami River reaches a river stage of 14 feet at the U.S. Geological Survey measurement gauge at Miamitown, Ohio. When flow in the river reaches this level, gravity flow from the site discharge pipe is affected. The well field remains off until the river stage falls below 14 feet. This approach was discussed with the U.S. Environmental Protection Agency (EPA) and the Ohio Environmental Protection Agency (Ohio EPA) during the March 14, 2018, regulatory meeting. These temporary well field shutdowns have not had a negative impact on remediation progress and could actually be beneficial from a rebound perspective. In 2019, the entire well field was off for a combined 7 days due to high river levels. In 2020, the entire well field was off for a combined 4 days due to high river levels. Individual shutdowns and durations for 2020 were March 20 to March 22 (2 days) and May 19 to May 21 (2 days).

In response to a State of Ohio Department of Health Director's Stay at Home Order, issued on March 22, 2020, to prevent the spread of COVID-19, the DOE greatly reduced site activities. Working with EPA and Ohio EPA, DOE operated the extraction well field and the CAWWT system from Monday morning to Thursday morning every week to avoid substantial maintenance issues that might have developed upon restart, if the system had been shut down entirely. This reduced operation schedule for the well field was conducted for 8 weeks. A phased reopening began the week of May 18, 2020, when the well field again operated 7 days a week. As a result, the well field operated 3 days a week for a total of 32 operating days from March 22 to May 18, 2020.

A.1.3 South Field Module

Eleven extraction wells were operational in the South Field Module in 2020. 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 2020 was 2,875 gpm. Table A.1-1 presents the combined performance data for the South Field Module. Tables A.1-2 through A.1-12 provide individual extraction well performance data for the South Field Module wells in 2020. Target pumping rates are reported on each individual extraction well performance table, and footnotes explain individual extraction well outages of greater than 24 hours.

During 2020, 1,286.29 million gallons (Mgal) of groundwater were pumped from the active extraction wells in the South Field Module, resulting in the removal of 246.06 pounds (lb) of uranium from the Great Miami Aquifer (GMA). Since startup in July 1998, the South Field Module has removed 26.529 billion gallons of water and 9,193.97 lb of uranium from the GMA.

A.1.4 South Plume Module

Six extraction wells were operational in the South Plume Module in 2020. 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 2020 was 1,300 gpm. As discussed in Section A.1-8, in July 2018 the pumping rate at RW-4 was reduced from 200 gpm down to 100 gpm.

Table A.1-1 presents the combined performance data for the South Plume Module. Tables A.1-13 through A.1-18 provide individual extraction well performance data for the South Plume Module wells in 2020. Target pumping rates are reported on each individual extraction well performance table, and footnotes explain individual extraction well outages of greater than 24 hours.

During 2020, 592.67 Mgal of groundwater were pumped from the active extraction wells in the South Plume Module, resulting in the removal of 81.75 lb of uranium from the GMA. Since its startup in August 1993, the South Plume Module has removed 18.280 billion gallons of groundwater and 3,501.38 lb of uranium from the GMA.

During 2020, 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 2020, as in previous years, PRRS constituents of concern (arsenic, phosphorus, potassium, sodium, and volatile organic compounds) were monitored at 10 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 10 wells monitored were 2128, 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 constituent data collected from these wells. As indicated in Table A.1-19, two parameters at four different wells that were monitored for PRRS constituents of concern had "up" trends:

- Potassium in monitoring wells 2898, 2899, 3898, and 3899
- Sodium in monitoring wells 2898, 2899, 3898, and 3899

Figures A.1-5 through A.1-12 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 2020 indicate that flow to monitoring wells 2898, 2899, 3898, 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 well 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 2020.

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.1.5 Waste Storage Area Module

Three extraction wells were operational in the former WSA Module in 2020. 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 2020 was 800 gpm. The combined performance data for the WSA Module are presented in Table A.1-1. Tables A.1-20 through A.1-22 provide individual extraction well performance data for the WSA Module wells for 2020. Target pumping rates are reported on each individual extraction well performance table, and footnotes explain individual extraction well outages of greater than 24 hours.

During 2020, 322.02 Mgal of groundwater were pumped from extraction wells in the WSA Module, resulting in the removal of 61.65 lb of uranium from the GMA. Since startup in May 2002, the WSA Module has removed 8.068 billion gallons of water and 2,415.04 lb of uranium from the GMA.

A.1.6 Total Uranium Data

In 2020, 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 data are also used to determine if a well needs to be routed to treatment.

The current aquifer remedy is able to achieve 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 routine groundwater treatment. Routine groundwater treatment has not been needed since 2010. Since 2010, occasionally, groundwater was sent to treatment for very short periods. The reasons for the short periods of treatment varied. For instance, treatment can be needed when wells pumping low uranium concentrations are turned off for maintenance and wells pumping higher uranium concentrations continue pumping. With conversion to the smaller 50 gpm treatment system (which became operational on April 3, 2018), a small amount of groundwater is routed to treatment each month and blended with water from the backwash basin to dilute anion concentrations in the backwash basin water prior to treatment.

In 2020, 2.20 billion gallons of groundwater were pumped from the GMA, and 6.30 Mgal (0.29%) of groundwater was treated. The table below provides a summary of how much groundwater was treated each month. The minimum and maximum total uranium concentrations provided are for individual wells. The average is for all wells operating that month.

Month	Water Treated (gallons)	Minimum Total Uranium (µg/L)	Maximum Total Uranium (µg/L)	Average Total Uranium (µg/L)
January	700,940	2.0	32.6	19.6
February	896,895	2.0	34.0	20.6
March	571,665	3.4	35.2	22.3
April	309,705	2.6	31.9	21.2
May	367,085	2.4	33.3	21.1
June	346,825	2.6	35.9	22.3
July	315,360	2.6	33.4	20.7
August	521,215	2.5	30.8	19.8
September	568,895	2.5	32.8	20.6
October	723,360	2.5	33.4	19.9
November	525,085	2.6	33.1	19.5
December	452,260	2.9	32.3	20.7
Total	**6,299,290**			

Uranium concentration data collected from the extraction wells are tracked graphically and statistically to assess how the concentrations are trending. Uranium concentrations are plotted over time and fitted with a regression line. Figures A.1-13 through A.1-32 are uranium concentration versus time plots for each extraction well. Each graph displays three different datasets (operational data, the 95% upper confidence limit [95% UCL] of the operational data, and model predictions). Concentration trend lines for the operational dataset and the 95% UCL of the operational dataset were produced 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 dataset collected at each extraction well provides a prediction of how pumping concentrations will continue to decrease. However, the slope of a fitted regression curve through the pumped uranium concentration dataset 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 dataset also be used to help evaluate the uncertainty of the predicted trend.

The graphs in Figures A.1-13 through A.1-32 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 (FRL) for total uranium. Figures A.1-13 through A.1-32 also provide a comparison of the modeled uranium concentration predictions to the measured and 95% UCL data trends. The Fernald Preserve aquifer remediation was designed using the Variable Saturated Analysis Model in Three Dimensions (also called VAM-3D). When the site transitioned to the DOE Office of Legacy Management in 2006, the remediation was operating to a design that was established in 2005 called the WSA Phase II Design (DOE 2005). As explained in Section A.1.1, a new design, called the current Operational Design, was implemented in July 2014 (DOE 2014). Groundwater model predictions for both designs assume that an equilibrium linear isotherm adequately describes the partitioning of total uranium between the sorbed and dissolved phases.

The Fernald Preserve current Operational Design groundwater model predicts the future average pounds of uranium that will be removed from the aquifer for each year of the modeled remedy to eventually achieve concentration-based FRL goals. This prediction (broken down by year) is used to judge how closely the measured remediation is tracking the model predictions. The actual pounds of uranium 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 to achieve concentration-based FRL goals. Regression equations based on uranium concentration data collected at extraction wells through December 31, 2020, are summarized in Table A.1-23. Changing water levels in the aquifer result in cleanup prediction 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., presented the longest predicted cleanup times).

Every year, the average uranium concentration data used to create the regression curves for each extraction well are updated with the data for the current reporting year. The new regression equations are computed using Microsoft Excel software and the updated dataset to determine future mass removal predictions. This results in the regression equations for each well changing slightly from year to year in response to the incorporation of the new data.

At the end of December 2020, data indicated that 15,034 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 reinjected into the aquifer between 1998 and 2004. The current Operational Design predicts that pumping will continue until 2033, based on a start date of 2012.

Modeling predicts that from 2021 through 2033 an additional 1,289 lb of uranium will be removed from the GMA to achieve concentration-based FRL goals. The concentration dataset indicates that an additional 2,082 lb of uranium will be removed from the GMA based on regression analyses of the individual well data. The 95% UCL measured concentration dataset indicates that an additional 8,110 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 2020	15,034		
	Data	**Model**	**95% UCL**
Predicted pounds of uranium to be extracted between 2021 and the end of the pump-and-treat stage of the aquifer remedy (in accordance with the current Operational Design)	2,082	1,289	8,110
Total predicted pounds of uranium to be removed to achieve concentration-based FRL goals	**17,116**	**16,323**	**23,144**
Estimated percent complete (based on pounds of uranium to be removed)	**88%**	**92%**	**65%**

Table A.1-24 provides a yearly breakdown of the pounds of uranium to be removed from 2021 to 2033 based on the three predictions to achieve concentration-based FRL goals. Figure A.1-33 illustrates the relationship between the three estimates. Tracking pounds of uranium removed against groundwater modeling predictions provides an indirect status on progress being made to attain cleanup goals. Other methods (mapping and the Ricker Method) of tracking reduction in the plume size are presented in Attachment A.2.

Results shown above indicate that as of December 31, 2020, the estimated percent complete (based on pounds of uranium to be removed to achieve concentration-based FRL goals) are 88%, 92%, and 65% for the data, model, and 95% UCL of the data, respectively. Following the EPA guidelines mentioned earlier, the estimated percent complete based on pounds of uranium removed is between 65% and 88%. The groundwater model prediction indicates 92% complete.

A.1.7 Total Uranium Data Discussion

The data provided in Table A.1-24 for 2020 show that actual remediation progress is trailing model predictions.

- At the end to 2020, the model prediction for percent complete (92%) is four percentage points higher than the percent complete based on actual concentration measurements (88%).
- The groundwater model is based on an initial mass loading of 16,000 pounds of uranium while the regression of measured concentration data predicts overall mass to be removed will exceed 17,000 pounds.

As reported in Table A.1-1, in 2020 the annual pounds of uranium removed from the aquifer was 389.46 pounds. This value was more than the model predicted (232 pounds) as reported on Table A.1-24 in the 2019 Site Environmental Report (DOE 2020).

A comparison of groundwater model-predicted uranium concentrations and the actual uranium concentrations measured at each extraction well is provided in Table A.1-25. This is the sixth year this comparison has been completed for the current Operational Design. The comparison shows that the average model-predicted total uranium concentration for 2020 (14.1 µg/L) is lower than the actual average concentration measured in December 2020 (20.7 µg/L). The residual average uranium concentration (actual uranium concentration minus model-predicted uranium concentration) was 6.6 µg/L. The standard deviation for the residual dataset was 8.0. The same annual summary statistics for 2015 through 2019 are also provided at the bottom of Table A.1-25. Average model-predicted concentrations decreased from 23.1 µg/L in 2015 to 14.1 µg/L in 2020. During that same period, the actual average concentrations measured were 22.6 µg/L in 2015 and 20.7 µg/L in 2020. Uranium data collected at the extraction wells indicate that model-predicted uranium concentrations are decreasing at a faster rate than the actual uranium concentration data collected at the extraction wells, indicating that the pumping operation is becoming less efficient over time.

A comparison of groundwater model-predicted concentrations and actual observed concentrations measured at selected monitoring wells in 2020 is provided in Table A.1-26. Actual uranium concentrations measured in the first half of 2020 are compared against model-predicted uranium concentrations for April 2020. Changing water levels in the aquifer result in model-predicted cleanup variations and uncertainty. Modeling is, therefore, conducted under low water-level conditions, high water-level conditions, and nominal water-level conditions. The comparison shown in Table A.1-26 represents high water-level conditions. Groundwater modeling conducted under high water-level conditions resulted in the longest cleanup time predictions; therefore, they are the most conservative. Comparing observed uranium concentrations against the model-predicted concentrations began in 2016. It should be noted that starting in 2017 the comparison is based on 13 fewer data points as a result of the monitoring reductions implemented in 2017.

As shown in Table A.1-26, the average residual uranium concentration in 2020 was 32.4 µg/L. As was presented in previous years, Table A.1-27 shows the average residual for 2020 with the five monitoring wells that were the main contributors to the difference (2386, 2387, 23273, 23281, and 83294_C2) removed. Those five wells are in the South Field. The average residual decreases from 32.44 µg/L (all the measured wells) to 9.97 µg/L (five wells removed). These larger discrepancies found at these five wells are indicators that the model predictions are less reasonable for these five locations.

Decreasing efficiency in mass removal is a common challenge to pumping operations. Uranium concentration decreases plotted at each extraction well illustrate that the concentration curves are trending asymptotic. It was this trend, in part, that resulted in DOE optimizing the remediation operation and implementing a more aggressive cleanup design in 2014.

As discussed in Attachment A.2, calculations show that more uranium is sorbed to aquifer sediments than is dissolved in the water. The slow desorption process controls how much uranium is dissolved each year into the water and subsequently pumped out of the aquifer by the extraction wells. As the remedy proceeds, the desorption rate becomes slower and the remedy becomes less efficient, regardless of how much water is flushed through the sediments. Finding the right balance between desorption rate and pumping rate is difficult.

All of the information provided above collectively indicates that pumping operations in the South Plume and the Southern South Field will need to continue past 2022, and that additional modeling should be conducted to optimize the performance of the system again (as was done in 2014). Additional modeling is currently in the process of being planned. Remedy efficiency will be discussed in a DOE National Laboratory collaboration in 2021.

It should be recognized that pumping may only progress the remediation to a certain point and there may be recalcitrant area challenges remaining that will need to be addressed using a different approach. For instance, progress in achieving a concentration-based cleanup is being assessed in part by attributing uranium concentration declines being measured to the pounds of uranium being removed from the aquifer through active pumping. Reducing conditions in the aquifer could also be playing a role in lowering dissolved uranium concentrations in the groundwater. Under reducing conditions, uranium sorbs to sediments, which would also contribute to lower dissolved concentrations. Reducing conditions could also play a role in why some areas of the aquifer might not respond as well to pump-and-treat as other areas. 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.

As the groundwater remedy progresses, additional work to define the uranium partitioning coefficient (K_d) may also be deemed beneficial to help refine cleanup efforts in recalcitrant areas of the uranium plume. Selecting a K_d for uranium in the groundwater model that reflects actual site conditions everywhere in the uranium plume over the life of the groundwater remediation effort might not be appropriate. Groundwater model predictions for the Fernald Preserve are based on the assumption that an equilibrium linear isotherm adequately describes the partitioning of total uranium between sorbed and dissolved phases. One K_d value ($K_d = 3$) is used to represent the entire model domain and time frame. This value was determined empirically by the Sandia National Laboratory using core samples of aquifer sediment collected from contaminated areas across the Fernald site (SNL 2004). It is considered to be a good representative K_d value overall, but it might not reflect reality in all areas of the plume.

A.1.8 Pumping Rates

Target extraction well pumping rates for 2020 are provided in Table A.1-28. From July 1, 2014, through June 2018, extraction wells were operated to achieve a design pumping rate of 5,075 gpm (DOE 2014). The design pumping rate is the pumping rate used in the groundwater model to estimate cleanup times for the aquifer remedy. Beginning in July 2018, the design pumping rate was reduced to 4,975 gpm because of a decreased pumping rate from 200 to 100 gpm in extraction well RW-4. 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 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 current Operational 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 current Operational Design targets are being pumped at a higher rate for a shorter period each day to remove the daily volume of water prescribed by the current 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 the new pumping schedule will maintain capture of the 30 µg/L uranium plume. Extraction well 31561 (EW-20) has a target pumping rate of 200 gpm under the current Operational Design, so pulse pumping is no longer being used at this well.

In 2018, extraction well 3927 (RW-4) was no longer able to maintain its design setpoint of 200 gpm. This well is in the South Plume Module off DOE property, is 26 years old, and has a hole in the screen that has been repaired with a concrete plug (Figure A.1-1). Rehabilitation attempts are no longer effective in getting the pumping rate back up to 200 gpm. The current Operational Design had extraction well 3927 (RW-4) pumping until 2022. Given the limited time that this well was projected to be needed, DOE completed modeling to determine if a replacement well was warranted.

The modeling indicated that the extraction well 3927 (RW-4) could be turned off in 2018 without impacting the model-predicted cleanup times and that capture of the remaining uranium plume would be maintained. Particle track maps showed that water supplying extraction well 3927 (RW-4) was coming mostly from outside the remaining uranium plume footprint. Based on the modeling results, DOE took a conservative approach and continues to pump extraction well 3927 (RW-4) at 100 gpm, rather than 200 gpm, and plans to continue to operate the well until it fails. The continued pumping at the lower rate should help to further flush the aquifer in this area. This approach was discussed with EPA and Ohio EPA at an update meeting held on July 11, 2018, at the Fernald Preserve. Both EPA and Ohio EPA concurred with this revised operational approach for extraction well 3927 (RW-4). In 2020, RW-4 remained in operation.

A.1.9 CAWWT Capacity Reduction and Backwash Basin Replacement

As presented in the *Fernald Preserve 2015 Site Environmental Report* (DOE 2016), the CAWWT system had become oversized and had reached the end of its useful life. Additionally, equipment corrosion and corrective maintenance had become ongoing issues for facility operations.

In March 2015, a CAWWT Condition Assessment Report was finalized (Whitman, Requardt & Associates 2015) confirming that many of the treatment system components were at or nearing the end of their useful life. A decision was made to replace the CAWWT treatment system with a 50 gpm system inside the CAWWT building. DOE received concurrence on a 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.

The project was initiated in 2016 and implemented in three steps:

1. Treatment media removal and demolition of existing piping and tanks to allow room for the new system in the existing building.
2. Design of the new system.
3. Construction, installation, and commissioning of the new system.

Step 1 was completed in January 2017. Four multimedia filters, four of the six existing ion-exchange vessels, and associated piping were removed to provide space for installation of the new system. The two remaining existing ion-exchange vessels and associated piping remained to be available to handle treatments needs until the new system was operational. The current CAWWT building remains to house the smaller treatment system, laboratory, operations control room office, and maintenance shop and to provide storage space.

Step 2, design of the new system, was completed in the spring of 2017. The system was designed to meet the site’s wastewater treatment needs through 2039.

Step 3, construction, installation, and commissioning of the new system, was completed in 2018. The new system became operational on April 3, 2018.

In 2019, the backwash basin (which is used to hold wastewater from the site before being treated) was refurbished. Refurbishment efforts included the removal, shipping, and disposal of approximately 600 cubic yards of low-level radiological waste at a commercial disposal facility in west Texas. While the backwash basin was being refurbished, well field maintenance activities were put on hold until the new backwash basin was available to temporarily store spent well maintenance fluids prior to being treated in the CAWWT system.

A.1.10 References

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

	Reporting Period					
	January 2020 Through December 2020			August 1993 Through December 2020		
	Gallons Pumped/ Reinjected (Mgal)	**Total Uranium Removed/ Reinjected (lb)**	**Uranium Removal Index (lb/Mgal)[a]**	**Gallons Pumped/ Reinjected (Mgal)**	**Total Uranium Removed/ Reinjected (lb)**	**Uranium Removal Index (lb/Mgal)[a]**
South Field Module	1,286.29	246.06	0.19	26,528.68	9,193.97	0.35
Waste Storage Area Module	322.02	61.65	0.19	8,068.17	2,415.04	0.30
South Plume Module	592.67	81.75	0.14	18,279.66	3,501.38	0.19
Reinjection Module[b]	0	0	NA	1,936.48	76.27	NA
Aquifer Restoration Systems Totals						
Extraction Wells	2,200.97	389.46	0.18	52,876.50	15,110.39	0.29
(Reinjection Wells[b])	0	0	NA	(1,936.48)	(76.27)	NA
Net	2,200.97	389.46	NA	50,940.02	15,034.12	NA

[a] NA = not applicable.
[b] Reinjection Module was shut down in September 2004.

Table A.1-2. Extraction Well 31550 (EW-18) Operational Summary for 2020

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: 1,532.5

Hours pumped: 7,227.5
Operational percent: 82.51

Adjusted operational percent[a]: 89.36

Target pumping rate: 100 gpm

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**Volume Pumped (Mgal)**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lb of total uranium removed/Mgal pumped)**
Jan	110.0	4.912	29.6	0.25
Feb	110.2	4.603	31.3	0.26
Mar	87.9	3.923	34.5	0.29
Apr	43.7	1.890	31.9	0.27
May	65.1	2.907	32.1	0.27
Jun	51.9	2.242	35.9	0.30
Jul	91.8	4.097	33.4	0.28
Aug	110.3	4.924	25.6	0.21
Sep	110.9	4.792	32.1	0.07
Oct	110.3	4.923	33.0	0.28
Nov	110.3	4.766	31.1	0.26
Dec	110.5	4.933	32.3	0.27
	Average 117.3	Total 61.656	Average 31.9	Average 0.21

[a] Adjusted for planned annual well field shutdowns.
[b] Well EW-18 was down from March 20 to March 22 due to high river level.
Well EW-18 only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well EW-18 was down from May 19 to May 21 due to high river level.
Well EW-18 was down from June 15 to July 13 for planned annual well field shutdown.
[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 2020

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: 2,086.50

Hours pumped: 6,673.50
Operational percent: 76.18

Adjusted operational percent[a]: 82.51

Target pumping rate: 100 gpm

Monthly Measurements at Well Field							
Month	**Monthly Average Pumping Rate[b] (gpm)**		**Volume Pumped (Mgal)**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lb of total uranium removed/Mgal pumped)**
Jan	96.1		4.289		16.0		0.13
Feb	9.3		0.390		11.2		0.09
Mar	88.1		3.935		19.6		0.16
Apr	47.9		2.068		15.3		0.13
May	65.2		2.909		19.1		0.16
Jun	51.5		2.223		21.7		0.18
Jul	93.1		4.157		19.3		0.16
Aug	109.7		4.898		19.5		0.16
Sep	110.8		4.788		18.7		0.16
Oct	111.1		4.959		18.0		0.15
Nov	111.4		4.814		16.6		0.14
Dec	114.3		5.101		17.4		0.15
Average	84.0	Total	44.530	Average	17.7	Average	0.15

[a] Adjusted for planned annual well field shutdowns.
[b] Well EW-19 was down from February 3 to February 28 to replace pump and motor.
Well EW-19 was down from March 20 to March 22 due to high river level.
Well EW-19 only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well EW-19 was down from May 19 to May 21 due to high river level.
Well EW-19 was down from June 15 to July 13 for planned annual well field shutdown.
[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 2020

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 not pumped: 1,859.0

Hours pumped: 6,901.0
Operational percent: 78.78

Adjusted operational percent[a]: 85.32

Target pumping rate: 200 gpm

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**Volume Pumped (Mgal)**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lb of total uranium removed/Mgal pumped)**
Jan	201.0	8.972	32.6	0.27
Feb	220.6	9.211	34.0	0.28
Mar	162.6	7.257	35.2	0.29
Apr	92.4	3.991	29.9	0.25
May	127.2	5.680	27.9	0.23
Jun	85.4	3.689	31.1	0.26
Jul	113.8	5.082	27.5	0.23
Aug	204.6	9.132	26.4	0.22
Sep	203.8	8.803	28.4	0.24
Oct	220.4	9.838	29.1	0.24
Nov	217.7	9.403	29.0	0.24
Dec	214.8	9.590	29.4	0.25
	Average 172.0	Total 90.647	Average 30.0	Average 0.25

[a] Adjusted for planned annual well field shutdowns.
[b] Well EW-20 was down from January 14 to January 16 for chemical treatment.
Well EW-20 was down from March 20 to March 22 due to high river level.
Well EW-20 was down from March 23 to March 25 for chemical treatment.
Well EW-20 only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well EW-20 was down from May 19 to May 21 due to high river level.
Well EW-20 was down from June 15 to July 13 for planned annual well field shutdown.
Well EW-20 was down from August 18 to August 19 due to a system electrical issue.
Well EW-20 was down from September 8 to September 10 for chemical treatment.
[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 2020

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: 1,835.5

Hours pumped: 6,924.5
Operational percent: 79.05

Adjusted operational percent[a]: 85.61

Target pumping rate: 175 gpm

Monthly Measurements at Well Field							
Month	**Monthly Average Pumping Rate[b] (gpm)**		**Volume Pumped (Mgal)**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lb of total uranium removed/Mgal pumped)**
Jan	190.9		8.522		9.6		0.08
Feb	194.5		8.124		10.7		0.09
Mar	138.8		6.195		11.7		0.10
Apr	82.8		3.577		10.9		0.09
May	113.1		5.049		10.9		0.09
Jun	76.7		3.315		11.4		0.00
Jul	104.4		4.659		11.0		0.09
Aug	193.9		8.654		10.5		0.09
Sep	181.1		7.823		10.2		0.09
Oct	195.1		8.708		10.2		0.09
Nov	196.0		8.469		9.5		0.08
Dec	163.0		7.278		10.5		0.09
Average	152.5	Total	80.374	Average	10.6	Average	0.08

[a] Adjusted for planned annual well field shutdowns.
[b] Well EW-17a was down from March 20 to March 22 due to high river level.
Well EW-17a was down from March 23 to March 24 for chemical treatment.
Well EW-17a only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well EW-17a was down from May 19 to May 21 due to high river level.
Well EW-17a was down from June 9 to June 11 for chemical treatment.
Well EW-17a was down from June 15 to July 13 for planned annual well field shutdown.
Well EW-17a was down from September 21 to September 23 or chemical treatment.
Well EW-17a was down from December 17 to December 23 to inspect the pipe and pump.
[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 2020

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: 1,569.5

Hours pumped: 7,190.5
Operational percent: 82.08

Adjusted operational percent[a]: 88.90

Target pumping rate: 300 gpm

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**Volume Pumped (Mgal)**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lb of total uranium removed/Mgal pumped)**
Jan	329.4	14.704	19.4	0.16
Feb	329.8	13.771	20.5	0.00
Mar	262.7	11.728	22.5	0.19
Apr	139.9	6.042	22.2	0.19
May	191.1	8.528	23.1	0.19
Jun	154.0	6.654	25.1	0.21
Jul	191.5	8.547	23.7	0.20
Aug	327.8	14.632	21.1	0.18
Sep	329.9	14.250	20.5	0.17
Oct	330.0	14.732	20.0	0.17
Nov	330.4	14.274	18.8	0.16
Dec	326.9	14.592	19.0	0.16
	Average 270.3	Total 142.454	Average 21.3	Average 0.16

[a] Adjusted for planned annual well field shutdowns.
[b] Well EW-22 was down from March 20 to March 22 due to high river level.
Well EW-22 only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well EW-22 was down from May 19 to May 21 due to high river level.
Well EW-22 was down from June 15 to July 13 for planned annual well field shutdown.
[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 2020

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: 1,830.5

Hours pumped: 6,929.5
Operational percent: 79.10

Adjusted operational percent[a]: 85.68

Target pumping rate: 400 gpm

Monthly Measurements at Well Field							
Month		**Monthly Average Pumping Rate[b] (gpm)**		**Volume Pumped (Mgal)**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lb of total uranium removed/Mgal pumped)**
Jan		377.7		16.861		25.7		0.21
Feb		397.3		16.593		26.5		0.22
Mar		276.6		12.345		28.5		0.24
Apr		169.5		7.324		25.5		0.21
May		252.9		11.287		24.8		0.21
Jun		202.8		8.762		26.8		0.22
Jul		225.9		10.085		23.6		0.20
Aug		436.6		19.488		24.0		0.20
Sep		409.7		17.699		24.8		0.21
Oct		436.0		19.462		26.5		0.22
Nov		409.0		17.669		26.3		0.22
Dec		434.3		19.386		27.4		0.23
	Average	335.7	Total	176.964	Average	25.9	Average	0.22

[a] Adjusted for planned annual well field shutdowns.
[b] Well EW-24 was down from January 13 to January 15 for chemical treatment.
Well EW-24 was down from March 20 to March 22 due to high river level.
Well EW-24 was down from March 23 to March 26 for chemical treatment.
Well EW-24 only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well EW-24 was down from May 19 to May 21 due to high river level.
Well EW-24 was down from June 15 to July 13 for planned annual well field shutdown.
Well EW-24 was down from September 29 to October 1 for chemical treatment.
Well EW-24 was down from November 2 to November 4 for chemical treatment.
[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 2020

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: 1,916.0

Hours pumped: 6,844.0
Operational percent: 78.13

Adjusted operational percent[a]: 84.62

Target pumping rate: 500 gpm

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**Volume Pumped (Mgal)**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lb of total uranium removed/Mgal pumped)**
Jan	439.4	19.616	32.3	0.27
Feb	494.3	20.640	33.5	0.28
Mar	343.0	15.311	34.4	0.29
Apr	230.9	9.976	29.5	0.25
May	318.1	14.199	29.2	0.24
Jun	252.5	10.909	32.0	0.27
Jul	318.0	14.197	26.6	0.22
Aug	515.3	23.004	30.8	0.26
Sep	439.2	18.973	32.8	0.27
Oct	473.6	21.143	33.4	0.28
Nov	472.0	20.390	31.1	0.26
Dec	432.2	19.295	31.3	0.26
	Average 394.0	Total 207.652	Average 31.4	Average 0.26

[a] Adjusted for planned annual well field shutdowns.
[b] Well EW-23 was down from January 27 to January 29 for chemical treatment.
Well EW-23 was down from March 20 to March 22 due to high river level.
Well EW-23 only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well EW-23 was down from May 19 to May 21 due to high river level.
Well EW-23 was down from June 15 to July 13 for planned annual well field shutdown.
Well EW-23 was down from September 29 to October 1 for chemical treatment.
Well EW-23 was down from November 17 to November 19 for chemical treatment.
Well EW-23 was down from December 16 to December 22 for pump replacement.
[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 2020

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: 1,940.5

Hours pumped: 6,819.50
Operational percent: 77.85

Adjusted operational percent[a]: 84.32

Target pumping rate: 100 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[b] (gpm)**		**Volume Pumped (Mgal)**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lb of total uranium removed/Mgal pumped)**
Jan		111.6		4.982		22.9		0.19
Feb		109.6		4.578		23.9		0.20
Mar		65.3		2.916		23.4		0.20
Apr		48.9		2.115		24.9		0.21
May		61.5		2.746		25.5		0.21
Jun		45.8		1.980		24.3		0.00
Jul		54.0		2.409		26.0		0.22
Aug		110.5		4.931		21.7		0.18
Sep		105.1		4.542		22.1		0.18
Oct		111.2		4.965		13.6		0.11
Nov		112.3		4.853		21.6		0.18
Dec		115.5		5.154		20.9		0.17
	Average	87.6	Total	46.171	Average	22.6	Average	0.17

[a] Adjusted for planned annual well field shutdowns.
[b] Well EW-25 was down from March 2 to March 10 to replace damaged wires in control panel.
Well EW-25 was down from March 20 to March 22 due to high river level.
Well EW-25 was down from March 23 to March 25 for chemical treatment.
Well EW-25 only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well EW-25 was down from May 19 to May 21 due to high river level.
Well EW-25 was down on May 28 due to a failed pressure indicating transmitter.
Well EW-25 was down from June 9 to June 11 for chemical treatment.
Well EW-25 was down from June 15 to July 13 for planned annual well field shutdown.
Well EW-25 was down on August 25 due to the variable frequency drive overheating.
Well EW-25 was down from September 28 to September 30 for chemical treatment.
[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 2020

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: 1,890.5

Hours pumped: 6,869.5
Operational percent: 78.42

Adjusted operational percent[a]: 84.93

Target pumping rate: 300 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[b] (gpm)**		**Volume Pumped (Mgal)**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lb of total uranium removed/Mgal pumped)**
Jan		313.0		13.971		17.8		0.15
Feb		271.8		11.352		20.0		0.17
Mar		232.7		10.388		24.8		0.21
Apr		139.9		6.043		25.8		0.22
May		191.0		8.526		24.8		0.21
Jun		153.9		6.647		25.4		0.21
Jul		180.8		8.072		27.0		0.23
Aug		327.6		14.625		24.6		0.21
Sep		299.5		12.939		22.8		0.19
Oct		313.4		13.992		19.5		0.16
Nov		315.6		13.634		20.0		0.17
Dec		283.7		12.666		23.6		0.20
	Average	251.9	Total	132.856	Average	23.0	Average	0.19

[a] Adjusted for planned annual well field shutdowns.
[b] Well EW-15a was down from February 24 to February 27 for chemical treatment.
Well EW-15a was down from March 20 to March 22 due to high river level.
Well EW-15a was down from March 23 to March 26 for chemical treatment.
Well EW-15a only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well EW-15a was down from May 19 to May 21 due to high river level.
Well EW-15a was down from June 15 to July 13 for planned annual well field shutdown.
Well EW-15a was down from September 21 to September 23 for chemical treatment.
Well EW-15a was down from December 3 to December 7 to replace the pump.
[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 2020

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 not pumped: 1,673.5

Hours pumped: 7,086.5
Operational percent: 80.90

Adjusted operational percent[a]: 87.62

Target pumping rate: 400 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[b] (gpm)**		**Volume Pumped (Mgal)**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lb of total uranium removed/Mgal pumped)**
Jan		409.2		18.265		10.8		0.09
Feb		439.5		18.352		12.2		0.10
Mar		352.8		15.748		13.2		0.11
Apr		184.1		7.954		13.6		0.11
May		255.0		11.382		13.4		0.11
Jun		204.2		8.820		12.4		0.10
Jul		409.7		17.699		24.8		0.21
Aug		436.3		19.479		10.7		0.09
Sep		406.0		17.537		11.2		0.09
Oct		438.6		19.578		9.9		0.08
Nov		439.8		18.998		9.8		0.08
Dec		434.0		19.372		10.0		0.08
	Average	367.4	Total	193.184	Average	12.7	Average	0.11

[a] Adjusted for planned annual well field shutdowns.
[b] Well EW-30 was down from January 14 to January 16 for chemical treatment.
Well EW-30 was down from March 20 to March 22 due to high river level.
Well EW-30 only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well EW-30 was down from May 19 to May 21 due to high river level.
Well EW-30 was down from June 15 to July 13 for planned annual well field shutdown.
Well EW-30 was down from September 8 to September 10 for chemical treatment.
[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 2020

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 not pumped: 1,910.5

Hours pumped: 6,849.5
Operational percent: 78.19

Adjusted operational percent[a]: 84.69

Target pumping rate: 300 gpm

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**Volume Pumped (Mgal)**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lb of total uranium removed/Mgal pumped)**
Jan	284.7	12.711	24.2	0.20
Feb	327.7	13.683	24.7	0.21
Mar	238.3	10.636	26.5	0.22
Apr	135.0	5.831	29.7	0.25
May	191.4	8.544	33.3	0.28
Jun	153.2	6.618	32.5	0.00
Jul	184.5	8.234	33.0	0.28
Aug	281.9	12.583	26.9	0.22
Sep	329.3	14.224	26.8	0.22
Oct	304.7	13.602	20.0	0.17
Nov	286.4	12.373	21.8	0.18
Dec	220.1	9.826	21.6	0.18
	Average 244.8	Total 128.867	Average 26.8	Average 0.20

[a] Adjusted for planned annual well field shutdowns.
[b] Well EW-21a was down from January 13 to January 15 for chemical treatment.
Well EW-21a was down from March 20 to March 22 due to high river level.
Well EW-21a was down from March 23 to March 25 for chemical treatment.
Well EW-21a only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well EW-21a was down from May 19 to May 21 due to high river level.
Well EW-21a was down from June 15 to July 13 for planned annual well field shutdown.
Well EW-21a was down from August 14 to August 18 due to a failed variable frequency drive.
Well EW-21a was down from October 5 to October 7 for chemical treatment.
Well EW-21a was down from November 30 to December 3 for chemical treatment.
Well EW-21a setpoint was reduced to 220 gpm due to low specific capacity.
[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 2020

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: 962.5
Hours pumped: 7,797.5
Operational percent: 89.01
Target pumping rate: 200 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[a] (gpm)**		**Volume Pumped (Mgal)**		**Monthly Total Uranium Concentration[b] (µg/L)**		**Uranium Removal Index (lb of total uranium removed/Mgal pumped)**
Jan		219.5		9.800		10.2		0.09
Feb		219.5		9.168		11.7		0.10
Mar		160.0		7.142		13.1		0.11
Apr		94.0		4.062		13.3		0.11
May		128.0		5.715		10.1		0.08
Jun		227.3		9.819		10.6		0.09
Jul		219.7		9.807		6.0		0.05
Aug		217.9		9.728		9.6		0.08
Sep		205.4		8.873		10.3		0.09
Oct		219.6		9.805		11.0		0.09
Nov		220.0		9.502		10.6		0.09
Dec		217.5		9.711		11.7		0.10
	Average	195.7	Total	103.131	Average	10.7	Average	0.09

[a] Well RW-1 was down from March 17 to March 19 for chemical treatment.
Well RW-1 was down from March 20 to March 22 due to high river level.
Well RW-1 only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well RW-1 was down from May 19 to May 21 due to high river level.
Well RW-1 was down from September 14 to September 16 for chemical treatment.
[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 2020

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 not pumped: 1,134.5
Hours pumped: 7,625.5
Operational percent: 87.05
Target pumping rate: 200 gpm

Monthly Measurements at Well Field							
Month		Monthly Average Pumping Rate[a] (gpm)		Volume Pumped (Mgal)		Monthly Total Uranium Concentration[b] (µg/L)	Uranium Removal Index (lb of total uranium removed/Mgal pumped)
Jan		191.9		8.566		13.3	0.11
Feb		219.2		9.152		12.4	0.10
Mar		153.7		6.862		13.3	0.11
Apr		93.8		4.052		10.9	0.09
May		122.0		5.447		12.6	0.11
Jun		200.5		8.662		13.6	0.11
Jul		219.7		9.806		13.2	0.11
Aug		216.9		9.683		12.4	0.10
Sep		204.9		8.851		11.9	0.10
Oct		219.4		9.795		13.0	0.11
Nov		202.8		8.760		12.2	0.10
Dec		216.3		9.658		13.2	0.11
	Average	188.4	Total	99.293	Average	12.7	Average 0.11

[a] Well RW-2 was down from January 21 to January 23 for chemical treatment.
Well RW-2 was down from March 17 to March 19 for chemical treatment.
Well RW-2 was down from March 20 to March 22 due to high river level.
Well RW-2 only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well RW-2 was down from May 19 to May 21 due to high river level.
Well RW-2 was down on June 2 to replace the flow meter.
Well RW-2 was down from June 22 to June 24 for chemical treatment.
Well RW-2 was down from September 14 to September 16 for chemical treatment.
Well RW-2 was down from November 17 to November 19 for chemical treatment.

[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 2020

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 not pumped: 1,256.0
Hours pumped: 7,504.0
Operational percent: 85.66
Target pumping rate: 200 gpm

Monthly Measurements at Well Field							
Month		**Monthly Average Pumping Rate[a] (gpm)**		**Volume Pumped (Mgal)**		**Monthly Total Uranium Concentration[b] (µg/L)**		**Uranium Removal Index (lb of total uranium removed/Mgal pumped)**
Jan		203.3		9.076		20.2		0.17
Feb		218.9		9.143		18.6		0.16
Mar		173.8		7.760		18.7		0.16
Apr		93.8		4.054		17.0		0.14
May		127.6		5.695		17.9		0.15
Jun		206.7		8.929		18.3		0.15
Jul		216.4		9.660		17.6		0.15
Aug		209.9		9.371		16.3		0.14
Sep		180.9		7.817		17.2		0.14
Oct		218.4		9.749		17.8		0.15
Nov		203.3		8.781		18.0		0.15
Dec		164.7		7.351		22.1		0.18
	Average	184.8	Total	97.385	Average	18.3	Average	0.15

[a] Well RW-3 was down from January 21 to January 23 for chemical treatment.
Well RW-3 was down from March 20 to March 22 due to high river level.
Well RW-3 only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well RW-3 was down from May 19 to May 21 due to high river level.
Well RW-3 was down from June 29 to July 1 for chemical treatment.
Well RW-3 was down from September 15 to September 17 for chemical treatment.
Well RW-3 was down from November 2 to November 4 for chemical treatment.
Well RW-3 was down from December 8 to December 15 due to a leaking seal in a pitless adaptor.
[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 2020

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 not pumped: 1,670.0
Hours pumped: 7.090.0
Operational percent: 80.94
Target pumping rate: 200/100[a] gpm

Monthly Measurements at Well Field								
Month		Monthly Average Pumping Rate[b] (gpm)		Volume Pumped (Mgal)		Monthly Total Uranium Concentration[c] (µg/L)		Uranium Removal Index (lb of total uranium removed/Mgal pumped)
Jan		13.4		0.598		2.0		0.02
Feb		146.7		6.126		2.0		0.02
Mar		117.5		5.244		3.4		0.03
Apr		62.0		2.679		2.6		0.02
May		81.2		3.626		2.4		0.02
Jun		138.3		5.974		2.6		0.02
Jul		139.6		6.231		2.6		0.02
Aug		134.7		6.012		2.5		0.02
Sep		109.1		4.714		2.5		0.02
Oct		140.7		6.280		2.5		0.02
Nov		137.0		5.920		2.6		0.02
Dec		120.6		5.384		2.9		0.02
	Average	111.7	Total	58.787	Average	2.6	Average	0.02

[a] The target pumping rate changed from 200 to 100 gpm in July 2018.
[b] Well RW-4 was down from January 27 to January 29 for chemical treatment.
Well RW-4 was down from March 20 to March 22 due to high river level.
Well RW-4 only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well RW-4 was down from May 19 to May 21 due to high river level.
Well RW-4 was down from July 6 to July 8 for chemical treatment.
Well RW-4 was down from September 28 to September 30 for chemical treatment.
[c] 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 2020

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: 1,788.5

Hours pumped: 6,971.5
Operational percent: 79.58

Adjusted operational percent[a]: 86.20

Target pumping rate: 300 gpm

Monthly Measurements at Well Field							
Month		**Monthly Average Pumping Rate[b] (gpm)**		**Volume Pumped (Mgal)**		**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lb of total uranium removed/Mgal pumped)**
Jan		224.1		10.006		27.2	0.23
Feb		224.1		9.359		28.9	0.24
Mar		168.4		7.517		30.4	0.25
Apr		119.2		5.148		27.2	0.23
May		170.5		7.611		25.9	0.22
Jun		135.0		5.833		26.8	0.00
Jul		152.9		6.825		22.7	0.19
Aug		325.6		14.534		24.9	0.21
Sep		317.6		13.720		25.8	0.22
Oct		286.9		12.809		28.7	0.24
Nov		261.0		11.277		28.6	0.24
Dec		254.1		11.342		31.1	0.26
	Average	220.0	Total	115.981	Average	27.4	Average 0.21

[a] Adjusted for planned annual well field shutdown.
[b] Well RW-6 was down from March 20 to March 22 due to high river level.
Well RW-6 was down from March 23 to March 24 for chemical treatment.
Well RW-6 only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well RW-6 was down from May 19 to May 21 due to high river level.
Well RW-6 was down from June 15 to July 13 for planned annual well field shutdown.
Well RW-6 was down from November 9 to November 12 for chemical treatment.
Well RW-6 was down from December 3 to December 4 to replace the pump.
Well RW-6 setpoint reduced to 250 gpm due to low specific capacity.
[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 2020

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 pumped: 6,682.5 | Target pumping rate: 300 gpm
Hours not pumped: 2,077.5 | Operational percent: 76.28

Adjusted operational percent[a]: 82.62

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**Volume Pumped (Mgal)**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lb of total uranium removed/Mgal pumped)**
Jan	312.4	13.944	18.2	0.15
Feb	286.7	11.975	19.6	0.16
Mar	213.7	9.538	20.5	0.17
Apr	127.4	5.502	18.3	0.15
May	179.2	8.000	18.5	0.15
Jun	141.5	6.114	20.2	0.00
Jul	153.0	6.830	16.8	0.14
Aug	273.6	12.213	19.5	0.16
Sep	278.3	12.022	20.7	0.17
Oct	274.3	12.245	22.0	0.18
Nov	242.2	10.464	19.7	0.16
Dec	207.0	9.241	22.1	0.18
	Average 224.1	Total 118.089	Average 19.7	Average 0.15

[a] Adjusted for planned annual well field shutdown.
[b] Well RW-7 was down from March 20 to March 22 due to high river level.
Well RW-7 was down from March 23 to March 24 for chemical treatment.
Well RW-7 only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well RW-7 was down from May 19 to May 21 due to high river level.
Well RW-7 was down from June 15 to July 13 for planned annual well field shutdown.
Well RW-7 was down on August 10 to replace flowmeter.
Well RW-7 was down on September 14 to replace the pump.
Well RW-7 was down from October 28 to November 4 for a failed variable frequency drive.
Well RW-7 was down from November 9 to November 12 for chemical treatment.
Well RW-7 was down from December 2 to November 9 for pump replacement.
Well RW-7 setpoint reduced to 250 gpm due to low specific capacity.
[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]	Minimum[a,b,c,d] (mg/L)	Maximum[a,b,c,d] (mg/L)	Average[a,b,c,d] (mg/L)	SD[a,b,c,d]	Trend[a,b,c,d,e]
Arsenic	2128	252	0.000195	0.188	0.0109	0.0201	Down
	2636	190	0.0100	0.0939	0.0434	0.0185	Down
	2898	69	0.000147	0.0820	0.00413	0.0105	No Trend[f]
	2899	62	0.00032	0.0283	0.00240	0.00376	No Trend[f]
	2900	251	0.00032	0.0609	0.00487	0.00530	Down
	3128	72	0.00040	0.234	0.00671	0.0276	No Trend
	3636	69	0.00050	0.0233	0.00278	0.00357	No Trend[f]
	3898	69	0.00050	0.0434	0.00413	0.00616	No Trend[f]
	3899	70	0.000147	0.0307	0.00266	0.00428	No Trend[f]
	3900	70	0.000375	0.0208	0.00280	0.0030	No Trend
Phosphorus	2128	78	0.0250	16.2	1.27	2.26	Down
	2636	42	9.60	170	78.9	42.6	Down
	2898	70	0.0050	9.95	0.224	1.20	Down
	2899	61	0.0050	0.831	0.0551	0.110	No Trend
	2900	68	0.0431	4.74	0.434	0.623	Down
	3128	79	0.0050	13.0	0.218	1.46	No Trend
	3636	68	0.0091	1.10	0.0667	0.135	No Trend
	3898	68	0.0075	1.24	0.0924	0.162	Down
	3899	69	0.0050	1.86	0.107	0.255	Down
	3900	70	0.0050	1.38	0.0821	0.221	Down
Potassium	2128	70	0.830	18.0	3.18	3.11	Down
	2636	42	4.60	218	58.7	49.8	Down
	2898	70	1.11	9.64	4.41	1.14	**Up**
	2899	62	1.36	8.85	4.11	0.91	**Up**
	2900	69	0.0095	6.00	1.96	1.04	No Trend
	3128	72	1.09	3.70	1.89	0.61	Down
	3636	68	1.09	4.24	2.09	0.57	Down
	3898	69	0.610	4.23	2.72	0.75	**Up**
	3899	70	0.875	4.55	2.85	0.802	**Up**
	3900	70	0.975	3.19	1.69	0.38	Down
Sodium	2128	70	12.3	75.2	33.5	11.2	Down
	2636	42	14.4	148	48.8	26.8	Down
	2898	70	4.95	31.0	19.8	4.7	**Up**
	2899	62	11.2	25.1	18.0	3.4	**Up**
	2900	69	0.0136	43.3	25.4	7.7	Down
	3128	72	3.52	13.4	5.48	2.46	Down
	3636	68	3.14	13.0	5.64	2.64	Down
	3898	69	7.29	28.8	13.0	5.9	**Up**
	3899	70	6.24	43.6	14.1	10.2	**Up**
	3900	70	3.13	10.8	4.73	1.71	Down

[a] The data are based on unfiltered samples from the Operable Unit 5 Remedial Investigation/Feasibility Study dataset (1988–1993) and 1994 through 2020 groundwater data (unfiltered and filtered for 2001–2020).
[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). This Mann-Kendall test for trend is performed with a 95% confidence interval.
[g] The original statistics indicated an upward trend; however, the upward trend was due to a slight increase in the method detection limit for nondetected concentrations. As a result, “No Trend” is indicated.

Table A.1-20. Extraction Well 32761 (EW-26) Operational Summary for 2020

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: 2,562.0

Hours pumped: 6,198.0
Operational percent: 70.75

Adjusted operational percent[a]: 76.63

Target pumping rate: 300 gpm

Monthly Measurements at Well Field								
Month		**Monthly Average Pumping Rate[b] (gpm)**		**Volume Pumped (Mgal)**		**Monthly Total Uranium Concentration[c] (µg/L)**		**Uranium Removal Index (lb of total uranium removed/Mgal pumped)**
Jan		329.3		14.701		19.9		0.17
Feb		328.9		13.737		22.5		0.19
Mar		251.6		11.229		23.8		0.20
Apr		141.1		6.097		24.9		0.21
May		193.4		8.635		23.5		0.20
Jun		153.9		6.650		24.7		0.21
Jul		0.0		0.000		0.0		0.00
Aug		83.2		3.712		23.3		0.19
Sep		329.9		14.253		22.6		0.19
Oct		330.0		14.732		21.0		0.18
Nov		324.7		14.028		19.3		0.16
Dec		326.6		14.579		21.1		0.18
	Average	232.7	Total	122.354	Average	20.6	Average	0.17

[a] Adjusted for planned annual well field shutdowns.
[b] Well EW-26 was down from March 20 to March 22 due to high river level.
Well EW-26 only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well EW-26 was down from May 19 to May 21 due to high river level.
Well EW-26 was down from June 15 to July 13 for planned annual well field shutdown.
Well EW-26 was down from July 13 to August 24 for rehabilitation.
[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 2020

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: 2,632.0

Hours pumped: 6,128
Operational percent: 69.95

Adjusted operational percent[a]: 75.77

Target pumping rate: 200 gpm

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**Volume Pumped (Mgal)**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lb of total uranium removed/Mgal pumped)**
Jan	175.2	7.821	19.3	0.16
Feb	219.6	9.171	24.7	0.21
Mar	175.3	7.827	25.3	0.21
Apr	94.2	4.070	24.6	0.21
May	128.4	5.730	24.3	0.20
Jun	103.9	4.487	25.1	0.21
Jul	36.3	1.619	21.6	0.18
Aug	40.8	1.822	22.1	0.18
Sep	219.7	9.493	24.7	0.21
Oct	219.9	9.816	24.8	0.21
Nov	220.6	9.530	22.8	0.19
Dec	215.9	9.640	24.9	0.21
	Average 154.2	Total 81.027	Average 23.7	Average 0.20

[a] Adjusted for planned annual well field shutdowns.
[b] Well EW-27 was down from January 1 to January 7 to replace the pump and motor.
Well EW-27 was down from March 20 to March 22 due to high river level.
Well EW-27 only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well EW-27 was down from May 19 to May 21 due to high river level.
Well EW-27 was down from June 15 to July 13 for planned annual well field shutdown.
Well EW-27 was down from July 20 to August 26 for rehabilitation.
[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 2020

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: 2,723.0

Hours pumped: 6,037.0
Operational percent: 68.92

Target pumping rate: 300 gpm

Adjusted operational percent[a]: 74.64

Monthly Measurements at Well Field				
Month	**Monthly Average Pumping Rate[b] (gpm)**	**Volume Pumped (Mgal)**	**Monthly Total Uranium Concentration[c] (µg/L)**	**Uranium Removal Index (lb of total uranium removed/Mgal pumped)**
Jan	306.5	13.684	19.8	0.17
Feb	329.5	13.758	23.5	0.20
Mar	257.6	11.497	23.8	0.20
Apr	137.9	5.956	25.0	0.21
May	180.8	8.069	22.9	0.19
Jun	153.3	6.624	26.4	0.22
Jul	0.0	0.000	0.0	0.00
Aug	71.9	3.211	23.7	0.20
Sep	322.3	13.922	26.0	0.22
Oct	329.6	14.712	24.5	0.20
Nov	302.0	13.048	21.2	0.18
Dec	317.1	14.157	22.4	0.19
	Average 225.7	Total 118.637	Average 21.6	Average 0.18

[a] Adjusted for planned annual well field shutdowns.
[b] Well EW-33a was down from January 28 to January 30 for chemical treatment.
Well EW-33a was down from March 20 to March 22 due to high river level.
Well EW-33a only operated Monday morning to Thursday morning from March 26 to May 18 due to reduced site activities as a result of the COVID-19 pandemic.
Well EW-33a was down on May 18 to facilitate groundwater sampling in the adjacent monitoring well.
Well EW-33a was down from May 19 to May 21 due to high river level.
Well EW-33a was down from June 15 to July 13 for planned annual well field shutdown.
Well EW-33a was down from July 13 to August 25 for rehabilitation.
[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, 2020

Extraction Well Number	Database Identification	Data Trend	R^2 [a]	95% Upper Confidence Limit	R^2 [a]	Function Type
RW-1	3924	$3.92E+32x^{-6.80}$	0.85	$1.28E+16x^{-3.13}$	0.76	Power
RW-2	3925	$y = 5.32E-07x^2 - 4.50E-02x + 9.66E+02$	0.77	$y = 5.32E-07x^2 - 4.50E-02x + 9.82E+02$	0.77	Polynomial
RW-3	3926	$y = 1.85E-10x^3 - 2.26E-05x^2 + 9.20E-01x - 1.24E+04$	0.74	$y = 1.85E-10x^3 - 2.26E-05x^2 + 9.20E-01x - 1.24E+04$	0.74	Polynomial
RW-4	3927	$y = 1.71E-16x^{3.52}$	0.30	$y = 6.14E-07x^{1.50}$	0.20	Power
RW-6	32308	$y = 1.02E+27x^{-5.52}$	0.87	$y = 7.33E+16x^{-3.26}$	0.85	Power
RW-7	32309	$y = 6.68E+34x^{-7.23}$	0.93	$y = 1.49E+19x^{-3.76}$	0.88	Power
EW-15a	33262	$y = 7.13E+34x^{-7.23E+00}$	0.80	$y = 1.130E+20x^{-3.95E+00}$	0.78	Power
EW-17a	33326	$y = 1.49E+04e^{-1.64E-04x}$	0.83	$y = 1.27E+03e^{-8.47E-05x}$	0.79	Exponential
EW-18	31550	$y = 2.19E+20x^{-4.07}$	0.53	$y = 3.45E+12x^{-2.31}$	0.48	Power
EW-19	31560	$y = 1.32E+51x^{-1.08E+01}$	0.84	$y = 1.45E+20x^{-3.94}$	0.72	Power
EW-20	31561	$y = 6.57E+14x^{-2.88}$	0.49	$y = 3.52E+10x^{-1.91}$	0.48	Power
EW-21a	33298	$y = 3.22E+37x^{-7.78}$	0.83	$y = 4.91E+18x^{-3.61}$	0.77	Power
EW-22	32276	$y = 2.39E+59x^{-1.25E+01}$	0.91	$y = 2.68E+22x^{-4.38}$	0.80	Power
EW-23	32447	$y = 1.70E+33x^{-6.83}$	0.88	$y = 5.30E+12x^{-2.28}$	0.89	Power
EW-24	32446	$y = 1.42E+31x^{-6.41}$	0.87	$y = 3.53E+17x^{-3.39}$	0.80	Power
EW-25	33061	$y = 3.38E+26x^{-5.43}$	0.59	$y = 5.54E+15x^{-3.03}$	0.57	Power
EW-30	33264	$y = 5.11E+75x^{-1.61E+01}$	0.97	$y = 6.23E+27x^{-5.57}$	0.91	Power
EW-26	32761	$y = 1.03E+50x^{-1.05E+01}$	0.82	$y = 7.57E+21x^{-4.31}$	0.74	Power
EW-27	33062	$y = 8.51E+51x^{-1.09E+01}$	0.80	$y = 1.91E+22x^{-4.37}$	0.66	Power
EW-33a	33347	$y =3.71E+13x^{-2.64}$	0.056	$y = 1.73E+09x^{-1.60}$	0.10	Power

[a] R^2 = Coefficient of Determination

Table A.1-24. Estimate of Pounds of Uranium to Be Removed to Achieve Concentration-Based FRL Goals and Mass Removal Completeness

Year	Estimate of Annual Pounds of Uranium to Be Extracted to Achieve Concentration-Based FRL Goals Based on Regression of Concentration Data	Estimate of Annual Pounds of Uranium to Be Extracted to Achieve Concentration-Based FRL Goals Based on Model Predictions	Estimate of Annual Pounds of Uranium to Be Extracted to Achieve Concentration-Based FRL Goals Based on Regression of 95% UCL
2021	447	210	1643
2022	426	193	1605
2023	174	179	624
2024	166	166	608
2025	158	156	592
2026	151	59	577
2027	144	55	563
2028	138	52	549
2029	60	47	282
2030	58	46	276
2031	56	44	270
2032	54	42	264
2033	52	40	258
Estimate of total to be extracted	2,082	1,289	8,110
Actual net pounds extracted through December 31, 2020	*15,034*	*15,034*	*15,034*
Estimate of total pounds to be extracted to achieve concentration-based FRL goals.	17,116	16,323	23,144

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
2020	88	92	65
2019	86	91	62
2018	87	89	62
2017	86	87	59
2016	84	84	55
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

Extraction Well	Model-Predicted Total Uranium Concentration December 2020[a] (µg/L)	Total Uranium Concentration December 2020 (µg/L)	Residual Total Uranium Concentration[b] (µg/L)
3924 (RW-1)	4.22[b]	11.7	7.5
3925 (RW-2)	6.65	13.2	6.6
3926 (RW-3)	8.33 [b]	22.1	13.8
3927 (RW-4)	3.23 [b]	2.80	-0.43
32308 (RW-6)	17.00	31.1	14.1
32309 (RW-7)	14.48	22.1	7.6
33262 (EW-15a)	21.14	23.6	2.5
33326 (EW-17a)	23.53	10.5	−13.0
31550 (EW-18)	17.32 [b]	32.3	15.0
31560 (EW-19)	14.10	17.4	3.3
31561 (EW-20)	17.45	29.4	12.0
33298 (EW-21a)	13.46	21.6	8.1
32276 (EW-22)	13.7	19.0	5.3
32447 (EW-23)	12.72	31.3	18.6
32446 (EW-24)	12.57	27.4	14.8
33061 (EW-25)	15.01	20.9	5.9
32761 (EW-26)	22.06	21.1	–1.0
33062 (EW-27)	9.24	24.9	15.7
33264 (EW-30)	5.78 [b]	10.0	4.2
33347 (EW-33a)	39.75	22.4	–17.4
2020 Average	14.1	20.7	6.6
2020 Standard	6.8	7.90	8.0
2020 Maximum	29.8	32.3	18.6
2020 Minimum	3.23	2.9	-13.0
2020 Range	26.6	29.4	31.6
2019 Average	15.3	19.9	4.70
2019 Standard	7.8	8.20	9.10
2019 Maximum	34.0	34.8	20.5
2019 Minimum	3.23	2.80	–14.6
2019 Range	30.8	32.0	35.1
2018 Average	16.8	21.1	4.3
2018 Standard	9.0	8.5	9.7
2018 Maximum	39.5	37.2	20.9
2018 Minimum	3.22	2.80	–16.6
2018 Range	36.3	34.4	37.6
2017 Average	18.5	22.0	3.5
2017 Standard	10.4	8.70	11.4
2017 Maximum	46.5	40.9	22.0
2017 Minimum	3.20	2.60	–26.8
2017 Range	43.3	38.3	48.8
2016 Average	20.5	23.5	2.99
2016 Standard	15.1	8.50	14.3
2016 Maximum	55.84	44.4	21.7
2016 Minimum	3.18	3.80	–35.4
2016 Range	52.7	40.6	57.1
2015 Average	23.1	22.6	–0.48
2015 Standard	15.1	8.50	15.4
2015 Maximum	69.2	41.0	14.7
2015 Minimum	3.16	3.60	–50.4
2015 Range	66.0	37.4	65.1

[a] Model predicted total uranium concentrations are from April 1, 2019.
[b] Residual total uranium concentration = actual total uranium concentration – model-predicted total uranium concentration.

Table A.1-26. Comparison of Model-Predicted Versus Actual Total Uranium Concentrations in Selected Monitoring Wells

Well Number	Observed Total Uranium Concentrations 1st Half 2020 (µg/L)	Predicted Total Uranium Concentrations[a] April 1, 2020 (µg/L)	Total Uranium Concentration Residuals (µg/L)
2045	38.5	14.45	24.0
2046	22.9	20.97	1.9
2049	32.2	18.19	14.0
2093	3.93	2.14	1.79
2385	16.4	66.03	–49.6
2386	111	23.67	87.3
2387	134	23.78	110
2821	8.65	17.14	–8.49
23271	49.1	24.11	25.0
23273	184	28.48	156
23274	75.0	38.97	36.0
23275	88.3	30.03	58.3
23276	80.1	43.73	36.4
23278	21.9	39.13	–17.2
23280	26.7	31.96	–5.3
23281	113	21.12	92
82433_C2	4.07	7.52	–3.45
83117_C2	23.8	24.46	–0.7
83124_C2	22.8	28.54	–5.7
83293_C2	2.54	4.73	–2.19
83294_C2	139	17.27	122
83295_C2	83.7	20.84	62.9
83296_C2	26.5	14.71	11.8
2020 Average	56.9	24.4	32.4
2020 Standard Deviation	51.1	13.8	51.1
2020 Maximum	184	66.0	156
2020 Minimum	2.54	2.14	–49.6
2020 Range	181	63.9	205
2019 Average	62.9	27.3	35.7
2019 Standard Deviation	52.2	15.6	52.5
2019 Maximum	174	72.5	156
2019 Minimum	2.20	2.19	–60.0
2019 Range	172	70.3	216
2018 Average	60.6	30.1	30.4
2018 Standard Deviation	57.6	17.6	57.5
2018 Maximum	203	81.4	182
2018 Minimum	2.80	2.20	–60.5
2018 Range	200	79.24	242
2017 Average	68.6	33.6	35.0
2017 Standard Deviation	68.7	20.0	68.2
2017 Maximum	250	91.77	225
2017 Minimum	3.36	2.21	–62.6
2017 Range	247	89.56	288

[a] Model predictions based on high water levels.

Table A.1-27. Comparison of Model-Predicted Versus Actual Total Uranium Concentrations with Select Wells Removed[a]

Well Number	Observed Total Uranium Concentrations 1st Half 2020 (µg/L)	Predicted Total Uranium Concentrations April 1, 2020[b] (µg/L)	Total Uranium Concentration Residuals (µg/L)
2045	38.5	14.45	24.0
2046	22.9	20.97	1.9
2049	32.2	18.19	14.0
2093	3.93	2.14	1.79
2385	16.4	66.03	–49.6
2821	8.65	17.14	–8.5
23271	49.1	24.11	25.0
23274	75.0	38.97	36.0
23276	88.3	30.03	58.27
23278	80.1	43.73	36.37
23280	21.9	39.13	–17.23
82433_C2	4.07	7.52	–3.45
83117_C2	23.8	24.46	–0.66
83124_C2	22.8	28.54	–5.74
83293_C2	2.54	4.73	–2.19
83295_C2	83.7	20.84	62.86
83296_C2	26.5	14.71	11.79
2020 Average	34.8	24.9	9.97
2020 Standard Deviation	28.5	15.6	27.3
2020 Maximum	88.3	66.0	62.9
2020 Minimum	2.54	2.14	–49.6
2020 Range	85.8	63.9	112
2019 Average	40.8	27.4	13.5
2019 Standard Deviation	31.2	17.6	30.0
2019 Maximum	106	72.5	55.2
2019 Minimum	2.20	2.19	–60.0
2019 Range	104	70.3	115.2
2018 Average	38.45	30.20	8.24
2018 Standard Deviation	30.90	19.22	29.54
2018 Maximum	110	81.44	58.56
2018 Minimum	2.80	2.20	–60.54
2018 Range	107.20	79.24	119.10
2017 Average	42.0	33.85	8.23
2017 Standard Deviation	32.9	21.89	30.48
2017 Maximum	120	91.77	61.7
2017 Minimum	3.36	2.21	–62.6
2017 Range	117	89.56	124

[a] Data from monitoring wells 2386, 2387, 23273, 23275, 23281, and 83294_C2 are not presented.
[b] Model predictions based on high water levels.

Table A.1-28. Extraction Well Target Pumping Rates

Module/Extraction Well	Target Pumping Rate (gpm)
South Plume	
3924 (RW-1)	200
3925 (RW-2)	200
3926 (RW-3)	200
3927 (RW-4)	200/100[a]
32308 (RW-6)	300
32309 (RW-7)	300
Subtotal	1,300
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	4,975[a]

[a] Pumping rate was changed to 100 gpm in July 2018.

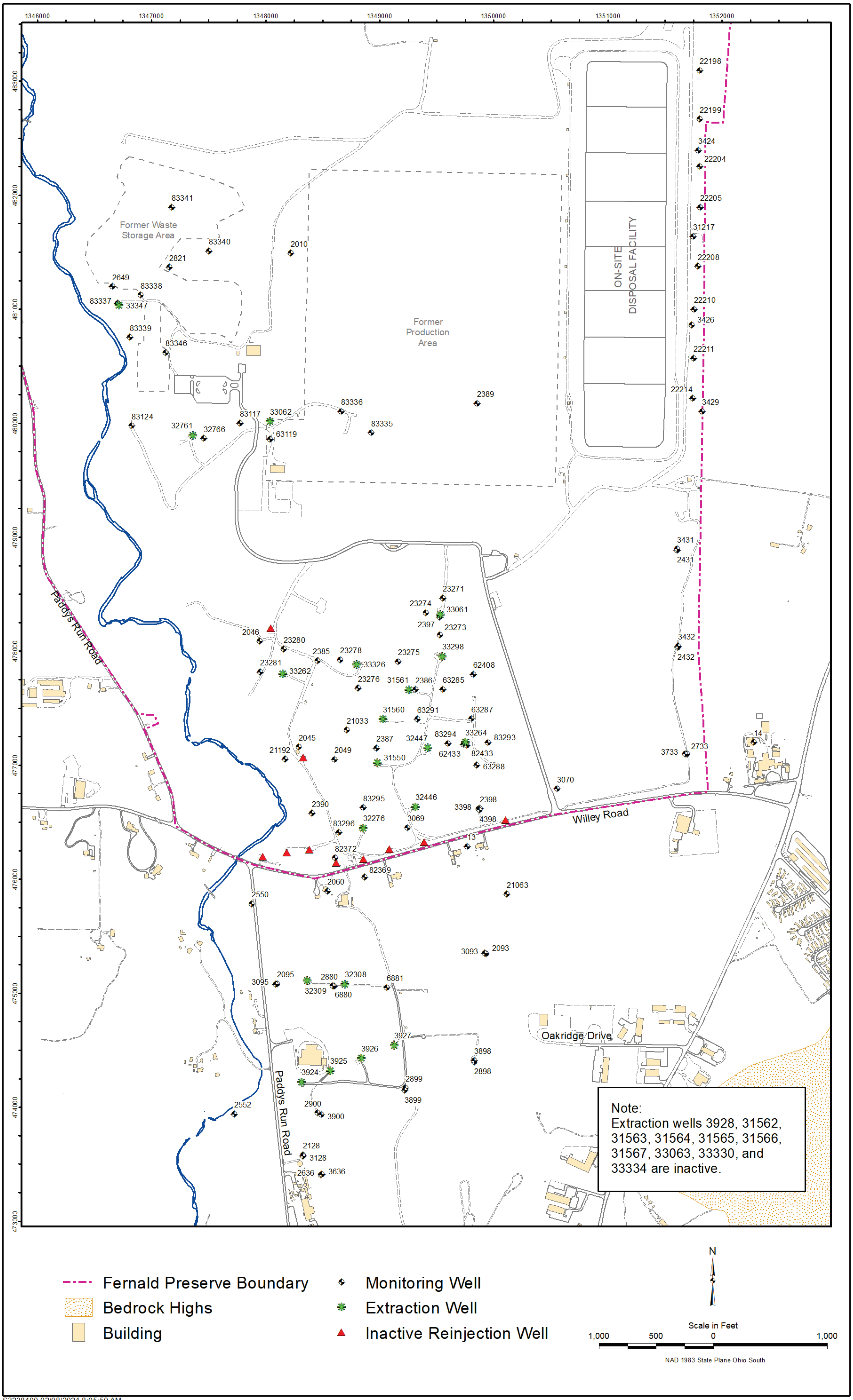

Figure A.1-1. Well Locations for South Plume, South Field, Waste Storage Area, and PRRS Monitoring Activities

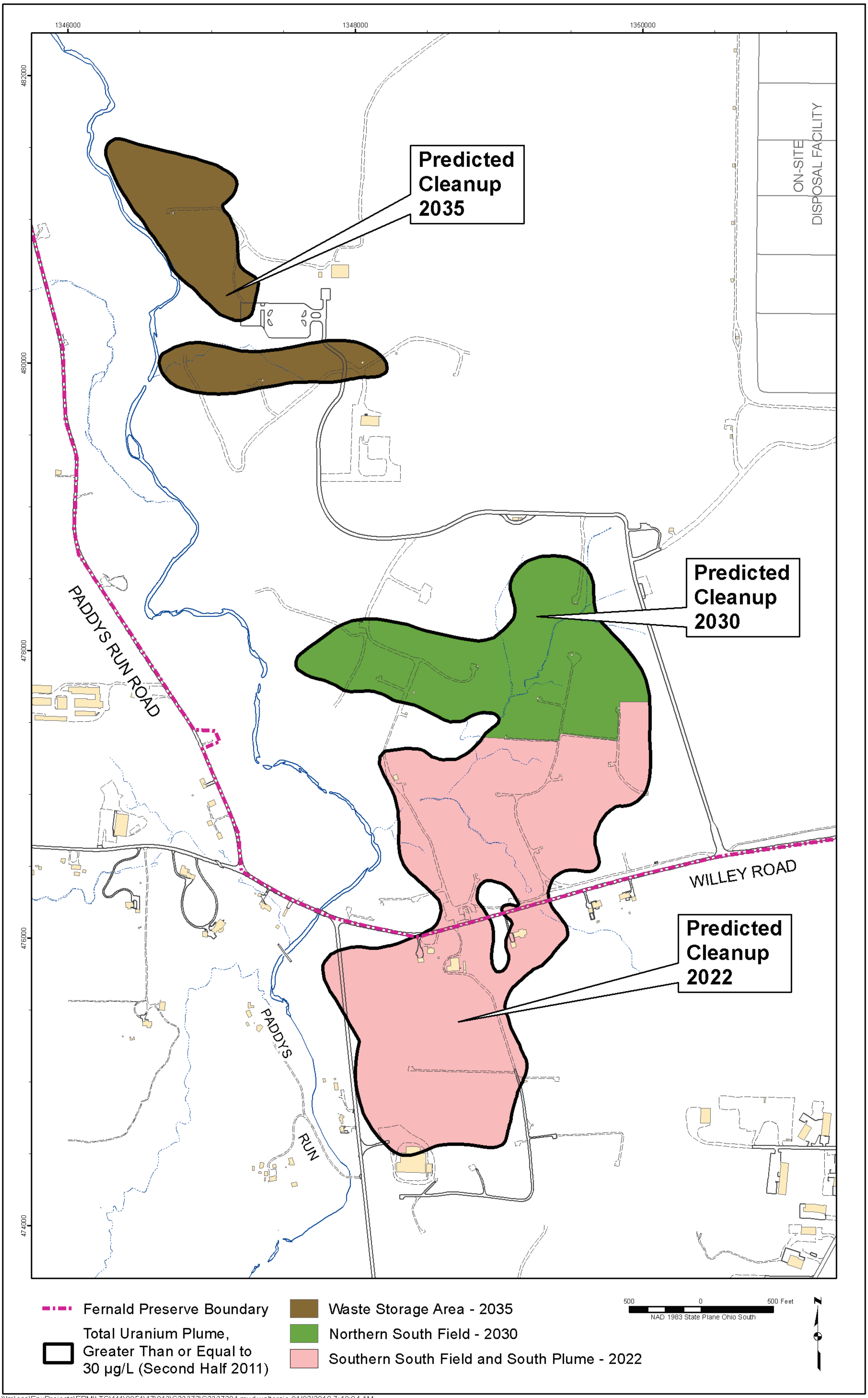

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Figure A.1-2. Operational Design

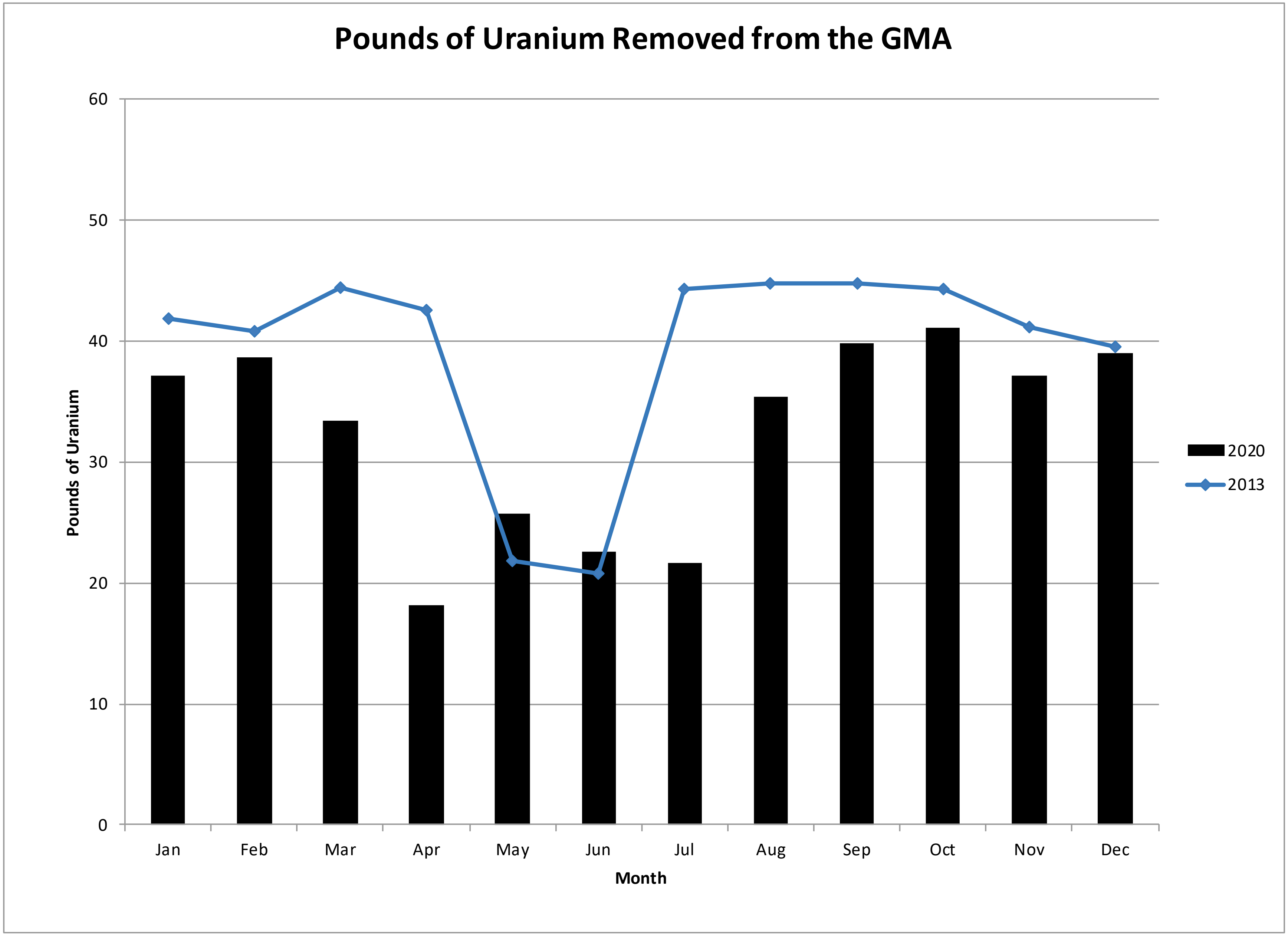

Figure A.1-3. Pounds of Uranium Removed from the Great Miami Aquifer

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

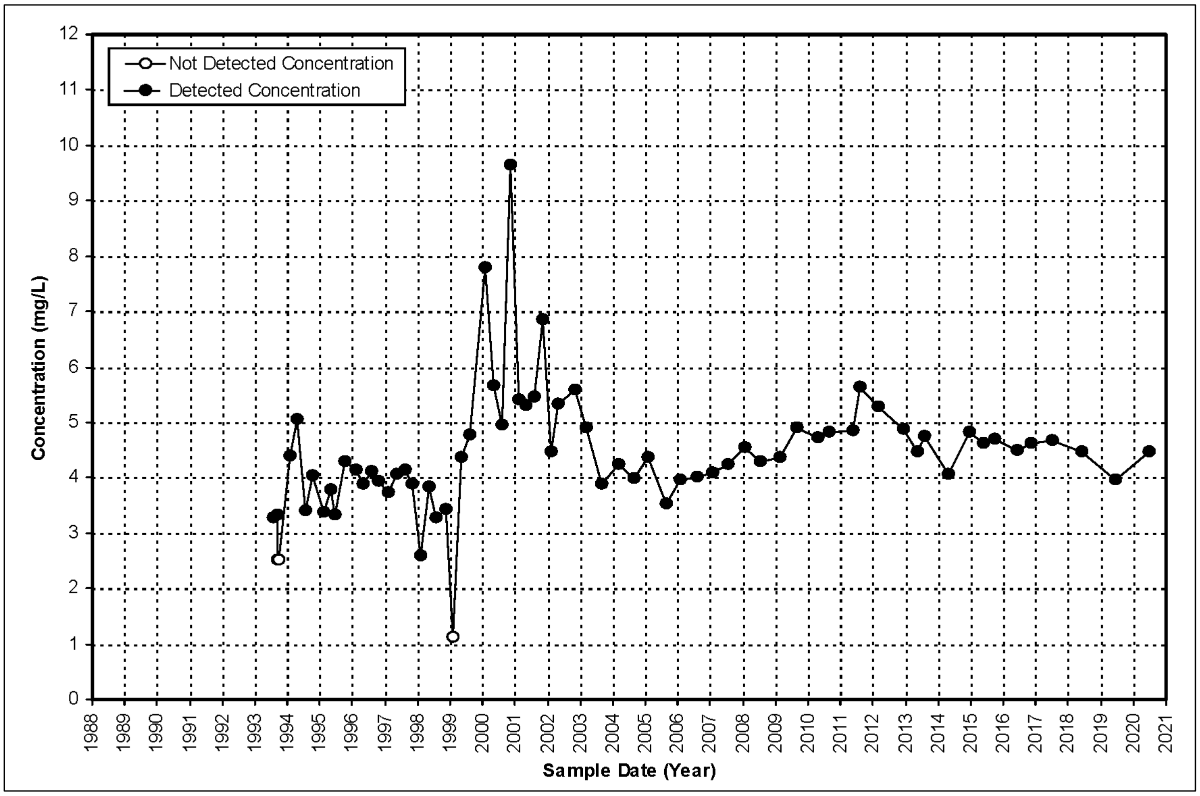

Figure A.1-5. Potassium Concentration Versus Time Plot for Monitoring Well 2898

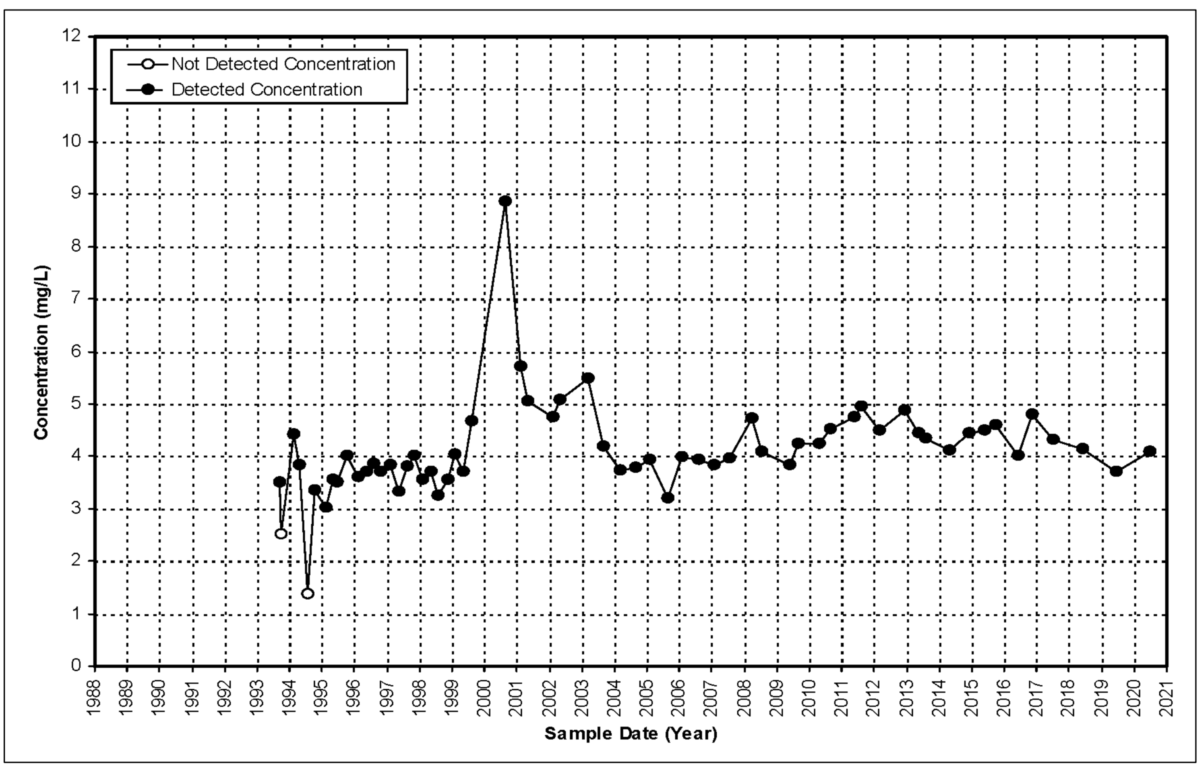

Figure A.1-6. Potassium Concentration Versus Time Plot for Monitoring Well 2899

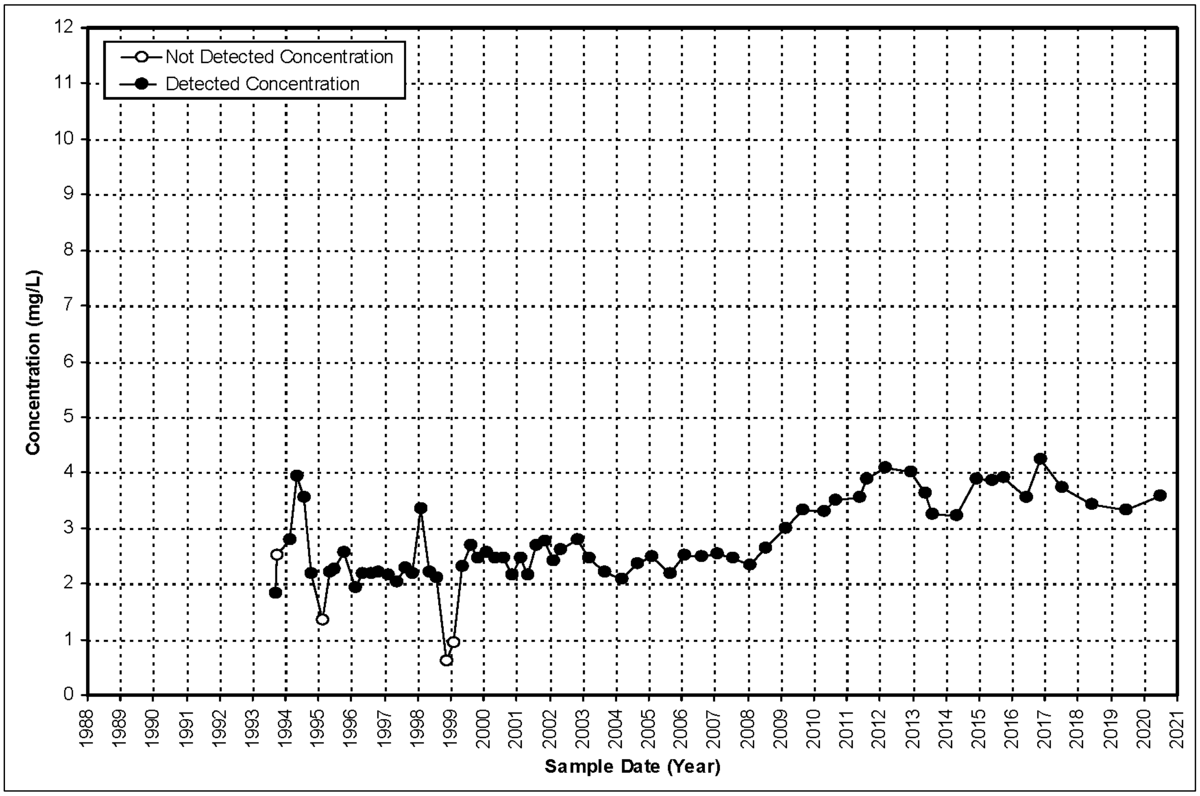

Figure A.1-7. Potassium Concentration Versus Time Plot for Monitoring Well 3898

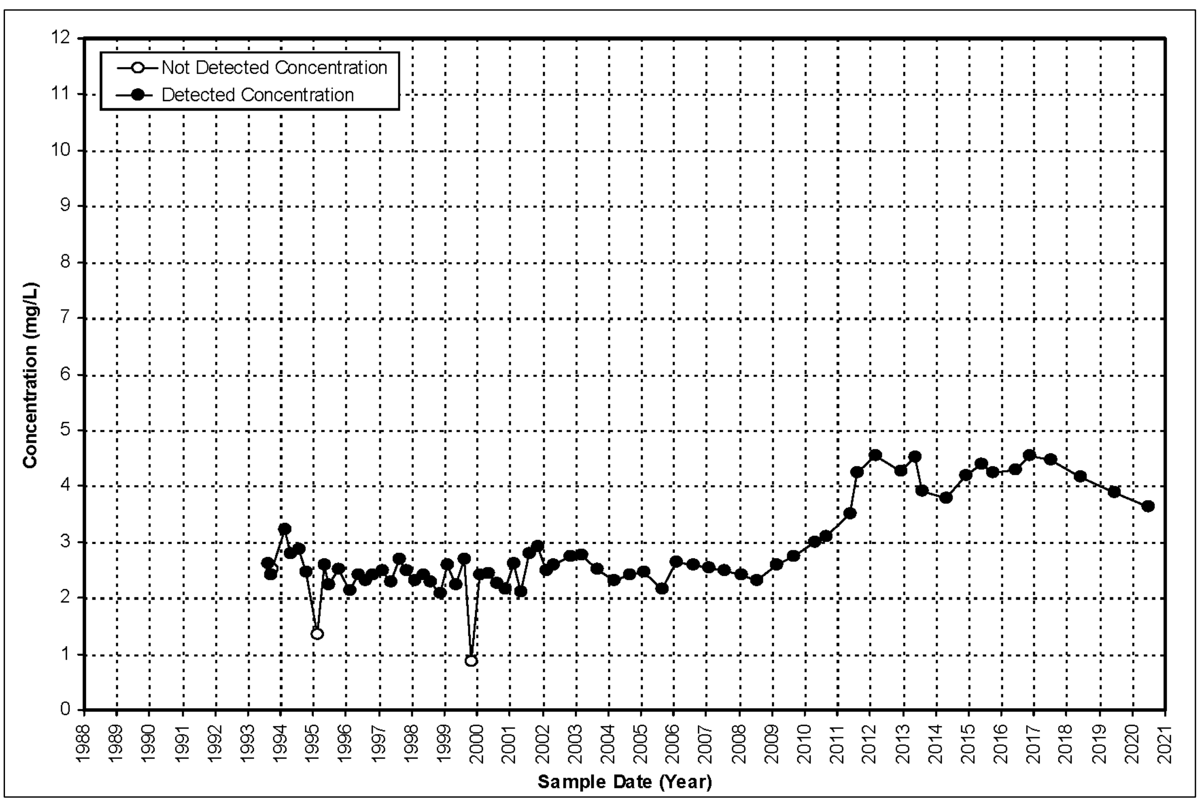

Figure A.1-8. Potassium Concentration Versus Time Plot for Monitoring Well 3899

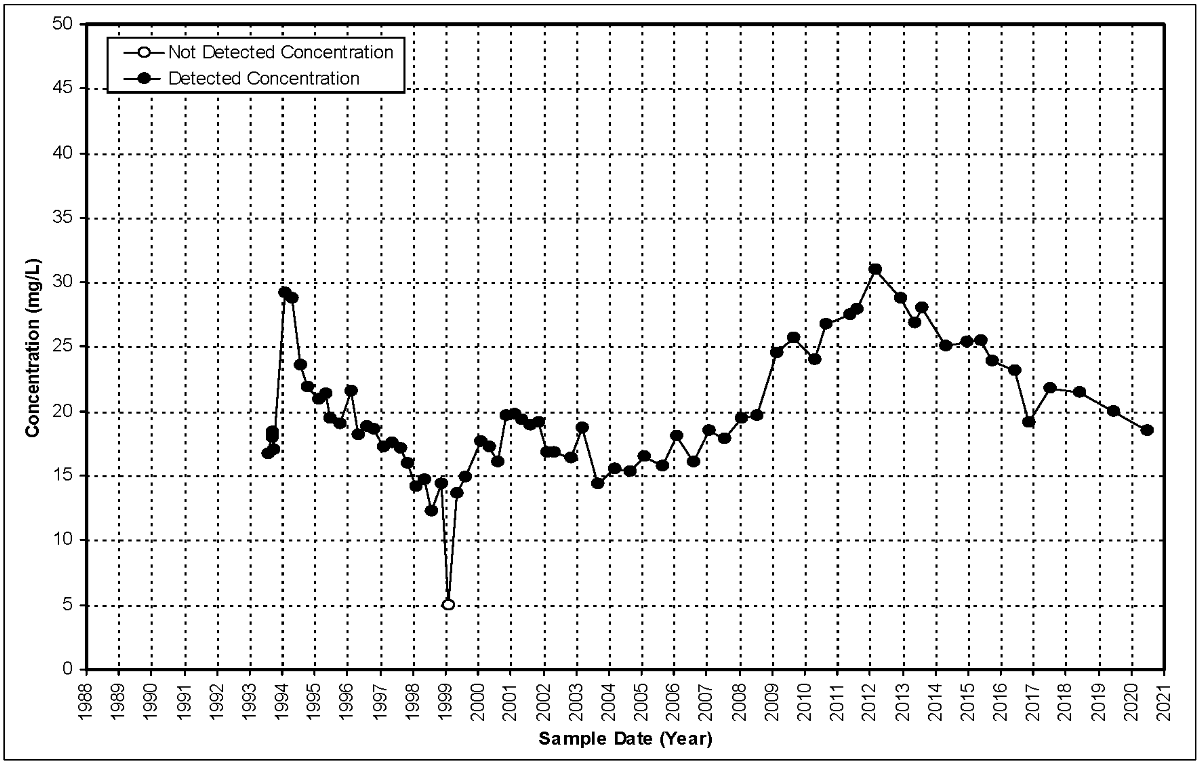

Figure A.1-9. Sodium Concentration Versus Time Plot for Monitoring Well 2898

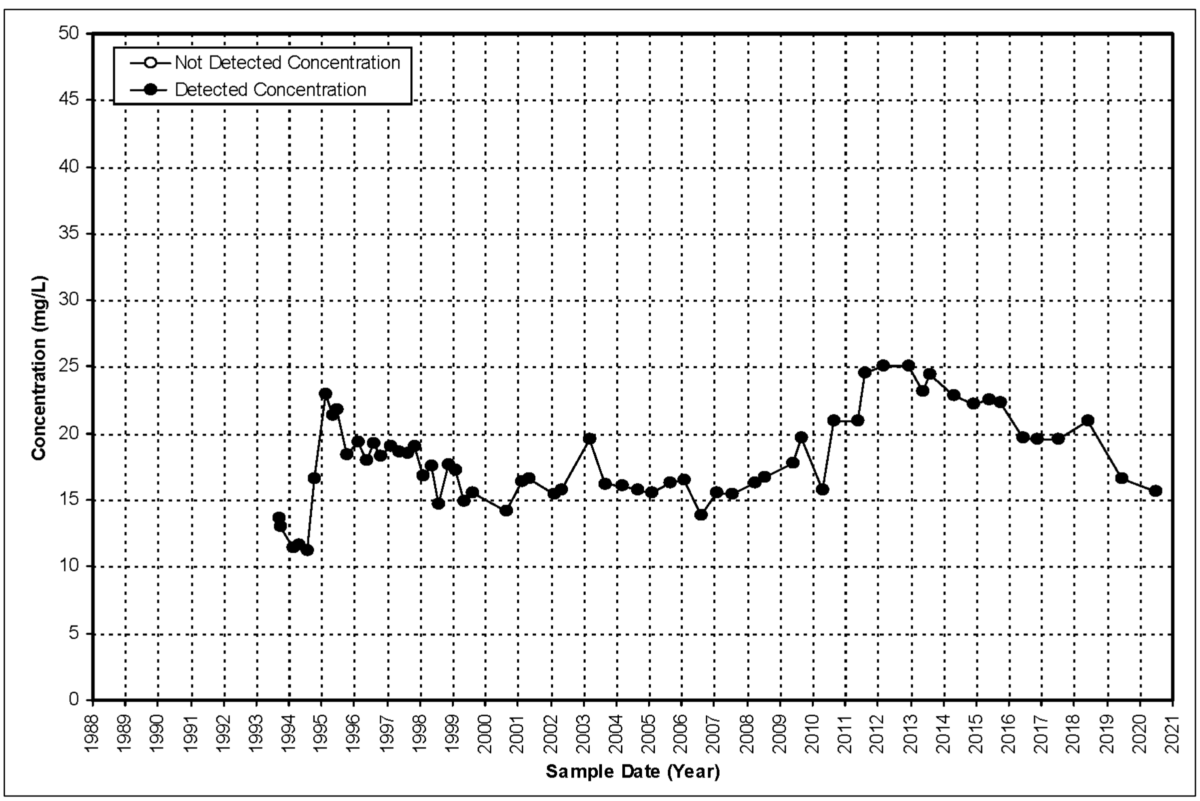

Figure A.1-10. Sodium Concentration Versus Time Plot for Monitoring Well 2899

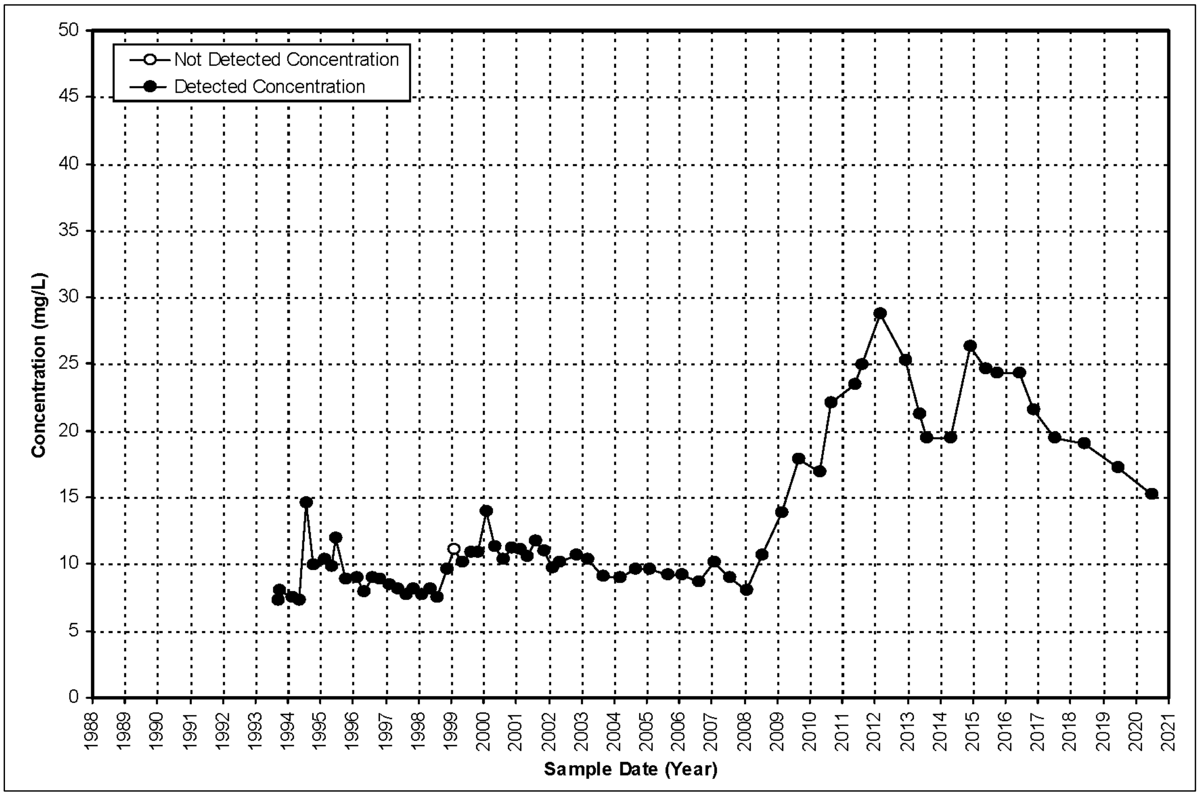

Figure A.1-11. Sodium Concentration Versus Time Plot for Monitoring Well 3898

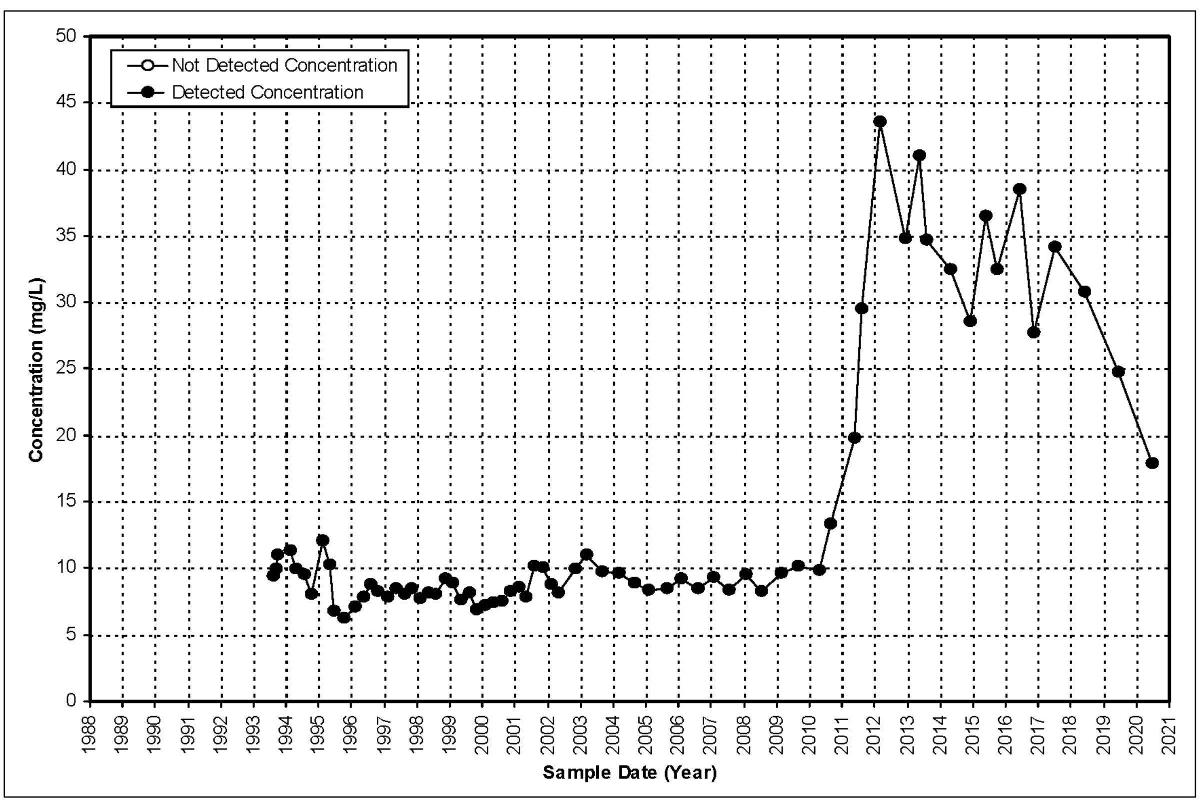

Figure A.1-12. Sodium Concentration Versus Time Plot for Monitoring Well 3899

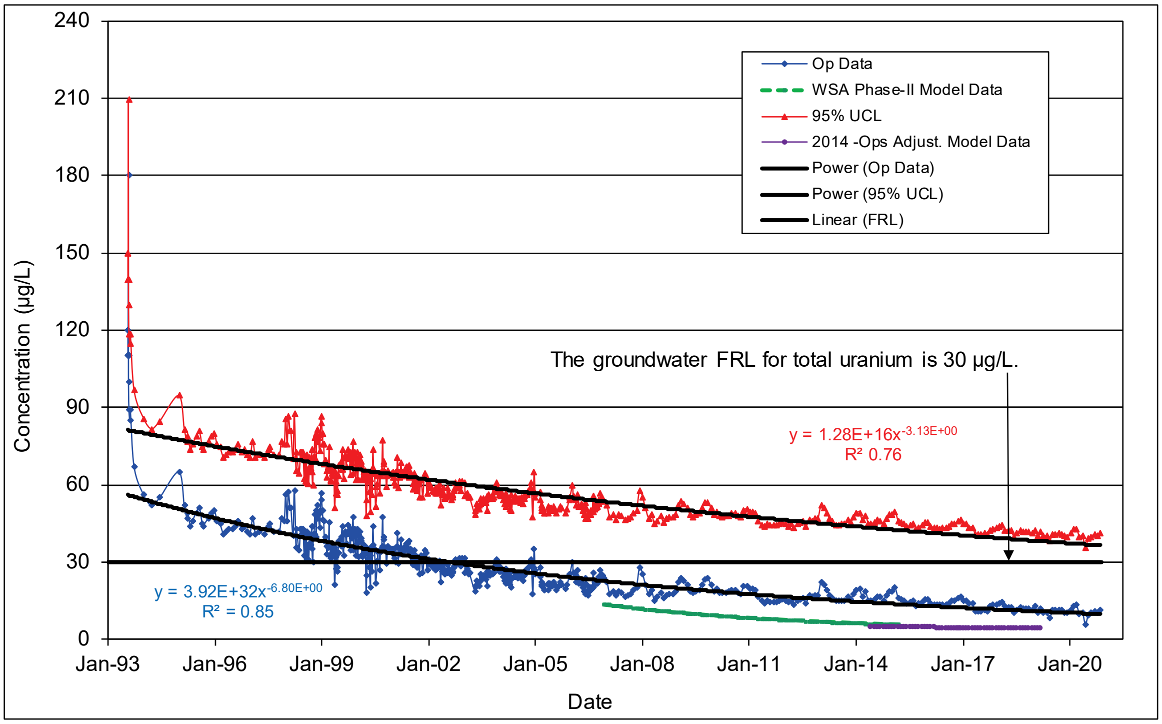

Figure A.1-13. Total Uranium Concentration Versus Time Plot for Extraction Well 3924 (RW-1) with Regression Analysis

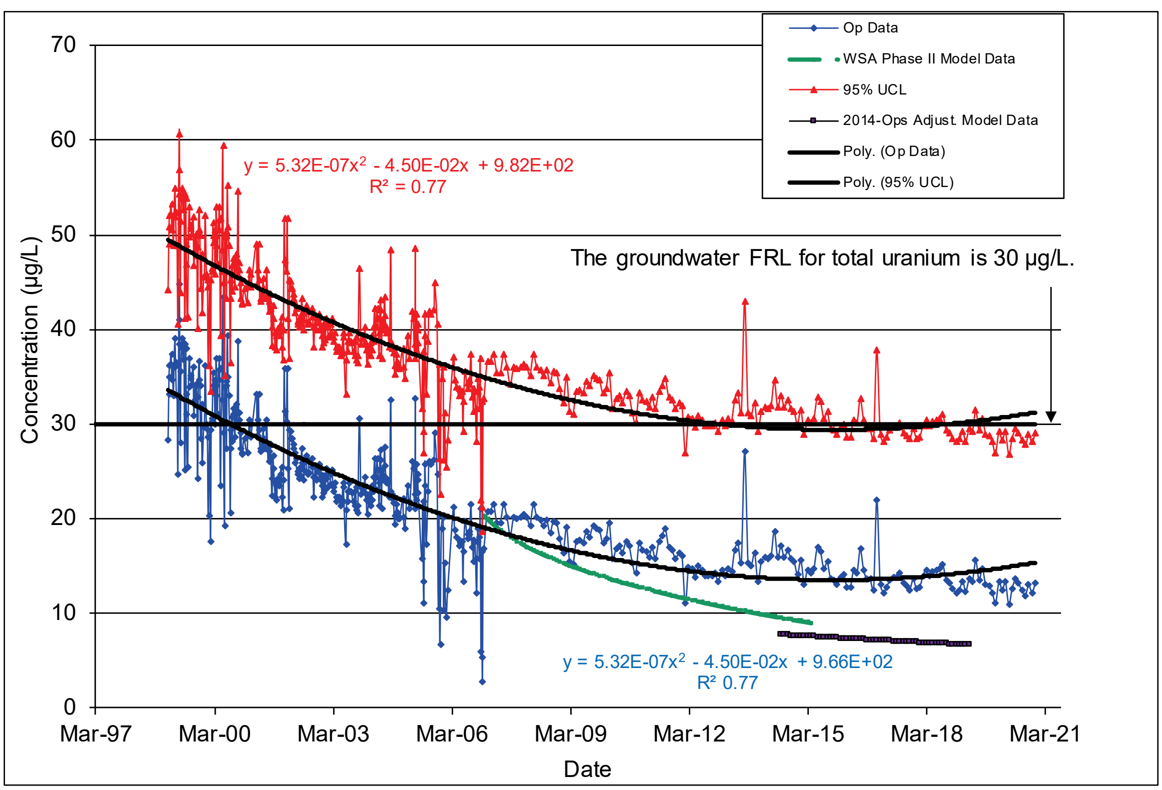

Figure A.1-14. Total Uranium Concentration Versus Time Plot for Extraction Well 3925 (RW-2) with Regression Analysis

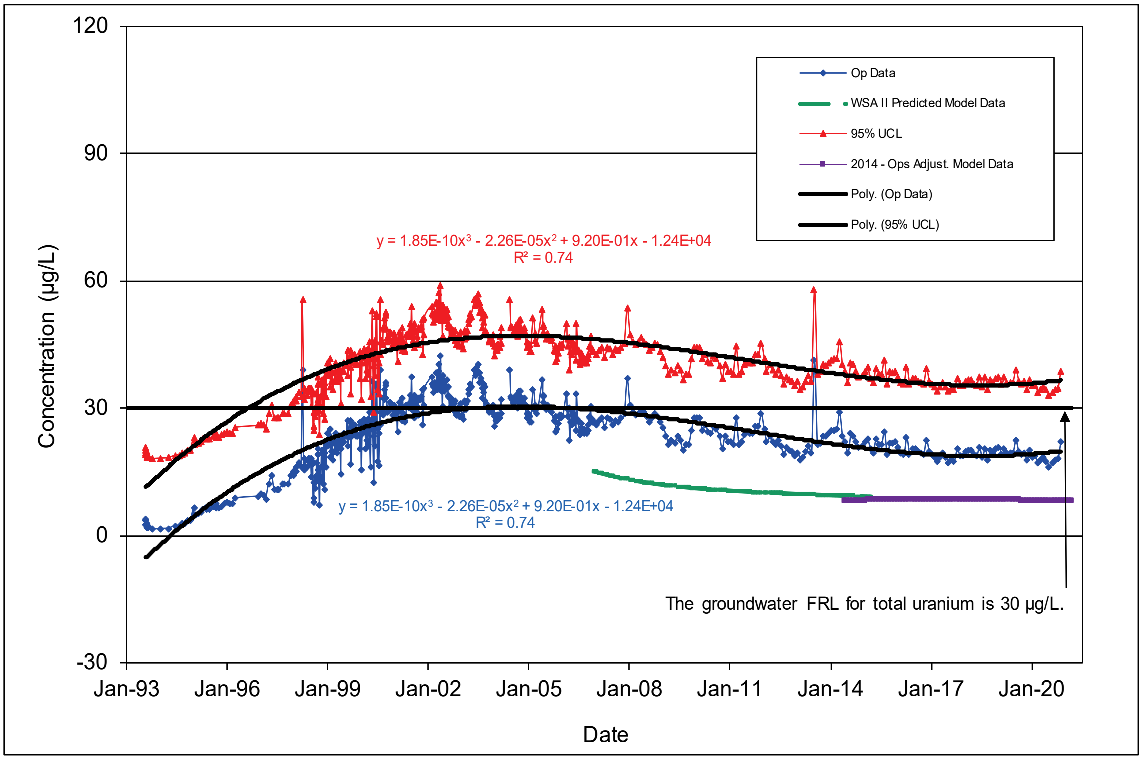

Figure A.1-15. Total Uranium Concentration Versus Time Plot for Extraction Well 3926 (RW-3) with Regression Analysis

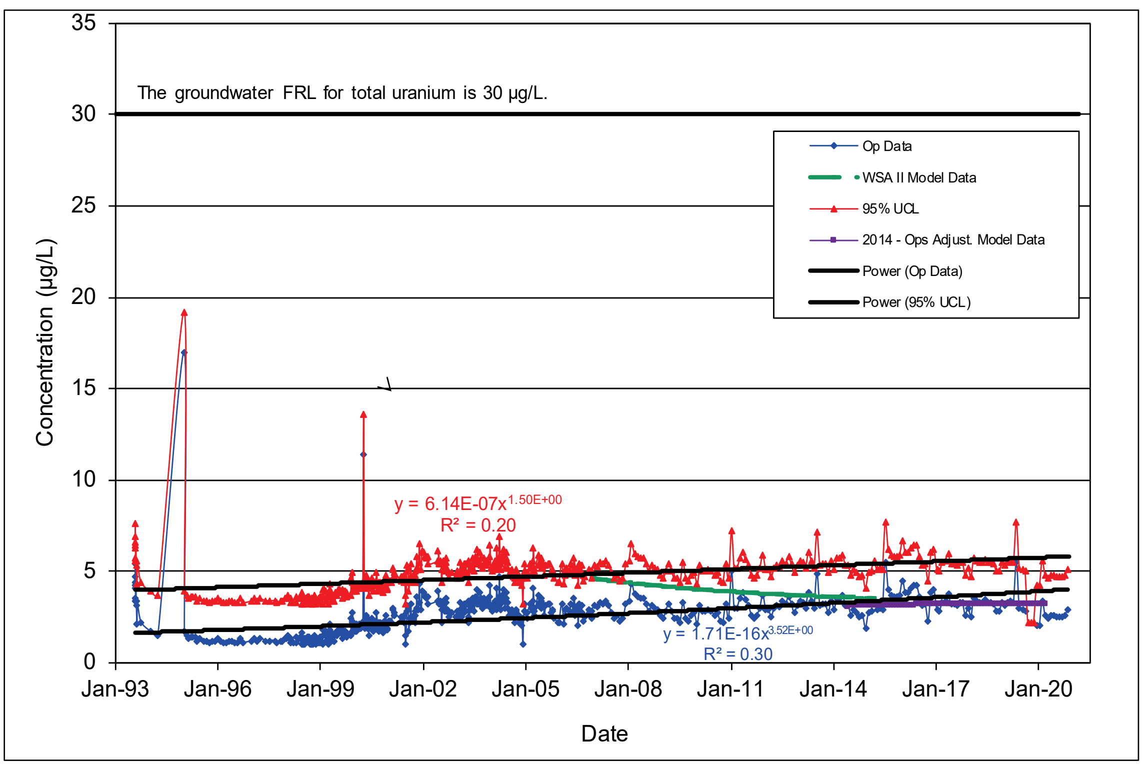

Figure A.1-16. Total Uranium Concentration Versus Time Plot for Extraction Well 3927 (RW-4) with Regression Analysis

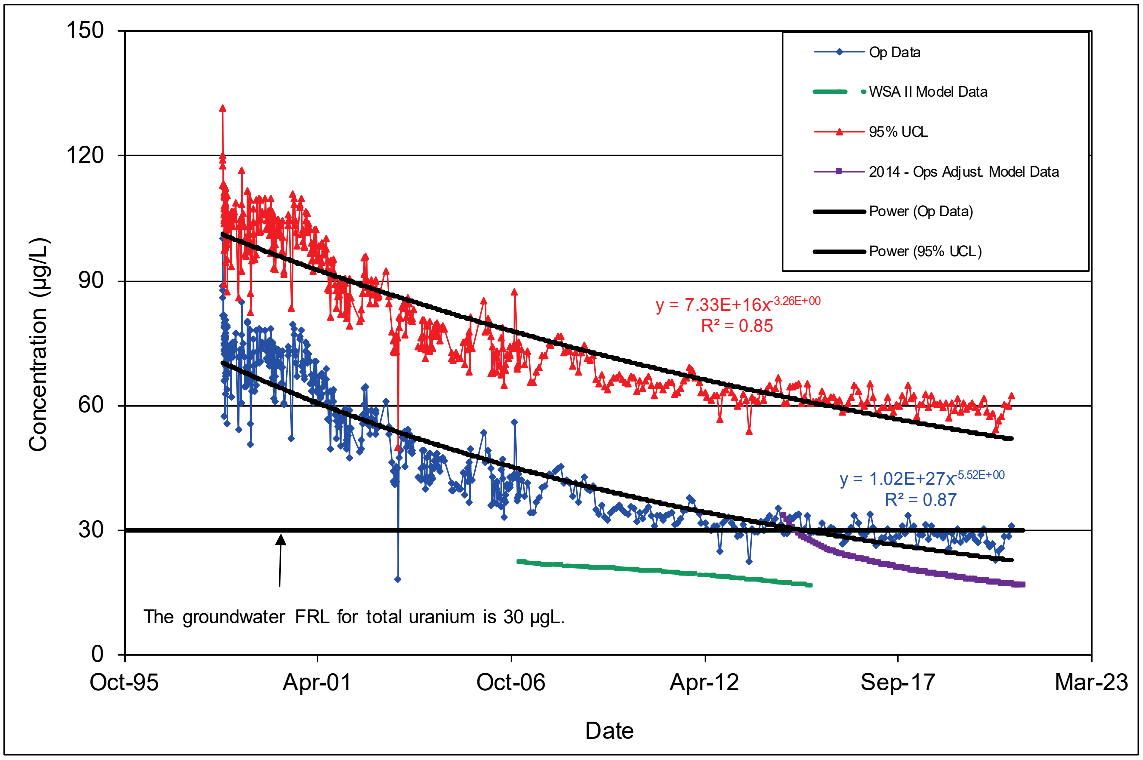

Figure A.1-17. Total Uranium Concentration Versus Time Plot for Extraction Well 32308 (RW-6) with Regression Analysis

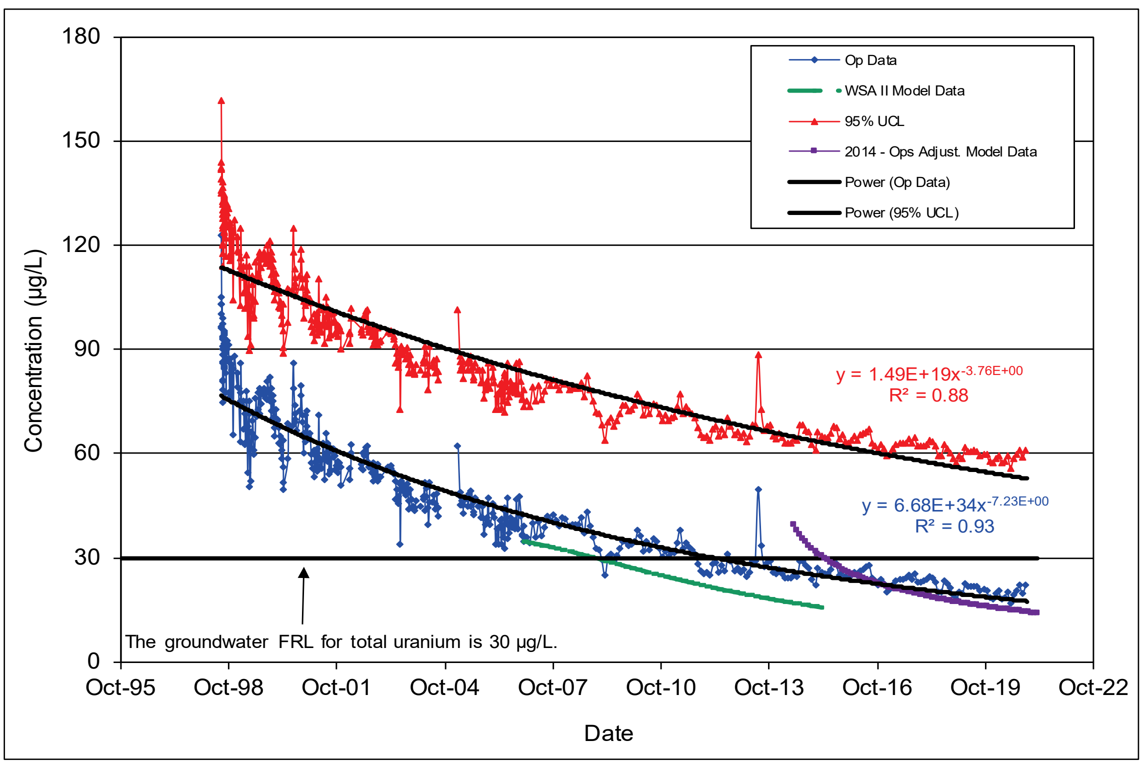

Figure A.1-18. Total Uranium Concentration Versus Time Plot for Extraction Well 32309 (RW-7) with Regression Analysis

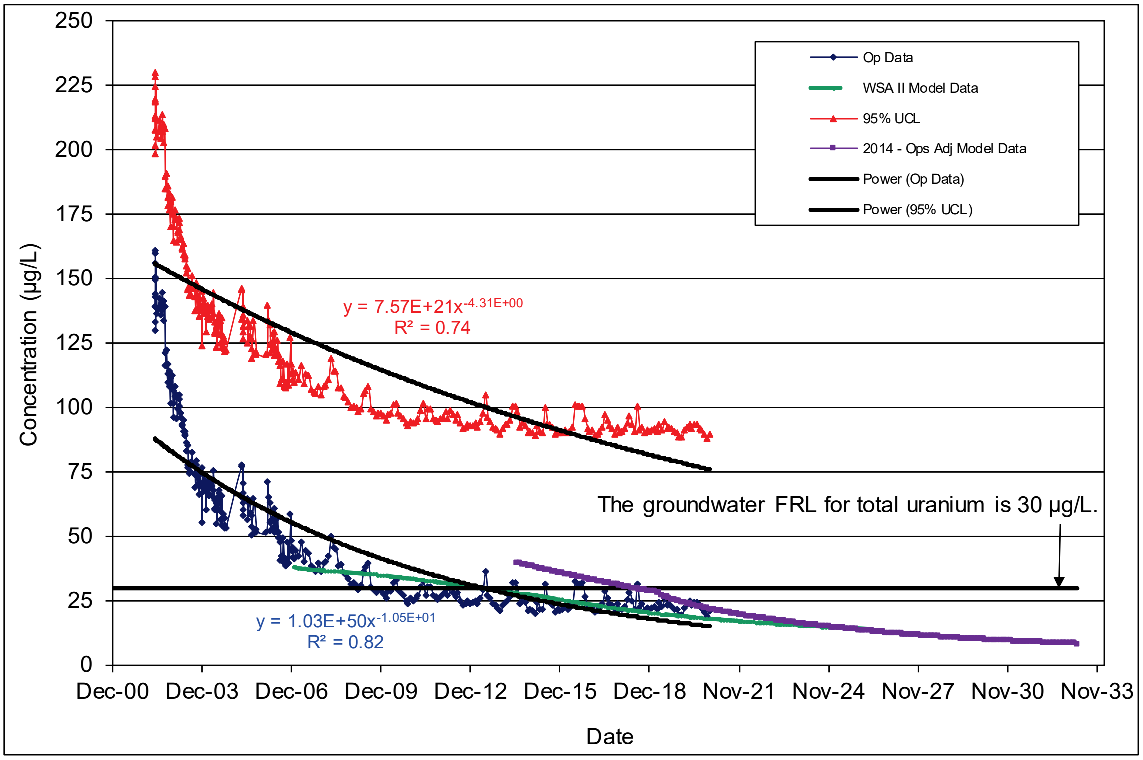

Figure A.1-19. Total Uranium Concentration Versus Time Plot for Extraction Well 32761 (EW-26) with Regression Analysis

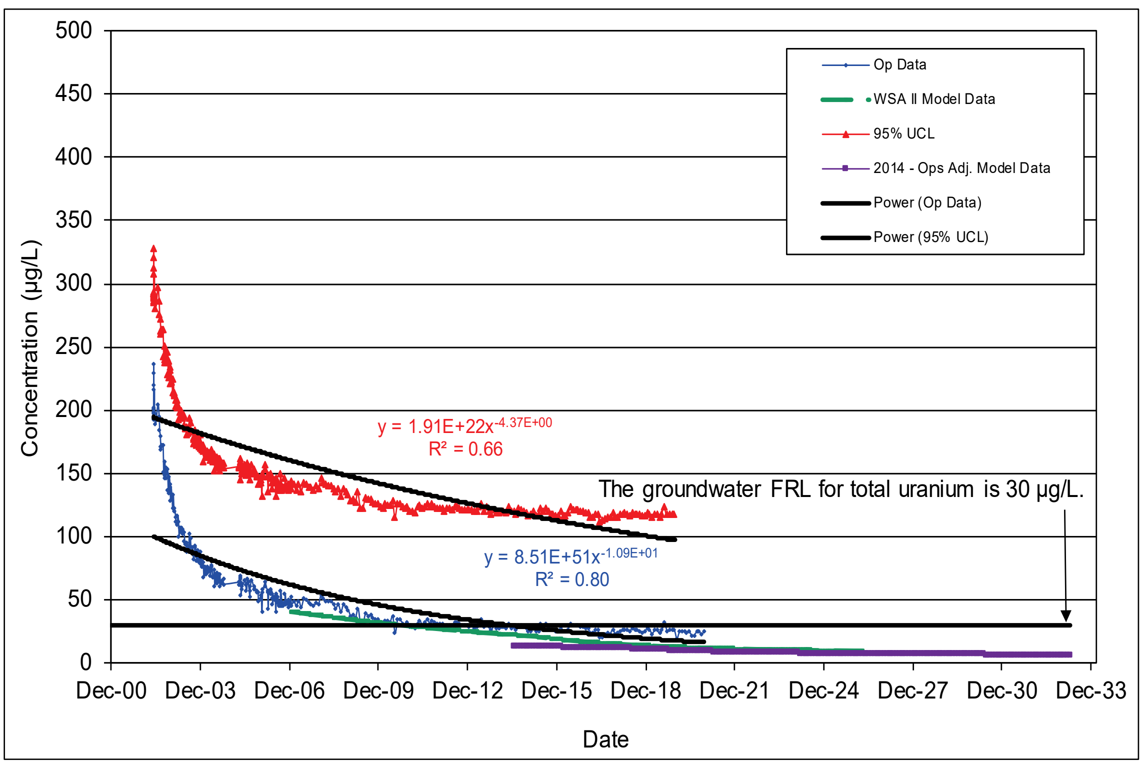

Figure A.1-20. Total Uranium Concentration Versus Time Plot for Extraction Well 33062 (EW-27) with Regression Analysis

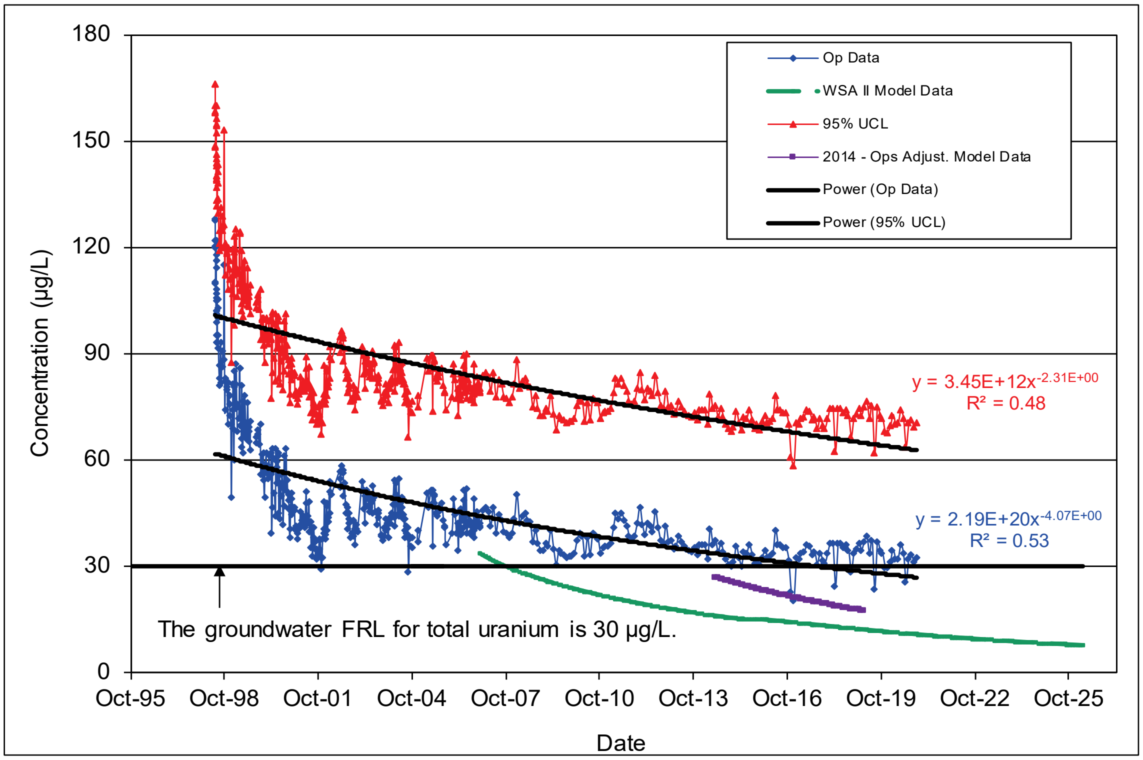

Figure A.1-21. Total Uranium Concentration Versus Time Plot for Extraction Well 31550 (EW-18) with Regression Analysis

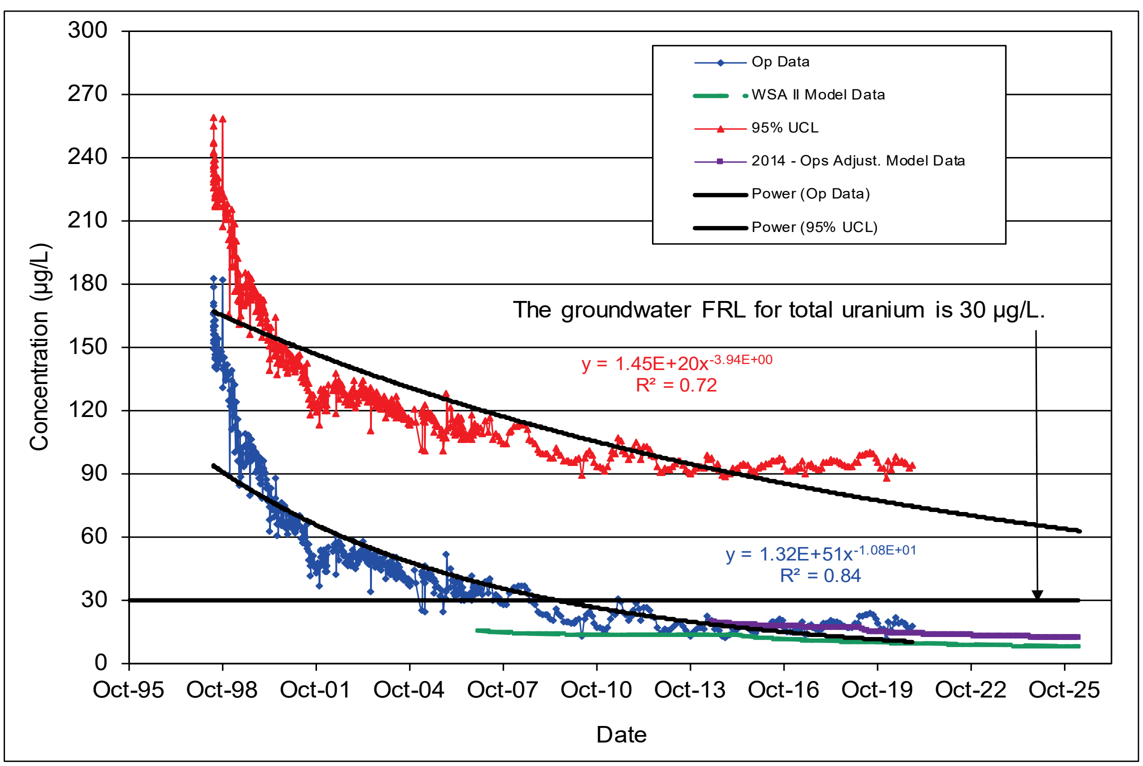

Figure A.1-22. Total Uranium Concentration Versus Time Plot for Extraction Well 31560 (EW-19) with Regression Analysis

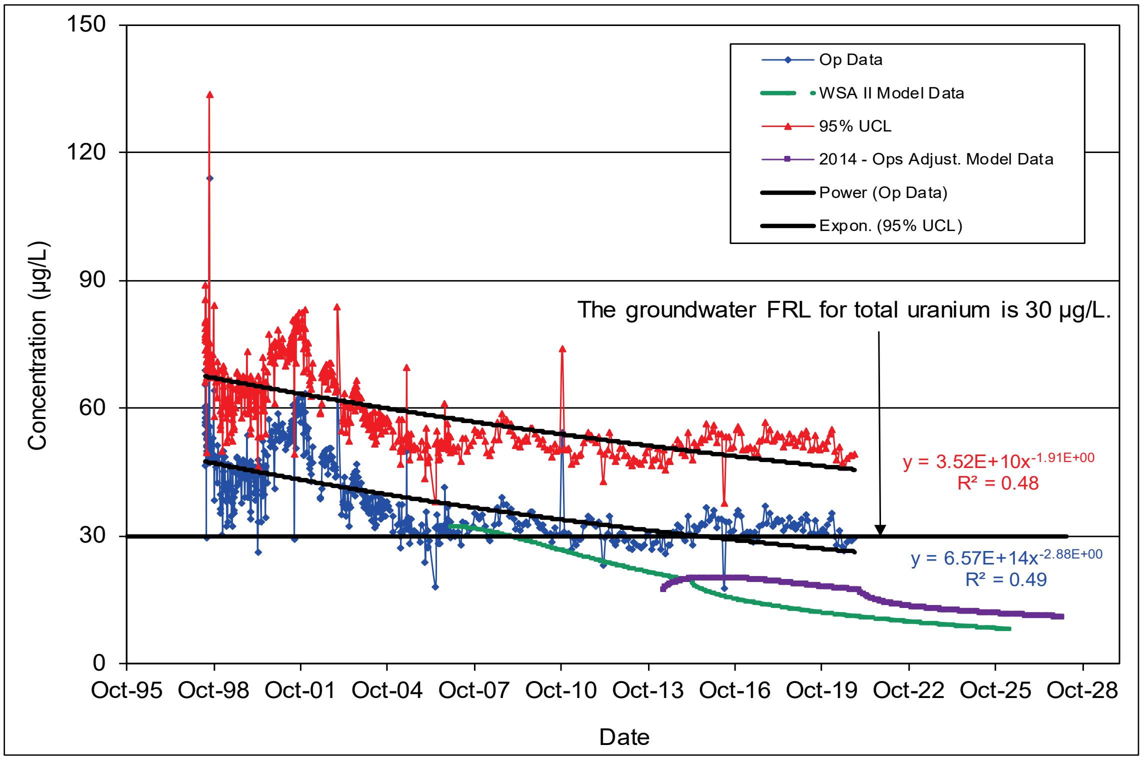

Figure A.1-23. Total Uranium Concentration Versus Time Plot for Extraction Well 31561 (EW-20) with Regression Analysis

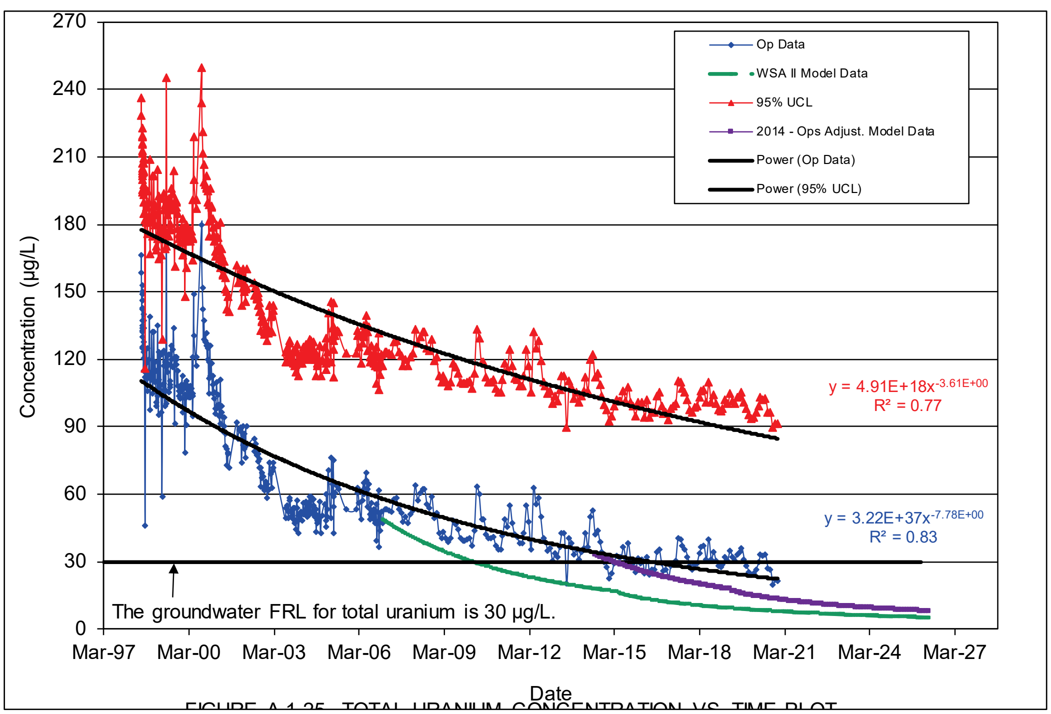

Figure A.1-24. Total Uranium Concentration Versus Time Plot for Extraction Wells 31562 (EW-21) and 33298 (EW-21a) with Regression Analysis

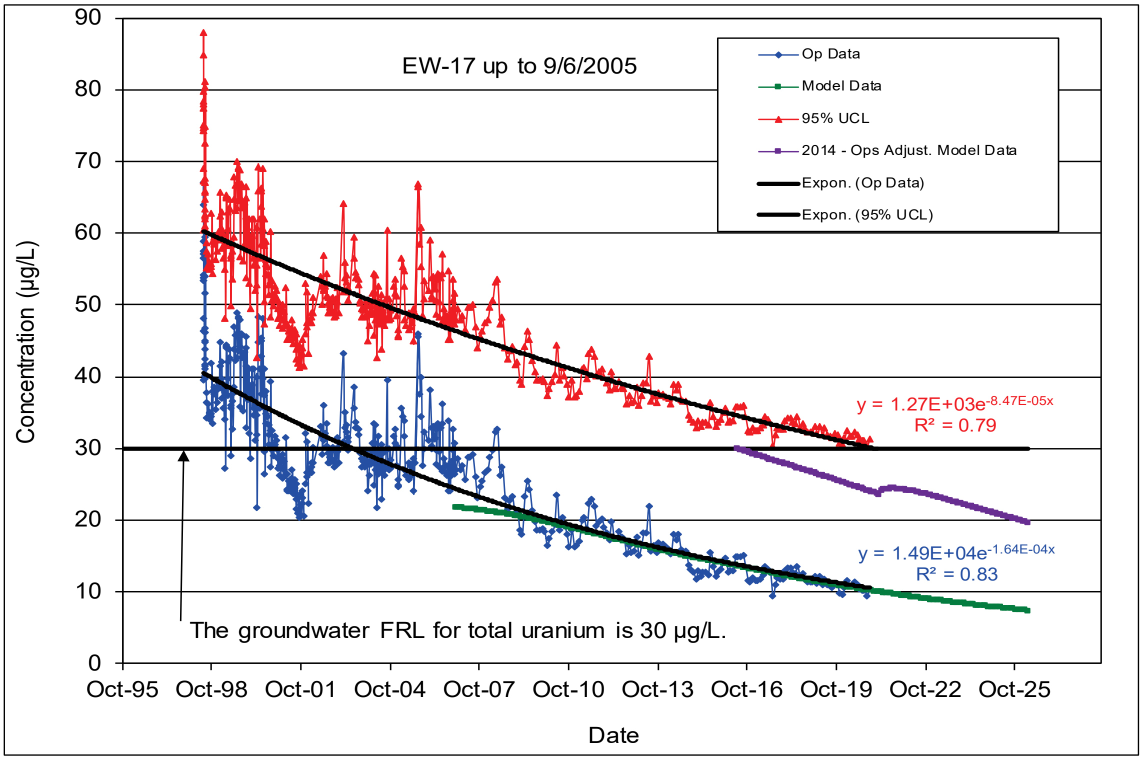

Figure A.1-25. Total Uranium Concentration Versus Time Plot for Extraction Wells 31567 (EW-17) and 33326 (EW-17a) with Regression Analysis

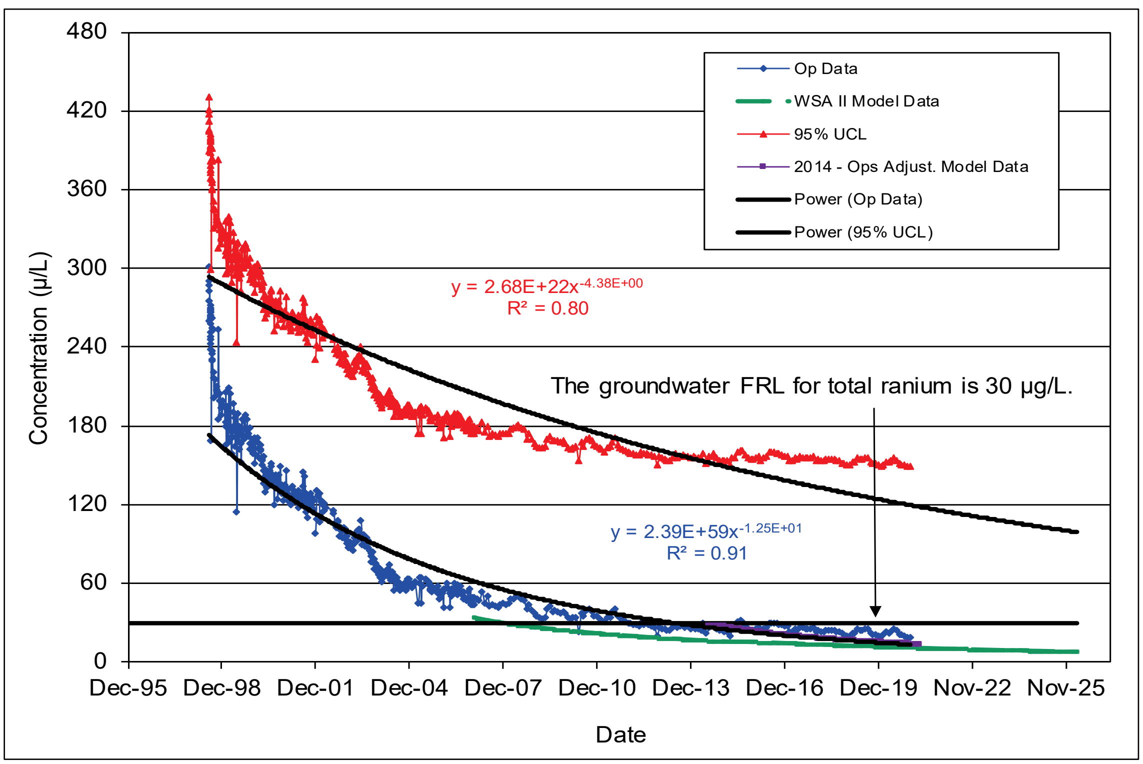

Figure A.1-26. Total Uranium Concentration Versus Time Plot for Extraction Well 32276 (EW-22) with Regression Analysis

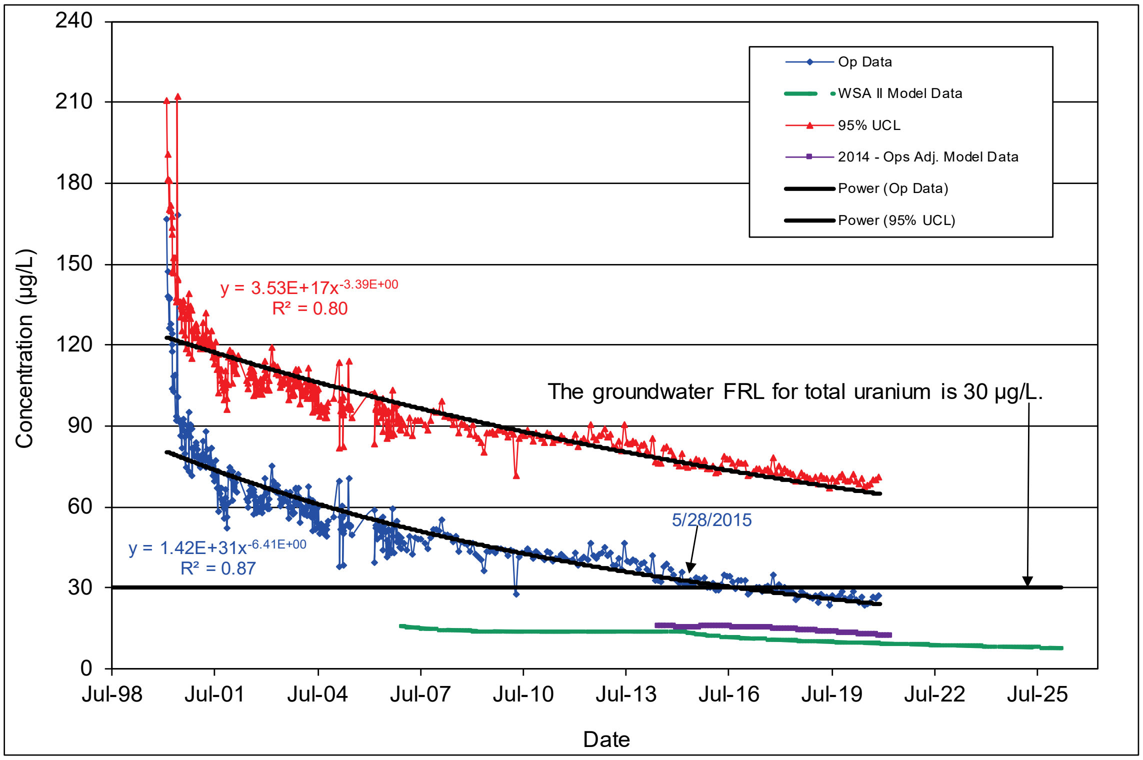

Figure A.1-27. Total Uranium Concentration Versus Time Plot for Extraction Well 32446 (EW-24) with Regression Analysis

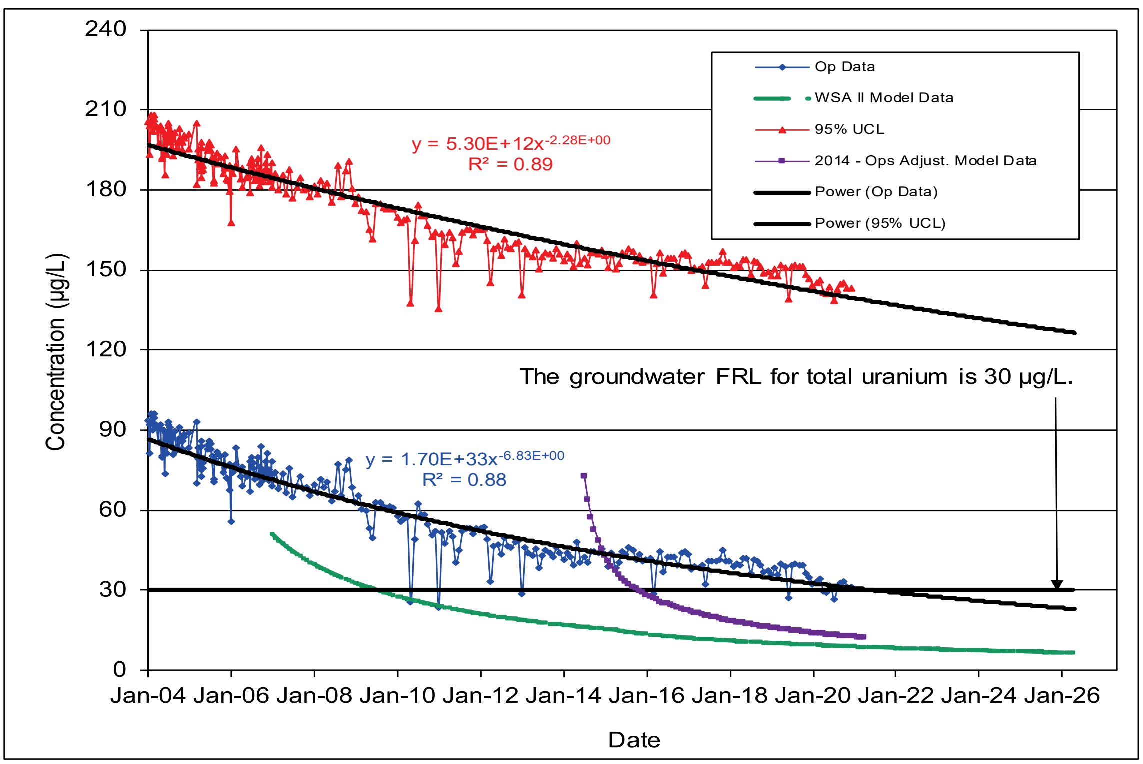

Figure A.1-28. Total Uranium Concentration Versus Time Plot for Extraction Well 32447 (EW-23) with Regression Analysis

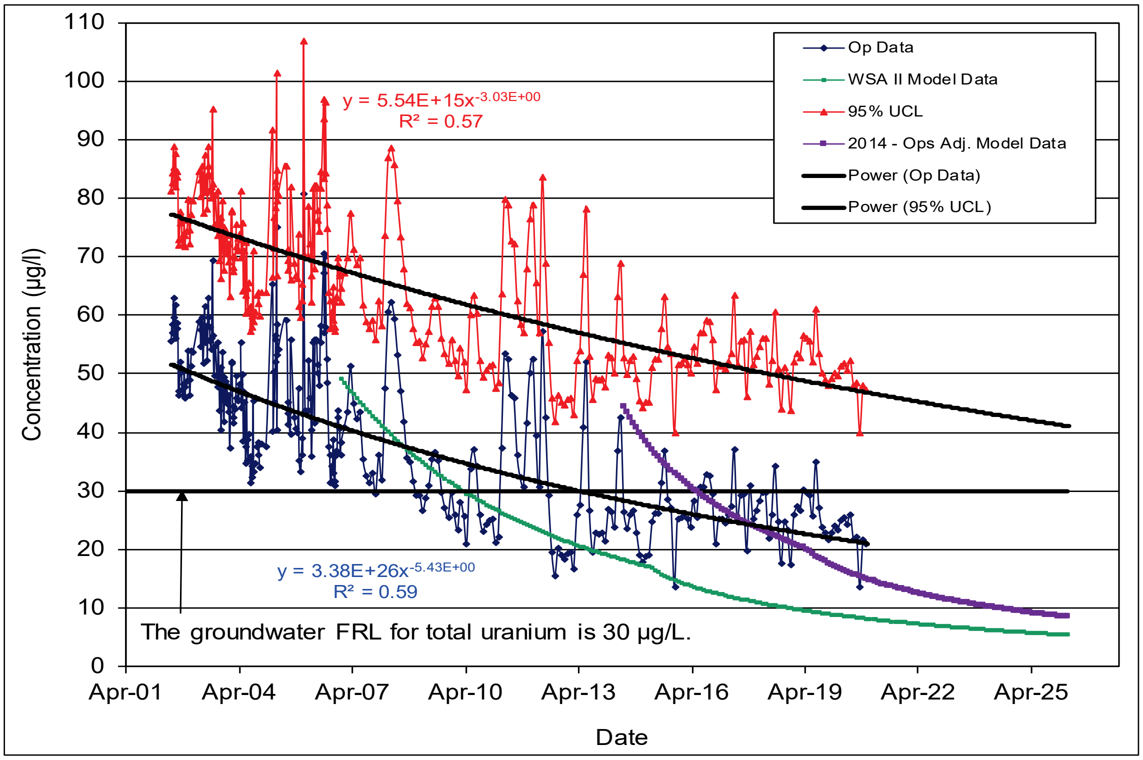

Figure A.1-29. Total Uranium Concentration Versus Time Plot for Extraction Well 33061 (EW-25) with Regression Analysis

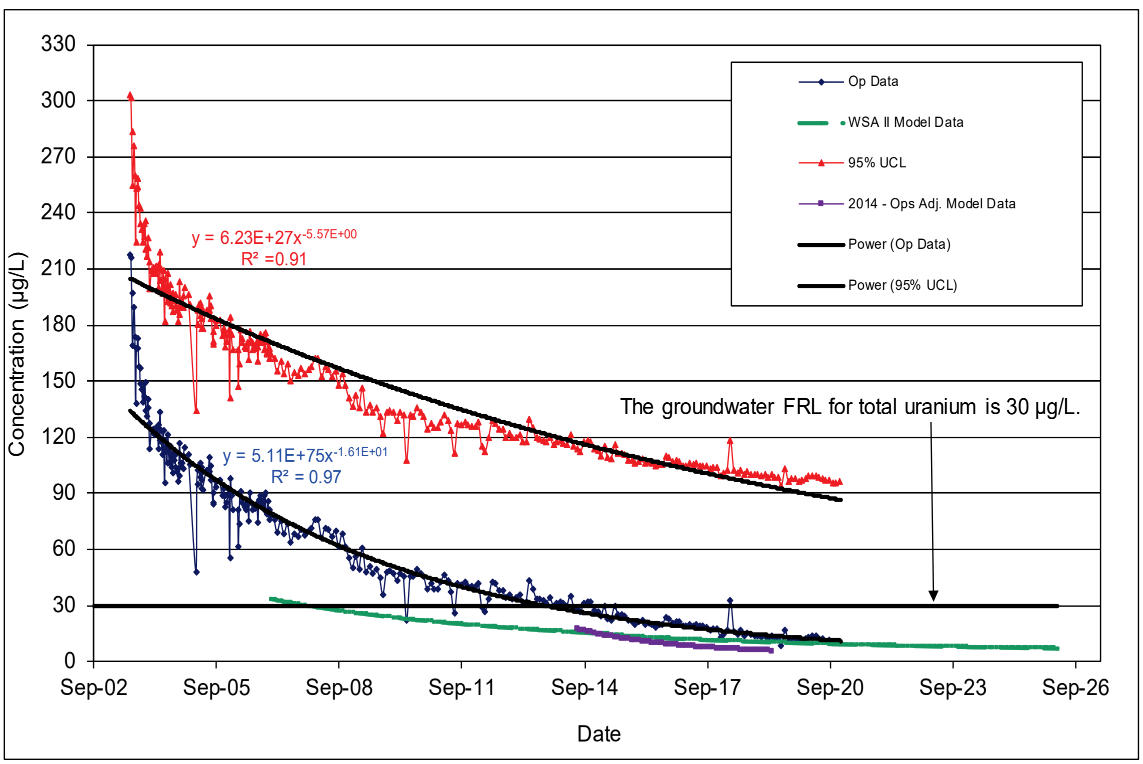

Figure A.1-30. Total Uranium Concentration Versus Time Plot for Extraction Well 33264 (EW-30) with Regression Analysis

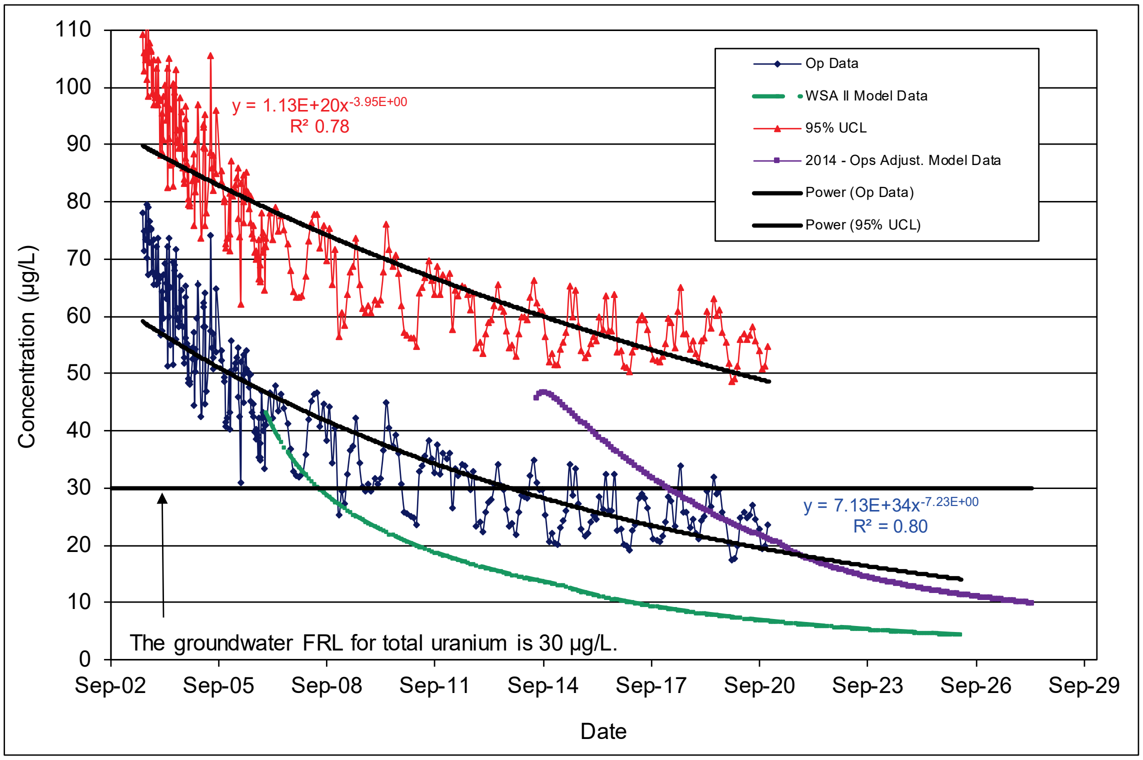

Figure A.1-31. Total Uranium Concentration Versus Time Plot for Extraction Well 33262 (EW-15a) with Regression Analysis

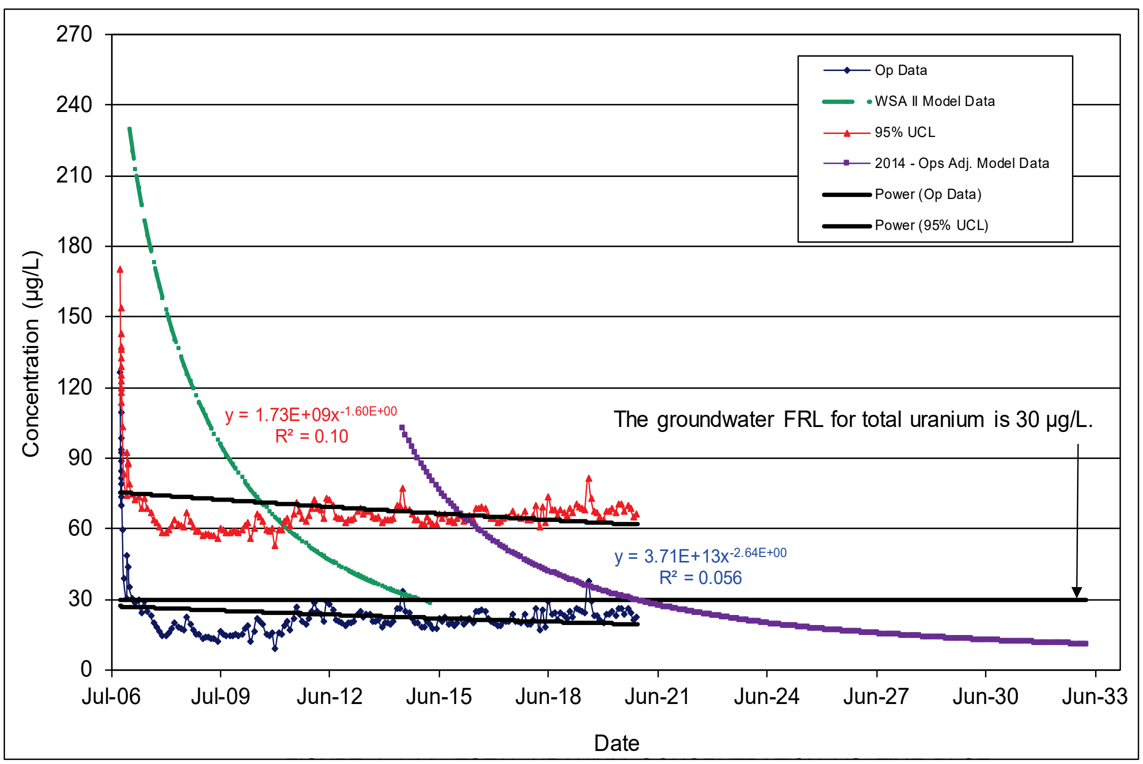

Figure A.1-32. Total Uranium Concentration Versus Time Plot for Extraction Well 33347 (EW-33a) with Regression Analysis

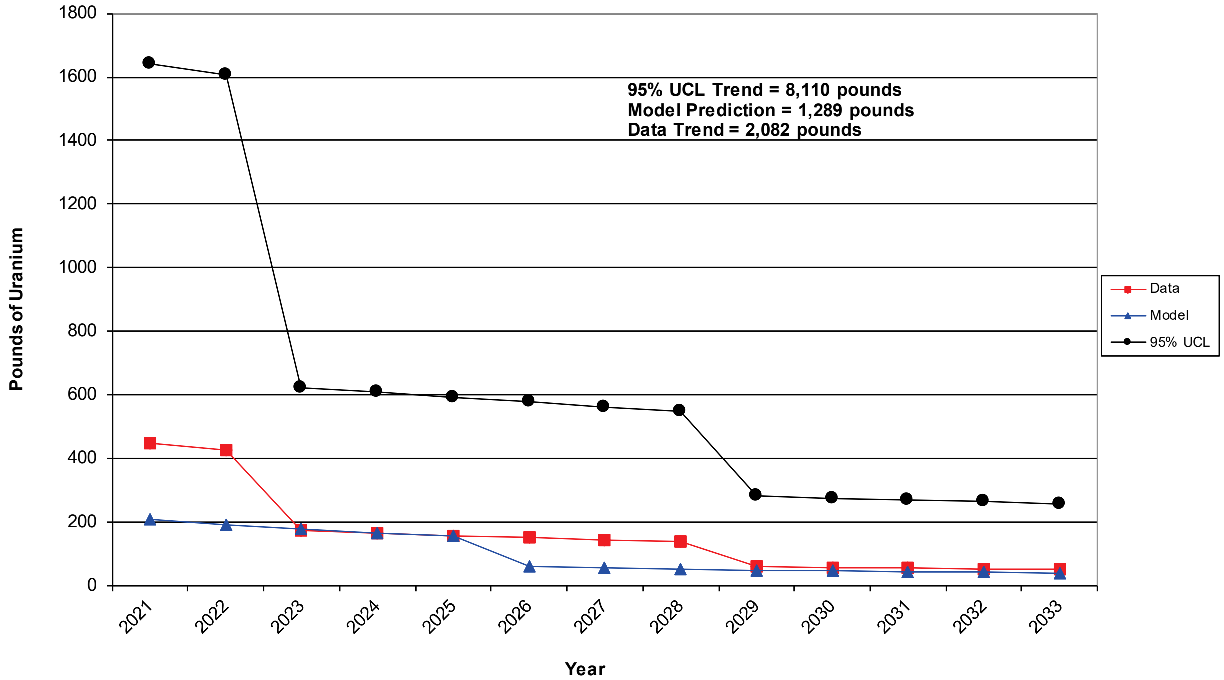

Figure A.1-33. Estimate of Yearly Pounds of Uranium to Be Pumped from Aquifer to Achieve Concentration-Based FRL Goals (Model Predictions Versus Measured Concentration Trends) Data Collected Through 2020

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Attachment A.2

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Contents

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Abbreviations

DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FRL	final remediation level
IEMP	Integrated Environmental Monitoring Plan
K_d	distribution coefficient
Ohio EPA	Ohio Environmental Protection Agency
PPDD	Pilot Plant Drainage Ditch
WSA	Waste Storage Area

Measurement Abbreviations

amsl	above mean sea level
bgs	below ground surface
ft	feet
g/cm^3	grams per cubic centimeter
L	liters
L/kg	liters per kilogram
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mS/cm	millisiemens per centimeter
NTU	nephelometric turbidity unit
SU	standard unit

A.2.0 Assessment of Total Uranium Results

This attachment provides groundwater monitoring total uranium results through 2020, including summary statistics and plume maps, at the Fernald Preserve, Ohio, Site. The groundwater remediation at the Fernald Preserve is a concentration-based cleanup. The *Record of Decision for Remedial Actions at 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* (DOE 2019a). IEMP groundwater monitoring and extraction well locations are shown in Figure A.2-1. For integration purposes, locations of the On-Site Disposal Facility monitoring wells used to monitor the Great Miami Aquifer 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 2020. Direct-push sampling results for the 27 locations (13374G, 13495B, 13520, 13521, 13489B, 12824D, 13355B, 12411E, 13430C, 13471A, 13486A, 13494A, 13509A, 13522, 13523, 13524, 13227C, 13229H, 13239F, 13267B, 13421I, 13493D, 13512B, 13513A, 13525, 13526, and 13527) 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 2020, 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 value 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 monitoring well has a history of intermittent exceedances and the well location appears to be isolated from the main plume, then the well 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.

Past experience has shown that routinely producing an annual first half total uranium plume map provides very little benefit to the annual Site Environmental Report. Yearly comparisons of remedy progress reported in the Site Environmental Report are based on the second half total uranium plume map. Beginning in 2021, the U.S. Department of Energy (DOE) proposes to no longer routinely present a first half total uranium plume map in the Site Environmental Report each year. Uranium concentration data will continue to be collected in the first half of the year as prescribed by the IEMP, but it will no longer be reported in a first half total uranium plume map. If uranium concentration data ever indicates that a first half total uranium plume map would provide benefit to the reporting presented in the Site Environmental Report, then a first half map will be added on a case-by-case basis, as deemed appropriate.

Table A.2-28 lists the monitoring wells where total uranium concentrations exceeded the 30 µg/L FRL during 2020. 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 are discussed in Attachment A.1. Figure A.2-4 illustrates the statistics presented in Table A.2-28, showing where total uranium concentrations have an upward trend, downward trend, or no trend. Monitoring wells with an upward trend based on the Mann-Kendall 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 2019 compared to the footprint of the 30 µg/L total uranium plume from the second half of 2020. The 2019 plume is highlighted in yellow; the yellow indicates areas where the plume was reduced for 2020. 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 2019 and 2020 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
2019 (acres)	86.5	49.9	26.5
2020 (acres)	81.5	50.4	28.2
Decrease (acres)	5.0	(-0.5)	(-1.7)
Decrease (percent)	5.8	(-1.0)	(-6.4)

Between 2019 and 2020 the acreage mapped for the area of the maximum uranium plume above 50 µg/L and 100 µg/L increased. Periodic concentration fluctuations within the plume are expected and are attributed to dissolved uranium movement in response to active pumping.

Since 1997, the footprint of the total uranium plume being targeted for cleanup has decreased 156.10 acres. Table A.2-30 provides a tabulation of plume size from 1997 through 2020.

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.
- 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 inspection and maintenance.
- Section A.2.5 presents information concerning center-of-mass plume calculations for the total uranium plumes.
- Section A.2.6 presents total uranium cross sections.

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) decreased in size between 2019 and 2020. At the end of 2019, the mapped footprint (excluding the PPDD area described below) was estimated to be 8.50 acres. At the end of 2020, the mapped footprint (excluding the PPDD area described below) was estimated to be 7.28 acres, a decrease of 1.22 acres (14%).

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

Direct-push sampling was conducted in 2020 at three locations in the former WSA (locations 13374G, 13495B, and 13520).

Location 13374G

Direct-push sampling location 13374G is in the northwest corner of the former Waste Storage Area plume. Total uranium concentration data collected in 2020 for this location are provided in Table A.2-1, and the location is shown in the Inset 1 area of Figure A.2-3A.

This location has been sampled eight times: 2008, 2013, 2015, 2016, 2017, 2018, 2019, and 2020. The samples collected in 2008 were identified as location 13374. The samples collected in 2020 were identified as location 13374G. Total uranium concentration data for all eight sampling events are presented below.

Location 13374 (2008)		Location 13374A (2013)		Location 13374B (2015)		Location 13374C (2016)	
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	74.0	519	293	515	36.9	516	13.6
507	70.1	509	13.2	505	1.92	506	4.66
		499	2.05	495	2.57	496	2.49
		489	6.46	485	3.93		

Location 13374D (2017)		Location 13374E (2018)		Location 13374F (2019)		Location 13374G (2020)	
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	132	517	228	519	130	518	171
506	5.10	507	5.30	509	7.3	508	5.70
496	1.45	497	1.55	499	1.46	498	2.00
486	1.33	487	4.80	489	1.92	488	4.14

The total uranium concentration data presented above indicate that the maximum total uranium concentration in 2020 (171 µg/L) was collected from an elevation 518 ft above mean sea level (amsl) and was a foot lower in elevation than the maximum concentration measured in 2013 (293 µg/L, elevation 519 ft amsl). 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. No change was required for the 2020 maximum uranium plume map.

Location 13495B

Direct-push sampling location 13495B is located outside the northeast corner of the former Waste Storage Area plume. Total uranium concentration data collected in 2020 for this location are provided in Table A.2-2. The location is shown in the Inset 1 of Figure A.2-3A.

This location has been sampled three times: 2017, 2019, and 2020. The samples collected in 2017 was identified as location 13495, and the samples collected in 2020 were identified as location 13495B. Total uranium concentrations for all sampling events are presented below.

Location 13495 (2017)		Location 13495A (2019)		Location 13495B (2020)	
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	10.9	518	4.60	517	6.01
505	7.80	508	10.2	507	5.10
495	1.00	498	2.60	497	4.34
485	3.70	488	1.50	487	1.76
475	4.90	478	2.32	477	3.94
465	11.7	468	9.20	467	6.33

As shown in Table A.2-2, and above, the highest total uranium concentration measured in 2020 was 6.33 µg/L (elevation 467 ft amsl). This location was selected to provide additional data near where monitoring well 3821 used to be located. As discussed in the 2016 Site Environmental Report (DOE 2017a), monitoring well 3821 had an increasing uranium concentration trend. It was determined in 2017 (through a downhole camera survey) that the integrity of the well casing in monitoring well 3821 had been compromised. DOE properly abandoned monitoring well 3821 in 2018.

Location 13520

Location 13520 is located on the northeast of the Former Waste Storage Area plume. Direct-push sampling results for location 13520 are provided in Table A.2-3, and the location is identified in Figure A.2-3A.

As shown in Table A.2-3, the maximum total uranium concentration measured in 2020 was 12.7 µg/L (elevation 516 ft amsl). This location is near intermittent exceedance location 83340. It was sampled to confirm if additional uranium contamination might be present at concentrations above the uranium FRL. The 2020 result indicates that additional uranium contamination above the FRL was not present. The maximum uranium plume map did not need to be revised to honor the 2020 concentration.

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

Four monitoring wells (83339, 83340, 83341, and 83346) are identified on the maximum total uranium plume maps for 2020 in the former WSA (Figures A.2-2B and A.2-3B) as being monitoring locations with intermittent total uranium FRL exceedances.

Figure A.2-6 is a time versus concentration graph for monitoring well 83339. The graph shows that the total uranium concentrations for two of the channels (channels 2 and 3) have always been below 30 µg/L. Channel 1 has had one exceedance of the uranium FRL since 2013, and that was in 2019. Both samples collected in 2020 were below the uranium FRL.

Figure A.2-7 is a time versus concentration graph for monitoring well 83340. The graph shows that the total uranium concentrations for two of the channels (channels 2 and 3) have always been below 30 µg/L. The total uranium concentration for channel 1 was above 30 µg/L for both channels from 2018 to 2020.

Figure A.2-8 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) have always been below 30 µg/L. Channel 1 of monitoring well 83341 was dry between 2014 and 2017. The uranium concentrations of the samples collected in 2017 and 2018 were below 30 µg/L. The uranium concentration of the sample collected in the second half of 2019 was above 30 µg/L. The uranium concentration collected in the first half of 2020 in channel 1 was below 30 µg/L. Channel 1 was dry during the second half of 2020.

Figure A.2-9 is a time versus concentration graph for monitoring well 83346. The graph shows that the total uranium concentrations for two of the channels (channels 2 and 3) have always been below 30 µg/L. The total uranium concentration for channel 1 was above 30 µg/L in 2018 and 2019. It was below 30 µg/L in 2020.

All four of these monitoring wells 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 areas when water levels are high to determine if a plume can be defined. These four wells will continue to be identified on maximum total uranium plume maps as 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, two monitoring wells (83340 and 2649) had an increasing total uranium concentration trend in the former WSA. Monitoring well 83340 is discussed in the previous section. Monitoring well 2649 was reported in the 2013 through 2019 Site Environmental Reports (DOE 2014; DOE 2015; DOE 2016; DOE 2017a; DOE 2018; DOE 2019b; DOE 2020) as having increasing concentration trends. Table A.2-28 provides summary statistics for the well. Monitoring well 2649 is within capture of the groundwater remediation system.

Figure A.2-10 is a total uranium concentration versus time plot for monitoring well 2649. The figure shows an increase in uranium concentration in 2007. The increase is attributed to pumping in nearby extraction well 33347, which began in late 2006. As is shown in Figure A.2-10, the concentration of uranium in monitoring well 2649 has exceeded 1,000 µg/L in 2013 and 2018. This is an area of the plume where uranium contamination is known to be sorbed to aquifer sediments in the vadose zone. When this sediment is saturated or flushed due to high water levels in the aquifer, the uranium can desorb into the water, resulting in the high concentration measurements. Multichannel well 83337 is near monitoring well 2649. The shallowest channel in well 83337 is channel 1. As shown in Figure A.2-11, the uranium concentration of channel 1 in monitoring well 83337 has also been above 1,000 µg/L, while the other two deeper channels in that well have not. In 2020, concentration was as high as 966 µg/L.

A.2.1.1.4 Former WSA Summary

The following two groundwater remediation issues present challenges in the former WSA:

- Uranium contamination sorbed to sediments in the vadose zone beneath former source areas
- High surface water uranium concentrations occur in a swale located between the former waste pits and Paddys Run

Uranium contamination sorbed to sediments in the vadose zone beneath former source areas: 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, dissolved total uranium concentrations in the groundwater may increase (rebound) enough to exceed groundwater FRLs.

This issue is being somewhat alleviated each year by conducting a planned well field shutdown to allow water levels to rise and desorb some of the contamination in these areas. The confirmation that this issue has been addressed will be documented as described in the *Fernald Groundwater Certification Plan* (DOE 2006) after the pumping phase of the remediation ends. Certification monitoring will be conducted once the pumping wells are turned off to verify that concentrations above FRLs are not rebounding.

High surface water uranium concentrations occur in a swale located between the former waste pits and Paddys Run: Intermittent puddles of surface water occur in a swale bounded by Paddys Run to the west and the former waste pits to the east. As presented in Appendix B, the total uranium concentrations of many of the surface water samples collected from this area exceed the groundwater FRL.

Surface water that collects in the swale is sampled at surface water sampling locations SWD-05 and SWD-09. The uranium concentration measured at SWD-09 has exceeded the surface water FRL (530 µg/L). The highest uranium concentration reported was 2,087 µg/L in December 2016. The uranium contamination appears to be localized to the area around SWD-09, and the uranium concentrations measured in the surface water from SWD-09 appear to be influenced by seasonal changes.

During normal flow conditions, surface water from the swale area infiltrates into the ground. This is also the case in the former Waste Pit 3 area, where water infiltrates into the ground and serves as a source of recharge to the aquifer. The uranium concentration in the aquifer beneath this infiltration area is above the uranium groundwater FRL (30 µg/L). Surface water from much of the former WSA drains into the former Waste Pit 3. The area of infiltration in the swale and former WSA is within capture of the groundwater remediation system. Because the area is within capture, there is currently no risk to the public from the infiltrating surface water. Continued monitoring will document if the concentration in the infiltrating surface water decreases over time.

In 2014, groundwater modeling was conducted to determine the potential impact to model-predicted aquifer cleanup times if uranium-contaminated surface water 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.
- Used input infiltration rates of 50 inches per year rather than 6 inches per year.
- Used an input infiltrating total uranium concentration of 1,900 µg/L, which was 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. If infiltrating surface water with high uranium concentrations continues beyond 2035, DOE will work with the U.S. Environmental Protection Agency (EPA) and the Ohio Environmental Protection Agency (Ohio EPA) to determine the best path forward for remediation of the aquifer in this area.

A.2.1.2 PPDD Maximum Total Uranium Plume

The mapped footprint of the 30 µg/L maximum total uranium plume in the PPDD area between 2019 and 2020 remained unchanged at 5.8 acres (Figure A.2-5).

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

Direct-push sampling was conducted in 2020 at one location in the PPDD area (locations 13521).

Location 13521

Location 13521 is located on the east side of the PPDD plume. Direct-push sampling results for location 13521 are provided in Table A.2-4, and the location is identified in Figure A.2-3A.

As shown in Table A.2-4, the maximum total uranium concentration measured in 2020 was 210 µg/L (elevation 513 ft amsl). The maximum uranium plume map was adjusted to honor the 2020 concentration.

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 2020 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.2-12 provides a time versus total uranium concentration plot for monitoring well 83335. The figure shows that total uranium concentrations measured from 2013 through the first half of 2019 have been below the total uranium groundwater FRL for all monitoring channels. In the second half of 2019, channel 2 had a concentration of 32.4 µg/L. In 2020, the uranium concentration of both collected samples were below the total uranium groundwater FRL. Channel 1 has always been dry. 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 and Figure A.2-4, one monitoring well (83124_C4) had an increasing total uranium concentration trend in 2020 in the PPDD Area. Figure A.2-13 is a total uranium concentration versus time plot for monitoring well 83124. This monitoring well is located upgradient of extraction well 33062. The increase in uranium concentration in channel 1 is attributed to uranium contamination sorbed to aquifer sediments in the vadose zone.

A.2.2 Former Plant 6 Area

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

No direct-push sampling was conducted in 2020 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 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.2-14 is a total uranium concentration versus time plot for monitoring well 2389 and shows that sporadic total uranium FRL exceedances were detected at this well between 2002 and 2010, but exceedances have been constant since 2011. As discussed below, FRL exceedances are detected in this area when the sample is approximately 515 ft amsl or higher. Since 2011, water levels have been at or near 515 ft amsl, and the uranium FRL exceedances have been consistent. In 2020, total uranium concentrations were above 30 µg/L. As shown in Figure A.2-14, the water level during both 2020 sampling events was above 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 at or 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 sample was collected in 2019 (13360E). The elevation of the collected sample was the highest ever recorded (517 ft amsl). The concentration measured was also the highest ever measured at 63.0 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
2018	13360D	12.2	513
2019	13360E	63.0	517

Monitoring well 2389 will continue to be identified on the 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 in size between 2019 and 2020. The size of the footprint was 72.27 acres in 2019 and 68.41 acres in 2020, a decrease of 3.85 acres (5.3%) (Figure A.2-5).

The mapped footprint of the 50 µg/L area of the plume increased in size between 2019 and 2020. The size of the area was 39.79 acres in 2019 and 40.25 acres in 2020, an increase of 0.46 acre (1.2%).

The mapped footprint 100 µg/L area of the plume increased between 2019 and 2020. The size of the area was 18.88 acres in 2019 and 20.32 acres in 2020, an increase of 1.44 acres (7.6%).

A.2.3.1 South Field

In 2020, direct-push sampling was conducted at 12 locations in the South Field (locations 13489B, 12824D, 13355B, 12411E, 13430C, 13471A, 13486A, 13494A, 13509A, 13522, 13523, and 13524). Figure A.2-3A shows the locations and the 2020 total uranium results. Two of the locations are in the area of the former Flyash Pile (13489B and 12824D). The remaining locations were in the east side of the plume.

Location 13489B

Location 13489B is located on the west side of the total uranium plume in the former Flyash Pile Area of the South Field. Table A.2-5 provides direct-push sampling results for location 13489B. The location is identified in Figure A.2-3A.

This location has been sampled three times: 2016, 2019, and 2020. The samples collected in 2016 was identified as location 13489. The samples collected in 2020 were identified as location 13489B. The following table provides total uranium concentrations from the three sampling events.

Location 13489 (2016)		Location 13489A (2019)		Location 13489B (2020)	
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	90.6	518	63.5	519	15.6
504	8.90	508	9.50	509	4.10
494	1.30	498	2.30	499	2.30
484	1.80	488	1.30	489	1.50

The maximum total uranium concentration at this location has decreased from 90.6 µg/L in 2016 (elevation 514 ft amsl) to 15.6 µg/L in 2020 (elevation 519 ft amsl). The 30 µg/L contour on the total uranium plume map for 2020 was adjusted to honor the 2020 concentration.

Location 12824D

Location 12824D is situated in the center of the former Flyash Pile Area of the South Field. Direct-push sampling results for location 12824D are provided in Table A.2-6. The location is identified in Figure A.2-3A.

This location has been sampled five times: 2001, 2008, 2013, 2016, and 2020. The samples collected in 2001 were identified as location 12824. The samples collected in 2020 were identified as location 12824D. Total uranium concentrations from all five sampling events are provided below.

Location 12824 (2001)		Location 12824A (2008)		Location 12824B (2013)		Location 12824C (2016)		Location 12824D (2020)	
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)
511	405	514	632	518	445	514	617	515	308
504	30.0	504	124	508	161	504	23.5	505	15.7
494	20.0	494	18.6	498	21.0	494	6.00	495	4.70
484	34.0	484	15.0	488	18.7	484	7.60	485	8.80
474	27.0								
464	2.10								
454	1.10								

The maximum total uranium concentration between 2001 and 2016 ranged between 405 µg/L and 632 µg/L. The maximum total uranium concentration measured in 2020 was 308 µg/L. The 2020 maximum uranium plume map was adjusted to honor the 2020 measured concentration.

Location 13355B

Location 13355B is located along the west edge of the South Field plume, in approximately the middle of the plume. Direct-push sampling results for location 13355B are provided in Table A.2-7. The location is identified in Figure A.2-3A.

This location has been sampled three times: 2006, 2014, and 2020. The samples collected in 2006 were identified as location 13355. The samples collected in 2020 were identified as location 13355B. Total uranium concentrations for all three sampling events are provided below.

Location 13355 (2006)		Location 13355A (2014)		Location 13355B (2020)	
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)
		512	38.9	512	112
506	79.3	502	30.4	502	36.9
496	39.4	492	13.0	492	8.50
486	10.4	482	5.40	482	7.90
476	1.70				
466	0.50				

The highest maximum total uranium concentration measured at this location increased from 79.3 µg/L (elevation 506 ft amsl) in 2006 to 112 µg/L (elevation 512 ft amsl) in 2020. The 2020 total uranium plume map was revised to honor the 2020 concentration. The increase in concentration is attributed to the nearby extraction well pulling uranium to the location of the direct-push sampling location.

Location 12411E

Location 12411E is situated on the west side of the South Field. Direct-push sampling results for location 12411E are provided in Table A.2-8. The location is identified in Figure A.2-3A.

This location has been sampled six times: 1999, 2003, 2012, 2015, 2017, and 2020. The samples collected in 1999 was identified as location 12411. The samples collected in 2020 were identified as location 12411E. Total uranium concentrations for all six samples are provided below.

Location 12411 (1999)		Location 12411A (2003)		Location 12411B (2012)	
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
509	40.0	506	39.7	505	22.2
499	44.0	496	48.2	495	13.5
489	62.0	486	24.1	485	7.10
479	26.0	476	18.7	475	5.20
469	20.0	466	31.7	465	4.10
459	25.0	456	19.1	455	5.90
449	25.0	446	4.00	445	1.40
439	1.90	436	4.90		
429	2.60				

Location 12411C (2015)		Location 12411D (2017)		Location 12411E (2020)	
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)
512	39.1	512	51.1	514	52.0
502	16.0	502	20.6	504	22.9
492	11.6	492	11.9	494	6.10
482	5.20	482	7.10	484	6.70
472	6.60				

The maximum total uranium concentration measured at this location has been just above 50 µg/L since 2017. The maximum total uranium plume map for 2020 did not need to be adjusted to honor the 2020 concentration.

Location 13430C

Location 13430C is situated in the northwestern corner of the South Field total uranium plume, just south of the storm water retention basin. Direct-push sampling results for location 13430C are provided in Table A.2-9. The location is identified in Figure A.2-3A.

This location has been sampled four times: 2011, 2016, 2019, and 2020. The samples collected in 2011 was identified as location 13430. The samples collected in 2020 were identified as location 13430C. Results for all four sampling events are provided below.

Location 13430 (2011)		Location 13430A (2016)		Location 13430B (2019)		Location 13430C (2020)	
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	133.7	514	46.7	515	30.6	514	59.7
505	22.5	504	16.7	505	11.7	504	17.6
495	7.60	494	9.02	495	8.00	494	8.30
485	10.0			485	21.3	484	10.0
475	2.10						
465	3.20						

The maximum total uranium concentration at this location was decreasing from 2011 to 2019 but had an increase in 2020. A uranium concentration below 30 µg/L was anticipated based on the previous data trend, but a high concentration of 59.7 µg/L was measured. The maximum total uranium plume map for 2020 was adjusted to honor the 2020 concentration.

Location 13471A

Location 13471A is situated in approximately the center of the South Field Plume. Direct-push sampling results are provided in Table A.2-10. The location is identified in Figure A.2-3A.

This location has been sampled twice: 2014 and 2020. The samples collected in 2014 were identified as location 13471. The samples collected in 2020 were identified as location 13471A. Results for both sampling events are provided below.

Location 13471 (2014)		Location 13471A (2020)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
512	205	513	186
502	36.2	503	38.5
492	18.2	493	17.9
482	14.0	483	9.40
472	1.60	473	2.70

As shown in the table above, the maximum total uranium concentration measured was just above 200 µg/L in 2014, and just below 200 µg/L in 2020. The maximum uranium plume map for 2020 honors the 2020 concentration.

Location 13486A

Location 13486A is situated in the middle of the southern half of the South Field plume near monitoring well 83295. Direct-push sampling results are provided in Table A.2-11. The location is identified in Figure A.2-3A.

This location has been sampled twice: 2015 and 2020. The samples collected in 2015 were identified as location 13486. The samples collected in 2020 were identified as location 13486A. Results for both sampling events are provided below.

Location 13486 (2015)		Location 13486A (2020)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl	Total Uranium (µg/L)
515	95.5	515	82.9
505	49.5	505	38.7
495	56.4	495	35.9
485	26.0	485	6.40
475	18.9	475	10.0
465	23.5		

As shown in the table above, the maximum total uranium concentration was 95.5 µg/L in 2015 (elevation 515 ft amsl) and 82.9 µg/L in 2020 (elevation 515 ft amsl). No change was needed on the maximum uranium plume map for 2020 based on the 2020 concentration.

Location 13494A

Location 13494A is situated in the northern portion of the South Field plume, in about the middle of the plume. Direct-push sampling results are provided in Table A.2-12. The location is identified in Figure A.2-3A.

This location has been sampled twice: 2016 and 2020. The samples collected in 2016 were identified as location 13494. The samples collected in 2020 were identified as location 13494A. Results for both sampling events are provided below.

Location 13494 (2016)		Location 13494A (2020)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
517	388	515	200
507	126	505	52.3
497	40.9	495	75.1
487	19.3	485	11.5
477	3.00	475	2.00
467	2.00		

As shown in the table above, the maximum total uranium concentration was 388 µg/L in 2016 (elevation 517 ft amsl) and 200 µg/L in 2020 (elevation 515 ft amsl). The 300 µg/L contour was removed from the maximum uranium plume map for 2020 based on the 2020 concentration.

Location 13509A

Location 13509A is situated just north of the site property boundary in the southern portion of the South Field plume. Direct-push sampling results are provided in Table A.2-13. The location is identified in Figure A.2-3A.

This location has been sampled twice: 2018 and 2020. The samples collected in 2018 were identified as location 13509. The samples collected in 2020 were identified as location 13509A. Results for both sampling events are provided below.

Location 13509 (2018)		Location 13509A (2020)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl	Total Uranium (µg/L)
515	43.3	514	33.0
505	13.4	504	22.9
495	3.90	494	9.30
485	7.30	484	7.20
475	8.80	474	4.10

As shown in the table above, the maximum total uranium concentration was 43.3 µg/L in 2018 (elevation 515 ft amsl) and 33.0 µg/L in 2020 (elevation 514 ft amsl). The 30 µg/L contour was moved to the east based on the measured 2020 concentration.

Location 13522
Location 13522 is located in the west portion of the plume, east of the former Fly Ash Pile area of the South Field. Direct-push sampling results for location 13522 are provided on Table A.2-14, and the location is identified on Figure A.2-3A.

As shown in Table A.2-14, the maximum total uranium concentration measured in 2020 was 15.6 µg/L (elevation 496 ft amsl). The 30 µg/L contour on the maximum uranium plume map was adjusted to honor the 2020 measurement.

Location 13523
Location 13523 is situated on the west side of the South Field uranium plume in approximately the center of the north to south direction. Direct-push sampling results for location 13523 are provided in Table A.2-15, and the location is identified in Figure A.2-3A.

As shown in Table A.2-15, the maximum total uranium concentration measured in 2020 was 16.2 µg/L (elevation 504 ft amsl). Based on monitoring results in nearby monitoring well 2049, the 30 µg/L contour on the maximum uranium plume map for 2020 was not adjusted. Figure A.2-15 is a time versus uranium concentration plot for monitoring well 2049. As shown in Figure A.2-15, the first half 2020 uranium concentration at monitoring well 2049 was slightly above 30 µg/L in the first half of 2020.

Location 13524
Location 13524 is situated west of the South Field uranium plume, in the southern half of the South Plume. Direct-push sampling results for location 13524 are provided in Table A.2-16. The location is identified in Figure A.2-3A.

As shown in Table A.2-16, the maximum total uranium concentration measured in 2020 was 20.6 µg/L (elevation of 514 ft amsl). As shown in Figure A.2-16, the maximum uranium concentration in nearby monitoring well 2390 has been below 30 µg/L since 2018. The 30 µg/L contour was adjusted for the maximum uranium plume map to honor the 2020 concentration.

A.2.3.1.1 Intermittent Total Uranium FRL Exceedance Locations and Monitoring Wells with Increasing Total Uranium Concentration Trends

No intermittent total uranium FRL exceedance locations are 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 in the South Field—2045, 21192, 2386, 2387, and 83294_C1—had upward trends for total uranium concentrations in 2020. The locations are shown in Figure A.2-4. Figures A.2-17 through A.2-21 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 these wells are within the capture zone 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 2020, direct-push sampling was conducted at 11 locations in the South Plume (13227C, 13229H, 13239F, 13267B, 13421I, 13493D, 13512B, 13513A, 13525, 13526, and 13527). Sampling locations are shown in Figure A.2-3A. Sampling results are discussed below.

Location 13227C

Location 13227C is situated on the west edge of the north half of the South Plume. Direct-push sampling results for location 13227C are provided in Table A.2-17. The location is identified in Figure A.2-3A.

This location has been sampled four times: 2002, 2005, 2013, and 2020. The samples collected in 2002 were identified as location 13227. The samples collected in 2020 were identified as location 13227C. Total uranium concentration data from all four sampling events are provided below.

Location 13227 (2002)		Location 13227A (2005)		Location 13227B (2013)		Location 13227C (2020)	
Midpoint Screen Elevation (ft amsl)	Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Uranium (µg/L)
515	91.0	516	47.4	511	45.2	515	24.4
506	97.0	507	50.4	501	27.1	505	22.9
496	51.0	497	39.0	491	25.9	495	17.0
486	27.0	487	21.3	481	7.00	485	11.9
476	18.0	477	18.8				
466	2.60	467	3.00				
456	1.80						
446	1.70						
436	2.10						

The maximum total uranium concentration at this location has decreased from a high of 97.0 µg/L in 2002 (elevation 506 ft amsl) to 24.4 µg/L in 2020 (elevation 515 ft amsl). The 30 µg/L uranium contour was adjusted on the 2020 maximum total uranium plume map to honor the 2020 concentration.

Location 13229H

Location 13229H is situated on the west side of the middle of the South Plume. Direct-push sampling results for location 13229H are provided in Table A.2-18. The location is identified in Figure A.2-3A.

This location has been sampled nine times: 2002, 2003, 2008, 2013, 2015, 2017, 2018, 2019, and 2020. The samples collected in 2002 were identified as location 13229. The samples collected in 2020 were identified as location 13229H. Total uranium concentration data from all nine sampling events 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)	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	5.90	471	11.6
458	3.20	456	1.20			460	3.40		
448	<1.0								

Location 13229E (2017)		Location 13229F (2018)		Location 13229G (2019)		Location 13229H (2020)	
Midpoint Screen Elevation (ft amsl)	Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
512	49.8	511	58.2	516	58.8	515	46.7
502	32.2	501	36.3	506	37.2	505	20.8
492	14.0	491	24.7	496	32.9	495	18.1
482	13.5	481	21.5	486	17.5	485	12.5
472	5.30	471	14.9				
462	3.70						

The maximum total uranium concentration at this location has decreased from a high of 101 µg/L in 2002 (elevation 508 ft amsl) to 46.7 µg/L in 2020 (elevation 515 ft amsl). This location had been below 50 µg/L in 2015 and 2017. Total uranium concentrations measured at this location increased back above 50 µg/L in 2018 and 2019 and decreased below 50 µg/L again in 2020. The 50 µg/L contour on the 2020 maximum total uranium plume map was adjusted to honor the 2020 concentration.

Location 13239F

Location 13239F is situated north of extraction well 32309 in the approximate center of the South Plume. Direct-push sampling results for location 13239F are provided in Table A.2-19. The location is identified in Figure A.2-3A.

This location has been sampled seven times: 2002, 2013, 2015, 2016, 2017, 2019, and 2020. The samples collected in 2002 were identified as location 13239. The samples collected in 2020 was identified as location 13239F. Total uranium concentration data from all seven sampling events are provided below.

Location 13239 (2002)		Location 13239A (2013)		Location 13239B (2015)		Location 13239C (2016)	
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	65.0						
507	49.0	511	64.0	511	62.0	511	58.5
497	69.0	501	43.5	501	50.6	501	54.3
487	32.0	491	25.5	491	30.9	491	38.7
477	12.0	481	5.70	481	10.9	481	15.1
467	4.90	471	2.00	471	4.80	471	9.30
457	1.90						
447	1.20						

Location 13239D (2017)		Location 13239E (2019)		Location 13239F (2020)	
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)
511	46.5	514	59.5	512	53.6
501	40.5	504	45.5	502	46.4
491	34.7	494	40.6	492	33.2
481	3.00	484	12.3	482	11.7
471	4.80	474	14.6	472	6.90

From 2002 to 2016, the maximum uranium concentration measured at this location was above 50 µg/L. In 2017, the concentration was below 50 µg/L for the first time (46.5 µg/L at an elevation of 511 ft amsl). In 2019 and 2020, it was back up above 50 µg/L, at 59.5 µg/L (elevation 514 ft amsl) and 53.6 µg/L (elevation 512 ft amsl) respectively. The 2020 total uranium plume map did not need to be adjusted to honor the 2020 concentration.

Location 13267B

Location 13267B is situated in the southeast corner of the South Plume. Direct-push sampling results for location 13267B are provided in Table A.2-20. The location is identified in Figure A.2-3A.

This location has been sampled three times: 2002, 2013, and 2020. The samples collected in 2002 were identified as location 13267. The samples collected in 2020 were identified as location 13267B. Total uranium concentration data from all three sampling events are provided below.

Location 13267 (2002)		Location 13267A (2013)		Location 13267B (2020)	
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	5.80			514	8.30
508	64.0	511	16.3	504	52.2
498	60.0	501	18.8	494	34.5
488	54.0	491	16.8	484	12.4
478	30.0	481	18.2	474	8.70
468	3.60	471	7.70	464	7.60
458	0.90	461	0.50		
448	0.80				

The maximum total uranium concentration at this location has fluctuated between a high of 64.0 µg/L in 2002 (elevation 508 ft amsl) and 18.8 µg/L in 2013 (elevation 501 ft amsl). In 2020 the concentration was once again above 50 µg/L (52.2 µg/L at an elevation of 504 ft amsl). A 50 µg/L contour was added around this location on the 2020 total uranium plume map to honor the 2020 result.

Location 13421I

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

This area of the plume has been sampled 12 times. It 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 sampled three times: 1996, 2005, and 2007. The samples collected in 1996 were identified as location 12196. The samples collected in 2007 were identified as 12196B. Results for the three sampling events at location 12196 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	0.40	515	4.30		
509	0.30	505	87.5	512	6.7
499	0.70	495	101	502	59.6
489	0.50	485	14.4	492	104
479	0.30	475	37.4	482	3.2
469	0.50	465	18.7	472	9.0
459	0.70			462	3.0
449	0.40				
439	1.60				

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 492 to 495 ft amsl and had concentrations near 100 µg/L.

Location 13421 has been sampled nine times. It was sampled twice in 2011 and again in 2014, 2015, 2016, 2017, 2018, 2019, and 2020. The samples collected in 2011 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 concentration data from all nine acceptable sampling events 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 (t amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
		514	3.70	513	6.40	510	2.10
506	43.9	504	116	503	111	500	78.2
596	185	494	216	493	253	490	101
486	97.8	484	82.3	483	93.6	480	71.1
476	5.3	474	5.10	473	4.90	470	1.30
466	2.40	464	3.50	463	15.6	460	55.3
456	61.8	454	7.20	453	9.80	450	4.3
		444	6.40				

Location 13421E (2016)		Location 13421F (2017)		Location 13421G (2018)		Location 13421H (2019)	
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)
511	5.70	512	2.700	512	13.0	514	1.80
501	84.6	502	68.1	502	83.6	504	2.20
491	174.6	492	126.6	492	85.9	494	49.1
481	50.0	482	28.8	482	30.7	484	8.00
471	1.00	472	4.70	472	1.50	474	5.60
461	8.10	462	27.2	462	37.0	464	13.9
451	17.1	452	2.90	452	4.40	454	11.2
441	<1.00	442	<1.00				

Location 13421I (2020)	
514	1.80
504	46.5
494	83.8
484	58.9
474	10.4
464	8.80
454	13.4

The initial sampling event at location 13421 in 2011 resulted in a total uranium concentration of 185 µg/L at an elevation of 596 ft amsl and 61.8 µg/L at an elevation of 456 ft amsl. The high concentration at the 456 ft amsl 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 indicated that the total uranium plume was at an elevation of approximately 494 ft amsl and not also at an elevation of 456 ft amsl. A deeper FRL exceedance was measured again in 2015 (55.3 µg/L at an elevation of 460 ft amsl). Sampling in 2016 though did not show an exceedance at the 461 ft amsl elevation.

The samples collected between 2015 and 2017 indicate that the maximum uranium concentration at this location fluctuated within the 100–200 µg/L range. The maximum uranium concentration measured in 2018 was 85.9 µg/L (elevation 492 ft amsl) and the maximum measured in 2019 was 49.1 µg/L (elevation 494 ft amsl). The maximum uranium plume map for 2019 was adjusted to honor the 2019 concentration. In 2020 the maximum uranium concentration was 83.8 µg/L (elevation 494 ft amsl). The 2020 total uranium plume map was revised to honor the 2020 concentration.

Location 13493D

Location 13493D is located west of the west side of the South Plume. Direct-push sampling results for location 13493D are provided in Table A.2-22. The location is identified in Figure A.2-3A.

This location has been sampled five times: 2016, 2017, 2018, 2019, and 2020. The samples collected in 2016 were identified as location 13493. The samples collected in 2020 were identified as location 13493D. Total uranium concentrations from all five sampling events are provided below.

Location 13493 (2016)		Location 13493A (2017)		Location 13493B (2018)		Location 13493C (2019)		Location 13493D (2020)	
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)
512	33.3	514	30.6	513	32.8	515	30.3	516	20.4
502	24.5	504	19.4	503	15.7	505	19.0	506	7.00
492	16.0	494	10.0	493	7.3	495	12.2	496	11.1
482	12.4	484	8.3	483	12.2	485	15.3	486	15.9
472	8.8			473	8.5				

The maximum uranium concentration at this location in 2020 was below 30 µg/L. The 30 µg/L contour on the 2020 total uranium plume map was adjusted to honor the 2020 concentration.

Location 13512B

Location 13512B is located west of the west side of the South Plume. Direct-push sampling results for location 13512B are provided in Table A.2-23. The location is identified in Figure A.2-3A.

This location has been sampled three times: 2018, 2019, and 2020. The samples collected in 2018 were identified as location 13512. The samples collected in 2020 were identified as location 13512B. Total uranium concentrations from all three sampling events are provided below.

Location 13512 (2018)		Location 13512A (2019)		Location 13512B (2020)	
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)
512	2.2	516	1.6	516	1.40
502	39.3	506	33.7	506	14.0
492	20.4	496	23.8	496	14.3
482	12.9	486	14.8	486	13.5
472	14.4				

The maximum total uranium concentration measured in 2020 was below 30 µg/L. The 30 µg/L contour on the 2020 total uranium plume map was adjusted to honor the 2020 concentration.

Location 13513A

Location 13513A is situated in the southeast corner of the South Plume. Direct-push sampling results for location 13513A are provided in Table A.2-24. The location is identified on Figure A.2-3A.

This location has been sampled two times: 2018 and 2020. The samples collected in 2018 were identified as location 13513. The samples collected in 2020 were identified as location 13513A. Total uranium concentrations from both sampling events are provided below.

Location 13513 (2018)		Location 13513A (2020)	
Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)	Midpoint Screen Elevation (ft amsl)	Total Uranium (µg/L)
513	10.1	515	10.3
503	26.4	505	19.3
493	43.5	495	45.3
483	33.0	485	10.8
473	<1.00	475	1.40

The maximum total uranium concentration at this location remains above 30 ug/L. No change was made to the maximum total uranium plume map based on the 2020 result.

Location 13525
Location 13525 is located in the north portion the South Plume, just below Willey Road. Direct-push results are provided in Table A.2-25. This location is identified on Figure A.2-3A.

The maximum total uranium concentration measured in 2020 was 44.5 µg/L (elevation 516 ft amsl). No change was made to the 2020 maximum total uranium plume map based on this result.

Location 13526
Location 13526 is in the northeast portion of the South Plume. Direct-push results are provided in Table A.2-26. The 2020 sampling event was the first time this location was sampled. This location is identified in Inset 2 on Figure A.2-3A.

The maximum total uranium concentration measured in 2020 was 63.4 µg/L (elevation 502 ft amsl). The 50 µg/L contour on the 2020 maximum total uranium plume map was revised to honor the 2020 concentration.

Location 13527
Location 13527 is in the southeast corner of the South Plume. Direct-push results are provided in Table A.2-27. The 2020 sampling event was the first time this location was sampled. This location is identified on Figure A.2-3A.

The maximum total uranium concentration measured in 2020 was 25.5 µg/L (elevation 502 ft amsl). The 30 µg/L contour on the 2020 maximum total uranium plume map was revised to honor the 2020 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 2020 in the South Plume (Figures A.2-2B and A.2-3B) as being monitoring locations with intermittent total uranium FRL exceedances. Beginning in 2017, monitoring well 2900 is only sampled once a year during the first half of the year.

A time versus total uranium concentration plot for monitoring well 2552 is provided in Figure A.2-22. The figure shows that no total uranium FRL exceedances have been measured since 2016.

A time versus total uranium concentration plot for monitoring well 2900 is provided in Figure A.2-23. The figure indicates that no total uranium FRL exceedances occurred in 2020. 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 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, three monitoring wells (2880, 6881, and 82369_C2) had upward trends for total uranium concentration in the South Plume in 2020. Time versus concentration graphs for these wells are provided in Figures A.2-24, A.2-25, and A.2-26. All these wells are located within the capture zone of the extraction wells and, as such, the increasing concentration trends are not considered to be a threat to human health or the environment.

A.2.4 Monitoring Well Inspection and Maintenance

All monitoring wells were inspected in 2020 with particular emphasis on those wells that are not routinely used for sampling or water level measurements. The main concern noted for wells not routinely sampled was that protective casings on some of them need to be painted and have identification markings reapplied. Additional minor findings include:

- Some protective casing lids were hard to open.
- Some wells need to have vegetation or branches removed from around them to improve access.
- Uneven surfaces were noted around some wells.

Many of the inspection findings noted above were corrected immediately (e.g., vegetation removal). Deficiencies that could not be corrected immediately (e.g., removal of overhanging trees) will be corrected as time permits.

Annual visual inspections of all monitoring wells will continue in future years with any deficiencies documented and corrected. Additionally, camera surveys of monitoring wells that are not routinely sampled will be conducted every 5 years. The last survey of these wells was begun in 2017 and completed in 2018; therefore, the next camera surveys of these wells will occur in 2022.

A.2.5 Plume Metrics

Uranium plume area, center of mass, and remaining uranium mass calculations were first reported in the 2015 Site Environmental Report (DOE 2016), per the request of Ohio EPA. The calculations follow the approach presented by Joseph A. Ricker in “A Practical Method to Evaluate Ground Water Contaminant Plume Stability” (Ricker 2008).

Use of the Ricker method calculations supplements other remedy tracking metrics (i.e., maximum uranium plume maps, model predictions, and uranium concentration data regressions) that are also being reported. The other metrics were developed over many years of interaction with EPA and Ohio EPA, have proven to be reasonable and useful, and are considered to be good for measuring the extraction system’s effectiveness. The Ricker method provides an additional good assessment tool.

As reported in the 2016 Site Environmental Report (DOE 2017a), plume area calculations based on the Ricker method compared reasonably well with plume area calculations made by conservatively mapping the maximum uranium plume each year. However, the Ricker method calculation of uranium mass remaining in the aquifer was reported as being an order of magnitude lower than predictions presented in Attachment A.1 (based on groundwater modeling predictions and a regression of monitoring data). As discussed below, refinement of the calculation methodology since 2017 indicates that the calculations are in closer agreement when the difference between the mass of uranium in the groundwater and the mass of uranium sorbed to aquifer sediments is recognized and taken into account in the calculation.

As reported in the 2016 Site Environmental Report (DOE 2017a), a notable difference between the Ricker method and the other metrics being used was that the Ricker method did not include the results of groundwater samples collected using the Geoprobe, while the other metrics did include these data. The groundwater data collected using the Geoprobe were not included in the Ricker calculation because the Ricker calculation requires a dataset that is consistent in location over time; the annual Geoprobe effort does not sample the same locations every year. Ohio EPA requested that future calculations include Geoprobe results to see if the included data improve estimates of uranium mass remaining (DOE 2017b).

The analysis presented in this year's report uses the annual maximum concentration in 2006, 2010, 2014, 2016, 2017, 2018, 2019, and 2020 and a consistent set of monitoring well data that span all 8 selected years. The most recent maximum total uranium results available at Geoprobe locations were also included. Surfer software (Version 15.5.382) was used for kriging the data and mapping the results. Until 2017, the analysis was conducted for three separate plume areas: the PPDD, the South Field and South Plume, and the former WSA. With the addition of Geoprobe data, the analysis in 2017 changed to being applied to the entire plume. A homogenous effective porosity equal to that modeled for the aquifer (28%) was assumed, and a plume thickness of 30 ft was used.

Figure A.2-27 provides a uranium plume map that identifies the calculated center of mass for each year (2006, 2010, 2014, 2016, 2017, 2018, 2019, and 2020). As shown in Figure A.2-27, the center of mass in each plume area has remained fairly stationary (i.e., in the same general area) over this period, 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. In the former WSA, the center of mass has shifted slightly to the northwest over time. This is attributed to the higher uranium results in the northwest area as a result of additional Geoprobe sampling in the area. In the PPDD Area, the center of mass has shifted slightly to the west. This is attributed to cleanup of the east portion of the PPDD plume. In the South Field and South Plume, the center of mass has shifted slightly to the north. This is attributed to continuing uranium concentration reductions in the South Plume and southern South Field as cleanup proceeds. With inclusion of the Geoprobe data beginning in 2017, the dataset includes more samples collected near and outside plume boundaries, which helps better define the boundaries of the plume.

DOE plans to continue presenting these plume metrics in future Site Environmental Reports and will include Geoprobe data. With the addition of Geoprobe data, the analysis lends itself better to being applied to the entire plume, rather than dividing the plume into three different areas (i.e., WSA, PPDD, and the combined South Field and South Plume). Including the Geoprobe data also provides plume maps that appear to be better defined at the plume boundaries.

Figure A.2-28 provides 2020 Ricker method results for the total uranium plume area, the average total uranium concentration within the plume, and the total dissolved uranium mass remaining within the plume area. These trends are useful in illustrating remediation progress. As shown in Figure A.2-28, for 2020, the Ricker method calculations indicate that the total uranium plume area was 85.9 acres, the average uranium plume concentration was 80.8 µg/L, and the total uranium plume dissolved mass was 158 pounds.

A.2.5.1 Total Uranium Plume Area

Table A.2-31 presents a comparison of the second half of 2020 plume size interpretation (Figures A.2-3A and A.2-3B) to the Ricker method calculation. Previous years are also presented. The comparison indicates that between 2014 and 2020, the percent difference has ranged between 2.6% and 7.4%. The percent difference in 2020 was 5.4%.

A.2.5.2 Total Mass of Uranium Remaining in the Aquifer

The value of 158 pounds for the total mass of uranium remaining in the aquifer based on the Ricker method presented in Figure A.2-28 represents the dissolved mass of total uranium remaining in the aquifer based on 2020 data. As shown below, this result can be put into the context of the aquifer remediation by using the relationship of the contaminant distribution coefficient (K_d).

The distribution coefficient is the ratio of the concentration of a contaminant sorbed on the surfaces of the aquifer sediments to the concentration of the contaminant dissolved in groundwater and is represented as follows:

$$K_d = C_s/C_{aq}$$

where:

K_d = distribution coefficient, liters per kilogram (L/kg)

C_s = concentration of total uranium sorbed to aquifer sediments, milligrams per kilogram (mg/kg)

C_{aq} = concentration of total uranium dissolved in groundwater, milligrams per liter (mg/L).

The site-specific K_d for uranium used in the groundwater model is 3 L/kg (DOE 2003), which indicates that the concentration of uranium sorbed to aquifer sediments is 3 times the concentration of uranium in the groundwater. However, as discussed below, the sorbed mass of uranium is actually greater than 3 times the dissolved mass in solution because of the units used for K_d (Deutsch 1997).

The mass of aquifer solid in contact with 1 liter (L) of groundwater under saturated conditions can be defined as the bulk density of the solid (ρ_b) divided by the porosity of the aquifer (η). In the groundwater model, the bulk density is 1.85 grams per cubic centimeter (g/cm^3) and aquifer porosity is 28%; therefore, $\rho_b/\eta = 6.61$ g/cm^3.

The total uranium mass in the aquifer can be estimated by adding both the aqueous mass and solid mass using the following formula (Deutsch 1997):

$$\text{Total mass} = [(C_{aq})(1\ L)] + [(\rho_b/\eta)(C_s)(1\ L)]$$

where:

C_{aq} = concentration of total uranium dissolved in groundwater, mg/L

ρ_b = bulk density of aquifer sediments, g/cm^3

η = porosity of aquifer, percent

C_s = concentration of total uranium sorbed to aquifer sediments, mg/kg

This equation is solved below for a 1 L aquifer volume with an assumed C_{aq} of 1 mg/L. Site-specific values defined in the groundwater model for bulk density (1.85 g/cm^3) and aquifer porosity (28%) are used. A K_d of 3 L/kg is used to define a C_s of 3 mg/kg.

$$\text{Total Mass} = [(C_{aq})(1\ L)] + [(\rho_b/\eta)(C_s)(1\ L)]$$

$$\text{Total Mass} = [(1\ mg_{aq}/L)(1\ L)] + \{[(1.85\ g/cm^3)/0.28][(3\ mg/kg)(1\ L)]\}$$

$$\text{Total Mass} = (1\ mg_{aq}) + \{(6.61\ g/cm^3)[(3\ mg/kg)(1\ L)]\}$$

<u>Unit Conversions</u>

$(6.61\ g/cm^3)(1000\ cm^3/L) = 6610\ g/L$

$(6610\ g/L)(1000\ mg/g) = 6{,}610{,}000\ mg/L)$

$$\text{Total Mass} = (1\ mg_{aq}) + [(6{,}610{,}000\ mg/L)(3\ mg/kg)(1\ L)]$$

<u>Unit Conversion</u>

$(3\ mg/kg)(1\ kg/1{,}000{,}000\ mg) = 0.000003$

$$\text{Total Mass} = 1\ mg_{aq} + (6{,}610{,}000\ mg/L)[(0.000003)(1\ L)]$$

$$\text{Total Mass} = 1\ mg_{aq} + 19.83\ mg_s$$

This total mass calculation shows that the uranium mass sorbed in a 1 L volume of aquifer is 19.83 times greater than the uranium mass dissolved. This relationship can be combined with the result of the Ricker dissolved mass estimate to determine a total uranium mass for the aquifer. The Ricker method estimated a dissolved uranium mass of 158 pounds (Figure A.2-28); therefore, the estimated total mass in the aquifer (based on 2020 data) was 3,291.14 pounds.

$$3{,}291.14\ \text{pounds total} = 158\ \text{pounds}_{aq} + (158\ \text{pounds}_{aq})(19.83)$$

$$3{,}291.14\ \text{pounds total} = 158\ \text{pounds} + 3{,}133.14\ \text{pounds}$$

The result of 3,291.14 pounds of uranium mass total from the Ricker method can be compared to the predicted dissolved mass removal estimates presented in Attachment A.1 to achieve an estimate of the dissolved mass required to be removed from the aquifer to achieve a concentration-based cleanup of 30 μg/L. The estimate will also show how much sorbed uranium mass will remain in the aquifer when the concentration-based cleanup is achieved.

As shown in Table A.1-24 in Attachment A.1, two estimates are provided for the estimated total pounds of dissolved uranium mass to be removed from the aquifer to achieve the concentration-based cleanup FRL of 30 µg/L:

- 1,289 pounds dissolved mass (based on model predictions)
- 2,082 pounds dissolved mass (based on regression of concentration data)

The range in the predicted mass of dissolved uranium that needs to be removed indicates that between 1,209.14 and 2,002.14 pounds of uranium will remain sorbed to aquifer sediments when the concentration-based cleanup of 30 µg/L is achieved:

- 3,291.14 pounds – 1,289 pounds = 2,002.14 pounds sorbed uranium mass remains
- 3,291.14 pounds – 2,082 pounds = 1,209.14 pounds sorbed uranium mass remains

From a percentage perspective, this equates to 32% to 56% of the remaining mass (as of 2020).

- (2,002.14 pounds/3,291.14 pounds)(100) = 60.8 %
- (1,209.14 pounds/3,291.14 pounds)(100) = 36.7 %

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 in Figures A.2-29A, A.2-29B, and A.2-29C. These three figures also display the maximum total uranium plume interpretation for the second half of 2020. The cross sections (A–A′, B–B′, C–C′, D–D′, and E–E′) are provided in Figures A.2-30 through A.2-34, respectively.

Surfer software (Version 15.5.382) was used to krige the total uranium concentration datasets and produce the plume cross sections. Point kriging of the data for all total uranium 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 of area 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 2020. 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 with 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 References

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Table A.2-1. Geoprobe Location 13374G

Easting '83:	**1346349**	feet
Northing '83:	**481506**	feet
Ground Elevation:	**558**	feet above mean sea level (AMSL)
Depth to Water Table:	**35.00**	feet below ground surface (BGS)
Water Table Elevation:	**523.07**	feet AMSL
Work Completed:	**7/20/2020**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium[a,b] (ug/L) (FRL=30)	Uranium[c] (ug/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	518	40	0 - 10	168	171	1.61	1.26	0.354	0.0207	0.0124	20.7	7.27	0.780	>999	>999	6.85
2	508	50	10 - 20	5.70	4.34	-2.94	0.512	0.296	0.0193	0.00861	17.6	7.55	0.660	>999	>999	5.63
3	508	50	10 - 20	5.30	4.13	-1.21	0.460	0.289	0.0179	0.00794	17.6	7.55	0.660	>999	>999	5.63
4	498	60	20 - 30	2.00	1.89	-4.89	0.0170	0.346	0.0145	0.00669	16.8	7.61	0.640	>999	53.3	5.95
5	488	70	30 - 40	4.14	1.93	1.60	0.170	0.401	0.01590	0.00609	16.3	7.59	0.650	>999	>999	6.42

[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 13495B

Easting '83:	**1347156**	feet
Northing '83:	**481329**	feet
Ground Elevation:	**580**	feet above mean sea level (AMSL)
Depth to Water Table:	**58.00**	feet below ground surface (BGS)
Water Table Elevation:	**522.37**	feet AMSL
Work Completed:	**7/14/2020**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium[a,b] (ug/L) (FRL=30)	Uranium[c] (ug/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] (^0C)	pH[a] (SU)	Specific Conductance[a] (mS/cm)	Turbidity (NTU)	Turbidity[a] (NTU)	Dissolved Oxygen[a] (mg/L)
1	517	63	0 - 10	5.40	6.01	17.3	12.2	0.607	0.0426	0.0127	21.0	7.55	1.08	>999	>999	6.95
2	507	73	10 - 20	4.90	5.10	4.73	30.5	0.659	0.118	0.0130	19.8	7.63	1.00	>999	>999	5.87
3	507	73	10 - 20	4.81	4.42	0.583	30.2	0.507	0.110	0.00886	19.8	7.63	1.00	>999	>999	5.87
4	497	83	20 - 30	4.34	1.76	4.80	17.60	0.235	0.0402	0.00753	20.6	7.89	0.900	>999	>999	6.18
5	487	93	30 - 40	1.76	1.65	8.61	1.17	0.753	0.0262	0.0119	17.1	7.54	0.820	>999	>999	5.49
6	477	103	40 - 50	3.94	3.67	-0.244	0.0170	0.731	0.0144	0.00656	18.4	7.63	0.780	>999	563	4.79
7	467	113	50 - 60	6.33	6.09	0.623	0.0170	0.617	0.0250	0.0111	19.6	7.35	0.780	>999	>999	5.46

[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 13520

Easting '83:	**1347548**	feet
Northing '83:	**481451**	feet
Ground Elevation:	**582**	feet above mean sea level (AMSL)
Depth to Water Table:	**61.00**	feet below ground surface (BGS)
Water Table Elevation:	**520.81**	feet AMSL
Work Completed:	**7/13/2020**	

Sample Point	Elevation (ft AMSL)	Depth (ft BGS)	Sample Interval (ft)	Uranium[a,b] (ug/L) (FRL=30)	Uranium[c] (ug/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	516	66	0 - 10	11.0	12.7	1.04	8.40	0.862	0.0269	0.0137	20.0	7.57	0.990	>999	445	6.70
2	506	76	10 - 20	1.27	1.16	1.97	8.68	0.613	0.0136	0.00988	18.1	7.74	0.540	>999	469	6.23
3	506	76	10 - 20	1.17	1.14	-1.14	8.40	0.608	0.0131	0.00955	18.1	7.74	0.540	>999	469	6.23
4	496	86	20 - 30	1.04	1.23	-1.67	19.0	0.930	0.0123	0.0136	17.3	7.73	1.03	>999	485	6.27
5	486	96	30 - 40	2.23	2.95	-1.41	17.8	0.757	0.00573	0.00813	17.9	7.64	1.13	>999	>999	5.35
6	476	106	40 - 50	1.21	2.47	3.21	0.0170	0.513	0.0135	0.0115	19.1	7.63	0.950	>999	>999	5.33

[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 13521

Easting '83:	**1347965**	feet
Northing '83:	**480026**	feet
Ground Elevation:	**576**	feet above mean sea level (AMSL)
Depth to Water Table:	**58.00**	feet below ground surface (BGS)
Water Table Elevation:	**518.47**	feet AMSL
Work Completed:	**6/22/2020**	

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	513	63	0 - 10	**210**	**17.9**	**7.44**	**0.930**	**>999**	**342**	**6.10**
2	503	73	10 - 20	**11.1**	**17.9**	**7.61**	**0.720**	**>999**	**20.7**	**5.23**
3	503	73	10 - 20	**10.9**	**17.9**	**7.61**	**0.720**	**>999**	**20.7**	**5.23**
4	493	83	20 - 30	**13.7**	**17.6**	**7.76**	**0.710**	**>999**	**>999**	**5.98**
5	483	93	30 - 40	**10.3**	**17.3**	**7.72**	**0.680**	**>999**	**94.4**	**7.14**
6	473	103	40 - 50	**3.30**	**18.1**	**7.75**	**0.690**	**>999**	**31.6**	**5.09**

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

Table A.2-5. Geoprobe Location 13489B

Easting '83:	**1347565**	feet
Northing '83:	**477987**	feet
Ground Elevation:	**539**	feet above mean sea level (AMSL)
Depth to Water Table:	**15.00**	feet below ground surface (BGS)
Water Table Elevation:	**524.26**	feet AMSL
Work Completed:	**5/22/2020**	

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	519	20	0 - 10	**15.6**	**16.5**	**8.12**	**0.574**	**>999**	**96.8**	**9.04**
2	509	30	10 - 20	**4.10**	**13.6**	**7.74**	**0.554**	**>999**	**>999**	**8.74**
3	509	30	10 - 20	**3.80**	**13.6**	**7.74**	**0.554**	**>999**	**>999**	**8.74**
4	499	40	20 - 30	**2.30**	**13.0**	**8.00**	**0.532**	**>999**	**>999**	**6.22**
5	489	50	30-40	**1.50**	**11.6**	**8.13**	**0.546**	**>999**	**>999**	**7.79**

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

Table A.2-6. Geoprobe Location 12824D

Easting '83:	**1348034**	feet
Northing '83:	**477920**	feet
Ground Elevation:	**568**	feet above mean sea level (AMSL)
Depth to Water Table:	**48.00**	feet below ground surface (BGS)
Water Table Elevation:	**519.67**	feet AMSL
Work Completed:	**5/20/2020**	

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	515	53	0 - 10	**308**	**12.0**	**8.23**	**0.006**	**>999**	**737.0**	**10.90**
2	505	63	10 - 20	**15.7**	**12.9**	**7.98**	**0.589**	**>999**	**136.0**	**7.49**
3	505	63	10 - 20	**15.5**	**12.9**	**7.98**	**0.589**	**>999**	**136.0**	**7.49**
4	495	73	20 - 30	**4.70**	**12.9**	**8.06**	**0.586**	**>999**	**>999**	**10.16**
5	485	83	30 - 40	**8.80**	**12.1**	**7.97**	**0.627**	**>999**	**>999**	**9.61**

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

Table A.2-7. Geoprobe Location 13355B

Easting '83:	**1348980**	feet
Northing '83:	**477357**	feet
Ground Elevation:	**568**	feet above mean sea level (AMSL)
Depth to Water Table:	**51.00**	feet below ground surface (BGS)
Water Table Elevation:	**517.27**	feet AMSL
Work Completed:	**6/29/2020**	

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	512	56	0 - 10	**112**	**16.9**	**7.65**	**0.610**	**>999**	**642**	**8.83**
2	502	66	10 - 20	**36.9**	**16.4**	**7.61**	**0.730**	**>999**	**82.9**	**7.20**
3	502	66	10 - 20	**35.7**	**16.4**	**7.61**	**0.730**	**>999**	**82.9**	**7.20**
4	492	76	20 - 30	**8.50**	**16.2**	**7.72**	**0.590**	**>999**	**295**	**7.40**
5	482	86	30 - 40	**7.90**	**19.7**	**7.91**	**0.670**	**>999**	**>999**	**6.50**

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

Table A.2-8. Geoprobe Location 12411E

Easting '83:	**1348468**	feet
Northing '83:	**476845**	feet
Ground Elevation:	**570**	feet above mean sea level (AMSL)
Depth to Water Table:	**51.00**	feet below ground surface (BGS)
Water Table Elevation:	**519.38**	feet AMSL
Work Completed:	**6/4/2020**	

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	514	56	0 - 10	**52.0**	**17.5**	**7.78**	**0.840**	**>999**	**87.2**	**7.94**
2	504	66	10 - 20	**22.9**	**15.8**	**7.98**	**0.620**	**>999**	**269**	**7.49**
3	504	66	10 - 20	**22.3**	**15.8**	**7.98**	**0.620**	**>999**	**269**	**7.49**
4	494	76	20 - 30	**6.10**	**16.3**	**8.04**	**0.620**	**>999**	**>999**	**5.78**
5	484	86	30 - 40	**6.70**	**16.3**	**8.06**	**0.570**	**>999**	**>999**	**7.75**

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

Table A.2-9. Geoprobe Location 13430C

Easting '83:	**1349212**	feet
Northing '83:	**478474**	feet
Ground Elevation:	**575**	feet above mean sea level (AMSL)
Depth to Water Table:	**56.00**	feet below ground surface (BGS)
Water Table Elevation:	**519.12**	feet AMSL
Work Completed:	**6/25/2020**	

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	514	61	0 - 10	**59.7**	**19.7**	**7.49**	**1.04**	**>999**	**327**	**7.37**
2	504	71	10 - 20	**17.6**	**18.2**	**7.53**	**0.760**	**>999**	**600**	**5.71**
3	504	71	10 - 20	**16.9**	**18.2**	**7.53**	**0.760**	**>999**	**600**	**5.71**
4	494	81	20 - 30	**8.30**	**17.4**	**7.59**	**0.730**	**>999**	**272**	**5.93**
5	484	91	30 - 40	**10.0**	**17.7**	**7.51**	**0.760**	**>999**	**311**	**5.50**

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

Table A.2-10. Geoprobe Location 13471A

Easting '83:	**1349306**	feet
Northing '83:	**477402**	feet
Ground Elevation:	**575**	feet above mean sea level (AMSL)
Depth to Water Table:	**57.00**	feet below ground surface (BGS)
Water Table Elevation:	**518.16**	feet AMSL
Work Completed:	**5/29/2020**	

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	513	62	0 - 10	**186**	**17.6**	**7.73**	**0.690**	**>999**	**>999**	**8.17**
2	503	72	10 - 20	**38.5**	**17.2**	**7.75**	**0.750**	**>999**	**92.0**	**5.63**
3	503	72	10 - 20	**36.4**	**17.2**	**7.75**	**0.750**	**>999**	**92.0**	**5.63**
4	493	82	20 - 30	**17.9**	**16.8**	**7.35**	**0.660**	**>999**	**273**	**5.83**
5	483	92	30 - 40	**9.40**	**16.1**	**7.93**	**0.640**	**>999**	**>999**	**4.29**
6	473	102	40 - 50	**2.70**	**16.6**	**7.93**	**0.610**	**>999**	**>999**	**1.83**

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

Table A.2-11. Geoprobe Location 13486A

Easting '83:	**1348818**	feet
Northing '83:	**476558**	feet
Ground Elevation:	**564**	feet above mean sea level (AMSL)
Depth to Water Table:	**44.00**	feet below ground surface (BGS)
Water Table Elevation:	**520.38**	feet AMSL
Work Completed:	**5/28/2020**	

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	515	49	0 - 10	**82.9**	**18.6**	**7.70**	**0.760**	**>999**	**26.0**	**7.93**
2	505	59	10 - 20	**38.7**	**17.1**	**8.01**	**0.720**	**>999**	**537**	**6.14**
3	505	59	10 - 20	**23.2**	**17.1**	**8.01**	**0.720**	**>999**	**537**	**6.14**
4	495	69	20 - 30	**35.9**	**15.5**	**8.02**	**0.670**	**>999**	**894**	**7.37**
5	485	79	30 - 40	**6.40**	**15.0**	**8.12**	**0.690**	**>999**	**46.6**	**4.58**
6	475	89	40 - 50	**10.0**	**17.5**	**8.14**	**0.720**	**>999**	**>999**	**6.61**

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

Table A.2-12. Geoprobe Location 13494A

Easting '83:	**1349451**	feet
Northing '83:	**478170**	feet
Ground Elevation:	**575**	feet above mean sea level (AMSL)
Depth to Water Table:	**55.00**	feet below ground surface (BGS)
Water Table Elevation:	**519.53**	feet AMSL
Work Completed:	**6/24/2020**	

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	515	60	0 - 10	**200**	**18.6**	**7.33**	**1.09**	**>999**	**203**	**5.97**
2	505	70	10 - 20	**52.3**	**17.5**	**7.52**	**0.900**	**>999**	**195**	**5.01**
3	505	70	10 - 20	**51.6**	**17.5**	**7.52**	**0.900**	**>999**	**195**	**5.01**
4	495	80	20 - 30	**75.1**	**16.6**	**7.29**	**0.960**	**>999**	**>999**	**5.57**
5	485	90	30 - 40	**11.5**	**16.9**	**7.54**	**0.750**	**>999**	**38.0**	**4.23**
6	475	100	40 - 50	**2.00**	**17.0**	**7.67**	**0.610**	**>999**	**16.8**	**4.29**

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

Table A.2-13. Geoprobe Location 13509A

Easting '83:	**1348727**	feet
Northing '83:	**476133**	feet
Ground Elevation:	**579**	feet above mean sea level (AMSL)
Depth to Water Table:	**60.00**	feet below ground surface (BGS)
Water Table Elevation:	**518.88**	feet AMSL
Work Completed:	**6/16/2020**	

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	514	65	0 - 10	**33.0**	**22.6**	**7.56**	**0.820**	**>999**	**>999**	**6.67**
2	504	75	10 - 20	**22.9**	**17.3**	**7.63**	**0.760**	**>999**	**>999**	**6.55**
3	504	75	10 - 20	**22.4**	**17.3**	**7.63**	**0.760**	**>999**	**>999**	**6.55**
4	494	85	20 - 30	**9.30**	**17.1**	**7.88**	**0.790**	**>999**	**>999**	**4.93**
5	484	95	30 - 40	**7.20**	**16.1**	**7.68**	**0.810**	**>999**	**>999**	**5.47**
6	474	105	40 - 50	**4.10**	**18.9**	**7.95**	**1.01**	**>999**	**>999**	**6.40**

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

Table A.2-14. Geoprobe Location 13522

Easting '83:	**1348635**	feet
Northing '83:	**477836**	feet
Ground Elevation:	**575**	feet above mean sea level (AMSL)
Depth to Water Table:	**54.00**	feet below ground surface (BGS)
Water Table Elevation:	**520.52**	feet AMSL
Work Completed:	**5/21/2020**	

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	516	59	0 - 10	**9.10**	**14.6**	**7.28**	**1.06**	**>999**	**20.3**	**6.72**
2	506	69	10 - 20	**14.7**	**13.6**	**7.87**	**0.660**	**>999**	**>999**	**8.12**
3	496	79	20 - 30	**15.6**	**13.6**	**7.87**	**0.660**	**>999**	**>999**	**8.12**
4	496	79	20 - 30	**15.5**	**13.6**	**7.77**	**0.631**	**>999**	**>999**	**7.13**
5	486	89	30 - 40	**10.7**	**13.5**	**7.88**	**0.650**	**>999**	**>999**	**6.83**
6	476	99	40 - 50	**1.10**	**13.6**	**7.88**	**0.650**	**>999**	**>999**	**6.15**

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

Table A.2-15. Geoprobe Location 13523

Easting '83:	**1348582**	feet
Northing '83:	**477052**	feet
Ground Elevation:	**541**	feet above mean sea level (AMSL)
Depth to Water Table:	**22.00**	feet below ground surface (BGS)
Water Table Elevation:	**519.30**	feet AMSL
Work Completed:	**6/17/2020**	

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	514	27	0 - 10	**< 1.00**	**16.0**	**7.65**	**0.450**	**>999**	**>999**	**9.69**
2	504	37	10 - 20	**16.2**	**16.4**	**7.71**	**0.750**	**>999**	**72.9**	**6.60**
3	504	37	10 - 20	**15.8**	**16.4**	**7.71**	**0.750**	**>999**	**72.9**	**6.60**
4	494	47	20 - 30	**4.90**	**14.3**	**7.99**	**0.640**	**>999**	**111**	**5.29**
5	484	57	30 - 40	**4.60**	**18.0**	**8.09**	**0.370**	**>999**	**68.8**	**5.30**
6	474	67	40 - 50	**10.2**	**13.9**	**8.10**	**0.580**	**>999**	**>999**	**5.78**

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

Table A.2-16. Geoprobe Location 13524

Easting '83:	**1348419**	feet
Northing '83:	**476555**	feet
Ground Elevation:	**568**	feet above mean sea level (AMSL)
Depth to Water Table:	**49.00**	feet below ground surface (BGS)
Water Table Elevation:	**519.28**	feet AMSL
Work Completed:	**6/9/2020**	

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	514	54	0 - 10	**20.6**	**17.6**	**7.48**	**0.790**	**>999**	**580**	**8.53**
2	504	64	10 - 20	**5.10**	**16.5**	**7.83**	**0.550**	**>999**	**838**	**7.40**
3	504	64	10 - 20	**5.00**	**16.5**	**7.83**	**0.550**	**>999**	**838**	**7.40**
4	494	74	20 - 30	**5.90**	**15.7**	**8.04**	**0.560**	**>999**	**75.8**	**7.80**
5	484	84	30 - 40	**4.50**	**15.7**	**7.98**	**0.590**	**>999**	**292**	**6.21**
6	474	94	40-50	**1.90**	**15.1**	**7.95**	**0.560**	**>999**	**>999**	**5.67**

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

Table A.2-17. Geoprobe Location 13227C

Easting '83:	**1348614**	feet
Northing '83:	**475757**	feet
Ground Elevation:	**576**	feet above mean sea level (AMSL)
Depth to Water Table:	**56.00**	feet below ground surface (BGS)
Water Table Elevation:	**520.41**	feet AMSL
Work Completed:	**5/27/2020**	

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	515	61	0 - 10	**24.4**	**16.9**	**7.61**	**0.890**	**>999**	**40.2**	**7.27**
2	505	71	10 - 20	**22.9**	**16.8**	**7.79**	**0.950**	**>999**	**218**	**7.39**
3	505	71	10 - 20	**22.7**	**16.8**	**7.79**	**0.950**	**>999**	**218**	**7.39**
4	495	81	20 - 30	**17.0**	**16.5**	**8.03**	**0.740**	**>999**	**111**	**6.25**
5	485	91	30 - 40	**11.9**	**16.9**	**8.08**	**0.580**	**>999**	**18.9**	**6.75**

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

Table A.2-18. Geoprobe Location 13229H

Easting '83:	**1348246**	feet
Northing '83:	**475529**	feet
Ground Elevation:	**572**	feet above mean sea level (AMSL)
Depth to Water Table:	**52.00**	feet below ground surface (BGS)
Water Table Elevation:	**519.81**	feet AMSL
Work Completed:	**5/26/2020**	

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	515	57	0 - 10	**46.7**	**16.8**	**7.53**	**0.810**	**>999**	**137**	**7.17**
2	505	67	10 - 20	**20.8**	**16.2**	**7.80**	**0.750**	**>999**	**>999**	**6.52**
3	505	67	10 - 20	**15.2**	**16.2**	**7.80**	**0.750**	**>999**	**>999**	**6.52**
4	495	77	20 - 30	**18.1**	**15.8**	**7.86**	**0.680**	**>999**	**219**	**4.56**
5	485	87	30-40	**12.5**	**15.5**	**7.97**	**0.660**	**>999**	**303**	**6.51**

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

Table A.2-19. Geoprobe Location 13239F

Easting '83:	**1348444**	feet
Northing '83:	**475400**	feet
Ground Elevation:	**579**	feet above mean sea level (AMSL)
Depth to Water Table:	**62.00**	feet below ground surface (BGS)
Water Table Elevation:	**517.20**	feet AMSL
Work Completed:	**7/8/2020**	

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	512	67	0 - 10	**53.6**	**18.3**	**7.50**	**0.760**	**>999**	**571**	**8.15**
2	502	77	10 - 20	**46.4**	**17.3**	**7.59**	**0.730**	**>999**	**58.8**	**6.37**
3	502	77	10 - 20	**44.0**	**17.3**	**7.59**	**0.730**	**>999**	**58.8**	**6.37**
4	492	87	20 - 30	**33.2**	**16.9**	**7.73**	**0.600**	**>999**	**>999**	**6.31**
5	482	97	30 - 40	**11.7**	**17.4**	**7.80**	**0.640**	**>999**	**139**	**5.68**
6	472	107	40 - 50	**6.90**	**17.4**	**7.80**	**0.660**	**>999**	**512**	**4.70**

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

Table A.2-20. Geoprobe Location 13267B

Easting '83:	**1348841**	feet
Northing '83:	**475194**	feet
Ground Elevation:	**580**	feet above mean sea level (AMSL)
Depth to Water Table:	**61.00**	feet below ground surface (BGS)
Water Table Elevation:	**519.36**	feet AMSL
Work Completed:	**7/9/2020**	

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	514	66	0 - 10	**8.30**	**18.8**	**7.73**	**0.810**	**>999**	**121**	**5.40**
2	504	76	10 - 20	**52.5**	**17.1**	**7.72**	**0.720**	**>999**	**>999**	**5.72**
3	504	76	10 - 20	**51.2**	**17.1**	**7.72**	**0.720**	**>999**	**>999**	**5.72**
4	494	86	20 - 30	**34.5**	**17.3**	**7.82**	**0.650**	**>999**	**>999**	**5.72**
5	484	96	30 - 40	**12.4**	**17.3**	**7.31**	**0.660**	**>999**	**797**	**4.22**
6	474	106	40 - 50	**8.70**	**16.9**	**7.71**	**0.740**	**>999**	**>999**	**4.58**
7	464	116	50 - 60	**7.60**	**18.1**	**7.68**	**0.800**	**>999**	**>999**	**5.84**

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

Table A.2-21. Geoprobe Location 13421I

Easting '83:	**1349309**	feet
Northing '83:	**476022**	feet
Ground Elevation:	**571**	feet above mean sea level (AMSL)
Depth to Water Table:	**52.00**	feet below ground surface (BGS)
Water Table Elevation:	**519.49**	feet AMSL
Work Completed:	**6/15/2020**	

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	514	57	0 - 10	**1.80**	**17.4**	**7.46**	**0.910**	**>999**	**235**	**7.73**
2	504	67	10 - 20	**46.5**	**16.0**	**7.74**	**0.780**	**>999**	**74.0**	**4.74**
3	504	67	10 - 20	**45.9**	**16.0**	**7.74**	**0.780**	**>999**	**74.0**	**4.74**
4	494	77	20 - 30	**83.8**	**17.4**	**7.90**	**0.750**	**>999**	**>999**	**6.67**
5	484	87	30 - 40	**58.9**	**15.8**	**7.86**	**0.730**	**>999**	**>999**	**6.12**
6	474	97	40 - 50	**10.4**	**16.3**	**7.98**	**0.750**	**>999**	**>999**	**5.46**
7	464	107	50 - 60	**8.80**	**15.8**	**7.88**	**0.790**	**>999**	**404**	**5.29**
8	454	117	60 - 70	**13.4**	**16.8**	**7.82**	**0.830**	**>999**	**>999**	**5.73**

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

Table A.2-22. Geoprobe Location 13493D

Easting '83:	**1348183**	feet
Northing '83:	**475710**	feet
Ground Elevation:	**573**	feet above mean sea level (AMSL)
Depth to Water Table:	**52.00**	feet below ground surface (BGS)
Water Table Elevation:	**521.34**	feet AMSL
Work Completed:	**6/12/2020**	

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	516	57	0 - 10	**20.4**	**16.5**	**7.91**	**0.690**	**>999**	**200**	**7.91**
2	506	67	10 - 20	**7.00**	**16.0**	**7.96**	**0.730**	**>999**	**38.3**	**4.57**
3	506	67	10 - 20	**6.10**	**16.0**	**7.96**	**0.730**	**>999**	**38.3**	**4.57**
4	496	77	20 - 30	**11.1**	**15.4**	**8.02**	**0.620**	**>999**	**189**	**5.93**
5	486	87	30 - 40	**15.9**	**14.9**	**7.85**	**0.740**	**>999**	**122**	**5.65**

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

Table A.2-23. Geoprobe Location 13512B

Easting '83:	**1348248**	feet
Northing '83:	**475394**	feet
Ground Elevation:	**552**	feet above mean sea level (AMSL)
Depth to Water Table:	**31.00**	feet below ground surface (BGS)
Water Table Elevation:	**520.65**	feet AMSL
Work Completed:	**6/2/2020**	

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	516	36	0 - 10	**1.40**	**15.3**	**7.55**	**0.620**	**>999**	**>999**	**9.60**
2	506	46	10 - 20	**14.0**	**14.8**	**7.66**	**0.710**	**>999**	**104**	**7.97**
3	506	46	10 - 20	**13.6**	**14.8**	**7.66**	**0.710**	**>999**	**104**	**7.97**
4	496	56	20 - 30	**14.3**	**15.4**	**7.80**	**0.660**	**>999**	**127**	**6.36**
5	486	66	30 - 40	**13.5**	**14.7**	**7.94**	**0.570**	**>999**	**360**	**7.17**

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

Table A.2-24. Geoprobe Location 13513A

Easting '83:	**1348892**	feet
Northing '83:	**475082**	feet
Ground Elevation:	**581**	feet above mean sea level (AMSL)
Depth to Water Table:	**61.00**	feet below ground surface (BGS)
Water Table Elevation:	**520.44**	feet AMSL
Work Completed:	**7/7/2020**	

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	515	66	0 - 10	**10.3**	**21.7**	**7.34**	**0.890**	**>999**	**447**	**8.24**
2	505	76	10 - 20	**19.3**	**17.1**	**7.72**	**0.770**	**>999**	**606**	**4.21**
3	505	76	10 - 20	**18.6**	**17.1**	**7.72**	**0.770**	**>999**	**606**	**4.21**
4	495	86	20 - 30	**45.3**	**17.5**	**7.76**	**0.710**	**>999**	**>999**	**4.87**
5	485	96	30 - 40	**10.8**	**18.2**	**7.76**	**0.700**	**>999**	**30.4**	**4.76**
6	475	106	40 - 50	**1.40**	**17.6**	**7.69**	**0.770**	**>999**	**498**	**4.83**

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

Table A.2-25. Geoprobe Location 13525

Easting '83:	**1348680**	feet
Northing '83:	**475960**	feet
Ground Elevation:	**579**	feet above mean sea level (AMSL)
Depth to Water Table:	**58.00**	feet below ground surface (BGS)
Water Table Elevation:	**520.72**	feet AMSL
Work Completed:	**6/10/2020**	

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	516	63	0 - 10	**44.5**	**20.2**	**7.65**	**0.510**	**>999**	**>999**	**6.36**
2	506	73	10 - 20	**20.6**	**18.2**	**7.75**	**0.770**	**>999**	**340**	**6.37**
3	506	73	10 - 20	**20.1**	**18.2**	**7.75**	**0.770**	**>999**	**340**	**6.37**
4	496	83	20 - 30	**9.80**	**17.8**	**7.89**	**0.610**	**>999**	**561**	**5.31**
5	486	93	30 - 40	**8.00**	**18.4**	**8.01**	**0.390**	**>999**	**>999**	**5.86**
6	476	103	40 - 50	**3.60**	**17.2**	**7.86**	**0.570**	**>999**	**60.3**	**4.06**

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

Table A.2-26. Geoprobe Location 13526

Easting '83:	**1349083**	feet
Northing '83:	**475784**	feet
Ground Elevation:	**582**	feet above mean sea level (AMSL)
Depth to Water Table:	**65.00**	feet below ground surface (BGS)
Water Table Elevation:	**517.30**	feet AMSL
Work Completed:	**6/1/2020**	

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	512	70	0 - 10	**15.9**	**18.1**	**7.88**	**0.920**	**>999**	**341**	**5.71**
2	502	80	10 - 20	**63.4**	**16.5**	**8.00**	**0.840**	**>999**	**362**	**6.85**
3	502	80	10 - 20	**62.0**	**16.5**	**8.00**	**0.840**	**>999**	**362**	**6.85**
4	492	90	20 - 30	**34.2**	**16.2**	**8.14**	**0.750**	**>999**	**151**	**5.90**
5	482	100	30 - 40	**14.4**	**16.1**	**8.12**	**0.730**	**>999**	**>999**	**5.85**
6	472	110	40 - 50	**1.60**	**16.7**	**7.92**	**0.750**	**>999**	**65.5**	**5.77**

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

Table A.2-27. Geoprobe Location 13527

Easting '83:	**1348924**	feet
Northing '83:	**475038**	feet
Ground Elevation:	**582**	feet above mean sea level (AMSL)
Depth to Water Table:	**65.00**	feet below ground surface (BGS)
Water Table Elevation:	**517.13**	feet AMSL
Work Completed:	**6/11/2020**	

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	512	70	0 - 10	**20.9**	**16.7**	**7.58**	**0.890**	**>999**	**44.1**	**6.00**
2	502	80	10 - 20	**25.5**	**15.7**	**7.71**	**0.790**	**>999**	**>999**	**5.23**
3	502	80	10 - 20	**25.4**	**15.7**	**7.71**	**0.790**	**>999**	**>999**	**5.23**
4	492	90	20 - 30	**11.5**	**15.3**	**7.87**	**0.740**	**>999**	**107**	**4.07**
5	482	100	30 - 40	**2.9**	**15.8**	**7.78**	**0.400**	**>999**	**250**	**4.77**
6	472	110	40 - 50	**1.2**	**15.7**	**7.76**	**0.820**	**>999**	**941**	**3.72**

[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 2020 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	89	12.0	462	112	95	Up
2046	88	16.7	907	125	187	Down
2049	67	3.00	178	66	44	Down
2060	95	8.40	332	71.2	58.1	Down
21192	12	7.55	966	101	273	Up
23271	38	34.6	144	69.6	31.0	Down
23273	38	114	421	220	77	Down
23274	58	75.0	384	159	62	Down
23275	37	88.3	349	162	53	No Trend
23276	38	3.56	115	78.1	19.7	Down
23280	38	19.1	700	129	131	Down
23281	38	16.1	367	115	76	Down
2386	61	6.67	131	31.4	26.0	Up
2387	61	18.1	492	155	76	Up
2389	50	0.899	120	32.9	22.0	Up
2397	47	135	737	354	124	Down
2649	57	6.01	1240	268	325	Up
2880	61	0.400	71.8	27.4	26.1	Up
3095	81	2.00	94.0	28.3	17.1	No Trend
63285	38	71.6	277	168	62	Down
6880	48	43.3	145	77.7	24.5	Down
6881	48	17.5	60.5	27.8	6.8	Up
82369_C1	16	12.1	210	123	46	No Trend
82369_C2	11	25.1	50.6	35.1	7.6	Up
82372_C1	19	26.8	62.4	38.7	9.0	Down
83117_C1	39	1.28	1620	708	321	Down
83117_C4	21	48.7	111	74.675.8	18.0	Down
83124_C1	60	102	1070	494	203	No Trend
83124_C2	35	22.8	103	44.4	18.0	Down
83124_C4	20	25.4	62.2	42.4	9.2	Up
83124_C5	20	24.4	61.4	46.7	9.0	Down
83294_C1	32	98.5	340	215	64	Up
83294_C2	51	1.24	575	310	113	Down
83294_C3	23	20.5	539	233	168	Down
83295_C2	33	53.1	178	114	39	Down
83295_C3	25	45.7	175	107	44	Down
83295_C5	20	29.9	155	64.7	32.9	Down
83296_C1	19	49.3	135	77.5	20.9	Down
83337_C1	35	255	2660	1400	580	Down
83337_C2	50	2.40	835	127	169	No Trend
83338_C1	25	282	1100	524	150	Down
83338_C2	30	14	648	92.3	143	Down
83340_C1	26	13.2	72.7	31.3	11.2	Up

[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 dataset (1988 through 1993) and 1994 through 2020 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.

Table A.2-28. Summary Statistics and Trend Analysis of Monitoring Wells for Total Uranium with 2020 Results Above FRLs (continued)

[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] The Mann-Kendall test for trend is performed with a 95% confidence interval, using data from third quarter 1998 through 2020.

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,d]
South Plume Module (August 27, 1993, through December 31, 2020)						
3924	712	1.2	180	27.4	15.0	Down
3925	716	0.5	84.0	22.6	8.1	Down
3926	702	1.5	42.4	24.4	7.8	No Trend
3927	701	1.0	17.0	2.72	1.13	Up
South Plume Optimization Module (August 9, 1998, through December 31, 2020)						
32308	632	18.4	100	49.9	16.9	Down
32309	644	15.6	123	49.1	21.1	Down
South Field Module (July 13, 1998, through December 31, 2020)						
31550	664	16.2	128	48.0	18.1	Down
31560	691	11.2	183	52.0	37.4	Down
31561	664	17.7	114[e]	38.7	10.1	Down
32276	706	12.3	290	87.6	63.7	Down
32446	559	17.4	168	54.0	21.3	Down
32447	582	9.4	302	92.8	55.0	Down
33061	461	13.6	98.5	41.3	15.2	Down
33262	420	17.4	110	41.3	14.8	Down
33264	412	3.6	364	64.6	44.2	Down
33298	369	10.1	76.2	45.9	12.8	Down
33326	319	8.3	62.2	21.3	8.2	Down
Waste Storage Area Module (May 8, 2002, through December 31, 2020)						
32761	451	19.3	161	51.7	32.1	Down
33062	465	10.2	236	58.1	42.843.0	Down
33347	275	7.0	126	25.4	15.8	No Trend

[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] Mann-Kendall test for trend is performed with a 95% confidence interval.

[e] 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, which is no longer active as an extraction well.

Table A.2-30. Plume Size 1997 Through 2020

Year	Area Greater Than 30 µg/L Total Uranium (acres)
1997	237.6[a]
1998	216.9[a]
1999	228.9[a]
2000	233.4[a]
2001	171.1
2002	176.0
2003	179.1
2004	195.2
2005	196.1
2006	189.3
2007	186.0
2008	186.9
2009	186.0
2010	184.0
2011	144.3
2012	130.3
2013	127.3
2014	110.9
2015	109.5
2016	105.0
2017	94.4
2018	89.3
2019	86.5
2020	81.5

[a] Plume size based on 20 µg/L total uranium.

Table A.2-31. Comparison of Plume Size Interpretation and Ricker Method Plume Size Calculation

Year	Maximum Uranium Plume Size Interpretation (acres)	Ricker Method Plume Size Calculation (acres)	Relative Percent Difference[a]
2006	189.3	145.7	23.0%
2010	184.0	132.7	27.9
2014	110.9	108.0	2.6%
2016	105.0	108.0	2.9%
2017	94.4	97.3	3.1%
2018	89.3	95.9	7.4%
2019	86.5	89.2	3.1%
2020	81.5	85.9	5.4%

[a] Relative percent difference = [(maximum-Ricker)/maximum]* 100

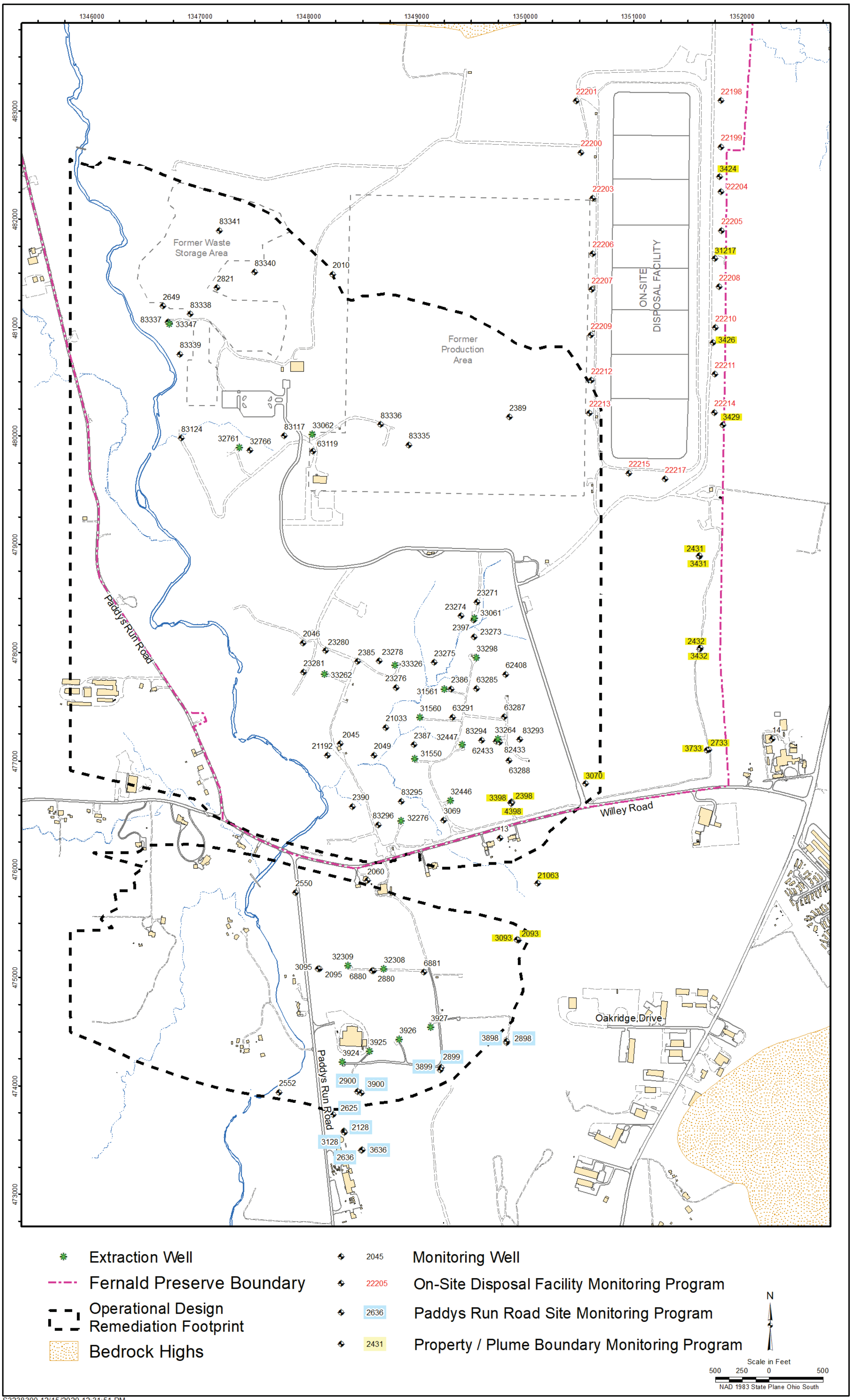

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Figure A.2-1. IEMP Water Quality Monitoring Wells and Extraction Wells

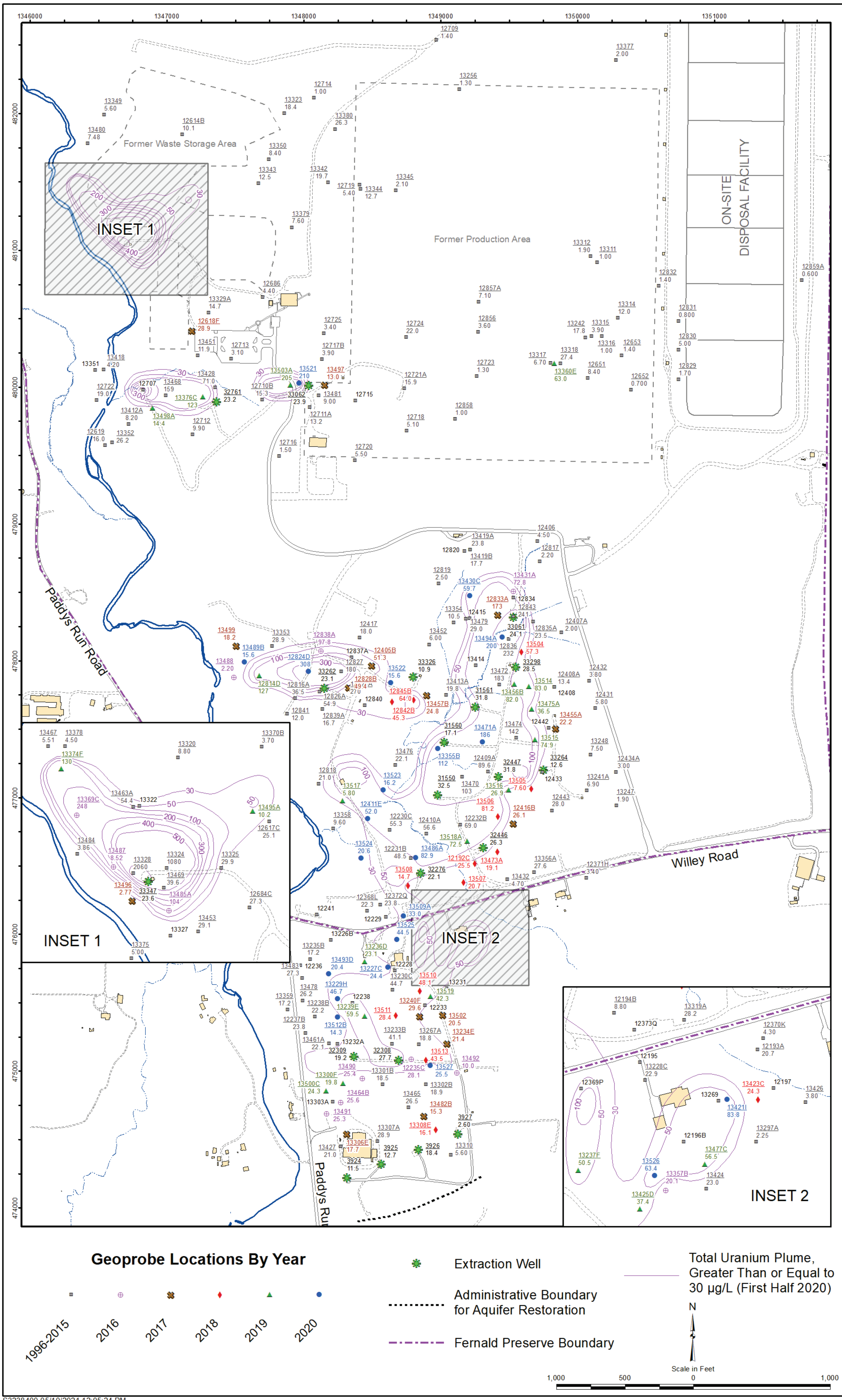

Figure A.2-2A. Direct-Push Data and Maximum Total Uranium Plume Through the First Half of 2020

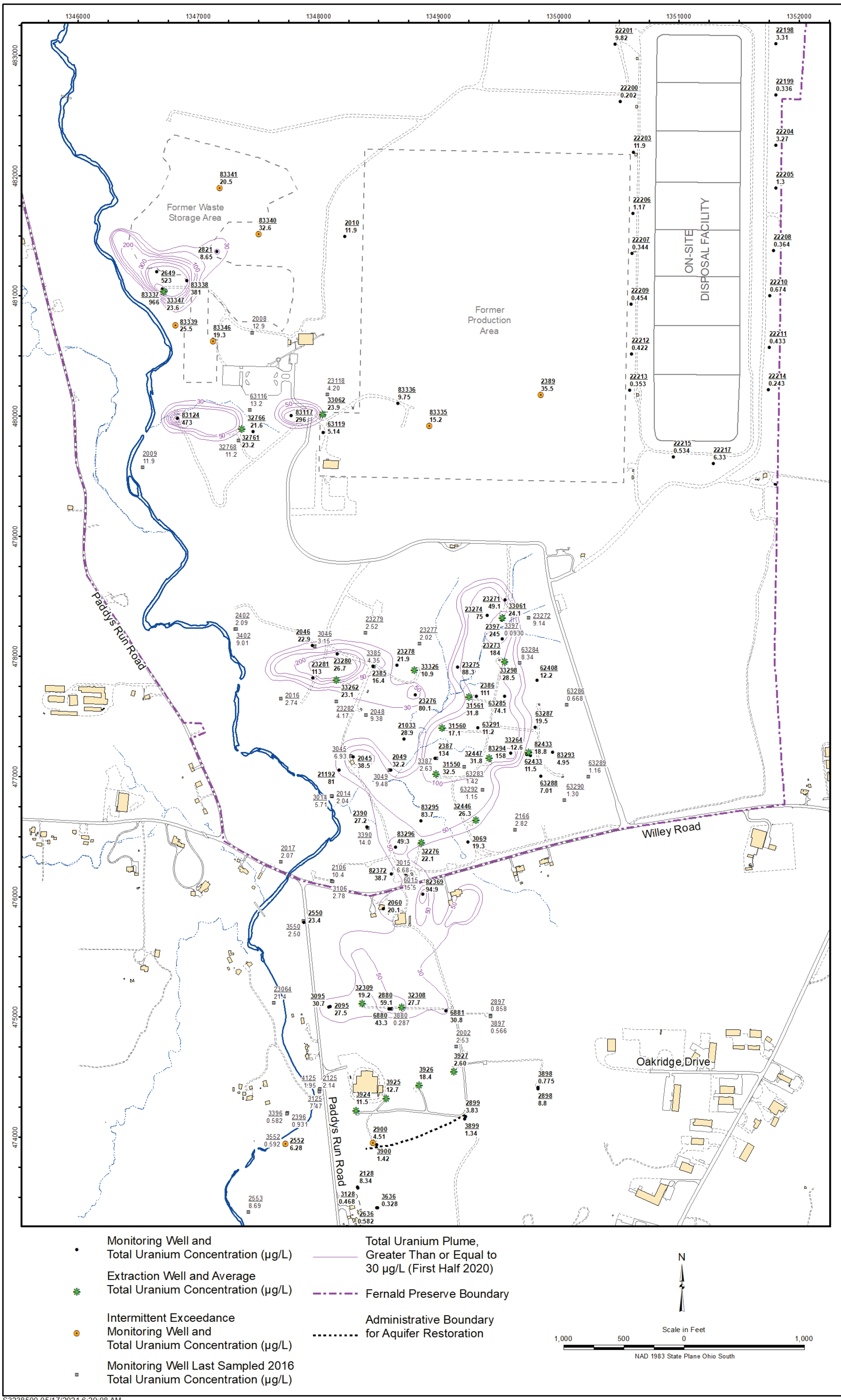

Figure A.2-2B. Monitoring Well Data and Maximum Total Uranium Plume Through the First Half of 2020

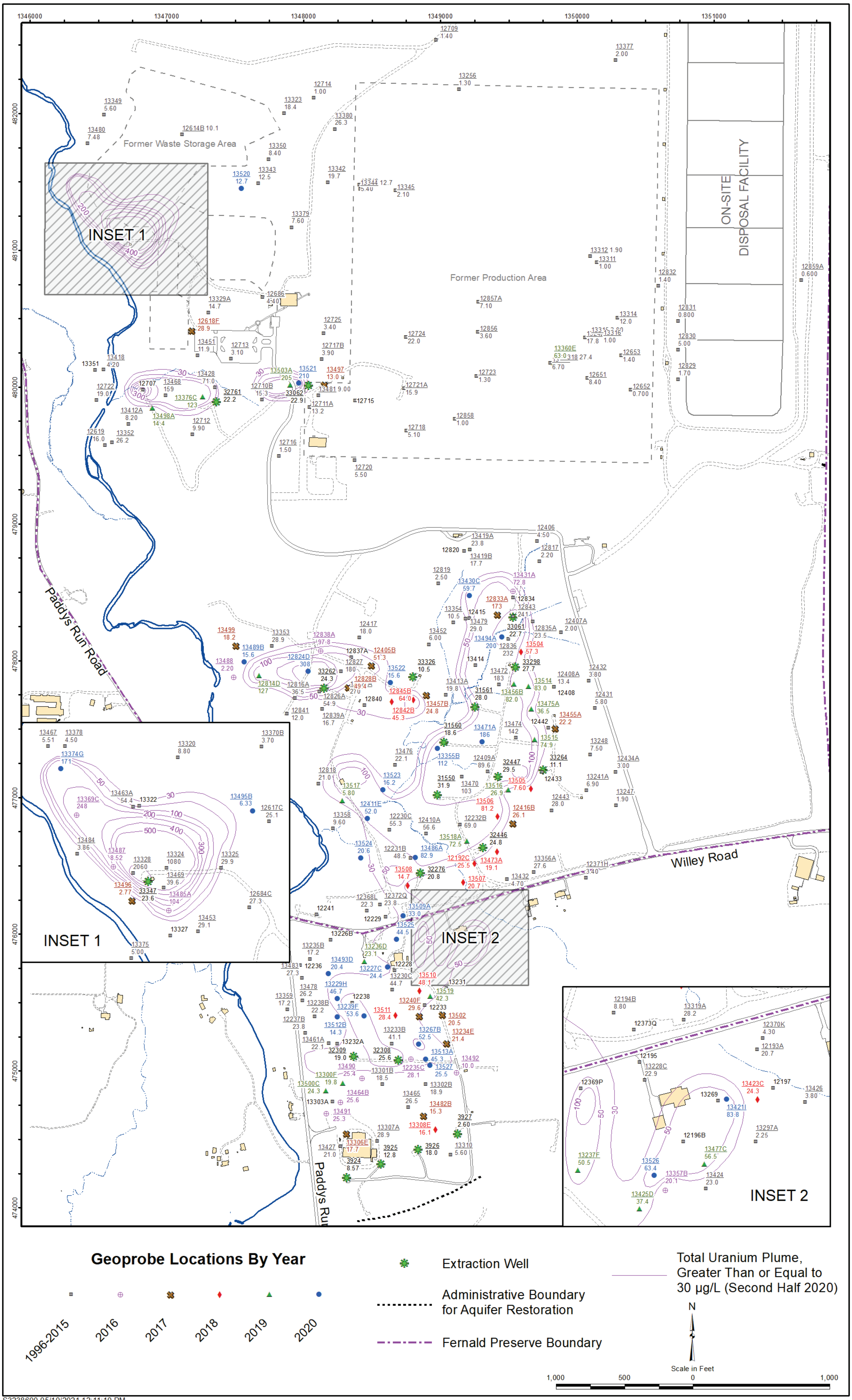

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Figure A.2-3A. Direct-Push Data and Maximum Total Uranium Plume Through the Second Half of 2020

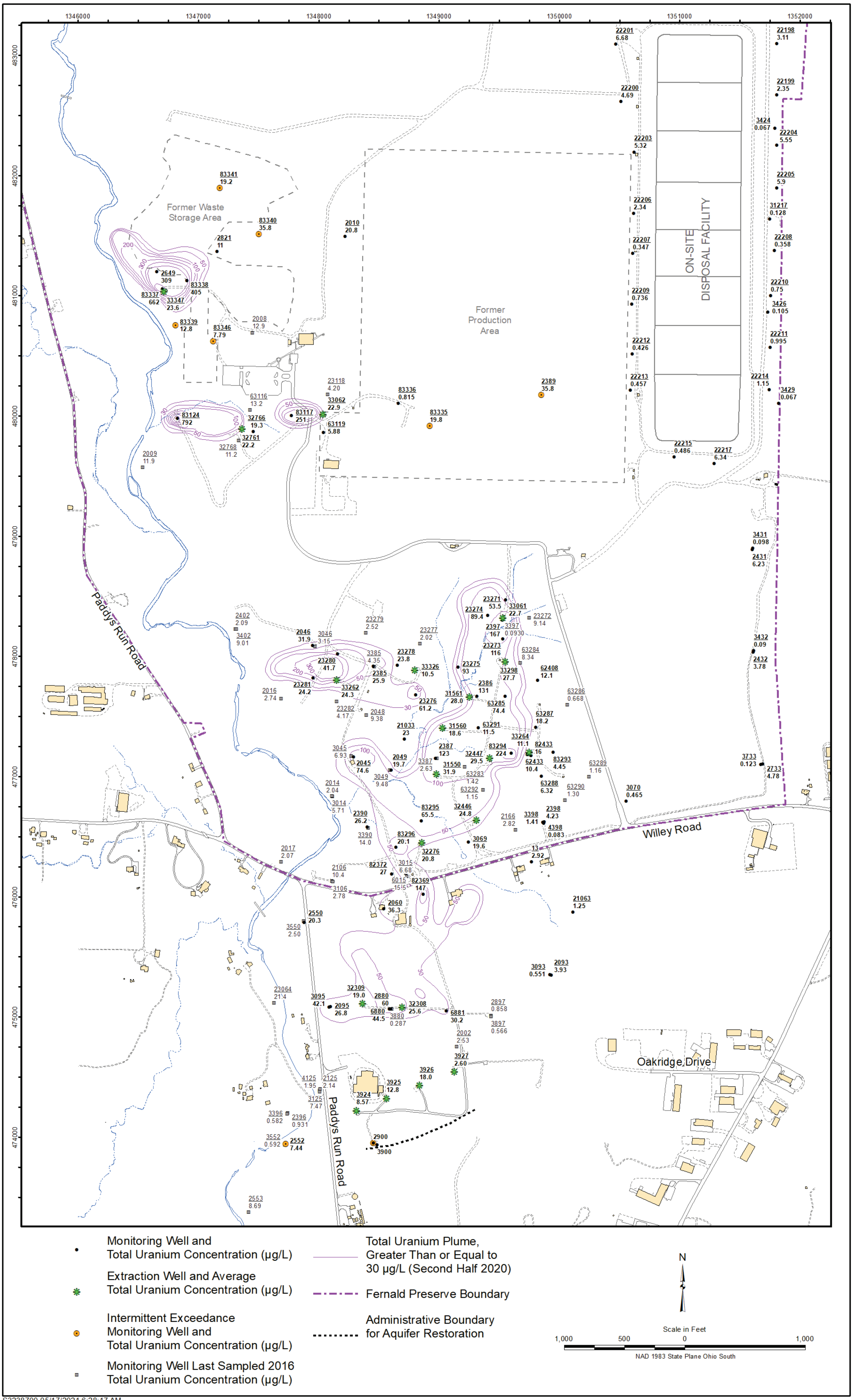

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Figure A.2-3B. Monitoring Well Data and Maximum Detected Total Uranium Plume Through the Second Half of 2020

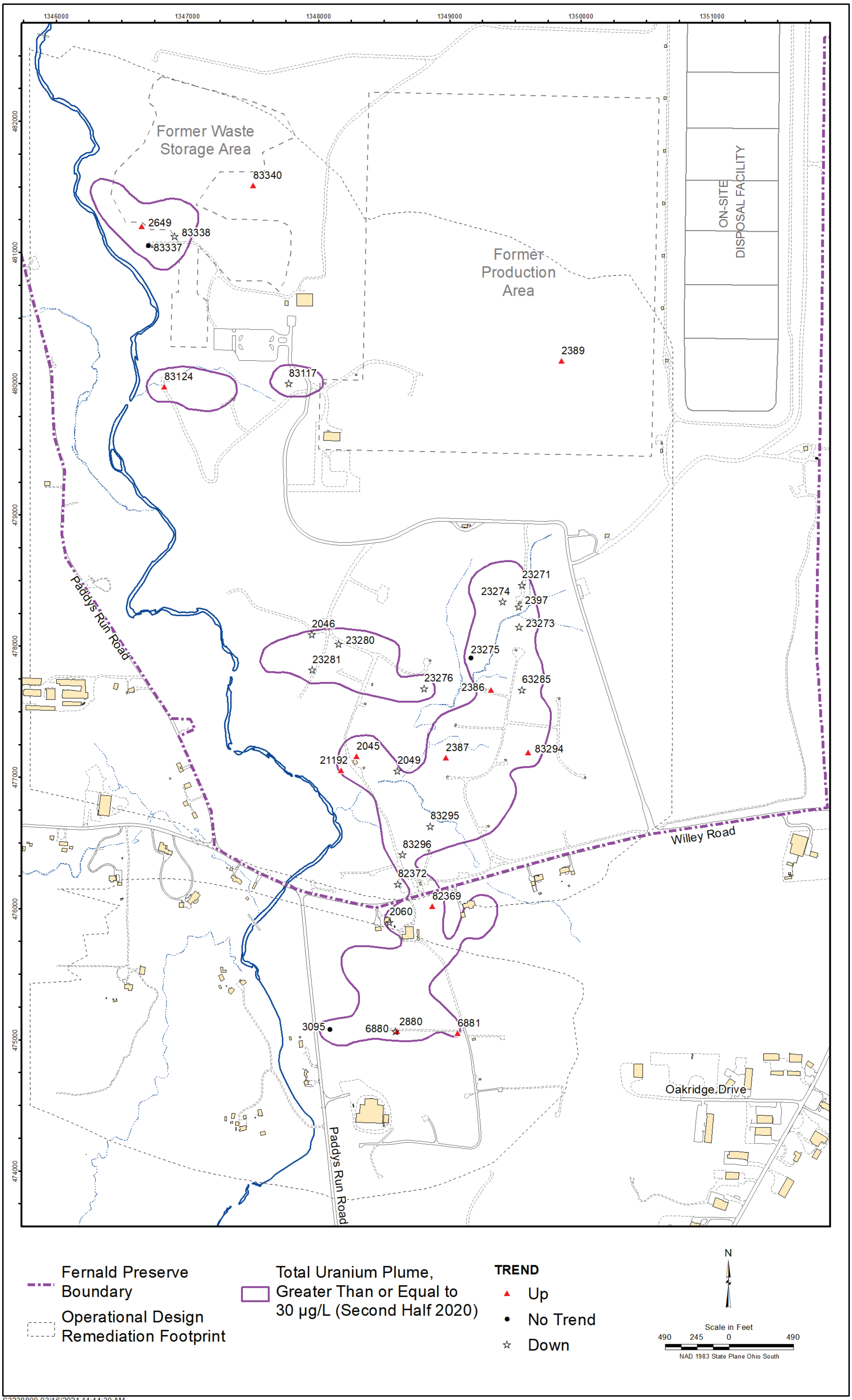

Figure A.2-4. Monitoring Wells with 2020 Exceedances for Total Uranium with Up, Down, or No Significant Trends

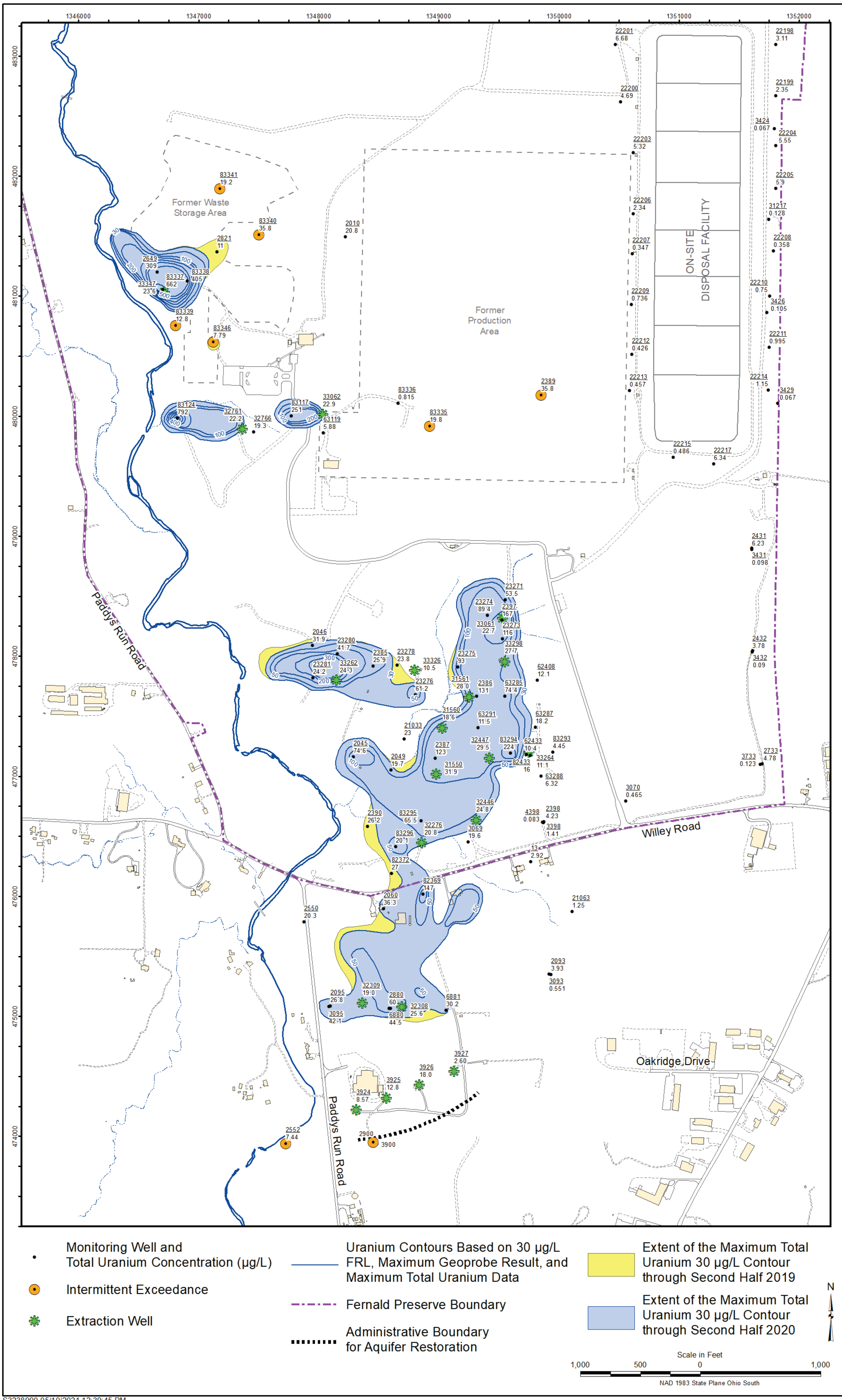

Figure A.2-5. Monitoring Well Data Through the Second Half of 2020 with Maximum Total Uranium Plume Footprint Through the Second Half of 2019 and 2020

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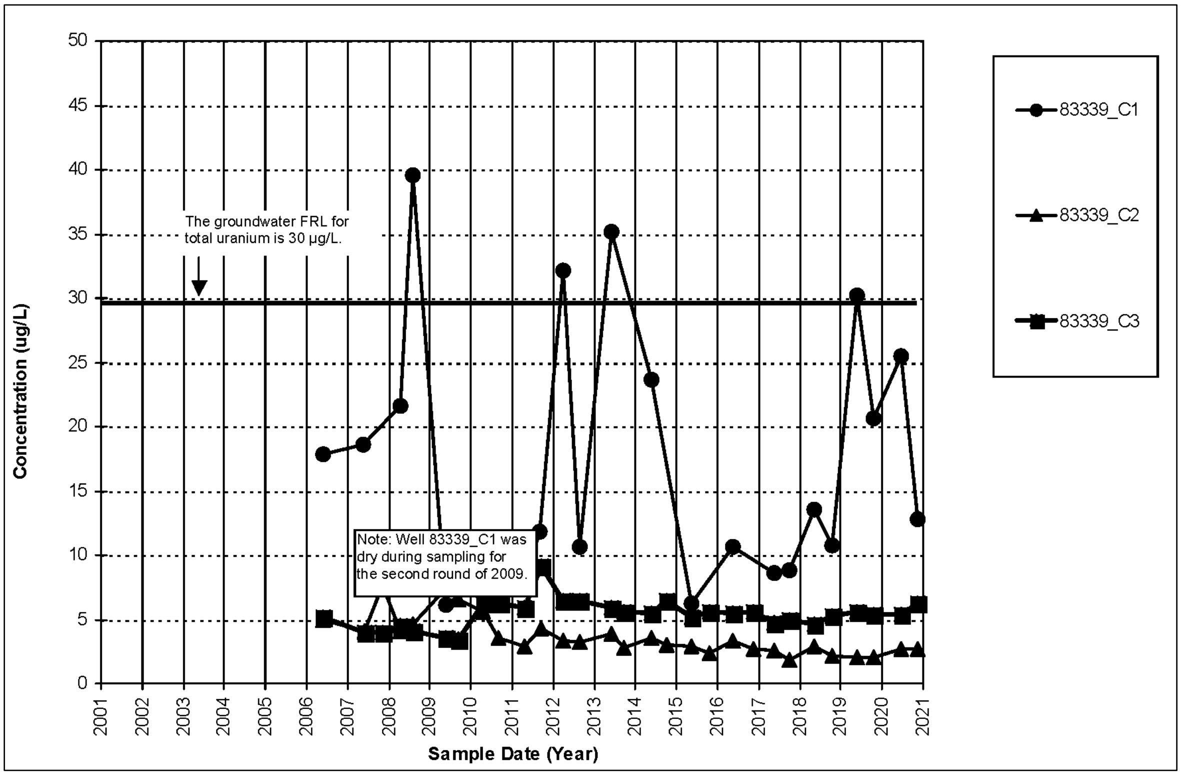

Figure A.2-6. Total Uranium Concentration Versus Time Plot for Monitoring Well 83339

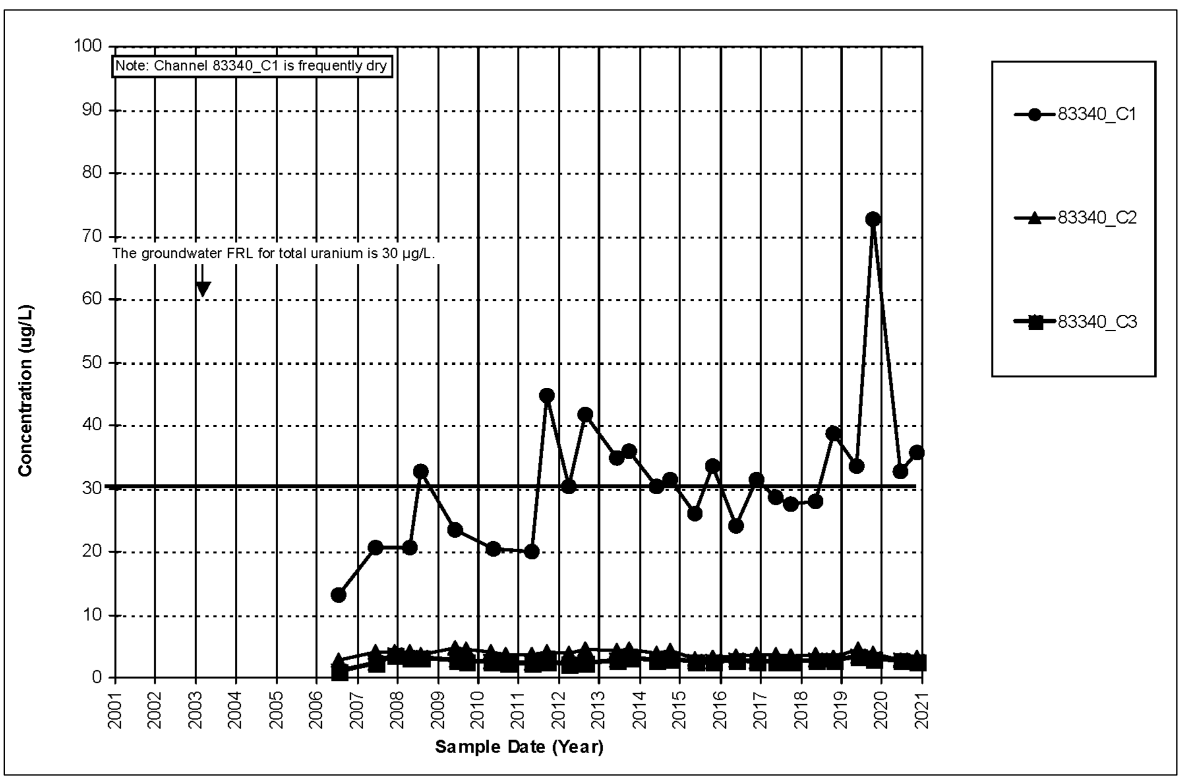

Figure A.2-7. Total Uranium Concentration Versus Time Plot for Monitoring Well 83340

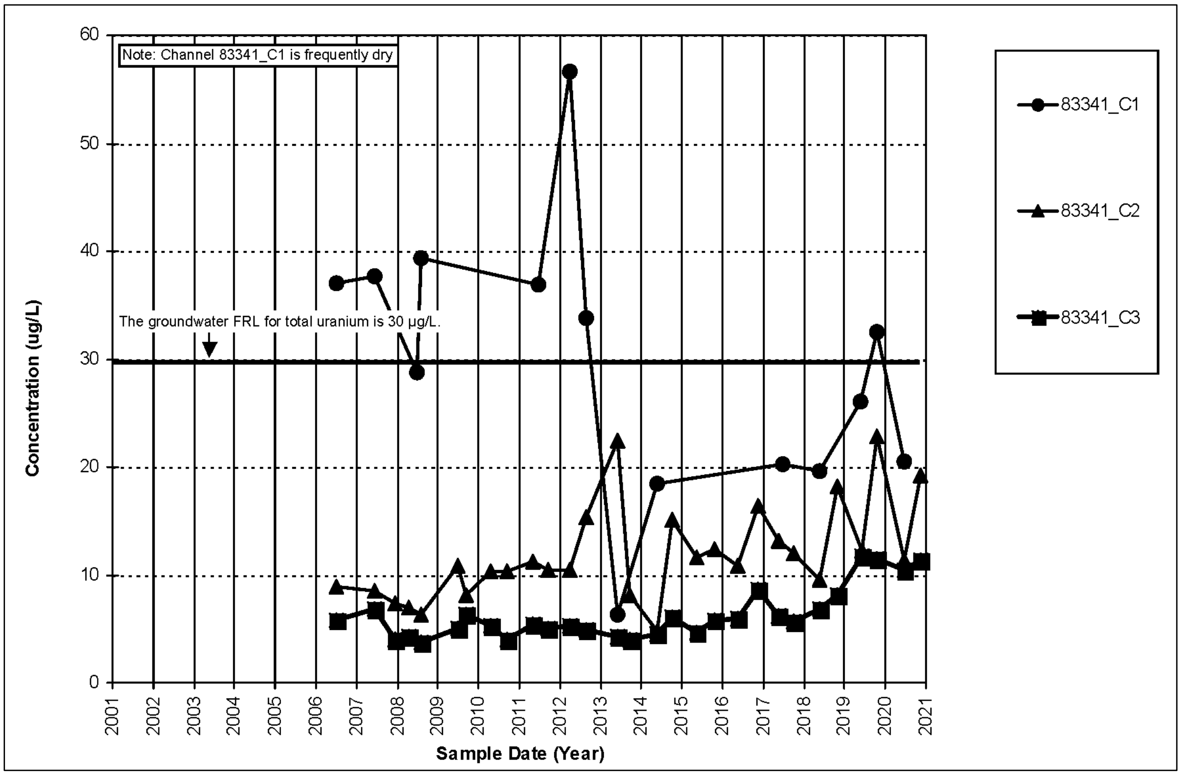

Figure A.2-8. Total Uranium Concentration Versus Time Plot for Monitoring Well 83341

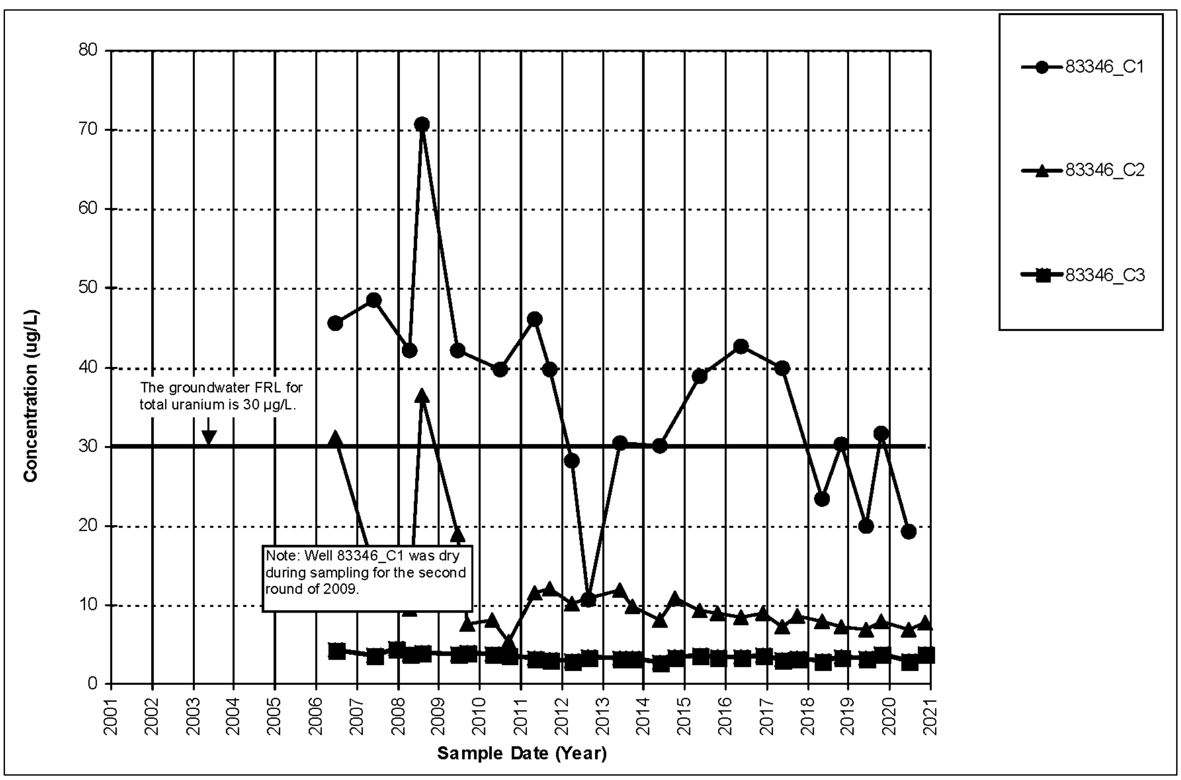

Figure A.2-9. Total Uranium Concentration Versus Time Plot for Monitoring Well 83346

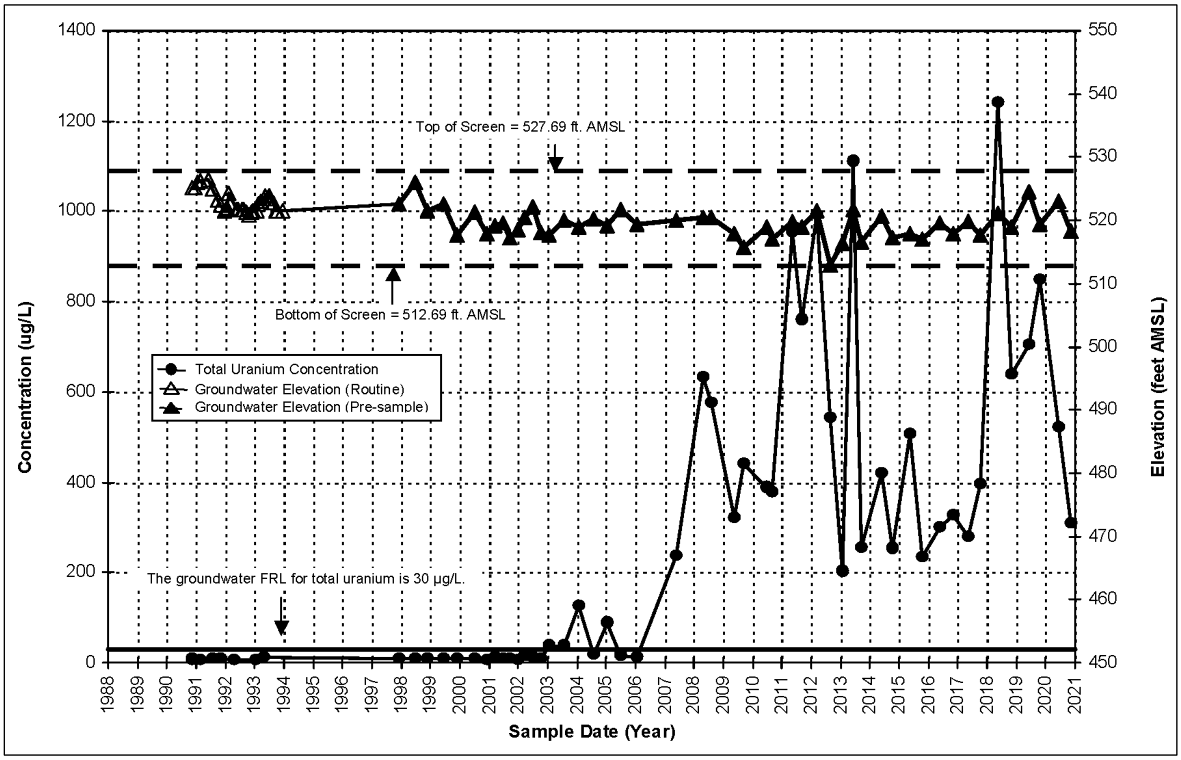

Figure A.2-10. Total Uranium Concentration Versus Time Plot for Monitoring Well 2649

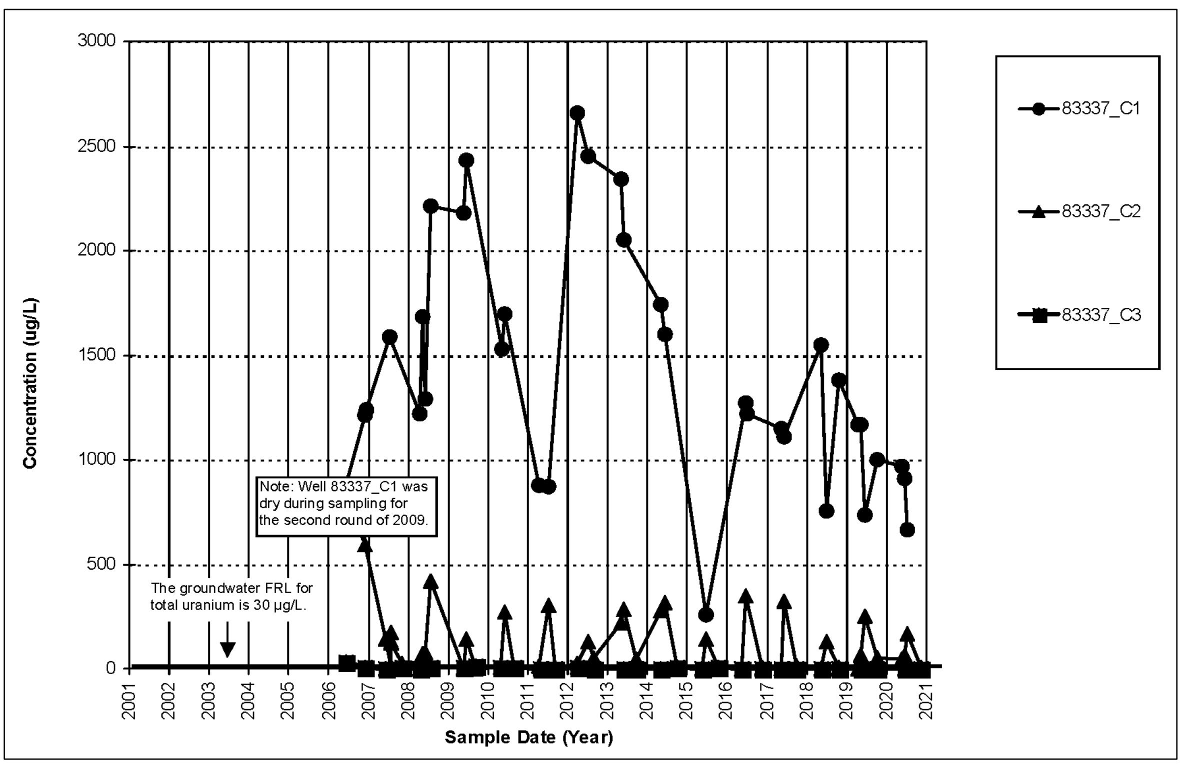

Figure A.2-11. Total Uranium Concentration Versus Time Plot for Monitoring Well 83337

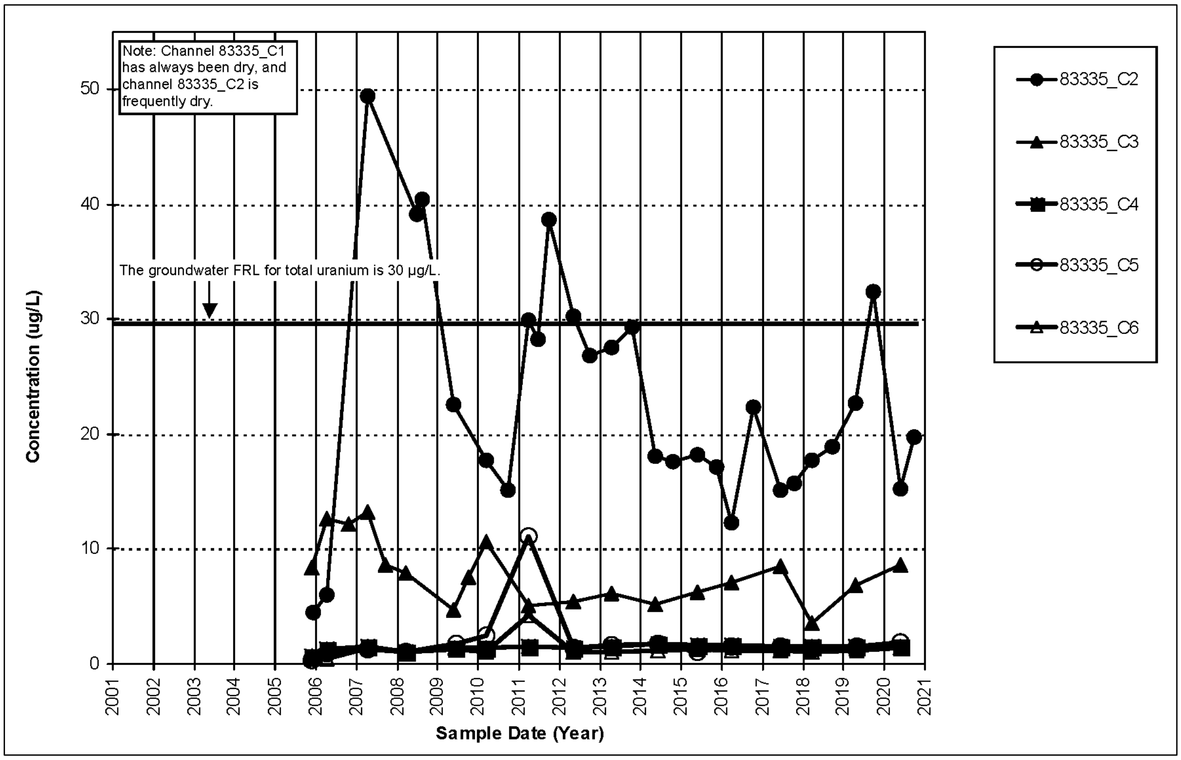

Figure A.2-12. Total Uranium Concentration Versus Time Plot for Monitoring Well 83335

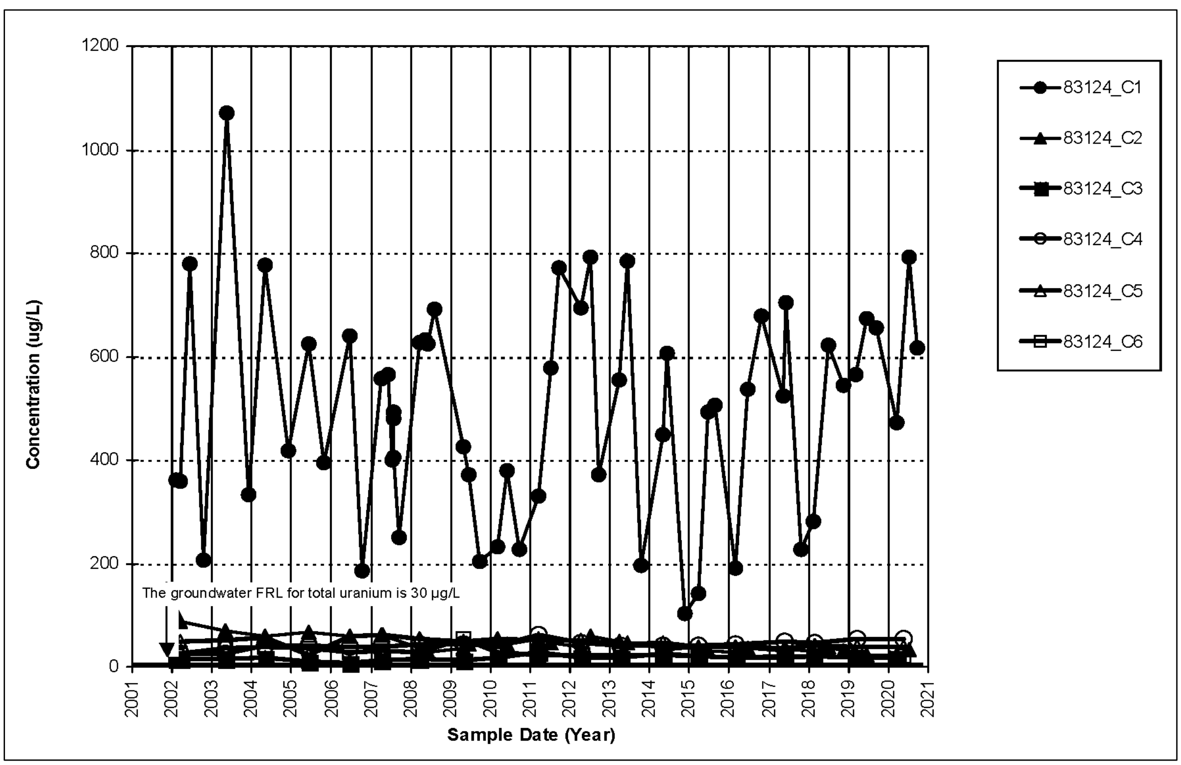

Figure A.2-13. Total Uranium Concentration Versus Time Plot for Monitoring Well 83124

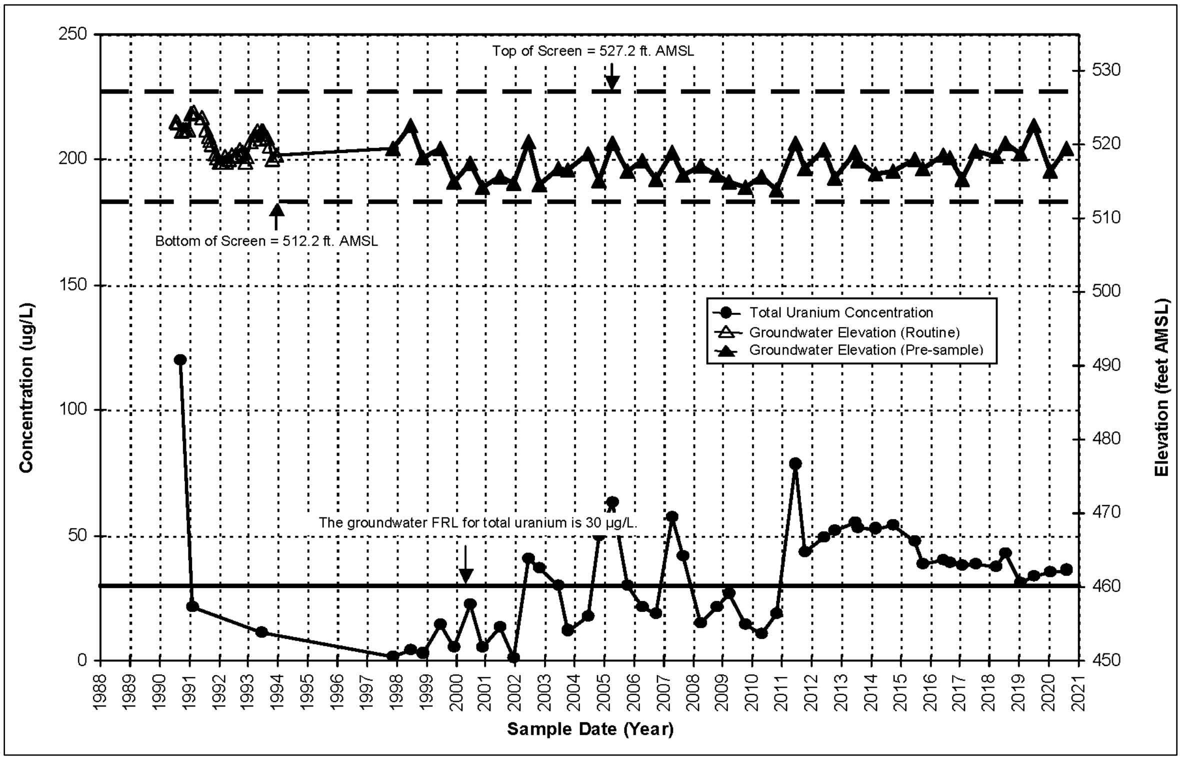

Figure A.2-14. Total Uranium Concentration Versus Time Plot for Monitoring Well 2389

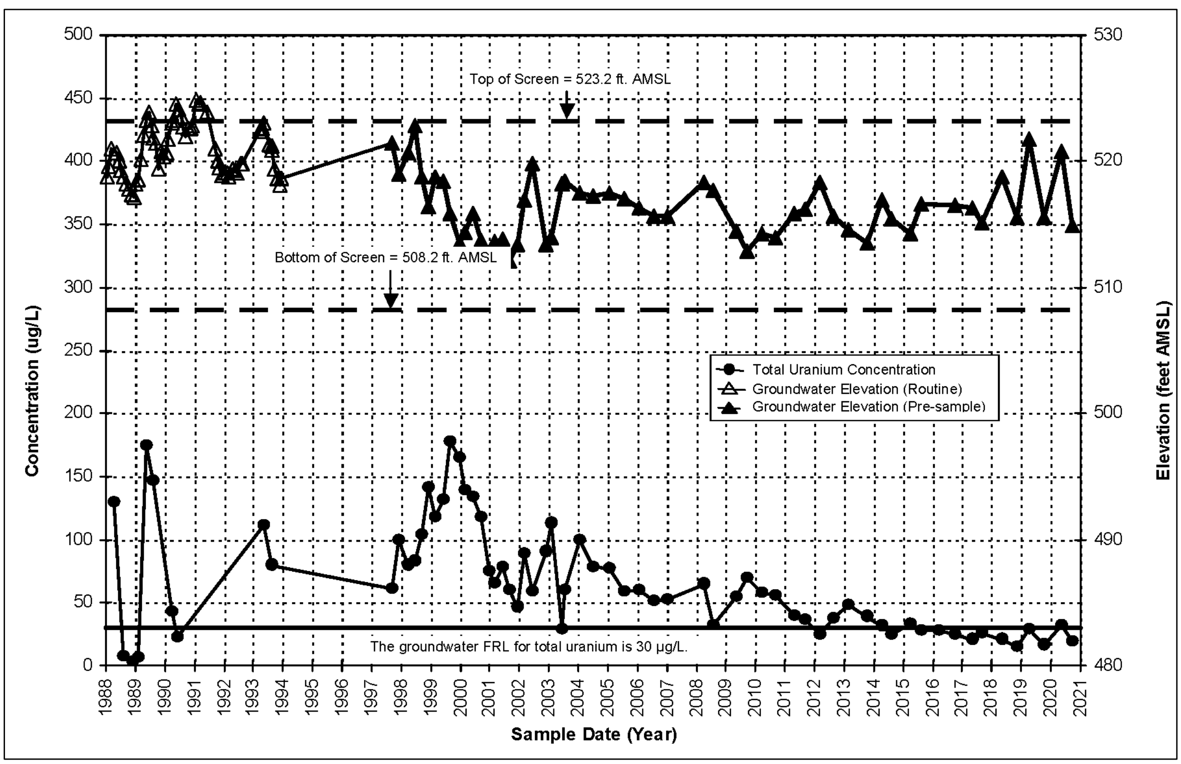

Figure A.2-15. Total Uranium Concentration Versus Time Plot for Monitoring Well 2049

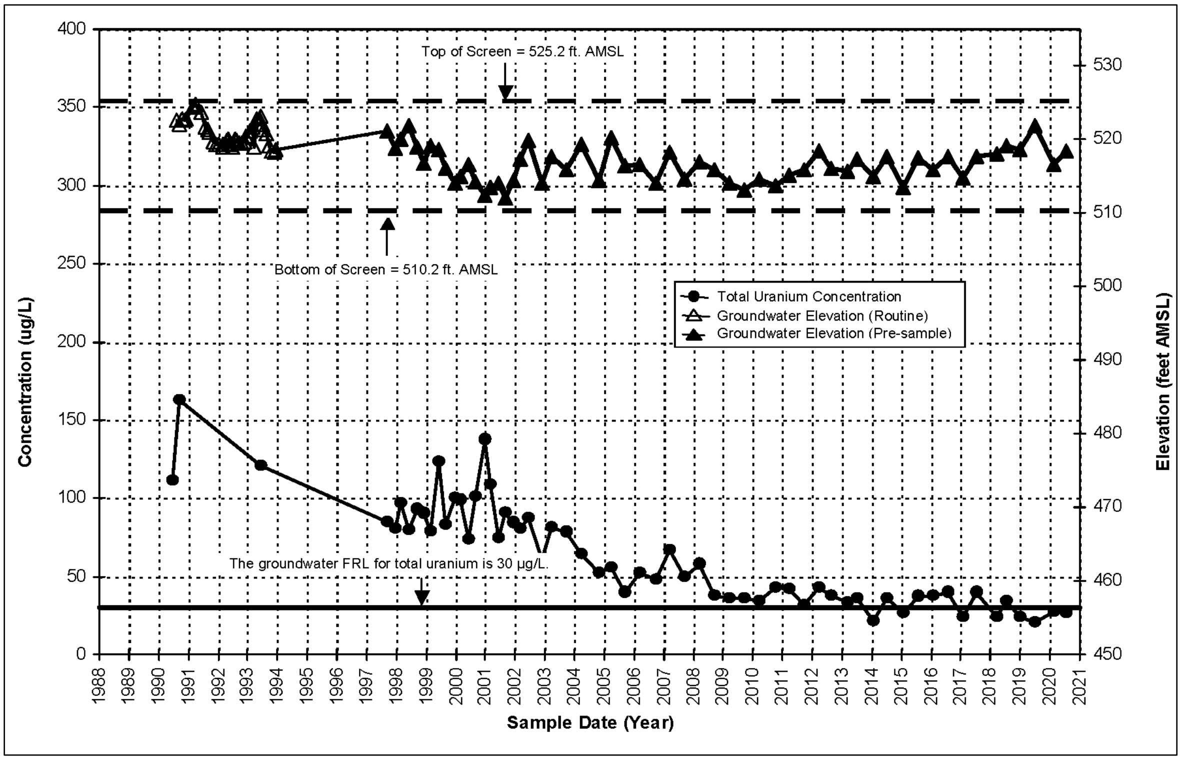

Figure A.2-16. Total Uranium Concentration Versus Time Plot for Monitoring Well 2390

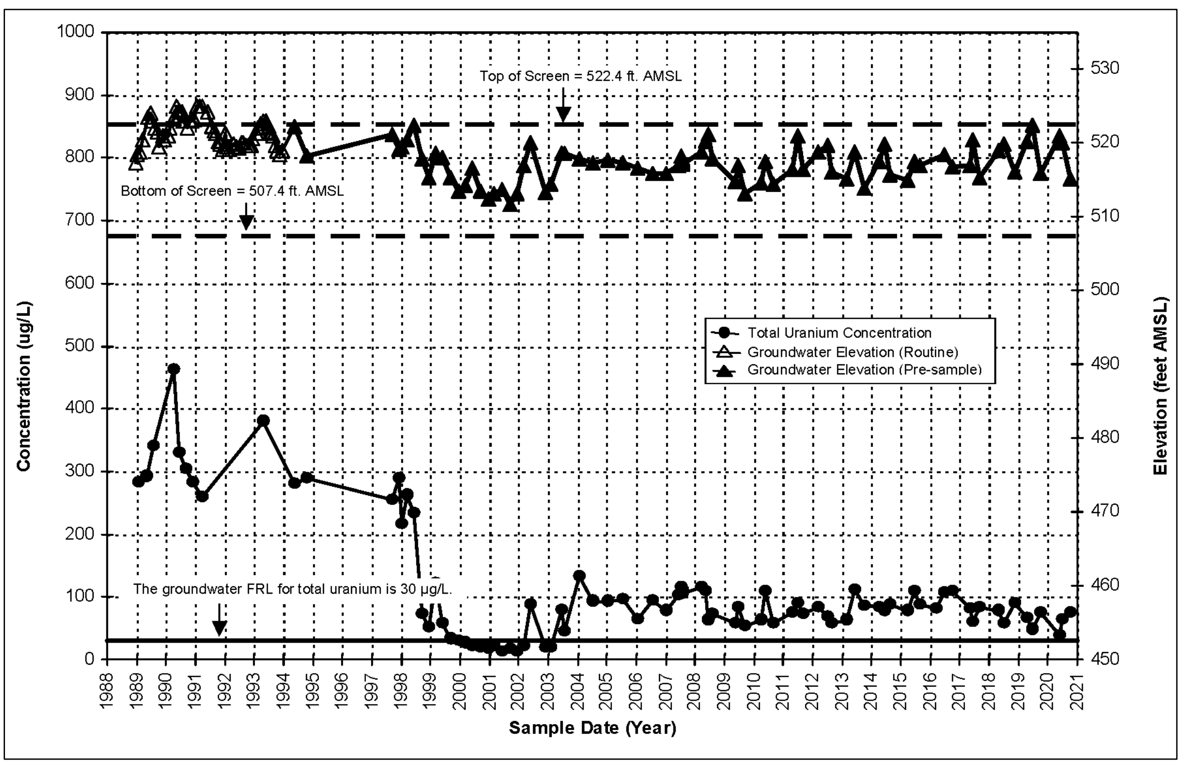

Figure A.2-17. Total Uranium Concentration Versus Time Plot for Monitoring Well 2045

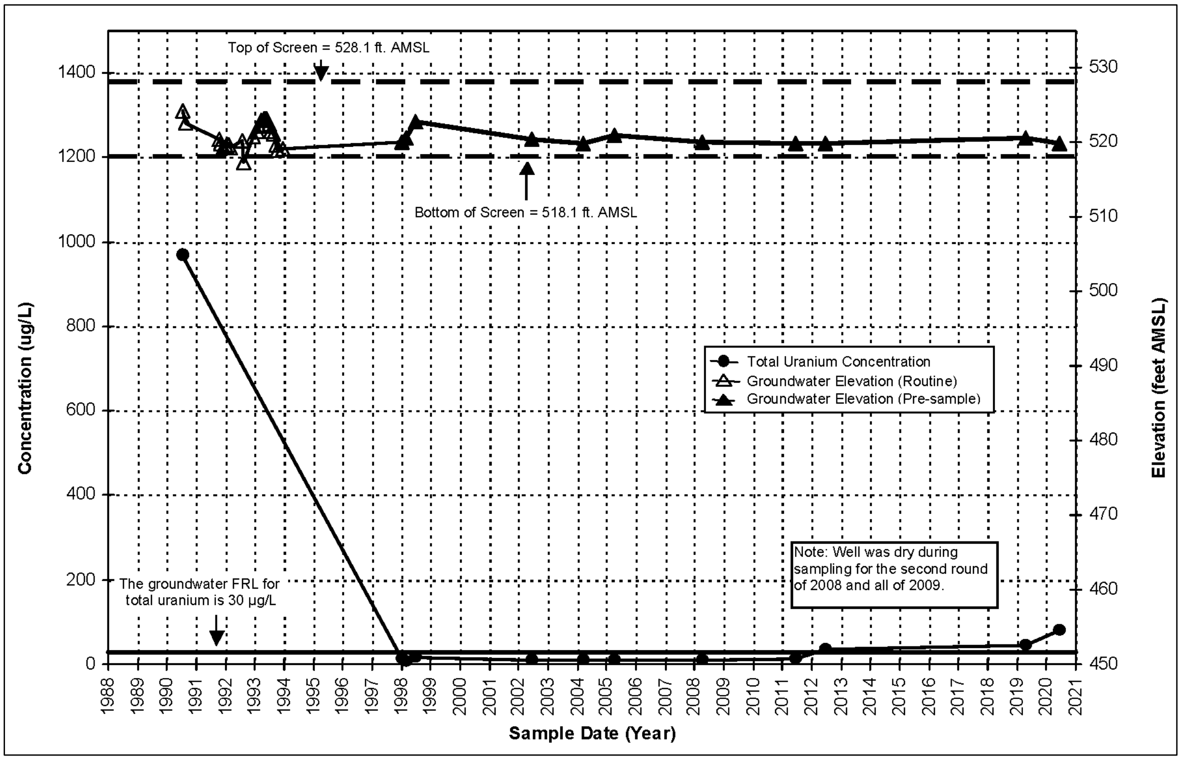

Figure A.2-18. Total Uranium Concentration Versus Time Plot for Monitoring Well 21192

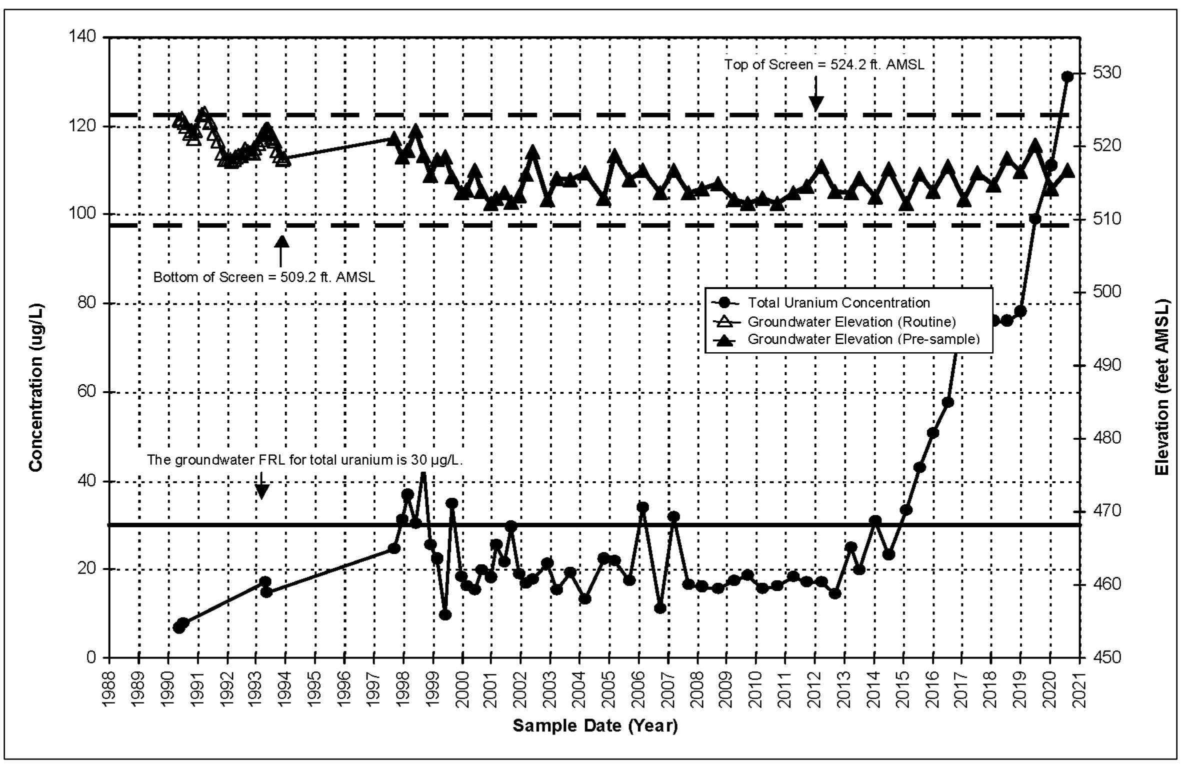

Figure A.2-19. Total Uranium Concentration Versus Time Plot for Monitoring Well 2386

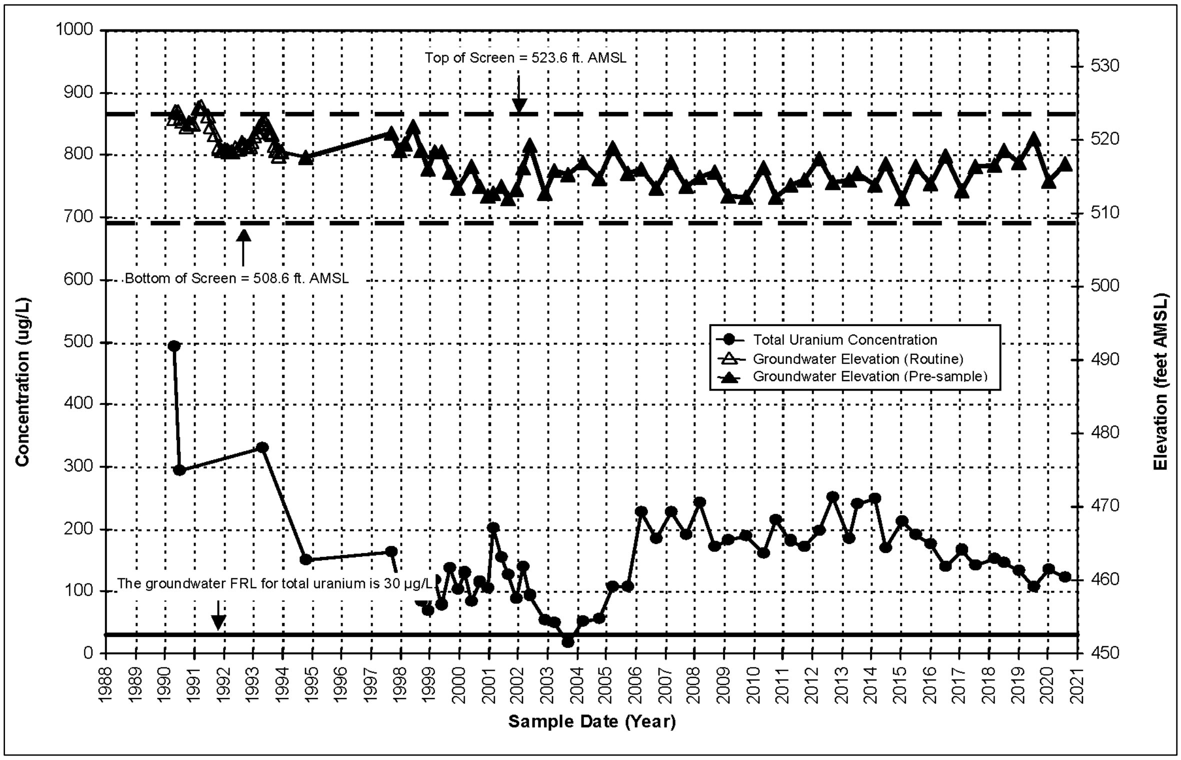

Figure A.2-20. Total Uranium Concentration Versus Time Plot for Monitoring Well 2387

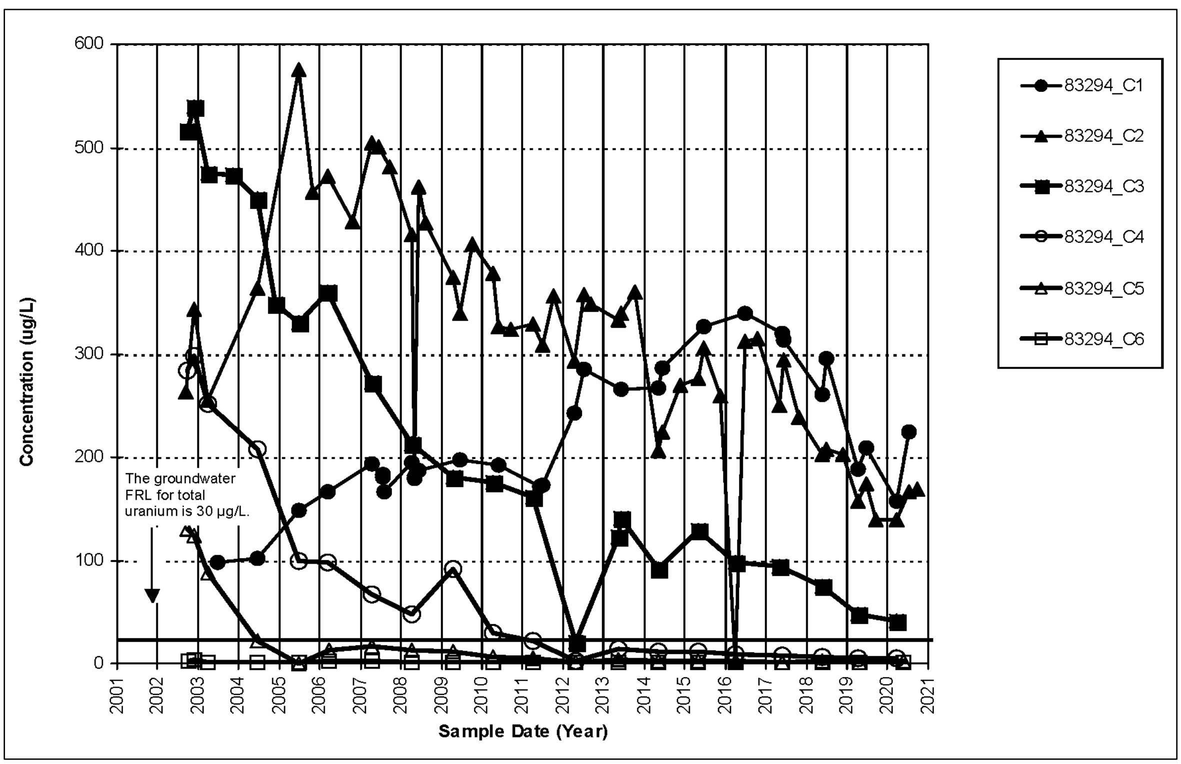

Figure A.2-21. Total Uranium Concentration Versus Time Plot for Monitoring Well 83294

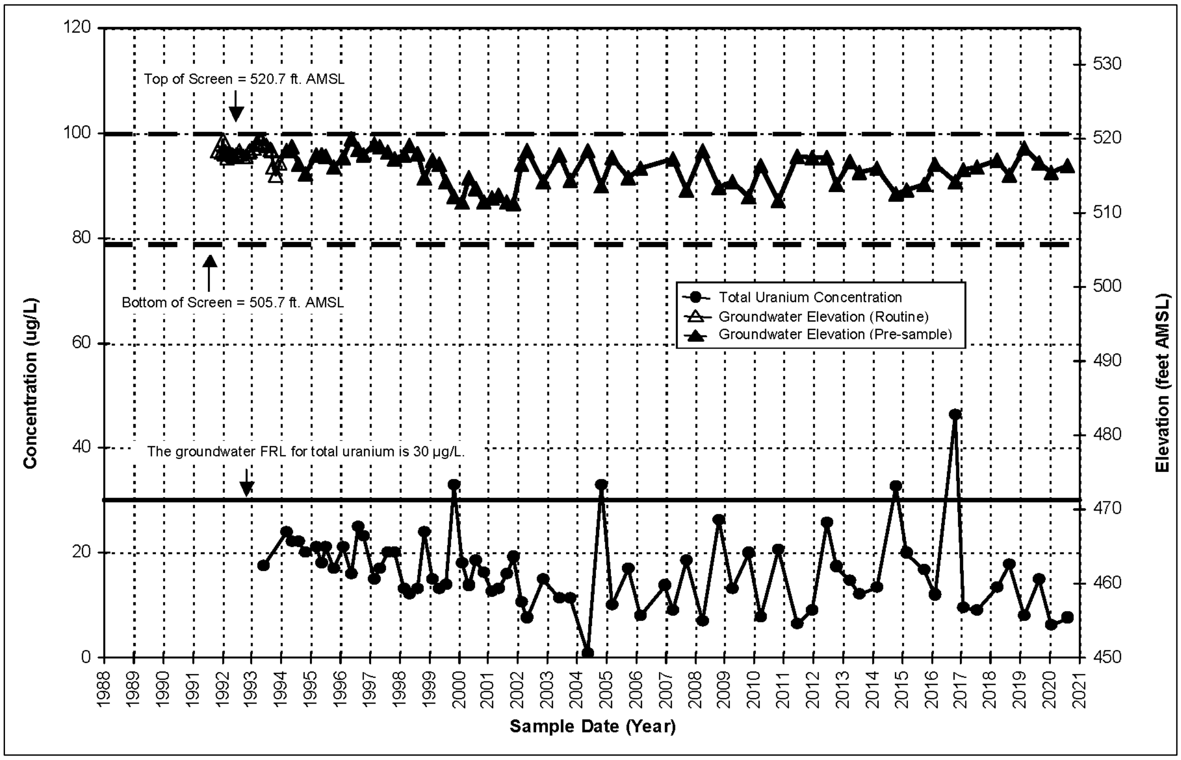

Figure A.2-22. Total Uranium Concentration Versus Time Plot for Monitoring Well 2552

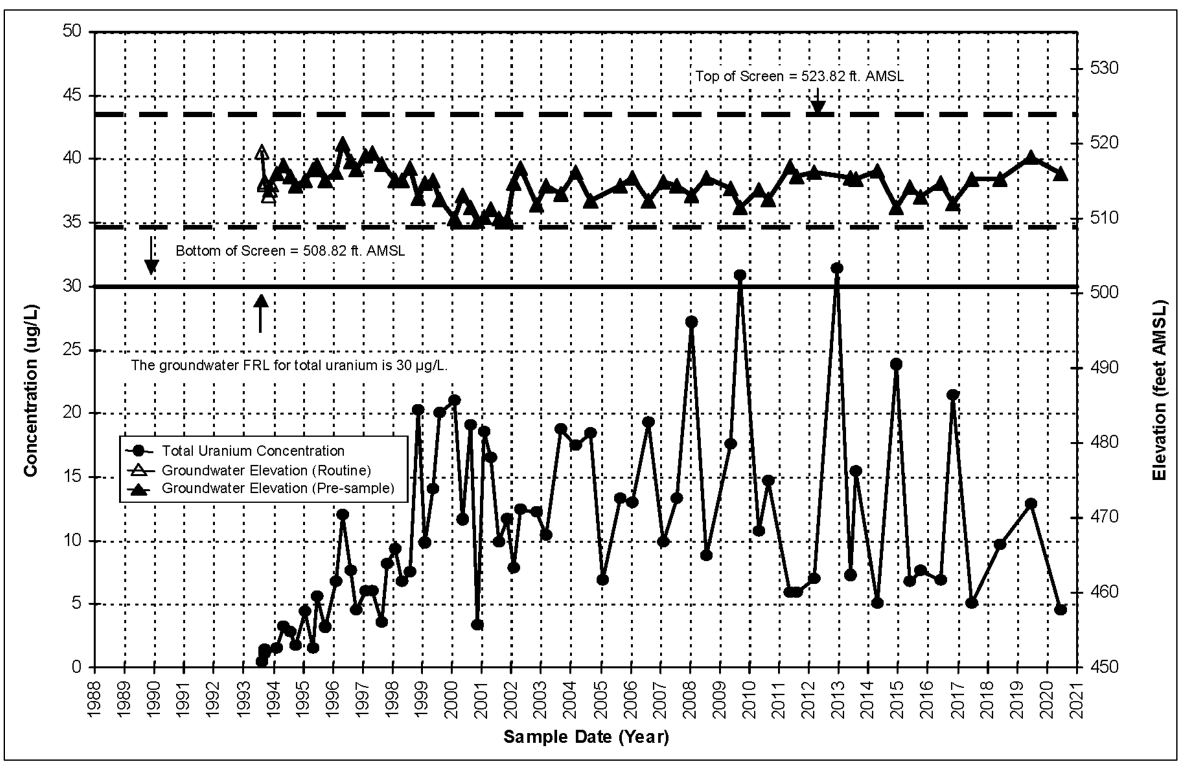

Figure A.2-23. Total Uranium Concentration Versus Time Plot for Monitoring Well 2900

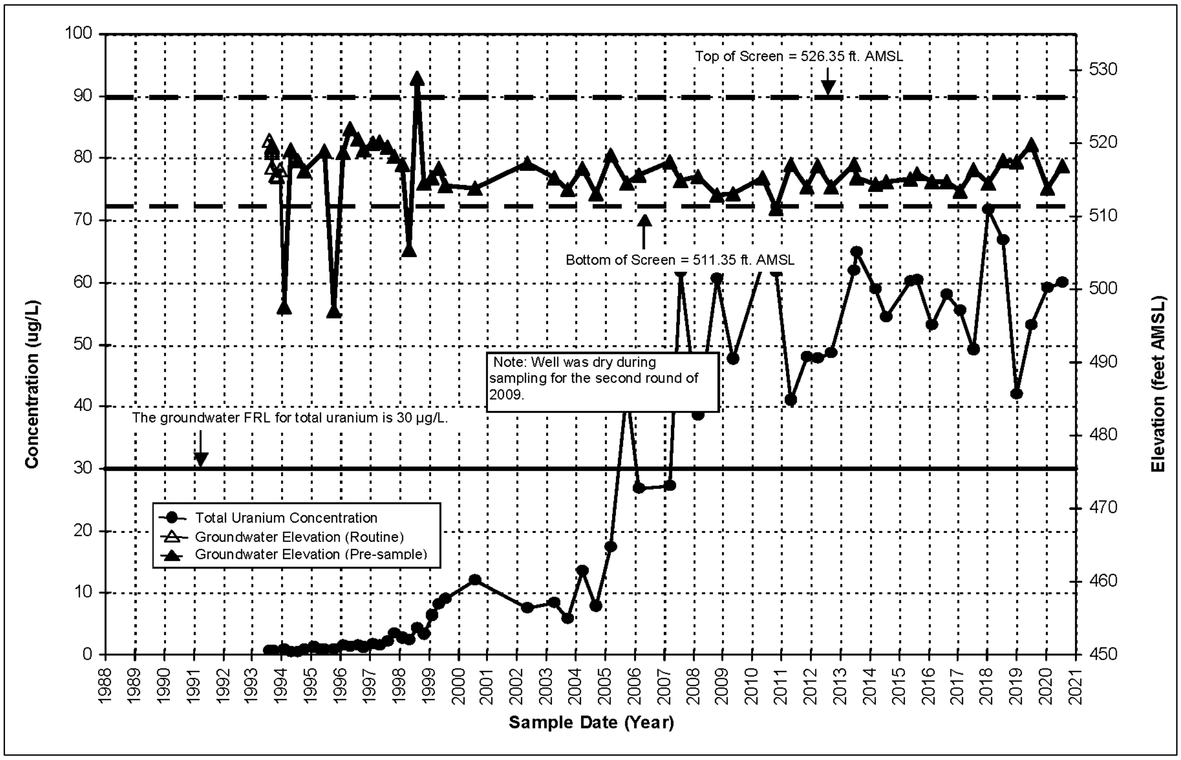

Figure A.2-24. Total Uranium Concentration Versus Time Plot for Monitoring Well 2880

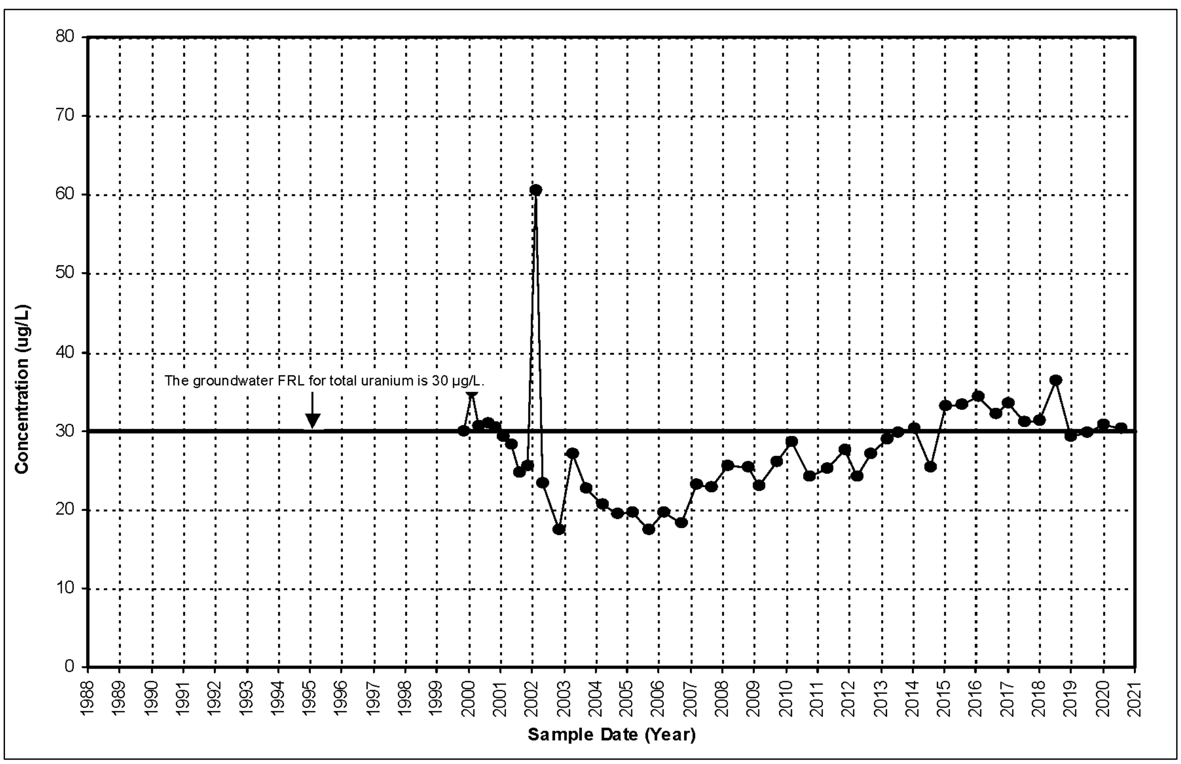

Figure A.2-25. Total Uranium Concentration Versus Time Plot for Monitoring Well 6881

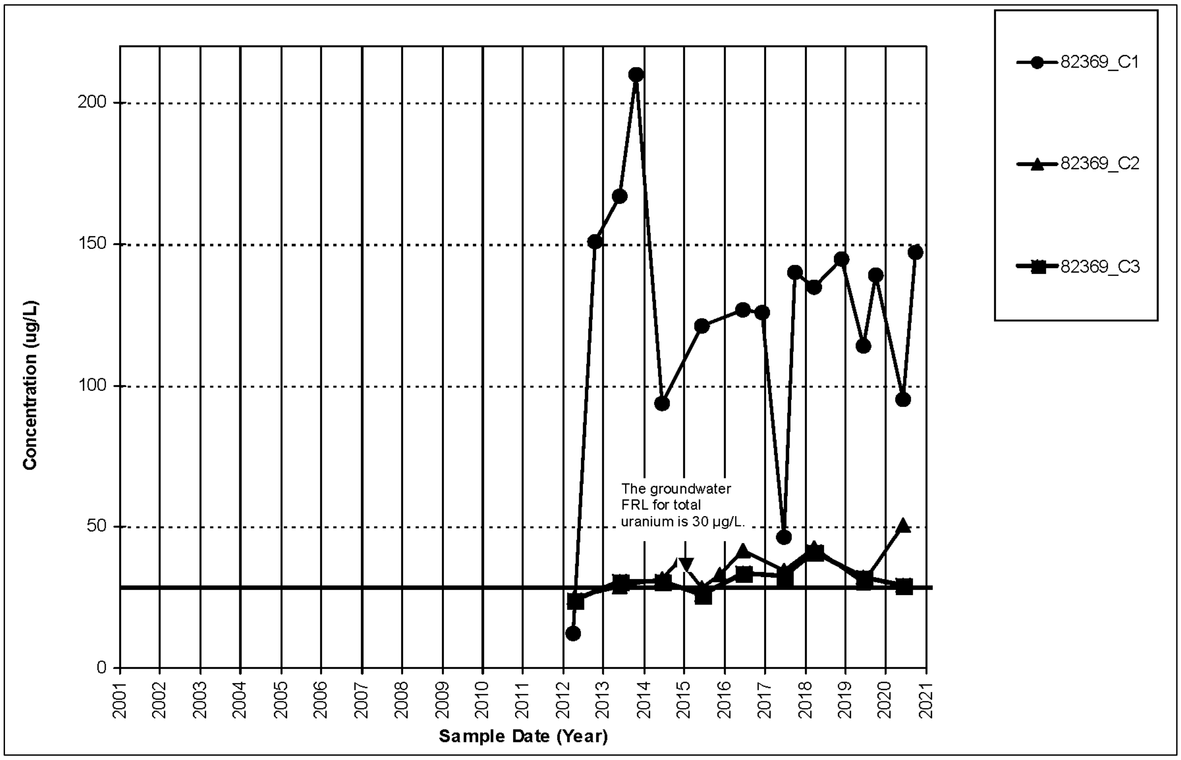

Figure A.2-26. Total Uranium Concentration Versus Time Plot for Monitoring Well 82396

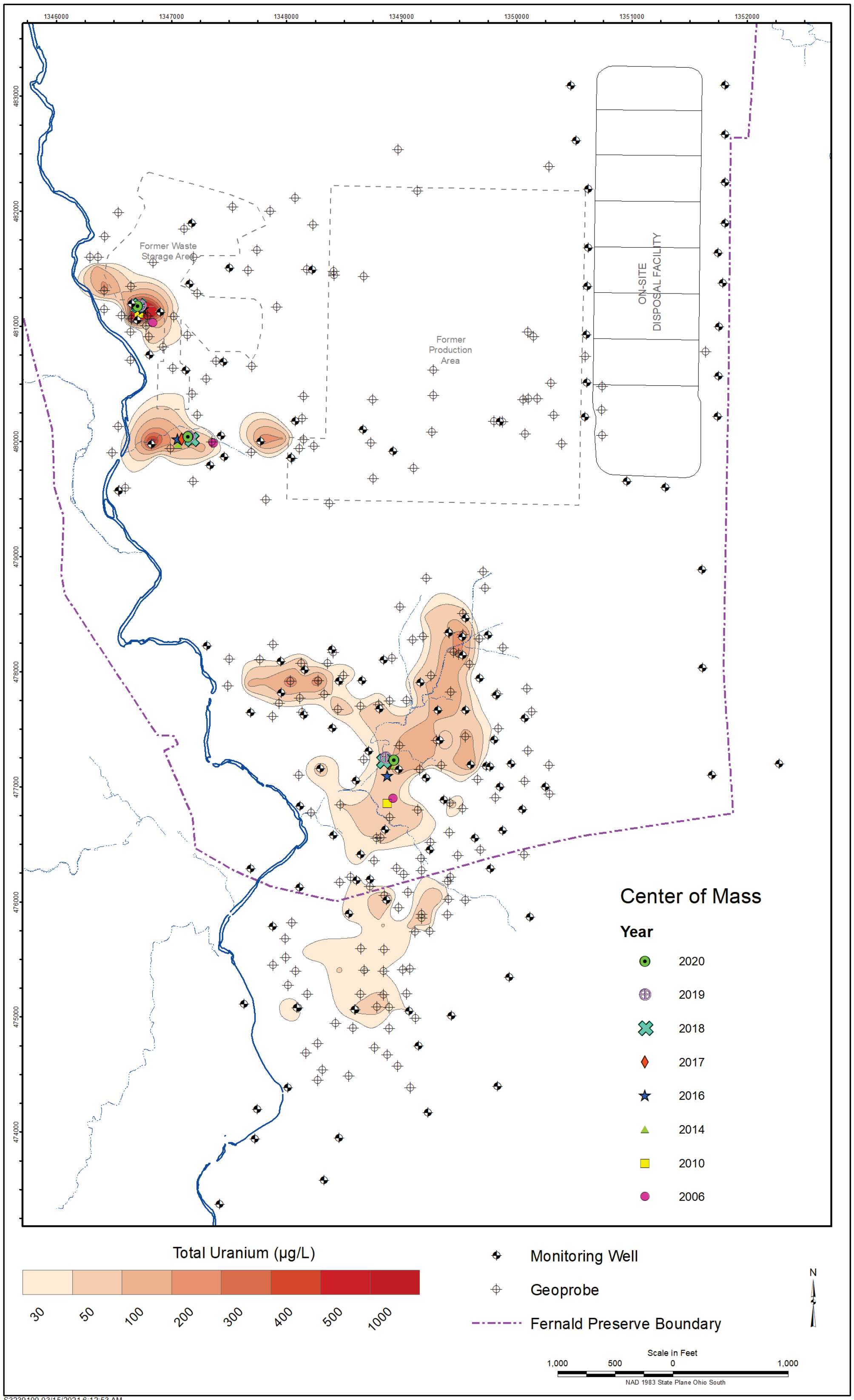

Figure A.2-27. Ricker Method Center of Mass

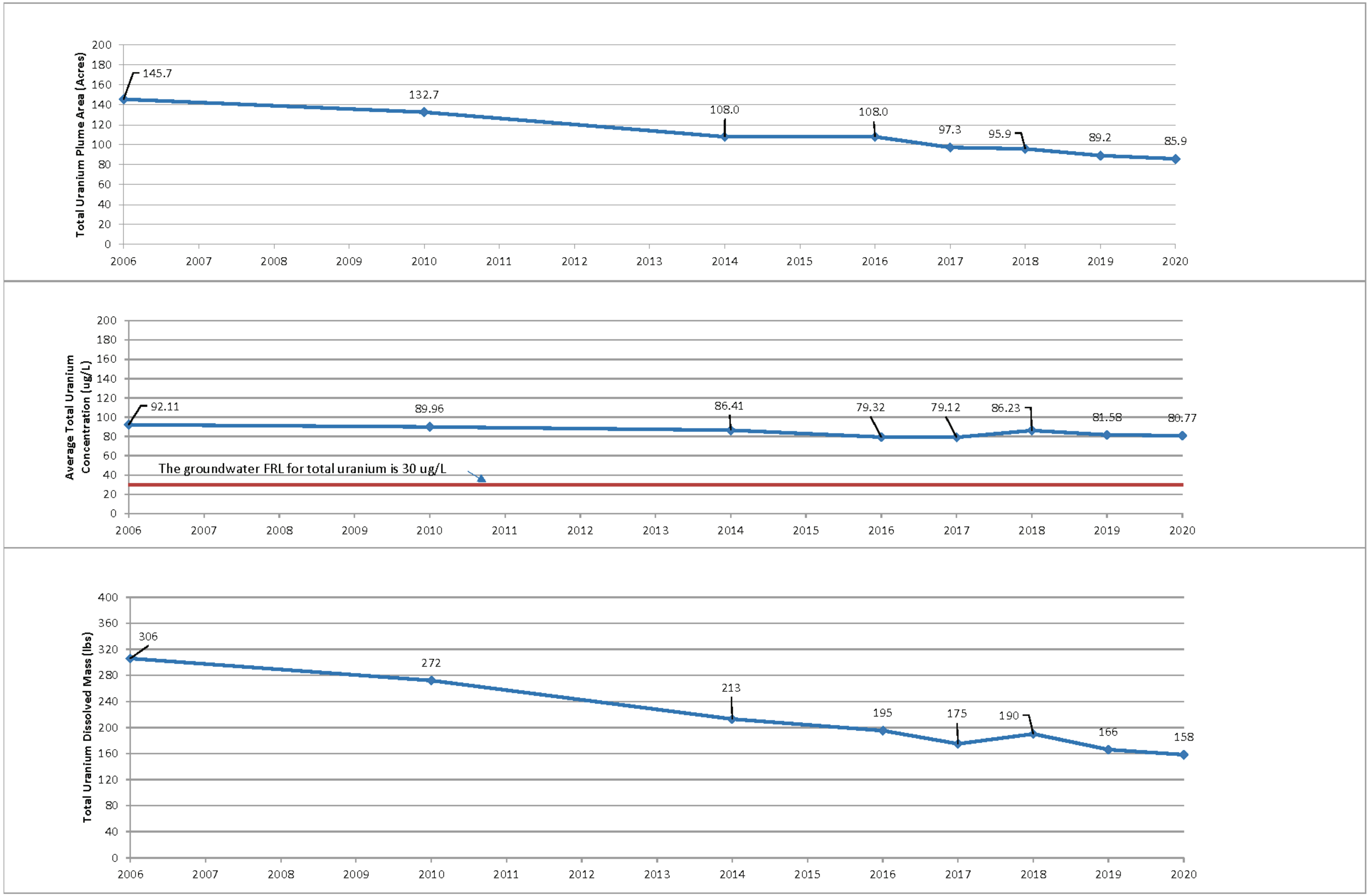

Figure A.2-28. Ricker Method Total Uranium Plume Calculations

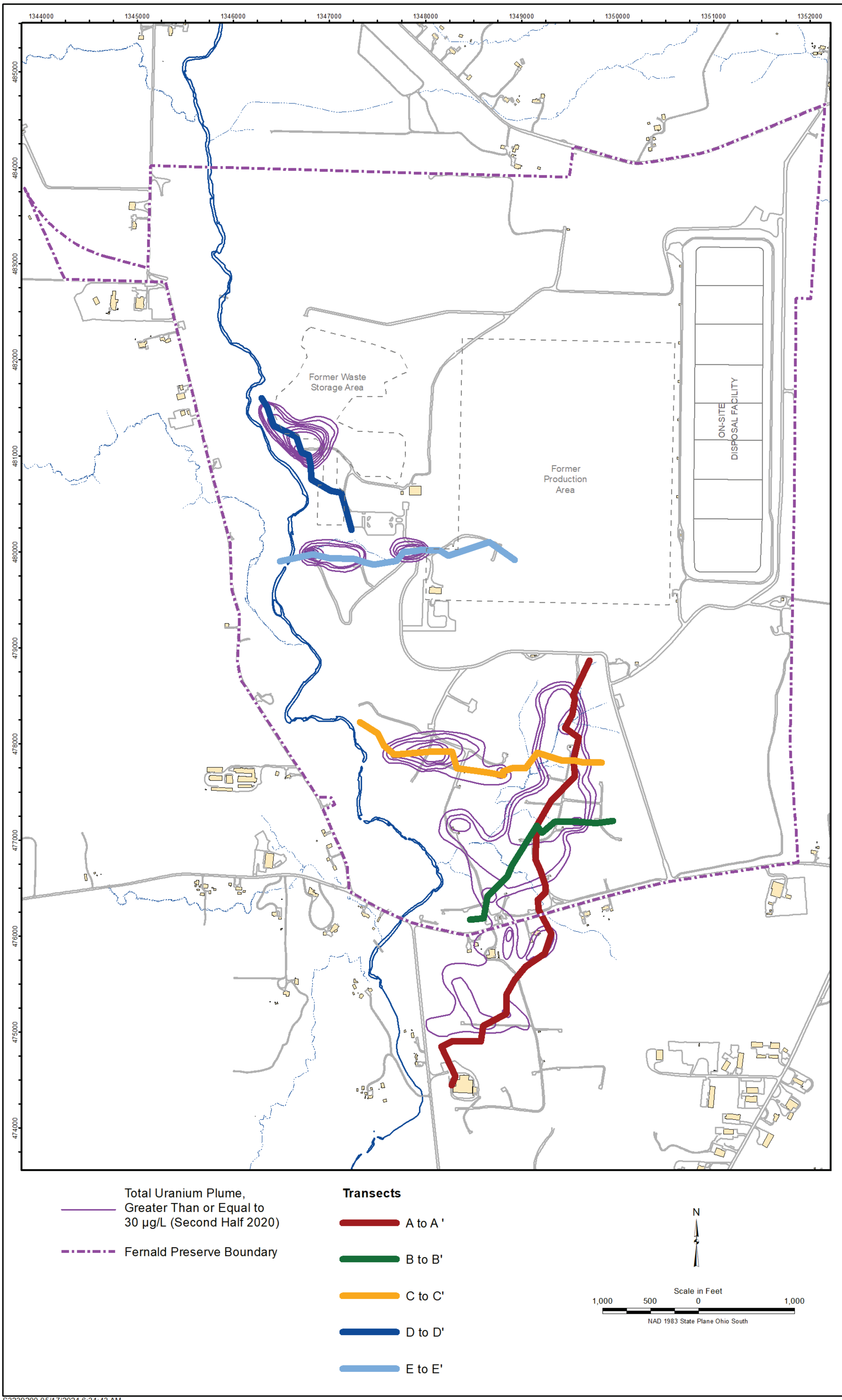

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Figure A.2-29A. Uranium Plume Cross Section Overview Map

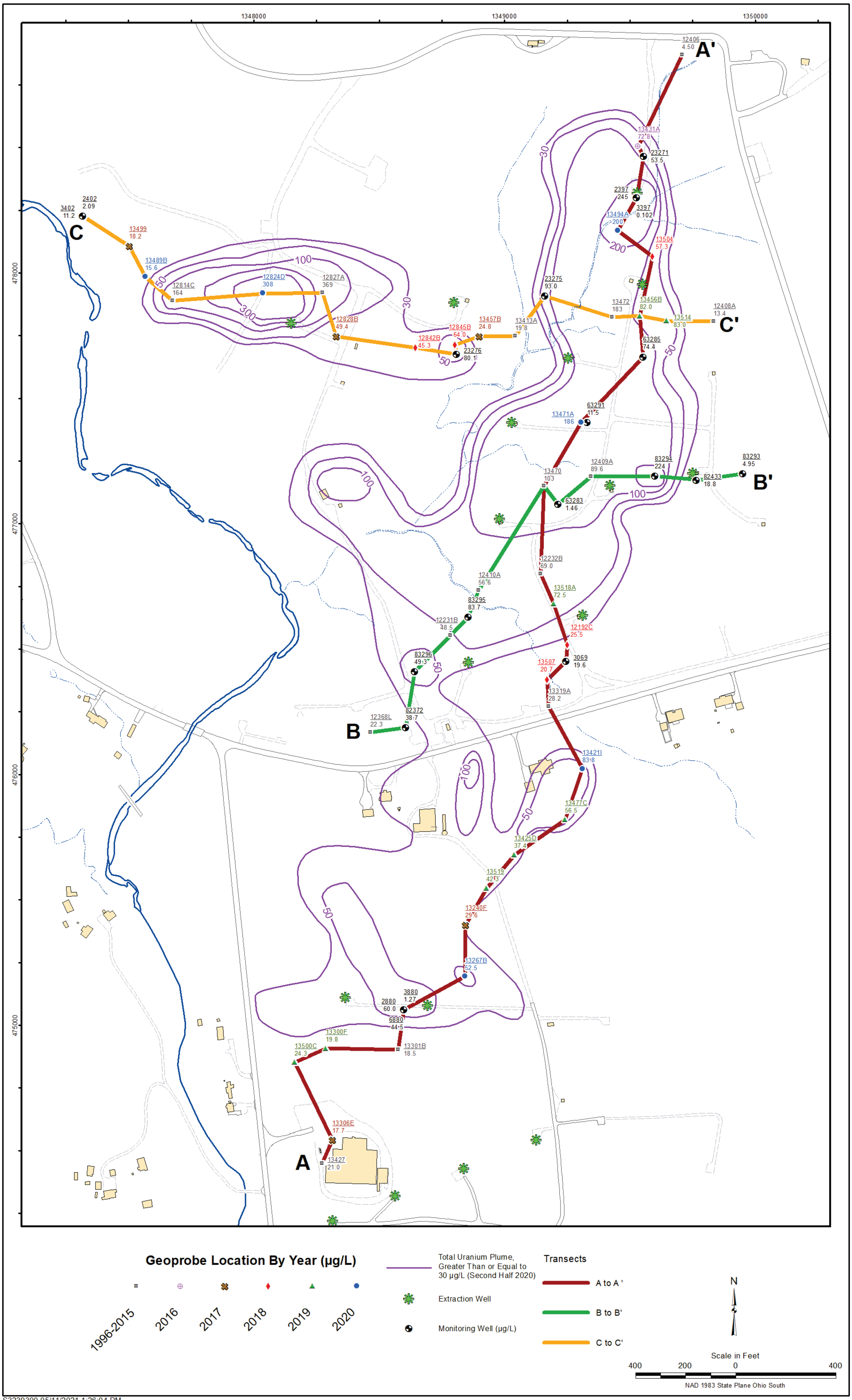


Figure A.2-29B. Uranium Plume South Cross Section Location Map

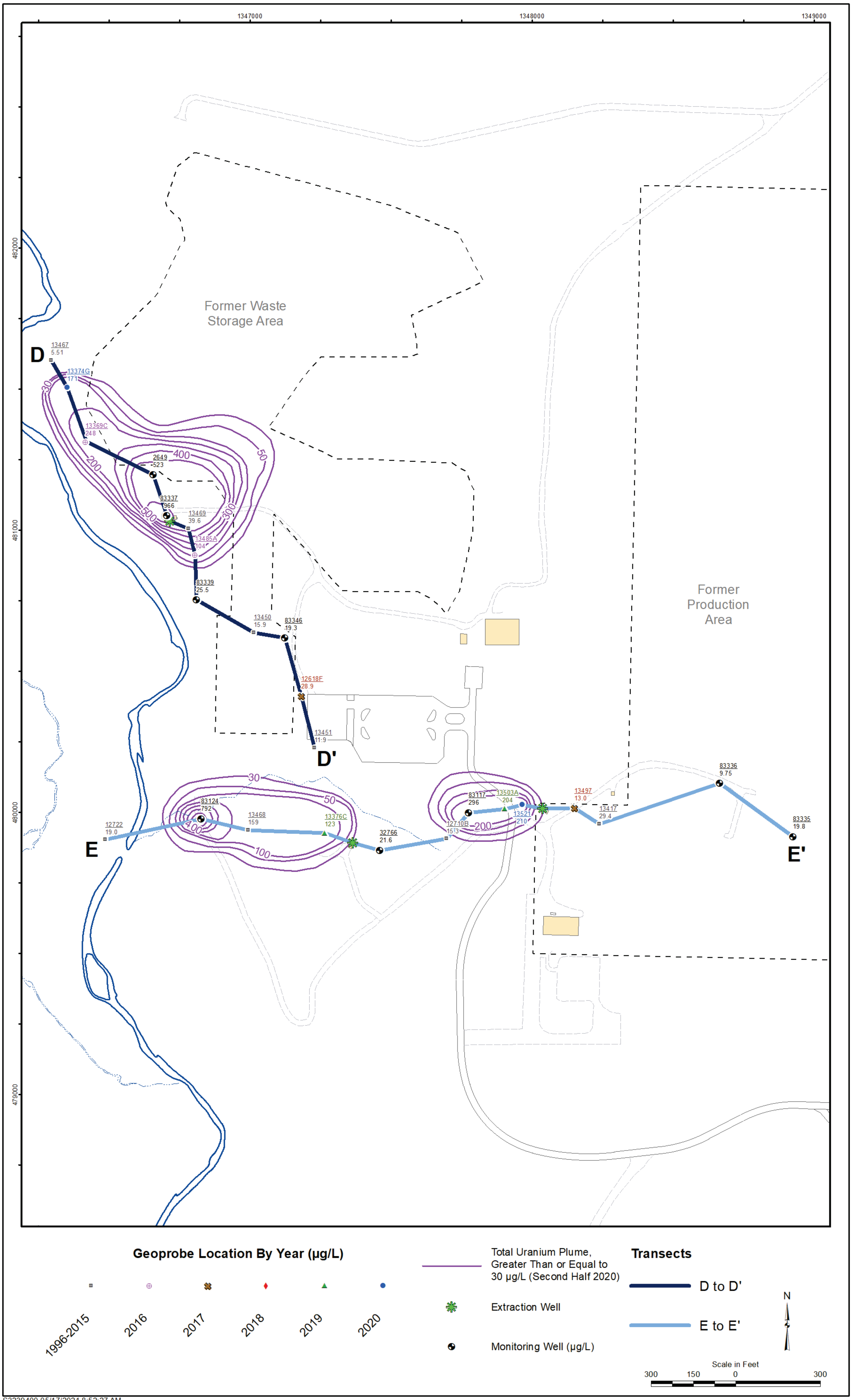
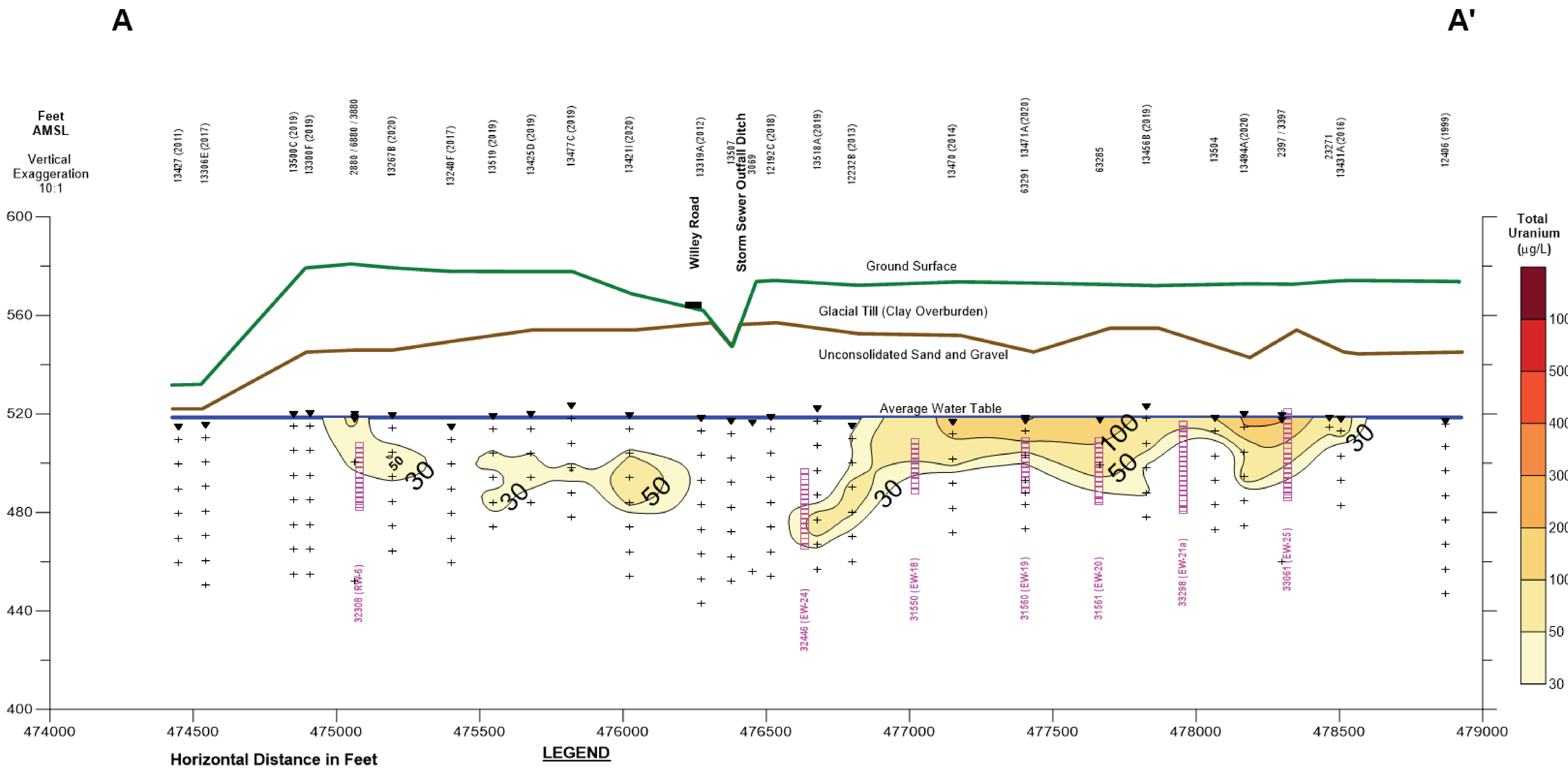


Figure A.2-29C. Uranium Plume North Cross Section Location Map



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.2-30. Total Uranium Plume Cross Section A–A'

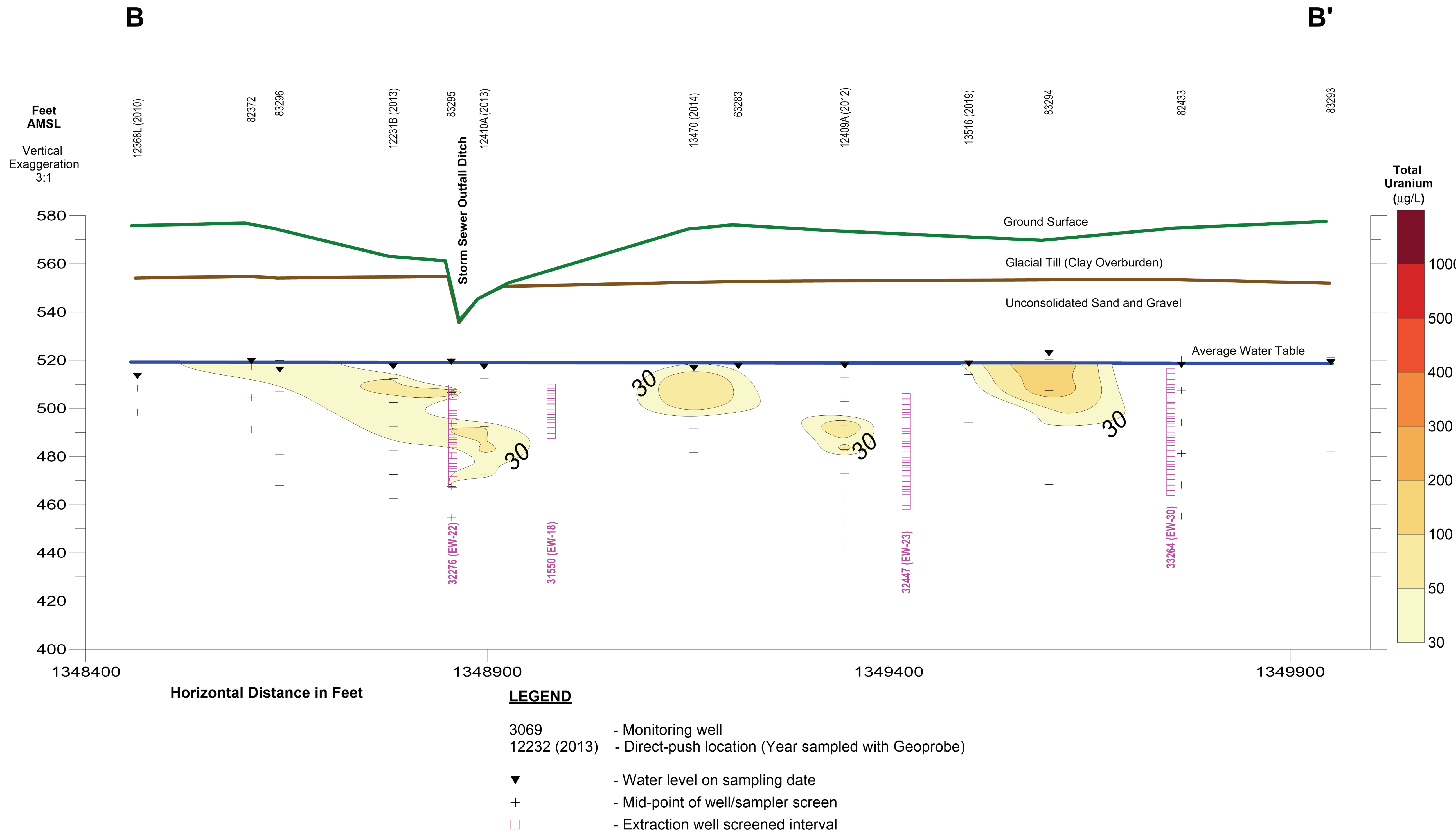
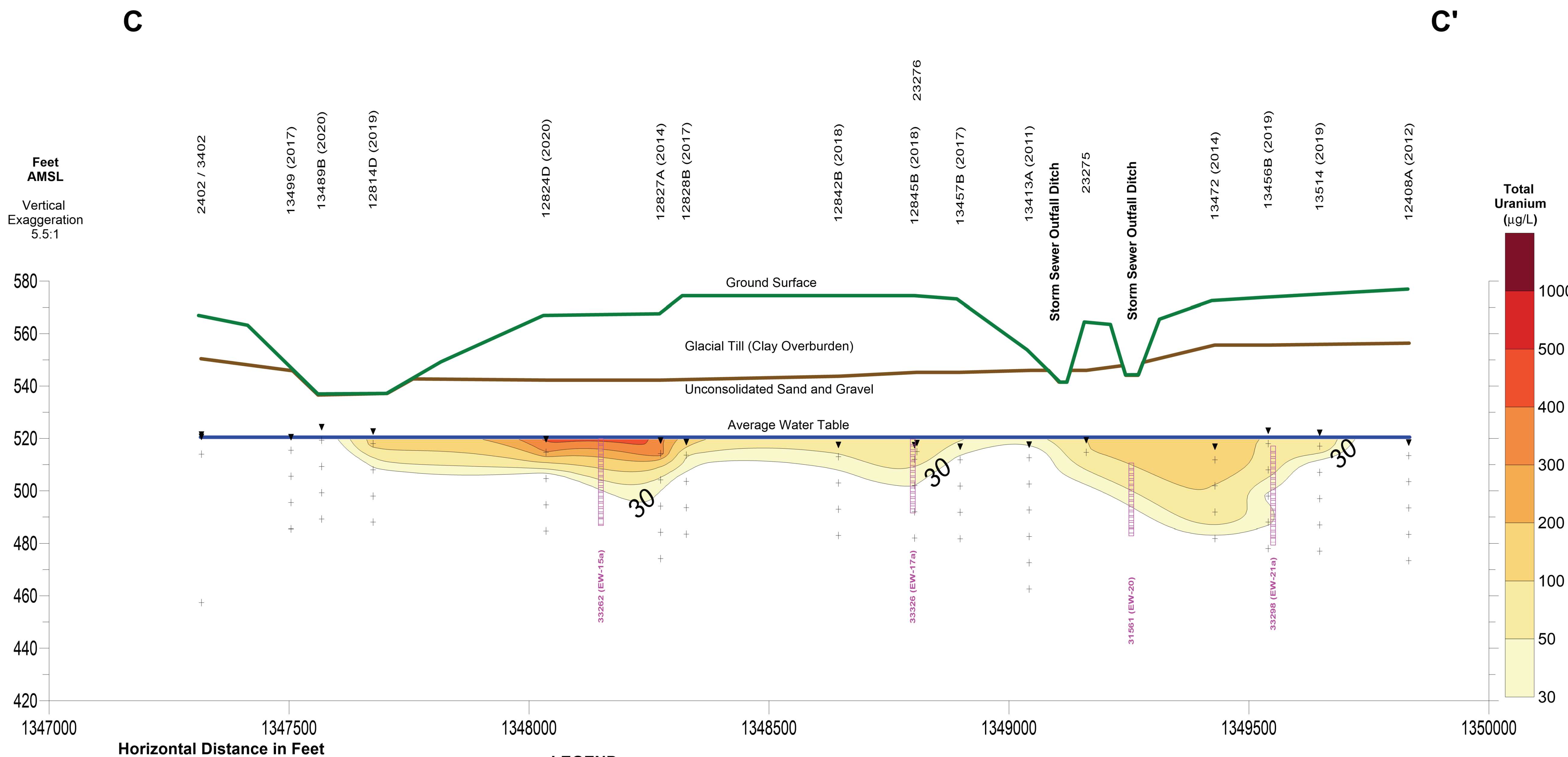


Figure A.2-31. Total Uranium Plume Cross Section B–B'

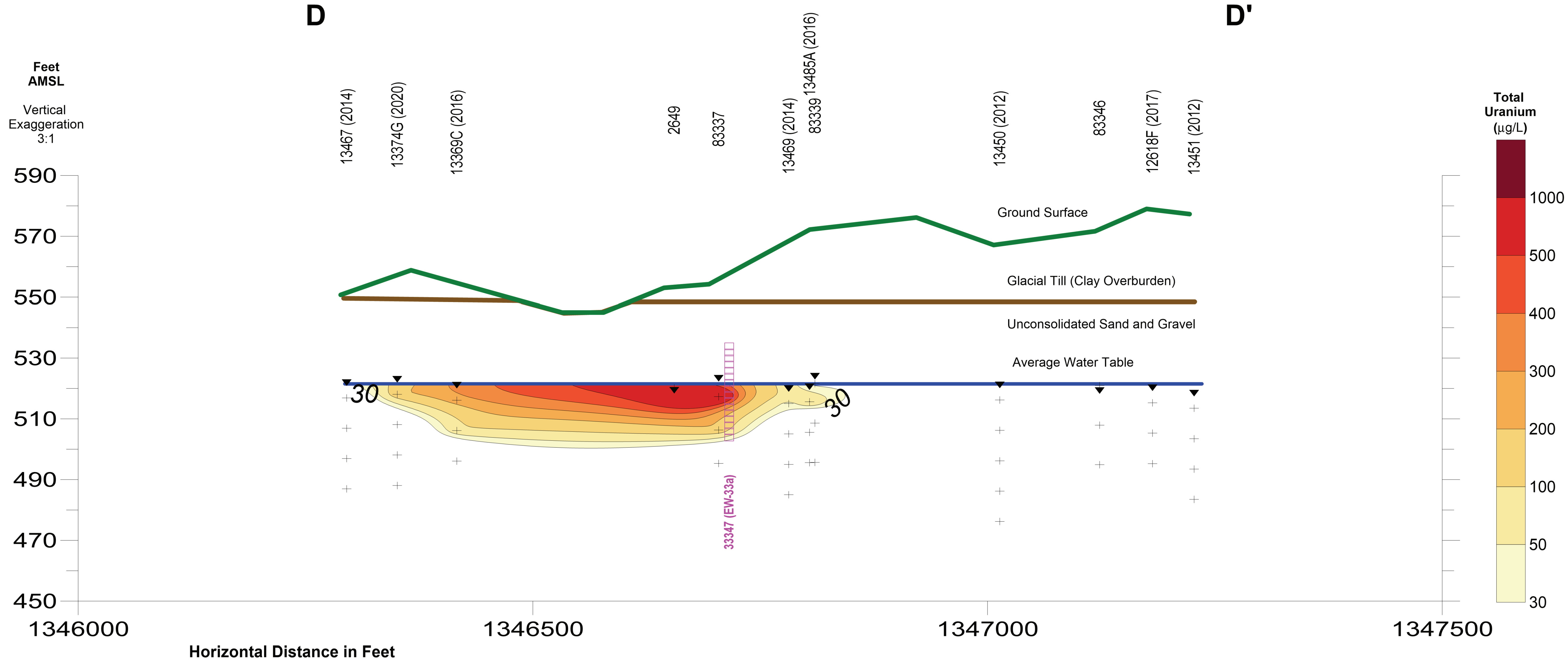


LEGEND

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.2-32. Total Uranium Plume 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.2-33. Total Uranium Plume Cross Section D–D'

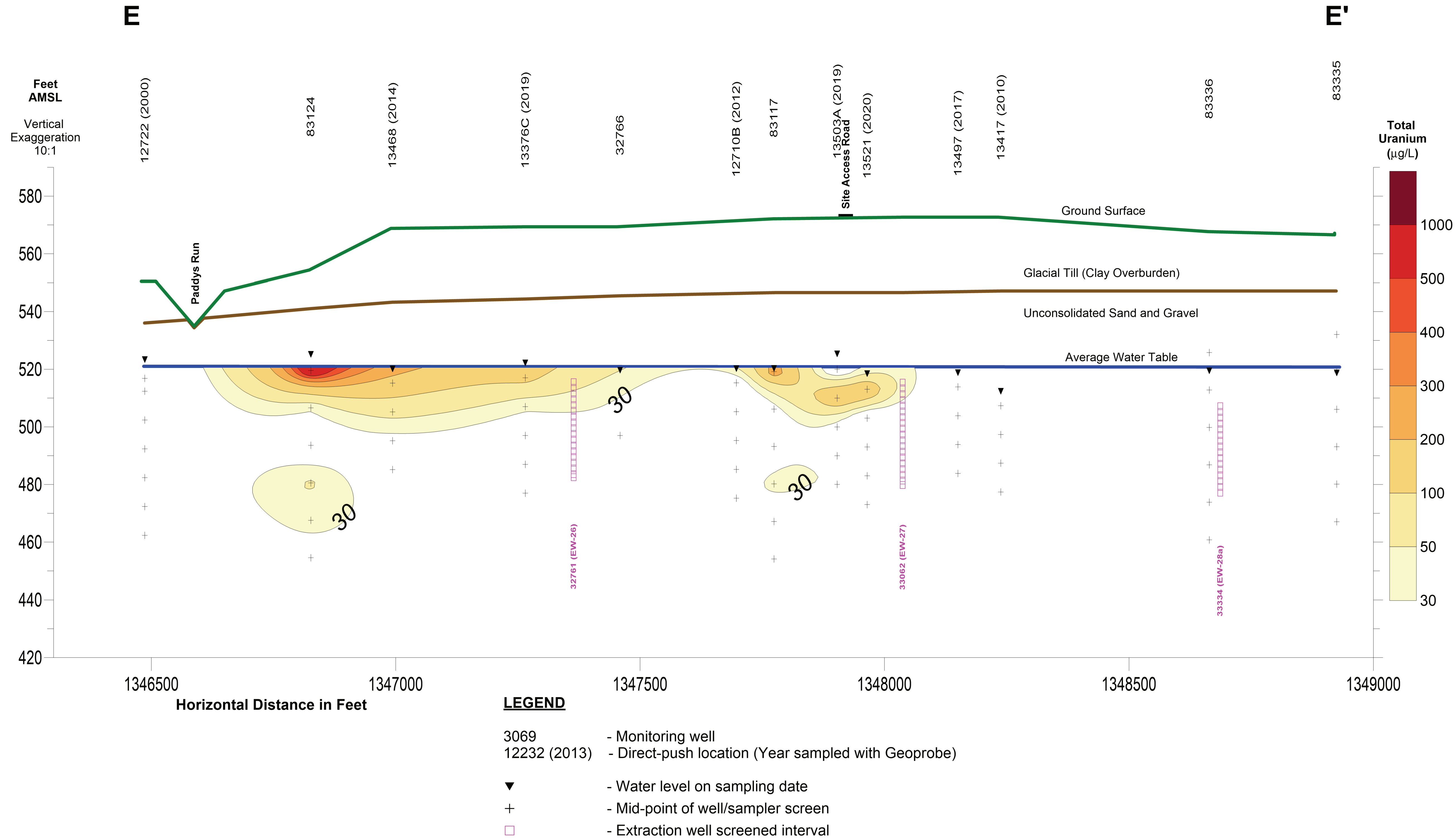


Figure A.2-34. Total Uranium Plume Cross Section E–E'

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Attachment A.3

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Contents

Tables

Figures

Abbreviations

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

Measurement Abbreviations

amsl	above mean sea level
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 2020 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 current Operational Design Remediation Footprint (based on particle tracks)
- Extent of the maximum 30 micrograms per liter (μg/L) total uranium plume
- Number of extraction wells in each module and the module-specific pumping rates during the period in which the groundwater elevations were measured

Water levels in 2020 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 2019). A total of 172 monitoring wells were available for measurement. As required by the IEMP, during the second quarter of 2020, all 172 wells were targeted for water level measurements. During the other three quarters, 99 of the 172 available wells were targeted for measurement. A summary of the results, is shown below.

Quarter	Measurement Dates (2020)	Number of Days	Average Water Level (ft amsl)[a]
1	January 6 to January 7	2	515.73
2	June 8 to June 10	3	519.60
3	August 31 to September 1	2	517.42
4	October 12 to October 14	3	515.68

[a]ft amsl = feet above mean sea level.

Seven monitoring wells and the uppermost channel in four multichannel wells were dry at various times of the year. A summary is provided below.

Well	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
2014	DRY	DRY		DRY
2128				DRY
2384	DRY			DRY
2636	DRY			DRY
2702				DRY
22192	DRY	DRY	DRY	DRY
22303	DRY			DRY
83293_C1	DRY		DRY	DRY
83295_C1	DRY		DRY	DRY
83335_C1	DRY	DRY	DRY	DRY
83336_C1	DRY		DRY	DRY

Quarterly groundwater elevation maps for 2020 are provided in Figures A.3-1 through A.3-4. Water level measurements are generally collected during times when all extraction wells are pumping; however, due to certain conditions (e.g., well maintenance), individual wells might be shut down during the measurement period. Any specific well shutdowns during the elevation measurement period are noted in Figures A.3-1 through A.3-4. The maps for 2020 illustrate capture of the maximum total uranium plume using groundwater elevation contours derived from quarterly water level measurements and model-predicted capture. The pumping rates reported in Figures A.3-1 through A.3-4 are averages of the actual pumping rates during the measurement period.

Model-predicted capture (called the current Operational Design Remediation Footprint) is based on particle tracks that were created using target system pumping rates defined in the current Operational Design. The current Operational Design Remediation Footprint used in this report was constructed using reverse, nonretarded, particle path interpretations from the Variable Saturated Analysis Model in Three Dimensions (VAM-3D) Zoom Groundwater Model. Figure A.3-5 shows the resulting particle tracks that were used to define the remediation footprint. Model particles were seeded at each extraction well. The resulting particle tracks represent the individual path that each particle traveled in 10 years during each of the three pumping stages 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 considered 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: 20 wells at a system rate of 5,075 gallons per minute (gpm)
- Stage 2: 10 wells at a system rate of 3,075 gpm
- Stage 3: 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 the first two quarters of 2020, flow in the vicinity of the On-Site Disposal Facility (OSDF) was generally from the northeast. During the last two quarters of 2020 flow in the vicinity of the OSDF was generally from the north to northwest. Flow direction is influenced by seasonal fluctuations in the aquifer and by the active pumping taking place for the groundwater remediation, which is predicted to last until 2035. 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 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 2020, as recorded at the Butler County Regional Airport. Cumulative precipitation in 2020 was 41.58 inches.

Between 2004 and 2020, the annual precipitation level has been as low as 33.20 inches (2010) and as high as 60.20 inches (2011).

Average annual water-table fluctuations and yearly ranges for 2006 through 2020 are as follows.

Year	Average Fluctuation (feet)	Fluctuation Range (feet)
2020	4.35	2.1 to 5.97
2019	3.82	0.21 to 7.09
2018	3.92	1.0 to 7.57
2017	3.80	0.15 to 4.83
2016	2.50	0.20 to 4.93
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

Capture zone interpretations for 2020 coupled with the particle track interpretations and contoured water-table gradients indicate that the 30 µg/L total uranium plume was being captured in 2020. The lengths of the unplanned shutdowns in 2020 due to river level rise and the COVID-19 response (discussed in Attachment A.1) were not long enough to lose capture of the uranium plume. Further information concerning how long the well field can be off without losing capture of the uranium plume is provided in the Operations and Maintenance Master Plan for Aquifer Restoration and Wastewater Treatment, which is Attachment A of the *Comprehensive Legacy Management and Institutional Controls Plan* (DOE 2019).

A.3.2 Annual Planned Well Field Shutdown

The entire well field (excluding the South Plume recovery wells RW-1 through RW-4) was shut down from June 15 to July 13 as planned to allow water levels to recover to nonpumping elevations. Quarterly measurement of water levels in 2020 was planned so that measurements were not collected 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 removed. 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 final 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, which automatically record water levels, are installed in 11 groundwater monitoring wells (2045, 2046, 2095, 2649, 3881, 23274, 62433, 32763, 22301, 22302, and 63119) for the shutdown (Figure A.3-7). Water level measurements were recorded twice each day at midnight and noon.

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 well, measured during the shutdown period in 2020, is presented below.

Planned Shutdown: June 15 to July 13, 2020

Location	Elevation at Midnight Prior to Shutdown June 15, 2020 (ft amsl)	Elevation at Midnight Prior to Restart July 13, 2020 (ft amsl)	Water Level Rise (ft)
2045	518.84	520.34	1.50
2046	519.80	520.87	1.07
2649	522.25	523.19	0.94
23274	519.04	520.63	1.59
63119	519.87	521.15	1.28
22302	517.65	519.46	1.81
3881	517.36	518.33	0.97
22301	517.96	519.65	1.69
2095	517.72	518.75	1.03
32763	521.10	522.04	0.94
62433	517.88	519.71	1.83

The water level rise measurements indicate that during the shutdown, the water level rise ranged from 0.94 feet (ft) (wells 2649 and 32763) to 1.83 ft (well 62433).

Figure A.3-8 shows water levels versus precipitation from May 25, 2007, through December 31, 2020. Three wells are shown in 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 2020 resulted in the following water level rises:

- 5.05 ft in the former WSA (monitoring well 2649)
- 5.38 ft in the west side of the South Field (monitoring well 2046)
- 7.36 ft in the east side of the South Field (monitoring well 62433)

Uranium Concentration Results

Consistent with previous years, total 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 2020 shutdown. The results of the 2020 IEMP first-half uranium sampling are used to represent uranium concentrations in the well before the shutdown. Groundwater samples collected in June and July represent concentrations during the shutdown. The results of the 2020 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 2020 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: 2045, 23274, 83124_C1 and C2, 83294_C1 and C2, and 83337_C2. As stated in the IEMP, 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. In the second half of 2020, 83294_C1 was dry.

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. After each well was 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. Recovery wells RW-1, RW-2, RW-3, and RW-4 continued to run during the shutdown.

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 within a month prior to the shutdown at each extraction well. As the data indicate, approximately half of the wells showed an increase in uranium concentrations. The largest increase in uranium concentration was measured in extraction well EW-15A (6.7 µg/L).

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 twice daily, at noon and midnight. Data from three of the six locations (former WSA [2649], west side of the South Field Area [2046], and east 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 December 31, 2020. The transducers will continue to record data to provide a more complete record of seasonal and short-term water-table fluctuations and continue to be used for planning the timing of future well field shutdowns.

A.3.4 References

DOE (U.S. Department of Energy), 2019. *Comprehensive Legacy Management and Institutional Controls Plan*, LMS/FER/S03496, Revision 12, Office of Legacy Management, January.

Table A.3-1. Uranium Concentrations at Monitoring Wells Before, During, and After the 2020 Well Field Shutdown

Well	Easting	Northing	First Half 2020 Pre-Shutdown Concentrations		Pre-Start-Up Concentrations June 2020		Second Half 2020 Post-Shutdown Concentrations	
			Date	Uranium (μg/L)	Date	Uranium (μg/L)	Date	Uranium (μg/L)
2045	1348291	477159	5/20/2020	38.5	7/6/2020	64.8	10/1/2020	74.6
2046	1347950	478088	2/18/2020	22.9	7/6/2020	16.7	7/23/2020	31.9
23274	1349406	478337	2/18/2020	75.0	7/6/2020	84.5	8/4/2020	89.4
83124_C1	1346826	479977	3/23/2020	473	7/7/2020	792	9/21/2020	617
83124_C2	1346826	479977	3/23/2020	22.8	7/7/2020	32.4	Not Sampled	Not Sampled
83294_C1	1349599	477190	3/23/2020	158	7/7/2020	224	Not Sampled	Dry
83294_C2	1349599	477190	3/23/2020	139	7/8/2020	166	9/30/2020	169
83337_C1	1346704	481052	5/20/2020	966	6/17/2020	909	7/9/2020	662
83337_C2	1346704	481052	5/20/2020	42.3	7/8/2020	165	11/18/2020	4.3

Table A.3-2. Total Uranium Concentration at Extraction Wells During 2020 Well Field Shutdown

Extraction Well	June 1, 2020 Uranium Concentration (ug/L)[a]	Date of Restart	Uranium Concentration (ug/L) After Well Field Re-Start							Maximum Post Re-Start Minus June 1, 2020 Concentration
			1st Restart Sample	2nd Restart Sample	3rd Restart Sample	4th Restart Sample	Minimum	Maximum	Range	
RW-1	10.6	7/13/2020	10.8	2.4	9.5	1.2	1.2	10.8	9.6	0.2
RW-2	13.6	7/13/2020	13.3	13.6	12.7	13.0	12.7	13.6	0.9	0
RW-3	18.3	7/13/2020	17.9	18.2	17.4	16.9	16.9	18.2	1.3	-0.10
RW-4	2.6	7/13/2020	2.3	2.7	2.8	2.6	2.3	2.8	0.5	0.2
RW-6	26.8	7/17/2020	22.0	22.9	23.0	23.0	22.0	23.0	1.0	-3.8
RW-7	20.2	7/14/2020	15.6	16.7	17.2	17.7	15.6	17.7	2.1	-2.5
EW-15A	25.4	7/14/2020	32.1	23.1	25.8	26.9	23.1	32.1	9.0	6.7
EW-17A	11.4	7/14/2020	11.7	11.0	10.5	10.7	10.5	11.7	1.2	0.3
EW-18	35.9	7/13/2020	33.2	35.1	32.4	32.7	32.4	35.1	2.7	-0.8
EW-19	21.7	7/13/2020	18.5	15.5	21.3	21.8	15.5	21.8	6.3	0.1
EW-20	31.1	7/13/2020	28.8	27.8	26.3	27.0	26.3	28.8	2.5	-2.3
EW-21A	32.5	7/14/2020	36.0	33.5	32.8	29.8	29.8	36.0	6.2	3.5
EW-22	25.1	7/14/2020	22.7	21.7	21.9	28.5	21.7	28.5	6.8	3.4
EW-23	32.0	7/14/2020	20.7	27.9	29.1	28.5	20.7	29.1	8.4	-2.9
EW-24	26.8	7/16/2020	25.2	23.3	23.0	23.0	23.0	25.2	2.2	-1.6
EW-25	24.3	7/16/2020	25.2	27.7	27.4	23.7	23.7	27.7	4.0	3.4
EW-26	24.7	8/24/2020	28.3	23.0	21.1	20.9	20.9	28.3	7.4	3.6
EW-27	25.1	7/16/2020	21.8	21.3	21.1	22.1	21.1	22.1	1.0	-3.0
EW-30	12.4	7/14/2020	13.2	12.3	11.5	10.9	10.9	13.2	2.3	0.8
EW-33A	26.4	8/25/2020	24.7	25.2	21.8	22.9	21.8	25.2	3.4	-1.2

Shading indicates uranium concentration after well field re-start was greater than June 1, 2020 uranium concentration.

[a] Shutdown began on June 15, 2020 at 7:00 a.m. and ended on July 13, 2020 for a duration of 28 days

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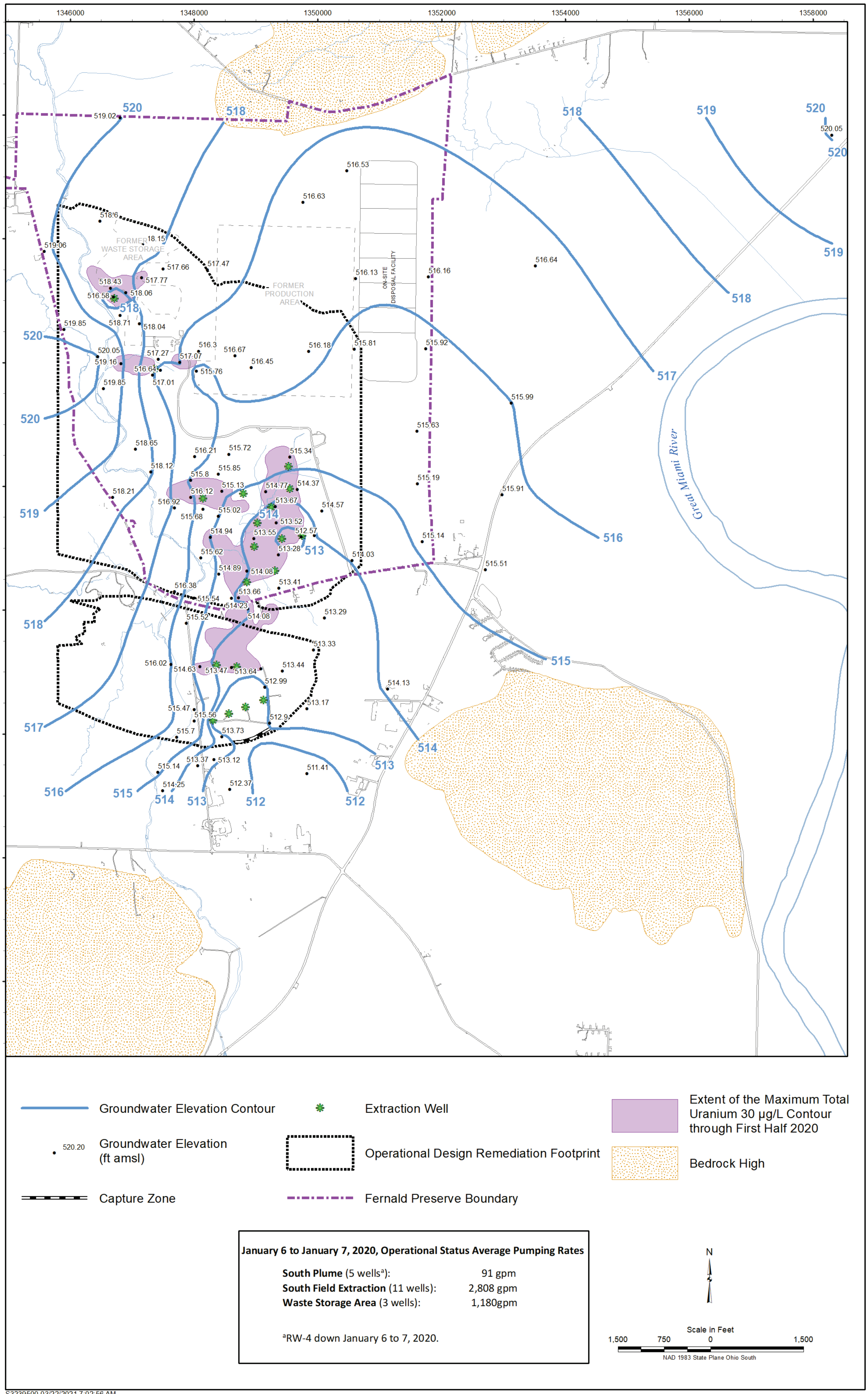

Figure A.3-1. Routine Groundwater Elevation Map, First Quarter 2020 (January 6 Through January 7, 2020)

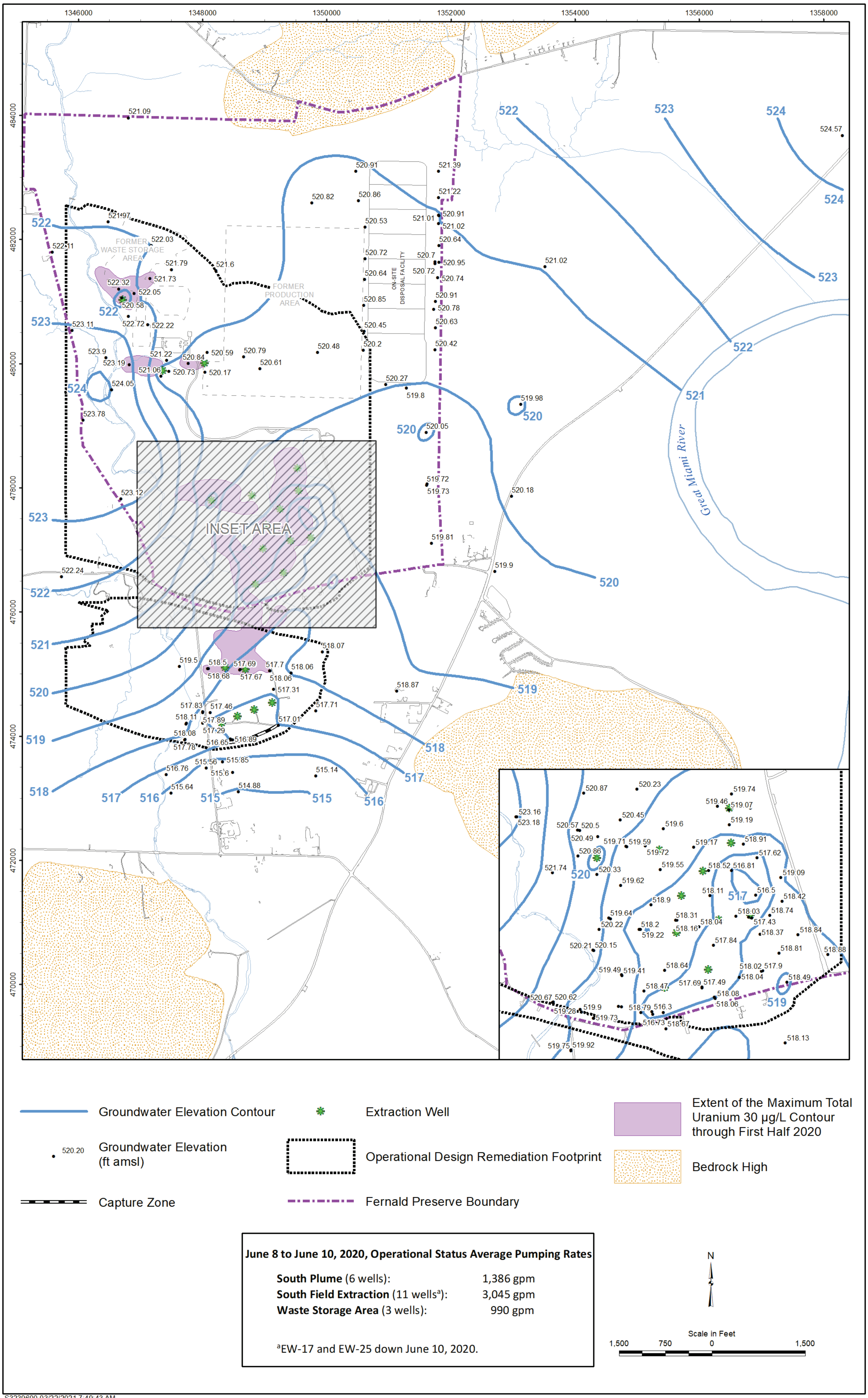

Figure A.3-2. Routine Groundwater Elevation Map, Second Quarter 2020 (June 8 Through June 10, 2020)

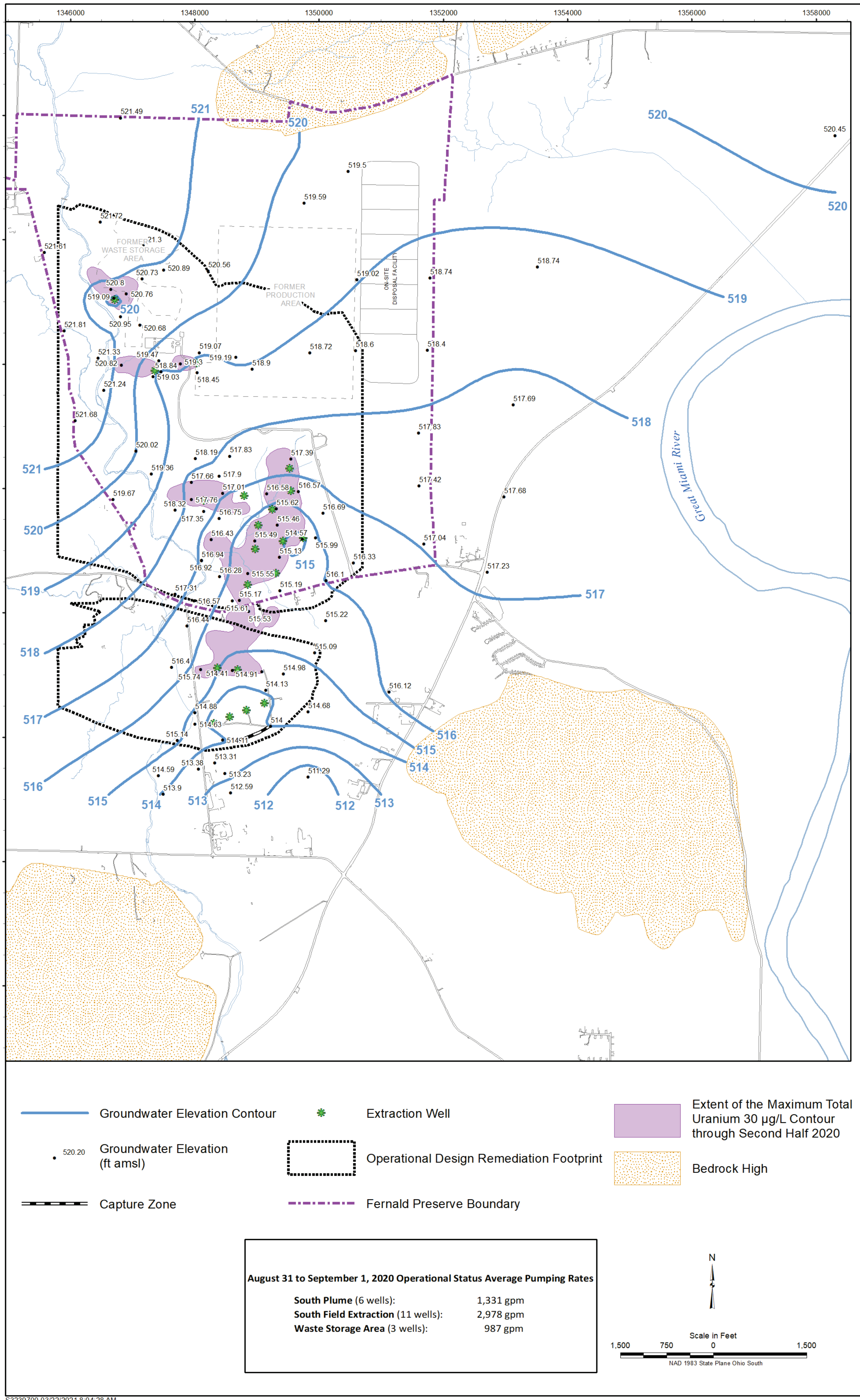

Figure A.3-3. Routine Groundwater Elevation Map, Third Quarter 2020 (August 31 Through September 1, 2020)

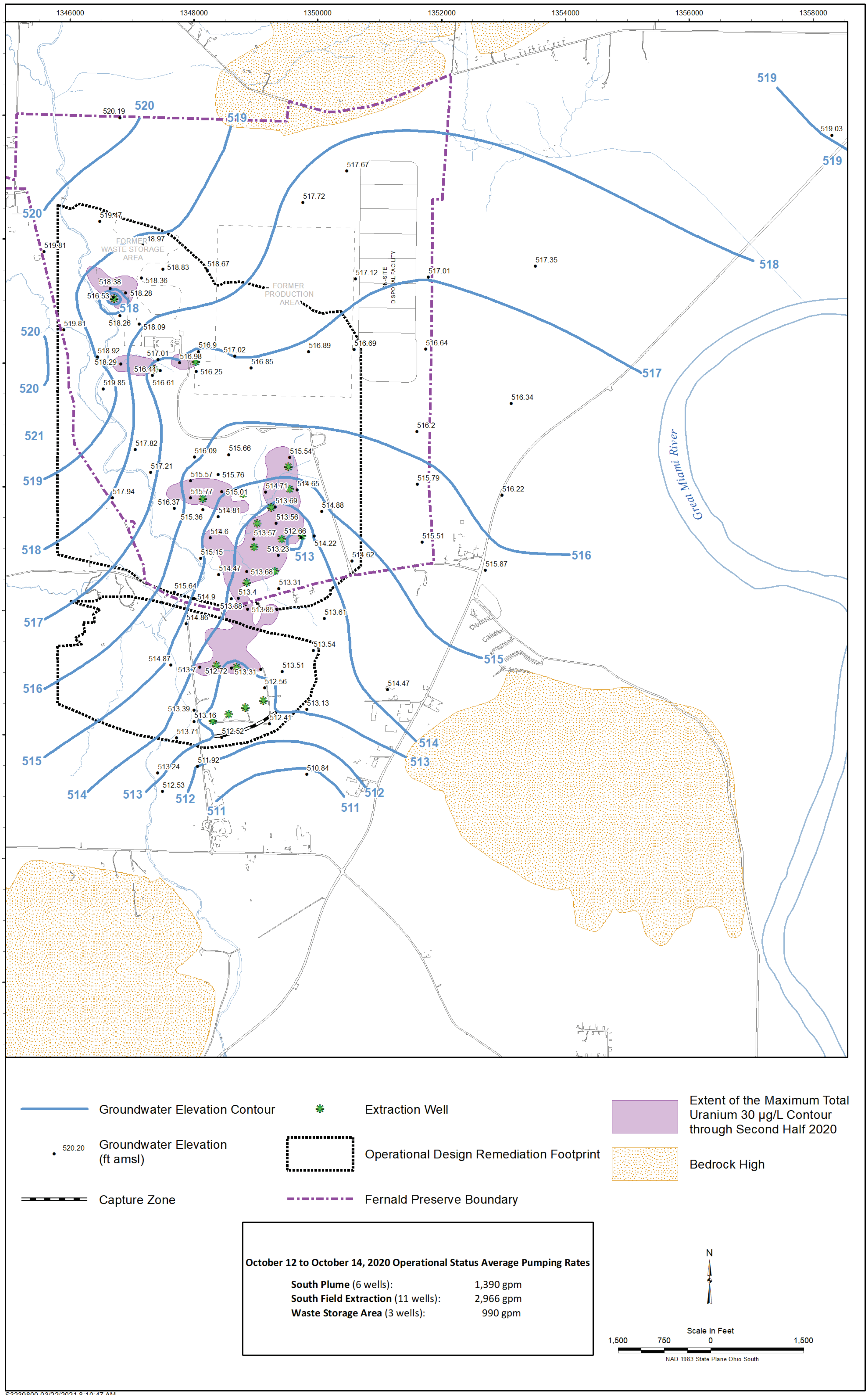

Figure A.3-4. Routine Groundwater Elevation Map, Fourth Quarter 2020 (October 12 Through October 13, 2020)

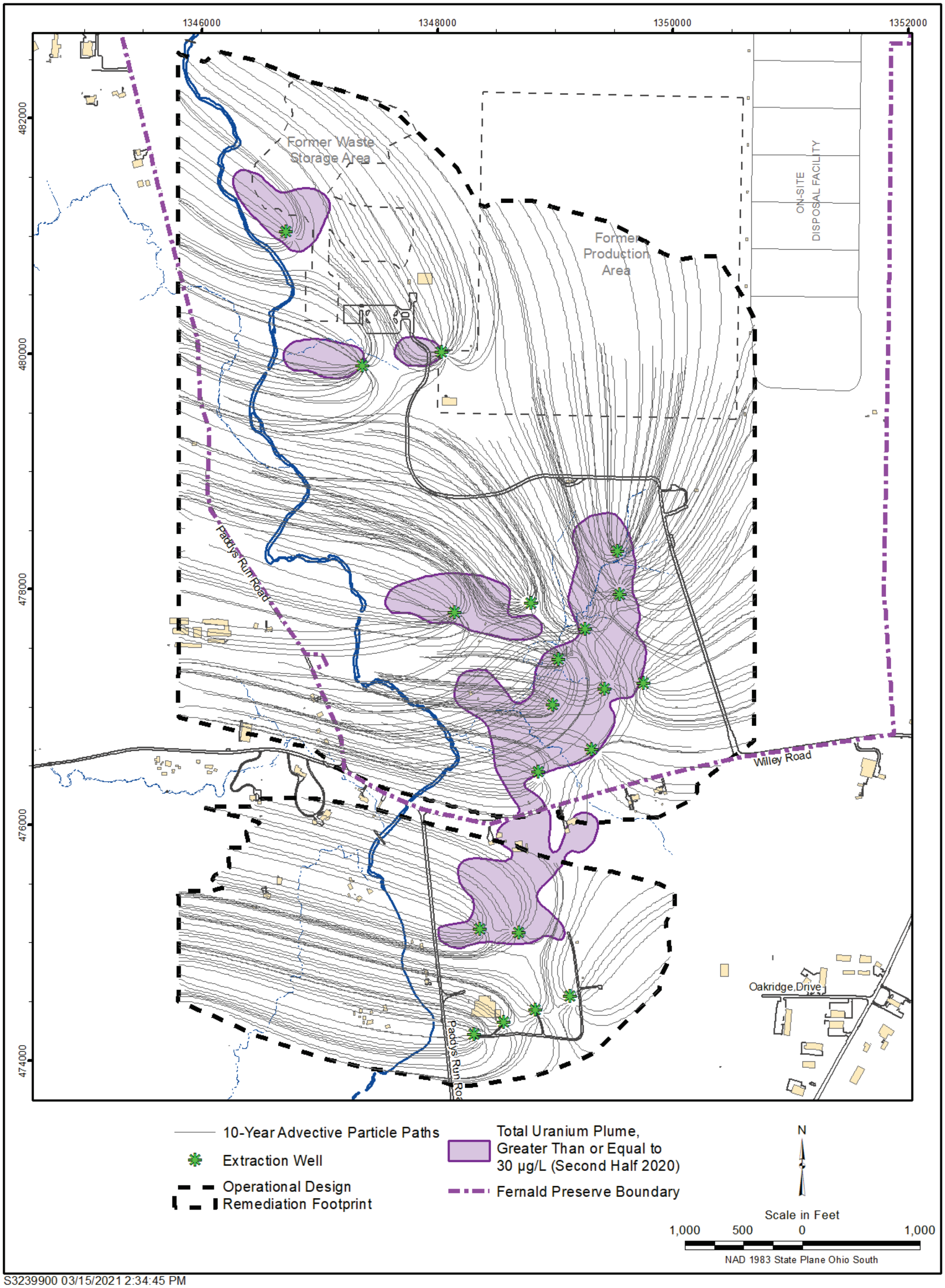

Figure A.3-5. Current Operational Design Remediation Footprint

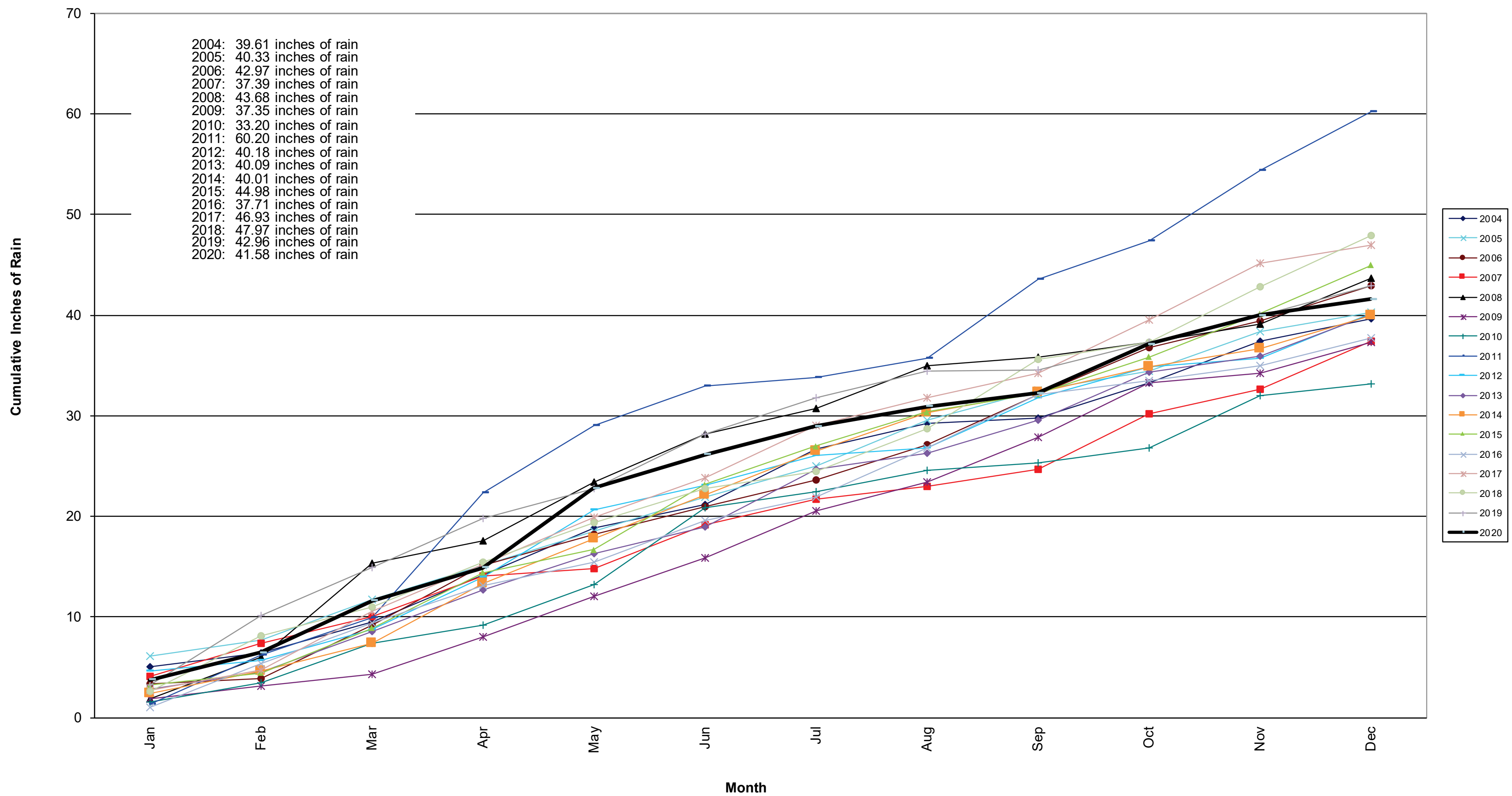

Figure A.3-6. Cumulative Annual Precipitation: 2004 Through 2020 as Recorded at the Butler County Regional Airport

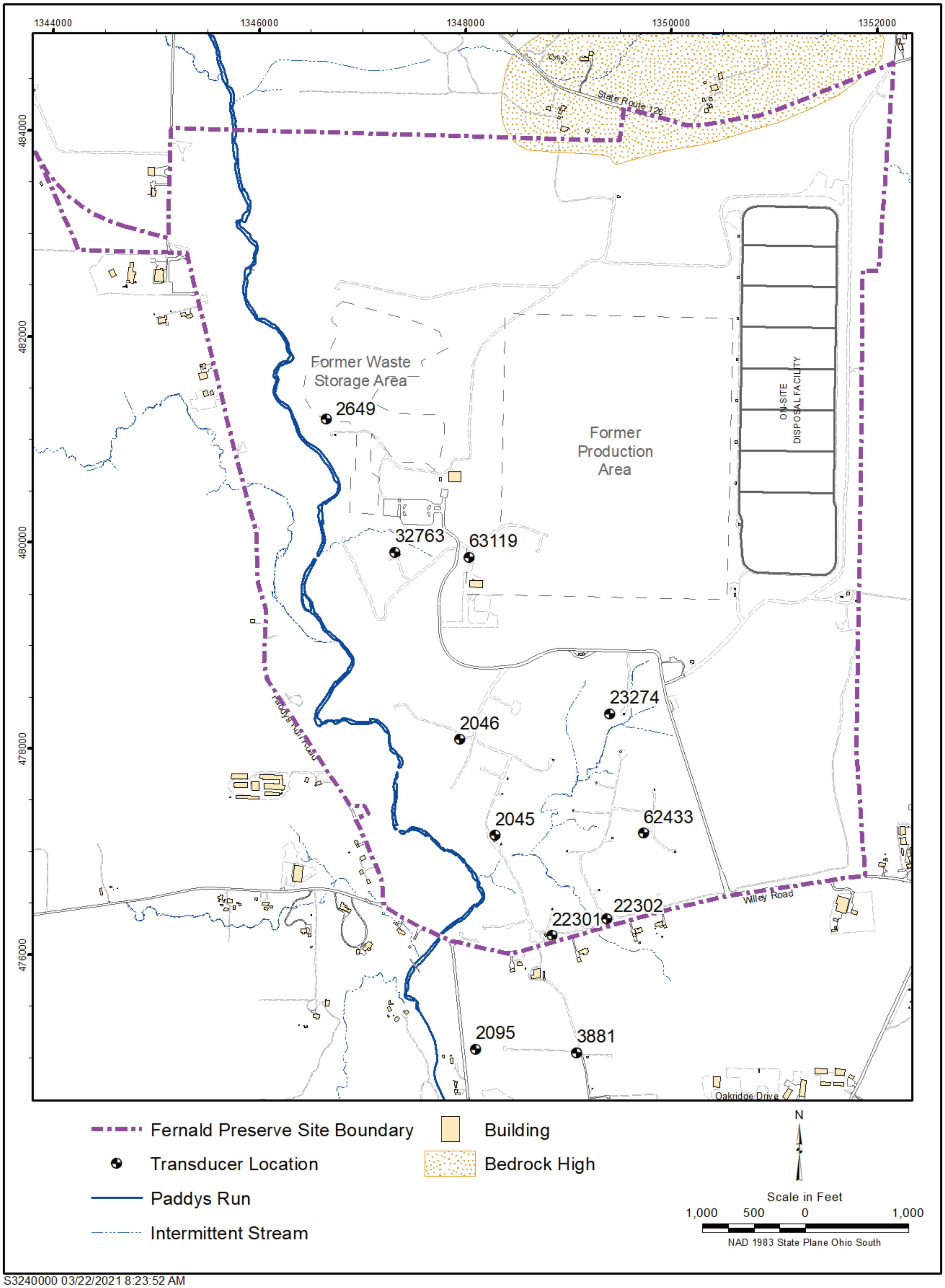

Figure A.3-7. Transducer Locations for the 2020 Operational Shutdown

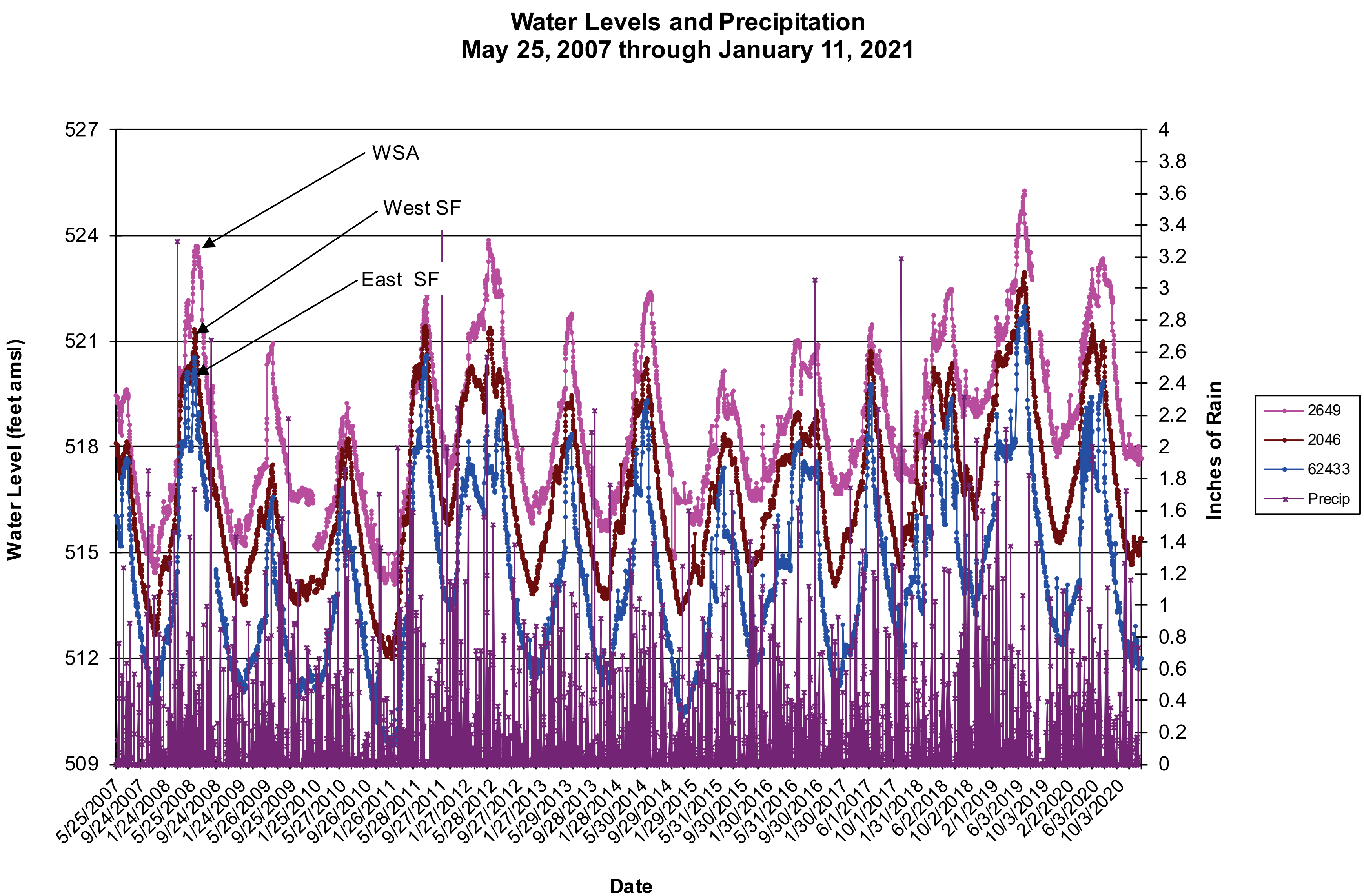

Figure A.3-8. Water Levels Versus Precipitation May 25, 2007, Through December 31, 2020

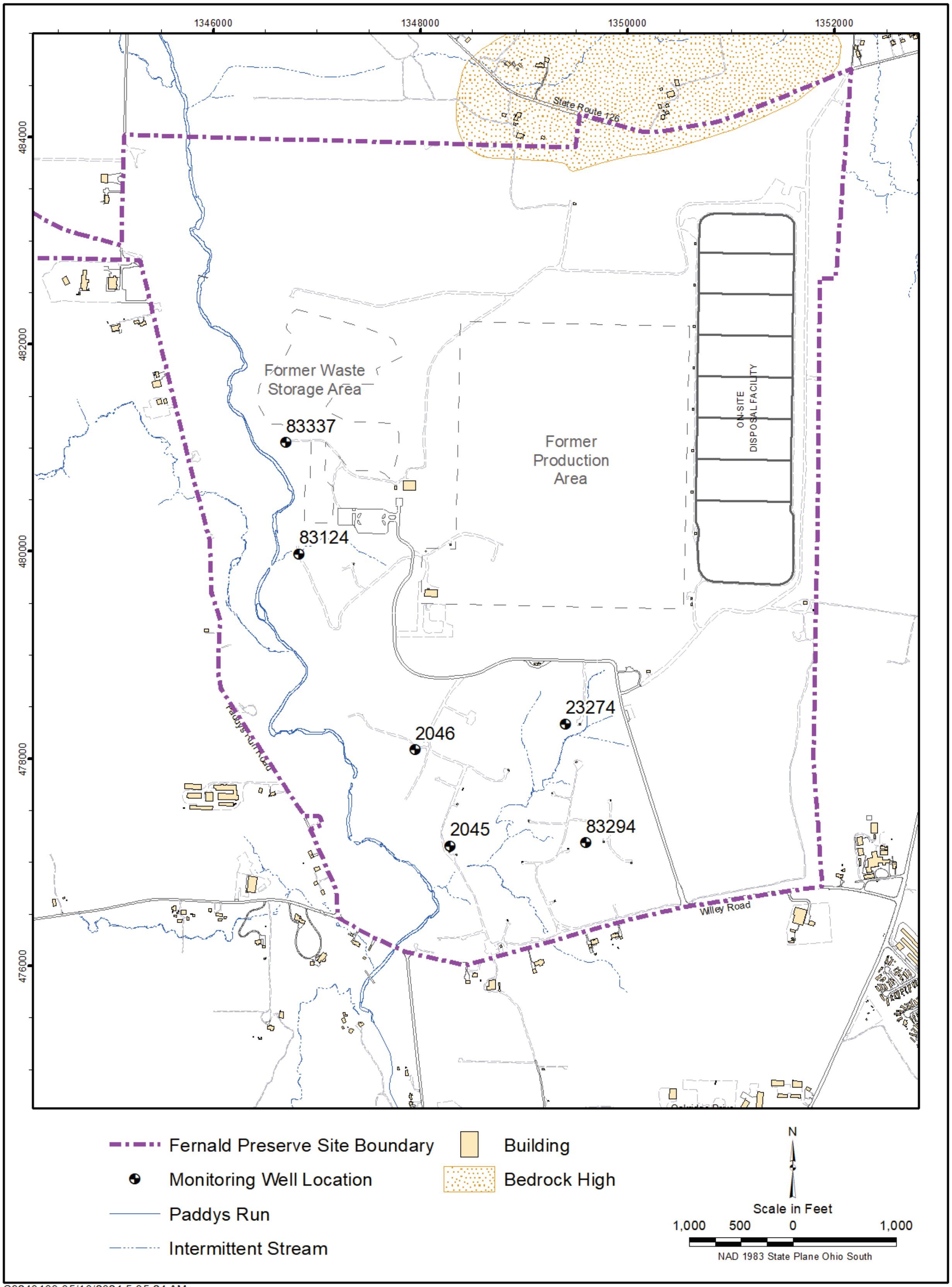

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Figure A.3-9. Monitoring Well Locations for the 2020 Operational Shutdowns

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Attachment A.4

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Contents

Tables

Figures

Abbreviations

FRL	final remediation level
GMA	Great Miami Aquifer
IEMP	Integrated Environmental Monitoring Plan
LMICP	*Comprehensive Legacy Management and Institutional Controls Plan*
OSDF	On-Site Disposal Facility
WSA	Waste Storage Area

Measurement Abbreviations

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

A.4.0 Non-Uranium Final Remediation Level Results

This attachment provides an analysis of the non-uranium final remediation level (FRL) exceedances both inside and outside the current Operational Design Remediation Footprint at the Fernald Preserve, Ohio, Site. This attachment evaluates non-uranium FRL results for 2020 collected under the “Integrated Environmental Monitoring Plan” (IEMP), which is Attachment D of the *Comprehensive Legacy Management and Institutional Controls Plan* (LMICP) (DOE 2019). The purpose of the evaluation is to:

- Identify 2020 non-uranium FRL exceedances (Section A.4.1).
- Determine the persistence of non-uranium FRL exceedances outside the current Operational Design Remediation Footprint (Section A.4.2).
- Describe the evaluation of 2020 non-uranium FRL exceedances outside the current Operational Design Remediation Footprint (Section A.4.2).
- Present conclusions (Section A.4.3).

Consistent with past Site Environmental Reports, non-uranium groundwater monitoring results from wells monitored in the Great Miami Aquifer (GMA) for performance of the On-Site Disposal Facility (OSDF) are included in the data evaluation presented in this section of the Site Environmental Report. Beginning in 2017, the number of non-uranium constituents being sampled in the OSDF monitoring program was reduced. Data presented and discussed in the *Fernald Preserve 2015 Site Environmental Report* (DOE 2016) supported making the changes to the OSDF monitoring program. The proposed changes were approved by the U.S. Environmental Protection Agency, the Ohio Environmental Protection Agency, and stakeholders during the routine review and approval process of the 2017 LMICP (DOE 2017a).

As a result of the OSDF monitoring changes, the following nine non-uranium constituents are no longer being routinely sampled for in the GMA as part of the OSDF monitoring program: total organic carbon, iron, sodium, cobalt, total alkalinity, barium, chloride, copper, and chromium. The non-uranium constituents currently being sampled in the GMA as part of the IEMP are provided in Table 6 in Attachment D of the LMICP (DOE 2019). A list of the constituents routinely sampled in the GMA as part of the OSDF monitoring program can be found in Section 3.2.1.3 in Attachment C of the LMICP. Tables and data analyses presented below reflect the current combined sampling effort.

A.4.1 Non-Uranium FRL Exceedances for 2020

Table A.4-1 shows the summary statistics and trend analysis for the 2020 non-uranium FRL exceedances from monitoring wells both inside and outside the current Operational Design Remediation Footprint. Five non-uranium FRL constituents had one or more FRL exceedances during 2020. Figure A.4-1 identifies the locations of these exceedances.

Figure A.4-1 shows that the non-uranium FRL exceedances in 2020 were in the former Waste Storage Area (WSA), and are within the current Operational Design Remediation Footprint (DOE 2014). Specific discussion regarding exceedances and persistence outside the footprint is provided in Section A.4.2.

Table A.4-2 identifies the locations and constituents that have had non-uranium FRL exceedances since 1997 for constituents monitored in 2020. The first column in Table A.4-2 lists the groundwater FRL constituents monitored in 2020. As discussed above, Table A.4-2 reflects the current monitoring effort. The 2016 Site Environmental Report (DOE 2017b) provides a discussion concerning the changes implemented in 2017. The second column in Table A.4-2 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 samples and a "2" denotes an exceedance for both samples. Beginning in 2017, the sampling frequency of several of the wells that had been sampled quarterly through 2013 was reduced from a semiannual to annual frequency. Data presented and discussed in the 2015 Site Environmental Report (DOE 2016) supported making the sampling frequency change. Table A.4-2 also indicates whether exceedances occurred inside or outside the remediation footprint (shading indicates the well is located outside the footprint).

As specified in Table 4 in the IEMP (DOE 2019), there were 13 non-uranium constituents monitored in 2020; as stated above, 5 had exceedances during 2020. The following table summarizes the 2020 non-uranium monitoring information.

Constituent (units)[a]	Groundwater Final Remediation Level	2020 Monitoring Summary[b]	2020 Maximum Exceedance[c]
Antimony (mg/L)	0.0060	No exceedances	NA
Arsenic (mg/L)	0.050	No exceedances	NA
Boron (mg/L)	0.33	No exceedances	NA
Carbon disulfide (mg/L)	5.5	No exceedances	NA
Fluoride (mg/L)	4	No exceedances	NA
Lead (mg/L)	0.015	No exceedances	NA
Manganese (mg/L)	0.90	Exceedances in former WSA wells	1.04
Molybdenum (mg/L)	0.10	Exceedances in former WSA wells	0.280
Nickel (mg/L)	0.10	No exceedances	NA
Nitrate + nitrite, as nitrogen (mg/L)	11	Exceedances in former WSA wells	56.3
Technetium-99 (pCi/L)	94	Exceedances in former WSA wells	515
Trichloroethene (μg/L)	5	Exceedances in former WSA wells	6.85
Zinc (mg/L)	0.021	No Exceedances	NA

[a] μg/L = micrograms per liter; mg/L = milligrams per liter; pCi/L = picocuries per liter.
[b] WSA = Waste Storage Area.
[c] NA = not applicable.

A.4.1.1 Non-Uranium Direct-Push Sampling Results for 2020

In 2020, three direct-push sampling locations in the former WSA (locations 13374G, 13495B, and 13520) were sampled for non-uranium constituents, as specified in the IEMP for the former WSA. These locations are identified in Attachment A.2, Figure A.2-3A. Direct-push sampling results for locations 13374G, 13495B, and 13520 for 2020 are provided in Tables A.2-1, A.2.-2, and A.2-3 respectively in Attachment A.2. Non-uranium results are discussed below. The former

WSA is within capture of the groundwater remediation system. Because the area is within capture, a non-uranium FRL exceedance in the former WSA poses no threat to human health or the environment.

Location 13374G

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

Samples have been collected at this location eight times, beginning in 2008 and then again in 2013, 2015, 2016, 2017, 2018, 2019, and 2020. The location sampled in 2008 was identified as 13374 and was analyzed only for total uranium. The location sampled in 2020 was identified as 13374G. The maximum non-uranium concentrations from all samples are provided below.

Constituent (Units)[a]	FRL	13374 (2008)[b]	13374A (2013)	13374B (2015)	13374C (2016)	13374D (2017)	13374E (2018)	13374F (2019)	13374G (2020)
Technetium-99 (pCi/L)	94	NS	**514**	3.48	1.94	27.1	3.76	65.9	1.61
Nitrate + Nitrite as Nitrogen (mg/L)	11	NS	**375**	0.296	0.340	6.20	<1.70	10.1	1.26
Manganese (mg/L)	0.90	NS	**2.49**	0.465	0.366	0.479	0.501	0.577	0.401
Molybdenum (mg/L)	0.10	NS	0.0457	0.0306	0.0317	0.0159	0.0189	0.0243	0.0207
Nickel (mg/L)	0.10	NS	0.0358	0.00859	0.00778	0.0118	0.0154	0.0229	0.012

Note: Bold indicates concentrations above FRL.
[a] mg/L = milligrams per liter; pCi/L = picocuries per liter.
[b] NS = not sampled.

The data indicate that no non-uranium FRL exceedances were detected in 2020.

Location 13495B

Direct-push sampling results for location 13495B are provided in Attachment A.2, Table A.2-2. The location is identified in Attachment A.2, Figure A.2-3A.

Samples have been collected at this location three times, beginning in 2017 and then again in 2019 and 2020. The location sampled in 2017 was identified as 13495. The location sampled in 2020 was identified as 13495B. The maximum non-uranium concentrations from all samples are provided below.

Constituent (Units)[a]	FRL	13495 (2017)	13495A (2019)	13495B (2020)
Technetium-99 (pCi/L)	94	34.7	34.1	17.3
Nitrate + Nitrite as Nitrogen (mg/L)	11	**26.8**	**21.9**	**17.60**
Manganese (mg/L)	0.90	0.787	**1.89**	0.753
Molybdenum (mg/L)	0.10	0.0557	0.0469	**0.118**
Nickel (mg/L)	0.10	0.0164	0.0452	0.013

Note: Bold indicates concentrations above FRL.
[a] mg/L = milligrams per liter; pCi/L = picocuries per liter.

The data indicate that concentrations of nitrate + nitrite as nitrogen and molybdenum exceeded the FRL in 2020.

Location 13520
Direct-push sampling results for location 13520 are provided in Attachment A.2, Table A.2-3. The location is identified in Attachment A.2, Figure A.2-3A.

This is the first time that this location was sampled. The maximum non-uranium concentrations from all samples are provided below.

Constituent (Units)[a]	FRL	13520 (2020)
Technetium-99 (pCi/L)	94	3.21
Nitrate + Nitrite as Nitrogen (mg/L)	11	19.0
Manganese (mg/L)	0.90	**0.930**
Molybdenum (mg/L)	0.10	0.0269
Nickel (mg/L)	0.10	0.0137

Note: Bold indicates concentrations above FRL.
[a] mg/L = milligrams per liter; pCi/L = picocuries per liter.

The data indicate that the concentration of manganese exceeded the FRL in 2020.

A.4.2 Evaluation of 2020 Non-Uranium FRL Exceedances Outside the Current Operational Design Remediation Footprint

This section presents an evaluation of the persistence of non-uranium FRL exceedances outside the current 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 whether 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 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 Analysis Model in Three Dimensions Zoom Groundwater Model. The footprint was updated in 2005 to reflect capture during the 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 Design Adjustment (DOE 2014). The footprint for the current 2014 Operational Design Adjustment 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 current 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. It is recognized that some non-uranium constituents can be oxidation-reduction sensitive, and their stability is controlled in large measure by the oxidation-reduction state of the groundwater, which can vary, perhaps causing transient FRL exceedances to come and go.

A.4.2.2 Evaluation and Discussion

Figure A.4-1 and the shaded portion of Table A.4-1 identify the 2020 non-uranium FRL exceedances outside the current Operational Design Remediation Footprint. In 2020 there were no FRL exceedances outside the current Operational Design Remediation Footprint.

Table A.4-3 addresses possible persistent FRL exceedances that occurred outside the current Operational Design Remediation Footprint in 2019. 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.

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

- The zinc FRL exceedance at monitoring well 3429, identified as being potentially persistent in 2019 was not persistent in 2020.
- The zinc FRL exceedance at monitoring well 22205, identified as being potentially persistent in 2019, requires that additional routine data be collected to determine if it is persistent.

Figures A.4-2, and A.4-3 present individual graphs of time versus concentration for the wells listed in Table A.4-3. Semiannual sampling results from OSDF monitoring activities are included in the evaluation of property boundary wells.

The year 2020 marks 24 years that an evaluation for persistence of non-uranium FRL exceedances in wells outside the current Operational Design Remediation Footprint has been conducted, as part of the IEMP. In the past, many exceedances identified as persistent became not persistent in later years. As of 2020, no persistent exceedances are identified outside the remediation footprint.

A.4.3 Conclusions

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

- Non-uranium FRL exceedances occurring in the former WSA were taken into consideration for the current Operational Design and are within capture of the groundwater remediation system.
- In 2020, a zinc FRL exceedance in monitoring well 22205 remains potentially persistent, and requires that additional routine data be collected in 2021 to determine if it is persistent.

A.4.4 References

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DOE (U.S. Department of Energy), 2019. *Comprehensive Legacy Management and Institutional Controls Plan*, LMS/FER/S03496, Revision 12, Office of Legacy Management, January.

Table A.4-1. Summary Statistics and Trend Analysis for Non-Uranium Constituents with 2020 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 2020[c,d]	Maximum Exceedance for 2020[b,c,d,e,f]	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]
Manganese (0.90 mg/L)					(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	
	2010	39	24	1	0.958	0.0886	6.74	1.82	1.75	Down
	83341_C1	13	6	1	1.04	0.0886	4.70	1.66	1.65	No Trend
Molybdenum (0.10 mg/L)	2649	41	41	2	0.280	0.178	1.26	0.489	0.235	No Trend
Nitrate + nitrite as nitrogen (11 mg/L)[h]	2821	51	32	2	37.9	1.38	120	26.0	27.7	Up
	83338_C1	24	19	2	53.5	0.404	73.8	39.1	21.8	No Trend
	83340_C1	25	18	2	761	0.470	761	49.2	149	Down
	83340_C2	28	27	2	36.0	2.93	86.7	42.6	24.2	No Trend
	83340_C3	28	25	2	52.5	1.13	133	41.4	33.4	Down
	83341_C1	13	9	1	56.3	0.265	56.3	19.2	18.7	Up
	83341_C2	28	8	1	17.8	0.090	258	20.8	48.8	Up
Technetium-99 (94 pCi/L)					(pCi/L)	(pCi/L)	(pCi/L)	(pCi/L)	(pCi/L)	
	2649	49	48	1	117	72.3	1660	507	432	Down
	2821	51	26	1	97.7	0.253	651	131	140	No Trend
	83338_C1	24	19	2	515	10.1	515	221	131	Up
	83340_C1	25	24	2	121	55.1	817	209	153	Down
Tricholorethene (5.0 µg/L)	2649	41	27	1	(µg/L) 6.85	(µg/L) 0.125	(µg/L) 120	(µg/L) 27.4	(µg/L) 30.9	Down

Note: Shading indicates well is outside the current Operational Design Remediation Footprint.

[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 2020.

[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 with a 95% confidence interval, using data from third quarter 1998 through 2020.

[h] FRL based upon nitrate from Record of Decision for Remedial Actions at Operable Unit 5 (DOE 1996), Table 9–4.

[i] pCi/L = picocuries per liter

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Table A.4-2. Groundwater FRL Exceedances from 1997 Through 2020

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		2016[d]		2017[e]		2018[e]		2019[e]		2020[e]	
				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	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									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																																																		
	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																																									
	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						1						1	
	22198	0	P/PB											1																																				
	22203	0	P/PB																																								1								
	22204	0	P/PB												1			1	1	1	1	1	1	1	1	1	2	2	2	1	1	2	2	2	2	2	2	2	2	2	2	2	1							
	22205	0	P/PB																	1										1																				
	22214	0	P/PB																													1																		
	2431	0	P/PB		2																																													
	2432	0	P/PB							1		2	1		1																																			
	2648	1	WSA	1		1		1	1		1		1					1	1		1																													
	2733	0	P/PB																																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														1	1	
	83341_C2	1	WSA																				1	1							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	1	1	1	1	1	1	1	1	1	1
Nickel																																																		
	22198	0	P/PB					1																																										
	2398	2	P/PB	1	2	2		2																																										
	4398	2	P/PB				1																																											
	83346_C1	1	WSA																							1																								
	83346_C2	1	WSA																							1	1																							
Nitrate/Nitrite																																																		
	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		1	1	1	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	1	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				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						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	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			1	1	1	1	1	1	1	1	1	1
	83341_C1	1	WSA																				1										1	1	1								1		1		1	1	1	
	83341_C2	1	WSA																							1								1				1				1				1	1	1	1	
	83341_C3	1	WSA																				1			1																1					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	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	1		1	1	1	2	1													1		1
	83338_C1	1	WSA																										1		1	1	1		1		1	1	1	1	1	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	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									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																										1																					
	22199	0	P/PB												1																																			
	22204	0	P/PB												1										1				1																					
	22205	0	P/PB																																												1			
	22210	0	P/PB																1		1						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	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																																	1									
	3429	0	P/PB				2																																						1					
	3431	0	P/PB										1																																					
	3733	0	P/PB												1																																			
	3899	4	PRRS								1																																							

Note: Shading indicates well is outside the current Operational Design remediation footprint.

[a]A "1" denotes an exceedance for the time period; a "2" denotes two exceedances during the time period due to quarterly sampling frequency or multiple sampling projects.

[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

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

[d] Prior to 2017, P/PB included OSDF monitoring results for some constituents.

[e] Beginning in 2017, monitoring frequency for P/PB and PRRS projects changed from semi-annual to annual.

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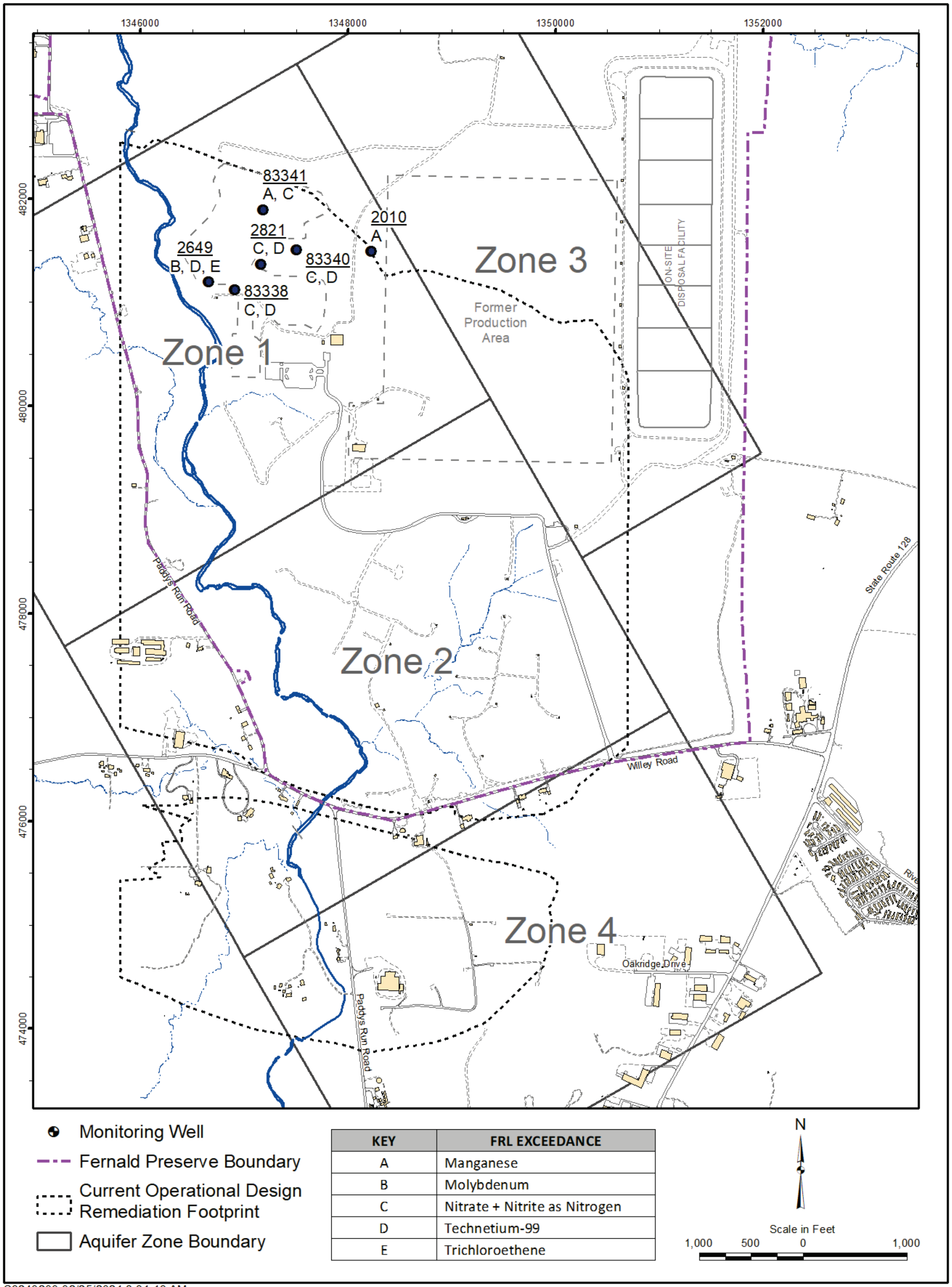
Table A.4-3. Summary of Persistence Evaluation of Non-Uranium FRL Exceedances Outside the Current Operational Design Remediation Footprint[a]

Constituent	Monitoring Well	Monitoring Program	Pertinent 2019 Results	2020 FRL Exceedance	Evaluation Results for 2020	Figure Number
Zinc	3429	P/PB	Additional routine data required	No	Not persistent	A.4-2
Zinc	22205	P/PB	Additional routine data required	No	Additional routine data required	A.4-3

[a] FRL = Final Remediation Level, NA = not applicable, P/PB = Property/Plume Boundary



KEY	FRL EXCEEDANCE
A	Manganese
B	Molybdenum
C	Nitrate + Nitrite as Nitrogen
D	Technetium-99
E	Trichloroethene

Figure A.4-1. Non-Uranium Constituent Locations with 2020 Results Above FRLs

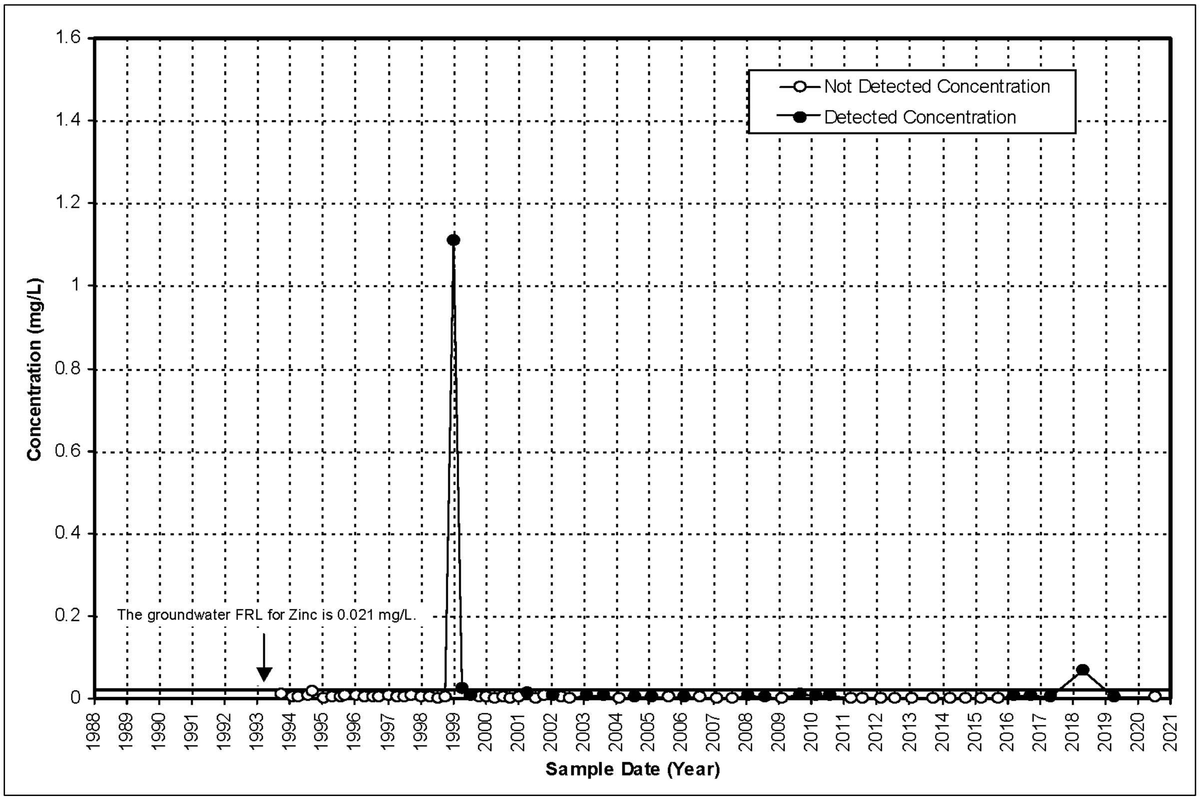


Figure A.4-2. Zinc Concentration Versus Time Plot for Monitoring Well 3429

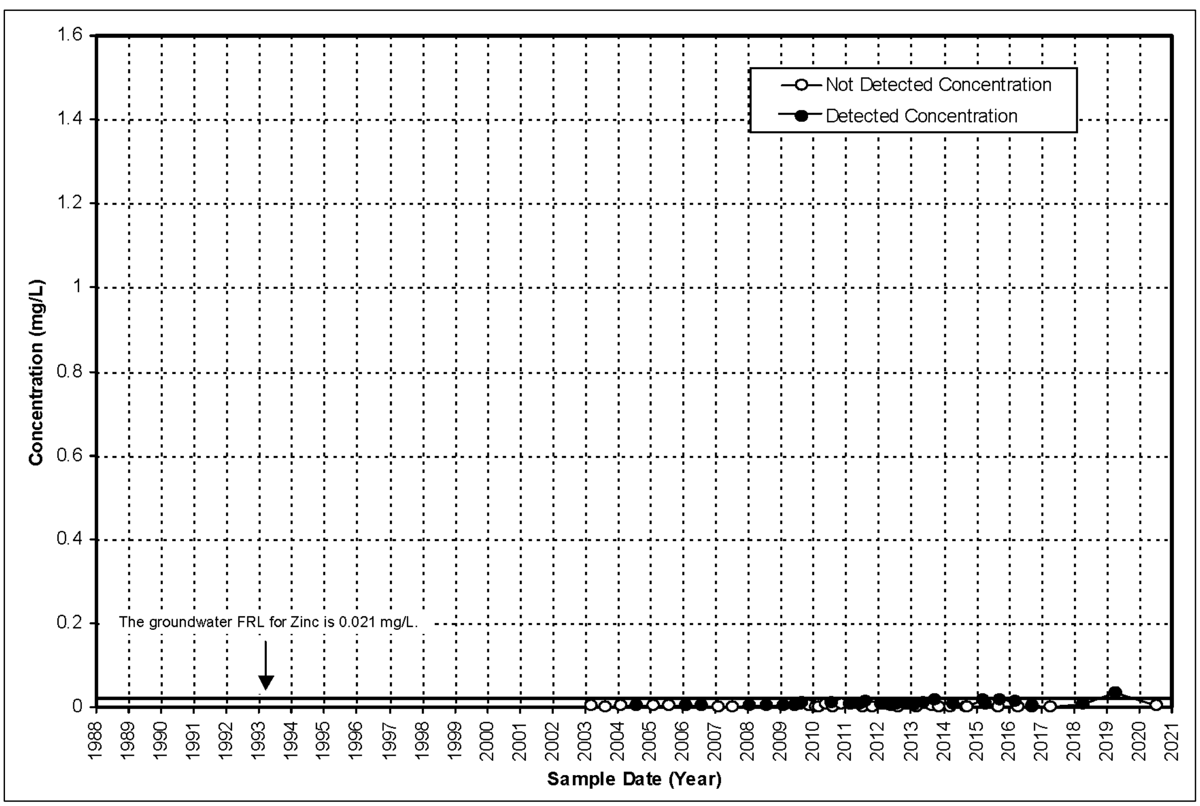


Figure A.4-3. Zinc Concentration Versus Time Plot for Monitoring Well 22205

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Attachment A.5

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Contents

Tables

Figures

Abbreviations

CAWWT	Converted Advanced Wastewater Treatment
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
LMICP	Legacy Management and Institutional Controls Plan
ODH	Ohio Department of Heath
Ohio EPA	Ohio Environmental Protection Agency
OSDF	On-Site Disposal Facility
OU5 RI/FS	Operable Unit 5 Remedial Investigation/Feasibility Study
SCL	Shewhart control limit

Measurement Abbreviations

ft	feet
gpad	gallons per acre per day
µg/L	micrograms per liter

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 at the Fernald Preserve, Ohio, Site. Monitoring and sampling were conducted in accordance with the *Comprehensive Legacy Management and Institutional Controls Plan* (LMICP), Attachment C, "Groundwater/Leak Detection and Leachate Monitoring Plan" (GWLMP) (DOE 2019a). 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 in the northeast area of the Fernald Preserve. It has a capacity of 2.96 million cubic yards and a maximum height of approximately 65 feet (ft). 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 completely 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):

- Multilayer composite cap system
- Leachate collection system (LCS)
- Leak detection system (LDS)
- Multilayer composite liner 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 is collected in tanks for sampling.

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 potential 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 by 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 and 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 and 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.
- The 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.
- The 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).

Information Organization

The 2020 OSDF leak detection and leachate monitoring information is organized into the following sections:

- Flow and Hydraulic Performance (Section A.5.1)
- Water Quality: Data Presentations and Evaluations (Section A.5.2)
- Cell Cap Inspections (Section A.5.3)
- Summary of Overall Performance and Findings and Recommendations (Section A.5.4)

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

Capacitance probes are used to measure water levels in each LCS tank. The water levels in the tanks are communicated to the Converted Advanced Wastewater Treatment (CAWWT) facility via radio signal. When the water level in the tank reaches 1.86 ft, the tank is approximately 80% full, and the pump automatically starts to pump water from the tank to the leachate lift station. The water in the lift station is pumped to the CAWWT facility backwash basin. To determine the volume of leachate pumped, the change in water level after pumping is converted to gallons using an equation from the tank manufacturer. If communication to the CAWWT facility is not functioning, tanks are pumped manually when tanks are between 40% and 80% full of water. In this case, volumes pumped are recorded manually on the leachate round sheet. Tanks are also pumped manually after each sampling event.

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 2020. Figure A.5-4 is a graph that shows the annual leachate volume from 2007 through 2020.

Leachate volumes shown in both figures are impacted by leachate line closures beginning in 2016 and continuing into 2019. Additional information concerning these closures is summarized in the table below. Contingencies for closing the valves are provided in the GWLMP in the 2019 LMICP (DOE 2019a). No line closures occurred in 2020.

From an operational perspective, when the leachate line valves are closed, water begins to collect on the liner of each cell. By design, 1 ft of water should not be allowed to accumulate on the liner. As discussed in the LMICP, 156 days is the current estimated minimum amount of days required to accumulate 1 ft of hydraulic head on the primary liner. As shown below, none of the closures exceeded 156 days.

Leachate Line Closure		Reason for Leachate Line Closure	Days Closed During Calendar Year
Shut Date	**Open Date**		
July 05, 2016	September 23, 2016[a]	Unplanned power outage	79
September 20, 2017	February 6, 2018[b]	CAWWT facility construction	103 (2017) and 37 (2018)
March 14, 2018	April 15, 2018	CAWWT facility construction	33
August 13, 2019	December 3, 2019[c]	CAWWT backwash basin refurbishment	112

[a] Valves were opened beginning September 23 and ending on September 30, 2016. Days reported are the maximum number of days for any cell.
[b] Valves were opened beginning February 2 and ending on February 6, 2018. Days reported are the maximum number of days for any cell.
[c] Valves were opened beginning December 3 and ending on December 6, 2019. Days reported are the maximum number of days for any cell.

Shutting the valves impacts the volume recorded for the facility over the calendar year. As reported in each annual Site Environmental Report for the year affected by valve closure, the reported leachate volumes either reflect a period that is less than a year, as in 2017, or the volume reported is more than a year, as in 2018. The effect of the relatively long period of leachate line closure that extended into the next reporting year affected the reporting of the leachate volumes for both 2017 and 2018. Leachate accumulation for 2017 reflected approximately 9 months of accumulation (75% of the year), whereas 2018 leachate accumulation reflected approximately 15 months (125% of the year). In 2019, the valves were closed for a planned shutdown to support the CAWWT backwash basin refurbishment discussed in Attachment A.1. The valves were shut for a period within the calendar year and do not affect the reporting of the volume in the same way as in 2017 and 2018.

Leachate volumes reported for 2019 reflect accumulation over the entire calendar year with the leachate valves being open 253 days (January 1 through August 13, and December 3 through December 31, 2019) during which time a total of 113,350 gallons of leachate were collected and pumped to the CAWWT backwash basin for subsequent treatment at the CAWWT facility.

Leachate volumes for 2020 reflect the entire calendar year with the valves open, during which time a total of 106,103 gallons of leachate were collected and pumped to the CAWWT backwash basin for subsequent treatment at the CAWWT facility. No additional closures of the OSDF leachate lines are planned in the next several years. Continued monitoring is expected to show that the annual leachate volume continues to decrease.

The volume of precipitation that fell on the OSDF in 2020 was approximately 61.1 million gallons (41.58 inches over 54.1 acres). The facility cap was designed to inhibit water from infiltrating the OSDF. Leachate collected in 2020 (106,103 gallons) represents approximately 0.17% of the 61.1 million gallons. This value indicates that in 2020 the cap was 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.

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 began 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. As explained below, the method of measuring flow in the LDS (for those cells that still have flow) has changed in response to the decreasing flow.

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 LDS flows are trending asymptotic at or near zero.

Through 2017, capacitance probes were used in the tank of each LDS to measure the water level within the tank. The capacitance probes can measure within hundredths of a foot of water in the bottom of the tank. Measured water levels were used to calculate the accumulation rate for each cell. Although water may register via the probes, there may not be enough water present to physically obtain a sample. Pumpout of the tank can occur automatically if an LDS tank water level reaches 80% of its capacity (1.86 ft of water). Pumpout also occurs after semiannual sampling is completed to remove any water that remains after sampling, to ensure newer water is sampled for the next semiannual sampling event.

In 2020, LDS tanks for Cells 1, 2, 3, 4, 5, and 7 were too dry to collect semiannual samples, so no pumpout occurred in these LDS tanks, resulting in an accumulation rate of 0.0 gpad. The LDS tanks in Cells 6 and 8 accumulated enough water to collect routine semiannual samples in 2020. However, the amount of water accumulated in each of those LDS tanks in 2020 was very low, so accumulation rates are estimated by tracking the volume of water manually pumped out of each LDS tank and the amount of time between pumpouts. To be conservative, a volume of 1 gallon was assumed for each sampling event. The calculation for estimated maximum accumulation rates based on tank pumpouts is summarized below.

Cell	Estimated Volume Pumped from LDS (gallons)	Estimated Maximum Accumulation Rate (gpad)
6	104	0.319
8	2	0.001

The *On-Site Disposal Facility Final Design Calculation Package* (DOE 1997) defines an initial response leakage rate for individual cells of 200 gpad. As a best management practice, the U.S. Department of Energy (DOE) imposed two lower leakage rates:

1. Initial Response Leakage Rate of 20 gpad
2. Low-Flow Response Leakage Rate of 2 gpad

The highest estimated maximum accumulation rate determined for 2020 (0.319 gpad in Cell 6) is only 16% of the low-flow response leakage rate of 2 gpad.

The 2020 estimated maximum LDS accumulation rates, the percent of the initial response leakage rate, and the percent of the low-flow response leakage rate for each cell are as follows.

Cell	2020 Estimated Maximum LDS Accumulation Rate Calculated from Tank Pumpouts (gpad)	Percent of Initial Response Leakage Rate	Percent of Low-Flow Response Leakage Rate
1	0.00	0.0	0.0
2	0.00	0.0	0.0
3	0.00	0.0	0.0
4	0.00	0.0	0.0
5	0.00	0.0	0.0
6	0.319	1.6	16.0
7	0.00	0.0	0.0
8	0.001	0.005	0.05

These estimated LDS accumulation rates indicate that the liner systems for the cells are performing well and within the specifications outlined in the approved OSDF design, as illustrated in Figure A.5-5. The initial response leakage rate of 20 gpad and the low-flow response leakage rate of 2 gpad are administrative criteria for commencing an investigation into the possibility that the cell is not performing as designed. They are one-tenth and one-hundredth of the design criterion of 200 gpad, respectively. Because all 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.

In 2020, the LDS tanks in 6 of the 8 cells (Cells 1, 2, 3, 4, 5, and 7) were dry (0.0 gpad). The estimated maximum accumulation rate measured for the remaining two cells that had flow in the LDS in 2020 (Cells 6 and 8) was only 0.319 gpad. The current LDS tanks hold approximately 300 gallons of water, making them oversized for current LDS flow conditions. In the 2018 Site Environmental Report, DOE reported plans to install tubing at an existing sampling port upstream of the LDS tank to provide a means to divert any future flow into a 5-gallon container. The thought was that the smaller container would better facilitate future sampling events and LDS flow measurement capabilities. Given that the LDS systems continue to dry up, DOE decided not to install the sampling ports. DOE will reevaluate the need to install the smaller sampling ports as deemed appropriate.

A.5.1.3 Liner Efficiencies

Cell-specific apparent liner hydraulic efficiencies are calculated using the following equation:

$$\text{Hydraulic efficiency} = [1 - (\text{Volume}_{LDS}/\text{Volume}_{LCS})] \times 100$$

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.

As stated previously, the LDSs in Cells 1, 2, 3, 4, 5 and 7 were dry in 2020, resulting in an LDS volume equal to 0 for the purposes of calculating the liner efficiency. Since 2019, liner efficiencies of only those cells that had LDS volumes greater than 0 are reported (Cells 6 and 8 for 2020).

Apparent Liner Efficiency (Percent), Quarterly for 2020

Quarter	Cell 6	Cell 8
First	100.00	100.00
Second	99.13	100.00
Third	96.81	100.00
Fourth	100.00	100.00

A.5.1.4 HTW Water Yields

HTW water yields are monitored at each cell to document trends in perched-water purge volumes. In 2020, the HTWs were purged twice (March and September). Average annual 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. Further information (total volumes pumped, number of months purged, and the average monthly purge volume) is provided in each cell's subattachment.

Horizontal Till Well Purge Events for 2020

Location ID	Cell	First Half Purge March 11, 2020 (Gallons)	Second Half Purge September 9, 2020 (Gallons)	Annual Total (Gallons)	Annual Average (Gallons)
12338	**Cell 1**	490	560	1,050	525
12339	**Cell 2**	820	825	1,645	823
12340	**Cell 3**	830	720	1,550	775
12341	**Cell 4**	470	530	1,000	500
12342	**Cell 5**	1,050	1,050	2,100	1,050
12343	**Cell 6**	455	285	740	370
12344	**Cell 7**	535	425	960	480
12345	**Cell 8**	Dry	Dry	Dry	Dry
	Totals	4,650	4,395	9,045	Not Applicable

A.5.2 Water Quality: Data Presentations and Evaluations

The water quality and data presentations and 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)
- Bivariate Plots (Section A.5.2.4)
- Upward Concentration Trends in the HTW and GMA Wells (Section A.5.2.5)

A.5.2.1 Semiannual Monitoring Summary Statistics

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. Until 2014, quarterly water quality monitoring occurred in the LCS, LDS, HTW, and GMA wells of each cell. With

U.S. Environmental Protection Agency (EPA) and Ohio Environmental Protection Agency (Ohio EPA) concurrence, at the start of 2014 monitoring changed from a quarterly sampling frequency to a semiannual sampling frequency.

With EPA and Ohio EPA concurrence, DOE reduced the number of parameters sampled from 24 to 13 beginning in January 2017 (total uranium, boron, sodium, sulfate, calcium, lithium, magnesium, nitrate + nitrite as nitrogen, potassium, selenium, technetium-99, total dissolved solids, and total organic halogens). All 13 parameters are sampled in the GMA wells; 4 of the 13 parameters (total uranium, boron, sodium, and sulfate) are sampled in the LCS, LDS, and HTW for each cell. The annual sampling in the LCS of each cell for the abbreviated list of Appendix I parameters and polychlorinated biphenyls listed in *Ohio Administrative Code* 3745-27-10 was eliminated beginning in January 2017 with EPA and Ohio EPA concurrence.

Summary statistics for all of the parameters monitored semiannually are provided in Subattachments A.5.1 through 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. Baseline data are included in the summary statistics. A discussion of data collected for the OSDF is provided in the "Groundwater/Leak Detection and Leachate Monitoring Plan" (Attachment C of the LMICP).

The summary of the statistical process used is illustrated in Figure A.5-6. Table A.5-2 lists the rules that are used to report the data provided in Tables A.5.1-1 through 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 in 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 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 four were collected; in 1999 there were seven; in 2000 there were six; and four each were collected in 2001 through 2003. To summarize, 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 periods with more sampling activity would carry more weight and, therefore, with respect to the calculations, would be considered more important. Additionally, sampling the same well at too short of an interval (often just 1 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.

Statistical calculations were conducted using ChemStat, Version 6.3, (a Starpoint Software program). ChemStat software is also 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.

As discussed in the *Fernald Preserve 2015 Site Environmental Report* (DOE 2016), low flow rates, coupled with LDS collection tanks that are open to the atmosphere, can bias analytical results high for some constituents and low for others. Because of the low-flow conditions, it is uncertain whether an LDS sample 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 LMICP "Groundwater/Leak Detection and Leachate Monitoring Plan" (DOE 2019a), monitoring accumulation rates from the LDS against established design and agreed-to administrative action rates is a much better approach.

A.5.2.2 Concentration Plots

Concentration plots for the parameters monitored semiannually in 2020 are presented in Subattachments A.5.1 through A.5.8. The plots are presented with a common vertical *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.

Table A.5.3 provides an OSDF Groundwater, Leachate, and LDS Monitoring Summary. As shown in Table A.5-3 and listed below, four new high total uranium concentrations were detected in 2020. Two were in the LDS horizon, one in the LCS horizon, and one was in the GMA.

- **GMA of Cell 2:** A new high of 4.69 micrograms per liter (µg/L) was measured in the second half of 2020 in the upgradient GMA well (22200). The previous high was 1.93 µg/L. The concentration measured in the first half of 2020 was 0.202 µg/L.
- **LCS of Cell 4:** A new high of 234 µg/L was measured in the first half of 2020. The previous high was 171 µg/L. The concentration measured in the second half of 2020 was 85.8 µg/L.
- **LDS of Cell 6:** A new high of 144 µg/L was measured in the second half of 2020. The previous high was 115 µg/L. The concentration measured in the first half of 2020 was 129 µg/L.
- **LDS of Cell 8:** Two new highs were measured in 2020. In the first half of 2020, a concentration of 120 µg/L was measured. In the second half of 2020, a concentration of 209 µg/L was measured. The previous high was 102 µg/L.

Bivariate plot results reported in Section A.5.2.4 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, new high uranium concentrations measured beneath the cells in GMA wells are attributed to fluctuating ambient concentrations beneath the cell and are not related to cell performance.

The new high uranium concentrations measured in the LDS of Cells 6 and 8 in 2020 are not attributed to communication with the LCS. A new high uranium concentration measured in the LDS is attributed to the impact that decreasing flow can have on the uranium concentration left in fluid remaining in the LDS, as the LDS dries up. Uranium concentration versus time plots for each cell are provided in Subsections A.5.1 through A.5.8. As shown in these figures, with the exception of Cell 3 LDS, an increasing uranium concentration trend was clearly observed in the LDS of other cells as they were drying up (Cells 1, 2, 4, 5, and 7). For Cell 3 the last sample collected showed an increasing uranium concentration, but the overall trend in the Cell 3 LDS leading up to the last sample was not increasing. The LDS of each cell is expected to dry up over time, and this indicates that the facility continues to operate as designed.

Figures A.5-7 and A.5-8 illustrates the trends observed at the two remaining cells that had enough fluid left in the LDS to sample in 2020 (Cells 6 and 8). Each figure shows three graphs, with a general trend line. The upper graph is the total uranium concentration versus time in the LDS fluid. The middle graph is the accumulation of fluid in gallons in the LDS, and the lower graph is the mass of uranium contained within the accumulated volume of fluid. The graphs illustrate that as the LDS dries up (decreasing accumulation volume), the uranium concentrations increase while the mass of uranium in the accumulated fluid does not show an overall increasing trend.

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 "not in 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 at least 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 and a value of 4.5 for the SCL.

EPA Statistical Analysis 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 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 was defined as 5 to equal the recommended CUSUM control limit (*h*). This combined limit is identified as *h*CL on the control charts. For interpretation purposes, the *h*CL will be regarded as the CUSUM control limit (*h*).

Twenty-five Shewhart-CUSUM control charts were prepared in 2020 and are presented in Subattachments A.5.1 through A.5.8 for parameters monitored semiannually in the HTW and GMA wells in 2020 that had data sets that achieved control chart criteria (i.e., more than eight samples, normal or lognormal distribution, no trend, and no serial correlation). All of the 25 control charts exhibited “in control” conditions.

A.5.2.4 Bivariate Plots

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 2008). 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. In 2020 the uranium concentration in the LCS of Cell 1 decreased enough to place it in the area of the bivariate plot occupied by HTW samples. The LDS of Cell 1 was dry in 2020. An additional bivariate plot of sodium-sulfate is provided for Cell 1 to illustrate that the sodium and sulfate concentrations indicate that the LCS and HTW zones are not mixing. Other combinations may be added in the future, if deemed appropriate.

Bivariate plots are presented for each cell in Subattachments A.5.1 through A.5.8. The bivariate plots illustrate the concentration signatures 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 were dated until 2018. Beginning with the *Fernald Preserve 2018 Site Environmental Report* (DOE 2019b), an arrow is provided on the plots from the first to most recent sample result for each monitoring horizon. The dates of the first and most recent sample plotted are also posted for each sampling horizon.

An additional bivariate plot for sodium–sulfate is presented for Cell 1 in Subattachment A.5.1. The additional sodium–sulfate bivariate plot provides supporting information concerning the water chemistry signatures present in the LCS and HTW of Cell 1—specifically, that they are separate and distinct.

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 present in the LDS and HTW of Cell 8—specifically, that they are separate and distinct.

The bivariate plots for 2020 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 2020 (HTW and/or GMA wells) are attributed to fluctuating ambient concentrations beneath the cell not related to cell performance.

In light of the water quality sampling challenges discussed in the 2016 Site Environmental Report (DOE 2017), DOE conducted an assessment to determine if the continued use of bivariate plots with data from the LDS is still warranted. Assessment results indicated that bivariate plots continue to be a valuable tool for assessing whether the monitoring zones are mixing (Geochemical Consultants 2016).

A.5.2.5 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 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. Trends are therefore being tracked in all GMA wells at this time.

An increasing concentration trend in a HTW or 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, and not connected to the operation of the facility.

As presented in Subattachments A.5.1 through A.5.8, several parameter datasets have upward concentration trends beneath the OSDF (i.e., HTW and GMA wells). Bivariate plots (uranium–sodium, uranium–sulfate, and sodium–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 HTW and 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 and include the toe of the side slopes, the drainage features around the base of the cell cap, and the fence line. In 2020 inspections were conducted in March, June, September, and December. A complete inspection of the cell cap is conducted annually. The inspection team typically includes representatives from Ohio EPA, Ohio Department of Health (ODH), and the site contractor. However, due to the State of Ohio response to the COVID-19 pandemic, Ohio EPA and ODH employees were not able to participate in all of the OSDF inspections in 2020. ODH participated in the June inspection. Ohio EPA participated in the September and December 2020 inspections by means of a virtual platform. Issues identified during inspections typically include rocks that surface as topsoil settles, animal burrows and digging, the presence of woody vegetation, and noxious and herbaceous species.

The issues are addressed as follows:

- Rocks greater than 4 inches in diameter 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.
- Woody vegetation is cut and stumps are treated with herbicide.
- Herbicide is applied to noxious weeds.

Following each inspection, a report is submitted to EPA and Ohio EPA, documenting the inspection and issues and stating how issues will be addressed. These reports are available to the public on the Fernald Preserve website at https://www.lm.doe.gov/fernald/sites.aspx. In 2020, there were no visual signs that the integrity of the cap had been compromised in any way. Appendix C provides additional information regarding the OSDF cap inspections and findings.

A.5.4 Summary of Overall Performance and Findings and Recommendations

Based on LCS and LDS flow data, the engineered cap, liners, and 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 (total uranium and sulfate in Cell 8, sodium-sulfate in Cell 1) 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. Surface inspections conducted in 2020 showed no visual signs that the integrity of the cap had been compromised in any way. It is therefore recommended that the only action to take at this time concerning the OSDF is to continue monitoring the facility as prescribed in the GWLMP.

Specific findings:

- LCS volumes continue to diminish with time. Total facility leachate volume in 2020 was 6.4% less than in 2019 (approximately 106,103 gallons in 2020 compared to 113,350 gallons in 2019).
- In 2020 there was not enough water in the LDS of Cells 1, 2, 3, 4, 5, and 7 to collect a water sample.
- LDS accumulation rates for 2020 in Cells 6 an 8 indicate that the liner systems are performing as designed. The largest estimated LDS maximum accumulation rate calculated

in 2020 was 0.319 gpad in Cell 6, approximately 1.6% of the initial response leakage rate of 20 gpad, and 16% of the low-flow response leakage rate of 2 gpad.

- Quarterly apparent liner efficiencies (with the exception of Cell 6 in the third quarter, 96.81%) were consistently greater than 99% for all cells in 2020.
- Four new high total uranium concentrations were detected in 2020. One was in the GMA, one was in the LCS, and two were in the LDS.
  - **GMA of Cell 2:** A new high of 4.69 µg/L was measured in the second half of 2020 in the upgradient GMA well (22200). The previous high was 1.93 µg/L. The concentration measured in the first half of 2020 was 0.202 µg/L.
  - **LCS of Cell 4:** A new high of 234 µg/L was measured in the first half of 2020. The previous high was 171 µg/L. The concentration measured in the second half of 2020 was 85.8 µg/L.
  - **LDS of Cell 6:** A new high of 144 µg/L was measured in the second half of 2020. The previous high was 115 µg/L. The concentration measured in the first half of 2020 was 129 µg/L.
  - **LDS of Cell 8:** Two new highs were measured in 2020. In the first half of 2020, 120 µg /L was measured. In the second half of 2020, 209 µg/L was measured. The previous high was 102 µg/L.
- Bivariate plots continue to show that the chemical signatures for uranium, sulfate, and sodium in the LCS, LDS, and HTW are separate and distinct, indicating that:
  - Mixing between the horizons is not occurring; therefore, concentration changes measured beneath the cells in GMA wells are attributed to fluctuating ambient concentrations beneath the cell and are not related to cell performance.
  - New high uranium concentrations measured in the LDS are not attributed to communication with the LCS. The new high uranium concentrations measured in the LDS are attributed to the impact that decreasing flow can have on the uranium concentration left in water remaining in the LDS, as the LDS dries up.
- In 2020, 25 datasets met the criteria for Shewhart-CUSUM control charts. All of the control charts exhibited “in control” conditions.
- In 2020, quarterly physical inspections of the OSDF revealed no visual signs that the integrity of the OSDF cap had been compromised.

A.5.5 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. OSDF Initiation and Completion Dates (continued)

Cell	Sample Initiation per Horizon[a]	Waste Placement Initiation	LDS Volume Measurement Initiation[b]	Cap Geomembrane Layer Completion[c]	Cap Completion[d]
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, 2006
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, 2006

[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	Minimum [a,b]	Maximum[a,b]	Average	Standard Deviation	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 "Insufficient"	report "Insufficient"	report "Insufficient"	report "Insufficient"	report "Insufficient"	
Only two results	Yes	Yes	Yes	report value	report value	report "Insufficient"	report "Insufficient"	report "Insufficient"	report "Insufficient"	report "Insufficient"	
All non-detects	Yes	Yes	Yes	report "ND"	report "NA"	report "Insufficient"	report "Insufficient"	report "Insufficient"	report "Insufficient"	report "Insufficient"	
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 detects 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.

Table A.5-3. OSDF Groundwater, Leachate, and LDS Monitoring Summary

Cell (Waste Placement)	Monitoring Location	Monitoring Zone	Date Sampling Started	Total Number of Samples	Range of Total Uranium Concentrations[a,b] (µg/L)	First Half 2020[a,c] (µg/L)	Second Half 2020[a,c] (µg/L)	Historical Trend[d] (Year Last Sampled)
Cell 1 (Dec 1997)	12338C	LCS	Feb 17, 1998	74	ND–206	9.16	7.58	Up (2020)
	12338D	LDS	Feb 18, 1998	37	1.50–37.0	DRY	DRY	Up (2011)
	12338	Glacial Till	Oct 30, 1997	83	ND–19	7.84	8.22	Up (2020)
	22201	Great Miami Aquifer	Mar 31, 1997	90	ND–12.4	9.82	6.68	Up (2020)
	22198	Great Miami Aquifer	Mar 31, 1997	137	0.540–15.2	3.31	3.11	None (2020)
Cell 2 (Nov 1998)	12339C	LCS	Nov 23, 1998	70	4.51–686	277	110	Up (2020)
	12339D	LDS	Dec 14, 1998	29	4.08–25.8[e]	DRY	DRY	None (2013)
	12339	Glacial Till	Jun 29, 1998	94	ND–36.9	15.1	16.8	Up (2020)
	22200	Great Miami Aquifer	Jun 30, 1997	85	ND–**4.69**	0.202	**4.69**	Up (2020)
	22199	Great Miami Aquifer	Jun 25, 1997	114	ND–12.1	0.336	2.35	Down (2020)
Cell 3 (Oct 1999)	12340C	LCS	Oct 13, 1999	68	9.27–206	128	116	Up (2020)
	12340D	LDS	Aug 26, 2002	20	8.90–27.7[e]	DRY	DRY	Down (2007)
	12340	Glacial Till	Jul 28, 1998	87	ND–58.5	17.8	18.4	None (2020)
	22203	Great Miami Aquifer	Aug 24, 1998	80	ND–15.4	11.9	5.32	Up (2020)
	22204	Great Miami Aquifer	Aug 24, 1998	109	ND–22.9	3.27	5.55	Up (2020)
Cell 4 (Nov 2002)	12341C	LCS	Nov 04, 2002	54	4.41–**234**	**234**	85.8	None (2020)
	12341D	LDS	Nov 04, 2002	40	5.74–55.9	DRY	DRY	Up (2019)[f]
	12341	Glacial Till	Feb 26, 2002	67	**3.76**–7.91	3.80	**3.76**	Down (2020)
	22206	Great Miami Aquifer	Nov 06, 2001	71	ND–5.78	1.17	2.34	Up (2020)
	22205	Great Miami Aquifer	Nov 05, 2001	96	0.446–19.7	1.30	5.90	None (2020)
Cell 5 (Nov 2002)	12342C	LCS	Nov 04, 2002	56	3.39–285	206	130	None (2020)
	12342D	LDS	Nov 04, 2002	40	2.93–27.1	DRY	DRY	Down (2013)
	12342	Glacial Till	Feb 26, 2002	68	7.45–21.1	8.28	8.59	Down (2020)
	22207	Great Miami Aquifer	Nov 06, 2001	71	ND–4.48	0.344	0.347	Down (2020)
	22208	Great Miami Aquifer	Nov 05, 2001	95	ND–2.1	0.364	0.358	None (2020)

Table A.5-3. (continued) OSDF Groundwater, Leachate, and LDS Monitoring Summary

Cell (Waste Placement)	Monitoring Location	Monitoring Zone	Date Sampling Started	Total Number of Samples	Range of Total Uranium Concentrations[a,b] (µg/L)	First Half 2020[a,c] (µg/L)	Second Half 2020[a,c] (µg/L)	Historical Trend[d] (Year Last Sampled)
Cell 6 (Nov 2003)	12343C	LCS	Oct 27, 2003	53	8.03–276	123	119	Down (2020)
	12343D	LDS	Oct 27, 2003	52	3.1–**144**	129	**144**	Up (2020)
	12343	Glacial Till	Mar 14, 2003	60	ND–24.2	12.9	9.33	Up (2020)
	22209	Great Miami Aquifer	Dec 16, 2002	66	ND–2.43	0.454	0.736	Down (2020)
	22210	Great Miami Aquifer	Dec 16, 2002	90	ND–1.02	0.674	0.750	None (2020)
Cell 7 (Sep 2004)	12344C	LCS	Sep 02, 2004	49	4.72–355	176	107	Down (2020)
	12344D	LDS	Sep 02, 2004	29	12.2–169[e]	DRY	DRY	Up (2015)
	12344	Glacial Till	Feb 24, 2004	57	0.674–12.1	3.45	3.88	Up (2020)
	22212	Great Miami Aquifer	Jan 21, 2004	59	ND–5.53	0.422	0.426	None (2020)
	22211	Great Miami Aquifer	Jan 21, 2004	80	ND–4.31	0.433	0.995	None (2020)
Cell 8 (Dec 2004)	12345C	LCS	Oct 18, 2004	46	1.51–335	95.5	149	None (2020)
	12345D	LDS	Oct 18, 2004	43	9.38–**209**	120	**209**	Up (2020)
	12345	Glacial Till	May 19, 2004	20	3.48–7.3	DRY	DRY	Up (2008)
	22213	Great Miami Aquifer	Mar 31, 2004	58	ND–0.71	0.353	0.457	Up (2020)
	22214	Great Miami Aquifer	Mar 31, 2004	80	ND–2.95	0.243	1.15	Down (2020)
	22215	Great Miami Aquifer	Aug 22, 2005	49	ND–16.4	0.534	0.486	None (2020)
	22217[g]	Great Miami Aquifer	Aug 22, 2005	48	ND–18.3	6.33	6.34	Down (2020)

Note: The data on this table represent the raw data from the database. However, data presented in the Attachment A.5 subattachments has gone through a statistical processing and analysis. In regard to the statistical processing, the data was quarterized (normalized to one result per quarter) and outliers were removed to arrive at an accurate distribution model. Because of the processing, the total number of samples and range of concentrations on this table might not match the text, tables, and figures in Attachment A.5. The rules used for the statistical processing and analysis in Attachment A.5 are discussed in Section A.5.2.1, and the results are summarized in Table A.5-2.

Note: Uranium concentration versus time graphs can be found in the Attachment A.5 subattachments. See Figures A.5.1-5A and A.5.1-5B for Cell 1; Figures A.5.2-5A and A.5.2-5B for Cell 2; Figures A.5.3-5A and A.5.3-5B for Cell 3; Figures A.5.4-5A and A.5.4-5B for Cell 4; Figures A.5.5-5A and A.5.5-5B for Cell 5; Figures A.5.6-5A and A.5.6-5B for Cell 6; Figures A.5.7-5A and A.5.7-5B for Cell 7; and Figures A.5.8-7A and A.5.8-7B for Cell 8.

[a] **Bold text** indicates a new high or low detected in 2020.
[b] ND = not detected.
[c] Where there are more than two data points for the half year, the higher result is used.
[d] The trends presented here are based on nonparametric Mann-Kendall procedure and come from the tables in Attachment A.5 subattachments for each cell. See Tables A.5.1-1, A.5.2-1, A.5.3-1, A.5.4-1, A.5.5-1, A.5.6-1, A.5.7-1, and A.5.8-1.
[e] Some data are not considered representative of LDS in Cell 2 (December 14, 1998, through May 23, 2000, data set) due to malfunction in Cell 2 leachate pipeline and resulting mixing of individual flows. It is suspected that some November 2004 samples were switched (i.e., 12339C with 12339D, and 12340C with 12340D). If data from these events were included above, maximum total uranium concentrations would be 71 µg/L for 12339D and 72.4 µg/L for 12340D. It is suspected that samples were switched in 2014 (i.e., 12344D with the field duplicate for 12345C). If the data point from this sampling event was not included above, maximum total uranium concentration for 12344D would be 37.6 µg/L.
[f] The Cell 4 LDS was dry, resulting in no data from fourth quarter 2011 through 2016.
[g] Monitoring location 22216 was plugged and abandoned in April 2006. Monitoring location 22217 is its replacement. The results listed for location 22217 also include the results for location 22216.

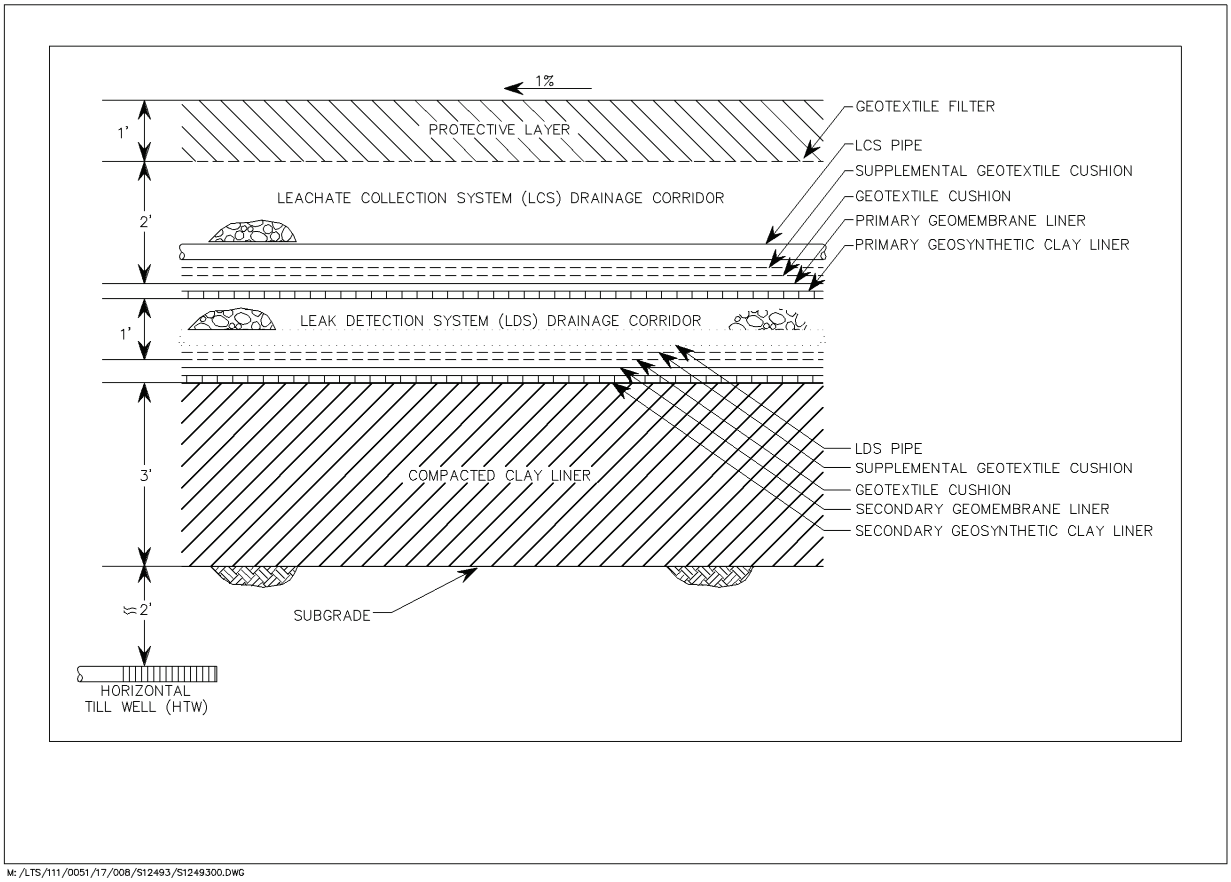

Figure A.5-1. Cross Section of On-Site Disposal Facility Liner System with HTW at the Drainage Corridor

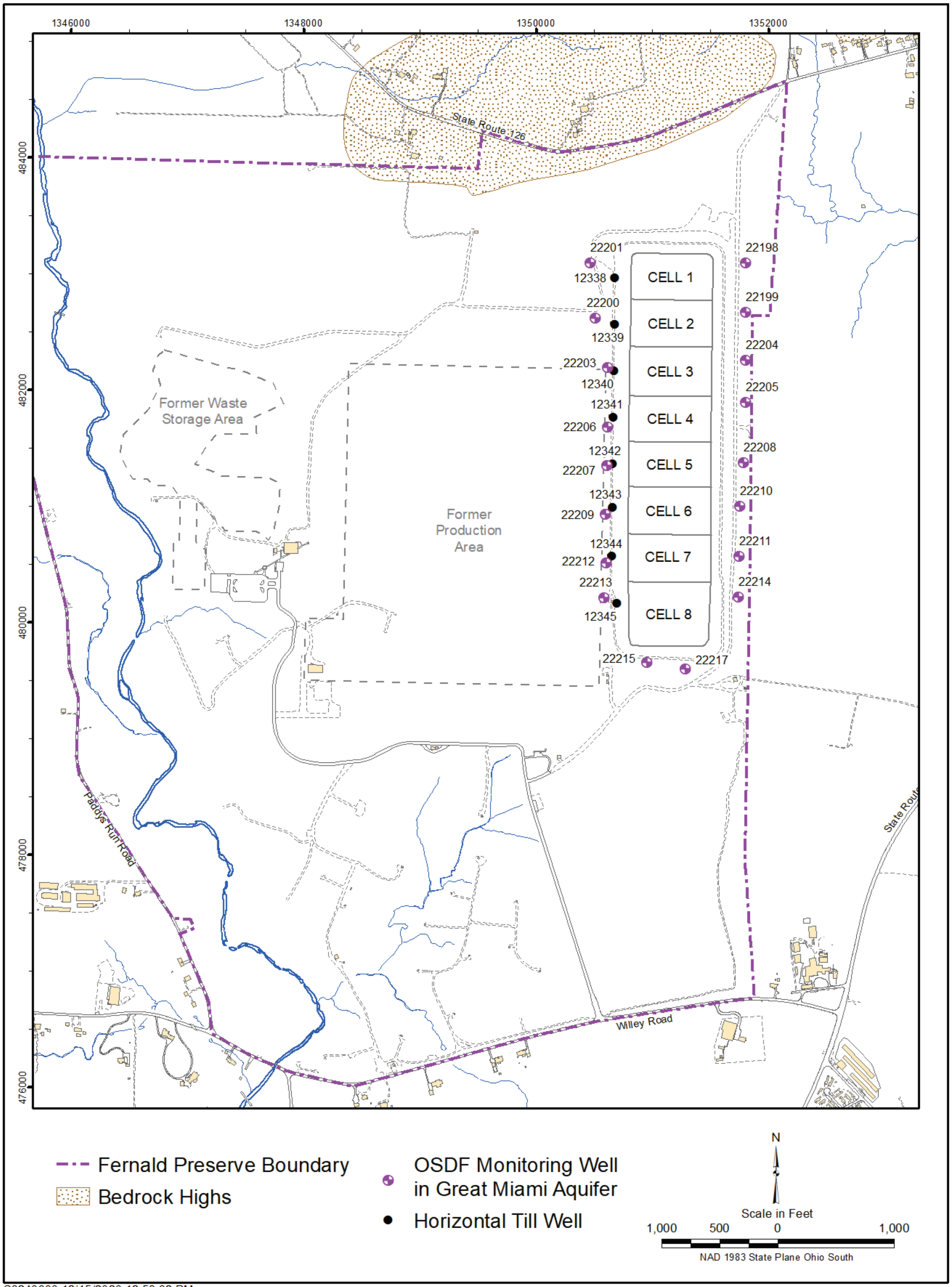

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Figure A.5-2. OSDF Footprint and Monitoring Well Locations

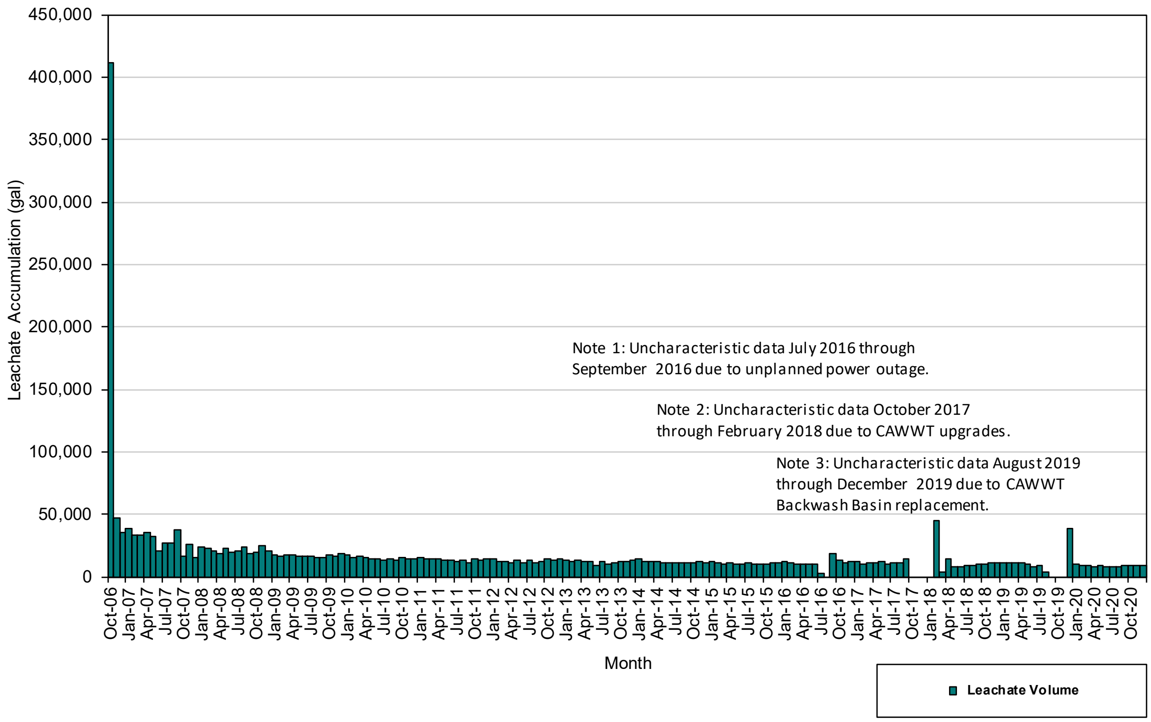

Figure A.5-3. OSDF Monthly LCS Flow (October 2006 Through December 2020)

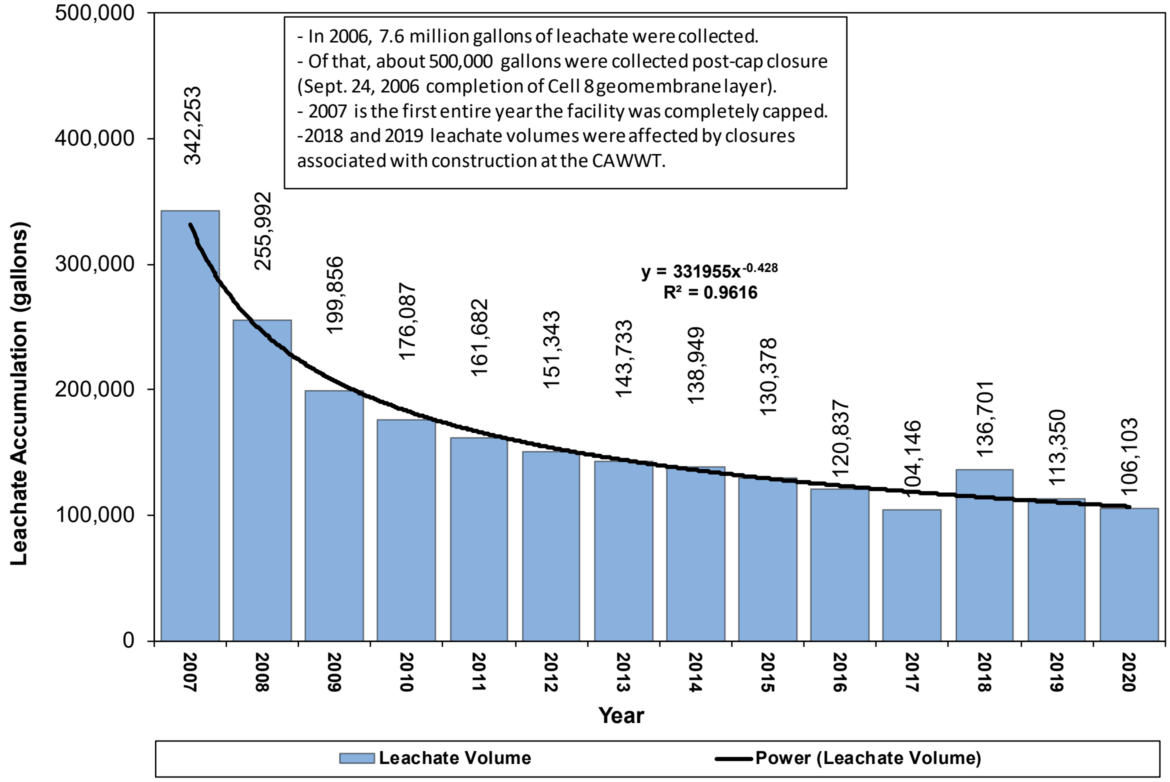

Figure A.5-4. OSDF Annual LCS Flow (2007 Through 2020)

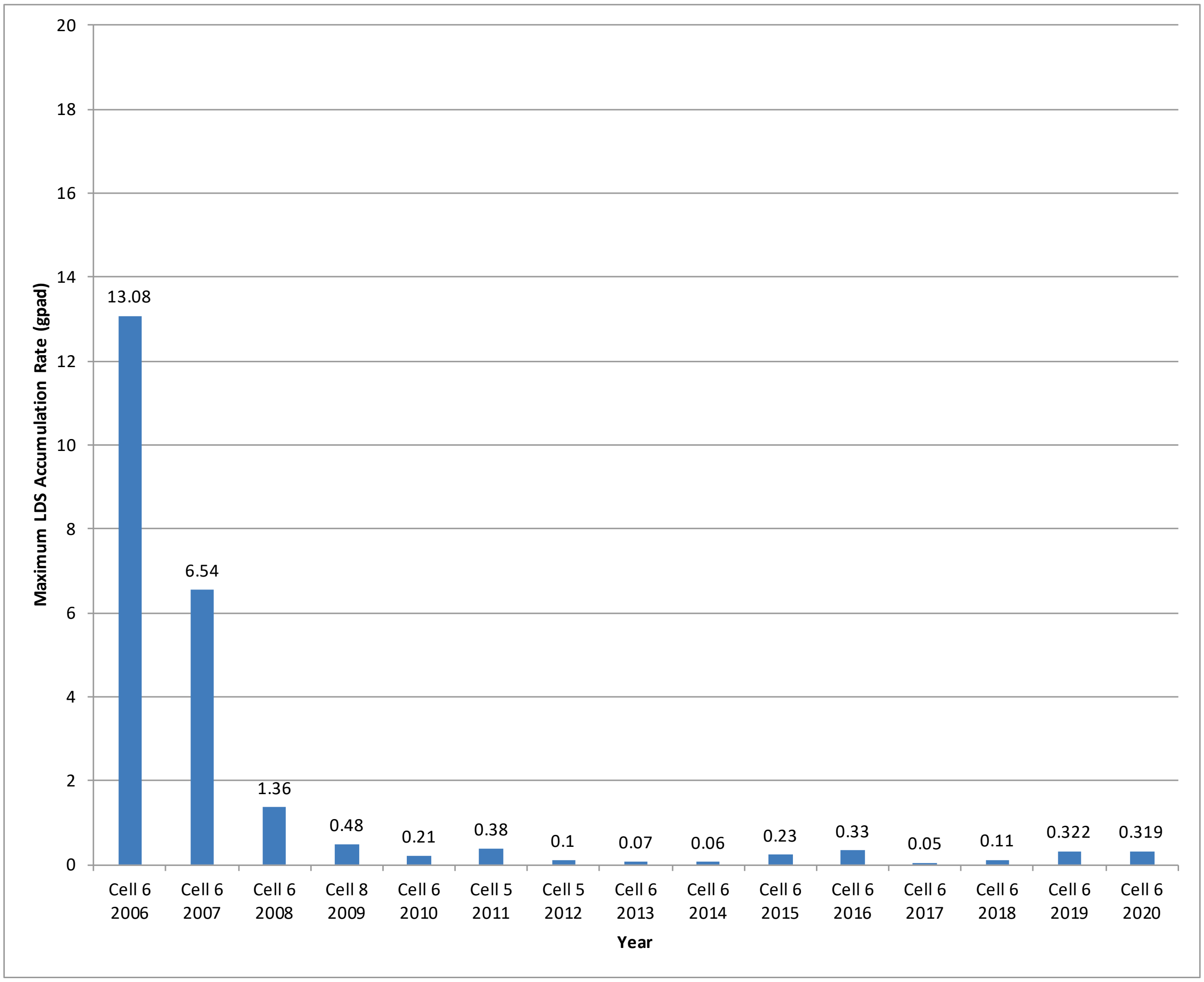

Figure A.5-5. Maximum LDS Accumulation Rate Between 2006 and 2020

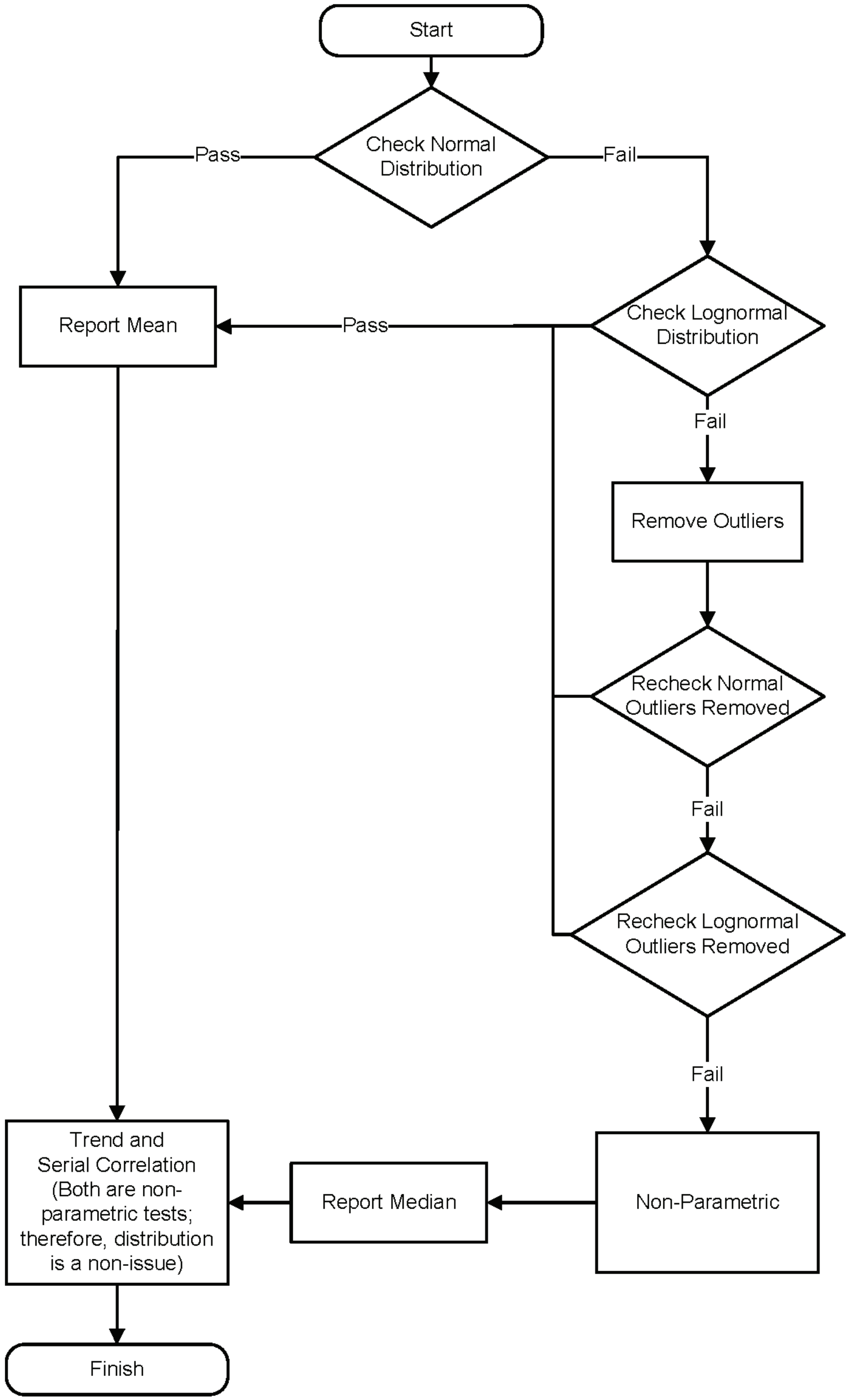

Figure A.5-6. OSDF Statistical Evaluation Process

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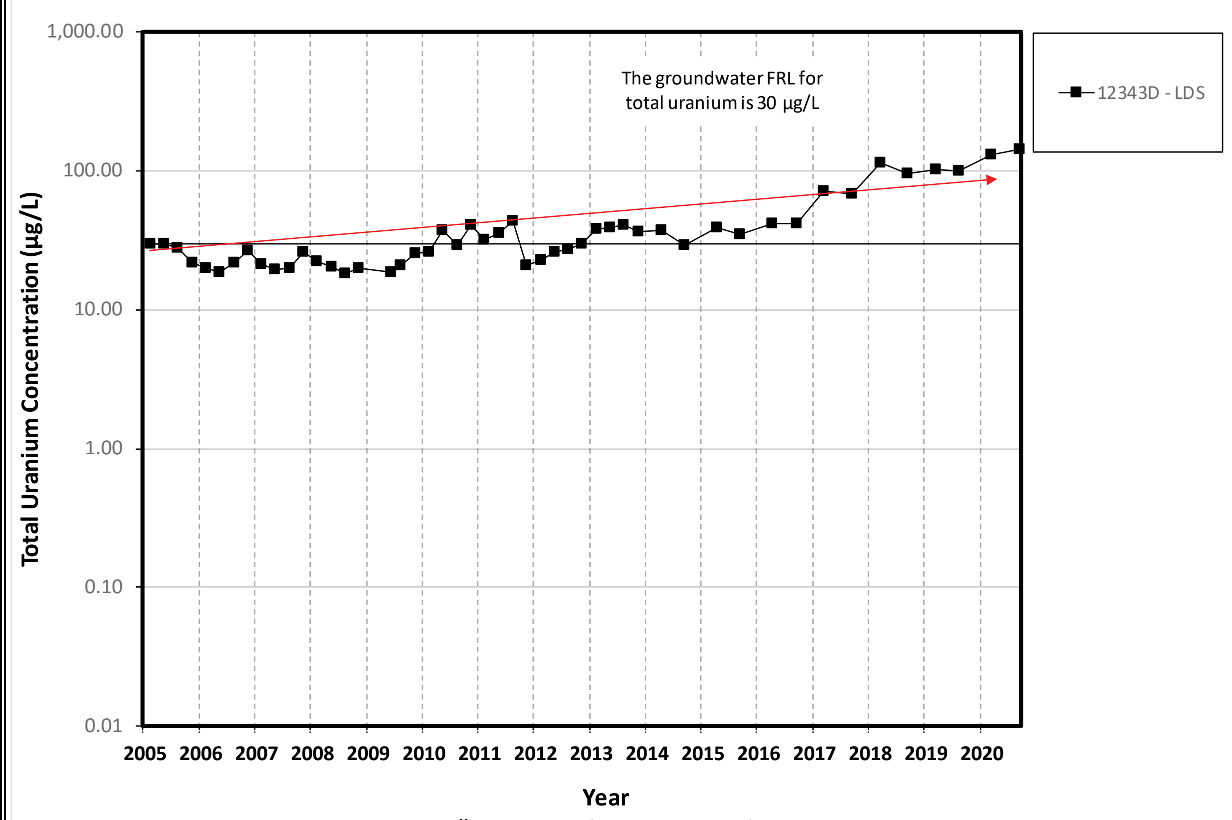
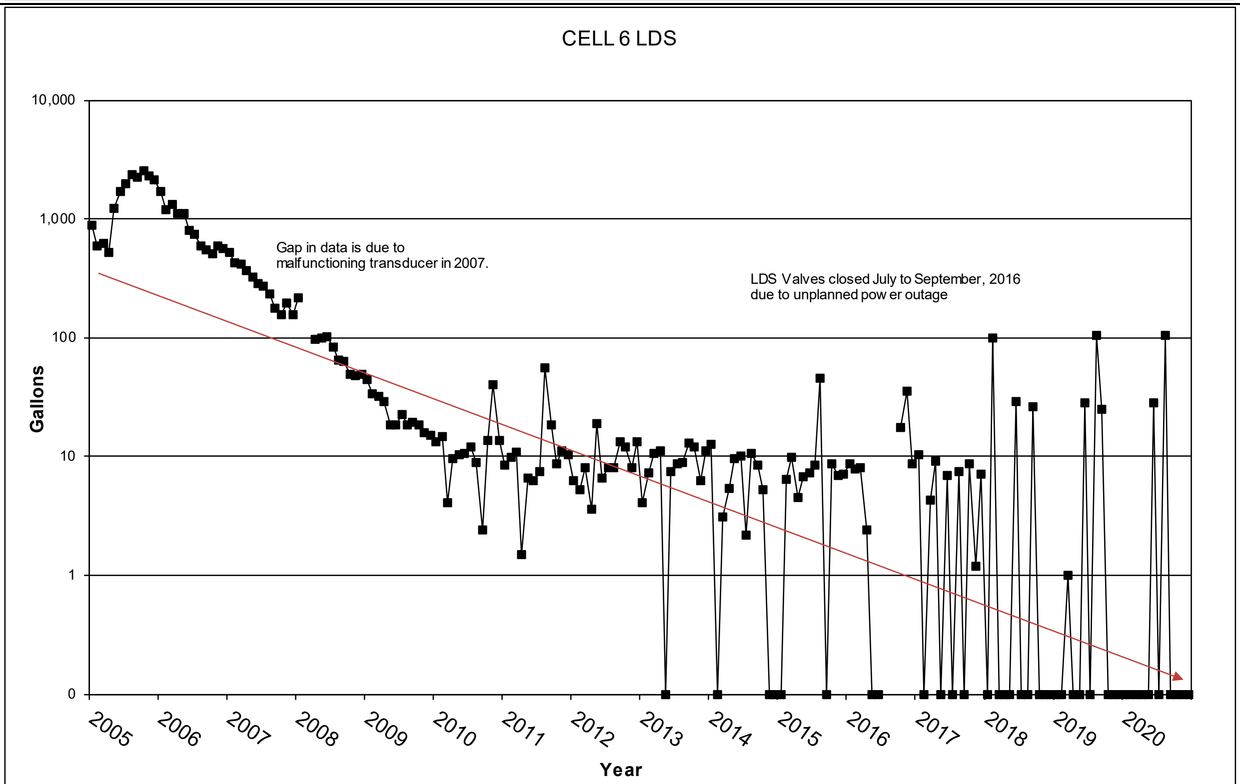
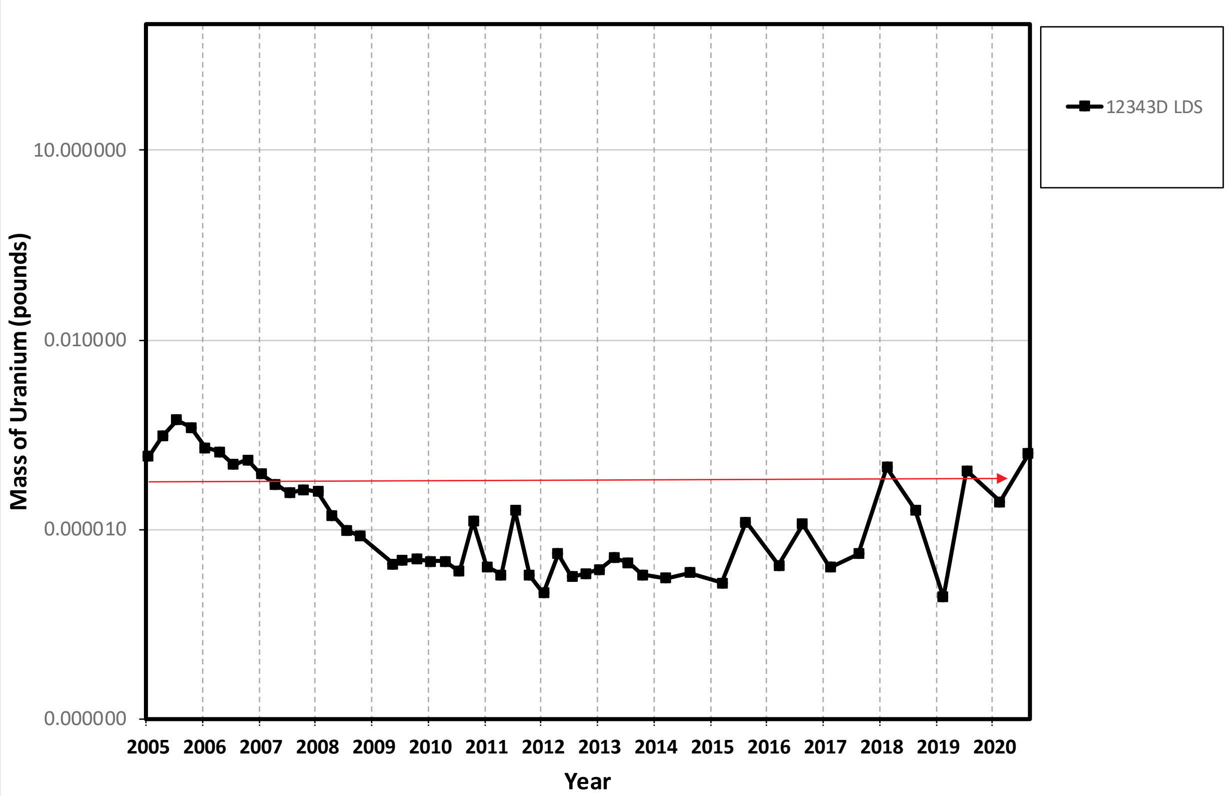


Cell 6 LDS Uranium Concentration



Cell 6 LDS Accumulaion



Cell 6 LDS Uranium Mass

Figure A.5-7. Cell 6 LDS Concentration, Accumulation Rate, and Uranium Mass Comparison

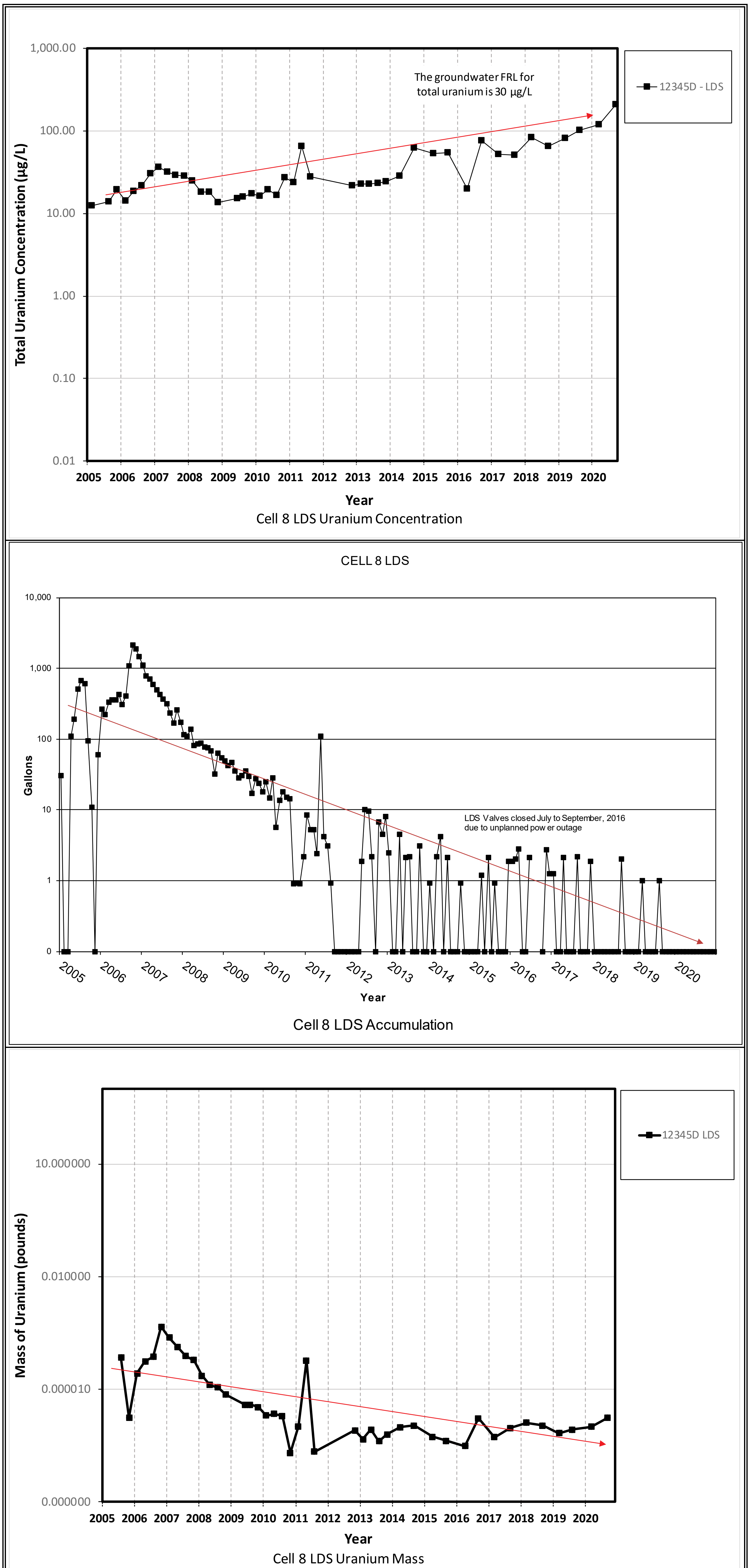


Figure A.5-8. Cell 8 LDS Concentration, Accumulation Rate, and Uranium Mass Comparison

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Subattachment A.5.1

Cell 1

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Contents

Tables

Figures

Abbreviations

CUSUM	Shewhart-cumulative sum
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
GMA	Great Miami Aquifer
GMA-D	Great Miami Aquifer–downgradient
GMA-U	Great Miami Aquifer–upgradient
HTW	horizontal till well
LCS	leachate collection system
LDS	leak detection system
Ohio EPA	Ohio Environmental Protection Agency
OSDF	On-Site Disposal Facility
SCL	Shewhart control limit

Measurement Abbreviations

amsl	above mean sea level
µg/L	micrograms per liter
mg/L	milligrams per liter
pCi/L	picocuries per liter

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This subattachment provides the following information about On-Site Disposal Facility (OSDF) Cell 1:

- Semiannual monitoring summary statistics (refer to Table A.5.1-1)
- Leachate collection system (LCS) monthly accumulation volumes (refer to Figure A.5.1-1)
- Leak detection system (LDS) monthly accumulation volumes (refer to Figure A.5.1-2)
- OSDF horizontal till well (HTW) 12338 water yield (refer to Table A.5.1-2)
- Great Miami Aquifer (GMA) water levels and total uranium concentration versus time (refer to Figures A.5.1-3 and A.5.1-4)
- Plots of concentration versus time (refer to Figures A.5.1-5A through A.5.1-17)
- A bivariate plot for total uranium–sodium (refer to Figure A.5.1-18)
- A bivariate plot for sodium–sulfate (refer to Figure A.5.1-19)
- Control charts (refer to Figures A.5.1-20 and A.5.1-21)

A.5.1.1 Water Quality Monitoring Results

Water quality within the cell is sampled in the LCS and the LDS. Water quality beneath the cell is sampled in the HTW and GMA wells. Concentration-versus-time plots, bivariate plots, and control charts are used to help interpret and present the results.

Until 2014, quarterly water quality monitoring occurred in the LCS, LDS, HTW, and GMA wells of each cell for the purpose of determining whether the OSDF was 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.

With EPA and Ohio EPA concurrence, DOE reduced the number of parameters sampled from 24 to 13 beginning in January 2017. All 13 parameters are sampled in the GMA wells; 4 of the 13 parameters (total uranium, boron, sodium, and sulfate) are sampled in the LCS, LDS, and HTW for each cell. The annual sampling in the LCS of each cell for the abbreviated list of Appendix I parameters and polychlorinated biphenyls listed in *Ohio Administrative Code* 3745-27-10 was also eliminated beginning in January 2017 with EPA and Ohio EPA concurrence (DOE 2017).

A.5.1.1.1 LCS and LDS Results

As shown in Table A.5.1-1 and summarized below, three parameters (total uranium, sodium, and sulfate) have upward trends in the LCS and/or LDS based on the Mann-Kendall test for trend. A new high sulfate concentration of 3,360 milligrams per liter (mg/L) was measured in the LCS of Cell 1 in April 2020. The previous high was 2,910 mg/L. In August 2020, the concentration was 1,510 mg/L. The volume of water in the LDS tank of Cell 1 has been insufficient to collect a sample since 2011.

Parameters with Upward Concentration Trends in the LCS and LDS of Cell 1[a]

Parameter	LCS 12338C 2020 Trend	LDS 12338D Trend (Year Last Sampled)
Total Uranium	Up	Up (2011)
Sodium	Up	Up (2011)
Sulfate	Up	Up (2011)

[a] No entry indicates that the trend was not upward.

A.5.1.1.2 HTW and Monitoring Well Results

As shown in Table A.5.1-1 and summarized below, five parameters (total uranium, boron, magnesium, nitrate + nitrite as nitrogen, and selenium) have upward trends in the HTW and/or the GMA wells based on the Mann-Kendall test for trend.

Parameters with Upward Concentration Trends in the HTW and GMA Wells of Cell 1[a]

Parameter	HTW 12338	GMA-U[b] 22201	GMA-D[b] 22198
Total Uranium	Up	Up	
Boron		Up	
Magnesium		Up	
Nitrate + Nitrite as Nitrogen		Up	
Selenium			Up

[a] No entry indicates that the trend was not upward.
[b] GMA-U = upgradient Great Miami Aquifer, GMA-D = downgradient Great Miami Aquifer.

A.5.1.1.3 Discussion

The uranium–sodium bivariate plot for the Cell 1 LCS, LDS, and HTW is provided in Figure A.5.1-18. On the figure, the first sample ever collected from the monitoring horizon is circled. An arrow leads from the first sample to the location of the most recent sample. The plot for 2020 shows that the uranium concentrations measured in the LCS were 9.16 micrograms per liter (µg/L) and 7.58 µg/L. These uranium concentrations in the LCS are similar to uranium concentrations measured in the HTW in 2020. In 2020, the uranium concentrations measured in the HTW were 3.45 µg/L and 3.88 µg/L. An additional sodium–sulfate bivariate plot for Cell 1 LCS and HTW is provided in Figure A.5.1-19 for the period April 2014 to August 2020. Since the LDS has been dry since 2011 it is not shown in Figure A.5.1-19. Figure A.5.1-19 shows that the chemical signatures for sodium and sulfate in the LCS and HTW are separate and distinct, indicating that mixing between the horizons is not occurring; therefore, upward concentration trends measured beneath the cells in GMA wells are attributed to fluctuating ambient concentrations beneath the cell and are not related to cell performance.

A.5.1.2 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. 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 "not in 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. Usually, two parameters are used to compute standardized limits: the decision value (h) and the Shewhart control limit (SCL).

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 eight samples were selected for control charts. By default, the ChemStat software plots both a CUSUM control limit (h) and an SCL on the control chart. The software recommends a value of 5 for the CUSUM control limit and a value of 4.5 for the SCL.

EPA Statistical Analysis Unified Guidance (EPA 2009) suggests that, to simplify the interpretation of the control chart, a "not in control" condition should be based on the CUSUM (h) limit alone. Plotting the SCL is not needed. The ChemStat software though, by default, plots both the SCL and CUSUM control limit on the charts. To address this issue, the SCL was defined as 5 to equal the recommended CUSUM (h) limit. This combined limit is identified as hCL on the control charts. For interpretation purposes, the hCL value will be regarded as the CUSUM (h) limit.

As shown in Table A.5.1-1 in gray shading and as summarized below, two parameters in the HTW and GMA wells of Cell 1 meet the criteria for control charts (i.e., at least eight samples, normal or lognormal distribution, no trend, and no serial correlation), resulting in two control charts (Figures A.5.1-20 and A.5.1-21). The two control charts for Cell 1 indicate "in control" conditions for calcium and lithium.

Parameter	Monitoring Point[a]	Well Number	Assessment	Figure Number
Calcium	GMA-U	22201	In Control	A.5.1-20
Lithium	GMA-U	22201	In Control	A.5.1-21

[a] GMA-U = upgradient Great Miami Aquifer.

A.5.1.3 Summary and Conclusions

- Three parameters monitored semiannually within the facility have an upward concentration trend in the LCS of Cell 1: total uranium, sodium, and sulfate. A new high sulfate concentration of 3,360 mg/L was measured in the LCS of Cell 1 in 2020. The previous high was 2,910 mg/L. In August 2020, the concentration was 1,510 mg/L.
- The volume of water in the LDS tank of Cell 1 has been insufficient to collect a sample since 2011.
- Five parameters have an upward concentration trend beneath the facility in the HTW and GMA wells: total uranium, boron, magnesium, nitrate + nitrite as nitrogen, and selenium.

Separate and distinct chemical signatures (1) for total uranium and sodium in the LCS, LDS, and HTW and (2) for sodium and sulfate in the LCS and HTW of Cell 1 indicate that water is not mixing between the horizons. Therefore, upward concentration trends beneath Cell 1 (i.e., HTW and GMA wells) are attributed to fluctuating ambient concentrations beneath the cell and not to cell performance.

- Two control charts were constructed for Cell 1 parameters for monitoring horizons beneath the facility (HTW and GMA wells). The two control charts for Cell 1 indicate “in control” conditions for calcium and lithium.

A.5.1.4 References

DOE (U.S. Department of Energy), 2017. *Fernald Preserve 2016 Site Environmental Report*, LMS/FER/S15232, Office of Legacy Management, Cincinnati, Ohio, May.

EPA (U.S. Environmental Protection Agency), 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities—Unified Guidance*, EPA 530/R-09-007, March.

OAC 3745-27-10. “Ground Water Monitoring Program for a Sanitary Landfill Facility,” *Ohio Administrative Code.*

Table A.5.1-1. Summary Statistics for Cell 1

Parameter	Horizon[a]	Location	Number of Detected Samples	Total Number of Samples	Percent Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[d]	Distribution Type[d,e]	Trend[d,f] (Year Last Sampled)	Serial Correlation[d,g]	Outliers[h,i]
Total Uranium (µg/L)	LCS	12338C	75	76	98.7	ND	159	79.5	35.8	Normal	Up (2020)	Detected	206(Q4-10)
	LDS	12338D	37	37	100	1.50	37.0	10.8	6.8	Undefined	Up (2011)	Detected	
	HTW	12338	72	74	97.3	ND	12.7	8.28	3.53	Undefined	Up (2020)	Detected	
	GMA-U	22201	77	81	95.1	ND	12.4	4.79	3.33	Undefined	Up (2020)	Detected	
	GMA-D	22198	87	87	100	0.57	15.2	4.70	2.54	Undefined	None (2020)	Detected	
Boron (mg/L)	LCS	12338C	76	77	98.7	ND	1.72	0.971	0.321	Undefined	Down (2020)	Detected	2.80(Q1-99), 2.53(Q3-04), 2.81(Q3-05), 2.33(Q4-07)
	LDS	12338D	37	38	97.4	0.169	0.345	0.243	0.066	Ln Normal	None (2011)	Not Detected	0.001(Q3-00), 0.0296(Q1-98)
	HTW	12338	54	57	94.7	ND	0.271	0.143	0.062	Normal	None (2020)	Detected	
	GMA-U	22201	79	81	97.5	ND	0.158	0.123	0.026	Undefined	Up (2020)	Detected	
	GMA-D	22198	76	80	95.0	ND	0.131	0.055	0.016	Ln Normal	Down (2020)	Not Detected	
Sodium (mg/L)	LCS	12338C	50	50	100	11.7	22.0	19.1	2.65	Undefined	Up (2020)	Detected	29.3(Q3-05)
	LDS	12338D	9	9	100	335	896	571	216	Normal	Up (2011)	Not Detected	
	HTW	12338	42	42	100	9.42	23.8	13.2	3.6	Undefined	Down (2020)	Detected	
	GMA-U	22201	33	33	100	26.2	65.5	44.7	13.0	Undefined	Down (2020)	Detected	
	GMA-D	22198	34	34	100	9.93	17.1	13.4	1.9	Normal	Down (2020)	Detected	
Sulfate (mg/L)	LCS	12338C	62	62	100	707	3360	1860	681	Undefined	Up (2020)	Detected	
	LDS	12338D	19	19	100	675	3500	1850	780	Ln Normal	Up (2011)	Detected	
	HTW	12338	52	52	100	476	907	636	121	Ln Normal	Down (2020)	Detected	
	GMA-U	22201	57	57	100	91.8	735	259	150	Ln Normal	None (2020)	Detected	1,980(Q4-04)
	GMA-D	22198	57	57	100	101	506	163	92	Undefined	Down (2020)	Not Detected	
Calcium (mg/L)	GMA-U	22201	26	26	100	143	334	206	43	Normal	None (2020)	Not Detected	
	GMA-D	22198	26	26	100	133	192	154	15	Normal	Down (2020)	Not Detected	
Lithium (mg/L)	GMA-U	22201	33	33	100	0.00665	0.0153	0.0107	0.0026	Normal	None (2020)	Not Detected	
	GMA-D	22198	33	33	100	0.00624	0.0107	0.0092	0.0008	Undefined	None (2020)	Not Detected	
Magnesium (mg/L)	GMA-U	22201	26	26	100	36.1	82.2	49.6	9.8	Ln Normal	Up (2020)	Not Detected	
	GMA-D	22198	26	26	100	36.2	47.8	40.6	3.1	Normal	Down (2020)	Not Detected	
Nitrate + Nitrite, as Nitrogen (mg/L)	GMA-U	22201	20	26	76.9	ND	1.44	0.241	0.475	Undefined	Up (2020)	Not Detected	
	GMA-D	22198	9	46	19.6	ND	0.55	0.018	0.180	Undefined	Down (2020)	Detected	
Potassium (mg/L)	GMA-U	22201	26	26	100	2.28	3.97	2.96	0.45	Normal	Down (2020)	Not Detected	
	GMA-D	22198	27	27	100	1.24	2.07	1.64	0.23	Normal	Down (2020)	Detected	
Selenium (mg/L)	GMA-U	22201	1	33	3.0	ND	0.0146	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
	GMA-D	22198	4	53	7.6	ND	0.0153	0.0025	0.0023	Undefined	Up (2020)	Detected	
Technetium-99 (pCi/L)	GMA-U	22201	1	30	3.3	ND	3.86	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
	GMA-D	22198	2	31	6.4	ND	8.30	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
Total Dissolved Solids (mg/L)	GMA-U	22201	33	33	100	594	1600	932	203	Normal	Down (2020)	Not Detected	
	GMA-D	22198	33	33	100	561	805	629	64	Undefined	Down (2020)	Not Detected	
Total Organic Halogens (mg/L)	GMA-U	22201	34	81	42.0	ND	0.0319	0.0063	0.0068	Undefined	Down (2020)	Not Detected	0.078(Q1-97), 0.308(Q2-2000)
	GMA-D	22198	16	80	20.0	ND	0.0235	0.00166	0.00537	Undefined	Down (2020)	Detected	0.0473(Q2-98), 0.092(Q2-00), 0.100(Q2-2010)

Note 1: Shading identifies a horizontal till well or Great Miami Aquifer well, with at least eight samples, Normal or Ln Normal distribution, no trend (None), and no serial correlation (Not Detected). These wells achieve control chart criteria.

Note 2: Data used in this table has been standardized to quarterly.

[a] LCS = leachate collection system; LDS = leak detection system; HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; and GMA-D = downgradient Great Miami Aquifer

[b] ND = not detected; NA = not applicable

[c] Averages were determined based on the distribution assumption.

[d] Insufficient is used for Distribution Type, Trend, or Serial Correlation whenever there is not enough data to run the test.

[e] Data distribution based on the Shapiro-Wilk statistic.

Normal: Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the Ln Normal assumption.

Ln Normal: Ln Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the Normal assumption.

Undefined: Normal and Lognormal Distribution assumptiions are both rejected or there are less than 25 percent detected values. "Average" is defined as the Median of the data.

[f] Trend based on nonparametric Mann-Kendall procedure.

[g] Serial correlation based on Rank Von Neumann test.

[h] Outliers determined by Rosner's (for sample sizes greater than 25) or Dixon procedure (for sample sizes less than or equal to 25).

[i] Q = quarter

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Table A.5.1-2. OSDF Horizontal Till Well 12338 (Cell 1) Water Yield

Year	Total Volume Purged (gallons)	Number of Months Purged	Average Volume Purged (gallons)
1999	5,655	9	628
2000	6,000	6	1,000
2001	4,060	4	1,015
2002	4,060	4	1,015
2003	4,325	4	1,081
2004	3,950	4	988
2005	4,250	4	1,063
2006	4,350	4	1,088
2007	3,625	4	906
2008	3,625	4	906
2009	2,750	4	917
2010	3,405	4	851
2011	3,675	4	919
2012	1,850	4	463
2013	1,235	4	309
2014	1,770	2	885
2015	650	2	325
2016	575	2	288
2017	785	2	393
2018	495	2	248
2019	950	2	475
2020	1,050	2	525

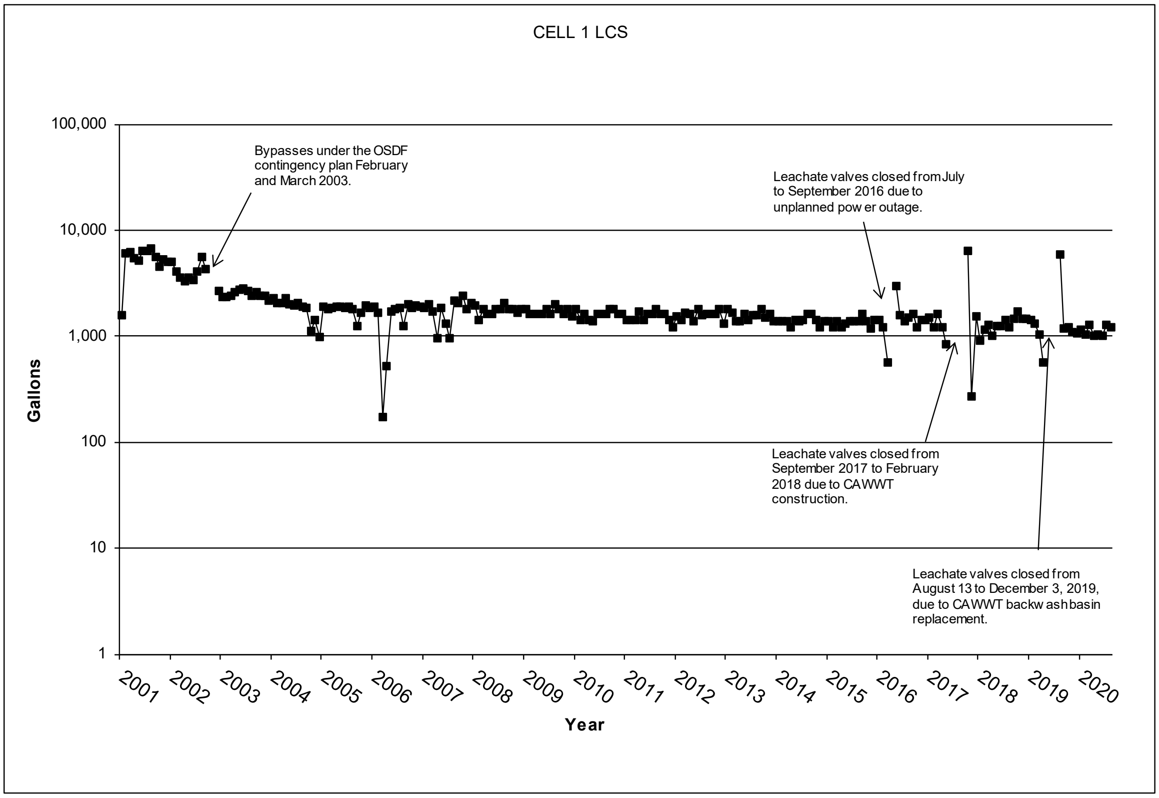

Figure A.5.1-1. Monthly Accumulation Volumes for Cell 1 LCS

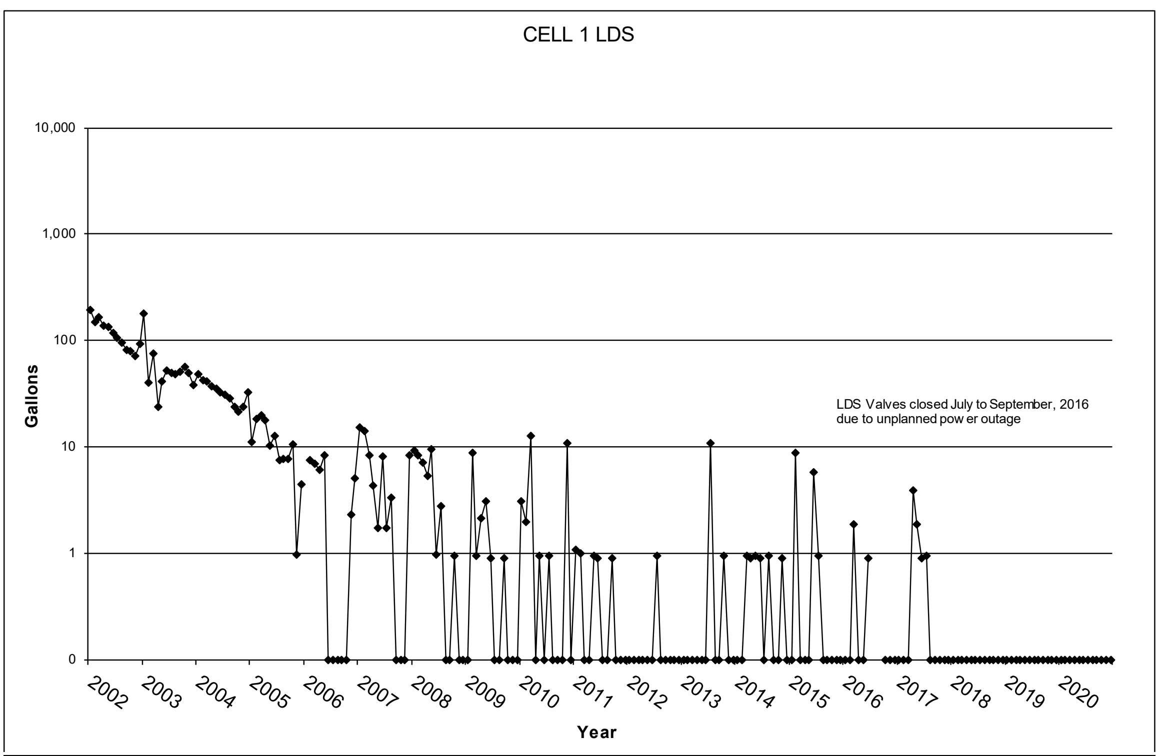

Figure A.5.1-2. Monthly Accumulation Volumes for Cell 1 LDS

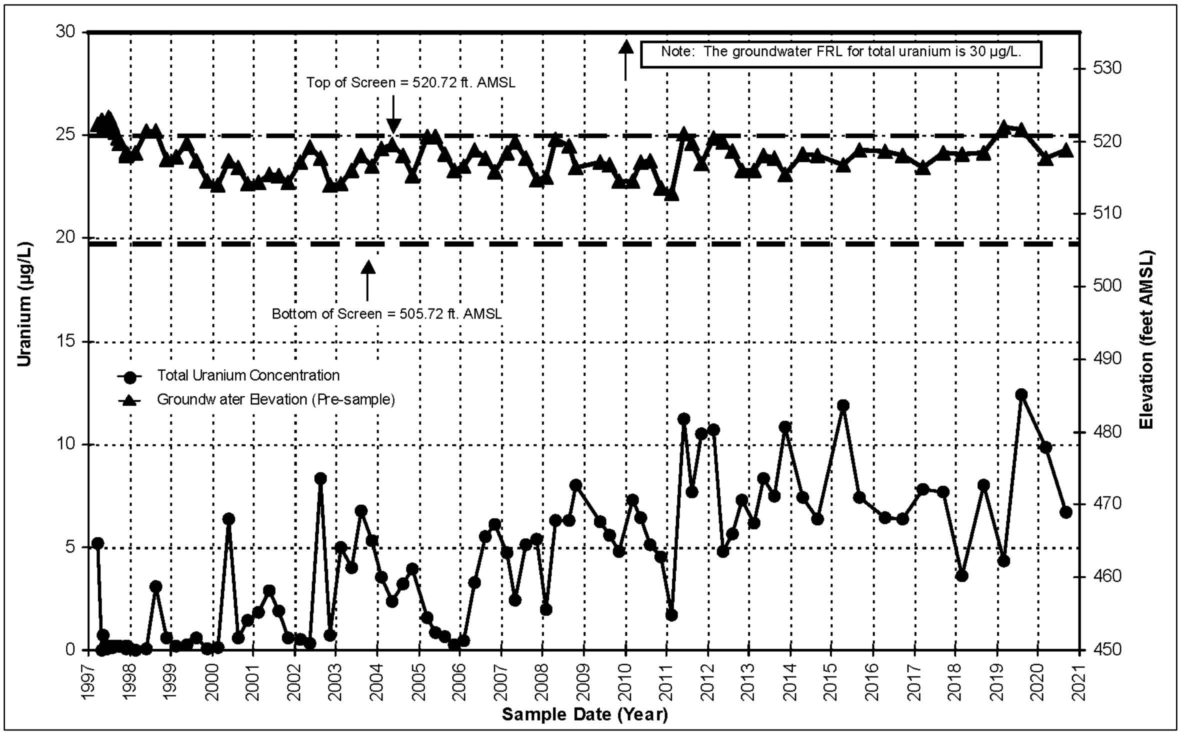

Figure A.5.1-3. Total Uranium Concentration and Groundwater Elevation Versus Time Plot for Cell 1 Upgradient Monitoring Well 22201

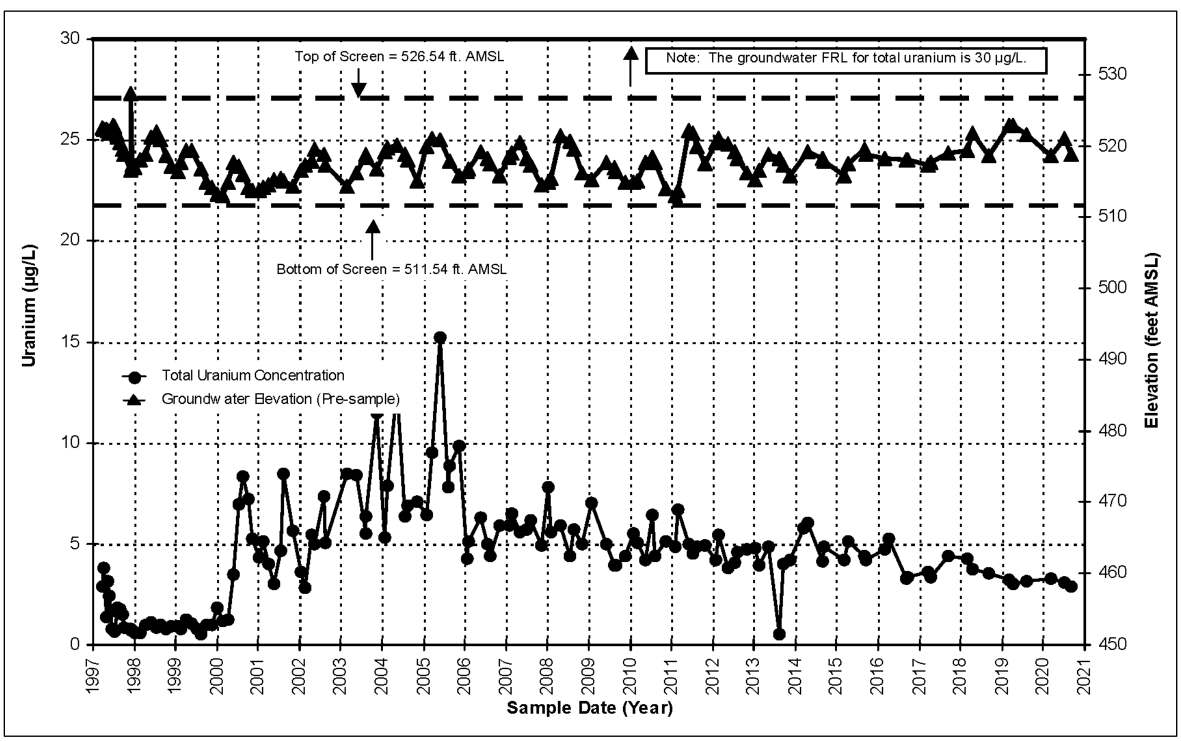

Figure A.5.1-4. Total Uranium Concentration and Groundwater Elevation Versus Time Plot for Cell 1 Downgradient Monitoring Well 22198

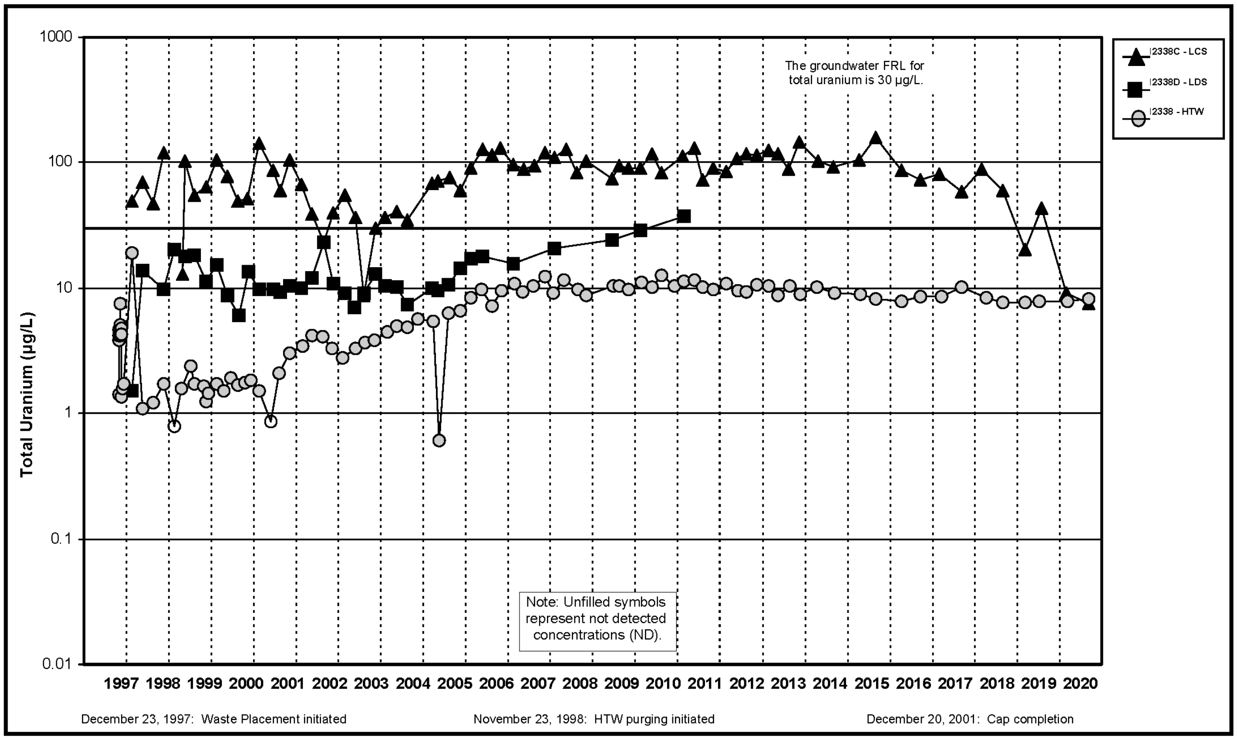

Figure A.5.1-5A. Cell 1 Total Uranium Concentration Versus Time Plot for LCS, LDS, and HTW

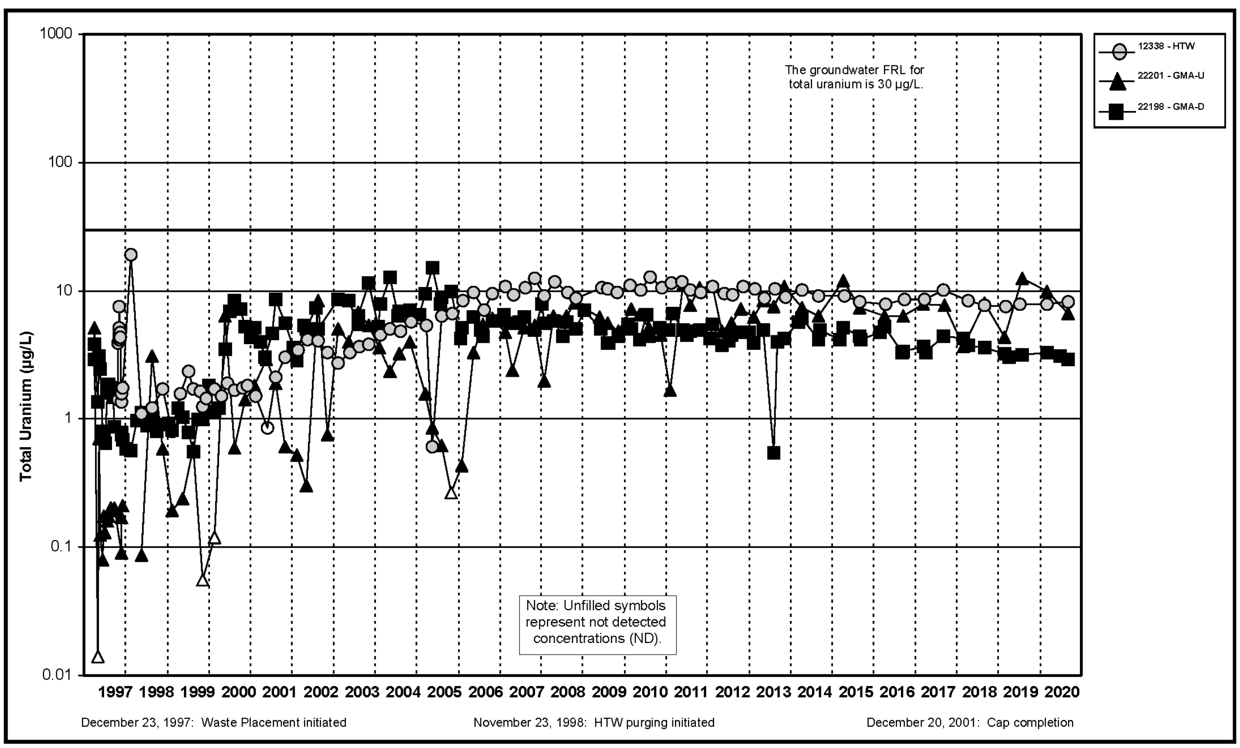

Figure A.5.1-5B. Cell 1 Total Uranium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

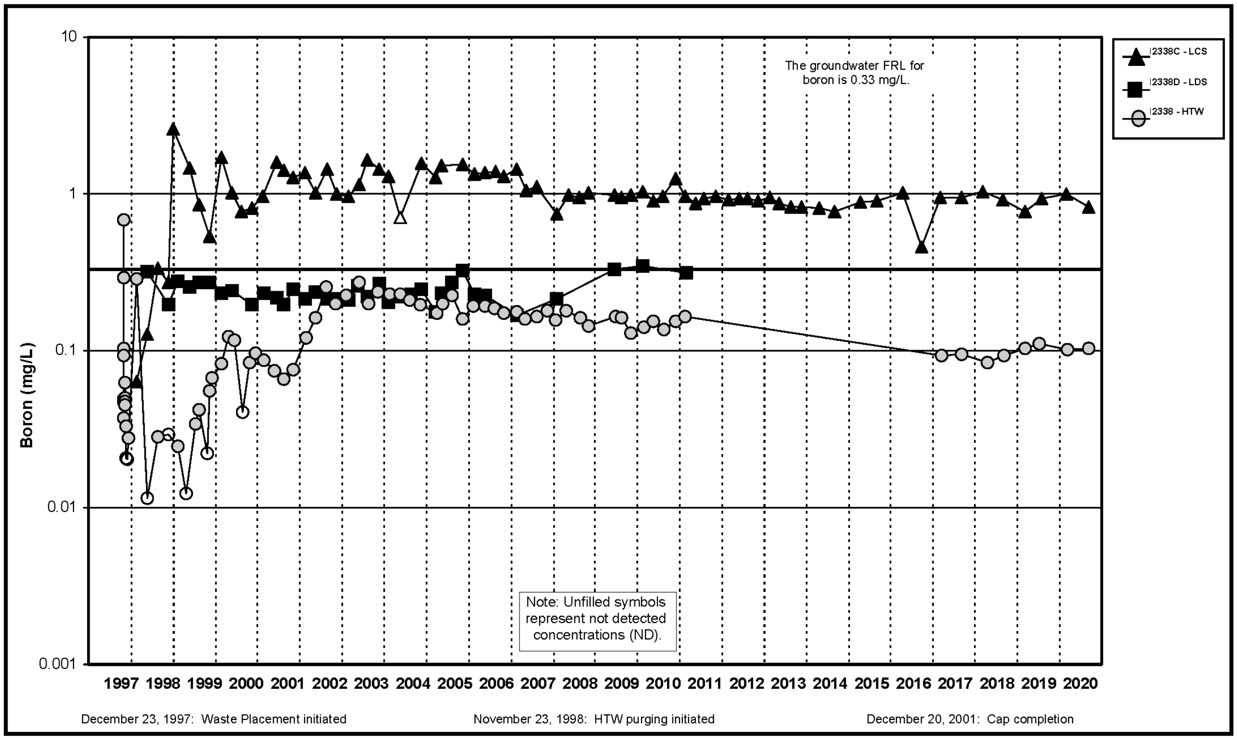

Figure A.5.1-6A. Cell 1 Boron Concentration Versus Time Plot for LCS, LDS, and HTW

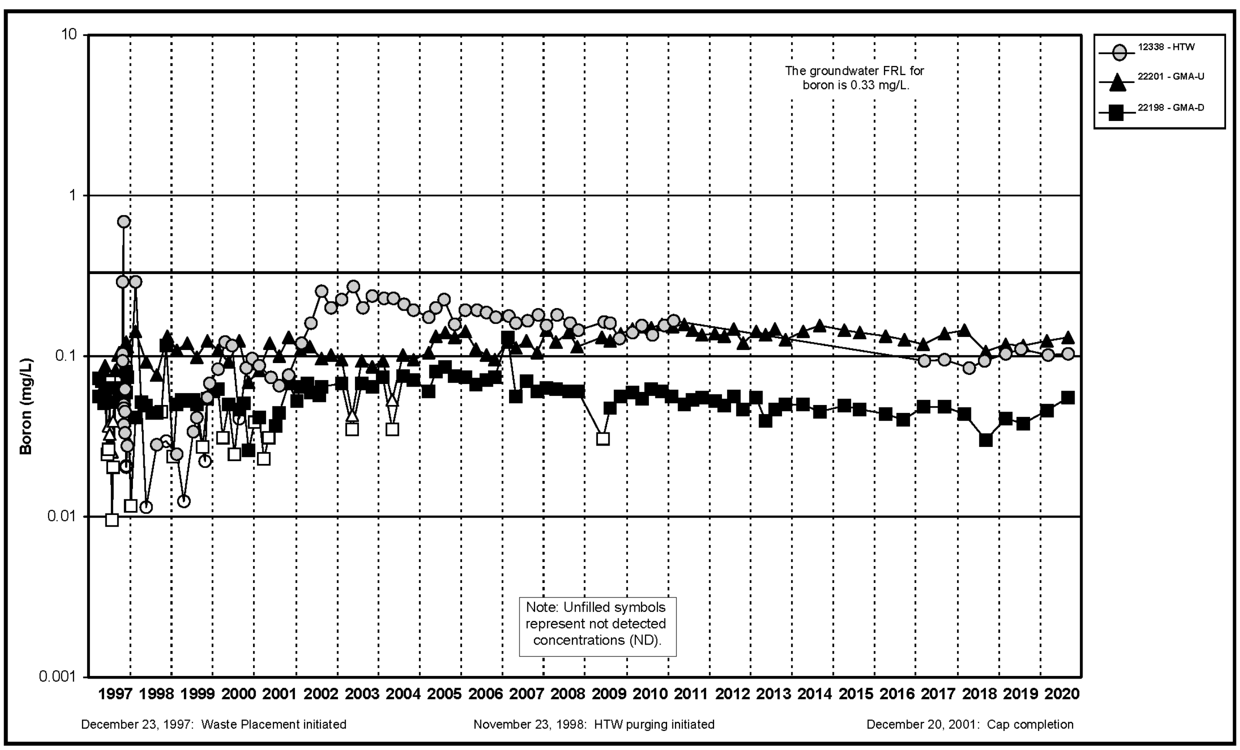

Figure A.5.1-6B. Cell 1 Boron Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

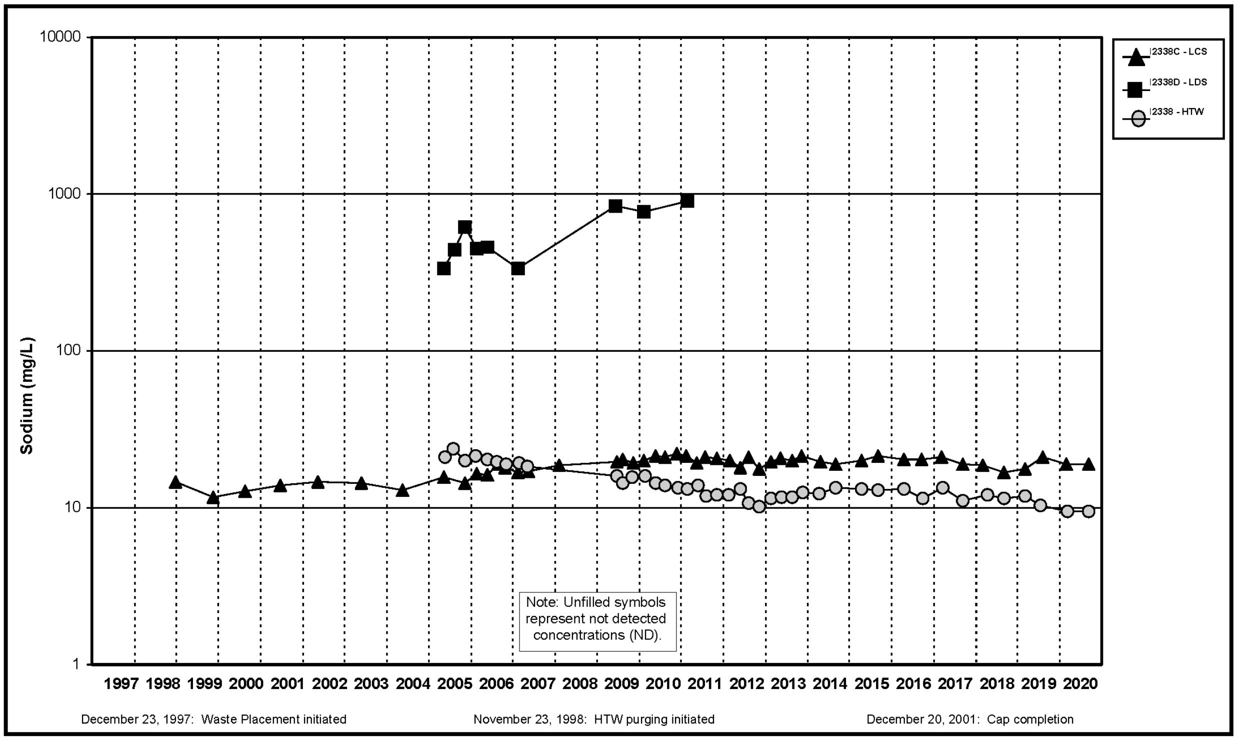

Figure A.5.1-7A. Cell 1 Sodium Concentration Versus Time Plot for LCS, LDS, and HTW

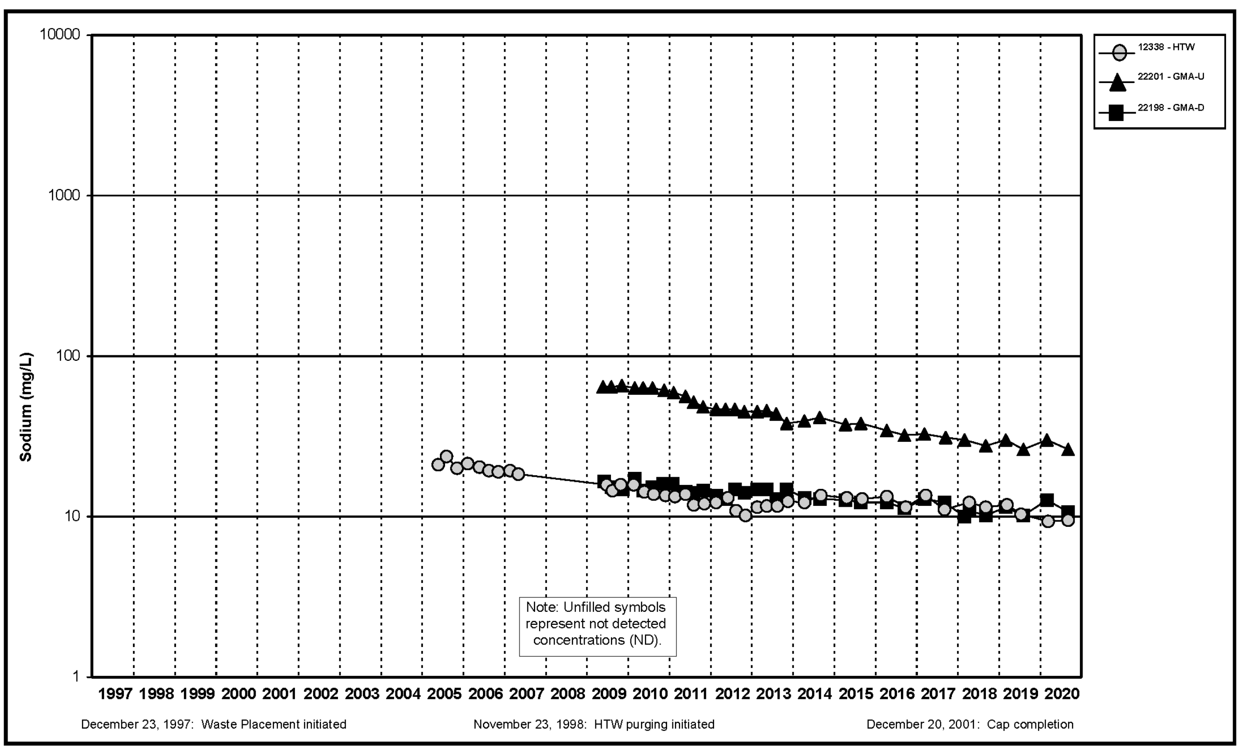

Figure A.5.1-7B. Cell 1 Sodium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

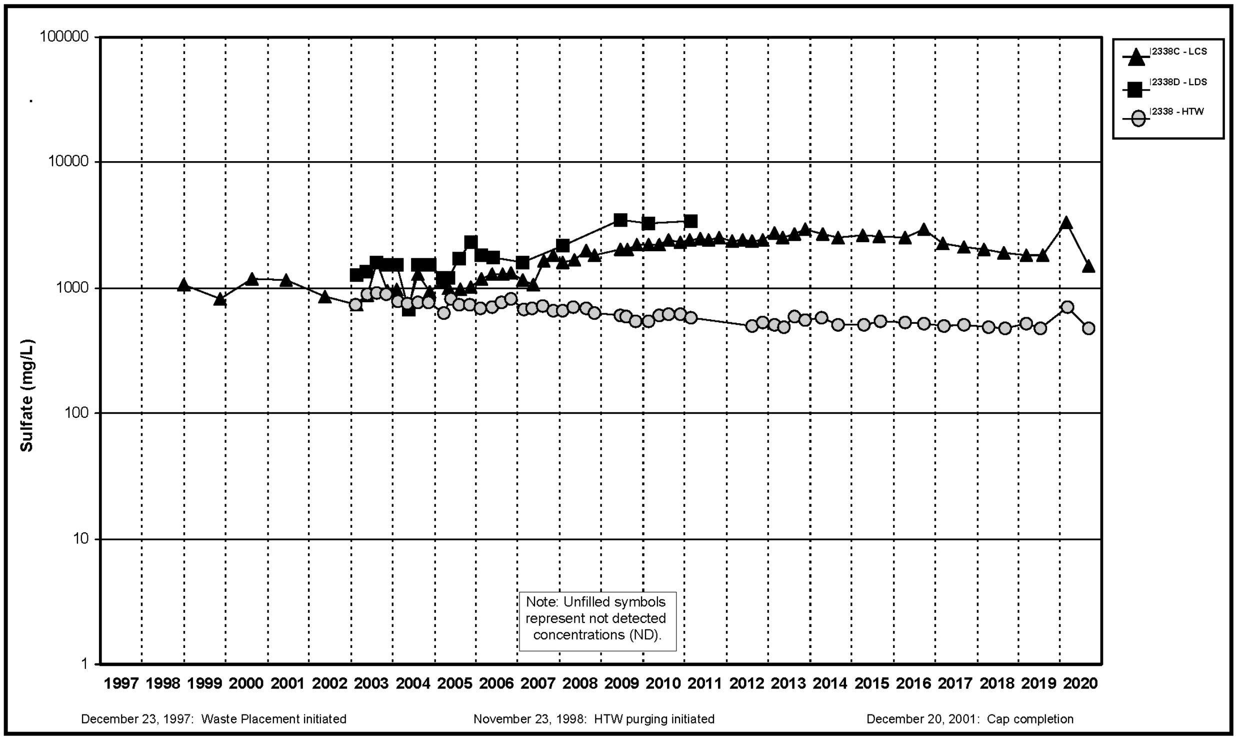

Figure A.5.1-8A. Cell 1 Sulfate Concentration Versus Time Plot for LCS, LDS, and HTW

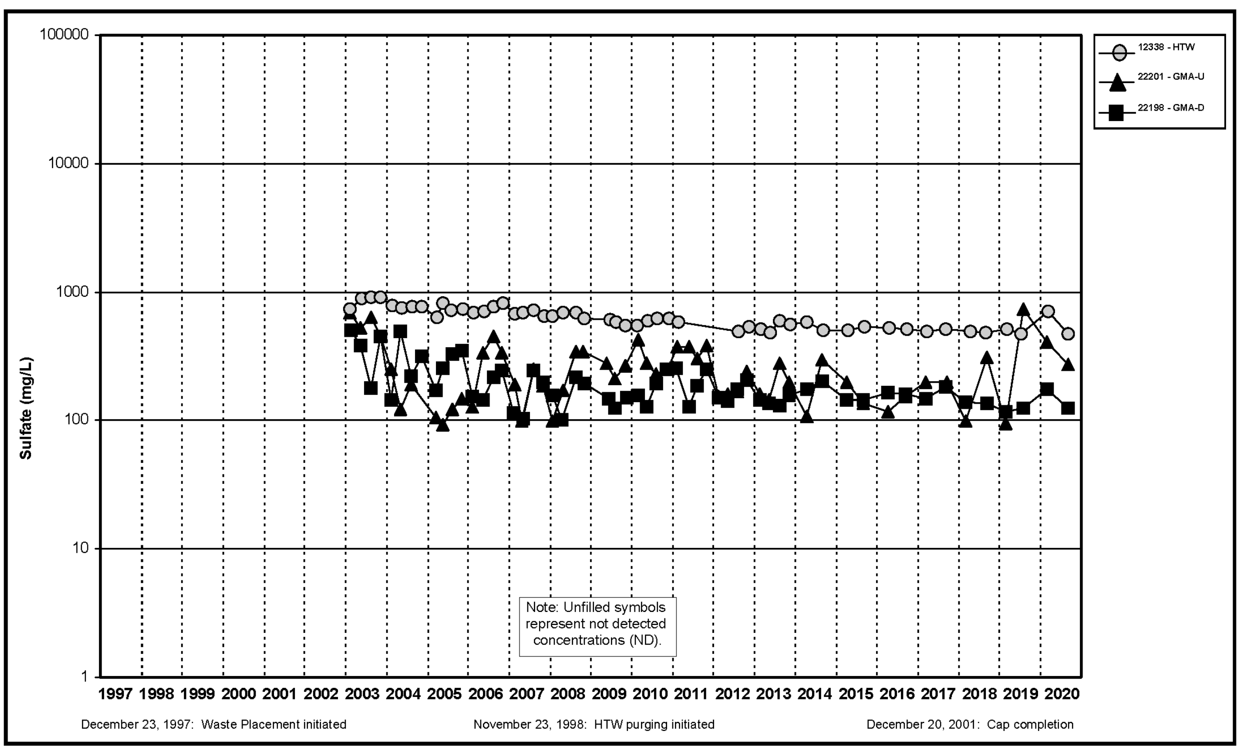

Figure A.5.1-8B. Cell 1 Sulfate Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

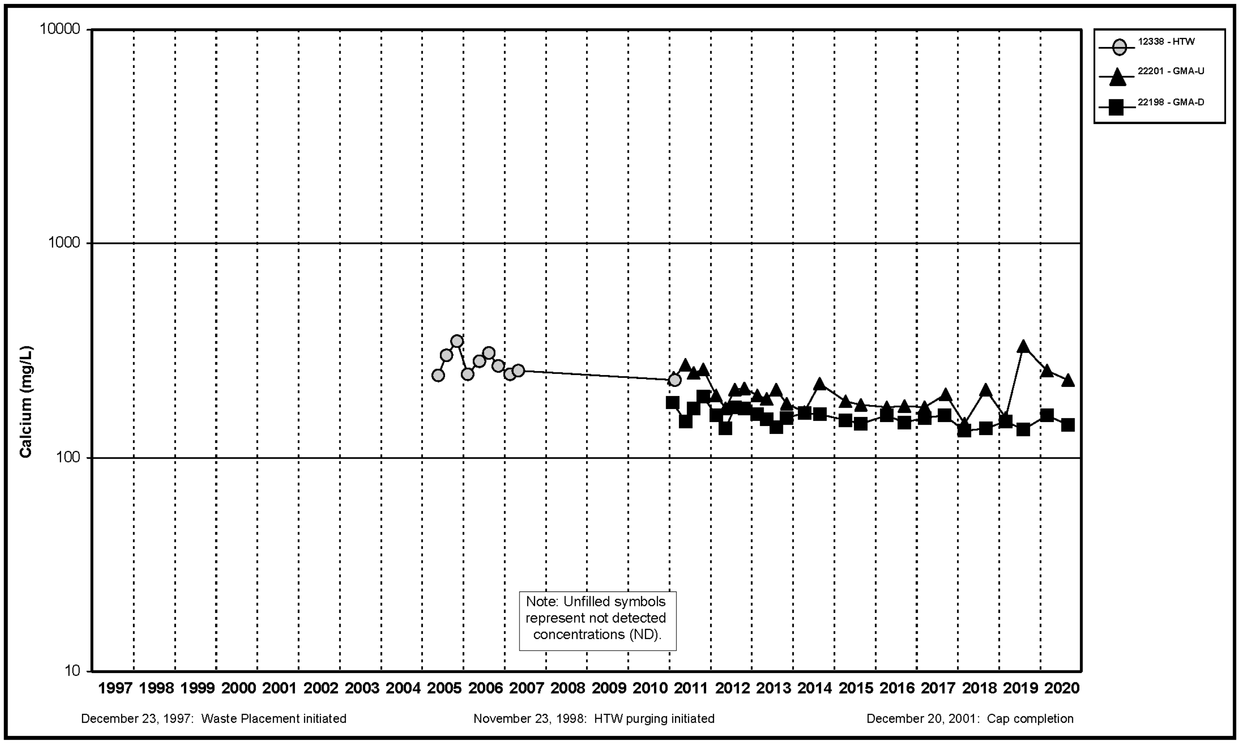

Figure A.5.1-9. Cell 1 Calcium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

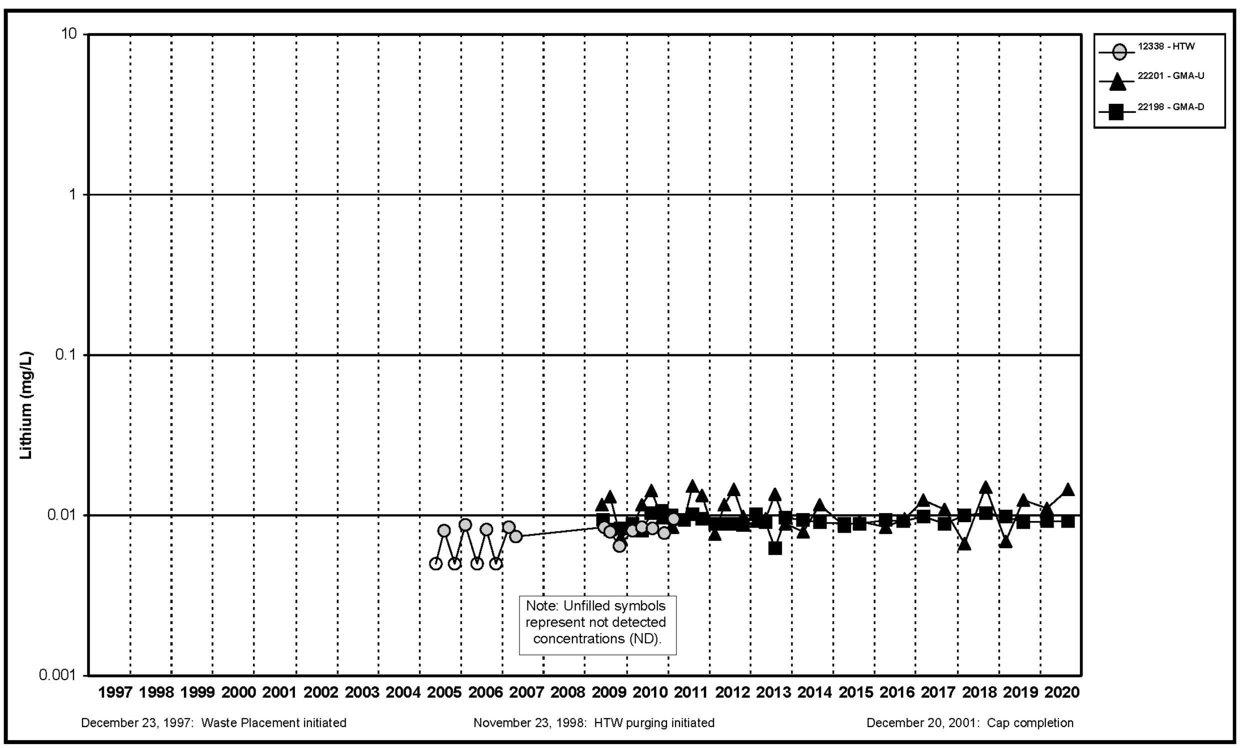

Figure A.5.1-10. Cell 1 Lithium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

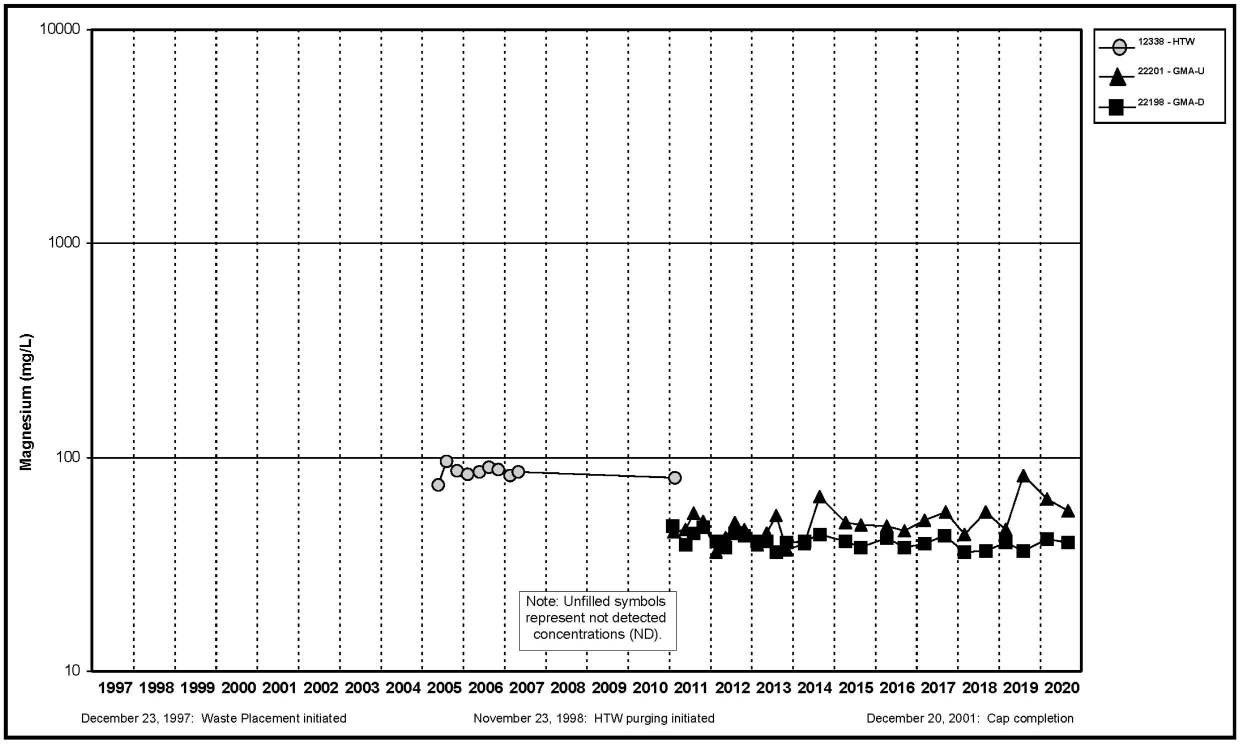

Figure A.5.1-11. Cell 1 Magnesium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

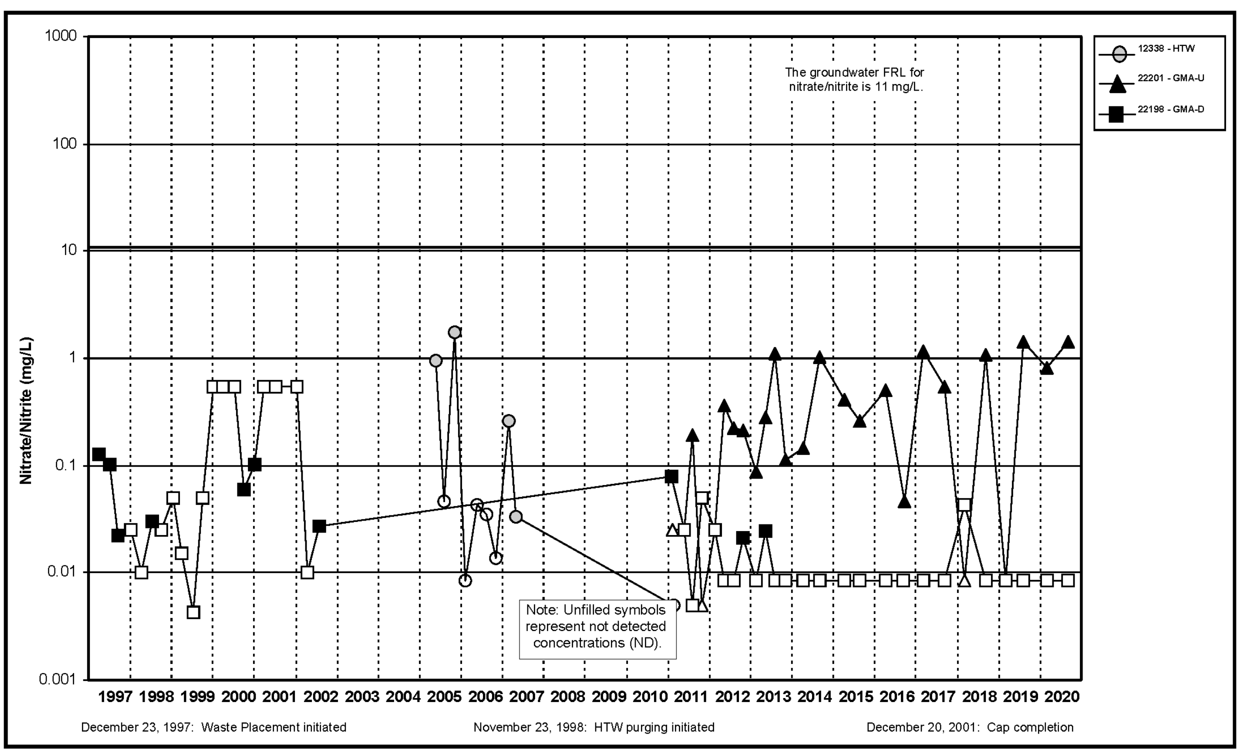

Figure A.5.1-12. Cell 1 Nitrate + Nitrite as Nitrogen Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

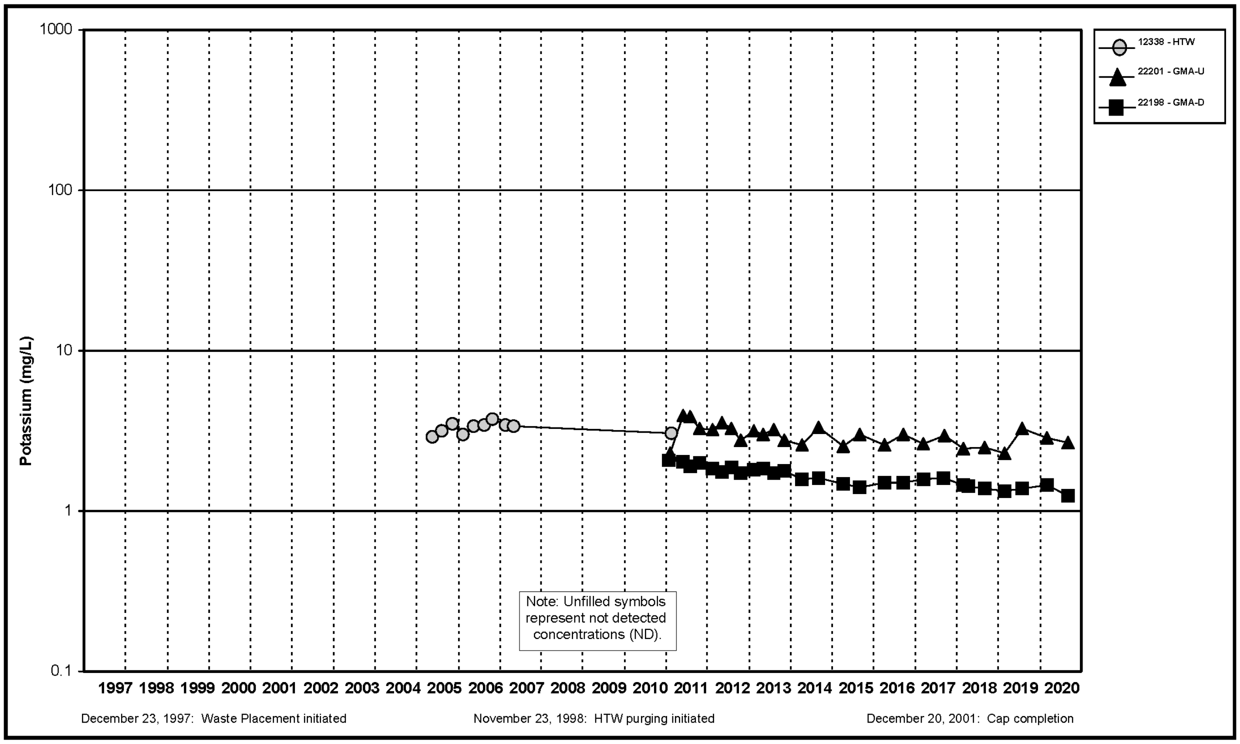

Figure A.5.1-13. Cell 1 Potassium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

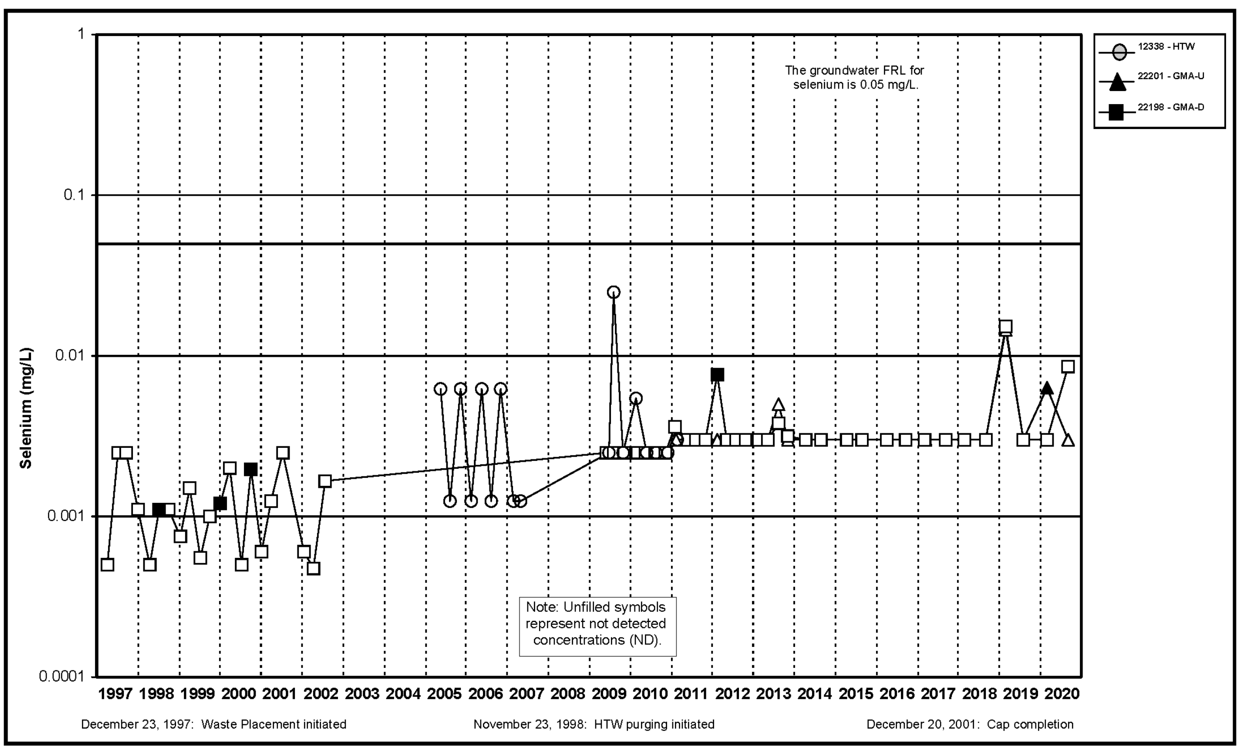

Figure A.5.1-14. Cell 1 Selenium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

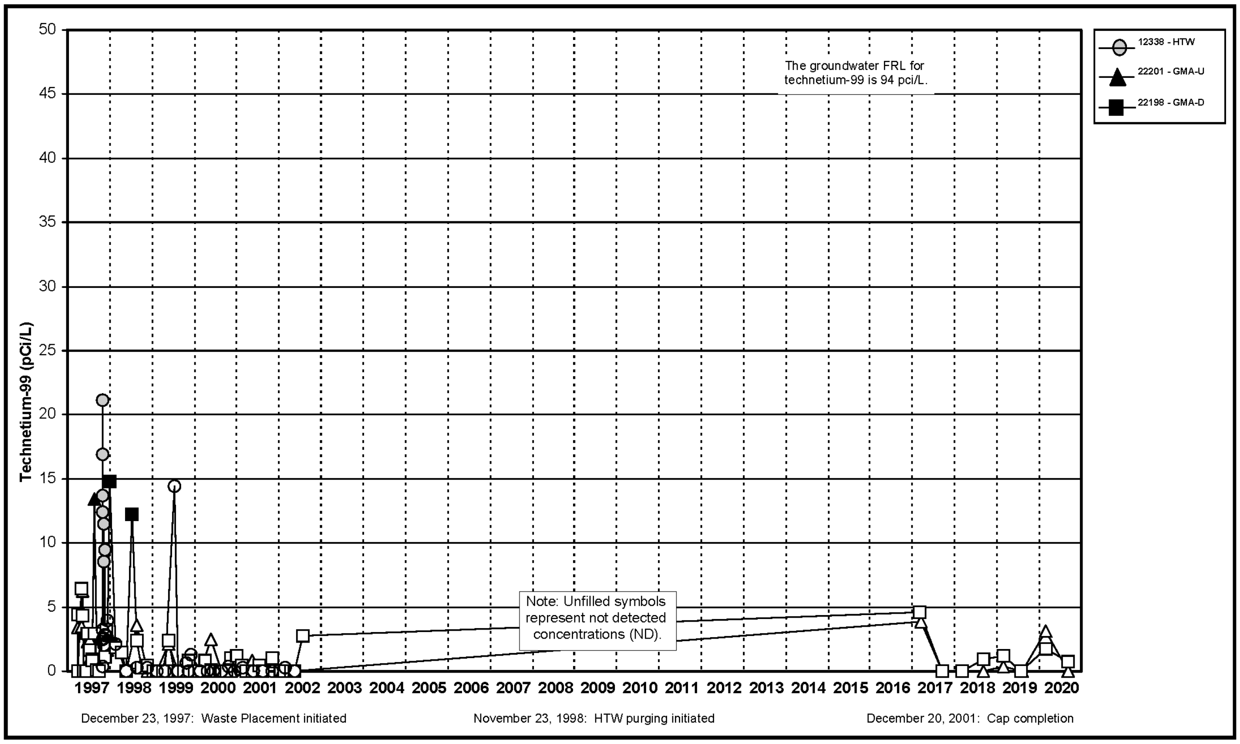

Figure A.5.1-15. Cell 1 Technetium-99 Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

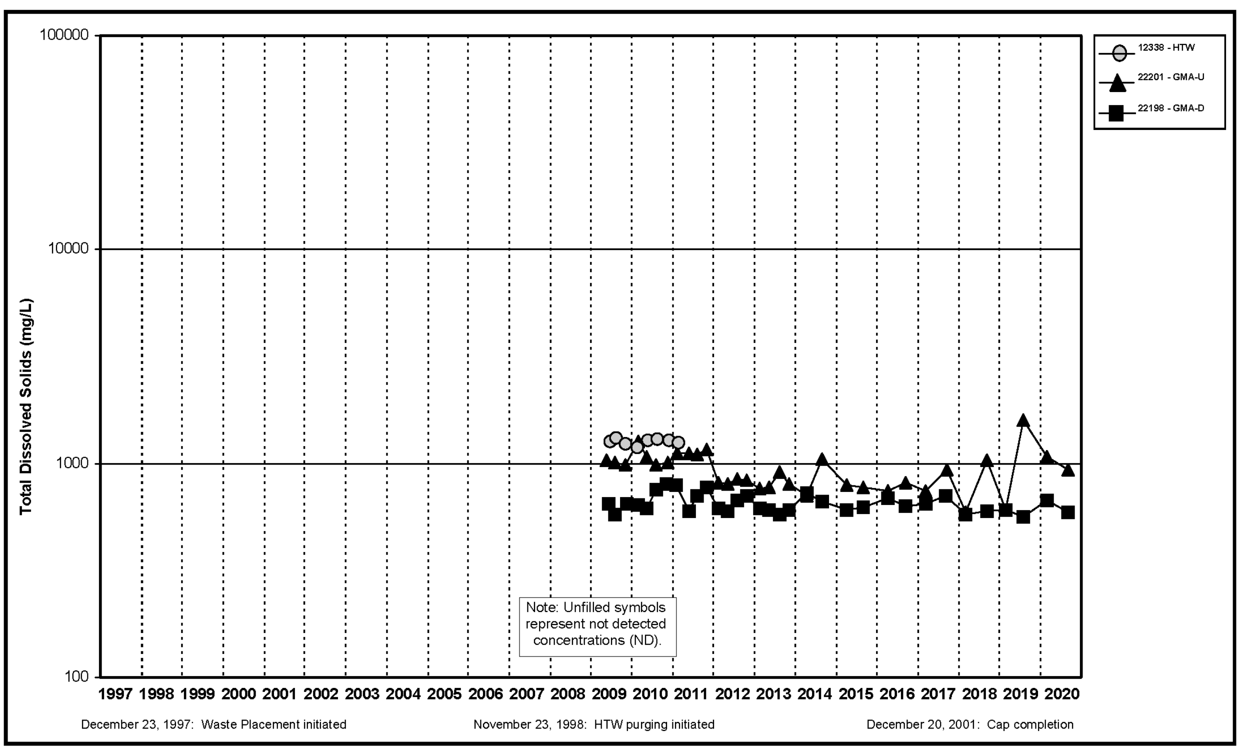

Figure A.5.1-16. Cell 1 Total Dissolved Solids Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

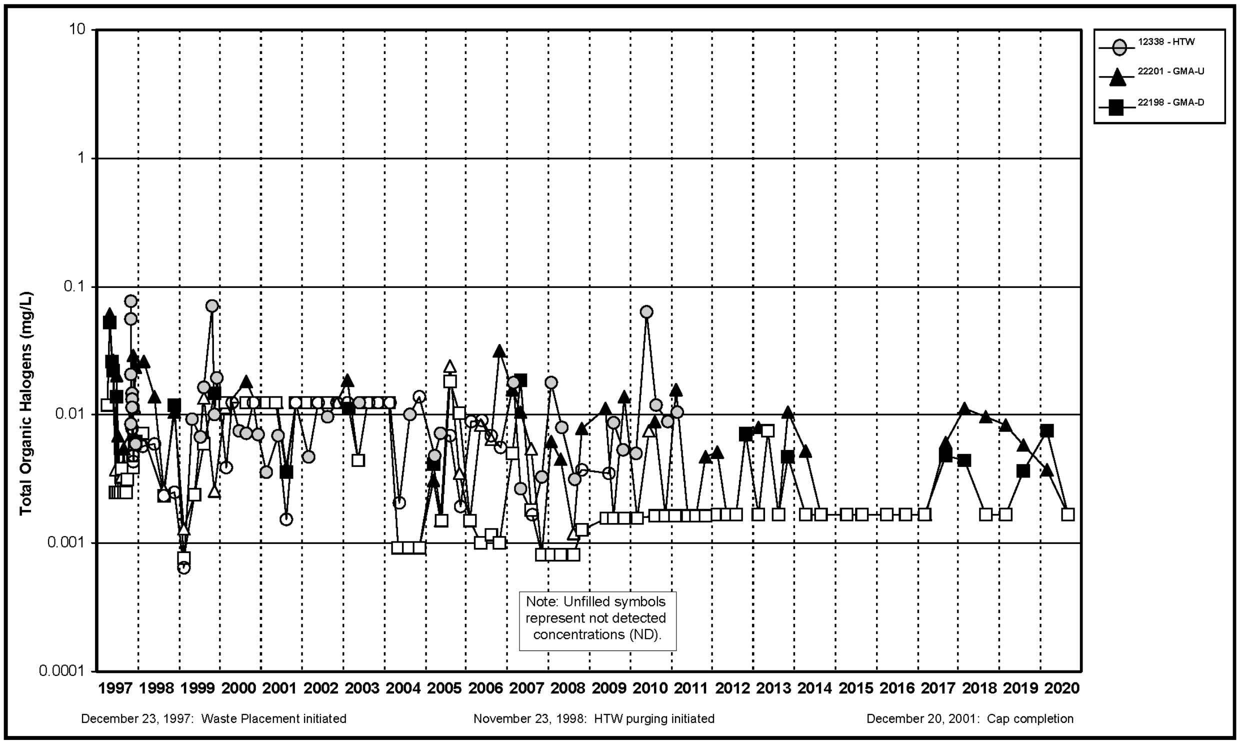

Figure A.5.1-17. Cell 1 Total Organic Halogens Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

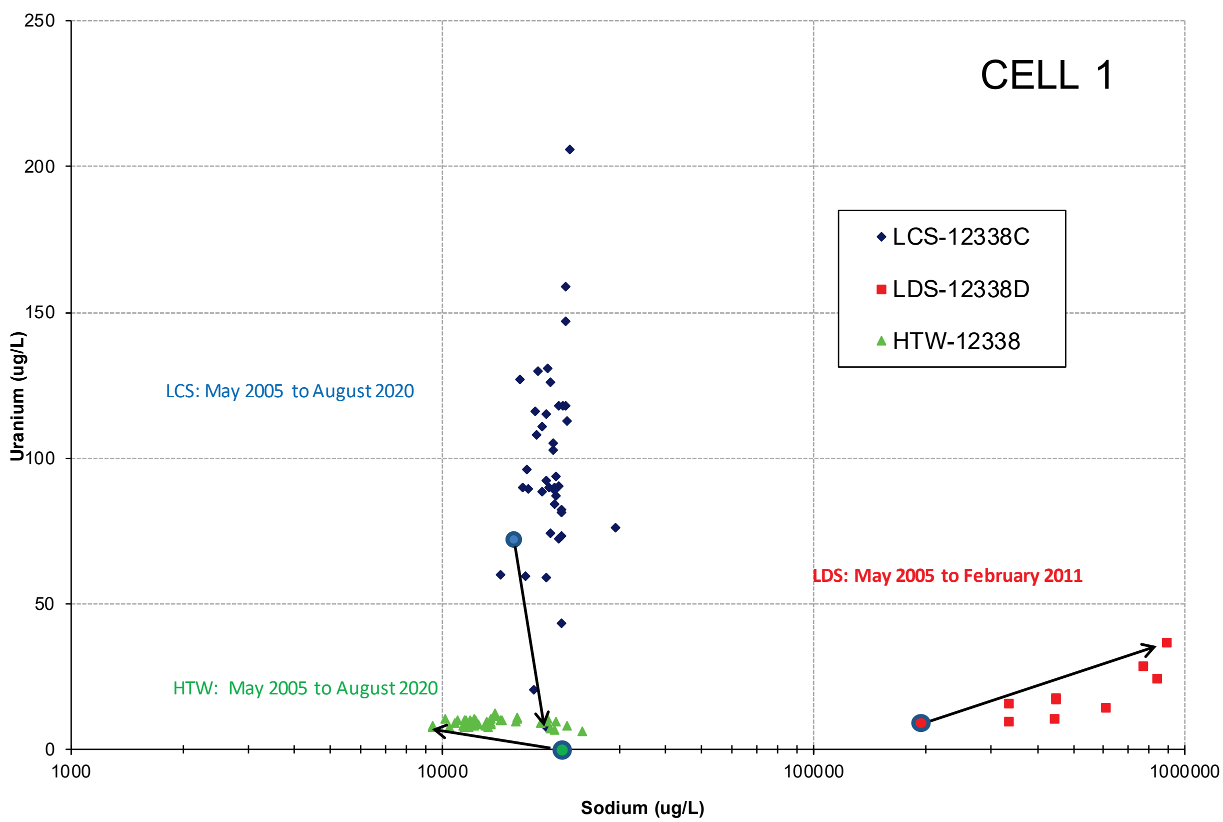

Figure A.5.1-18. Cell 1 Bivariate Plot for Uranium and Sodium

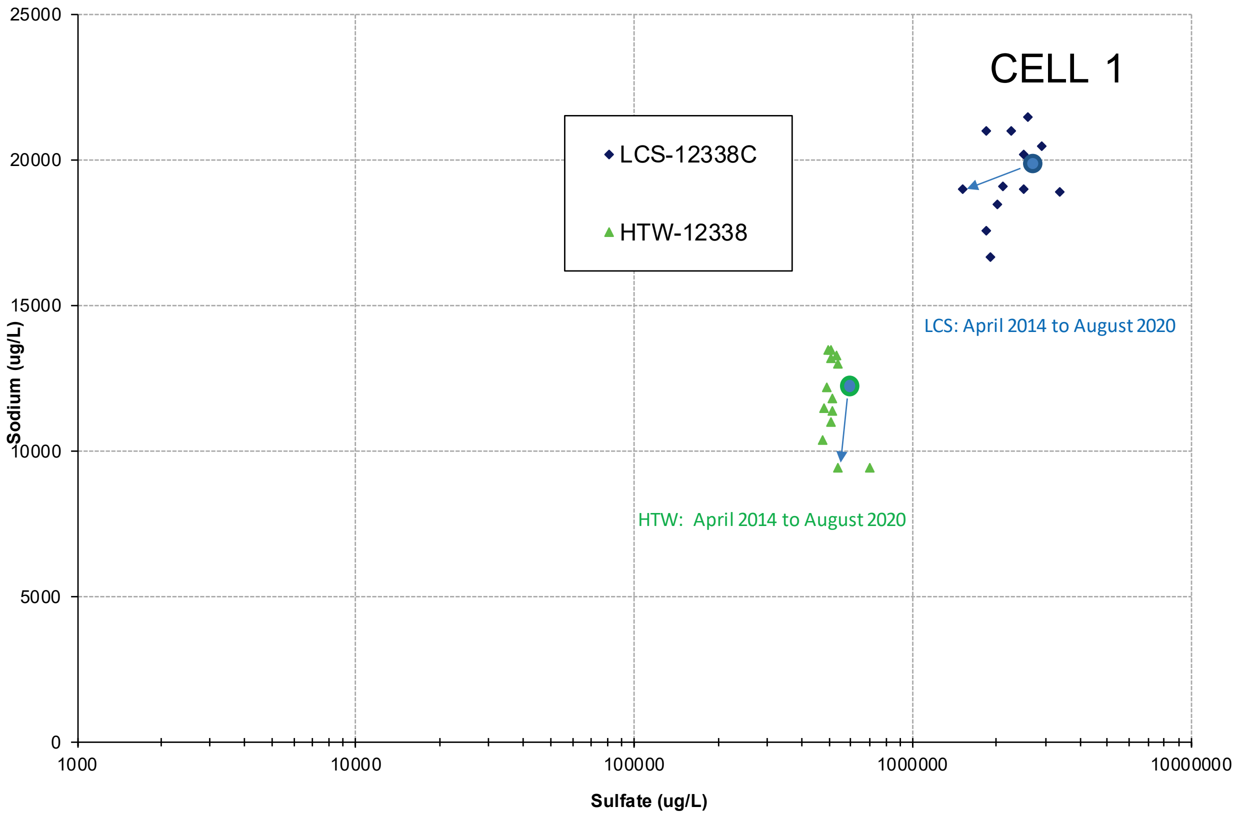

Figure A.5.1-19. Cell 1 Bivariate Plot for Sodium and Sulfate

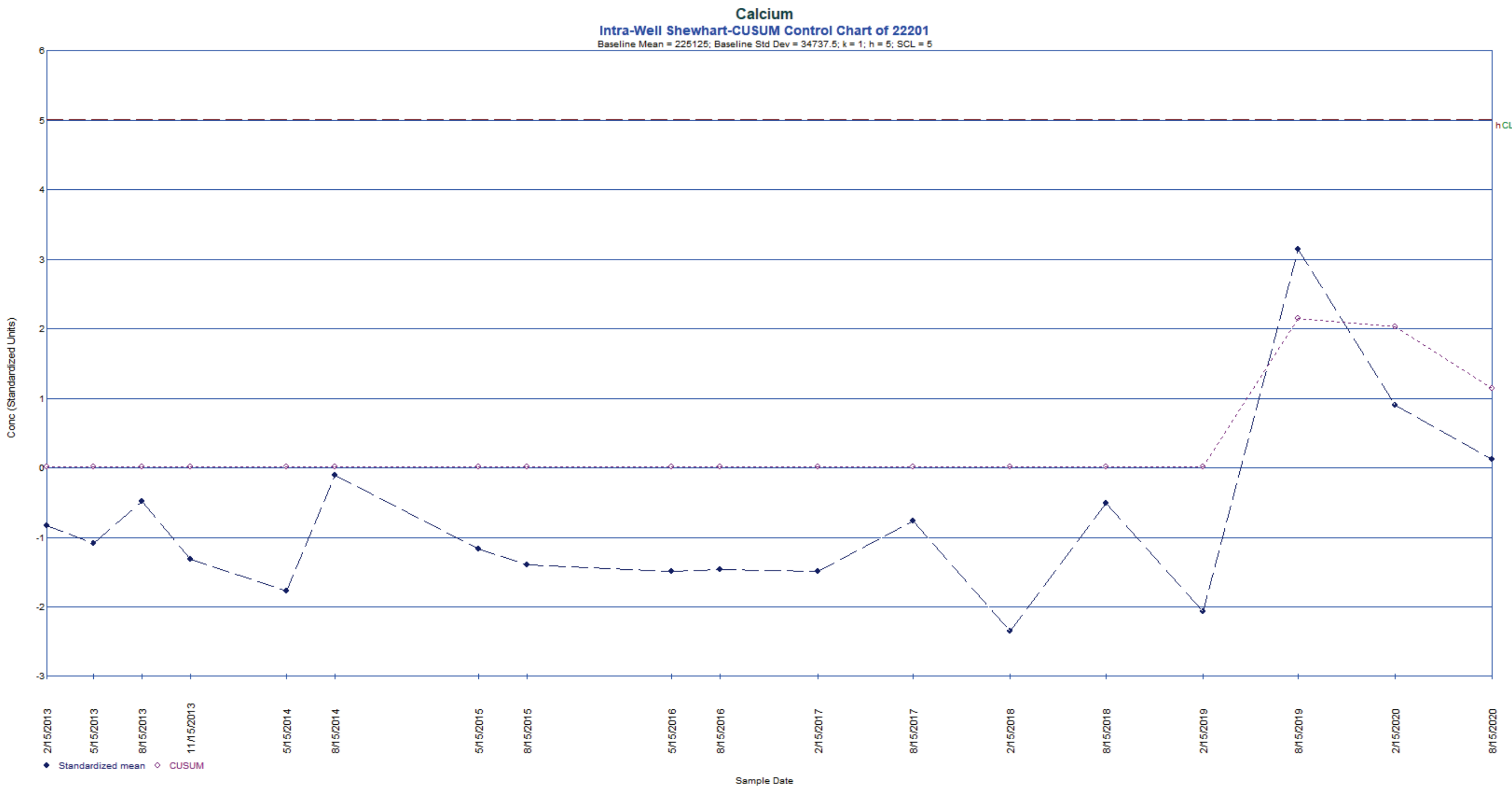

Figure A.5.1-20. Intrawell Shewhart-CUSUM Control Chart for Calcium in Monitoring Well 22201

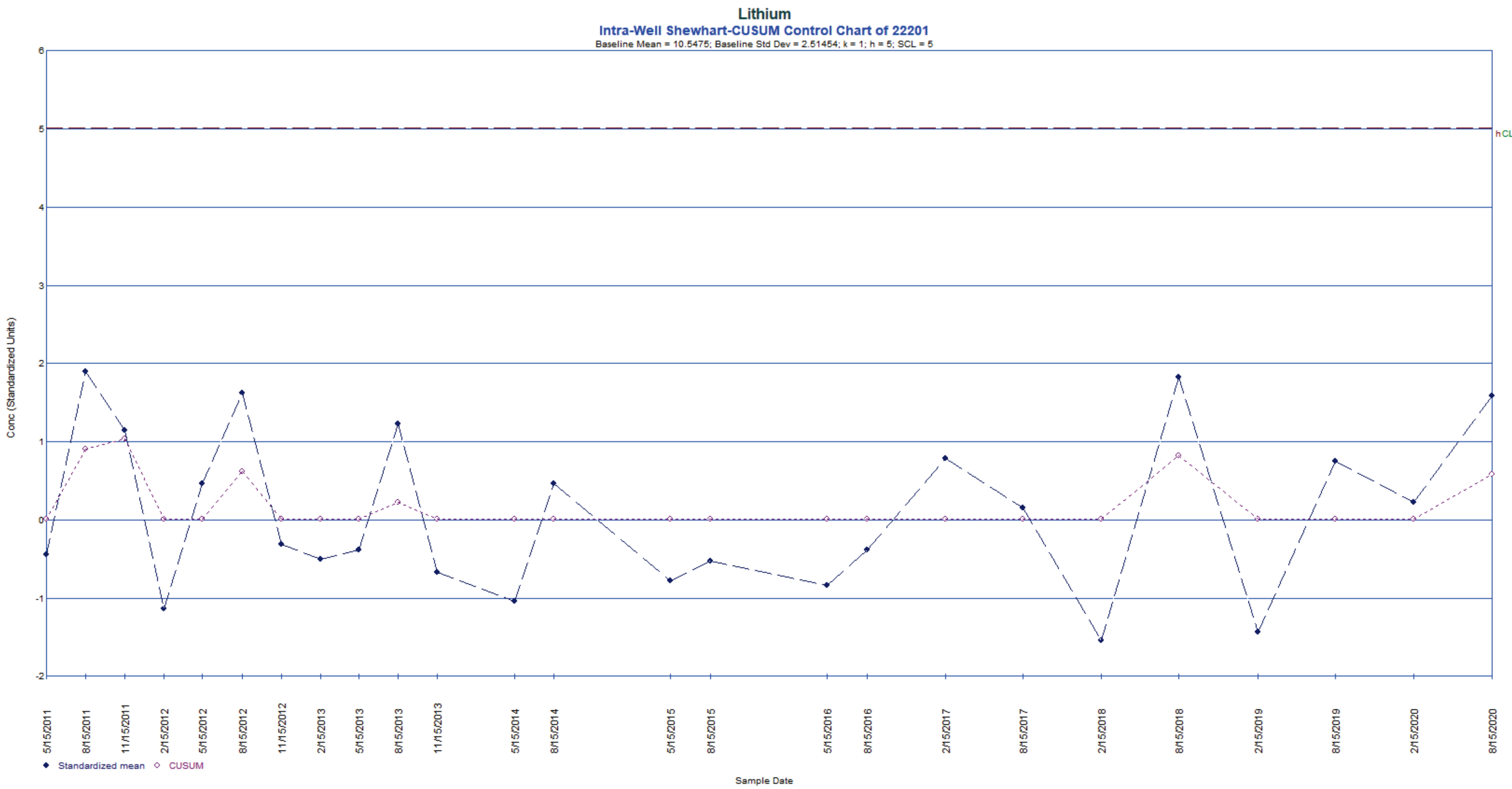

Figure A.5.1-21. Intrawell Shewhart-CUSUM Control Chart for Lithium in Monitoring Well 22201

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Subattachment A.5.2

Cell 2

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Contents

Tables

Figures

Abbreviations

CUSUM	Shewhart-cumulative sum
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
GMA	Great Miami Aquifer
GMA-D	Great Miami Aquifer–downgradient
GMA-U	Great Miami Aquifer–upgradient
HTW	horizontal till well
LCS	leachate collection system
LDS	leak detection system
Ohio EPA	Ohio Environmental Protection Agency
OSDF	On-Site Disposal Facility
SCL	Shewhart control limit

Measurement Abbreviations

amsl	above mean sea level
µg/L	micrograms per liter
mg/L	milligrams per liter
pCi/L	picocuries per liter

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This subattachment provides the following information about On-Site Disposal Facility (OSDF) Cell 2:

- Semiannual monitoring summary statistics (refer to Table A.5.2-1)
- Leachate collection system (LCS) monthly accumulation volumes (refer to Figure A.5.2-1)
- Leak detection system (LDS) monthly accumulation volumes (refer to Figure A.5.2-2)
- OSDF horizontal till well (HTW) 12339 water yield (refer to Table A.5.2-2)
- Great Miami Aquifer (GMA) water levels and total uranium concentration versus time (refer to Figures A.5.2-3 and A.5.2-4)
- Plots of concentration versus time (refer to Figures A.5.2-5A through A.5.2-17)
- A bivariate plot for uranium–sodium (refer to Figure A.5.2-18)
- Control charts (refer to Figures A.5.2-19 and A.5.2-20)

A.5.2.1 Water Quality Monitoring Results

Water quality within the cell is sampled in the LCS and LDS. Water quality beneath the cell is sampled in the HTW and GMA wells. Concentration-versus-time plots, bivariate plots, and control charts are used to help interpret and present the results.

Until 2014, quarterly water quality monitoring occurred in the LCS, LDS, HTW, and GMA wells of each cell for the purpose of determining whether 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.

With EPA and Ohio EPA concurrence, DOE reduced the number of parameters sampled from 24 to 13 beginning in January 2017. All 13 parameters are sampled in the GMA wells: 4 of the 13 parameters (total uranium, boron, sodium, and sulfate) are sampled in the LCS, LDS, and HTW for each cell. The annual sampling in the LCS of each cell for the abbreviated list of Appendix I parameters and polychlorinated biphenyls listed in *Ohio Administrative Code* 3745-27-10 was also eliminated beginning in January 2017 with EPA and Ohio EPA concurrence (DOE 2017).

A.5.2.1.1 LCS and LDS Results

As shown in Table A.5.2-1 and summarized below, four parameters (total uranium, boron, sodium, and sulfate) have upward trends in the LCS or LDS based on the Mann-Kendall test for trend. A new high sulfate concentration was measured in the LCS of Cell 2 in 2020 (1,960 micrograms per liter [µg/L]). The previous high was 1,870 µg/L. The volume of water in the LDS tank of Cell 2 has been insufficient to collect a sample since 2013.

Parameters with Upward Concentration Trends in the LCS and LDS of Cell 2[a]

Parameter	LCS 12339C 2020 Trend	LDS 12339D Trend (Year Last Sampled)
Total Uranium	Up	
Boron	Up	Up (2013)
Sodium	Up	Up (2013)
Sulfate	Up	Up (2013)

[a] No entry indicates that the trend was not up.

A.5.2.1.2 HTW and Monitoring Well Results

As shown in Table A.5.2-1 and summarized below, four parameters (total uranium, boron, lithium, and potassium) have upward trends in the HTW and/or the GMA wells based on the Mann-Kendall test for trend.

Parameters with Upward Concentration Trends in the HTW and GMA Wells of Cell 2[a]

Parameter	HTW 12339	GMA-U[b] 22200	GMA-D[b] 22199
Total Uranium	Up	Up	
Boron	Up	Up	Up
Lithium		Up	Up
Potassium		Up	

[a] No entry indicates that the trend was not up.
[b] GMA-U = upgradient Great Miami Aquifer; GMA-D = downgradient Great Miami Aquifer.

A.5.2.1.3 Discussion

The uranium–sodium bivariate plot for the Cell 2 LCS, LDS, and HTW is provided in Figure A.5.2-18. On the figure, the first sample ever collected from the monitoring horizon is circled. An arrow leads from the first sample to the location of the most recent sample. The plot shows that the chemical signatures for uranium and sodium in the LCS, LDS, and HTW are separate and distinct, indicating that mixing between the horizons is not occurring; therefore, upward concentration trends measured beneath the cells in GMA wells are attributed to fluctuating ambient concentrations beneath the cell and are not related to cell performance.

A.5.2.2 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. 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 "not in 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. Usually, two parameters are used to compute standardized limits—the decision value (*h*) and the Shewhart control limit (SCL).

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 eight samples were selected for control charts. By default, the ChemStat software plots both a CUSUM control limit (*h*) and an SCL on the control chart. The software recommends a value of 5 for the CUSUM control limit and a value of 4.5 for the SCL.

EPA Statistical Analysis 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 is not needed. The ChemStat software though, by default, plots both the SCL and CUSUM control limit on the charts. To address this issue, the SCL was defined as 5 to equal the recommended CUSUM (*h*) limit. This combined limit is identified as *h*CL on the control charts. For interpretation purposes, the *h*CL value will be regarded as the CUSUM (*h*) limit.

As shown in Table A.5.2-1 in gray shading and as summarized below, two parameters in the HTW or GMA wells of Cell 2 meet the criteria for control charts (i.e., at least eight samples, normal or lognormal distribution, no trend, and no serial correlation), resulting in two control charts (Figures A.5.2-19 and A.5.2-20). All control charts for Cell 2 indicate "in control" conditions.

Parameter	Monitoring Point[a]	Well Number	Assessment	Figure Number
Potassium	GMA-D	22199	In Control	A.5.2-19
Total Dissolved Solids	GMA-D	22199	In Control	A.5.2-20

[a] GMA-U = upgradient Great Miami Aquifer; GMA-D = downgradient Great Miami Aquifer.

A.5.2.3 Summary and Conclusions

- Four parameters monitored semiannually have an upward concentration trend in the LCS of Cell 2: total uranium, boron, sodium, and sulfate. A new high sulfate concentration was measured in the LCS of Cell 2 in 2020 (1,960 µg/L). The previous high was 1,870 µg/L.
- The volume of water in the LDS tank of Cell 2 has been insufficient to collect a sample since 2013.
- Four parameters monitored semiannually have an upward concentration trend in the HTW or GMA wells of Cell 2: total uranium, boron, lithium, and potassium. Separate and distinct chemical signatures for total uranium and sodium in the LCS, LDS, and HTW of Cell 2 indicate that water is not mixing between the horizons. Therefore, upward concentration trends beneath Cell 2 (i.e., HTW or GMA wells) are attributed to fluctuating ambient concentrations beneath the cell and not to cell performance.
- Two control charts were constructed for Cell 2 parameters. Both control charts exhibit "in control" conditions.

A.5.2.4 References

DOE (U.S. Department of Energy), 2017. *Fernald Preserve 2016 Site Environmental Report*, LMS/FER/S15232, Office of Legacy Management, Cincinnati, Ohio, May.

EPA (U.S. Environmental Protection Agency), 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities—Unified Guidance*, EPA 530/R-09-007, March.

OAC 3745-27-10. "Ground Water Monitoring Program for a Sanitary Landfill Facility," *Ohio Administrative Code.*

Table A.5.2-1. Summary Statistics for Cell 2

Parameter	Horizon[a]	Location	Number of Detected Samples	Total Number of Samples	Percent Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[d]	Distribution Type[d,e]	Trend[d,f] (Year Last Sampled)	Serial Correlation[d,g]	Outliers[h,i]
Total Uranium (µg/L)	LCS	12339C	72	72	100	4.51	686	129	116	Ln Normal	Up (2020)	Detected	
	LDS	12339D	35	35	100	4.08	71	14.5	13.2	Undefined	None (2013)	Detected	
	HTW	12339	73	74	98.6	ND	36.9	11.0	6.6	Undefined	Up (2020)	Detected	
	GMA-U	22200	60	80	75.0	ND	4.69	0.296	0.576	Undefined	Up (2020)	Not Detected	
	GMA-D	22199	82	87	94.2	ND	12.1	0.658	2.21	Undefined	Down (2020)	Not Detected	
Boron (mg/L)	LCS	12339C	73	73	100	0.207	4.78	2.66	1.10	Undefined	Up (2020)	Detected	
	LDS	12339D	35	35	100	0.289	2.22	0.422	0.371	Undefined	Up (2013)	Detected	
	HTW	12339	54	57	94.7	ND	0.213	0.102	0.054	Undefined	Up (2020)	Detected	
	GMA-U	22200	68	80	85.0	ND	0.105	0.0564	0.0235	Undefined	Up (2020)	Detected	
	GMA-D	22199	71	80	88.8	ND	0.0899	0.0502	0.0150	Normal	Up (2020)	Detected	
Sodium (mg/L)	LCS	12339C	49	49	100	3.32	42.8	20.2	6.7	Normal	Up (2020)	Detected	
	LDS	12339D	10	10	100	664	2450	1226	536	Normal	Up (2013)	Detected	
	HTW	12339	42	42	100	31.6	119	46.0	23.5	Undefined	Down (2020)	Detected	
	GMA-U	22200	33	33	100	20.4	32.9	26.8	3.4	Normal	Down (2020)	Detected	
	GMA-D	22199	34	34	100	7.94	19.5	13.6	3.2	Normal	Down (2020)	Detected	
Sulfate (mg/L)	LCS	12339C	61	61	100	155	1960	1600	320	Undefined	Up (2020)	Detected	
	LDS	12339D	18	18	100	2290	13,000	4800	2680	Ln Normal	Up (2013)	Detected	
	HTW	12339	52	52	100	344	850	563	122	Normal	Down(2020)	Detected	
	GMA-U	22200	57	57	100	61.1	434	136	95	Undefined	Down (2020)	Detected	
	GMA-D	22199	57	57	100	101	540	170	87	Undefined	None (2020)	Not Detected	
Calcium (mg/L)	GMA-U	22200	26	26	100	121	205	138	23	Undefined	None (2020)	Not Detected	
	GMA-D	22199	26	26	100	125	193	144	19	Undefined	None (2020)	Not Detected	
Lithium (mg/L)	GMA-U	22200	33	33	100	0.00345	0.00587	0.00422	0.00058	Ln Normal	Up (2020)	Not Detected	
	GMA-D	22199	33	33	100	0.0065	0.0101	0.00767	0.00079	Ln Normal	Up (2020)	Detected	
Magnesium (mg/L)	GMA-U	22200	26	26	100	33.1	54.9	39.0	5.1	Undefined	None (2020)	Not Detected	
	GMA-D	22199	26	26	100	36.2	54.8	41.0	4.7	Undefined	None (2020)	Not Detected	
Nitrate + Nitrite, as Nitrogen (mg/L)	GMA-U	22200	3	26	11.5	ND	0.200	0.0256	Insufficient	Insufficient	Insufficient	Insufficient	
	GMA-D	22199	2	26	7.7	ND	0.0425	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
Potassium (mg/L)	GMA-U	22200	26	26	100	1.5	2.14	1.84	0.18	Normal	Up (2020)	Detected	
	GMA-D	22199	27	27	100	1.28	1.75	1.47	0.11	Normal	None (2020)	Not Detected	
Selenium (mg/L)	GMA-U	22200	3	33	9.1	ND	0.0114	0.00376	Insufficient	Insufficient	Insufficient	Insufficient	
	GMA-D	22199	0	33	0	ND	NA	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
Technitium-99 (pCi/L)	GMA-U	22200	0	29	0	ND	NA	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
	GMA-D	22199	0	29	0	ND	NA	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
Total Dissolved Solids (mg/L)	GMA-U	22200	33	33	100	497	857	609	100	Undefined	None (2020)	Not Detected	
	GMA-D	22199	33	33	100	520	820	647	74	Normal	None (2020)	Not Detected	
Total Organic Halogens (mg/L)	GMA-U	22200	28	80	35.0	ND	0.177	0.00429	0.0247	Undefined	Down (2020)	Detected	
	GMA-D	22199	17	80	21.2	ND	0.0775	0.00250	0.0118	Undefined	Down (2020)	Detected	

Note 1: Shading identifies a horizontal till well or Great Miami Aquifer well, with at least eight samples, Normal or Ln Normal distribution, no trend (None), and no serial correlation (Not Detected). These wells achieve control chart criteria.

Note 2: Data used in this table has been standardized to quarterly.

[a]LCS = leachate collection system; LDS = leak detection system; HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; and GMA-D = downgradient Great Miami Aquifer

[b]ND = not detected; NA = not applicable

[c]Averages were determined based on the distribution assumption.

[d]Insufficient is used for Distribution Type, Trend, or Serial Correlation whenever there is not enough data to run the test.

[e]Data distribution based on the Shapiro-Wilk statistic.

Normal: Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the Ln Normal assumption.

Ln Normal: Ln Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the normal assumption.

Undefined: Normal and Ln Normal Distribution assumptiions are both rejected or there are less than 25 percent detected values. "Average" is defined as the Median of the data.

[f]Trend based on nonparametric Mann-Kendall procedure.

[g]Serial correlation based on Rank Von Neumann test.

[h]Outliers determined by Rosner's (for sample sizes greater than 25) or Dixon procedure (for sample sizes less than or equal to 25).

[i]Q = quarter

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Table A.5.2-2. OSDF Horizontal Till Well 12339 (Cell 2) Water Yield

Year	Total Volume Purged (gallons)	Number of Months Purged	Average Volume Purged (gallons)
1999	5,725	7	818
2000	5,750	6	958
2001	3,395	4	849
2002	3,625	4	906
2003	3,370	4	843
2004	3,220	4	805
2005	3,275	4	819
2006	3,175	4	1,088
2007	3,325	4	831
2008	3,050	4	763
2009	2,400	4	800
2010	3,275	4	819
2011	3,200	4	800
2012	3,110	4	778
2013	2,945	4	736
2014	1,605	2	803
2015	1,450	2	725
2016	1,535	2	768
2017	1,600	2	800
2018	1,605	2	803
2019	1,580	2	790
2020	1,645	2	823

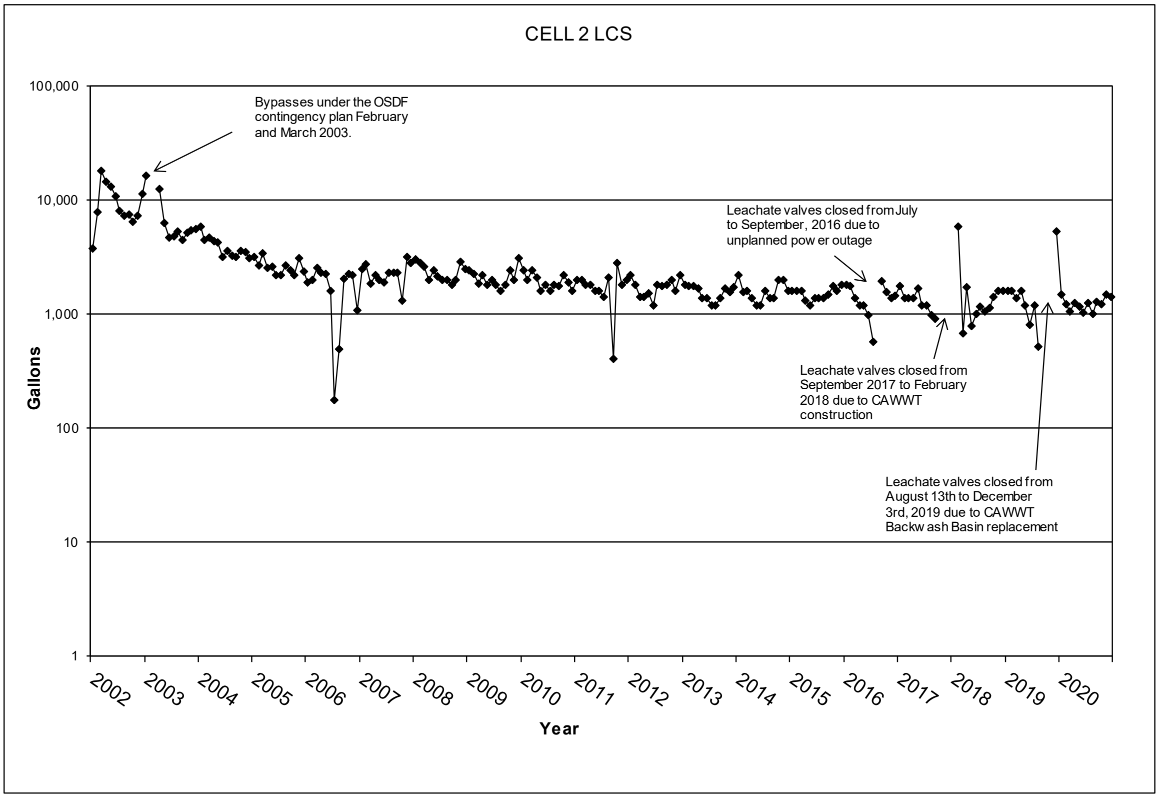

Figure A.5.2-1. Monthly Accumulation Volumes for Cell 2 LCS

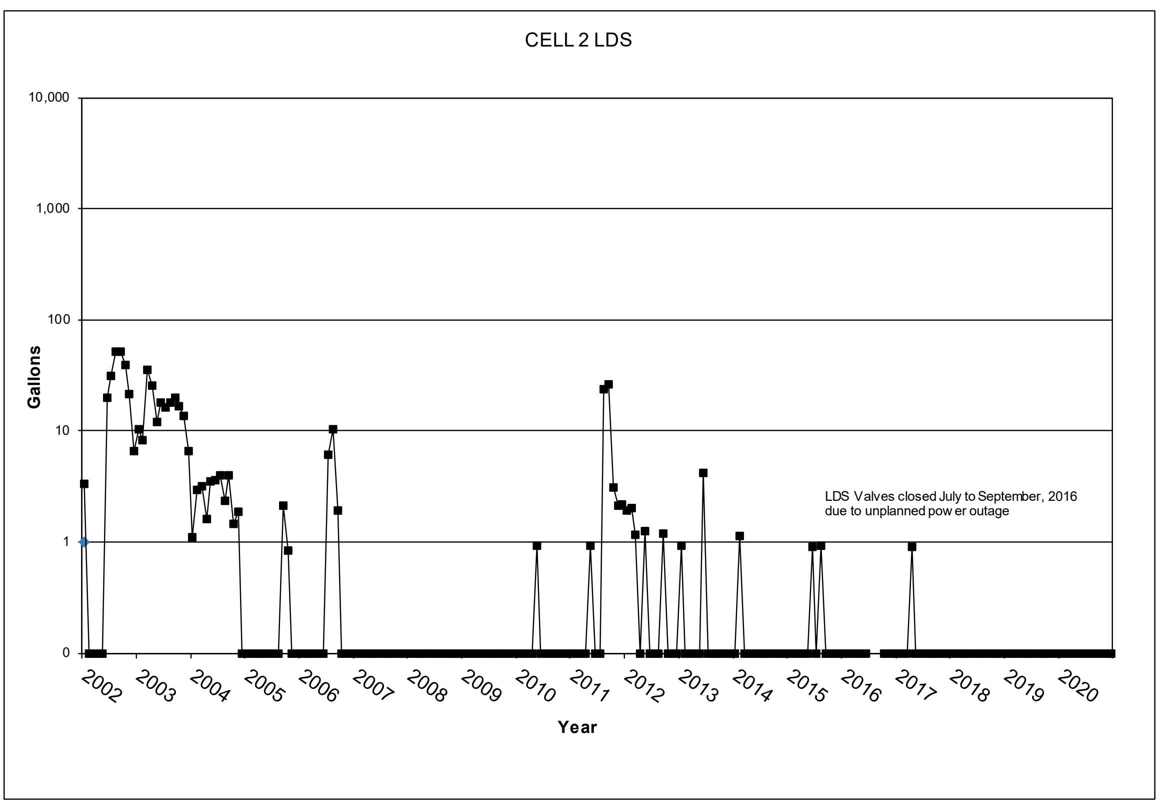

Figure A.5.2-2. Monthly Accumulation Volumes for Cell 2 LDS

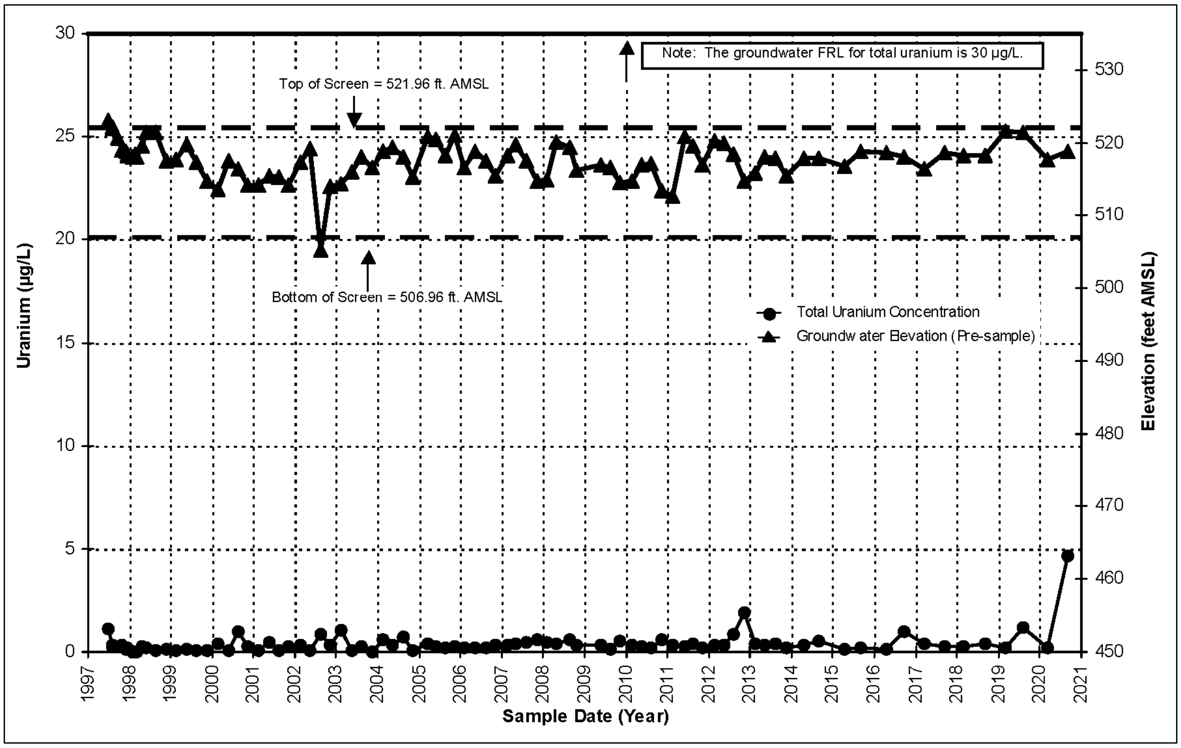

Figure A.5.2-3. Total Uranium Concentration and Groundwater Elevation Versus Time Plot for Cell 2 Upgradient Monitoring Well 22200

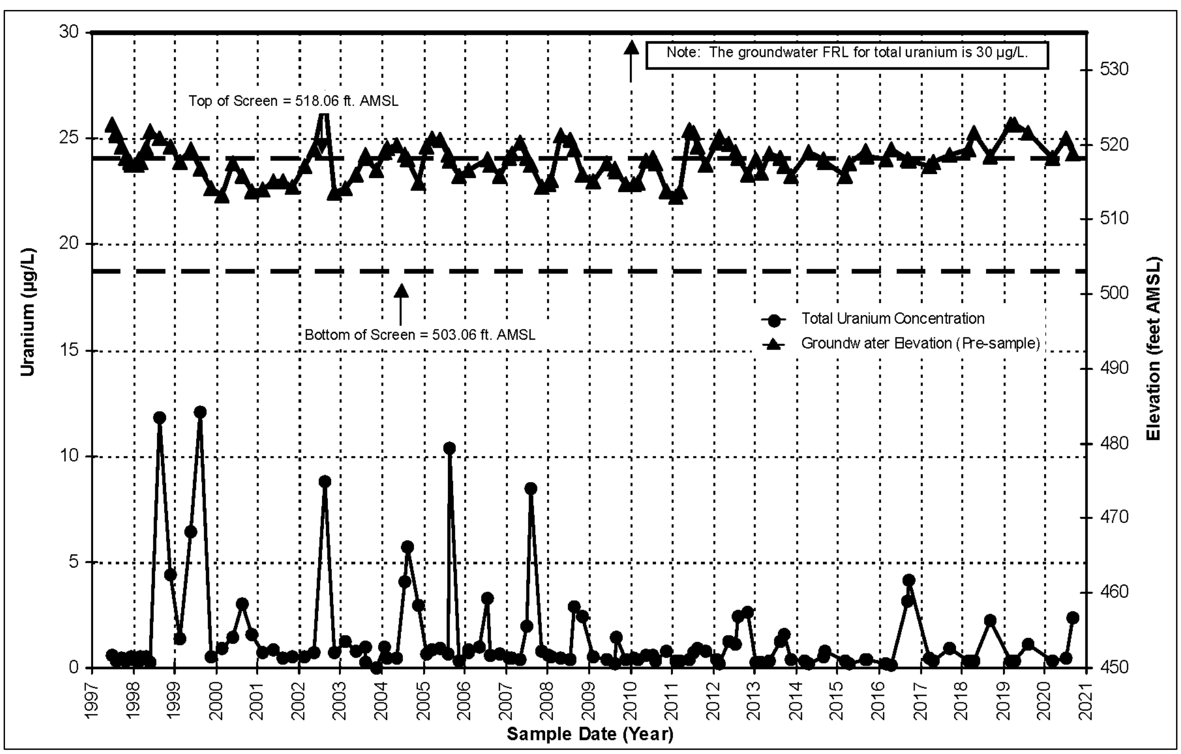

Figure A.5.2-4. Total Uranium Concentration and Groundwater Elevation Versus Time Plot for Cell 2 Downgradient Monitoring Well 22199

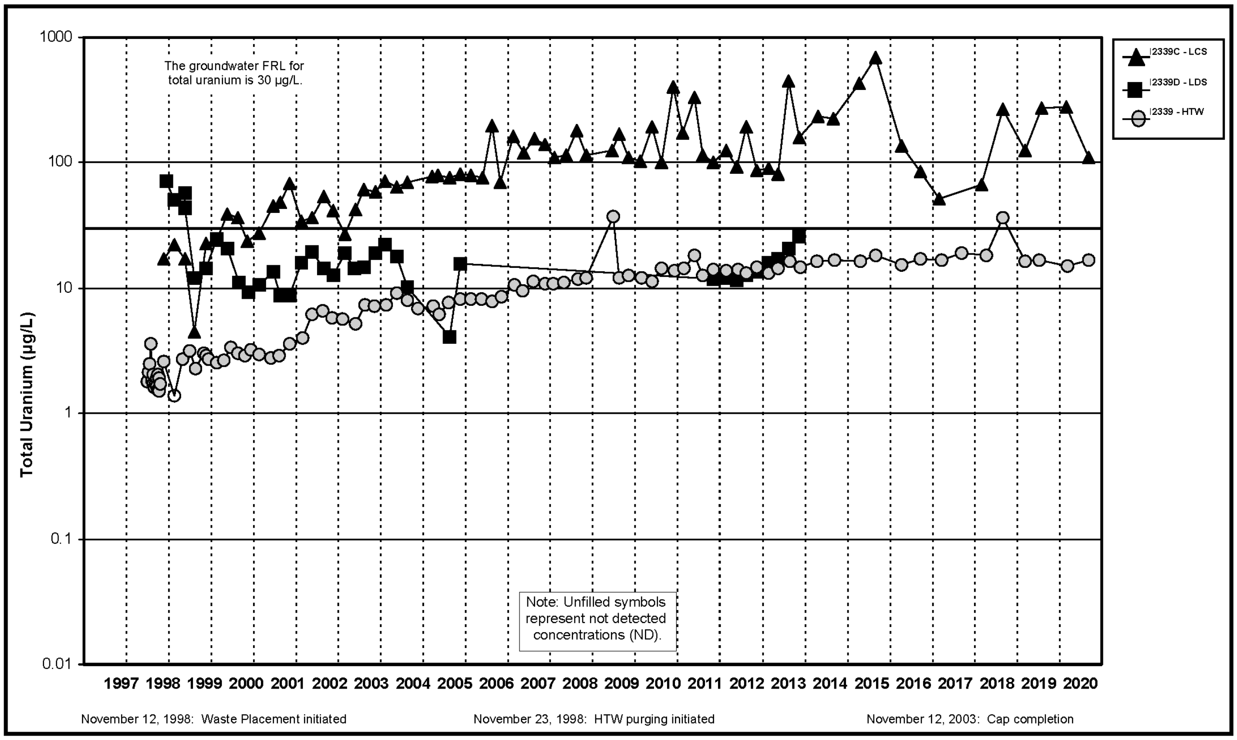

Figure A.5.2-5A. Cell 2 Total Uranium Concentration Versus Time Plot for LCS, LDS, and HTW

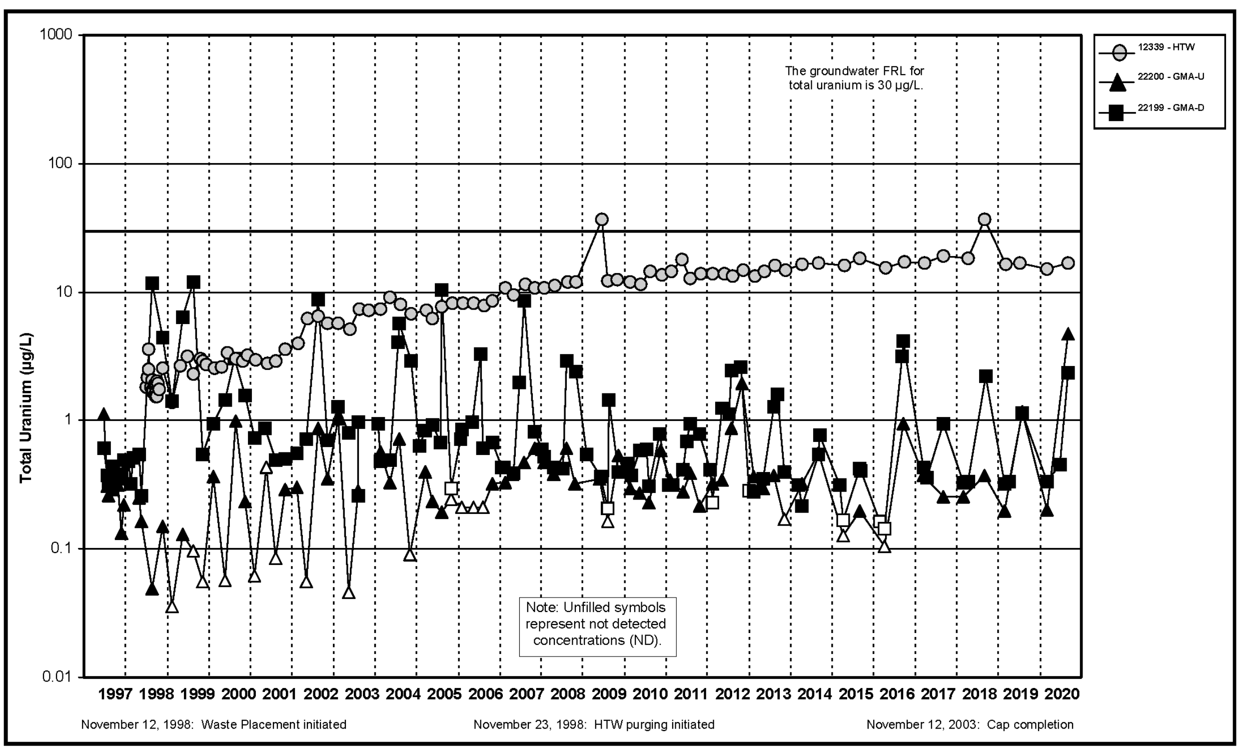

Figure A.5.2-5B. Cell 2 Total Uranium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

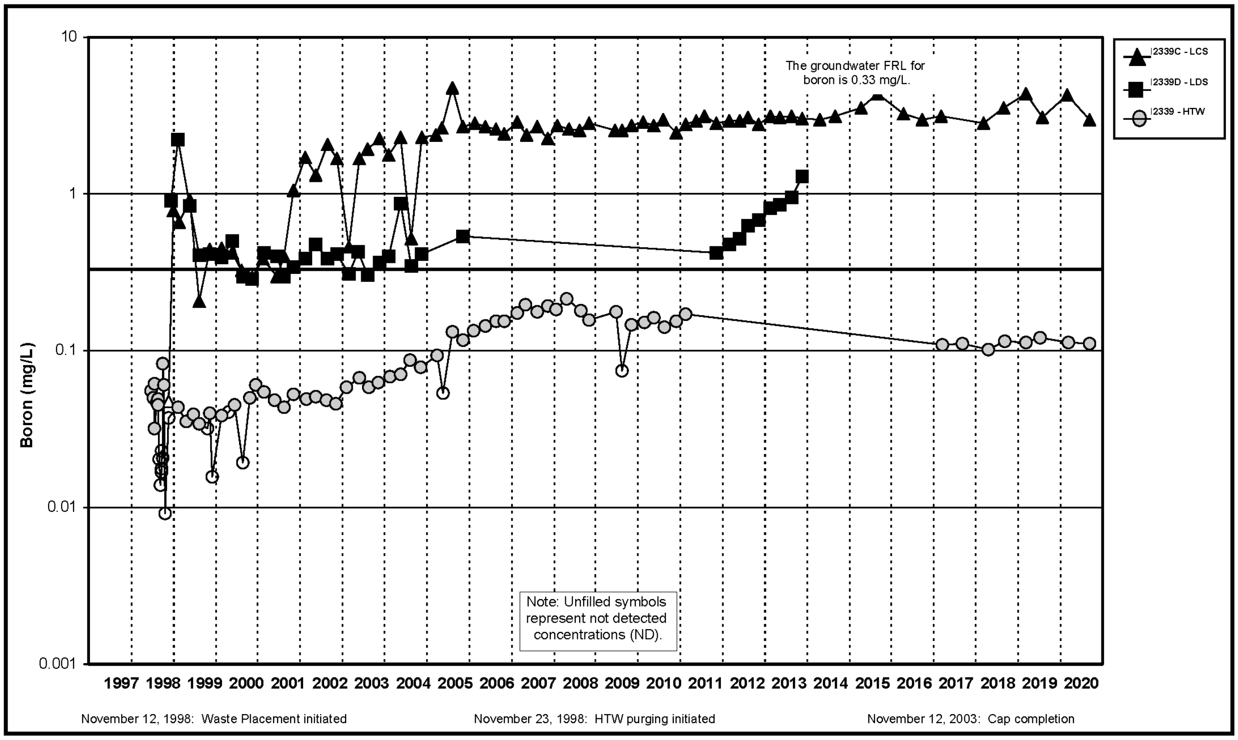

Figure A.5.2-6A. Cell 2 Boron Concentration Versus Time Plot for LCS, LDS, and HTW

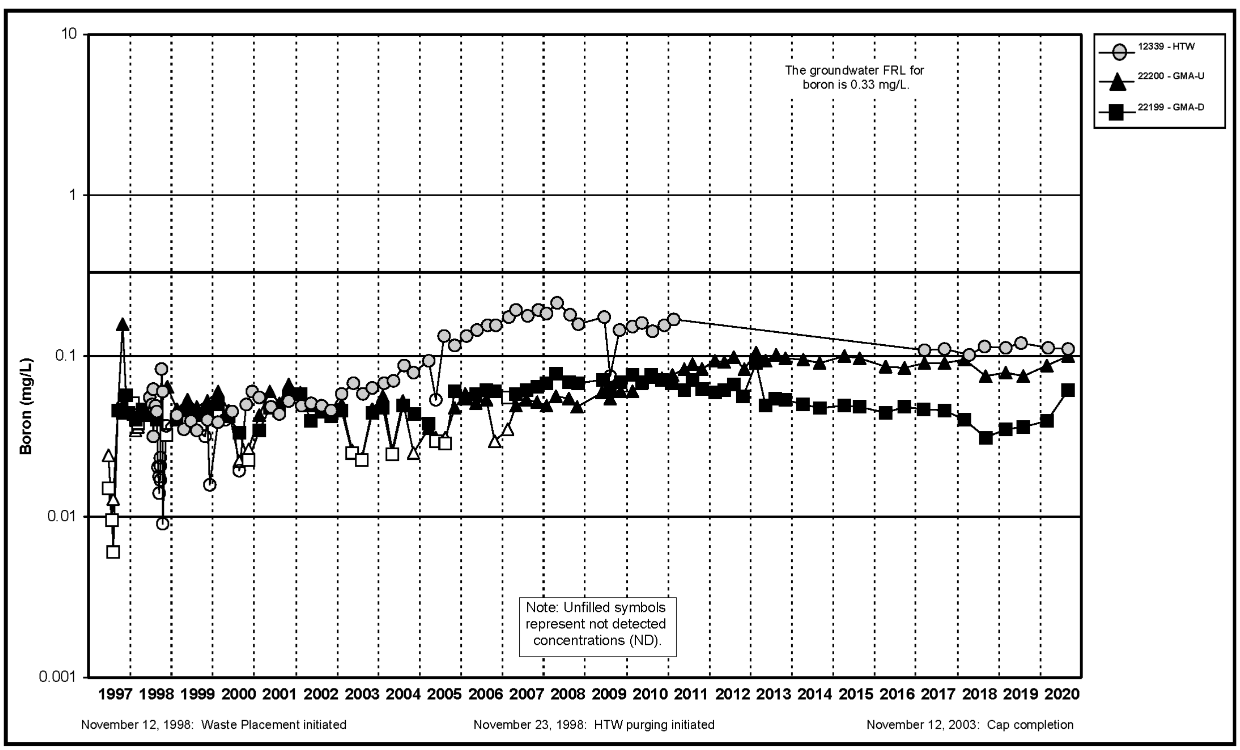

Figure A.5.2-6B. Cell 2 Boron Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

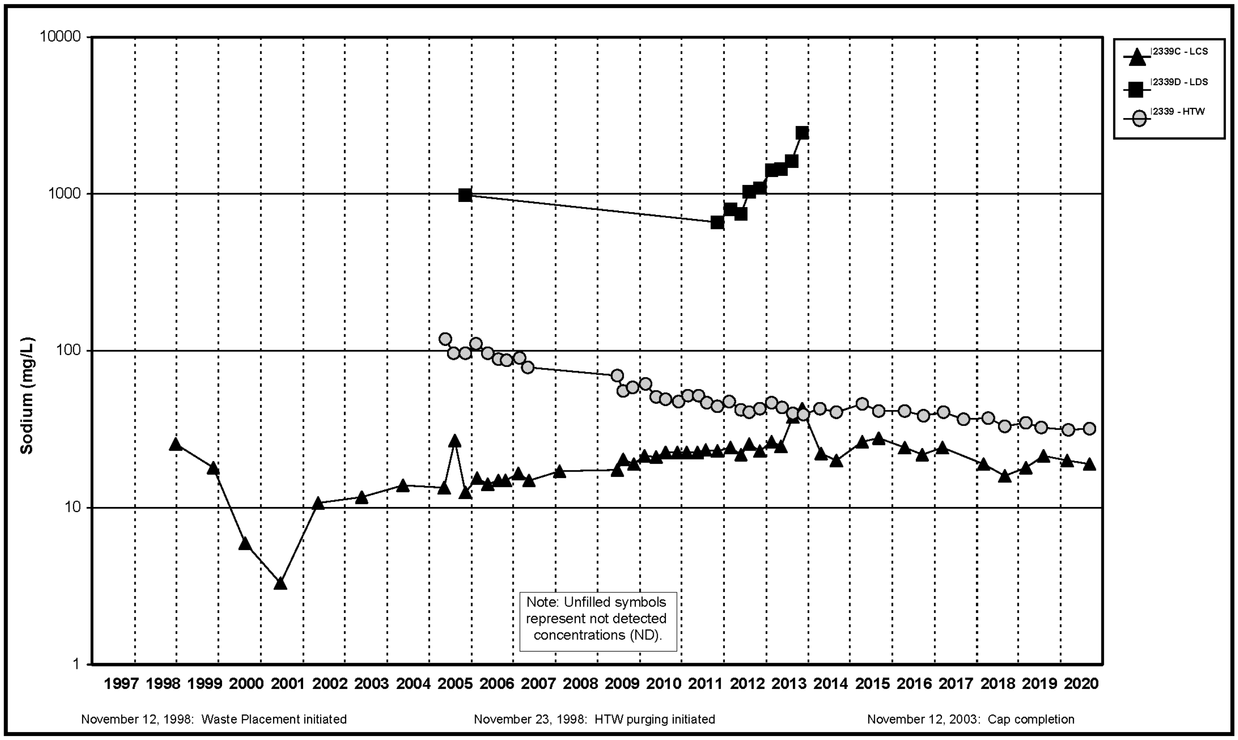

Figure A.5.2-7A. Cell 2 Sodium Concentration Versus Time Plot for LCS, LDS, and HTW

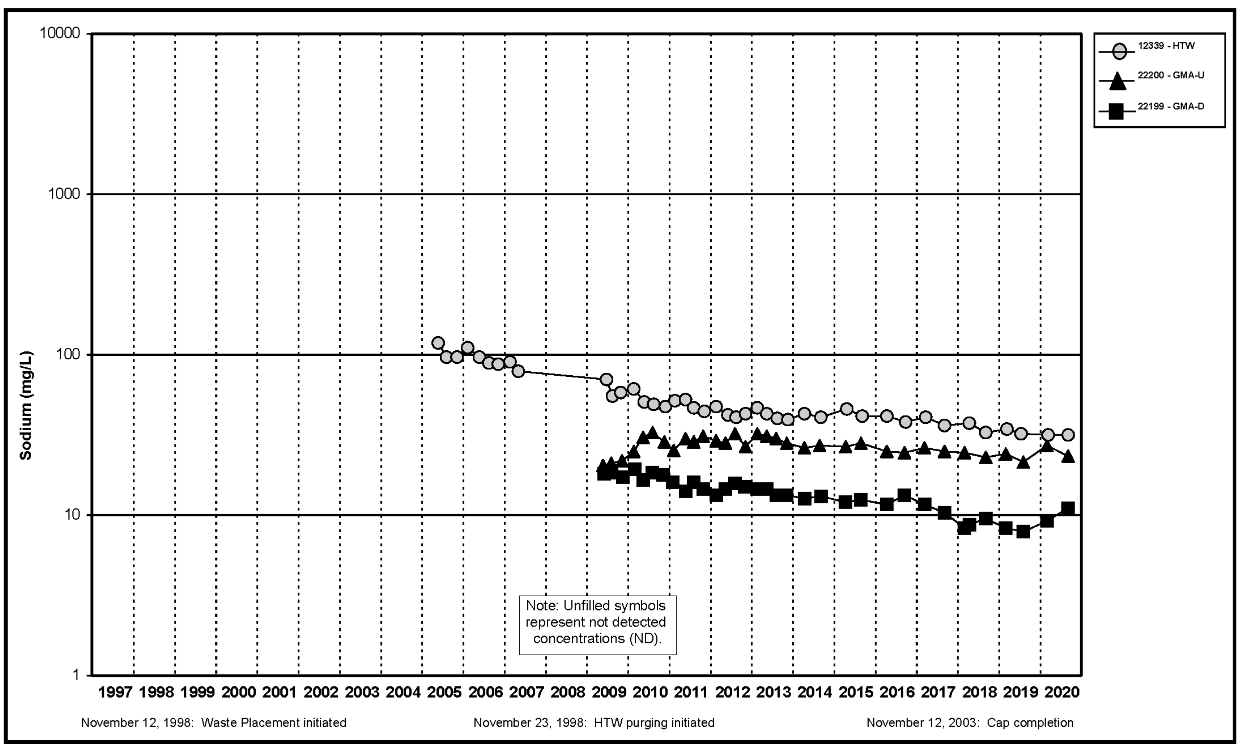

Figure A.5.2-7B. Cell 2 Sodium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

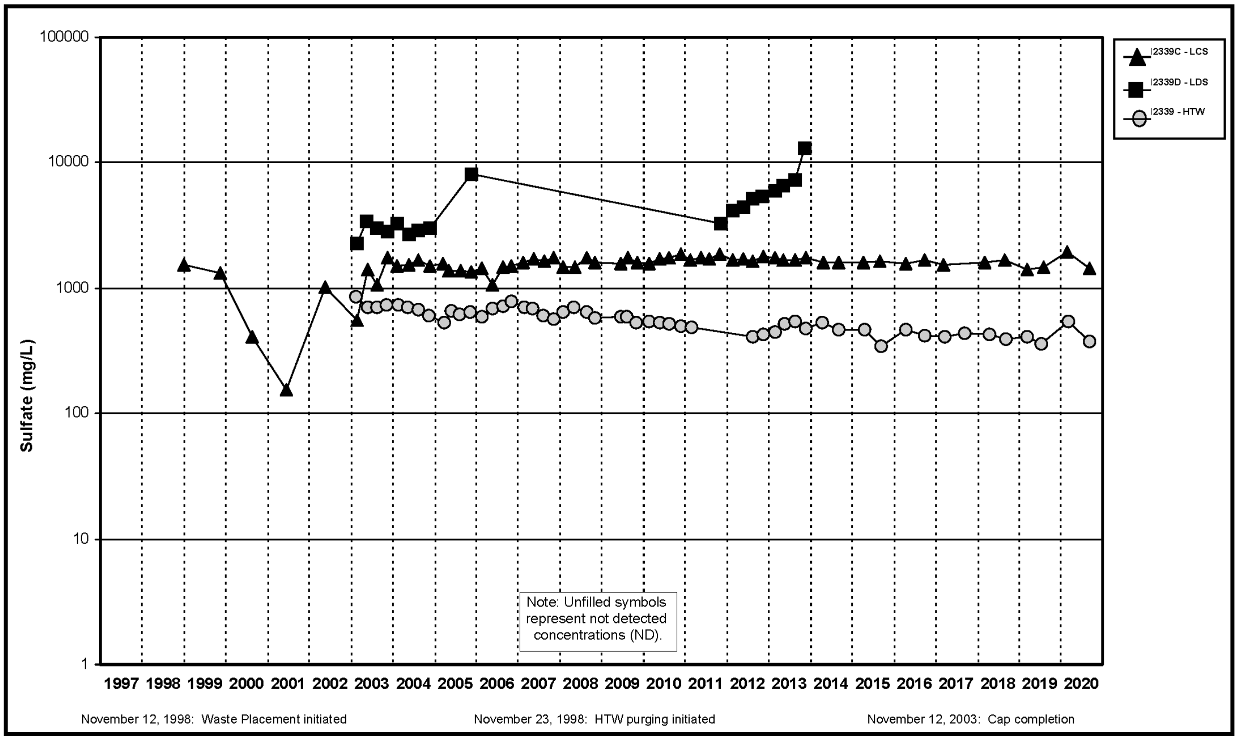

Figure A.5.2-8A. Cell 2 Sulfate Concentration Versus Time Plot for LCS, LDS, and HTW

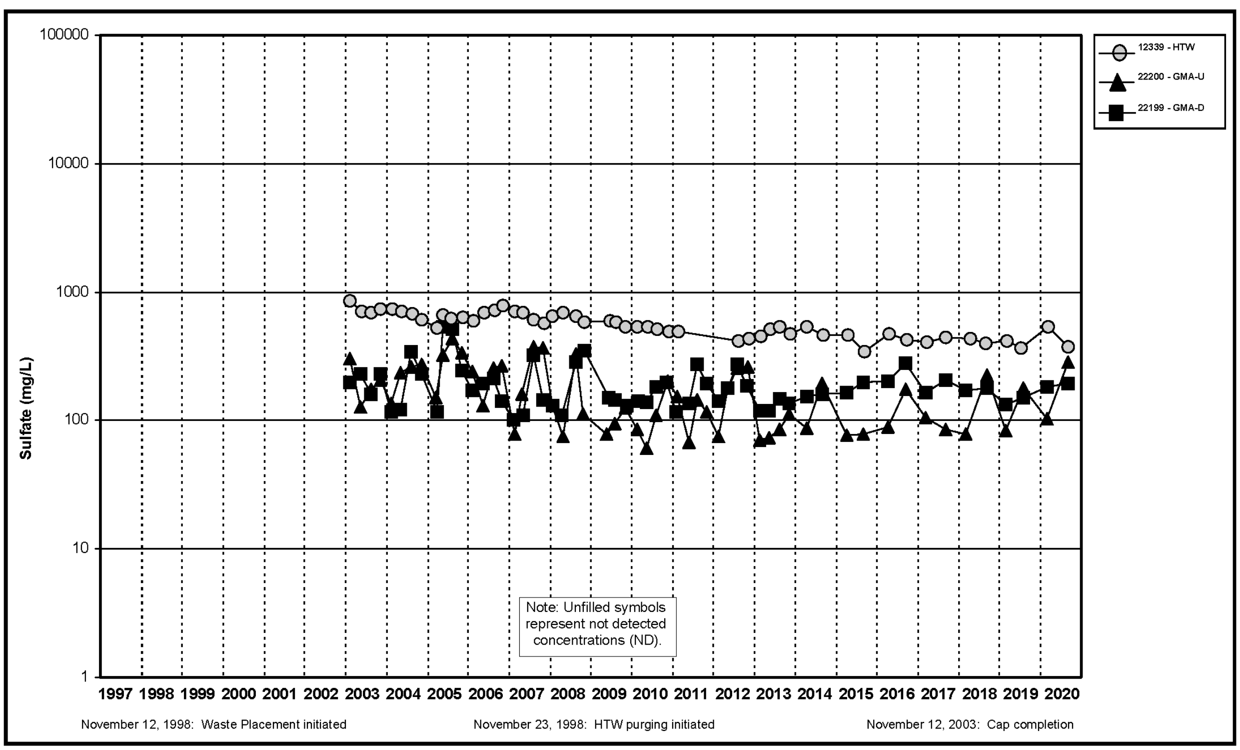

Figure A.5.2-8B. Cell 2 Sulfate Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

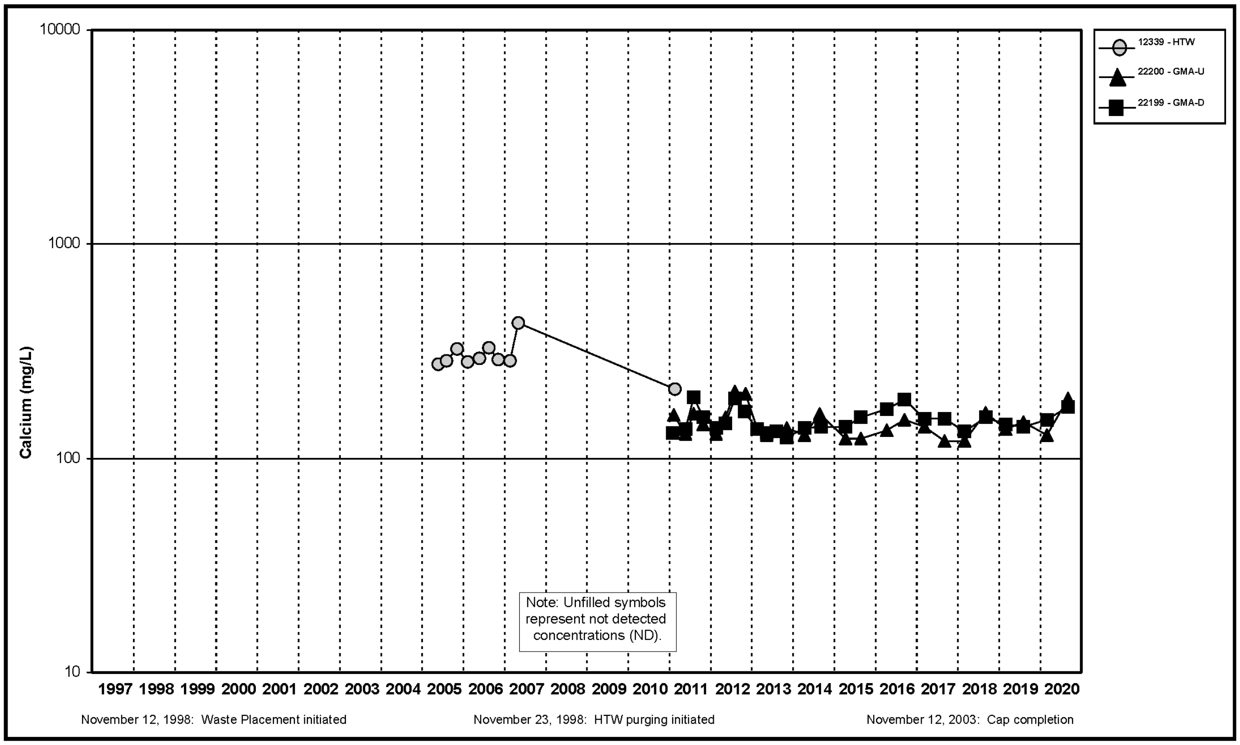

Figure A.5.2-9. Cell 2 Calcium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

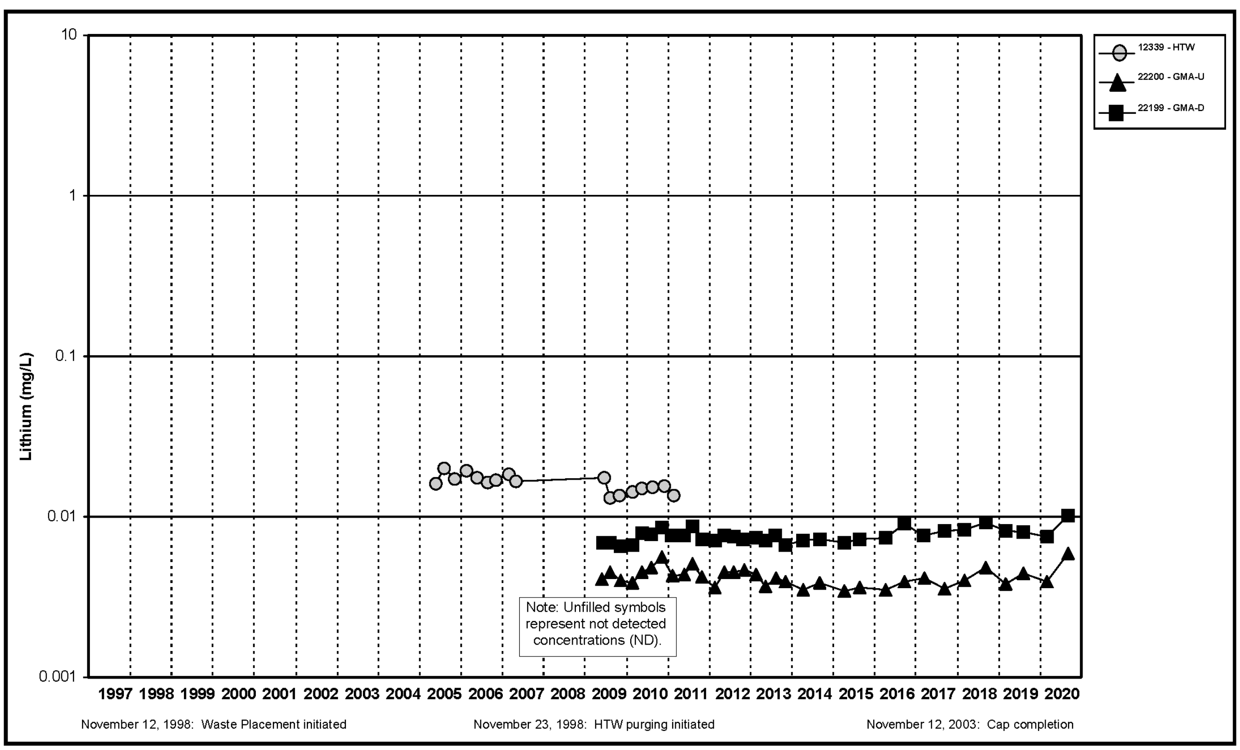

Figure A.5.2-10. Cell 2 Lithium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

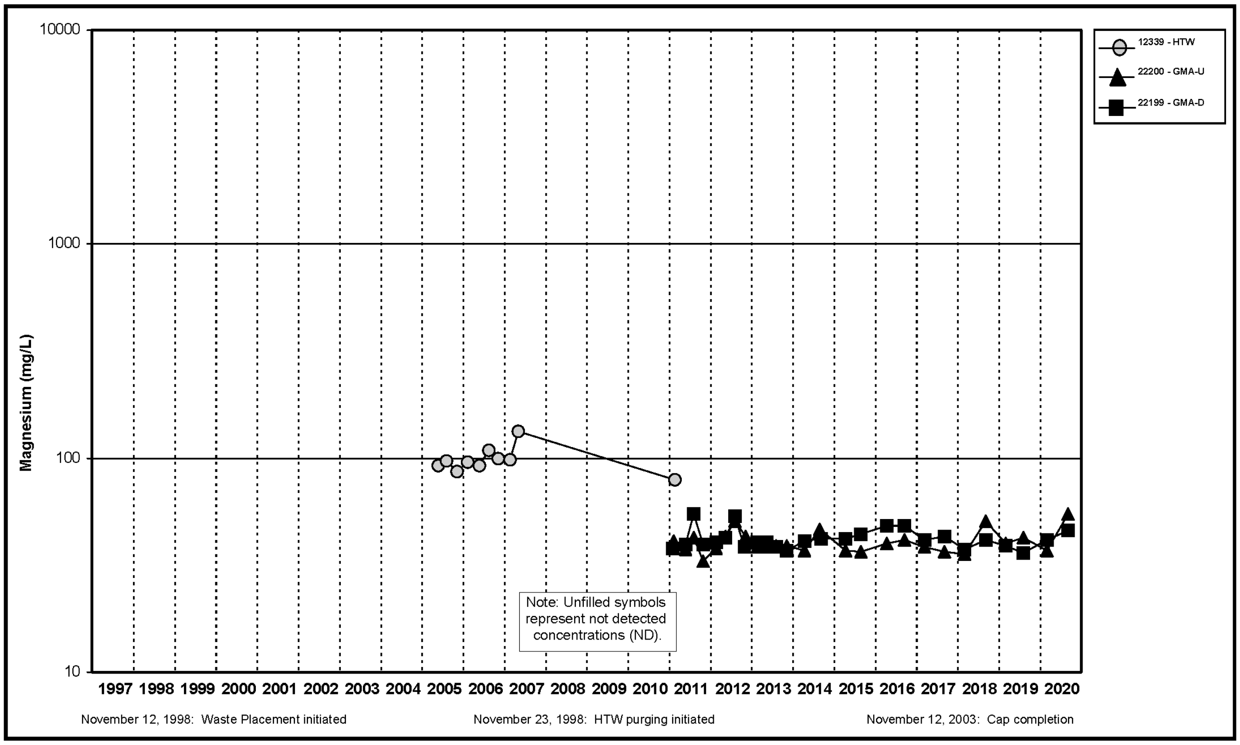

Figure A.5.2-11. Cell 2 Magnesium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

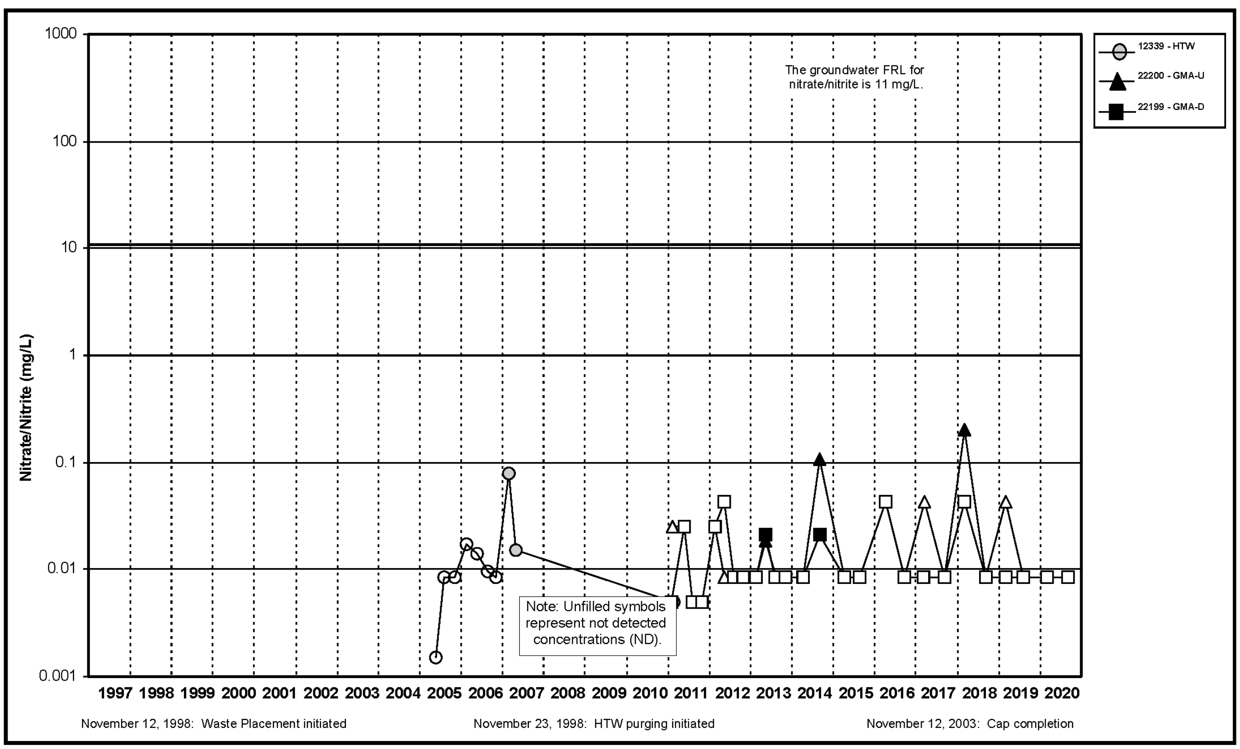

Figure A.5.2-12. Cell 2 Nitrate + Nitrite as Nitrogen Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

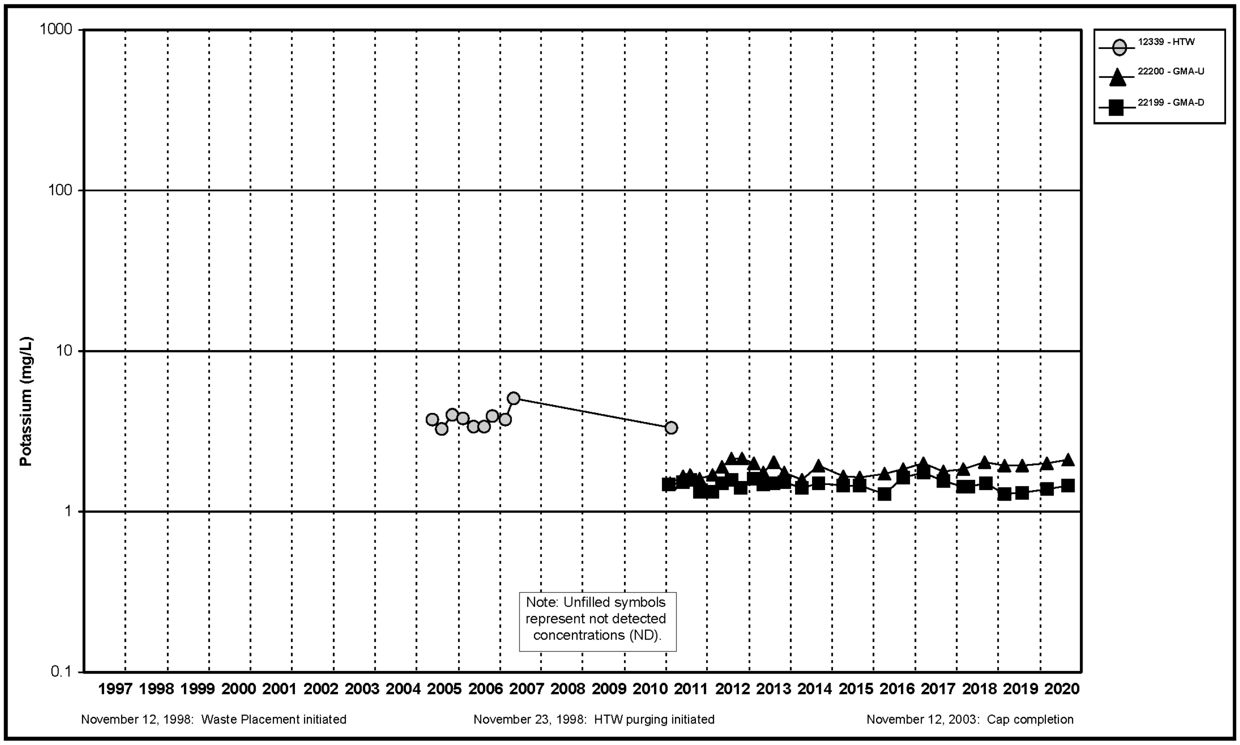

Figure A.5.2-13. Cell 2 Potassium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

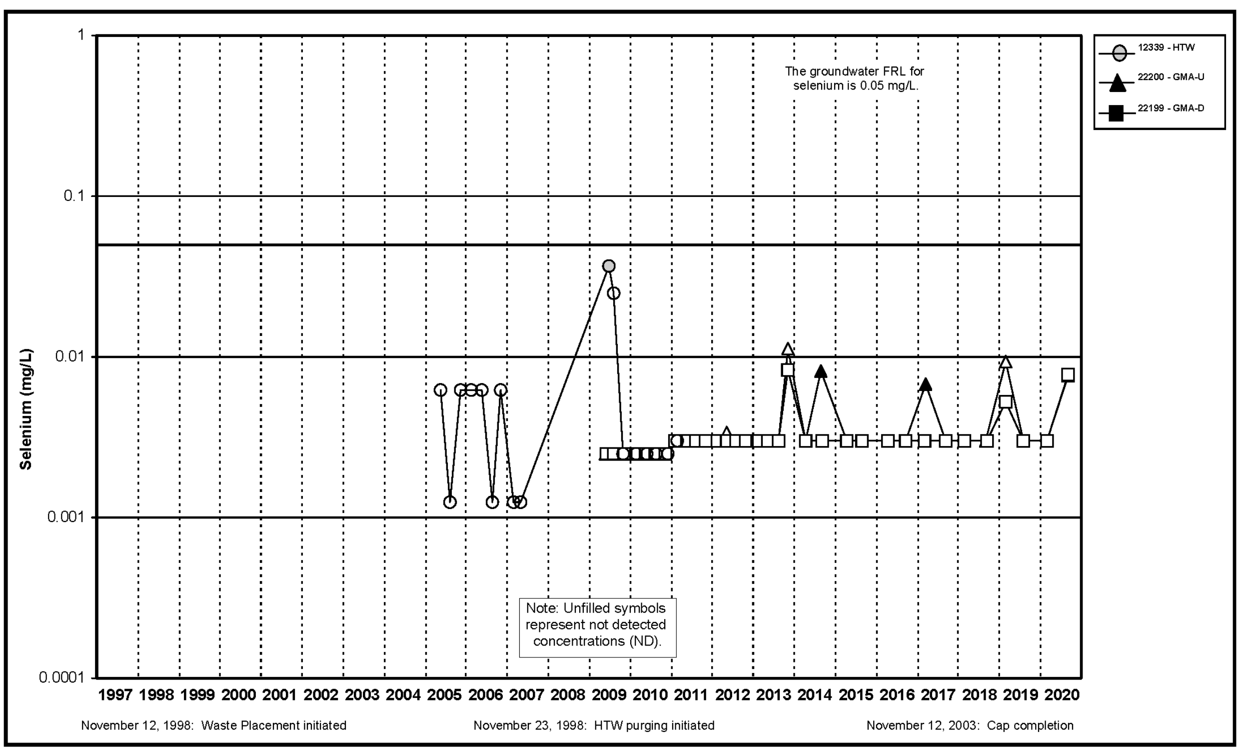

Figure A.5.2-14. Cell 2 Selenium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

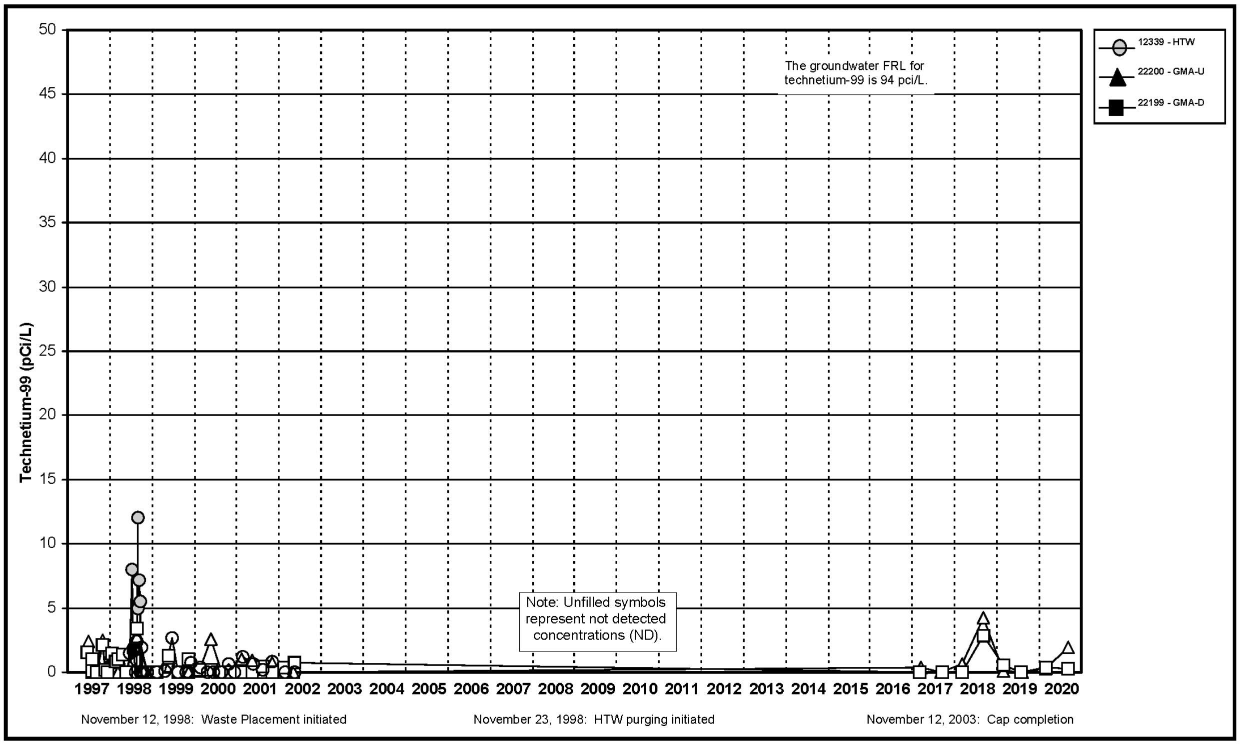

Figure A.5.2-15. Cell 2 Technetium-99 Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

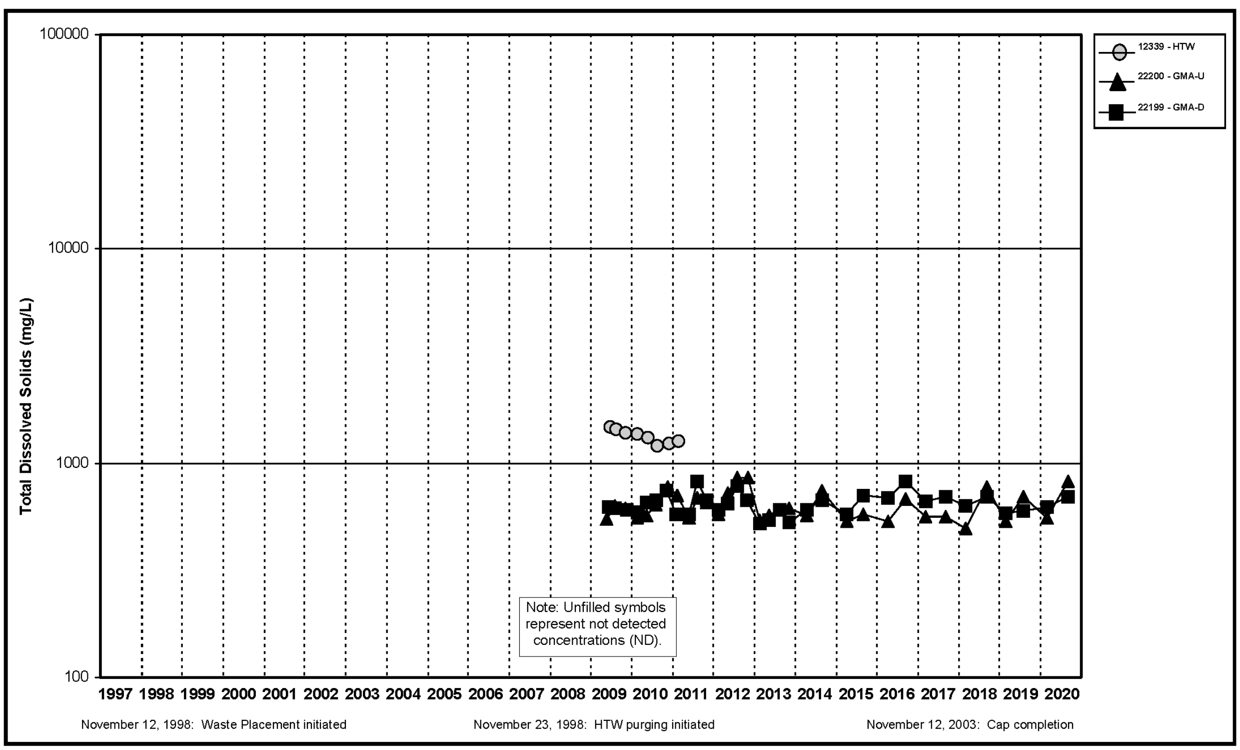

Figure A.5.2-16. Cell 2 Total Dissolved Solids Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

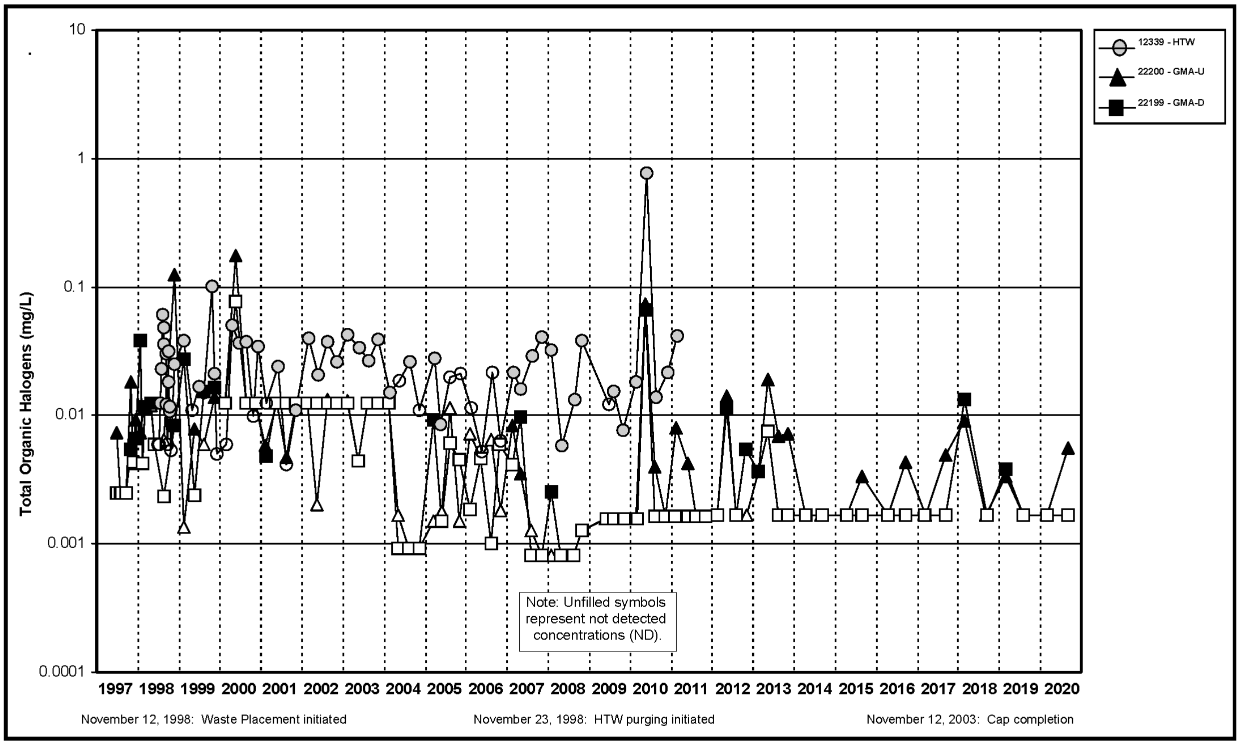

Figure A.5.2-17. Cell 2 Total Organic Halogens Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

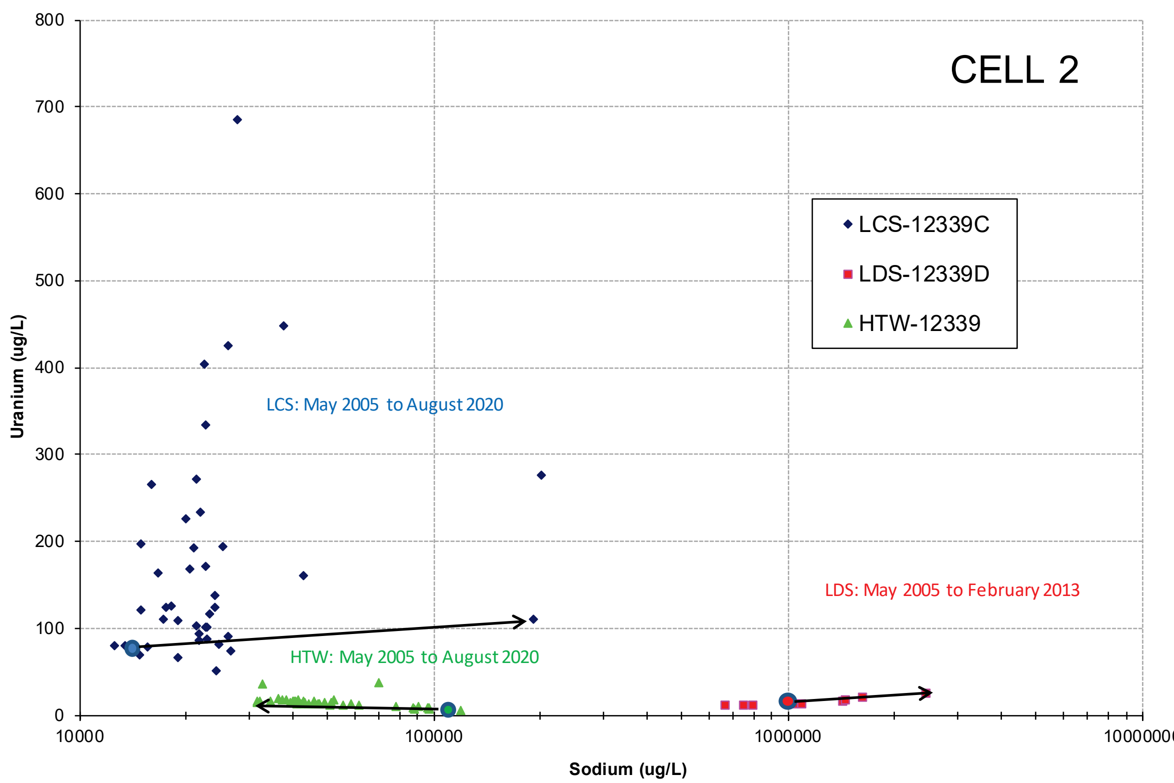

Figure A.5.2-18. Cell 2 Bivariate Plot for Uranium and Sodium

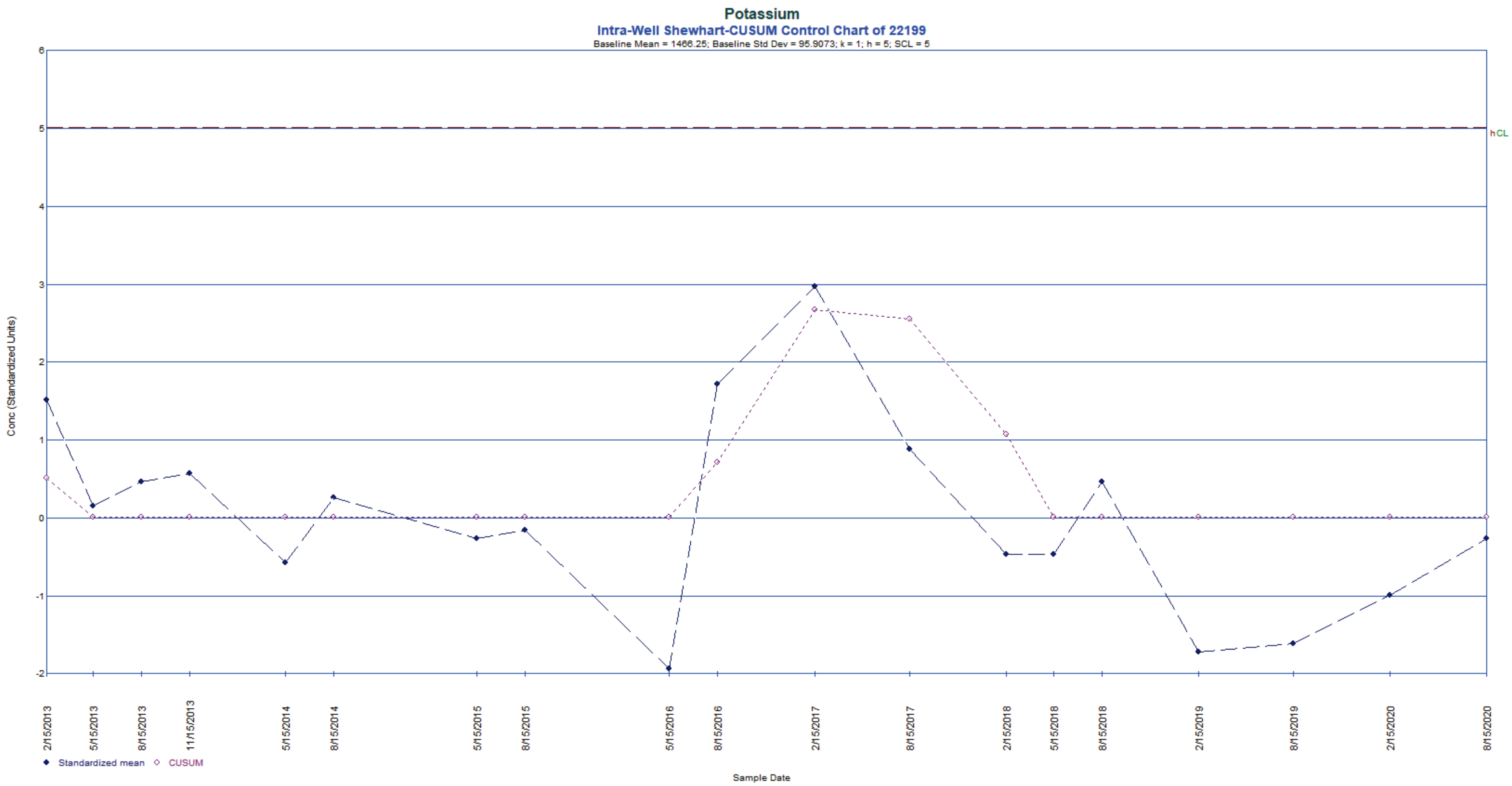

Figure A.5.2-19. Intrawell Shewhart-CUSUM Control Chart for Potassium in Monitoring Well 22199

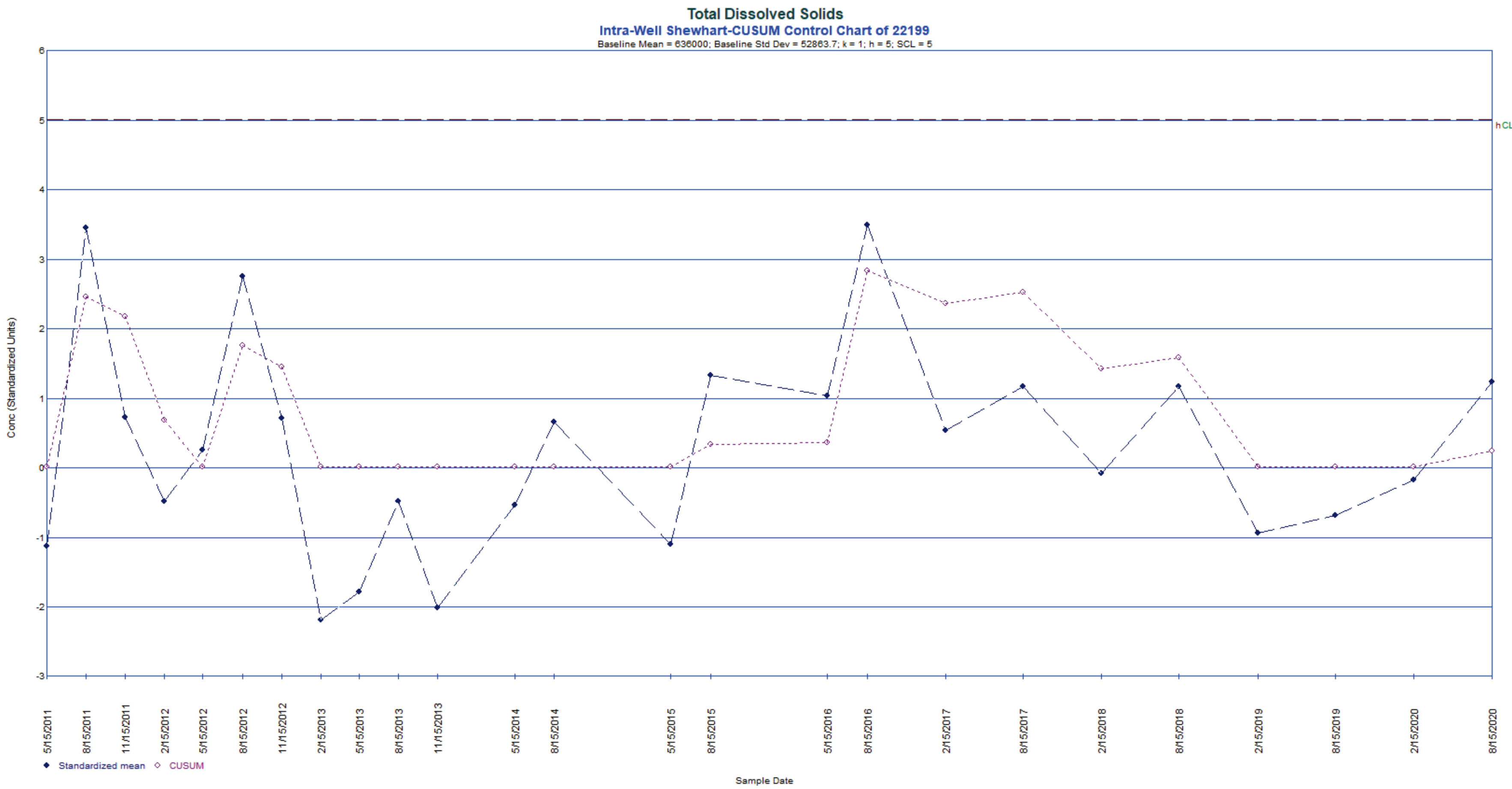

Figure A.5.2-20. Intrawell Shewhart-CUSUM Control Chart for Total Dissolved Solids in Monitoring Well 22199

Subattachment A.5.3

Cell 3

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Contents

Tables

Figures

Abbreviations

CUSUM	Shewhart-cumulative sum
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
GMA	Great Miami Aquifer
GMA-D	Great Miami Aquifer–downgradient
GMA-U	Great Miami Aquifer–upgradient
HTW	horizontal till well
LCS	leachate collection system
LDS	leak detection system
Ohio EPA	Ohio Environmental Protection Agency
OSDF	On-Site Disposal Facility
SCL	Shewhart control limit

Measurement Abbreviations

amsl	above mean sea level
µg/L	micrograms per liter
mg/L	milligrams per liter
pCi/L	picocuries per liter

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This subattachment provides the following information about the On-Site Disposal Facility (OSDF) Cell 3:

- Semiannual monitoring summary statistics (refer to Table A.5.3-1)
- Leachate collection system (LCS) monthly accumulation volumes (refer to Figure A.5.3-1)
- Leak detection system (LDS) monthly accumulation volumes (refer to Figure A.5.3-2)
- OSDF horizontal till well (HTW) 12340 water yield (refer to Table A.5.3-2)
- Great Miami Aquifer (GMA) water levels and total uranium concentration versus time (refer to Figures A.5.3-3 and A.5.3-4)
- Plots of concentration versus time (refer to Figures A.5.3-5A through A.5.3-17)
- A bivariate plot for uranium–sodium (refer to Figure A.5.3-18)
- Control charts (refer to Figures A.5.3-19 through A.5.3-21)

A.5.3.1 Water Quality Monitoring Results

Water quality within the cell is sampled in the LCS and LDS. Water quality beneath the cell is sampled in the HTW and GMA wells. Concentration-versus-time plots, bivariate plots, and control charts are used to help interpret and present the results.

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.

With EPA and Ohio EPA concurrence, DOE reduced the number of parameters sampled from 24 to 13 beginning in January 2017. All 13 parameters are sampled in the GMA wells; 4 of the 13 parameters (total uranium, boron, sodium, and sulfate) are sampled in the LCS, LDS, and HTW of each cell. The annual sampling in the LCS of each cell for the abbreviated list of Appendix I parameters and polychlorinated biphenyls listed in *Ohio Administrative Code* 3745-27-10 was also eliminated beginning in January 2017 with EPA and Ohio EPA concurrence (DOE 2017).

A.5.3.1.1 LCS and LDS Results

As shown in Table A.5.3-1 and summarized below, four parameters (total uranium, boron, sodium, and sulfate) have upward trends in the LCS based on the Mann-Kendall test for trend. A new high sodium concentration of 49.9 micrograms per liter (µg/L) was measured in the LCS of Cell 3 in 2020. The previous high was 30.8 µg/L. Since 2007, the volume of water in the LDS tank of Cell 3 has been insufficient to collect a sample.

Parameters with Upward Concentration Trends in the LCS and LDS of Cell 3[a]

Parameter	LCS 12340C 2020 Trend	LDS 12340D Trend (Year Last Sampled)
Total Uranium	Up	
Boron	Up	
Sodium	Up	
Sulfate	Up	

[a] No entry indicates that the trend was not up.

A.5.3.1.2 HTW and Monitoring Well Results

As shown in Table A.5.3-1 and summarized below, seven parameters (total uranium, boron, lithium, magnesium, nitrate + nitrite as nitrogen, selenium, and total dissolved solids) have upward trends in the HTW and/or the GMA wells based on the Mann-Kendall test for trend.

Parameters with Upward Concentration Trends in the HTW and GMA Wells of Cell 3[a]

Parameter	HTW 12340	GMA-U[b] 22203	GMA-D[b] 22204
Total Uranium		Up	Up
Boron	Up	Up	Up
Lithium		Up	
Magnesium		Up	
Nitrate + Nitrite as Nitrogen		Up	
Selenium			Up
Total Dissolved Solids		Up	

[a] No entry indicates that the trend was not up.
[b] GMA-U = upgradient Great Miami Aquifer; GMA-D = downgradient Great Miami Aquifer.

A.5.3.1.3 Discussion

The uranium–sodium bivariate plot for the Cell 3 LCS, LDS, and HTW is provided in Figure A.5.3-18. On the figure, the first sample ever collected from the monitoring horizon is circled. An arrow leads from the first sample to the location of the most recent sample. The plot shows that the chemical signatures for uranium and sodium in the LCS, LDS, and HTW are separate and distinct, indicating that mixing between the horizons is not occurring; therefore, upward concentration trends measured beneath the cells in GMA wells are attributed to fluctuating ambient concentrations beneath the cell and are not related to cell performance.

A.5.3.2 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. 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 "not in 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. Usually, two parameters are used to compute standardized limits—the decision value (*h*) and the Shewhart control limit (SCL).

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 eight samples were selected for control charts. By default, the ChemStat software plots both a CUSUM control limit (*h*) and an SCL on the control chart. The software recommends a value of 5 for the CUSUM control limit and a value of 4.5 for the SCL.

EPA Statistical Analysis 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 is not needed. The ChemStat software though, by default, plots both the SCL and CUSUM control limit on the charts. To address this issue, the SCL was defined as 5 to equal the recommended CUSUM (*h*) limit. This combined limit is identified as *h*CL on the control charts. For interpretation purposes, the *h*CL value will be regarded as the CUSUM (*h*) limit.

As shown in Table A.5.3-1 in gray shading and as summarized below, three parameters in the HTW and GMA wells of Cell 3 meet the criteria for control charts (i.e., at least eight samples, normal or lognormal distribution, no trend, and no serial correlation), resulting in three control charts (Figures A.5.3-19, A.5.3-20, and A.5.3-21).All three of the control charts for Cell 3 exhibit "in control" conditions.

Parameter	Monitoring Point[a]	Well Number	Assessment	Figure Number
Calcium	GMA-U	22203	In Control	A.5.3-19
Lithium	GMA-D	22204	In Control	A.5.3-20
Potassium	GMA-U	22203	In Control	A.5.3-21

[a] GMA-D = downgradient Great Miami Aquifer; GMA-U = upgradient Great Miami Aquifer.

A.5.3.3 Summary and Conclusions

- Four parameters monitored semiannually have an upward concentration trend in the LCS of Cell 3: total uranium, boron, sodium, and sulfate. A new high sodium concentration of 49.9 µg/L was measured in the LCS of Cell 3 in 2020. The previous high was 30.8 µg/L.
- The volume of water in the LDS tank of Cell 3 has been insufficient to collect a sample since 2007.
- Seven parameters monitored semiannually have an upward concentration trend in the HTW or GMA wells of Cell 3: total uranium, boron, lithium, magnesium, nitrate + nitrite as nitrogen, selenium, and total dissolved solids. Separate and distinct chemical signatures for total uranium and sodium in the LCS, LDS, and HTW of Cell 3 indicate that water is not mixing between the horizons. Therefore, upward concentration trends beneath Cell 3

(i.e., HTW or GMA wells) are attributed to fluctuating ambient concentrations beneath the cell and not to cell performance.

- Three control charts were constructed for Cell 3 parameters. All three of the control charts exhibit "in control" conditions.

A.5.3.4 References

DOE (U.S. Department of Energy), 2017. *Fernald Preserve 2016 Site Environmental Report*, LMS/FER/S15232, Office of Legacy Management, Cincinnati, Ohio, May.

EPA (U.S. Environmental Protection Agency), 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities—Unified Guidance*, EPA 530/R-09-007, March.

OAC 3745-27-10. "Ground Water Monitoring Program for a Sanitary Landfill Facility," *Ohio Administrative Code.*

Table A.5.3-1. Summary Statistics for Cell 3

Parameter	Horizon[a]	Location	Number of Detected Samples	Total Number of Samples	Percent Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[d]	Distribution Type[d,e]	Trend[d,f] (Year Last Sampled)	Serial Correlation[d,g]	Outliers[h,i]
Total Uranium (µg/L)	LCS	12340C	70	70	100	9.348100	206	77.6	39.7	Undefined	Up (2020)	Detected	
	LDS	12340D	21	21	100	8.90	27.7	17.0	5.0	Normal	Down (2007)	Not Detected	72.4 (Q4-04)
	HTW	12340	73	73	100	3.89	29.3	19.0	6.0	Undefined	None (2020)	Detected	58.5 (Q3-09), 42.1 (Q3-16)
	GMA-U	22203	72	75	96.0	0.12	15.4	2.19	3.65	Ln Normal	Up (2020)	Detected	
	GMA-D	22204	81	82	98.8	ND	22.9	4.15	4.70	Undefined	Up (2020)	Detected	
Boron (mg/L)	LCS	12340C	70	71	98.6	ND	9.19	4.47	1.86	Undefined	Up (2020)	Detected	
	LDS	12340D	20	21	95.2	ND	0.557	0.128	0.149	Undefined	Down (2007)	Detected	
	HTW	12340	56	56	100	0.0481	0.259	0.142	0.052	Normal	Up (2020)	Detected	0.960 (Q3-06)
	GMA-U	22203	64	75	85.3	ND	0.0870	0.0491	0.0171	Normal	Up (2020)	Detected	
	GMA-D	22204	67	75	89.3	ND	0.0887	0.0458	0.0154	Normal	Up (2020)	Detected	
Sodium (mg/L)	LCS	12340C	50	50	100	4.35	49.9	27.2	7.8	Undefined	Up (2020)	Detected	
	LDS	12340D	9	9	100	263	344	315	27	Normal	None (2007)	Not Detected	
	HTW	12340	42	42	100	15.5	74.1	36.6	16.8	Ln Normal	Down (2007)	Detected	
	GMA-U	22203	33	33	100	16.1	30.7	21.6	3.7	Normal	None (2020)	Detected	
	GMA-D	22204	34	34	100	7.88	20.5	13.7	3.7	Normal	Down (2020)	Detected	
Sulfate (mg/L)	LCS	12340C	62	62	100	26.1	2650	1830	530	Undefined	Up (2020)	Detected	
	LDS	12340D	19	19	100	112	2510	1250	700	Undefined	Down (2007)	Not Detected	
	HTW	12340	52	52	100	352	958	634	160	Normal	Down (2007)	Detected	
	GMA-U	22203	57	57	100	64.2	738	249	151	Ln Normal	None (2020)	Detected	4,020 (Q3-12)
	GMA-D	22204	57	57	100	199	779	441	154	Normal	Down (2020)	Not Detected	
Calcium (mg/L)	GMA-U	22203	26	26	100	135	290	181	40	Ln Normal	None (2020)	Not Detected	
	GMA-D	22204	26	26	100	155	365	231	57	Normal	Down (2020)	Detected	
Lithium (mg/L)	GMA-U	22203	33	33	100	0.00577	0.0225	0.00865	0.00490	Undefined	Up (2020)	Not Detected	
	GMA-D	22204	33	33	100	0.00694	0.0102	0.00862	0.00089	Normal	None (2020)	Not Detected	
Magnesium (mg/L)	GMA-U	22203	26	26	100	32.5	65.6	47.1	9.7	Normal	Up (2020)	Not Detected	
	GMA-D	22204	26	26	100	37.2	66.6	49.7	8.2	Normal	Down (2020)	Not Detected	
Nitrate + Nitrite, as Nitrogen (mg/L)	GMA-U	22203	13	26	50.0	ND	0.273	0.0250	0.0846	Undefined	Up (2020)	Not Detected	
	GMA-D	22204	1	26	3.8	ND	0.0425	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
Potassium (mg/L)	GMA-U	22203	26	26	100	2.07	3.50	2.59	0.36	Normal	None (2020)	Not Detected	
	GMA-D	22204	27	27	100	1.33	3.07	2.10	0.51	Normal	Down (2020)	Detected	
Selenium (mg/L)	GMA-U	22203	3	33	9.1	ND	0.0130	0.00376	Insufficient	Insufficient	Insufficient	Insufficient	
	GMA-D	22204	4	33	12.1	ND	0.0178	0.003	0.00307	Undefined	Up (2020)	Detected	
Technitium-99 (pCi/L)	GMA-U	22203	1	24	4.2	ND	8.44	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
	GMA-D	22204	0	24	0	ND	NA	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
Total Dissolved Solids (mg/L)	GMA-U	22203	33	33	100	524	1410	651	204	Undefined	Up (2020)	Detected	
	GMA-D	22204	33	33	100	487	1530	972	232	Normal	Down (2020)	Not Detected	
Total Organic Halogens (mg/L)	GMA-U	22203	38	75	50.7	ND	0.213	0.00524	0.0256	Undefined	None (2020)	Detected	
	GMA-D	22204	14	75	18.7	ND	0.0270	0.00166	0.00552	Undefined	Down (2020)	Detected	0.165 (Q2-00)

Note 1: Shading identifies a horizontal till well or Great Miami Aquifer well, with at least eight samples, Normal or Ln Normal distribution, no trend (None), and no serial correlation (Not Detected). These wells achieve control chart criteria.

Note 2: Data used in this table has been standardized to quarterly.

[a]LCS = leachate collection system; LDS = leak detection system; HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; and GMA-D = downgradient Great Miami Aquifer

[b]ND = not detected; NA = not applicable

[c]Averages were determined based on the distribution assumption.

[d]Insufficient is used for Distribution Type, Trend, or Serial Correlation whenever there is not enough data to run the test.

[e]Data distribution based on the Shapiro-Wilk statistic.

Normal: Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the Ln Normal assumption.

Ln Normal: Ln Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the Normal assumption.

Undefined: Normal and Lognormal Distribution assumptiions are both rejected or there are less than 25 percent detected values. "Average" is defined as the Median of the data.

[f]Trend based on nonparametric Mann-Kendall procedure.

[g]Serial correlation based on Rank Von Neumann test.

[h]Outliers determined by Rosner's (for sample sizes greater than 25) or Dixon procedure (for sample sizes less than or equal to 25).

[i]Q = quarter

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Table A.5.3-2. Horizontal Till Well 12340 Water Yield

Year	Total Volume Purged (gallons)	Number of Months Purged	Average Volume Purged (gallons)
1999	4,880	11	444
2000	1,090	6	182
2001	1,050	4	263
2002	1,200	4	300
2003	1,770	4	443
2004	2,875	4	719
2005	3,330	4	833
2006	3,115	4	779
2007	2,895	4	724
2008	2,875	4	719
2009	2,100	4	700
2010	2,650	4	663
2011	2,600	4	650
2012	2,150	4	538
2013	2,725	4	681
2014	1,455	2	728
2015	1,050	2	525
2016	1,445	2	723
2017	1,425	2	713
2018	1,400	2	700
2019	1,475	2	738
2020	1,550	2	775

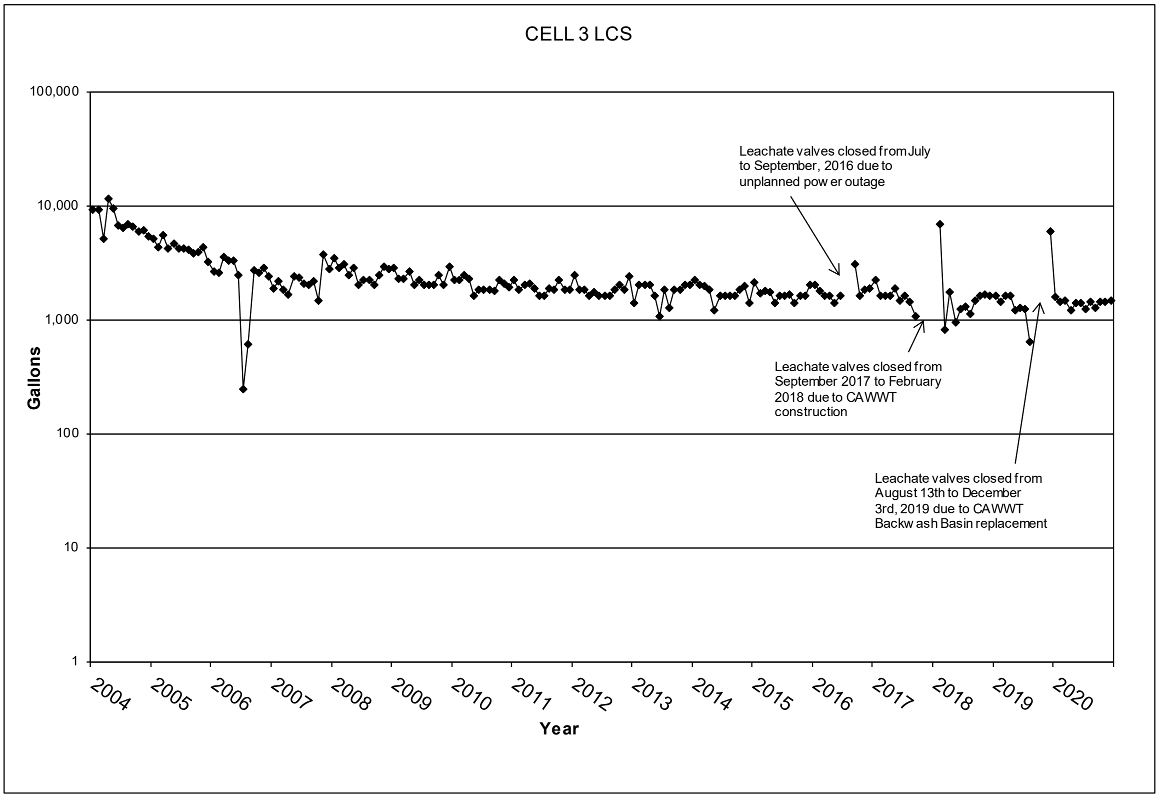

Figure A.5.3-1. Monthly Accumulation Volumes for Cell 3 LCS

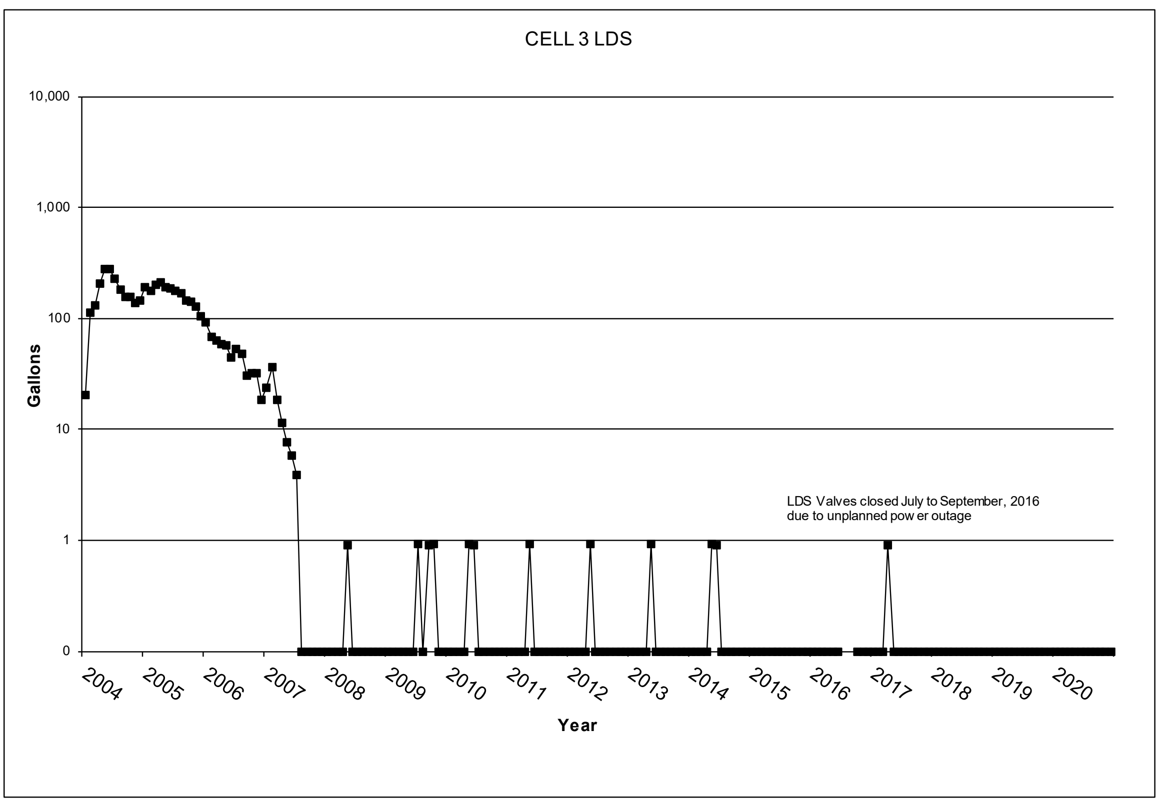

Figure A.5.3-2. Monthly Accumulation Volumes for Cell 3 LDS

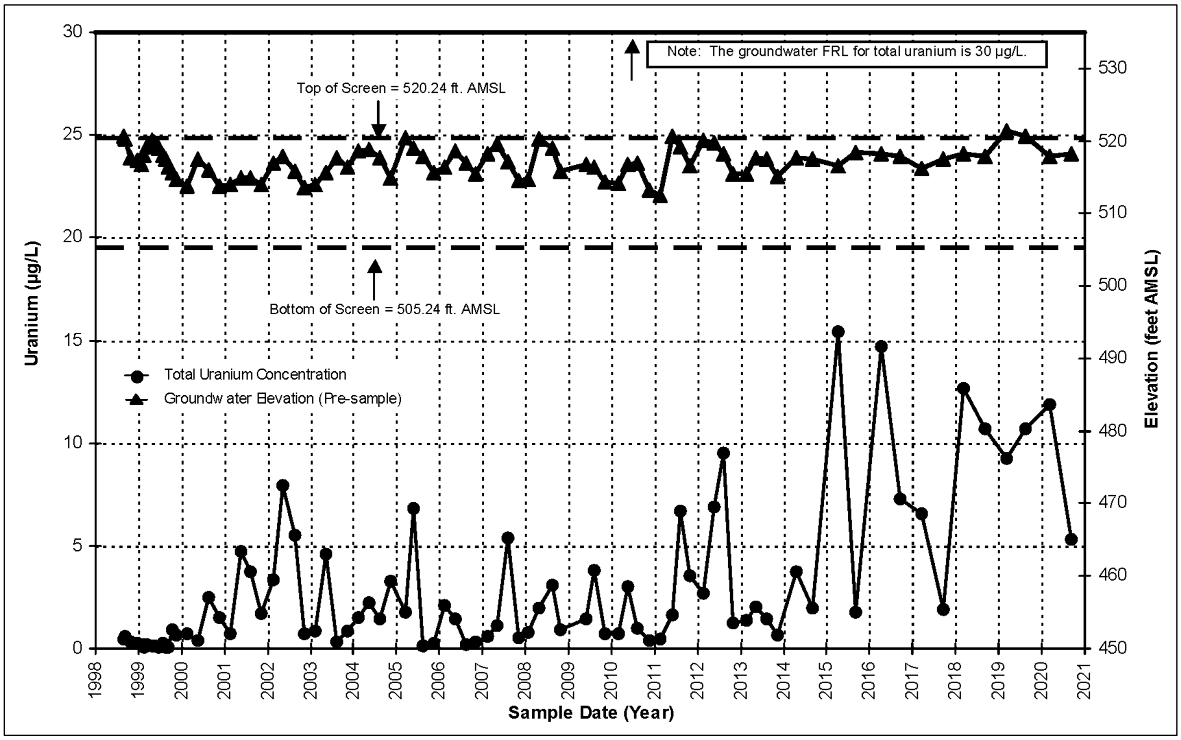

Figure A.5.3-3. Total Uranium Concentration and Groundwater Elevation Versus Time Plot for Cell 3 Upgradient Monitoring Well 22203

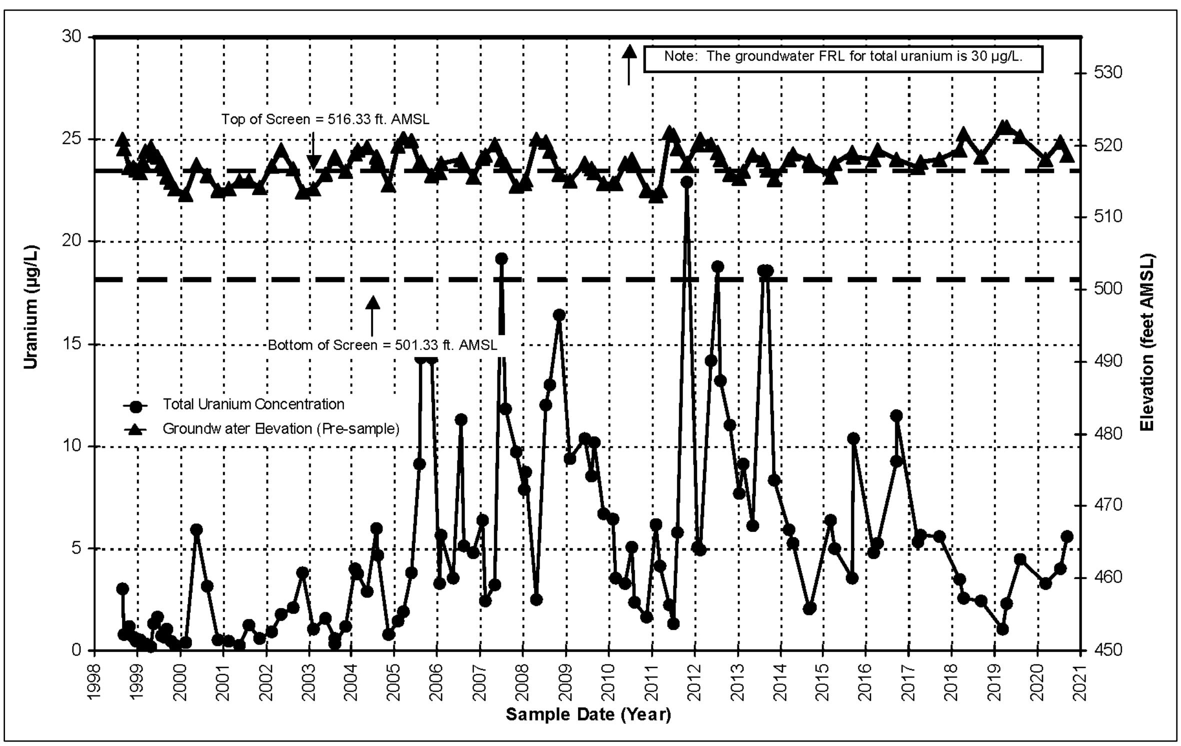

Figure A.5.3-4. Total Uranium Concentration and Groundwater Elevation Versus Time Plot for Cell 3 Downgradient Monitoring Well 22204

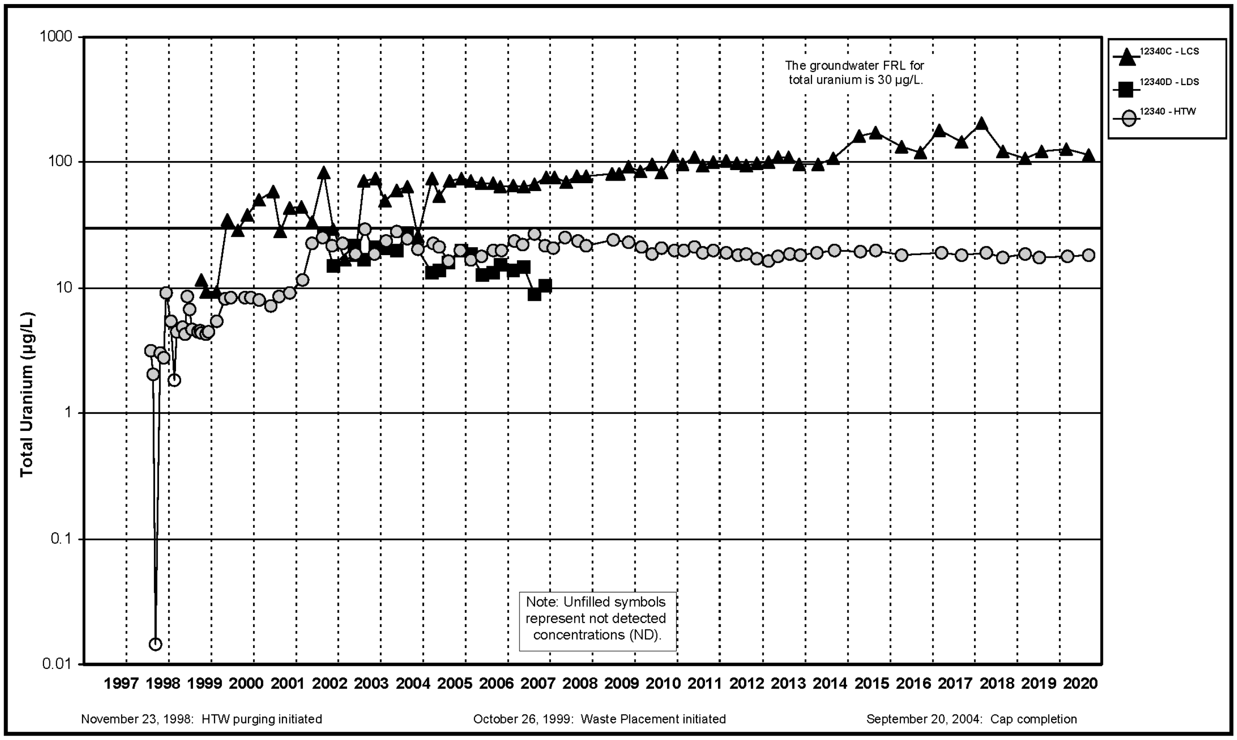

Figure A.5.3-5A. Cell 3 Total Uranium Concentration Versus Time Plot for LCS, LDS, and HTW

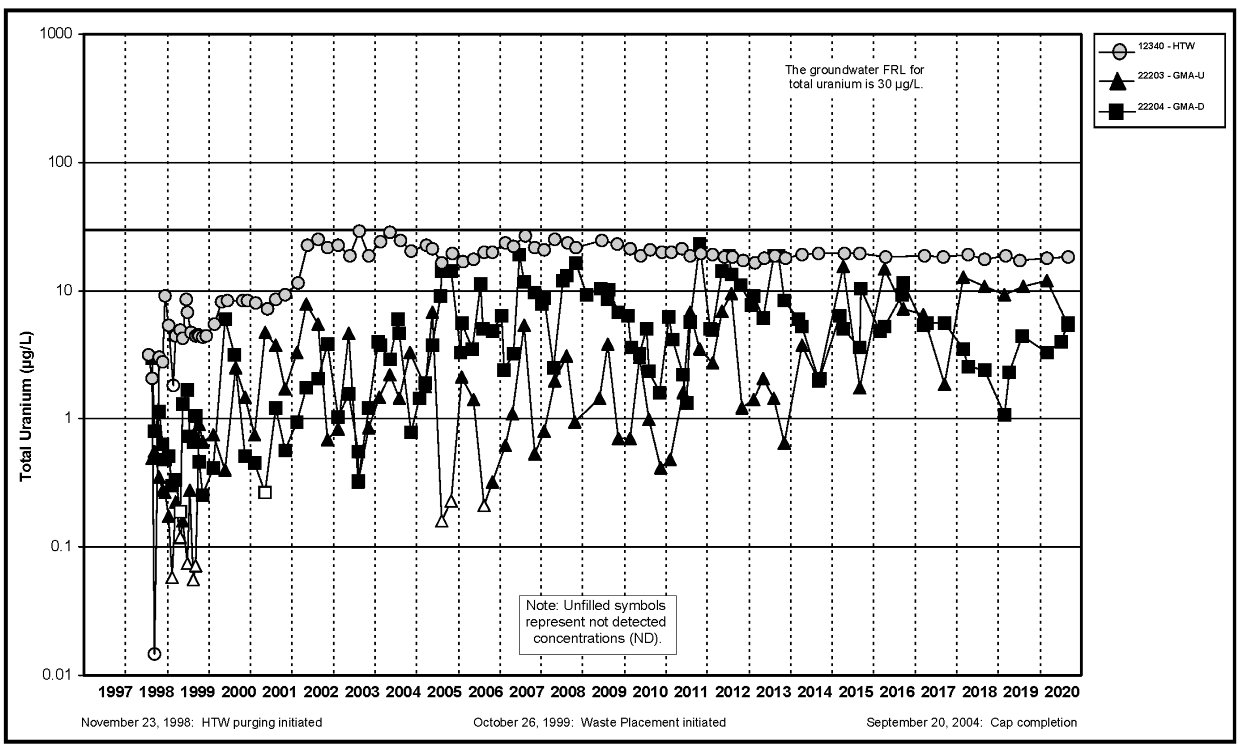

Figure A.5.3-5B. Cell 3 Total Uranium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

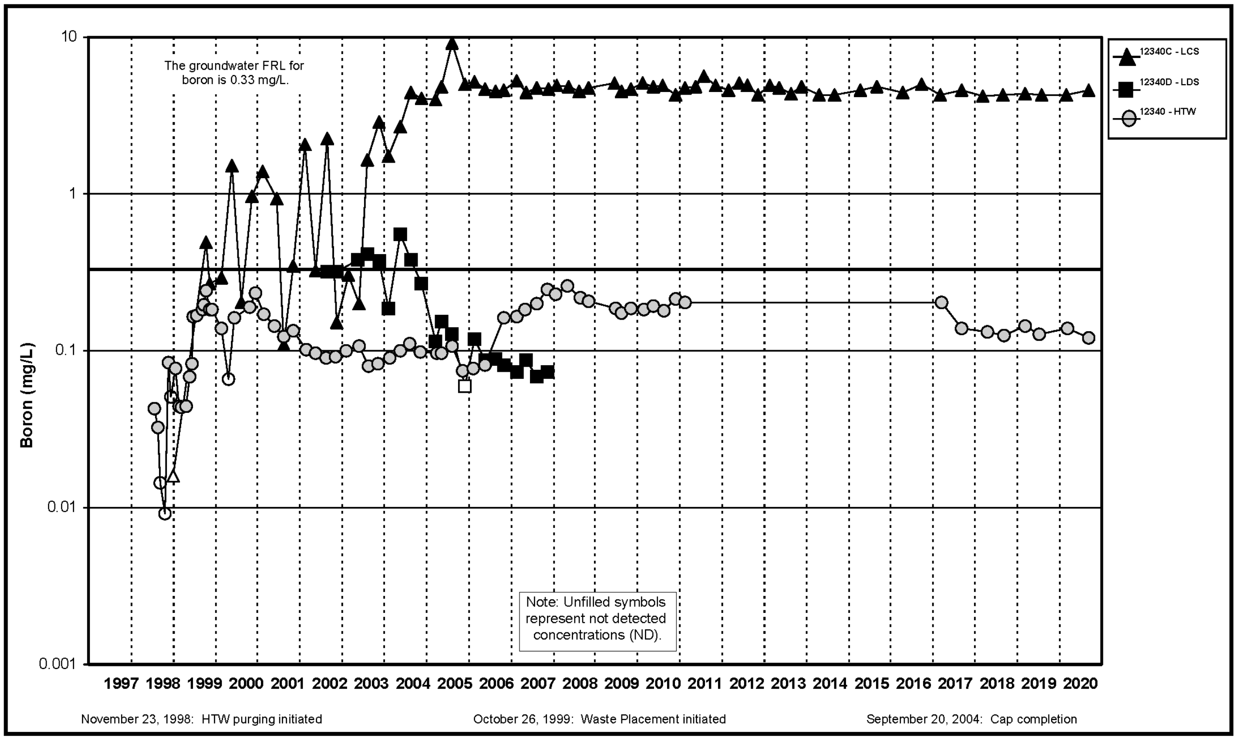

Figure A.5.3-6A. Cell 3 Boron Concentration Versus Time Plot for LCS, LDS, and HTW

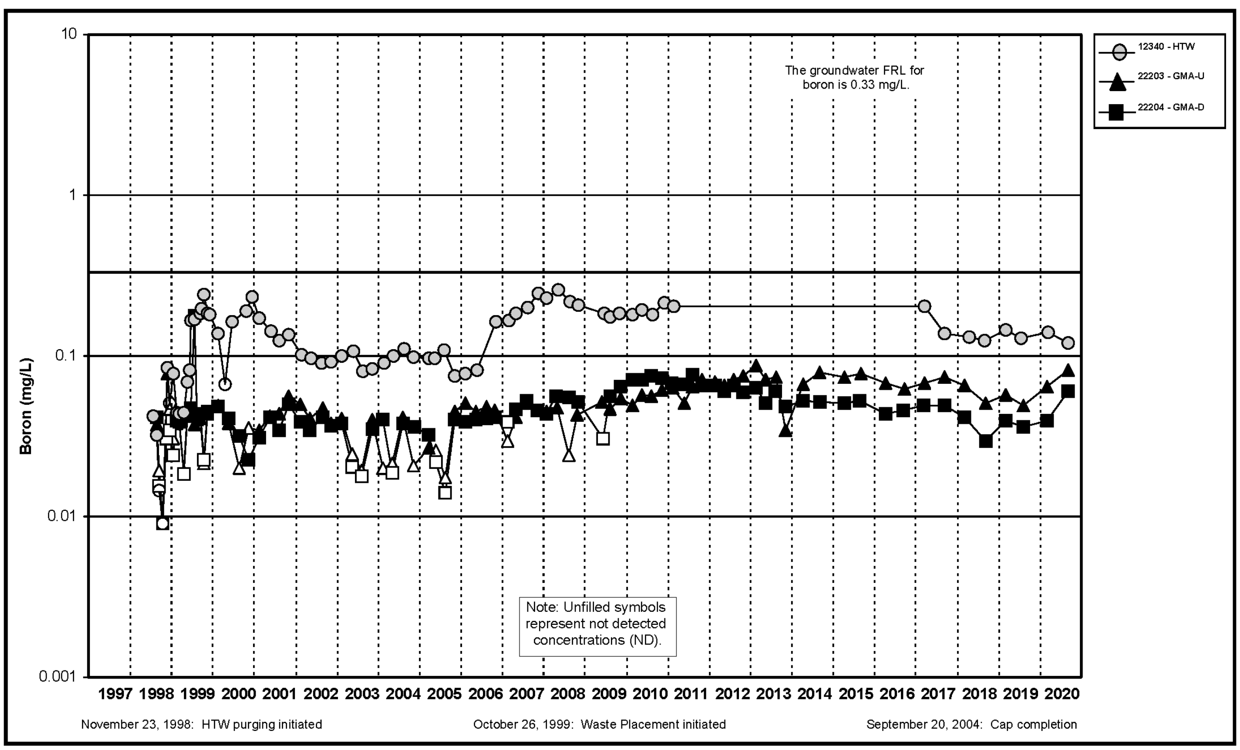

Figure A.5.3-6B. Cell 3 Boron Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

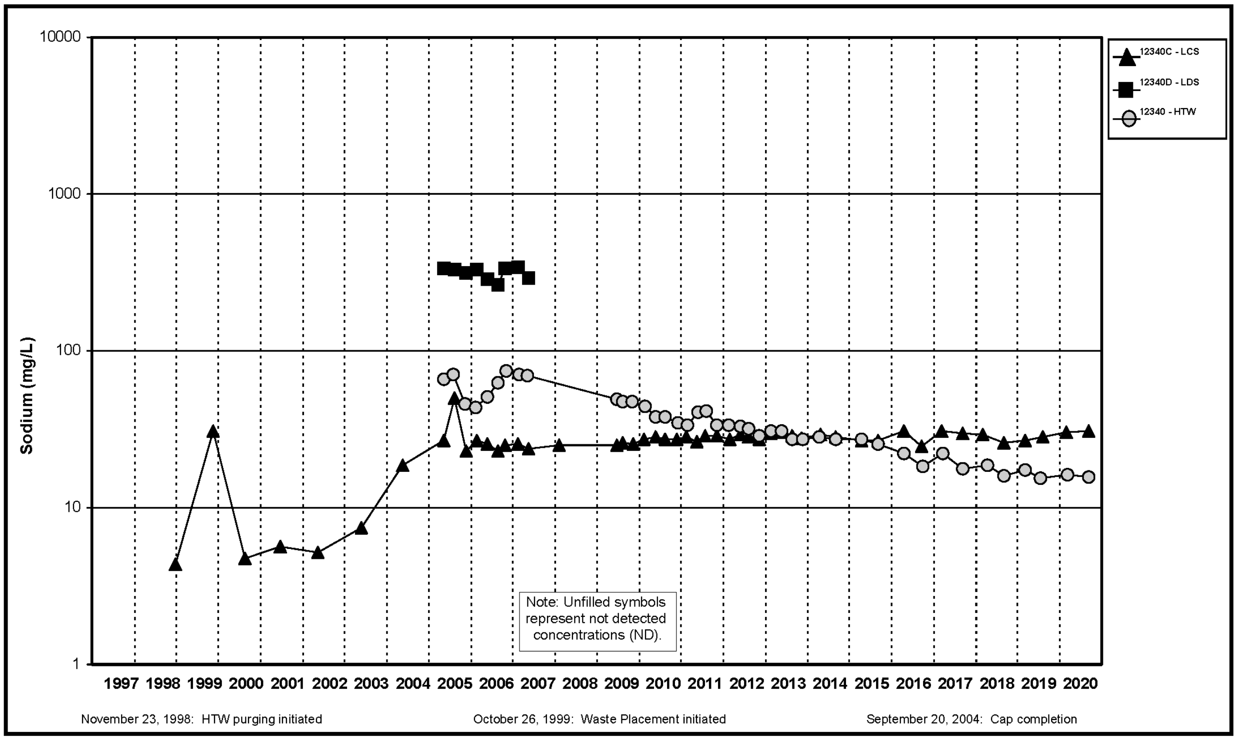

Figure A.5.3-7A. Cell 3 Sodium Concentration Versus Time Plot for LCS, LDS, and HTW

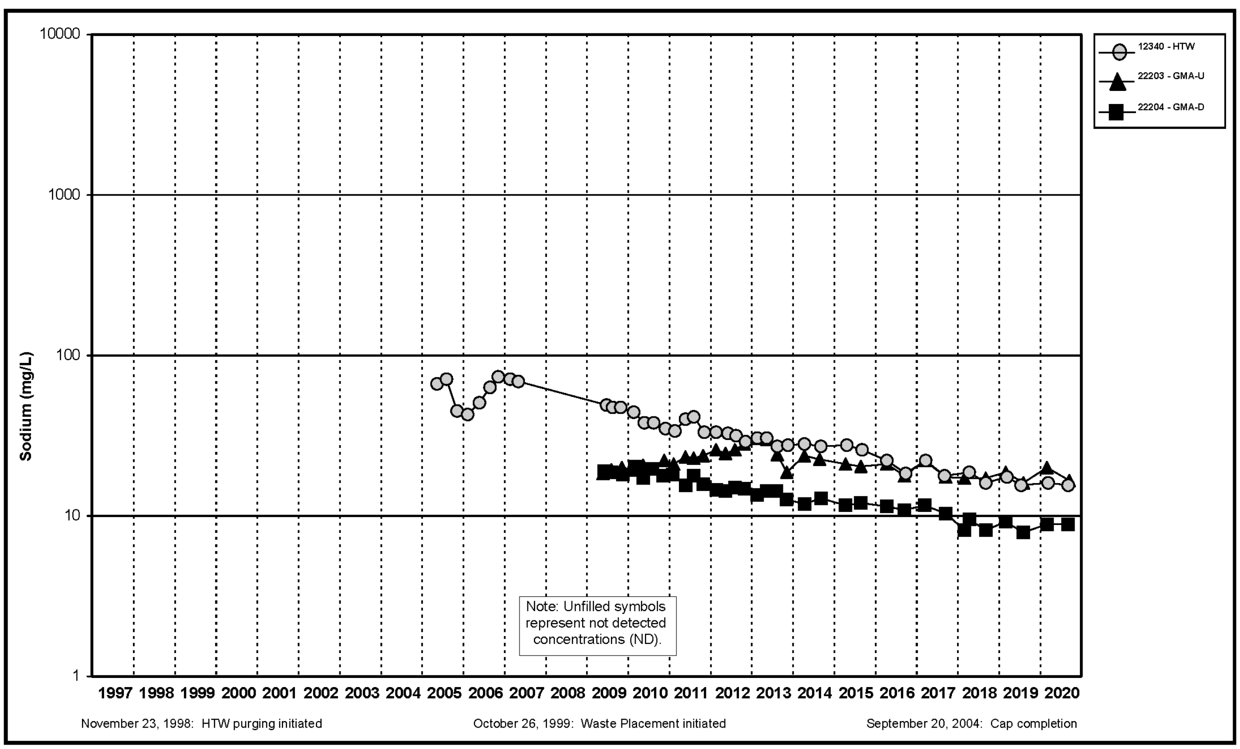

Figure A.5.3-7B. Cell 3 Sodium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

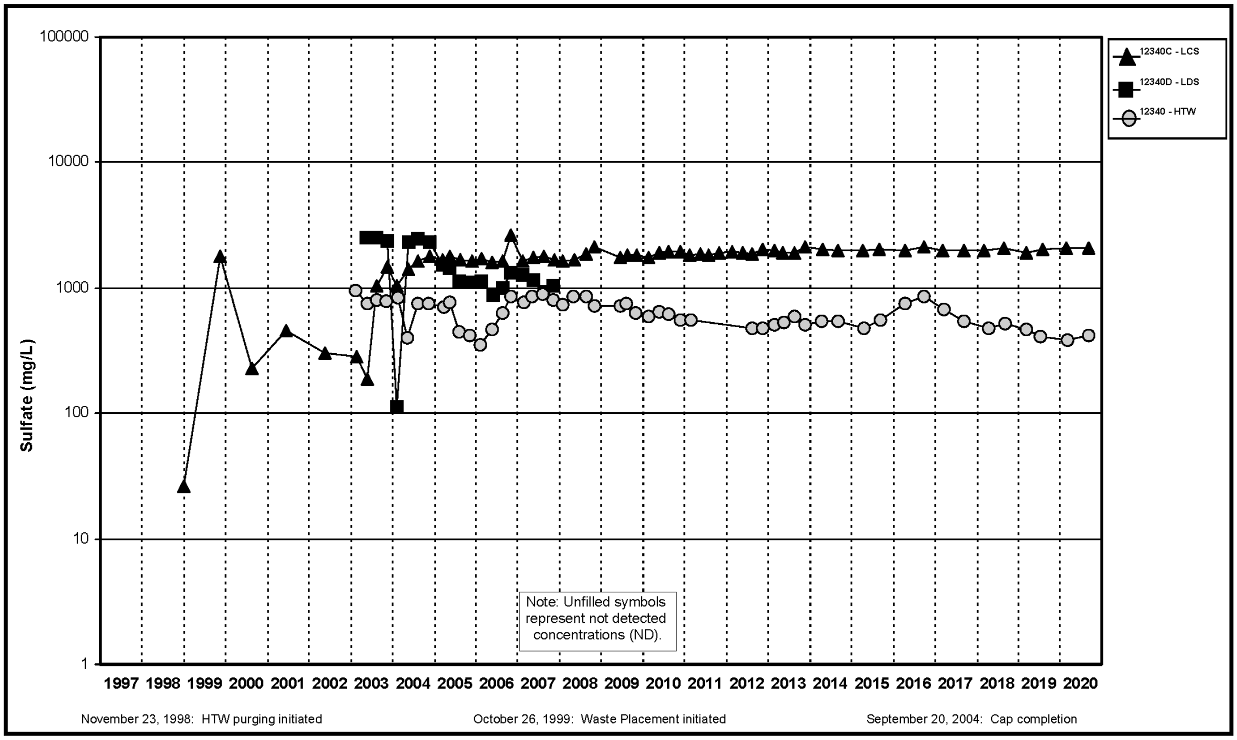

Figure A.5.3-8A. Cell 3 Sulfate Concentration Versus Time Plot for LCS, LDS, and HTW

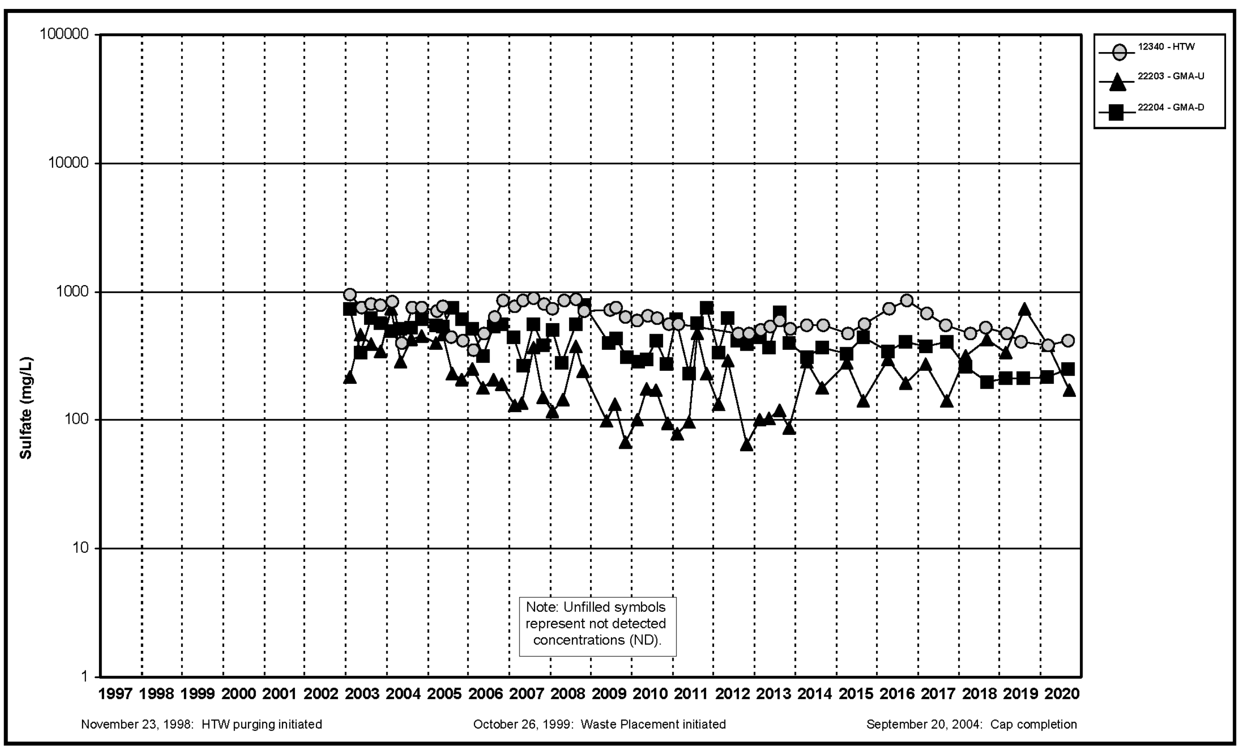

Figure A.5.3-8B. Cell 3 Sulfate Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

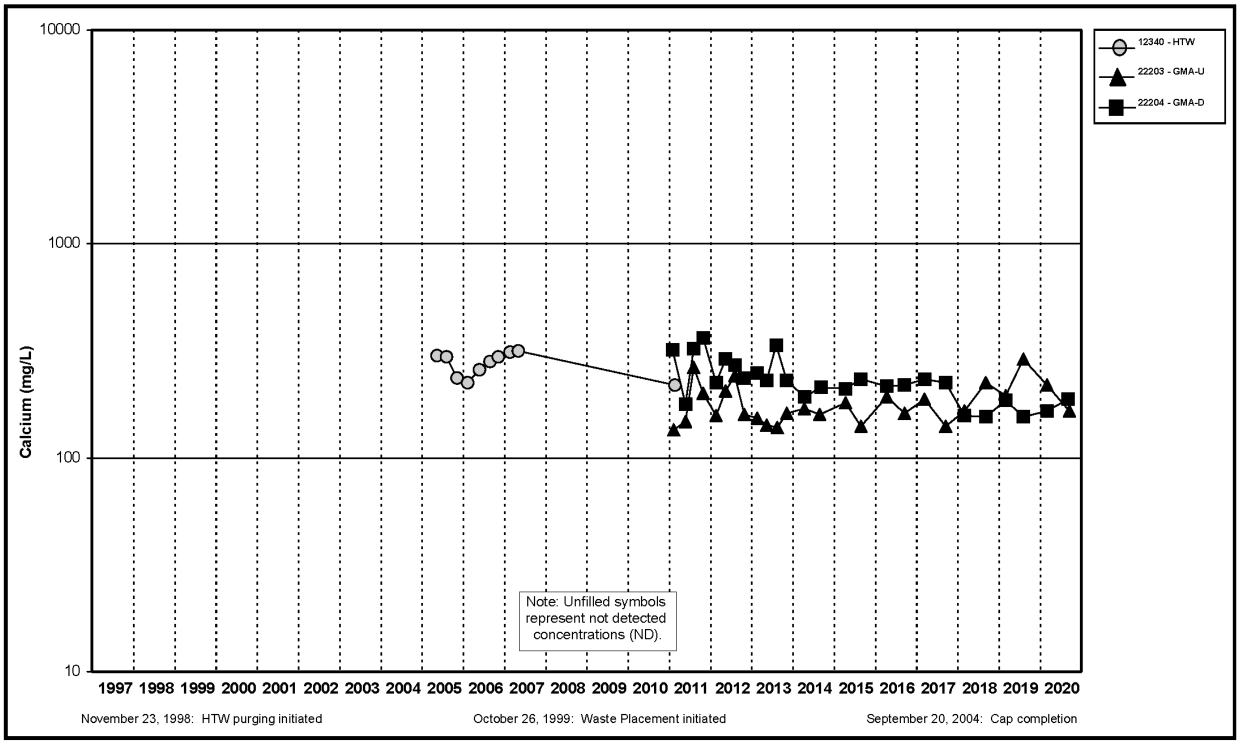

Figure A.5.3-9. Cell 3 Calcium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

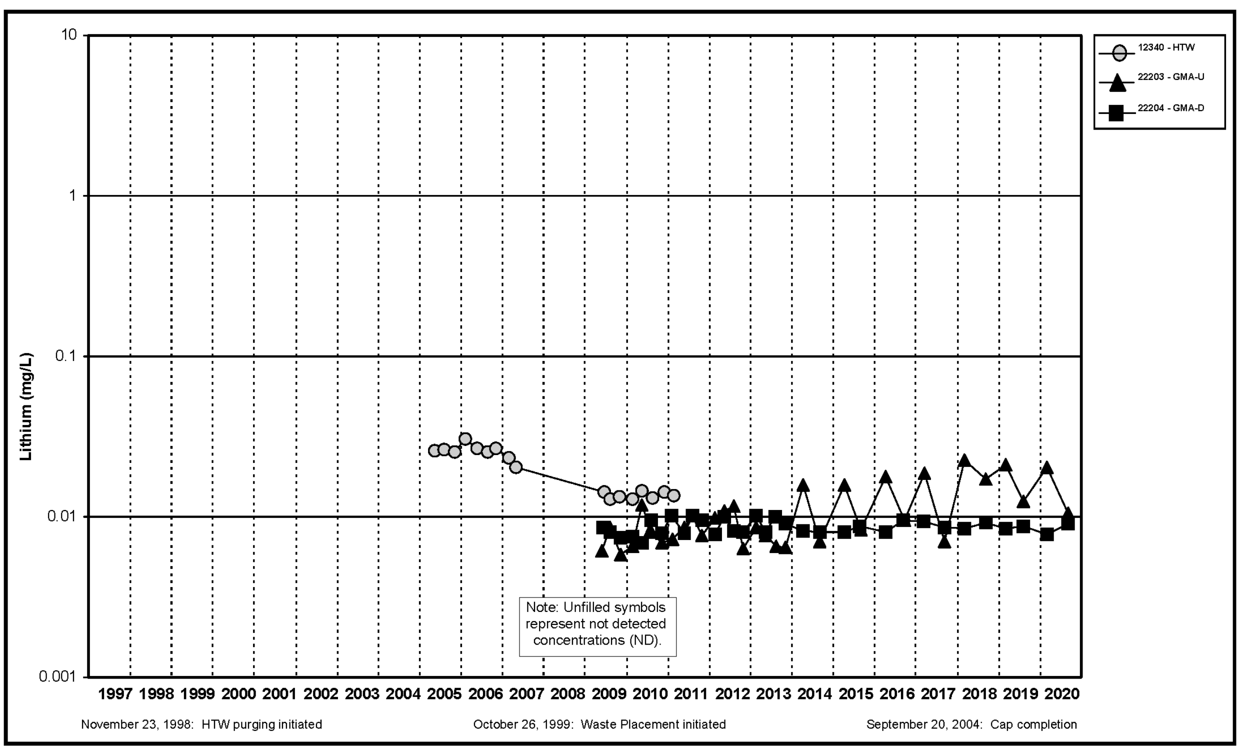

Figure A.5.3-10. Cell 3 Lithium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

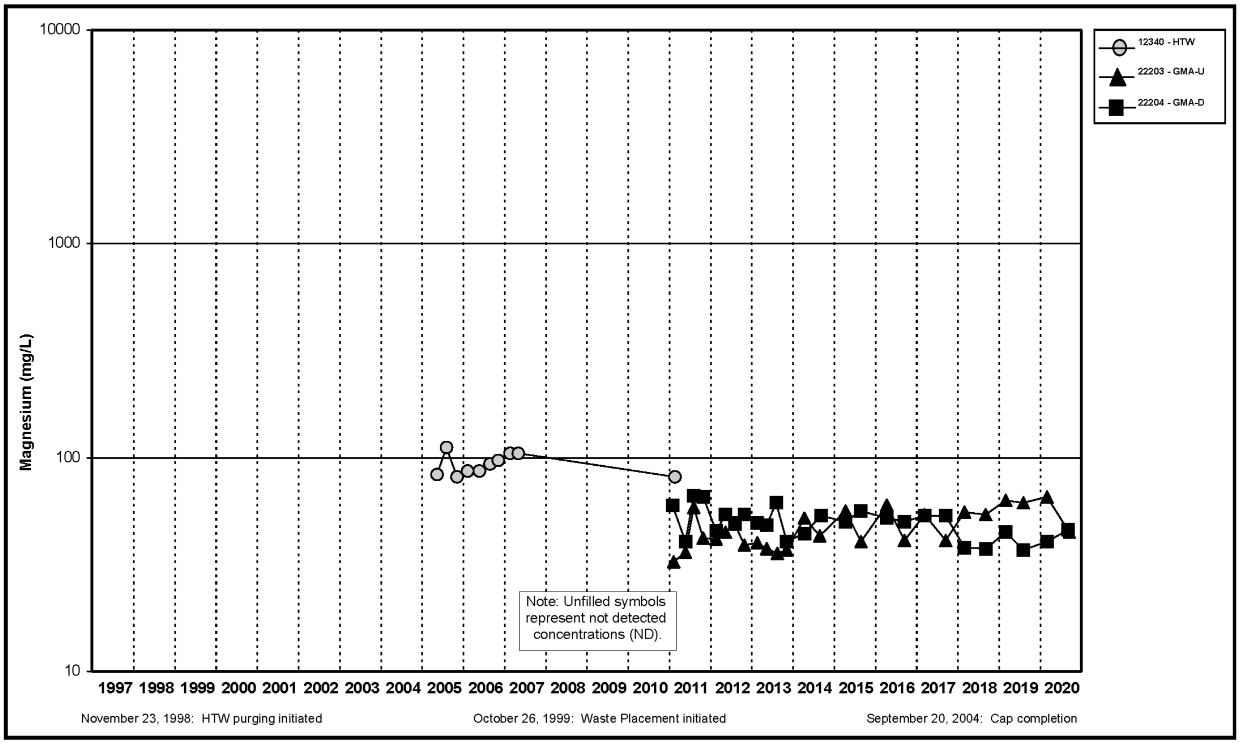

Figure A.5.3-11. Cell 3 Magnesium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

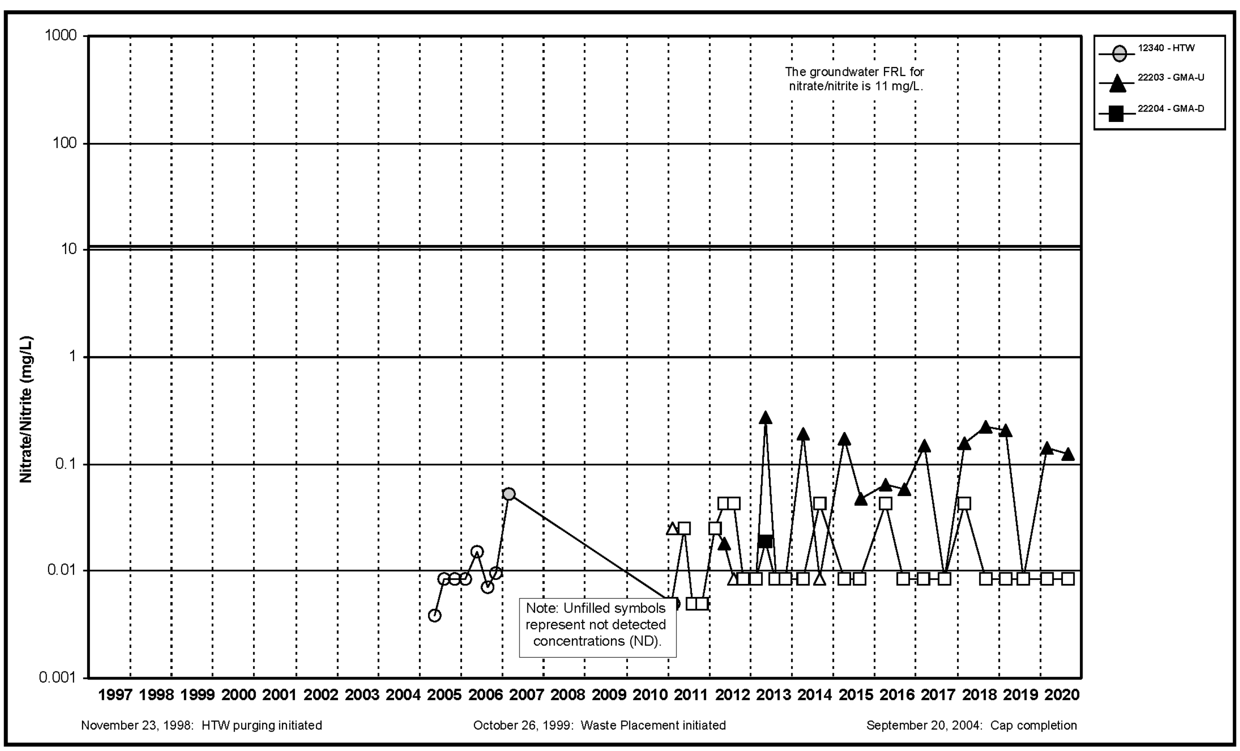

Figure A.5.3-12. Cell 3 Nitrate + Nitrate as Nitrogen Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

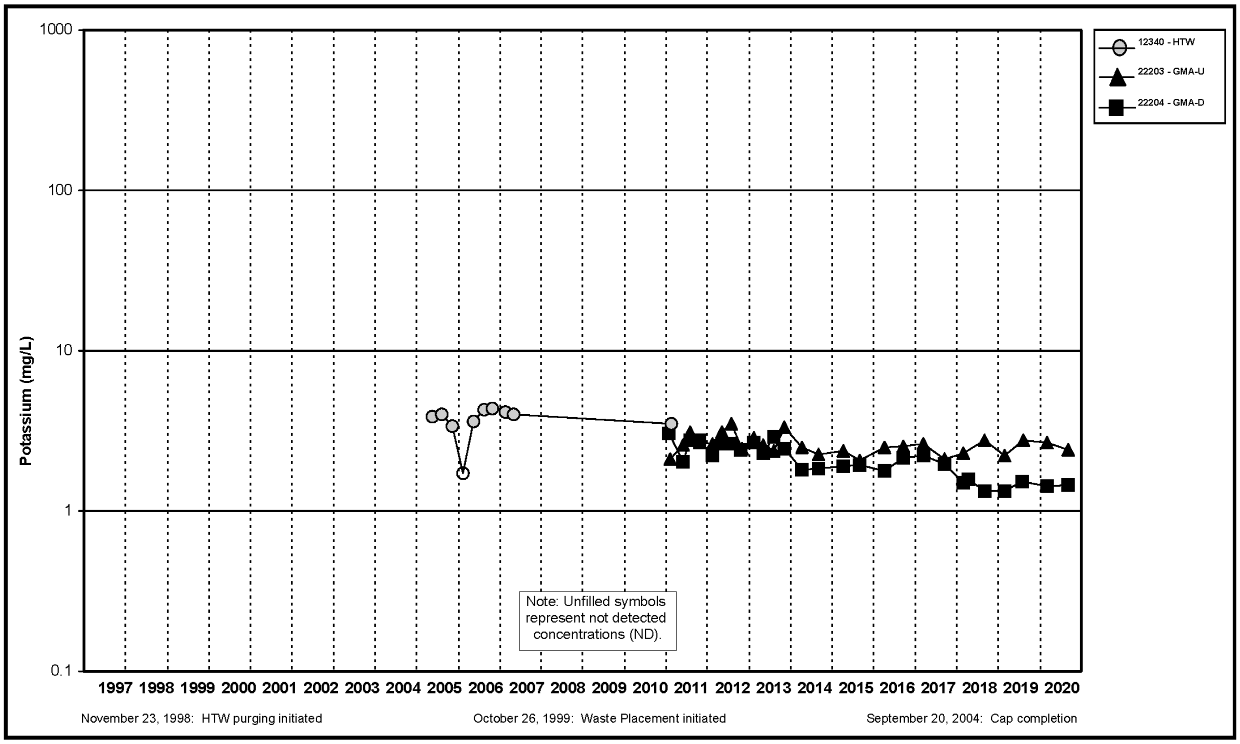

Figure A.5.3-13. Cell 3 Potassium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

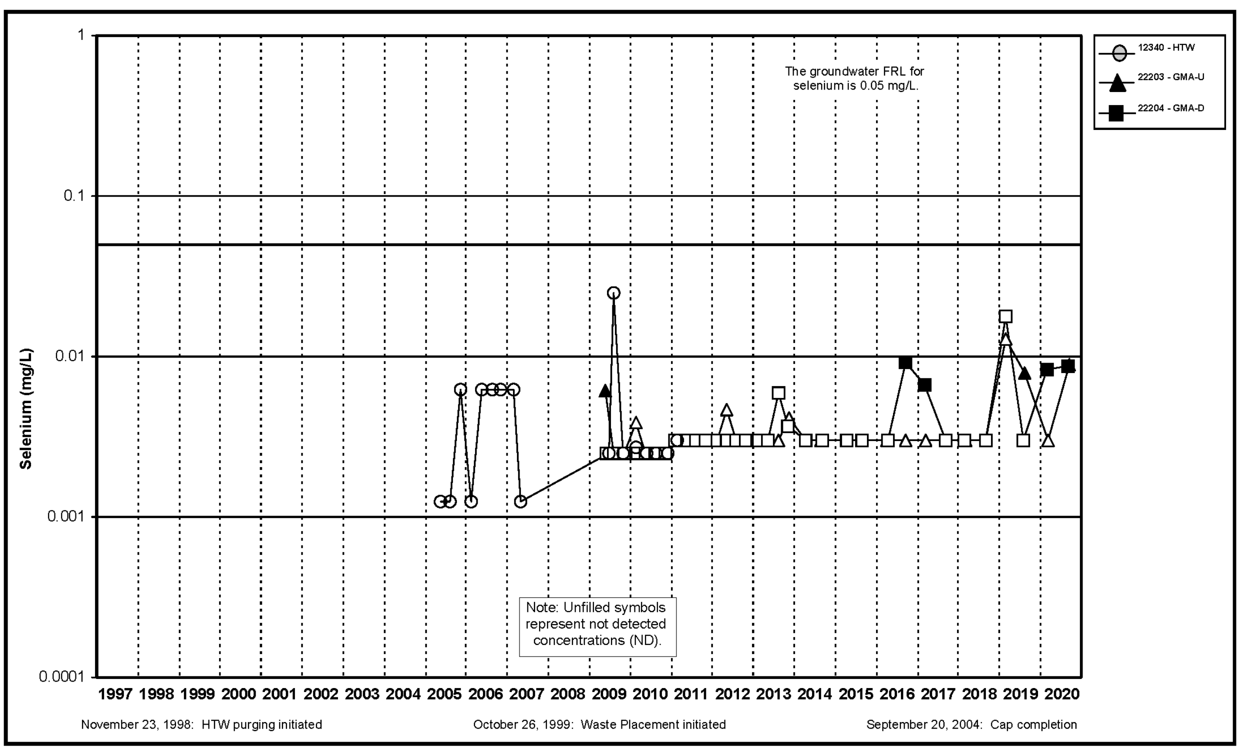

Figure A.5.3-14. Cell 3 Selenium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

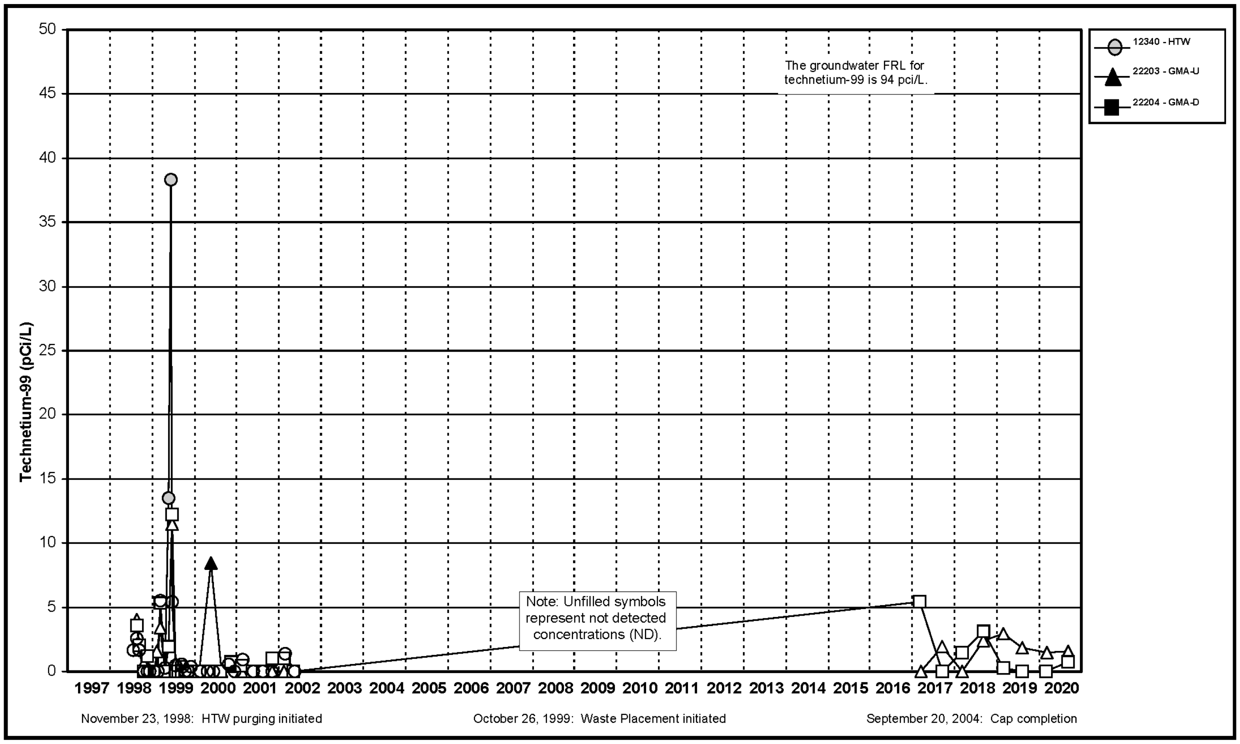

Figure A.5.3-15. Cell 3 Technetium-99 Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

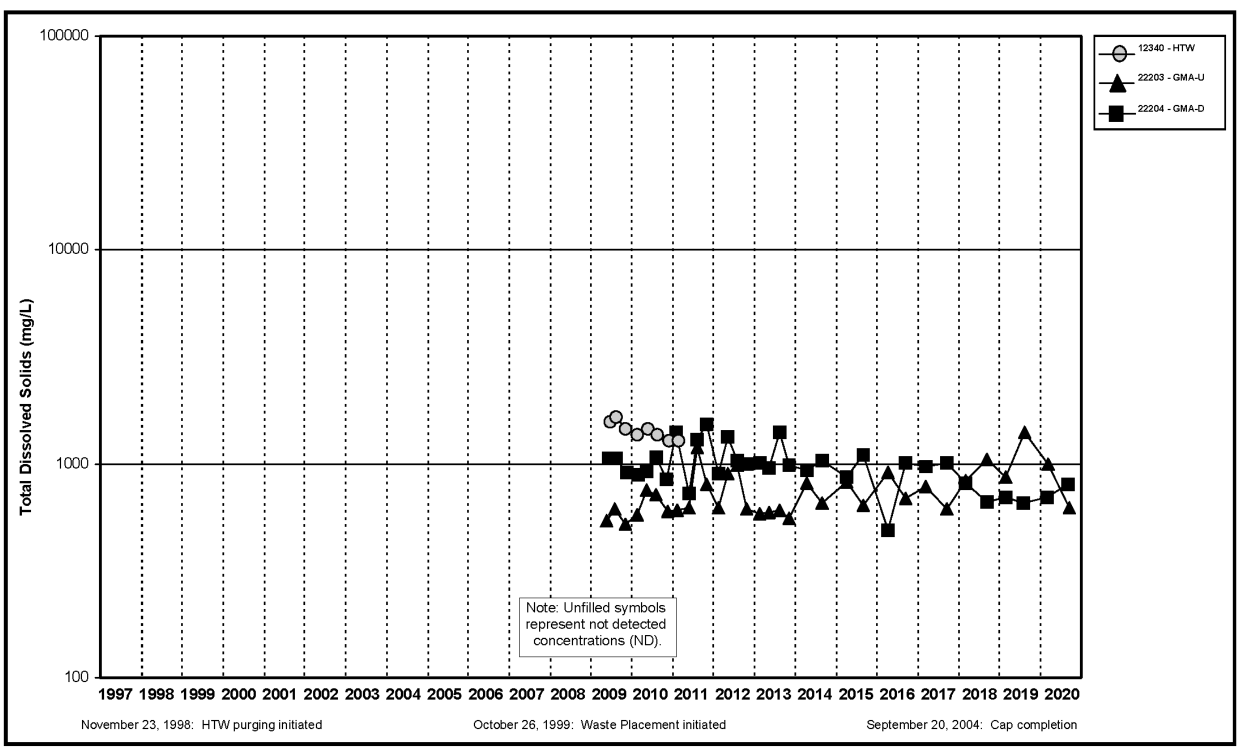

Figure A.5.3-16. Cell 3 Total Dissolved Solid Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

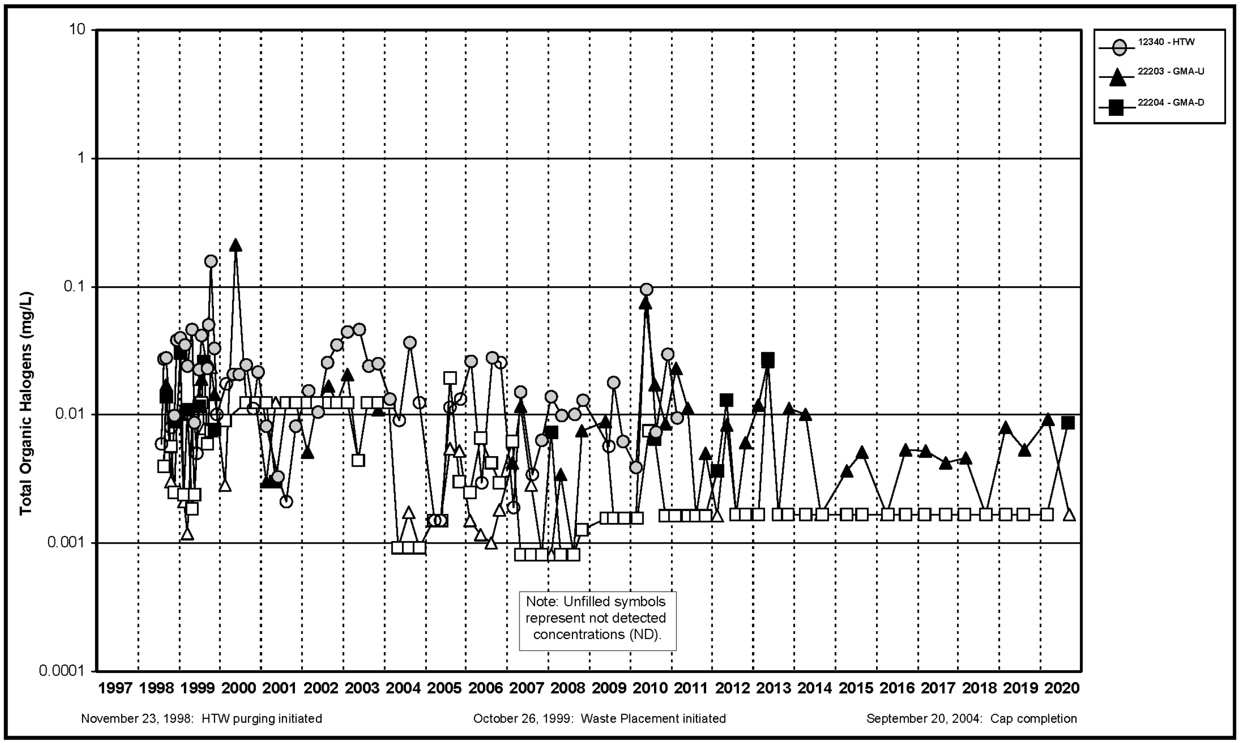

Figure A.5.3-17. Cell 3 Total Organic Halogens Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

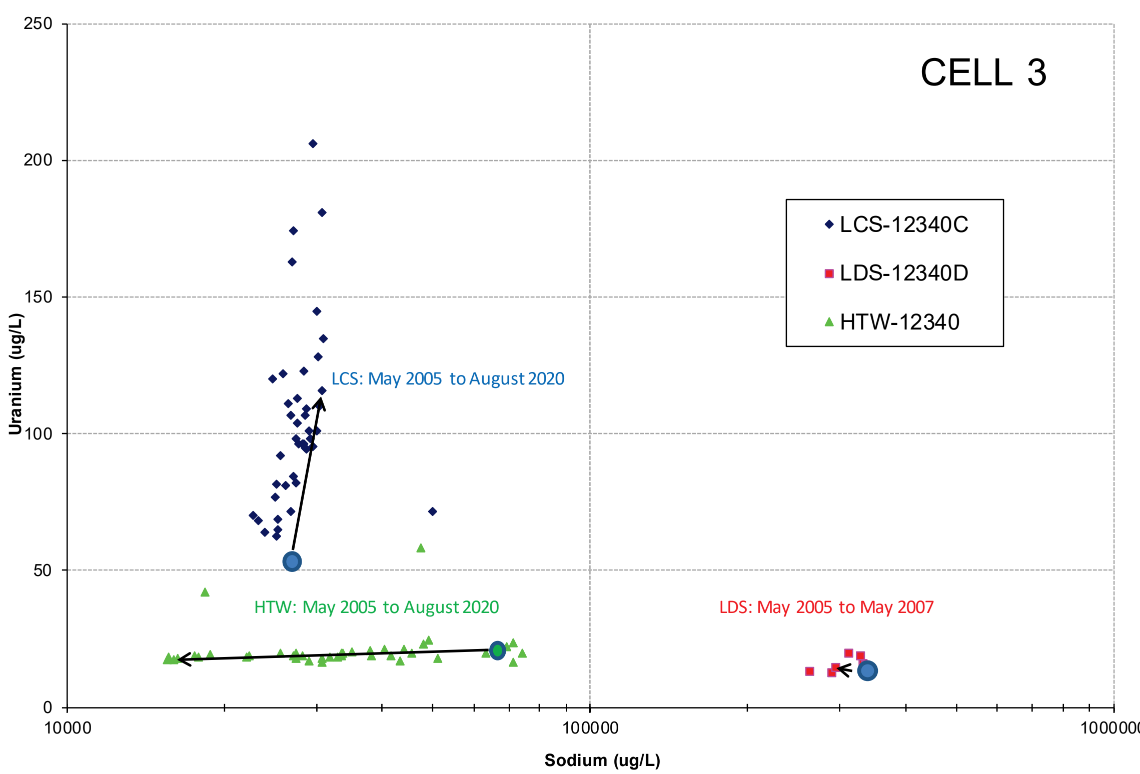

Figure A.5.3-18. Cell 3 Bivariate Plot for Uranium and Sodium

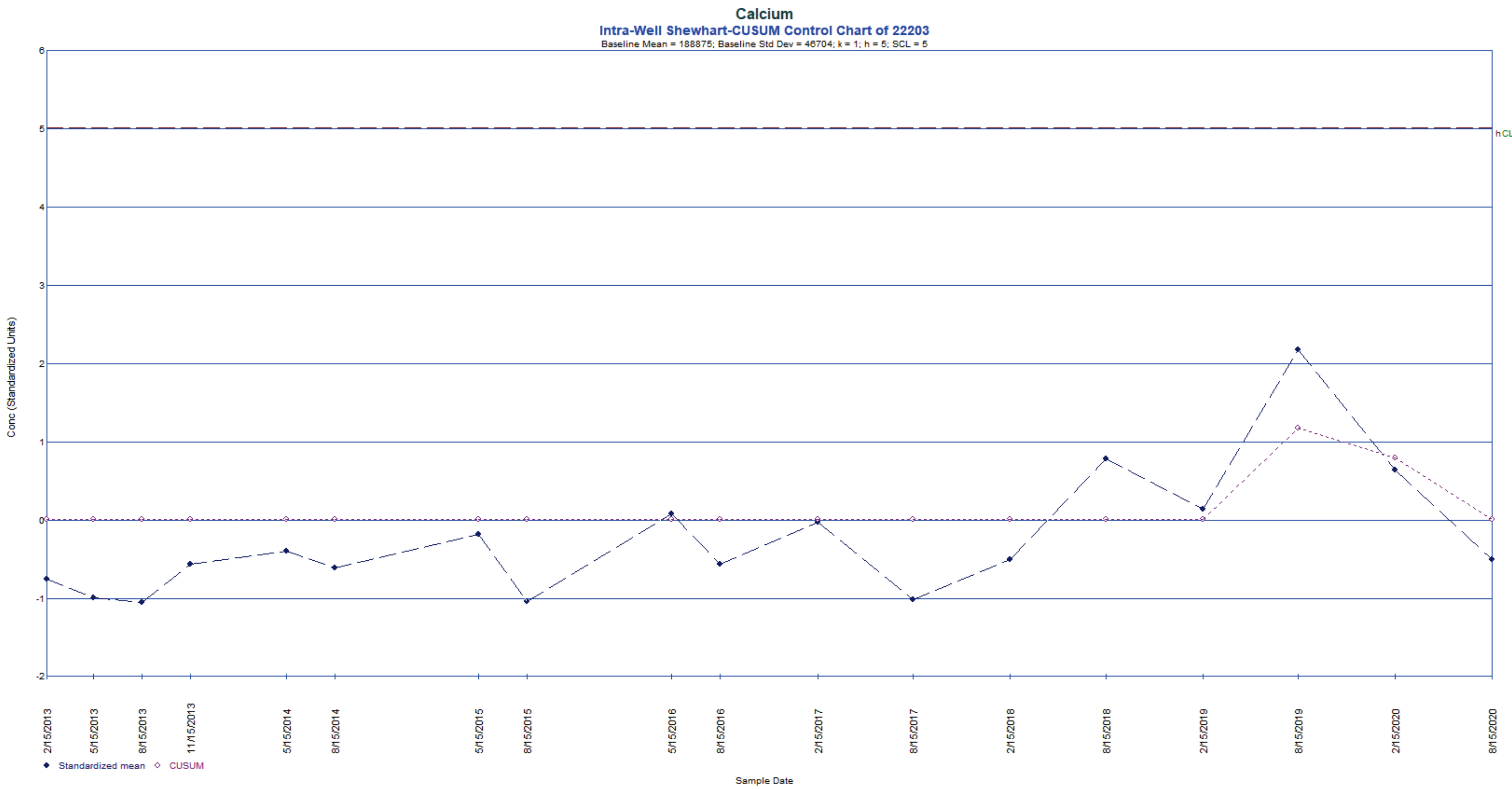

Figure A.5.3-19. Intrawell Shewhart-CUSUM Control Chart for Calcium in Monitoring Well 22203

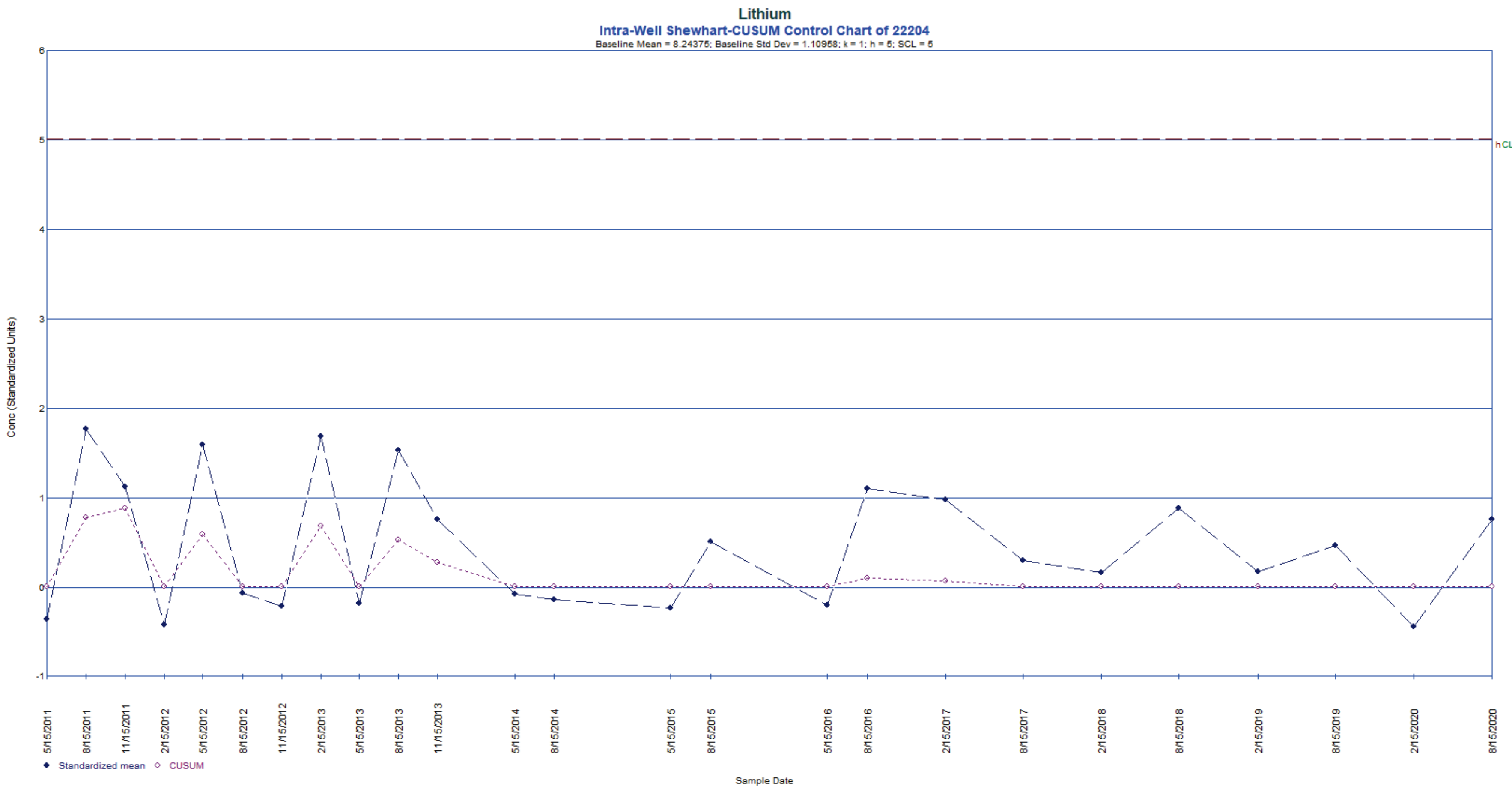

Figure A.5.3-20. Intrawell Shewhart-CUSUM Control Chart for Lithium in Monitoring Well 22204

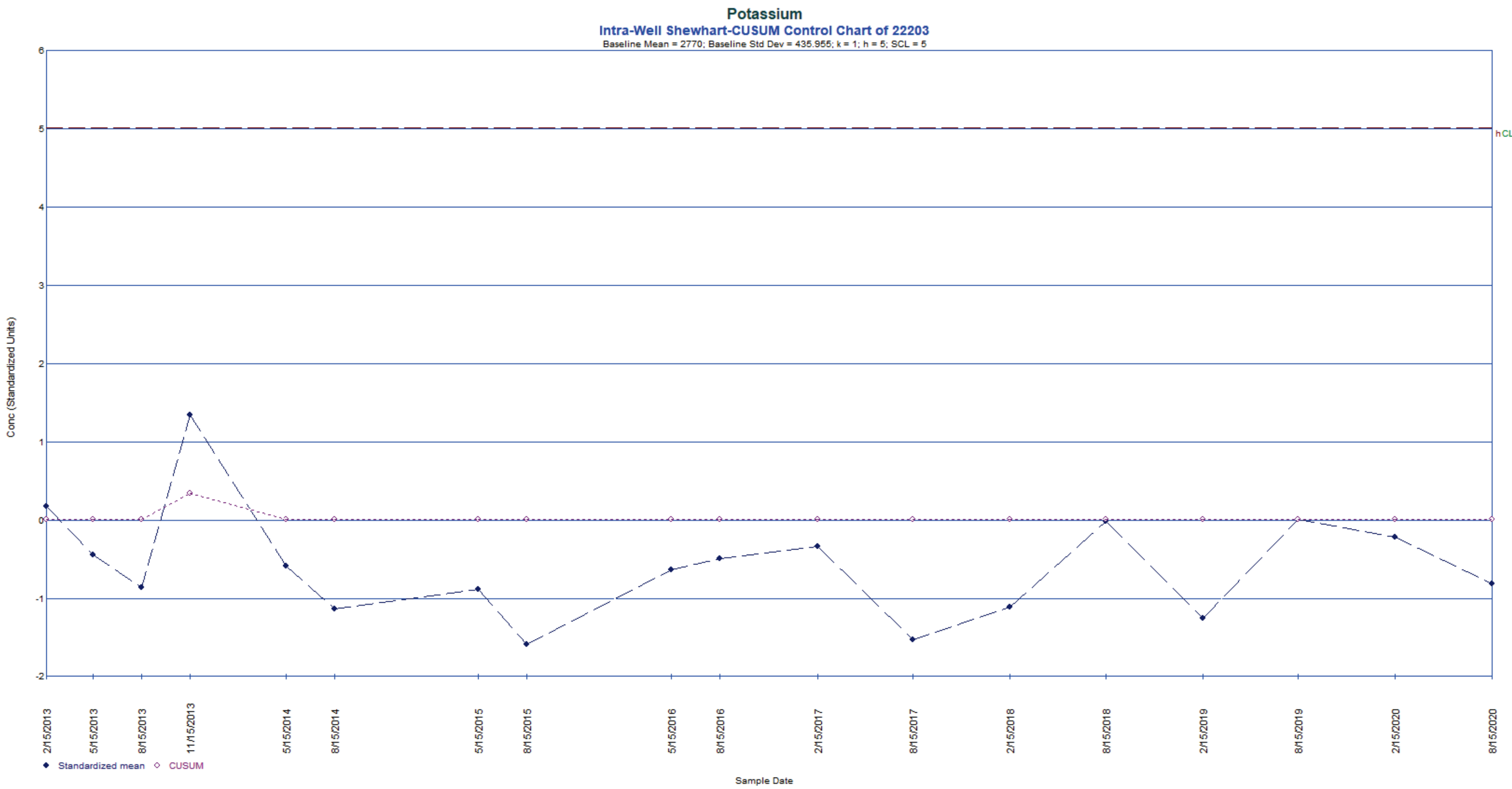

Figure A.5.3-21. Intrawell Shewhart-CUSUM Control Chart for Potassium in Monitoring Well 22203

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Subattachment A.5.4

Cell 4

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Contents

Tables

Figures

Abbreviations

CUSUM	Shewhart-cumulative sum
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
GMA	Great Miami Aquifer
GMA-D	Great Miami Aquifer–downgradient
GMA-U	Great Miami Aquifer–upgradient
HTW	horizontal till well
LCS	leachate collection system
LDS	leak detection system
Ohio EPA	Ohio Environmental Protection Agency
OSDF	On-Site Disposal Facility
SCL	Shewhart control limit

Measurement Abbreviations

amsl	above mean sea level
µg/L	micrograms per liter
mg/L	milligrams per liter
pCi/L	picocuries per liter

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This subattachment provides the following information about the On-Site Disposal Facility (OSDF) Cell 4:

- Semiannual monitoring summary statistics (refer to Table A.5.4-1)
- Leachate collection system (LCS) monthly accumulation volumes (refer to Figure A.5.4-1)
- Leak detection system (LDS) monthly accumulation volumes (refer to Figure A.5.4-2)
- OSDF horizontal till well (HTW) 12341 water yield (refer to Table A.5.4-2)
- Great Miami Aquifer (GMA) water levels and total uranium concentration versus time (refer to Figures A.5.4-3 and A.5.4-4)
- Plots of concentration versus time (refer to Figures A.5.4-5A through A.5.4-17)
- A bivariate plot for uranium–sodium (refer to Figure A.5.4-18)
- Control charts (refer to Figures A.5.4-19 through A.5.4-23)

A.5.4.1 Water Quality Monitoring Results

Water quality within the cell is sampled in the LCS and LDS. Water quality beneath the cell is sampled in the HTW and GMA wells. Concentration-versus-time plots, bivariate plots, and control charts are used to help interpret and present the results.

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.

With EPA and Ohio EPA concurrence, DOE reduced the number of parameters sampled from 24 to 13 beginning in January 2017. All 13 parameters are sampled in the GMA wells; 4 of the 13 parameters (total uranium, boron, sodium, and sulfate) are sampled in the LCS, LDS, and HTW of each cell. The annual sampling in the LCS of each cell for the abbreviated list of Appendix I parameters and polychlorinated biphenyls listed in *Ohio Administrative Code* 3745-27-10 was also eliminated beginning in January 2017 with EPA and Ohio EPA concurrence (DOE 2017).

A.5.4.1.1 LCS and LDS Results

As shown in Table A.5.4-1 and summarized below, four parameters (total uranium, boron, sodium, and sulfate) have upward trends in the LCS and/or LDS based on the Mann-Kendall test for trend.

From 2012 to 2016, the volume of water in the LDS tank of Cell 4 was insufficient to collect a sample. From 2016 to 2019, enough water was been present in the LDS tank of Cell 4 to sample it twice a year. The volume of water in the LDS tank of Cell 4 was insufficient to collect a sample in 2020. A new high uranium concentration of 234 micrograms per liter (µg/L) was measured in the LCS of Cell 4 in the first half of 2020. The previous high was 171 µg/L. The concentration measured in the second half of 2020 was 85.8 µg/L.

Parameters with Upward Concentration Trends in the LCS and LDS of Cell 4[a]

Parameter	LCS 12341C 2020 Trend	LDS 12341D Trend (Year Last Sampled)
Total Uranium		Up (2019)
Boron		Up (2019)
Sodium	Up	Up (2019)
Sulfate	Up	Up (2019)

[a] No entry indicates that the trend was not up.

A.5.4.1.2 HTW and Monitoring Well Results

As shown in Table A.5.4-1 and summarized below, five parameters (total uranium, boron, sodium, sulfate, and lithium) have upward trends in the HTW and/or GMA wells based on the Mann-Kendall test for trend.

Parameters with Upward Concentration Trends in the HTW and GMA Wells of Cell 4[a]

Parameter	HTW 12341	GMA-U[b] 22206	GMA-D[b] 22205
Total Uranium		Up	
Boron		Up	Up
Sodium		Up	
Sulfate	Up		
Lithium			Up

[a] No entry indicates that the trend was not up.
[b] GMA-U = upgradient Great Miami Aquifer; GMA-D = downgradient Great Miami Aquifer; HTW = Horizontal Till Well.

A.5.4.1.3 Discussion

The uranium–sodium bivariate plot for the Cell 4 LCS, LDS, and HTW is provided in Figure A.5.4-18. On the figure, the first sample ever collected from the monitoring horizon is circled. An arrow leads from the first sample to the location of the most recent sample. The plot shows that the chemical signatures for uranium and sodium in the LCS, LDS, and HTW are separate and distinct, indicating that mixing between the horizons is not occurring; therefore, upward concentration trends measured beneath the cells in GMA wells are attributed to fluctuating ambient concentrations beneath the cell and are not related to cell performance.

A.5.4.2 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. 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 “not in 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. Usually, two parameters are used to compute standardized limits—the decision value (h) and the Shewhart control limit (SCL).

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 eight samples were selected for control charts. By default, the ChemStat software plots both a CUSUM control limit (h) and an SCL on the control chart. The software recommends a value of 5 for the CUSUM control limit and a value of 4.5 for the SCL.

EPA Statistical Analysis 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 is not needed. The ChemStat software though, by default, plots both the SCL and CUSUM control limit on the charts. To address this issue, the SCL was defined as 5 to equal the recommended CUSUM (h) limit. This combined limit is identified as *h*CL on the control charts. For interpretation purposes, the *h*CL value will be regarded as the CUSUM (h) limit.

As shown in Table A.5.4-1 in gray shading and as summarized below, four parameters in the HTW or GMA wells of Cell 4 meet the criteria for control charts (i.e., at least eight samples, normal or lognormal distribution, no trend, and no serial correlation), resulting in five control charts (A.5.4-19 through A.5.4-23).

All of the control charts for Cell 4 exhibit “in control” conditions.

Parameter	Monitoring Point[a]	Well Number	Assessment	Figure Number
Uranium	GMA-D	22205	In Control	A.5.4-19
Sulfate	GMA-D	22205	In Control	A.5.4-20
Magnesium	GMA-U	22206	In Control	A.5.4-21
Magnesium	GMA-D	22205	In Control	A.5.4-22
Total Dissolved Solids	GMA-D	22205	In Control	A.5.4-23

[a] GMA-U = upgradient Great Miami Aquifer; GMA-D = downgradient Great Miami Aquifer, HTW = horizontal till well.

A.5.4.3 Summary and Conclusions

- Four parameters (total uranium, boron, sodium, and sulfate) have upward trends in the LCS and/or LDS based on the Mann-Kendall test for trend. A new high uranium concentration of 234 µg/L was measured in the LCS of Cell 4 in the first half of 2020. The previous high was 171 µg/L. The concentration measured in the second half of 2020 was 85.8 µg/L.
- The volume of water in the LDS tank of Cell 4 was insufficient to collect a sample in 2020.
- Five parameters monitored semiannually have an upward concentration in the HTW or GMA wells of Cell 4: total uranium, boron, sodium, sulfate, and lithium. Separate and distinct chemical signatures for total uranium and sodium in the LCS, LDS, and HTW of Cell 4 indicate that water is not mixing between the horizons. Therefore, upward

concentration trends beneath Cell 4 (i.e., HTW or GMA wells) are attributed to fluctuating ambient concentrations beneath the cell and not to cell performance.

- Five control charts were constructed for Cell 4 parameters. All of the control charts exhibit "in control" conditions.

A.5.4.4 References

DOE (U.S. Department of Energy), 2017. *Fernald Preserve 2016 Site Environmental Report*, LMS/FER/S15232, Office of Legacy Management, Cincinnati, Ohio, May.

EPA (U.S. Environmental Protection Agency), 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities—Unified Guidance*, EPA 530/R-09-007, March.

OAC 3745-27-10. "Ground Water Monitoring Program for a Sanitary Landfill Facility," *Ohio Administrative Code.*

Table A.5.4-1. Summary Statistics for Cell 4

Parameter	Horizon[a]	Location	Number of Detected Samples	Total Number of Samples	Percent Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[d]	Distribution Type[d,e]	Trend[d,f] (Year Last Sampled)	Serial Correlation[d,g]	Outliers[h,i]
Total Uranium (µg/L)	LCS	12341C	56	56	100	4.41	234	87.7	35.5	Undefined	None (2020)	Detected	
	LDS	12341D	40	40	100	5.74	55.9	14.8	11.6	Undefined	Up (2019)	Detected	
	HTW	12341	61	61	100	3.41	7.89	5.47	0.99	Normal	Down (2020)	Detected	
	GMA-U	22206	58	62	93.6	ND	4.67	1.35	0.98	Ln Normal	Up (2020)	Detected	
	GMA-D	22205	69	69	100	0.525	12.1	2.53	2.35	Ln Normal	None (2020)	Not Detected	
Boron (mg/L)	LCS	12341C	56	56	100	0.0626	1.93	0.858	0.272	Undefined	Down (2020)	Detected	
	LDS	12341D	40	40	100	0.415	2.89	0.689	0.648	Undefined	Up (2019)	Detected	
	HTW	12341	41	44	93.2	0.0284	1.24	0.0990	0.214	Undefined	Down (2020)	Detected	
	GMA-U	22206	57	62	91.9	ND	0.0817	0.0438	0.0126	Undefined	Up (2020)	Detected	
	GMA-D	22205	55	62	88.7	ND	0.0807	0.0459	0.0145	Normal	Up (2020)	Detected	
Sodium (mg/L)	LCS	12341C	46	46	100	22.0	117	53.6	13.2	Undefined	Up (2020)	Not Detected	
	LDS	12341D	26	26	100	307	1420	469	259	Undefined	Up (2019)	Not Detected	
	HTW	12341	42	42	100	13.7	18.1	15.2	1.0	Normal	Down (2020)	Detected	
	GMA-U	22206	33	33	100	12.3	22.3	17.2	3.0	Normal	Up (2020)	Detected	
	GMA-D	22205	34	34	100	9.26	22.2	15.5	4.0	Undefined	Down (2020)	Detected	
Sulfate (mg/L)	LCS	12341C	56	56	100	140	3940	2750	780	Undefined	Up (2020)	Detected	
	LDS	12341D	40	40	100	1470	9010	2570	1930	Undefined	Up (2019)	Detected	
	HTW	12341	52	52	100	153	527	256	115	Undefined	Up (2020)	Detected	
	GMA-U	22206	57	57	100	90.4	559	217	107	Ln Normal	Down (2020)	Detected	3,720 (Q3-12)
	GMA-D	22205	57	57	100	199	535	337	76	Normal	None (2020)	Not Detected	
Calcium (mg/L)	GMA-U	22206	26	26	100	137	217	150	23	Undefined	None (2020)	Not Detected	
	GMA-D	22205	26	26	100	168	268	220	21	Normal	Down (2020)	Not Detected	
Lithium (mg/L)	GMA-U	22206	33	33	100	0.00852	0.0175	0.0122	0.0024	Normal	Down (2020)	Detected	
	GMA-D	22205	33	33	100	0.00665	0.0167	0.00828	0.00230	Undefined	Up (2020)	Detected	
Magnesium (mg/L)	GMA-U	22206	26	26	100	30.2	43.8	35.9	3.7	Normal	None (2020)	Not Detected	
	GMA-D	22205	26	26	100	40.1	63.2	52.5	5.5	Normal	None (2020)	Not Detected	
Nitrate + Nitrite, as Nitrogen (mg/L)	GMA-U	22206	2	26	7.7	ND	0.0425	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
	GMA-D	22205	4	26	15.4	ND	0.0818	0.0085	0.0178	Undefined	None (2020)	Not Detected	
Potassium (mg/L)	GMA-U	22206	26	26	100	3.08	4.39	3.72	0.34	Normal	Down (2020)	Detected	
	GMA-D	22205	27	27	100	1.75	3.22	2.37	0.38	Normal	Down (2020)	Detected	
Selenium (mg/L)	GMA-U	22206	1	33	3.0	ND	0.0172	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
	GMA-D	22205	3	33	9.1	ND	0.0180	0.004315	Insufficient	Insufficient	Insufficient	Insufficient	
Technitium-99 (pCi/L)	GMA-U	22206	1	23	4.4	ND	8.54	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
	GMA-D	22205	0	23	0	ND	NA	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
Total Dissolved Solids (mg/L)	GMA-U	22206	33	33	100	551	877	626	83	Undefined	None (2020)	Not Detected	
	GMA-D	22205	33	33	100	726	1180	939	103	Normal	None (2020)	Not Detected	
Total Organic Halogens (mg/L)	GMA-U	22206	22	62	35.5	ND	0.0640	0.00370	0.00968	Undefined	Down (2020)	Detected	
	GMA-D	22205	14	62	22.6	ND	0.0142	0.00166	0.00396	Undefined	Down (2020)	Detected	0.0340 (Q2-13)

Note 1: Shading identifies a horizontal till well or Great Miami Aquifer well, with at least eight samples, Normal or Ln Normal distribution, no trend (None), and no serial correlation (Not Detected). These wells achieve control chart criteria.

Note 2: Data used in this table has been standardized to quarterly.

[a]LCS = leachate collection system; LDS = leak detection system; HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; and GMA-D = downgradient Great Miami Aquifer

[b]ND = not detected; NA = not applicable

[c]Averages were determined based on the distribution assumption.

[d]Insufficient is used for Distribution Type, Trend, or Serial Correlation whenever there is not enough data to run the test.

[e]Data distribution based on the Shapiro-Wilk statistic.

Normal: Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the Ln Normal assumption.

Ln Normal: Ln Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the Normal assumption.

Undefined: Normal and Lognormal Distribution assumptiions are both rejected or there are less than 25 percent detected values. "Average" is defined as the Median of the data.

[f]Trend based on nonparametric Mann-Kendall procedure.

[g]Serial correlation based on Rank Von Neumann test.

[h]Outliers determined by Rosner's (for sample sizes greater than 25) or Dixon procedure (for sample sizes less than or equal to 25).

[i]Q = quarter

[j]The Cell 4 LDS was dry, resulting in no data from fourth quarter 2011 through 2016.

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Table A.5.4-2. Horizontal Till Well 12341 Water Yield

Year	Total Volume Purged (gallons)	Number of Months Purged	Average Volume Purged (gallons)
2002	21,115	9	2,346
2003	3,950	6	658
2004	2,935	5	587
2005	2,500	4	625
2006	2,475	4	619
2007	2,425	4	606
2008	2,220	4	555
2009	2,150	4	717
2010	2,575	4	644
2011	2,350	4	588
2012	2,240	4	560
2013	2,460	4	615
2014	1,140	2	570
2015	975	2	488
2016	1,025	2	513
2017	1,175	2	588
2018	1,155	2	578
2019	1,045	2	523
2020	1,000	2	500

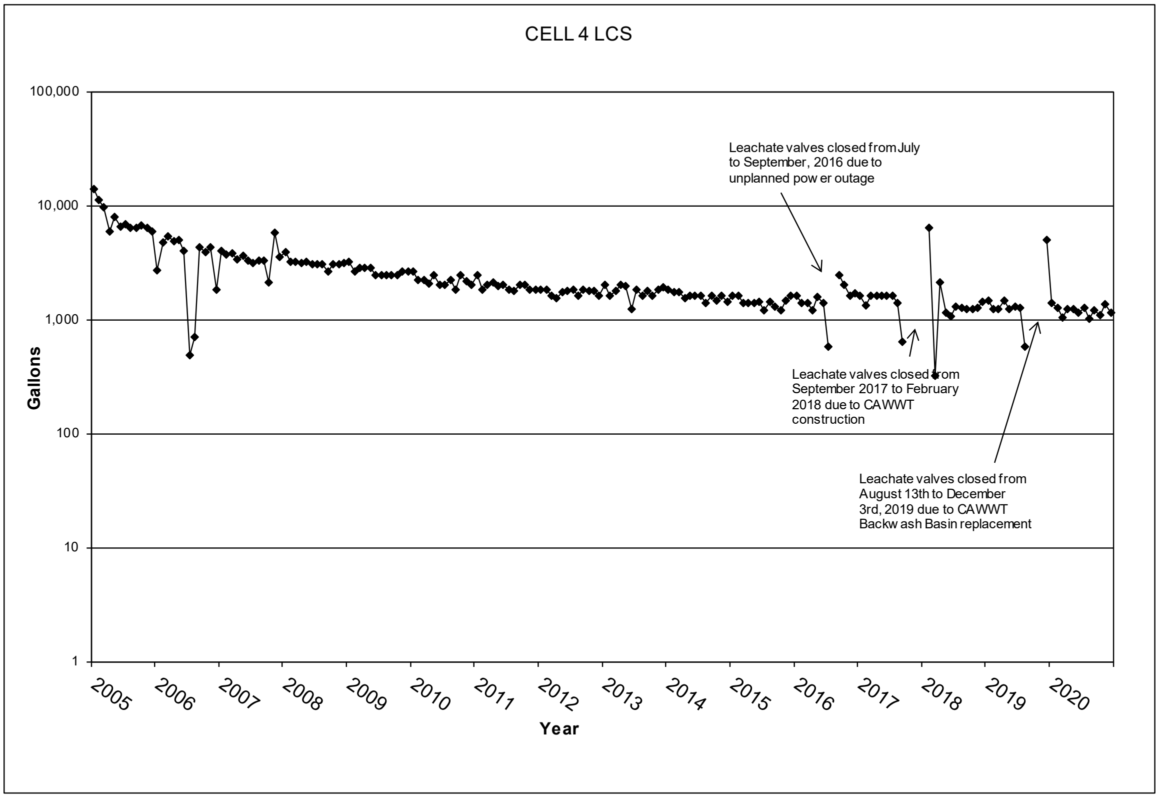

Figure A.5.4-1. Monthly Accumulation Volumes for Cell 4 LCS

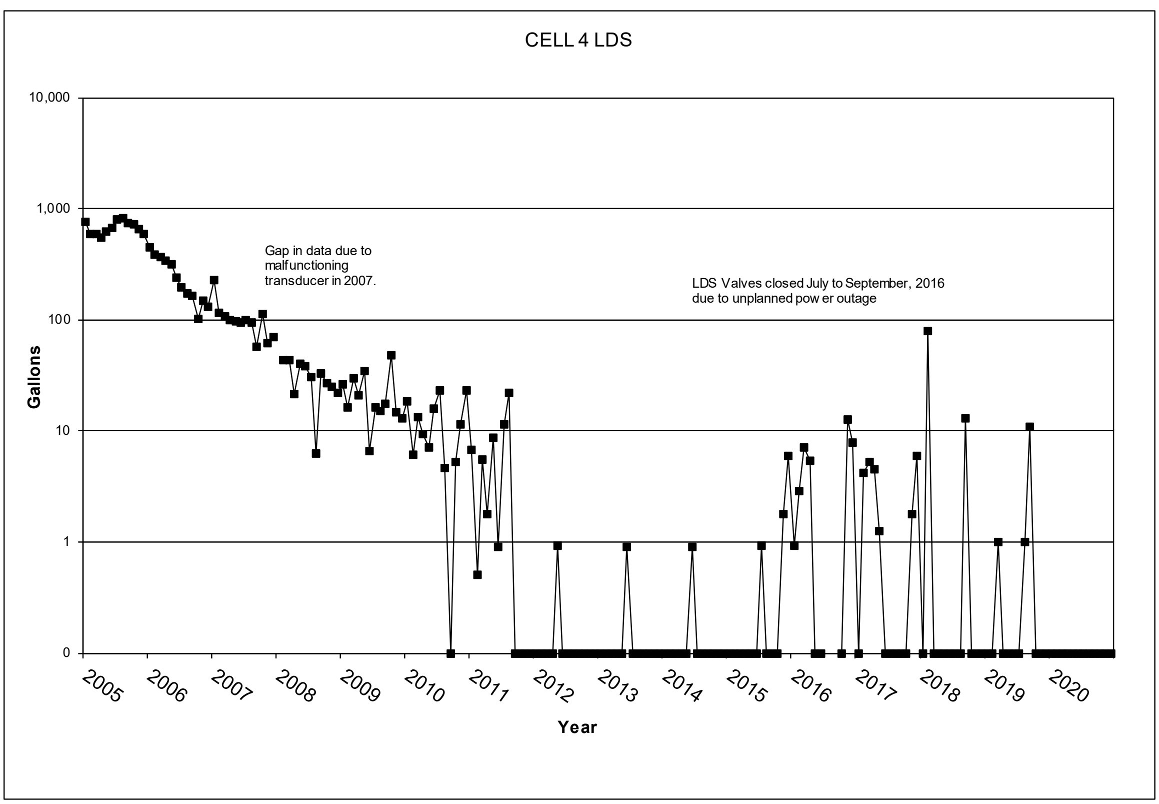

Figure A.5.4-2. Monthly Accumulation Volumes for Cell 4 LDS

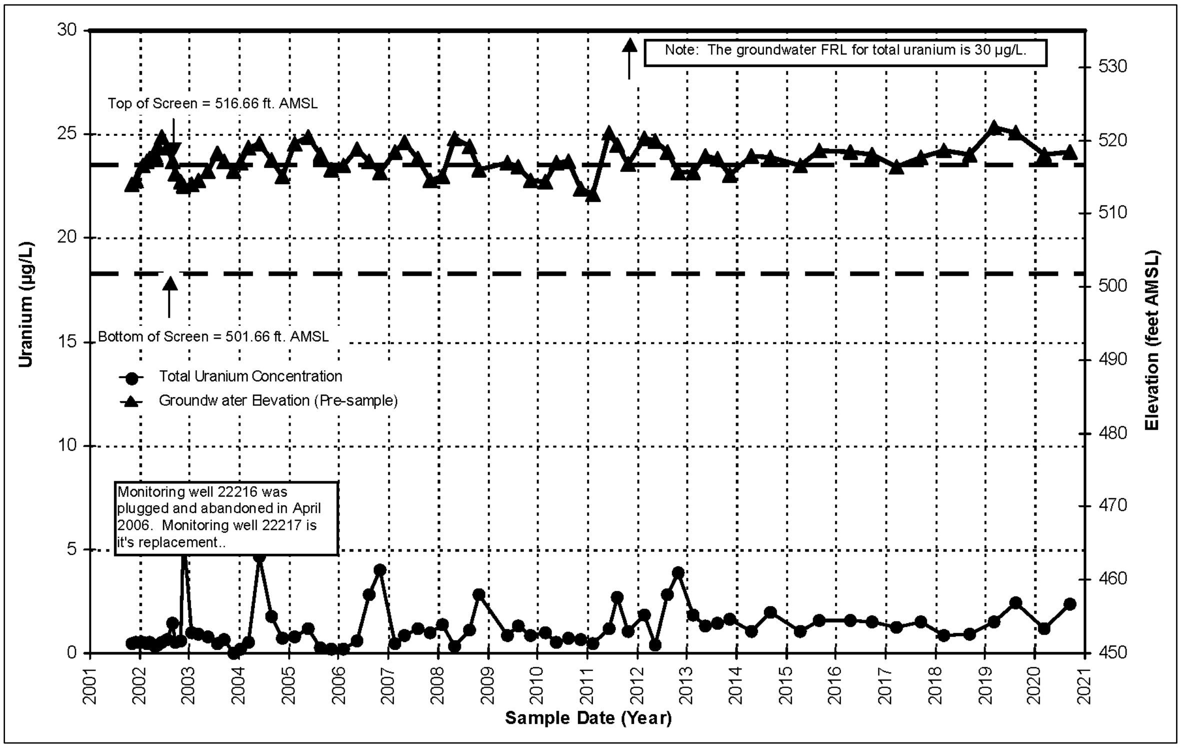

Figure A.5.4-3. Total Uranium Concentration and Groundwater Elevation Versus Time Plot for Cell 4 Upgradient Monitoring Well 22206

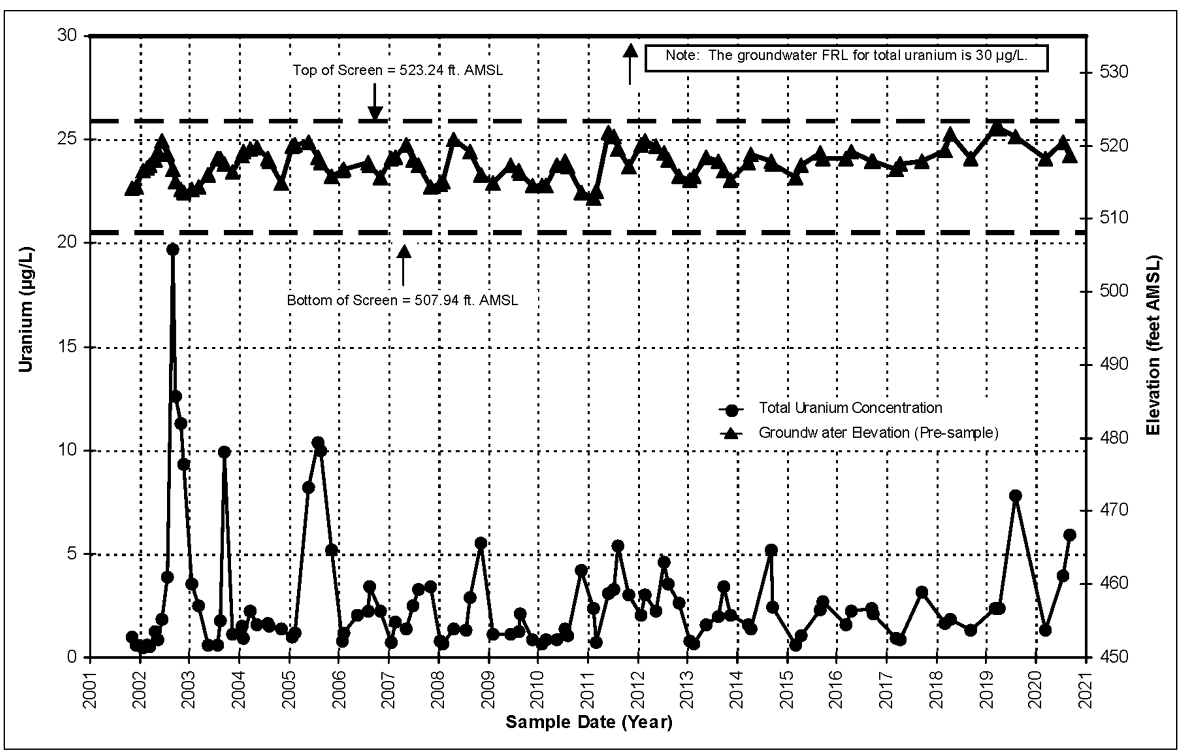

Figure A.5.4-4. Total Uranium Concentration and Groundwater Elevation Versus Time Plot for Cell 4 Downgradient Monitoring Well 22505

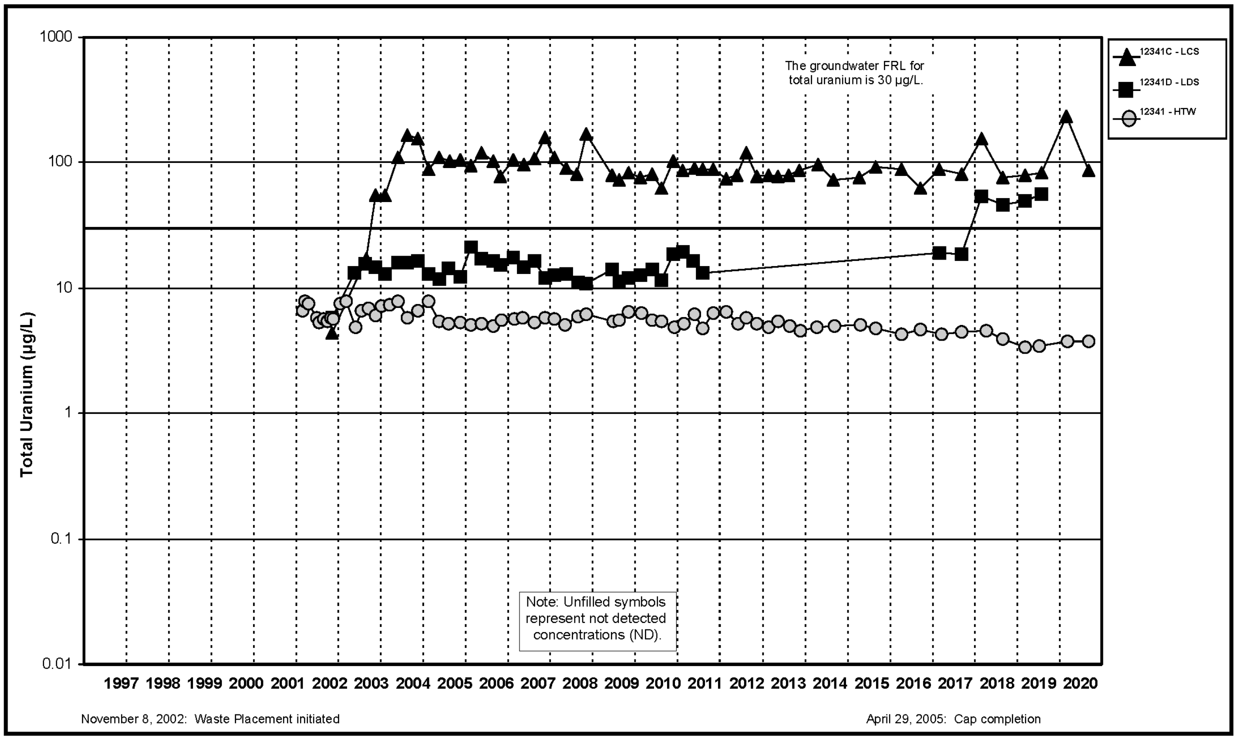

Figure A.5.4-5A. Cell 4 Total Uranium Concentration Versus Time Plot for LCS, LDS, and HTW

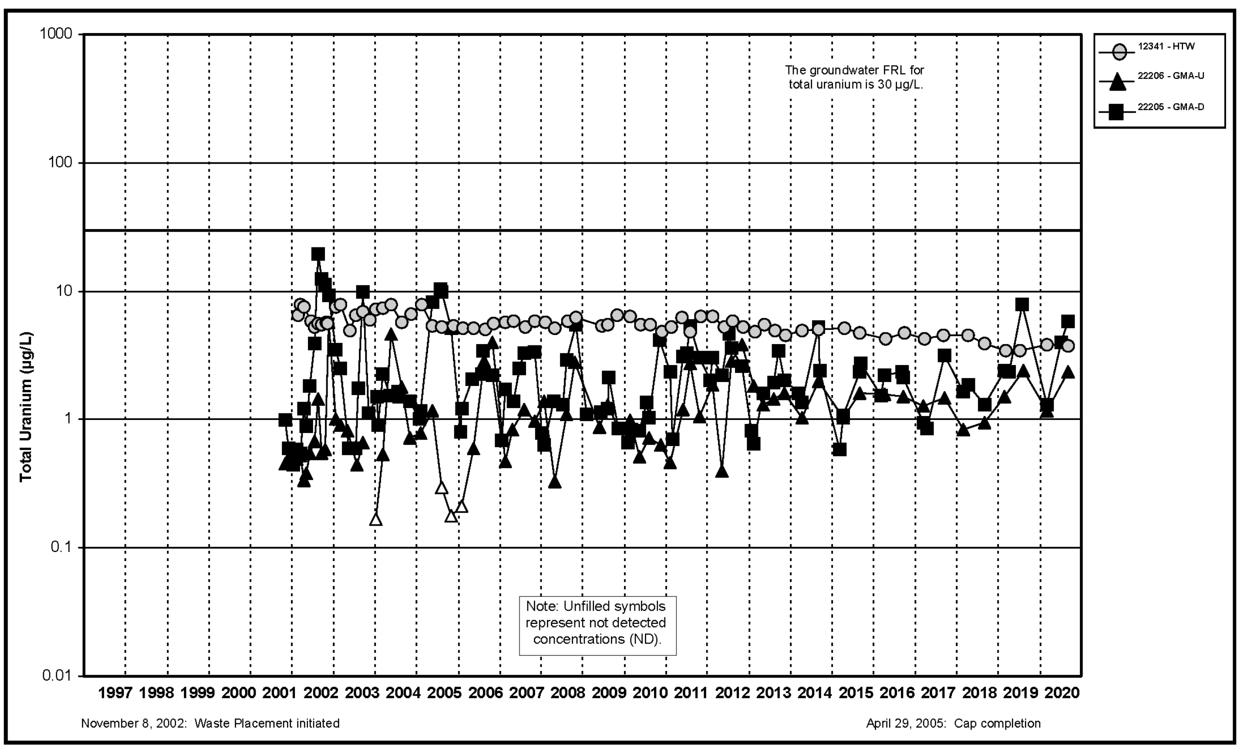

Figure A.5.4-5B. Cell 4 Total Uranium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

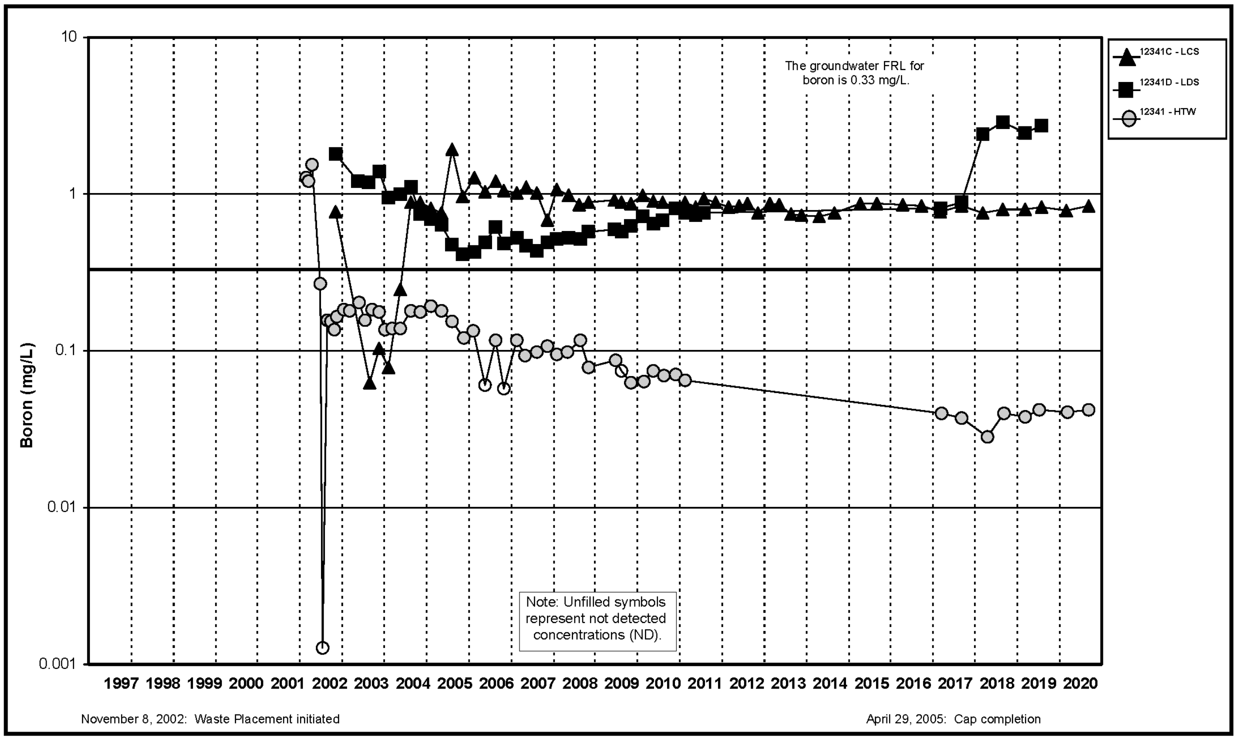

Figure A.5.4-6A. Cell 4 Boron Concentration Versus Time Plot for LCS, LDS, and HTW

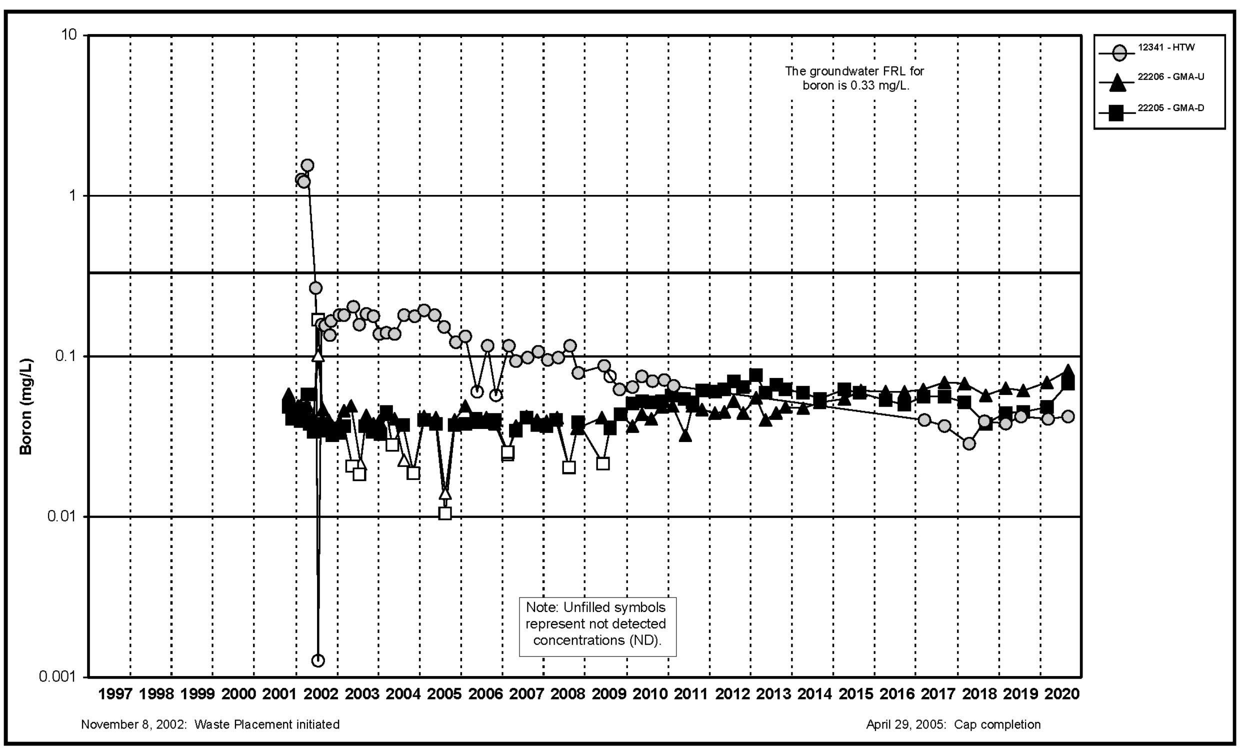

Figure A.5.4-6B. Cell 4 Boron Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

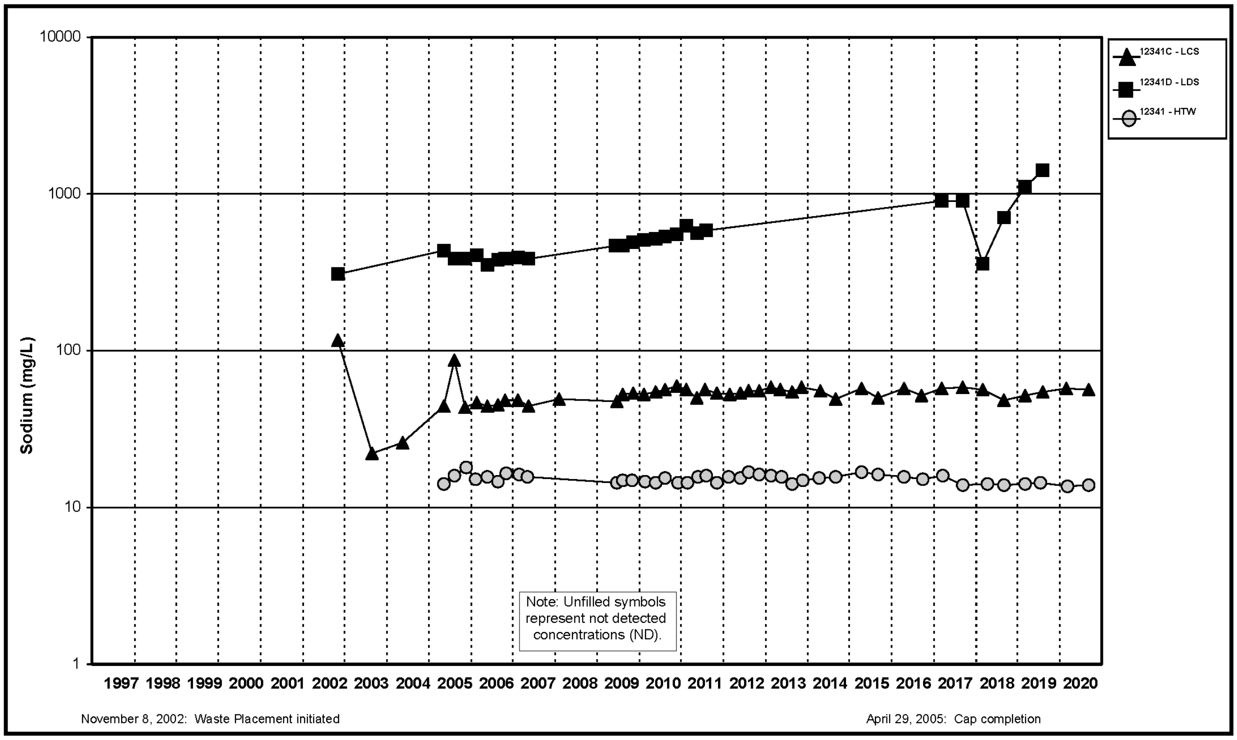

Figure A.5.4-7A. Cell 4 Sodium Concentration Versus Time Plot for LCS, LDS, and HTW

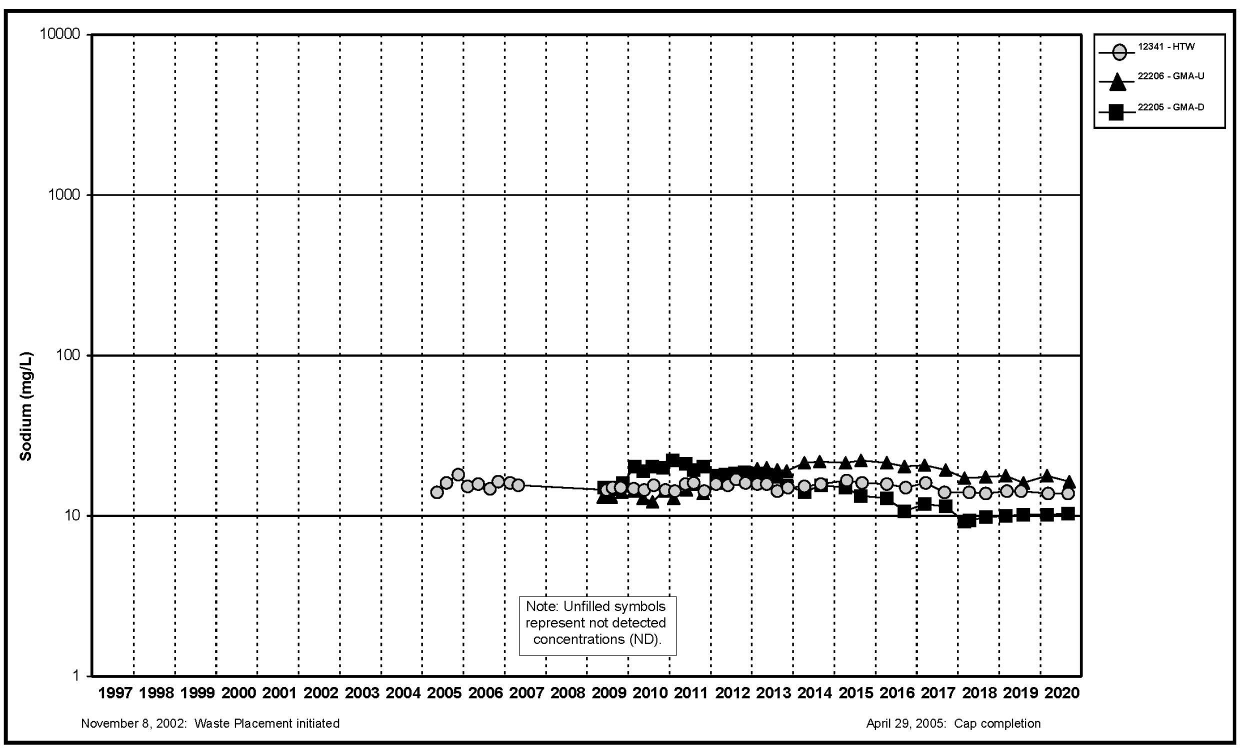

Figure A.5.4-7B. Cell 4 Sodium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

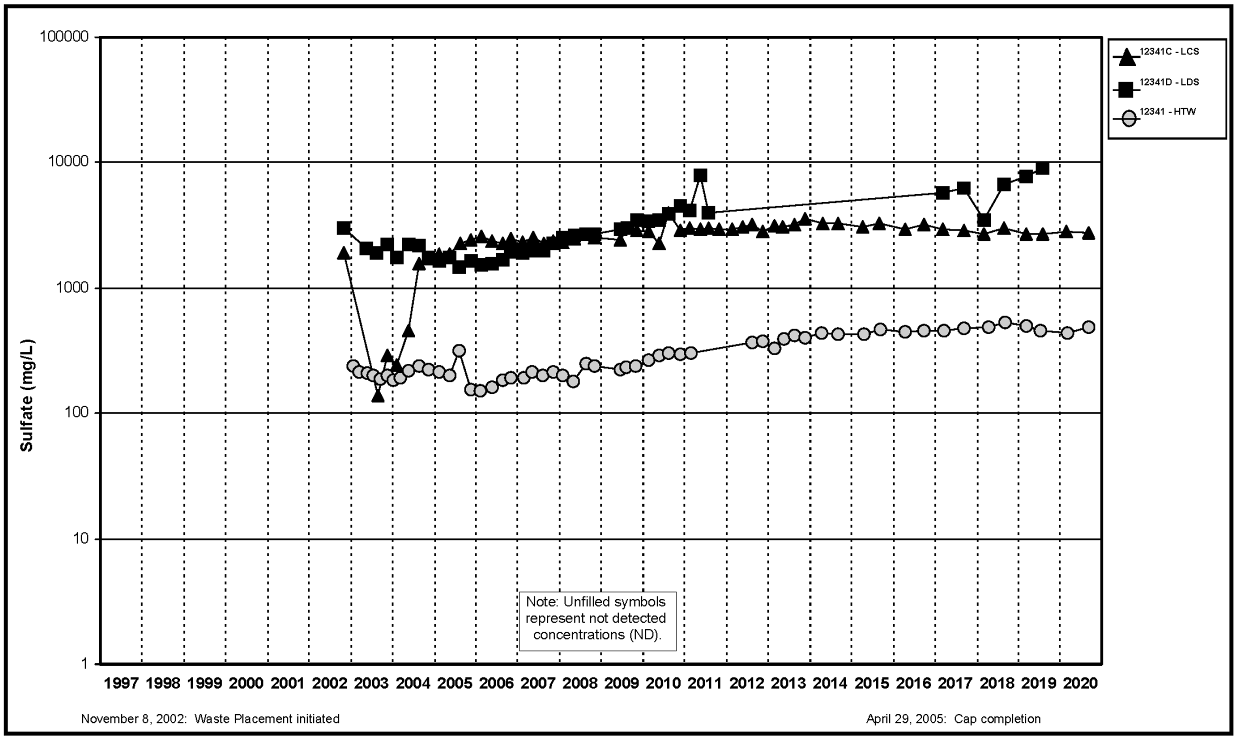

Figure A.5.4-8A. Cell 4 Sulfate Concentration Versus Time Plot for LCS, LDS, and HTW

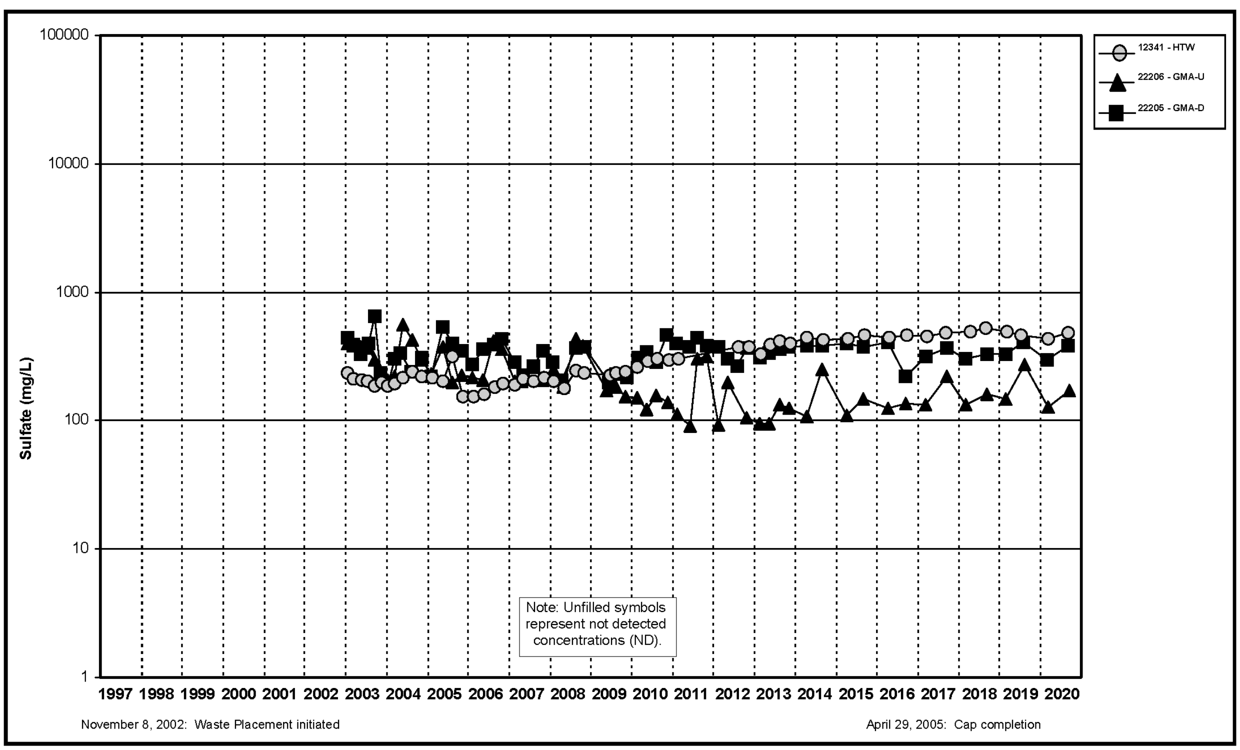

Figure A.5.4-8B. Cell 4 Sulfate Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

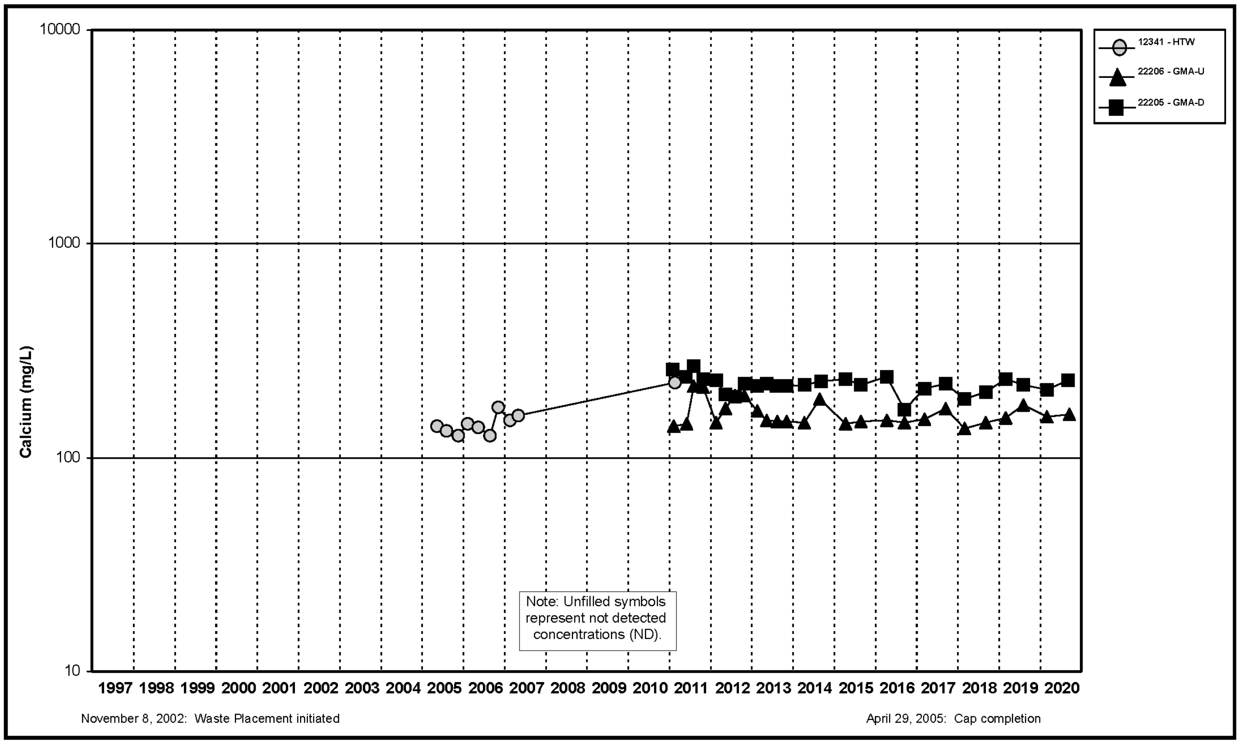

Figure A.5.4-9. Cell 4 Calcium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

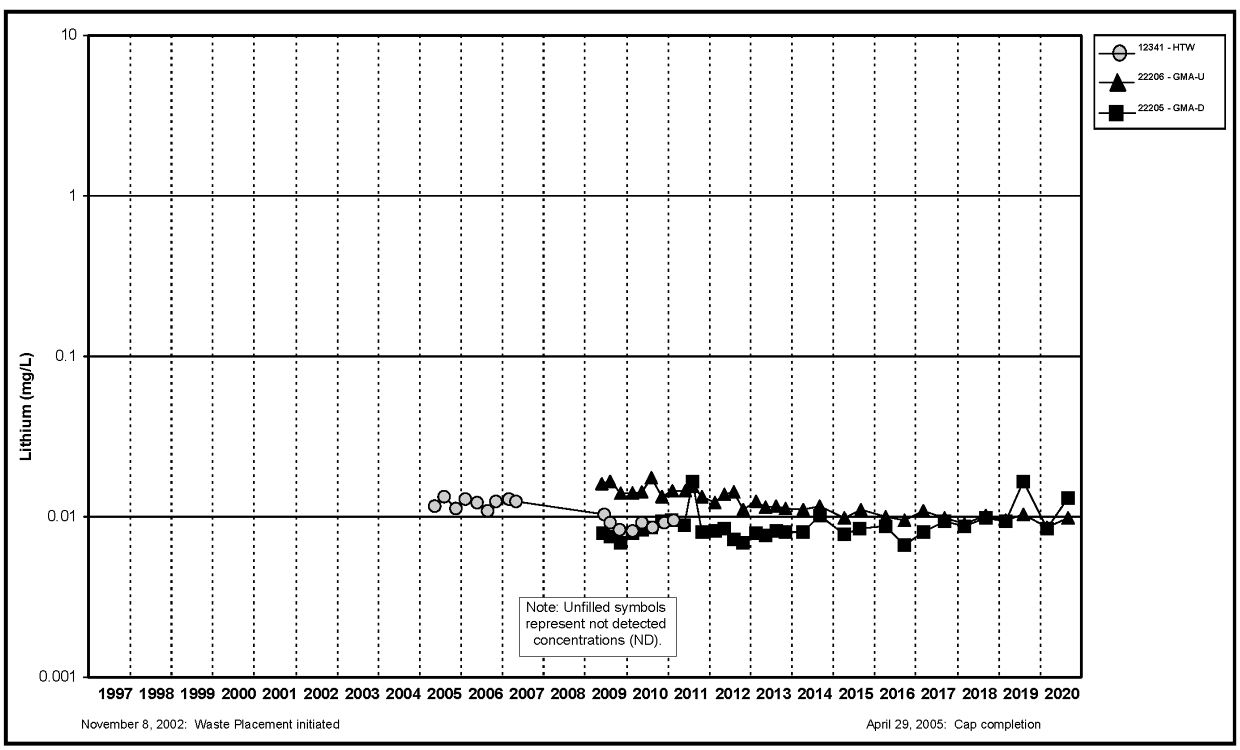

Figure A.5.4-10. Cell 4 Lithium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

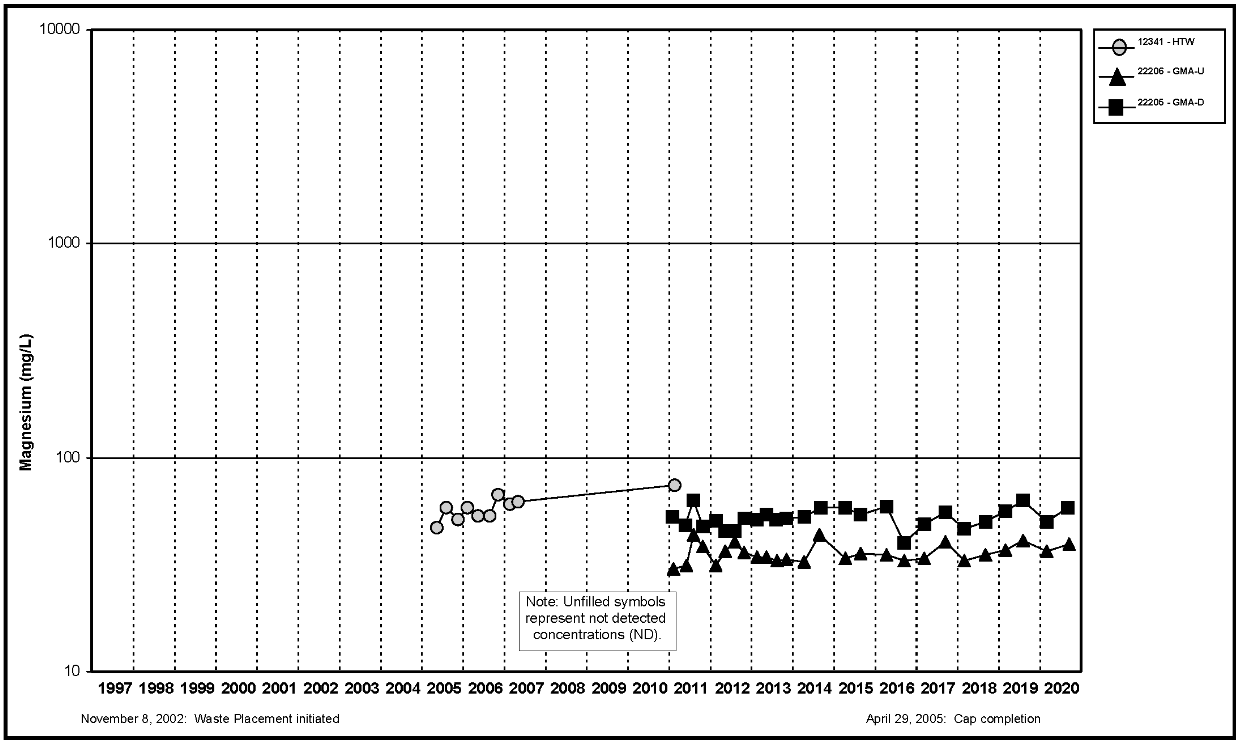

Figure A.5.4-11. Cell 4 Magnesium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

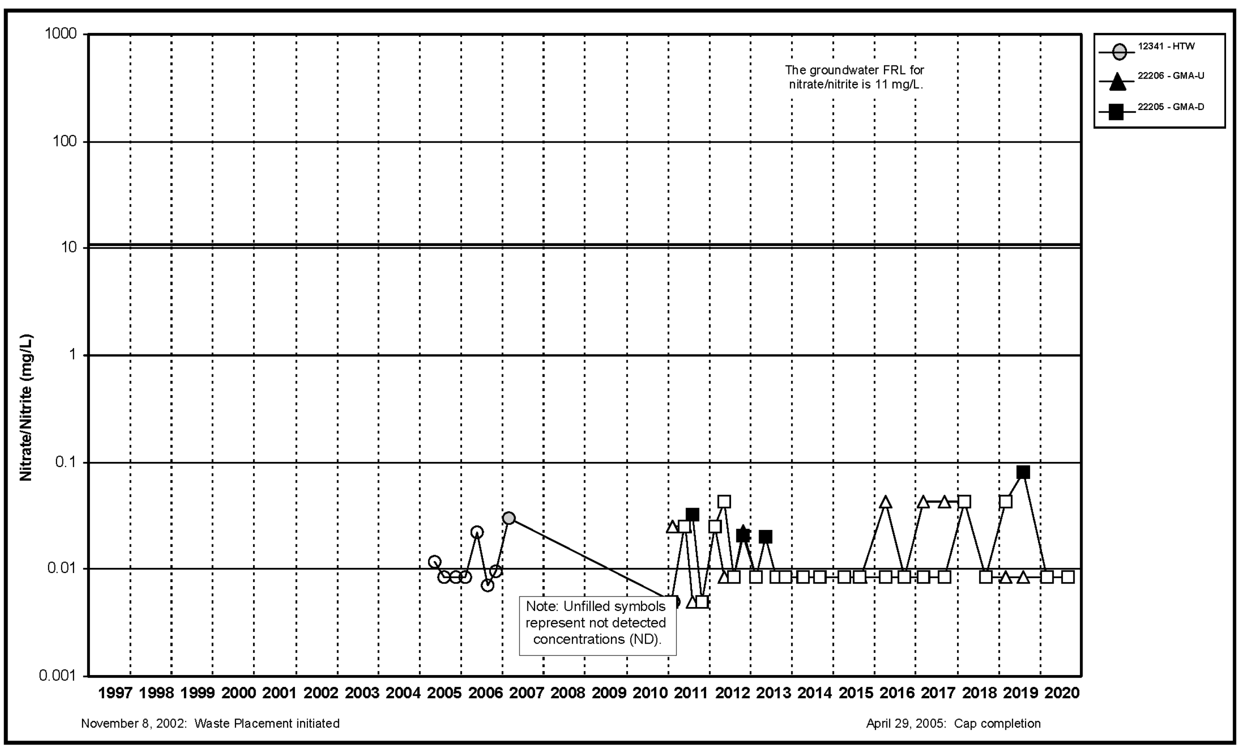

Figure A.5.4-12. Cell 4 Nitrate + Nitrite as Nitrogen Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

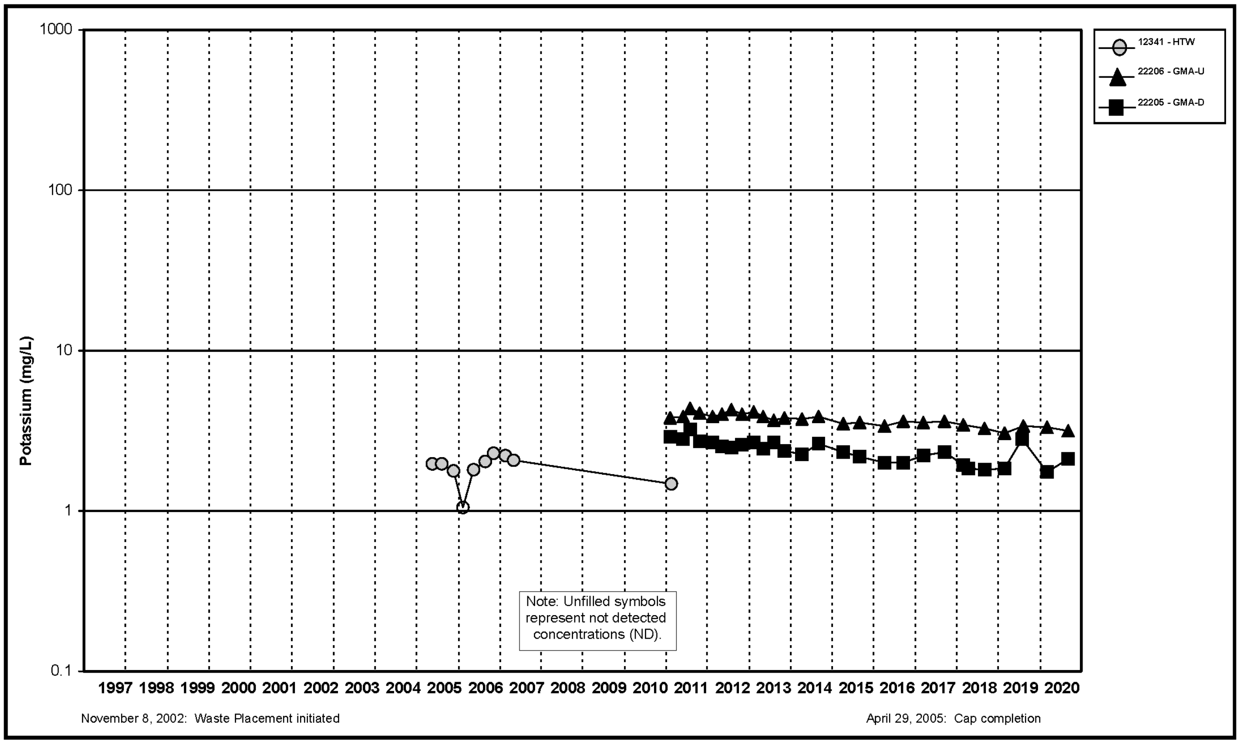

Figure A.5.4-13. Cell 4 Potassium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

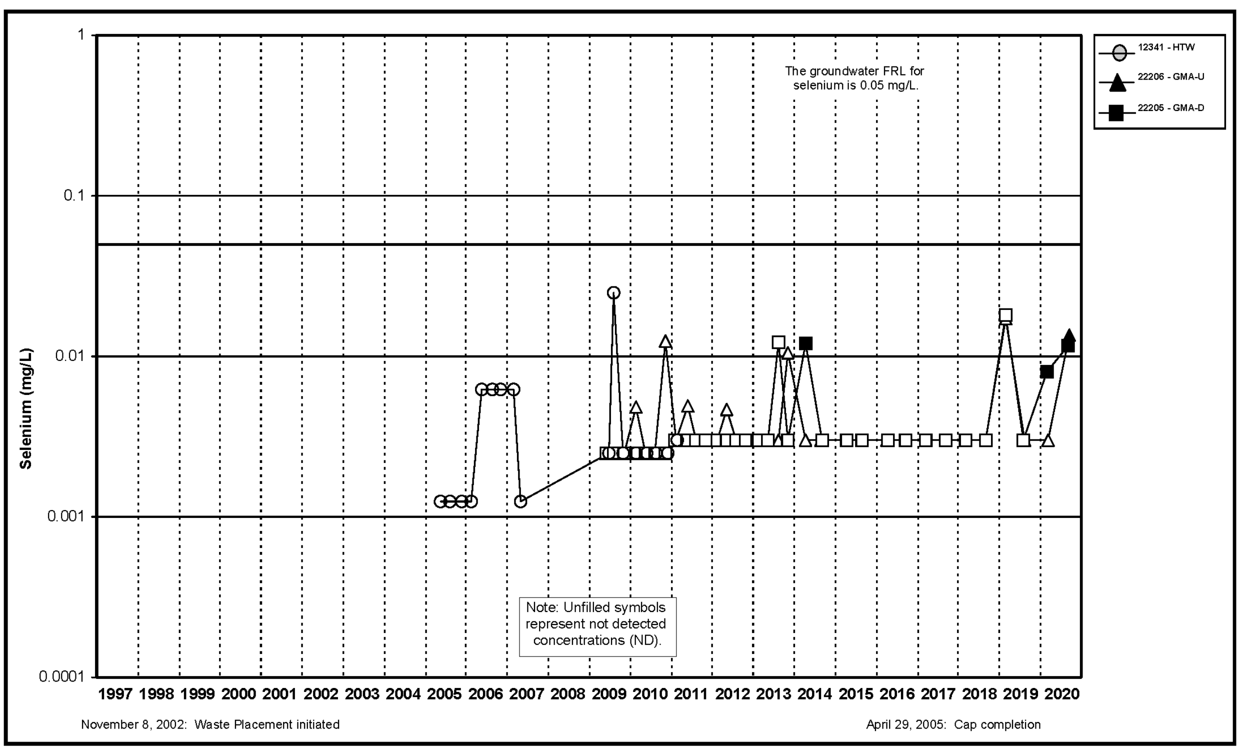

Figure A.5.4-14. Cell 4 Selenium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

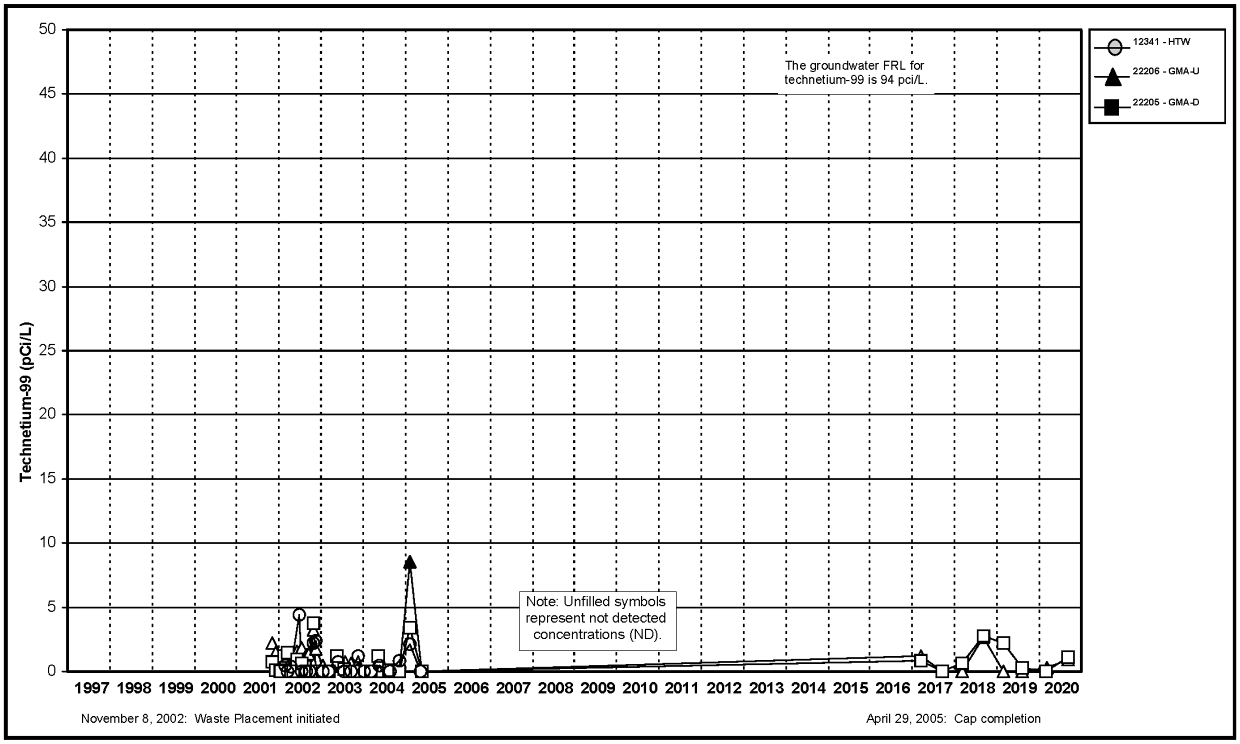

Figure A.5.4-15. Cell 4 Technetium-99 Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

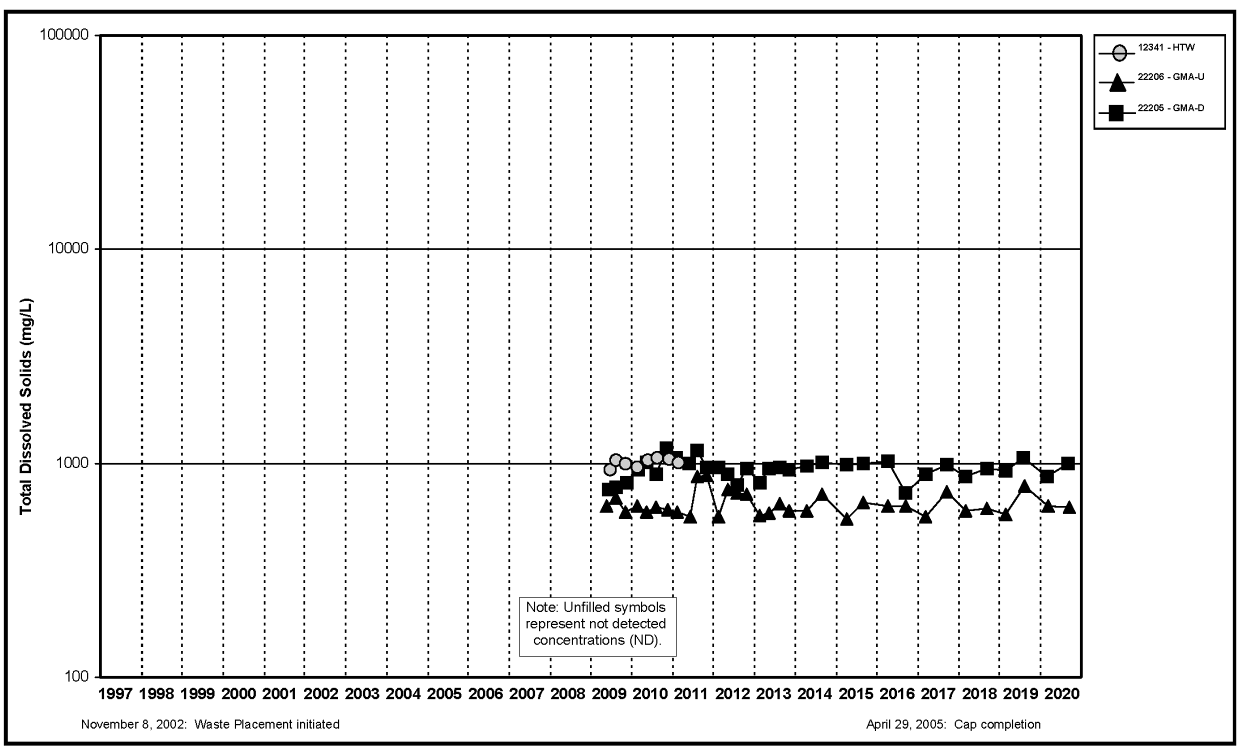

Figure A.5.4-16. Cell 4 Total Dissolved Solids Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

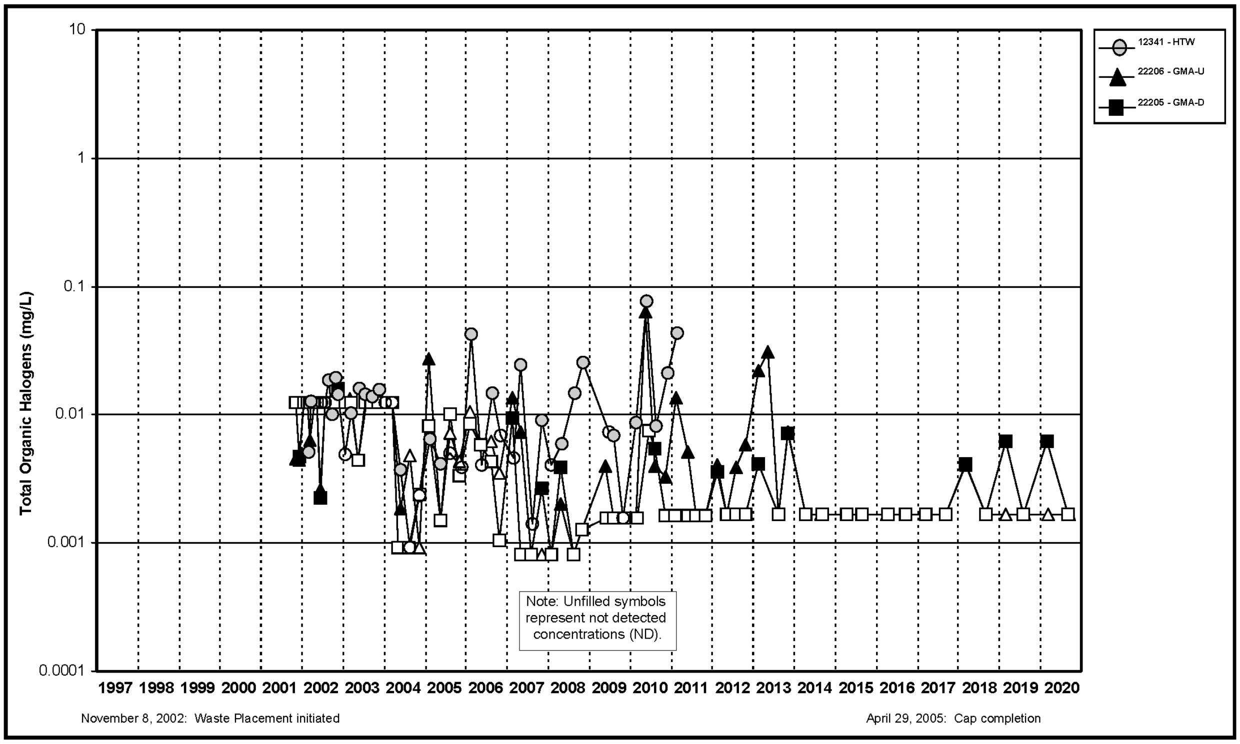

Figure A.5.4-17. Cell 4 Total Organic Halogens Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

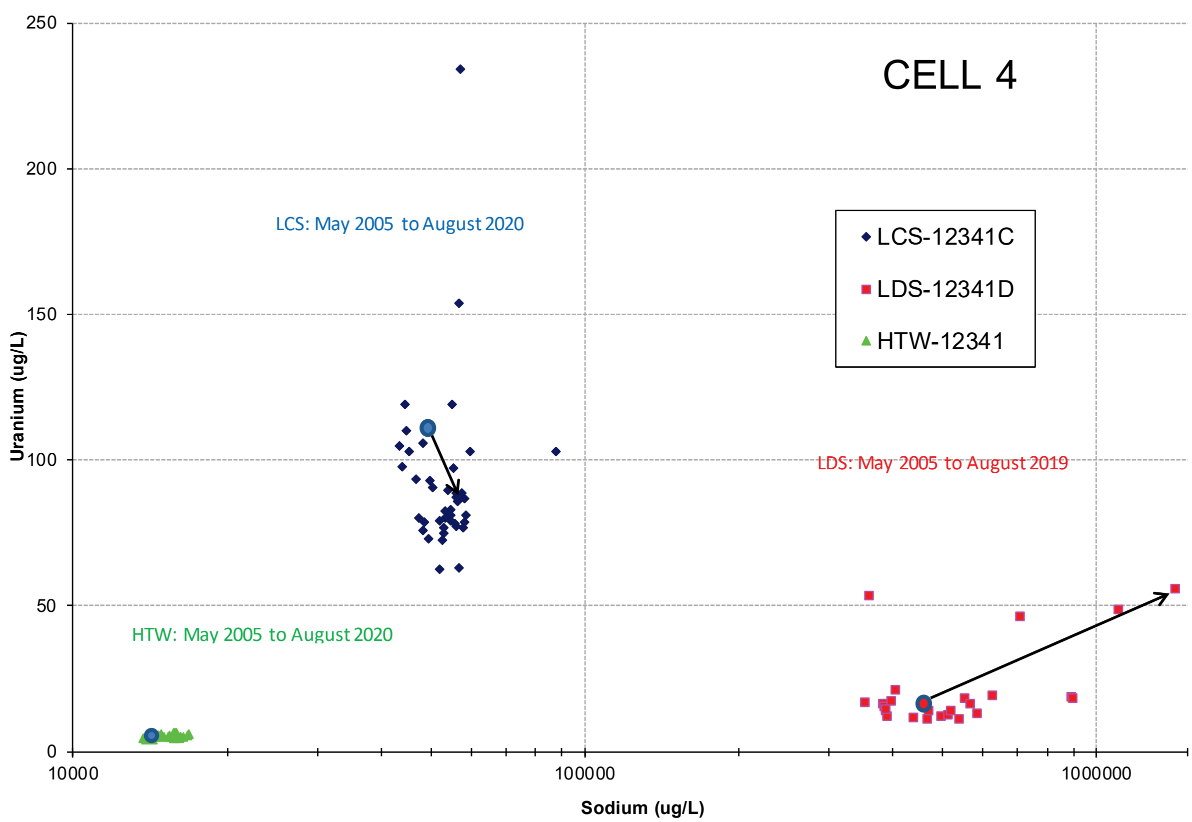

Figure A.5.4-18. Cell 4 Bivariate Plot for Uranium and Sodium

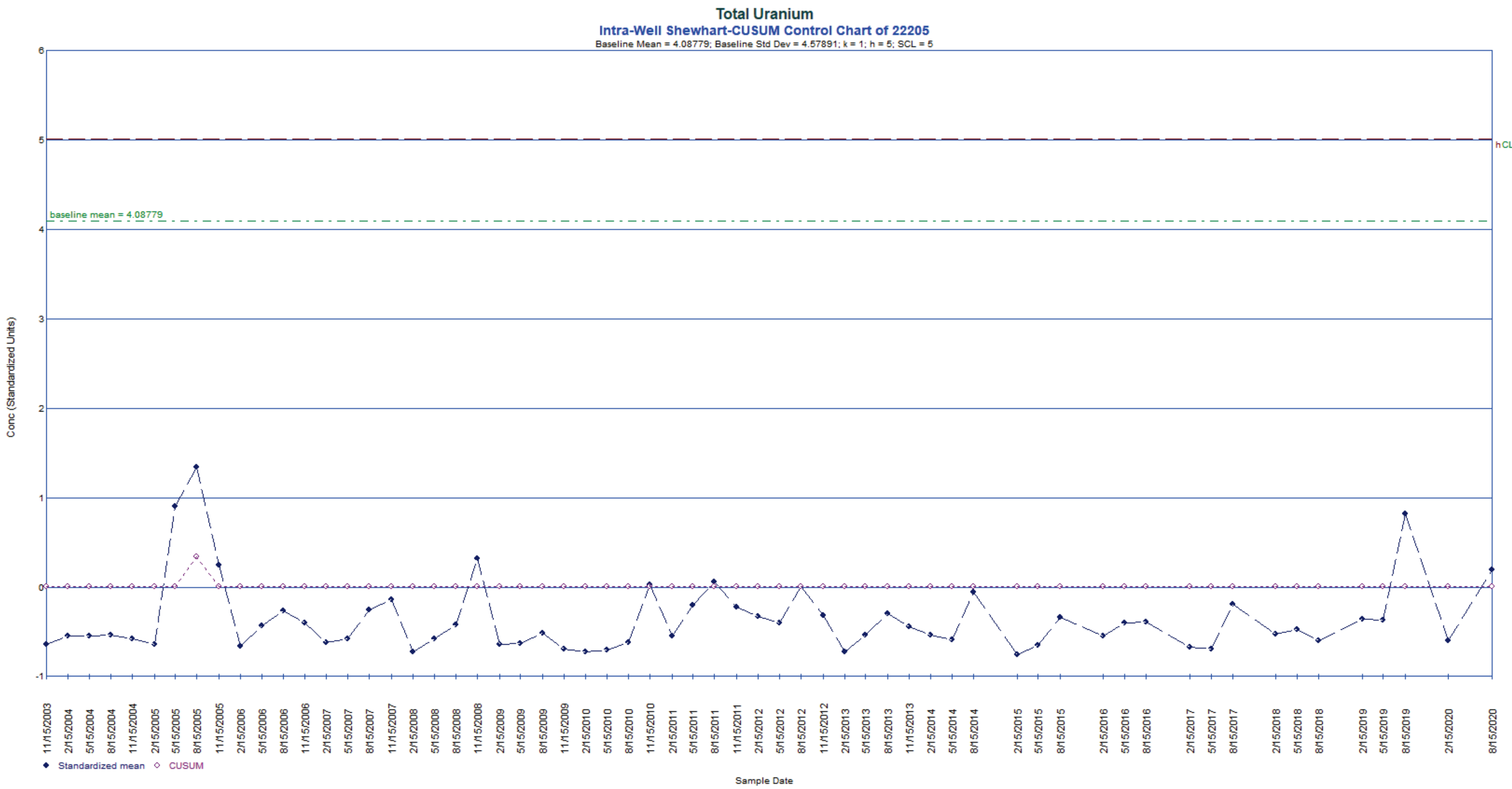

Figure A.5.4-19. Intrawell Shewhart-CUSUM Control Chart for Total Uranium in Monitoring Well 22205

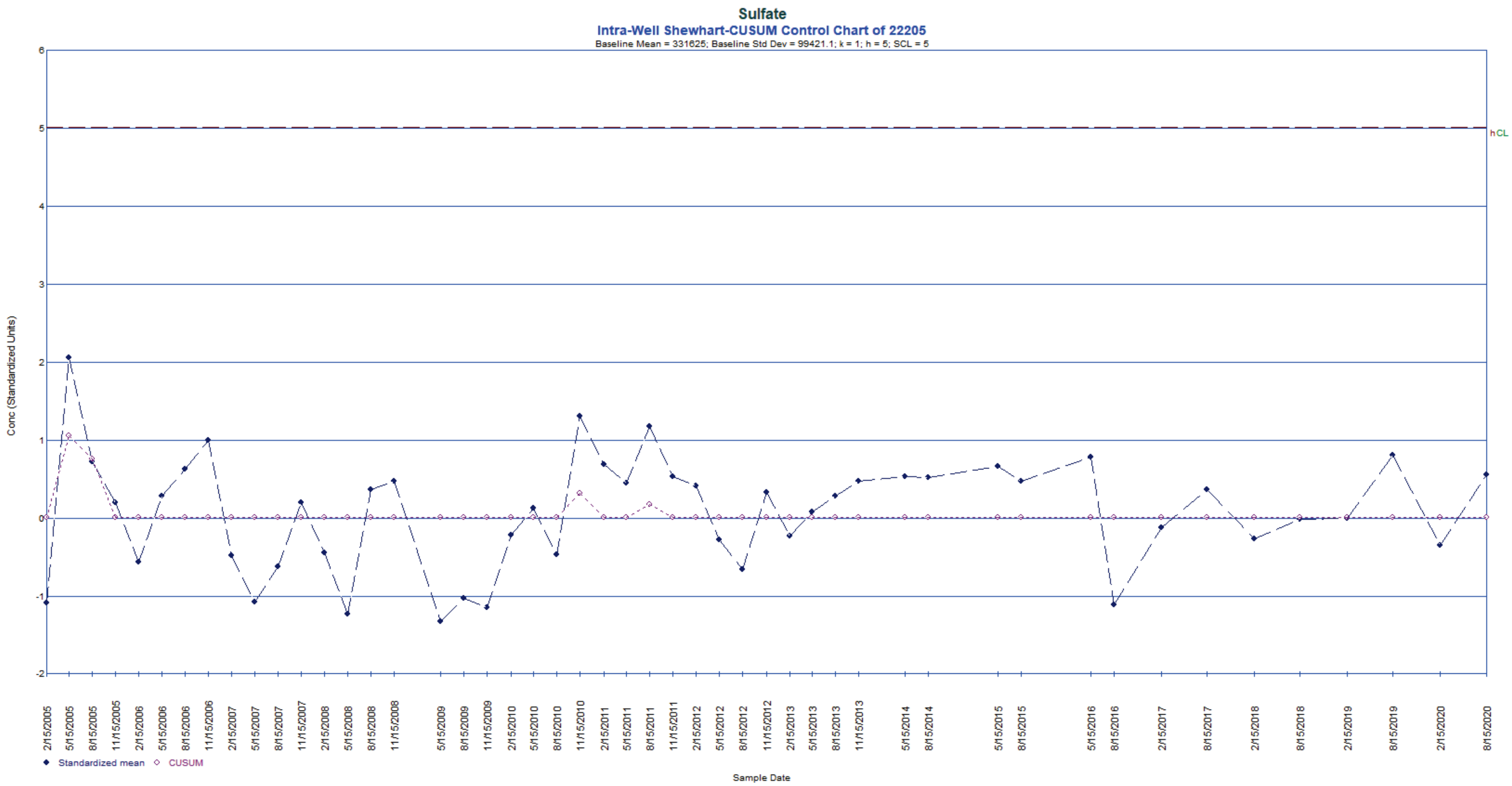

Figure A.5.4-20. Intrawell Shewhart-CUSUM Control Chart for Sulfate in Monitoring Well 22205

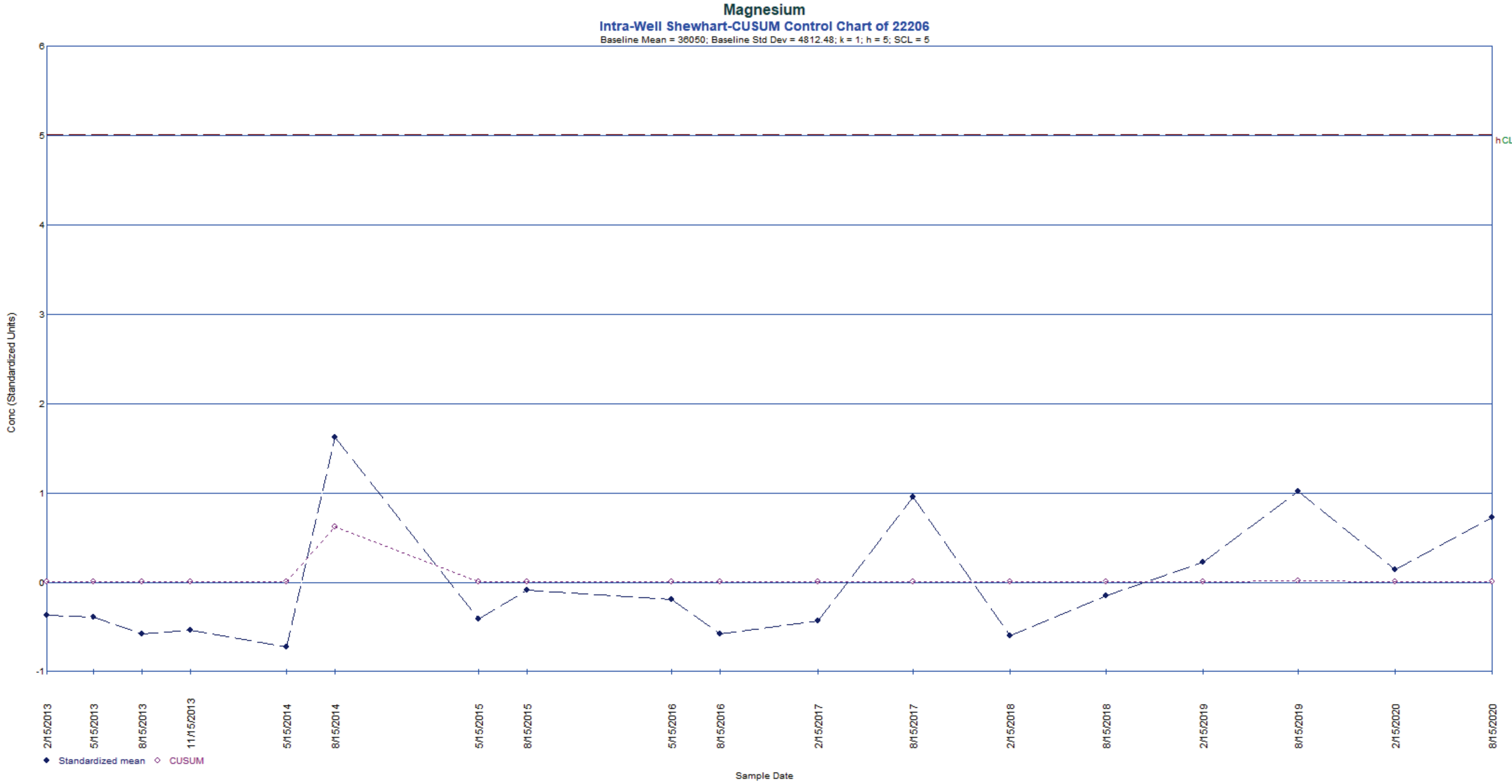

Figure A.5.4-21. Intrawell Shewhart-CUSUM Control Chart for Magnesium in Monitoring Well 22206

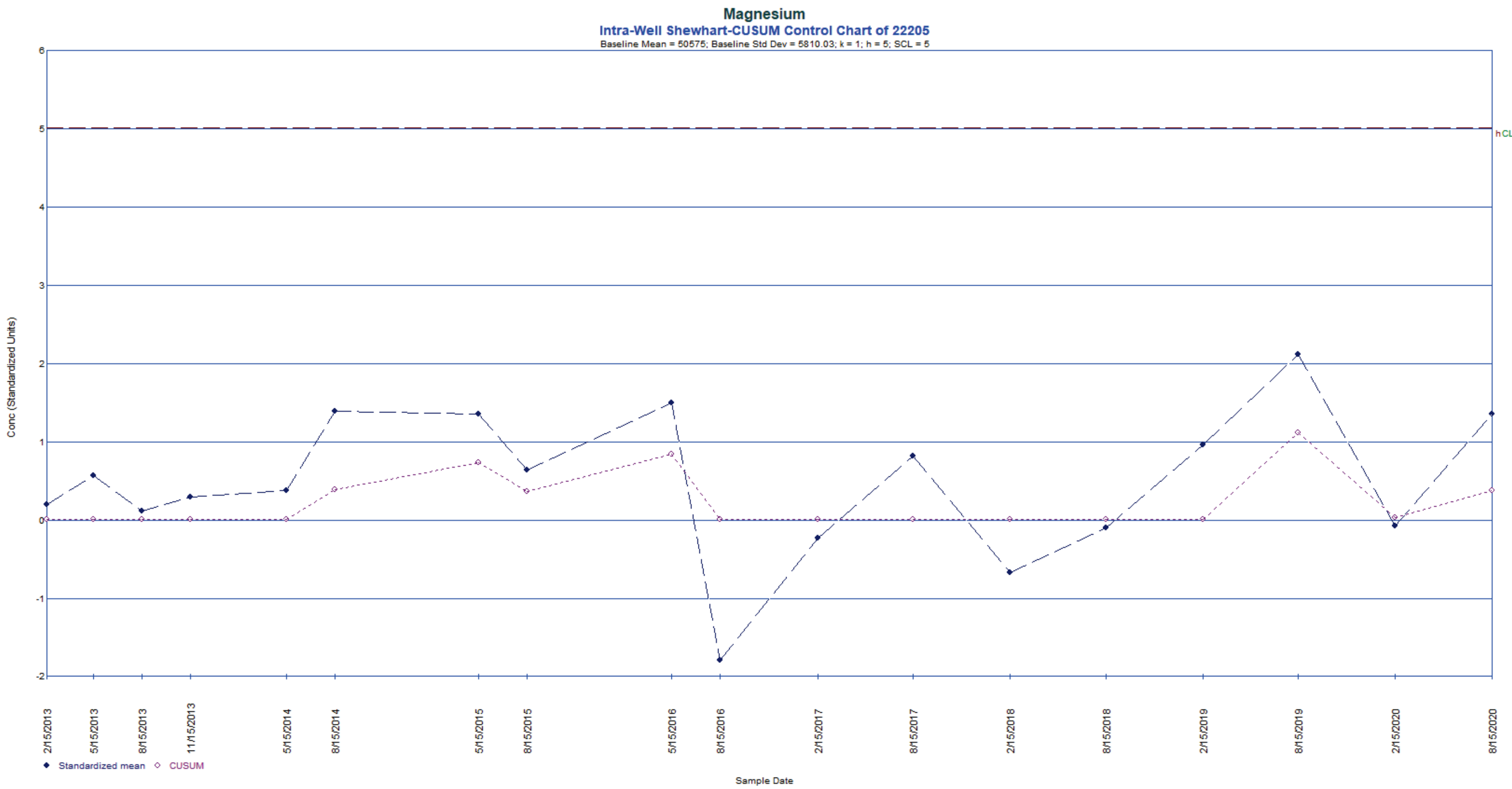

Figure A.5.4-22. Intrawell Shewhart-CUSUM Control Chart for Magnesium in Monitoring Well 22205

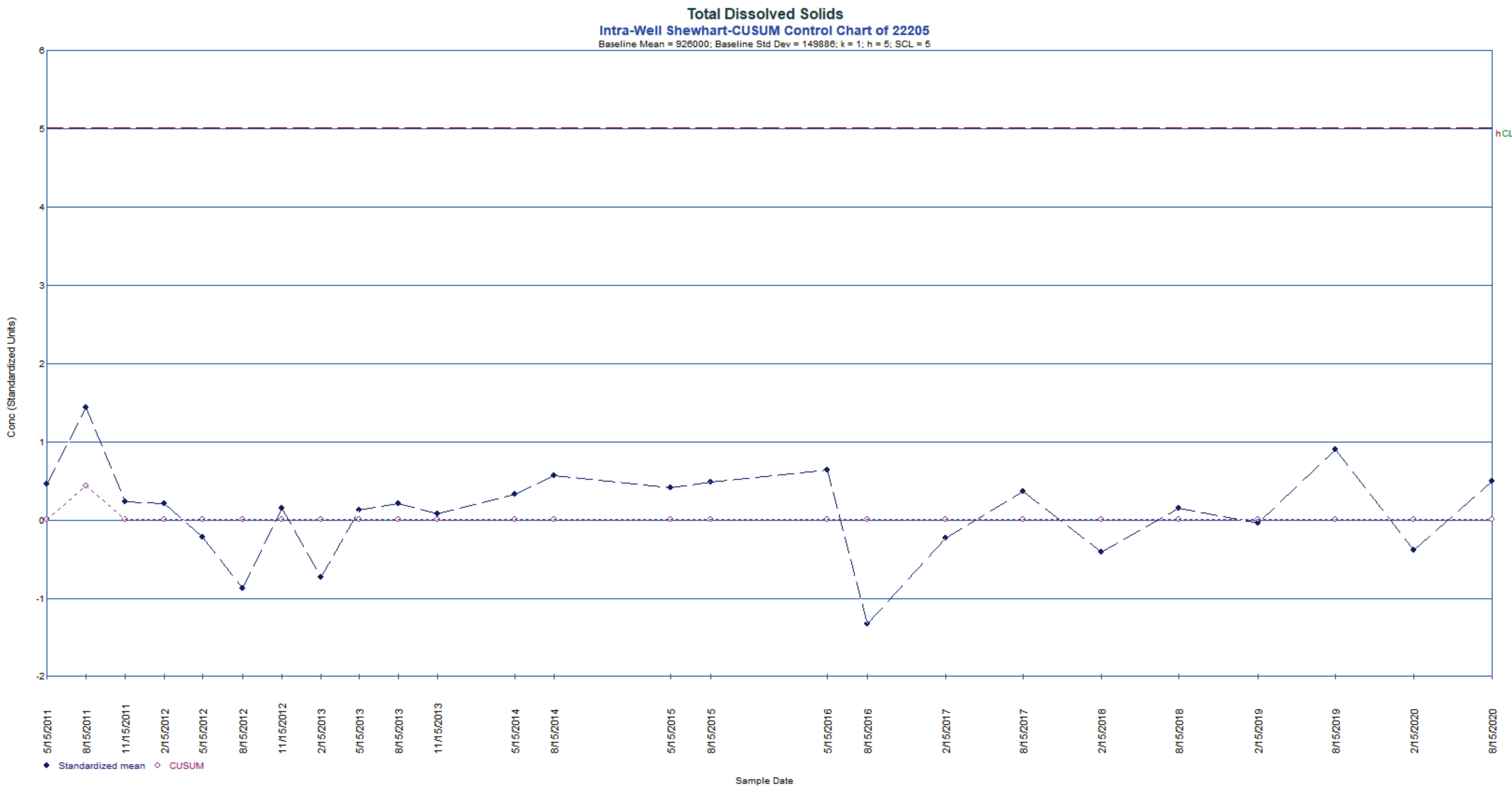

Figure A.5.4-23. Intrawell Shewhart-CUSUM Control Chart for Total Dissolved Solids in Monitoring Well 22205

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Subattachment A.5.5

Cell 5

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Contents

Tables

Figures

Abbreviations

CUSUM	Shewhart-cumulative sum
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
GMA	Great Miami Aquifer
GMA-D	Great Miami Aquifer–downgradient
GMA-U	Great Miami Aquifer–upgradient
HTW	horizontal till well
LCS	leachate collection system
LDS	leak detection system
Ohio EPA	Ohio Environmental Protection Agency
OSDF	On-Site Disposal Facility
SCL	Shewhart control limit

Measurement Abbreviations

amsl	above mean sea level
µg/L	micrograms per liter
mg/L	milligrams per liter
pCi/L	picocuries per liter

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This subattachment provides the following information about the On-Site Disposal Facility (OSDF) Cell 5:

- Semiannual monitoring summary statistics (refer to Table A.5.5-1)
- Leachate collection system (LCS) monthly accumulation volumes (refer to Figure A.5.5-1)
- Leak detection system (LDS) monthly accumulation volumes (refer to Figure A.5.5-2)
- OSDF horizontal till well (HTW) 12342 water yield (refer to Table A.5.5-2)
- Great Miami Aquifer (GMA) water levels and total uranium concentration versus time (refer to Figures A.5.5-3 and A.5.5-4)
- Plots of concentration versus time (refer to Figures A.5.5-5A through A.5.5-17)
- A bivariate plot for uranium–sodium (refer to Figure A.5.5-18)
- Control chart (refer to Figure A.5.5-19)

A.5.5.1 Water Quality Monitoring Results

Water quality within the cell is sampled in the LCS and LDS. Water quality beneath the cell is sampled in the HTW and GMA wells. Concentration-versus-time plots, bivariate plots, and control charts are used to help interpret and present the results.

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 was 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.

With EPA and Ohio EPA concurrence, DOE reduced the number of parameters sampled from 24 to 13 beginning in January 2017. All 13 parameters are sampled in the GMA wells; 4 of the 13 parameters (total uranium, boron, sodium, and sulfate) are sampled in the LCS, LDS, and HTW of each cell. The annual sampling in the LCS of each cell for the abbreviated list of Appendix I parameters and polychlorinated biphenyls listed in *Ohio Administrative Code* 3745-27-10 was also eliminated beginning in January 2017 with EPA and Ohio EPA concurrence (DOE 2017).

A.5.5.1.1 LCS and LDS Results

As shown in Table A.5.5-1 and summarized below, one parameter (sulfate) had an upward trend in the LCS based on the Mann-Kendall test for trend in 2020. The volume of water in the LDS tank of Cell 5 was insufficient to collect a sample in 2020.

Parameters with Upward Concentration Trends in the LCS and LDS of Cell 5[a]

Parameter	LCS 12342C 2020 Trend	LDS 12342D Trend (Year Last Sampled)
Sodium		Up (2013)
Sulfate	Up	Up (2013)

[a] No entry indicates that the trend was not up.

A.5.5.1.2 HTW and Monitoring Well Results

As shown in Table A.5.5-1 and summarized below, six parameters (boron, sodium, sulfate, lithium, magnesium, and potassium) have upward trends in the HTW and/or GMA wells based on the Mann-Kendall test for trend.

Parameters with Upward Concentration Trends in the HTW and GMA Wells of Cell 5[a]

Parameter	HTW 12342	GMA-U[b] 22207	GMA-D[b] 22208
Boron		Up	Up
Sodium		Up	
Sulfate	Up		
Lithium		Up	
Magnesium		Up	
Potassium		Up	

[a] No entry indicates that the trend was not up.
[b] GMA-U = upgradient Great Miami Aquifer; GMA-D = downgradient Great Miami Aquifer; HTW = horizontal till well.

A.5.5.1.3 Discussion

The uranium–sodium bivariate plot for the Cell 5 LCS, LDS, and HTW is provided in Figure A.5.5-18. On the figure, the first sample ever collected from the monitoring horizon is circled. An arrow leads from the first sample to the location of the most recent sample. The plot shows that the chemical signatures for uranium and sodium in the LCS, LDS, and HTW are separate and distinct, indicating that mixing between the horizons is not occurring; therefore, upward concentration trends measured beneath the cells in GMA wells are attributed to fluctuating ambient concentrations beneath the cell and are not related to cell performance.

A.5.5.2 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. 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 "not in 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. Usually, two parameters are used to compute standardized limits—the decision value (*h*) and the Shewhart control limit (SCL).

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 eight samples were selected for control charts. By default, the ChemStat software plots both a CUSUM control limit (*h*) and an SCL on the control chart. The software recommends a value of 5 for the CUSUM control limit and a value of 4.5 for the SCL.

EPA Statistical Analysis 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 is not needed. The ChemStat software though, by default, plots both the SCL and CUSUM control limit on the charts. To address this issue, the SCL was defined as 5 to equal the recommended CUSUM (*h*) limit. This combined limit is identified as *h*CL on the control charts. For interpretation purposes, the *h*CL value will be regarded as the CUSUM (*h*) limit.

As shown in Table A.5.5-1 in gray shading and as summarized below, one parameter in the HTW or GMA wells of Cell 5 met the criteria for control charts (i.e., at least eight samples, normal or lognormal distribution, no trend, and no serial correlation), resulting in one control chart (Figure A.5.5-19) which exhibits “in control” conditions.

Parameter	Monitoring Point	Well Number	Assessment	Figure Number
Calcium	GMA-U	22207	In Control	A.5.5-19

[a] GMA-U = upgradient Great Miami Aquifer; GMA-D = downgradient Great Miami Aquifer.

The one control chart is presented in Figure A.5.5-19. It exhibits “in control” conditions.

A.5.5.3 Summary and Conclusions

- One parameter (sulfate) had an upward trend in the LCS based on the Mann-Kendall test for trend.
- The volume of water in the LDS tank of Cell 5 was insufficient to collect a sample in 2020.
- Six parameters monitored semiannually have an upward concentration trend in the HTW or GMA wells of Cell 5: boron, sodium, sulfate, lithium, magnesium, and potassium. Separate and distinct chemical signatures for total uranium and sodium in the LCS, LDS, and HTW of Cell 5 indicate that water is not mixing between the horizons. Therefore, upward concentration trends beneath Cell 5 (i.e., HTW or GMA wells) are attributed to fluctuating ambient concentrations beneath the cell and not to cell performance.
- One control chart was constructed for Cell 5 parameters. It exhibits “in control” conditions.

A.5.5.4 References

DOE (U.S. Department of Energy), 2017. *Fernald Preserve 2016 Site Environmental Report*, LMS/FER/S15232, Office of Legacy Management, Cincinnati, Ohio, May.

EPA (U.S. Environmental Protection Agency), 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities—Unified Guidance*, EPA 530/R-09-007, March.

OAC 3745-27-10. "Ground Water Monitoring Program for a Sanitary Landfill Facility," *Ohio Administrative Code.*

Table A.5.5-1. Summary Statistics for Cell 5

Parameter	Horizon[a]	Location	Number of Detected Samples	Total Number of Samples	Percent Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[d]	Distribution Type[d,e]	Trend[d,f] (Year Last Sampled)	Serial Correlation[d,g]	Outliers[h,i]
Total Uranium (µg/L)	LCS	12342C	58	58	100	3.39	285	122	47	Undefined	None (2020)	Detected	
	LDS	12342D	40	40	100	2.93	27.1	15.6	5.2	Normal	Down (2013)	Detected	
	HTW	12342	61	61	100	7.45	19.2	9.03	2.18	Undefined	Down (2020)	Detected	
	GMA-U	22207	52	62	83.9	ND	0.631	0.313	0.294	Ln Normal	Down (2020)	Detected	2.39 (Q3-02)
	GMA-D	22208	58	69	84.1	ND	2.10	0.352	0.244	Undefined	None (2020)	Not Detected	
Boron (mg/L)	LCS	12342C	56	58	96.6	ND	1.59	0.764	0.269	Undefined	None (2020)	Detected	
	LDS	12342D	40	40	100	0.202	1.20	0.398	0.272	Undefined	None (2013)	Detected	
	HTW	12342	42	44	95.4	ND	0.221	0.104	0.044	Ln Normal	None (2020)	Detected	
	GMA-U	22207	57	62	91.9	ND	0.0684	0.0409	0.0113	Undefined	Up (2020)	Detected	
	GMA-D	22208	56	62	90.3	ND	0.0618	0.0360	0.0114	Normal	Up (2020)	Detected	
Sodium (mg/L)	LCS	12342C	45	46	97.8	57.0	79.7	68.2	5.1	Normal	Down (2020)	Detected	16.4 (Q2-03), 19.7 (Q2-04), 22.2 (Q2-05), 108 (Q3-05)
	LDS	12342D	27	27	100	84.6	808	432	137	Normal	Up (2013)	Detected	
	HTW	12342	42	42	100	17.0	33.6	25.7	4.5	Normal	None (2020)	Detected	
	GMA-U	22207	33	33	100	13.0	23.1	16.8	2.7	Ln Normal	Up (2020)	Detected	
	GMA-D	22208	34	34	100	10.1	17.9	15.6	2.3	Undefined	Down (2020)	Detected	
Sulfate (mg/L)	LCS	12342C	58	58	100	218	5910	3500	1260	Undefined	Up (2020)	Detected	
	LDS	12342D	40	40	100	1130	6100	1840	1030	Ln Normal	Up (2013)	Detected	
	HTW	12342	52	52	100	101	495	364	117	Undefined	Up (2020)	Detected	
	GMA-U	22207	57	57	100	97.8	770	195	124	Undefined	Down (2020)	Detected	
	GMA-D	22208	57	57	100	98.1	671	365	101	Normal	Down (2020)	Detected	
Calcium (mg/L)	GMA-U	22207	26	26	100	124	187	153	12	Normal	None (2020)	Not Detected	
	GMA-D	22208	26	26	100	107	285	216	36	Normal	Down (2020)	Detected	
Lithium (mg/L)	GMA-U	22207	33	33	100	0.00642	0.0165	0.0141	0.0032	Undefined	Up (2020)	Detected	
	GMA-D	22208	33	33	100	0.00425	0.00985	0.00802	0.00095	Undefined	None (2020)	Detected	
Magnesium (mg/L)	GMA-U	22207	26	26	100	26.1	38.5	33.2	3.0	Normal	Up (2020)	Detected	
	GMA-D	22208	26	26	100	24.3	66.4	53.8	8.4	Undefined	Down (2020)	Detected	
Nitrate + Nitrite, as Nitrogen (mg/L)	GMA-U	22207	2	26	7.7	ND	0.0850	Insufficient	Insufficient	Insufficient	Insufficeint	Insufficient	
	GMA-D	22208	2	26	7.7	ND	0.0500	Insufficient	Insufficient	Insufficient	Insufficeint	Insufficient	
Potassium (mg/L)	GMA-U	22207	26	26	100	2.75	4.82	3.68	0.61	Normal	Up (2020)	Detected	
	GMA-D	22208	27	27	100	2.45	3.53	3.02	0.33	Normal	Down (2020)	Detected	
Selenium (mg/L)	GMA-U	22207	1	33	3.0	ND	0.0137	Insufficient	Insufficient	Insufficient	Insufficeint	Insufficient	
	GMA-D	22208	3	33	9.1	ND	0.0128	0.0042	Insufficient	Insufficient	Insufficeint	Insufficient	
Technitium-99 (pCi/L)	GMA-U	22207	0	23	0	ND	NA	Insufficient	Insufficient	Insufficient	Insufficeint	Insufficient	
	GMA-D	22208	1	23	4.4	ND	6.40	Insufficient	Insufficient	Insufficient	Insufficeint	Insufficient	
Total Dissolved Solids (mg/L)	GMA-U	22207	33	33	100	552	770	634	49	Normal	None (2020)	Detected	987 (Q4-09)
	GMA-D	22208	33	33	100	456	1290	949	155	Normal	Down (2020)	Detected	
Total Organic Halogens (mg/L)	GMA-U	22207	20	62	32.3	ND	0.0150	0.00188	0.00449	Undefined	Down (2020)	Detected	0.0470 (Q2-10), 0.0280 (Q2-13)
	GMA-D	22208	18	62	29.0	ND	0.0260	0.00329	0.00528	Undefined	Down (2020)	Detected	

Note 1: Shading indicates a horizontal till well or Great Miami Aquifer well with at least eight samples, Normal or Ln Normal distribution, no trend (None), and no serial correlation (No Detected). These wells achieve contrl chart criteria.

Note 2: Data used in this table has been standardized to quarterly.

[a]LCS = leachate collection system; LDS = leak detection system; HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; and GMA-D = downgradient Great Miami Aquifer

[b]ND = not detected; NA = not applicable

[c]Averages were determined based on the distribution assumption.

[d]Insufficient is used for Distribution Type, Trend, or Serial Correlation whenever there is not enough data to run the test.

[e]Data distribution based on the Shapiro-Wilk statistic.

Normal: Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the Ln Normal assumption.

Ln Normal: Ln Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the Normal assumption.

Undefined: Normal and Lognormal Distribution assumptiions are both rejected or there are less than 25 percent detected values. "Average" is defined as the Median of the data.

[f]Trend based on nonparametric Mann-Kendall procedure.

[g]Serial correlation based on Rank Von Neumann test.

[h]Outliers determined by Rosner's (for sample sizes greater than 25) or Dixon procedure (for sample sizes less than or equal to 25).

[i]Q = quarter

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Table A.5.5-2. Horizontal Till Well 12342 Water Yield

Year	Total Volume Purged (gallons)	Number of Months Purged	Average Volume Purged (gallons)
2002	35,815	10	3,582
2003	6,200	6	1,033
2004	5,425	5	1,085
2005	4,270	4	1,068
2006	3,710	4	928
2007	4,250	4	1,063
2008	4,225	4	1,056
2009	3,225	4	1,075
2010	4,325	4	1,081
2011	4,225	4	1,056
2012	4,200	4	1,050
2013	4,200	4	1,050
2014	2,100	2	1,050
2015	2,100	2	1,050
2016	2,100	2	1,050
2017	2,100	2	1,050
2018	2,100	2	1,050
2019	2,100	2	1,050
2020	2,100	2	1,050

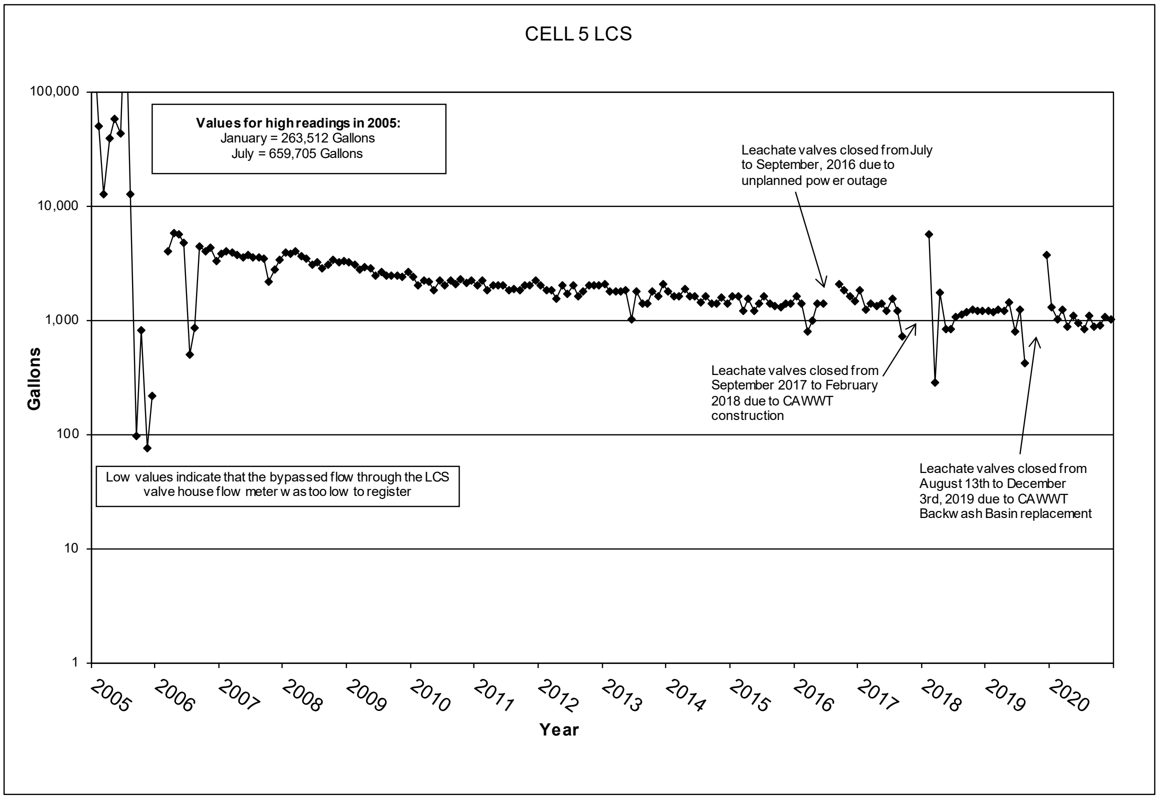

Figure A.5.5-1. Monthly Accumulation Volumes for Cell 5 LCS

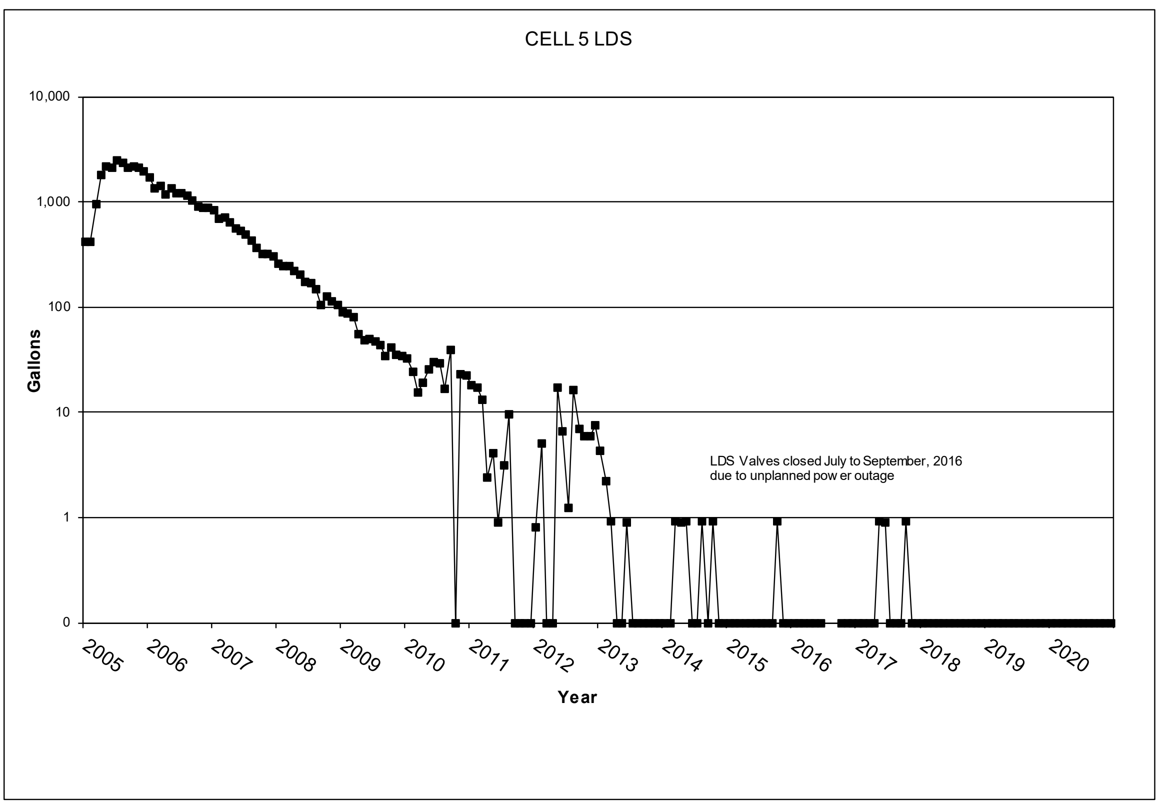

Figure A.5.5-2. Monthly Accumulation Volumes for Cell 5 LDS

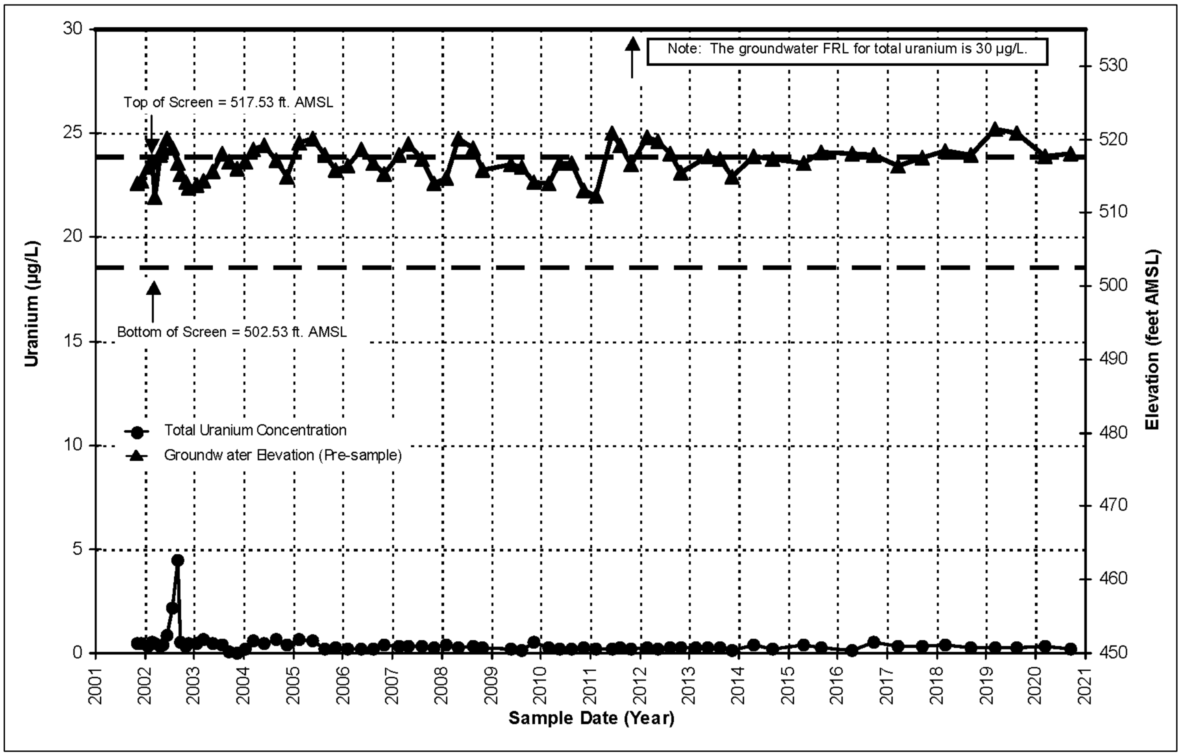

Figure A.5.5-3. Total Uranium Concentration and Groundwater Elevation Versus Time Plot for Cell 5 Upgradient Monitoring Well 22207

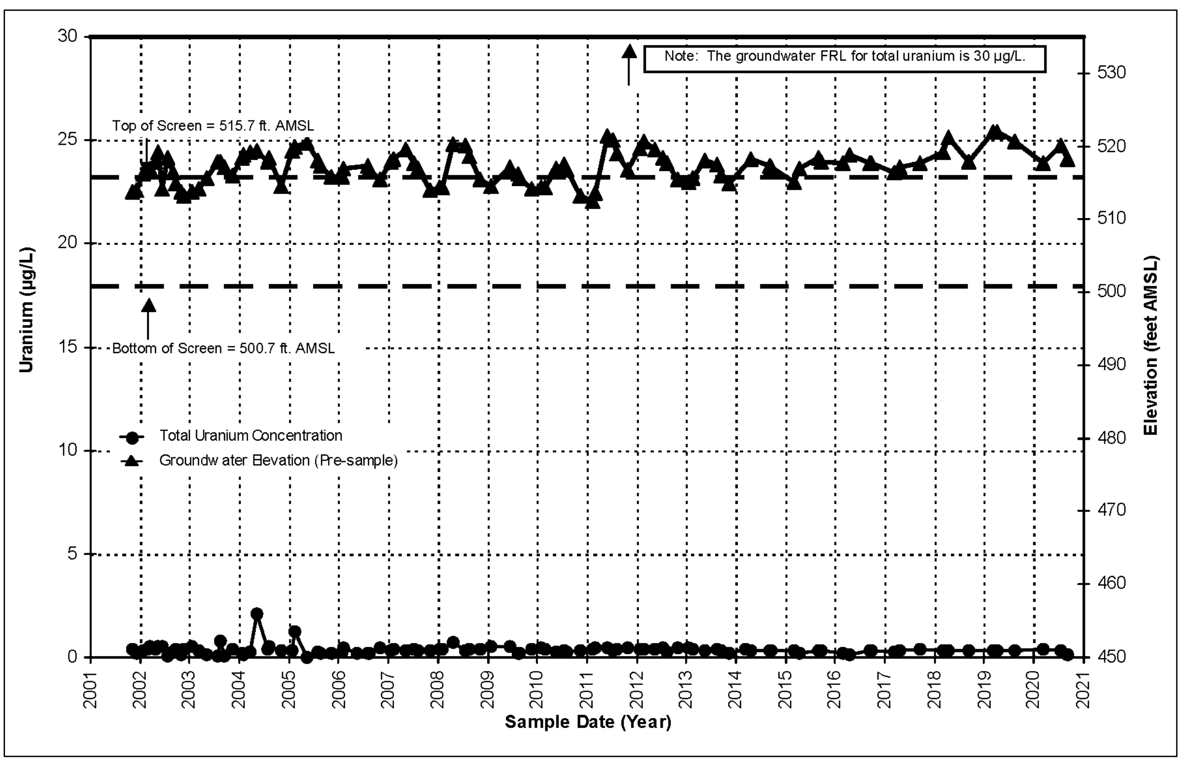

Figure A.5.5-4. Total Uranium Concentration and Groundwater Elevation Versus Time Plot for Cell 5 Downgradient Monitoring Well 22208

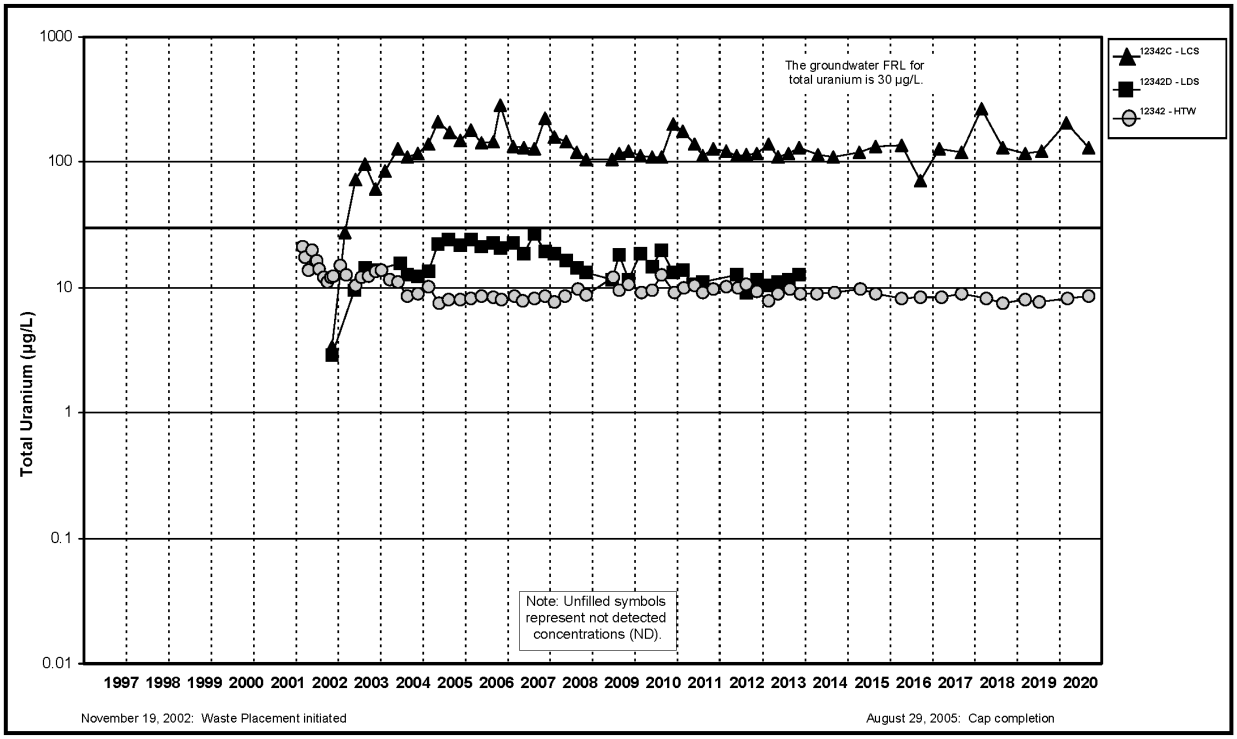

Figure A.5.5-5A. Cell 5 Total Uranium Concentration Versus Time Plot for LCS, LDS, and HTW

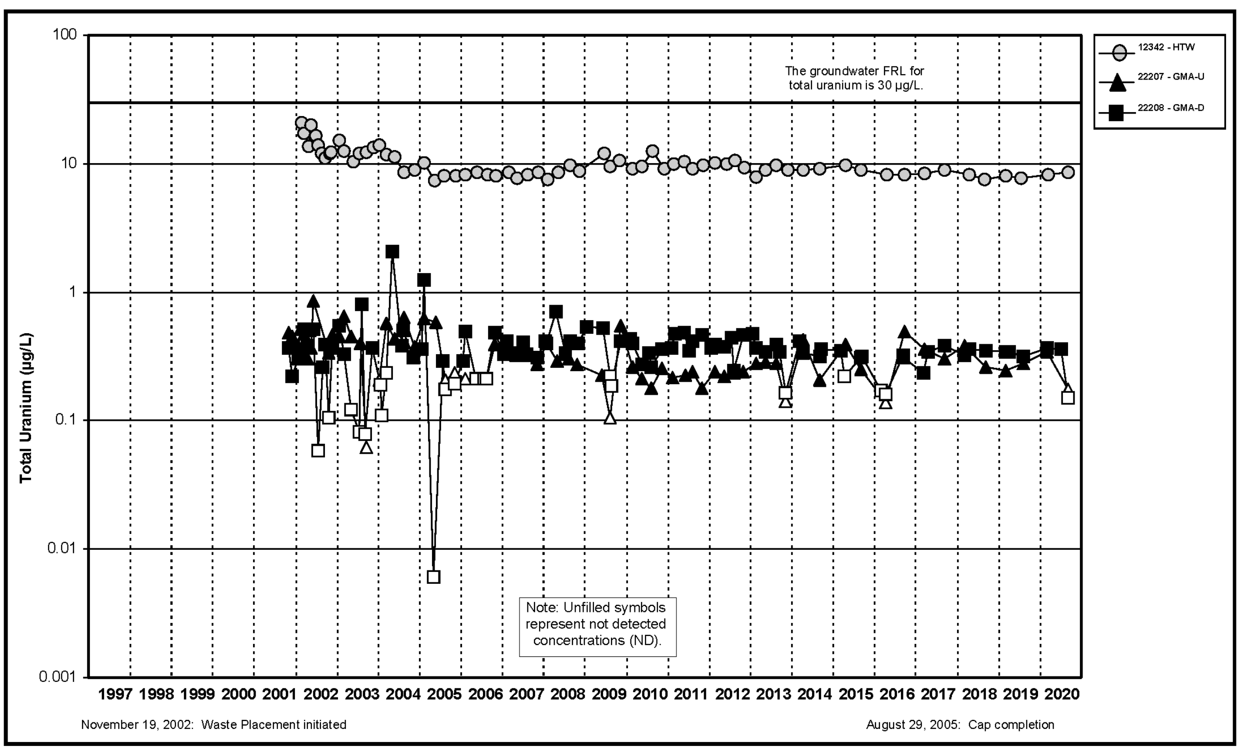

Figure A.5.5-5B. Cell 5 Total Uranium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

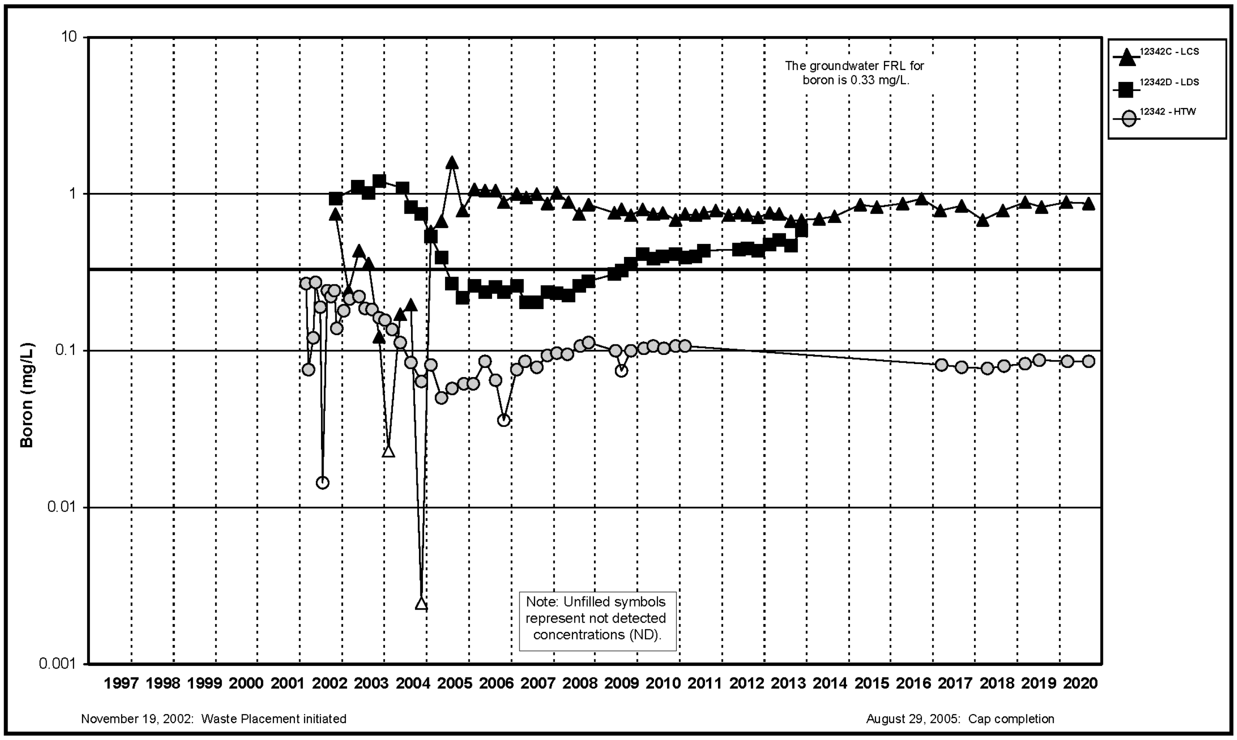

Figure A.5.5-6A. Cell 5 Boron Concentration Versus Time Plot for LCS, LDS, and HTW

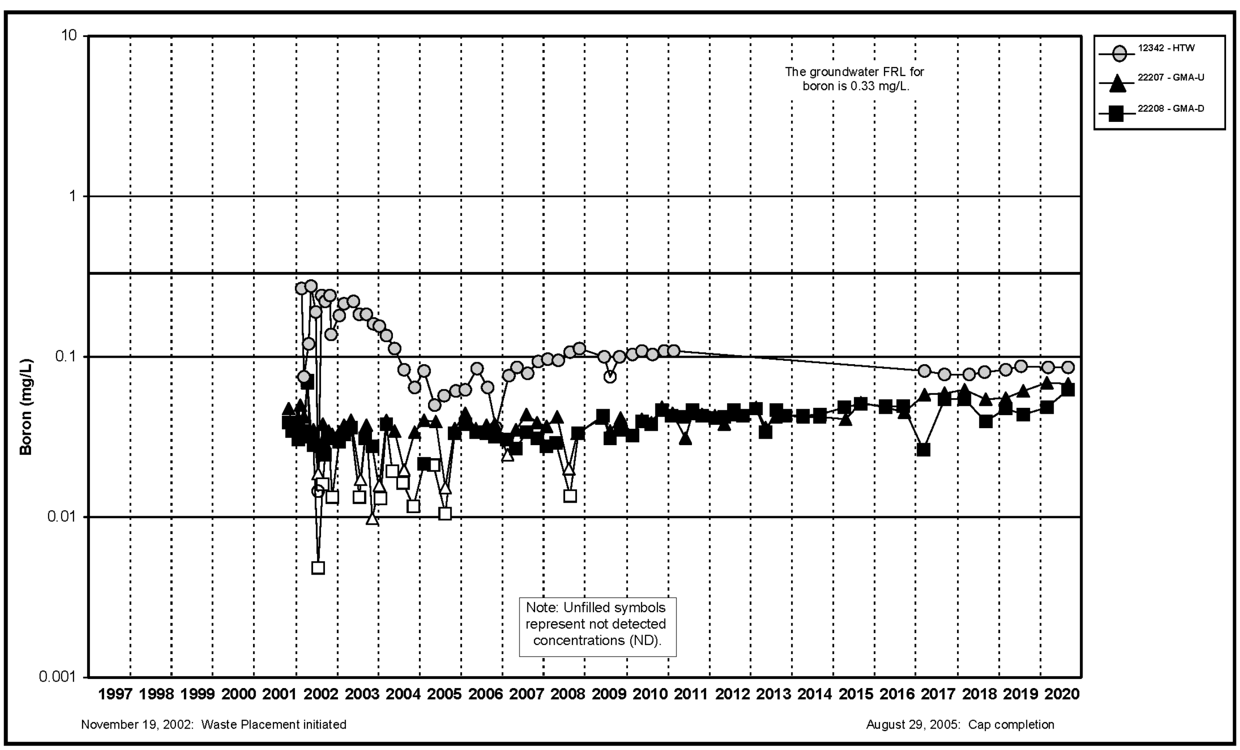

Figure A.5.5-6B. Cell 5 Boron Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

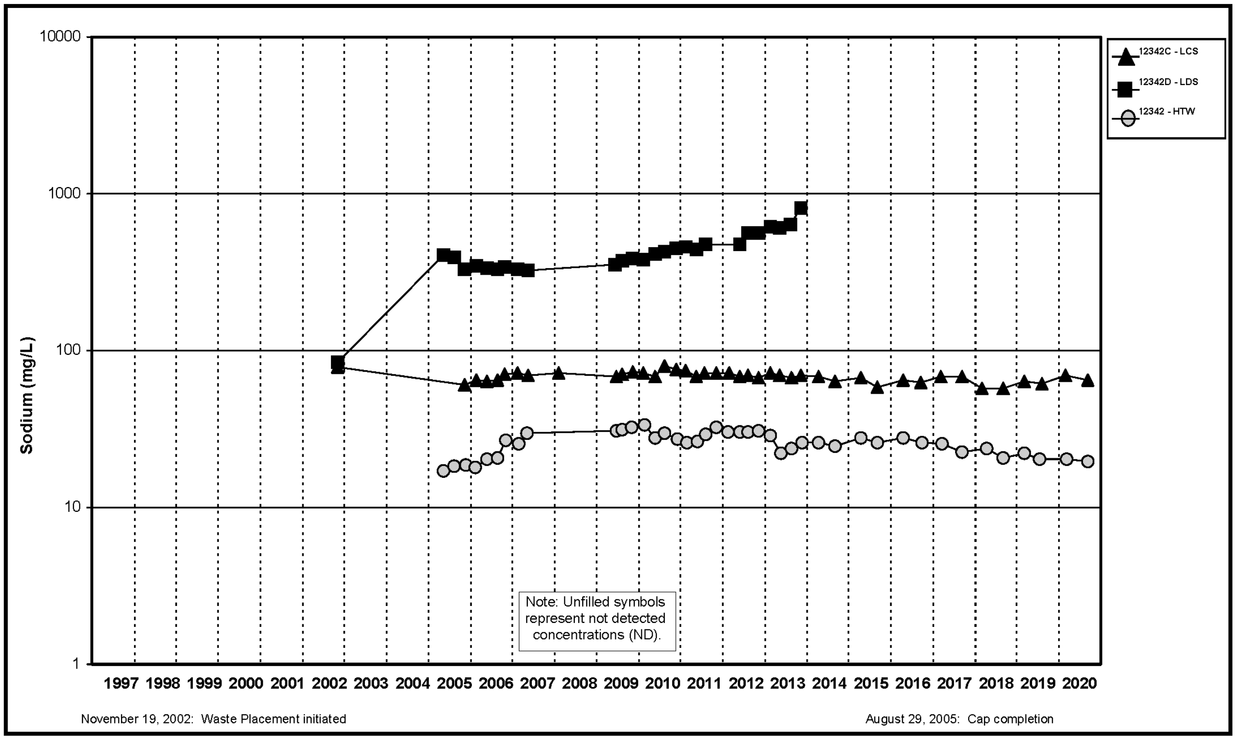

Figure A.5.5-7A. Cell 5 Sodium Concentration Versus Time Plot for LCS, LDS, and HTW

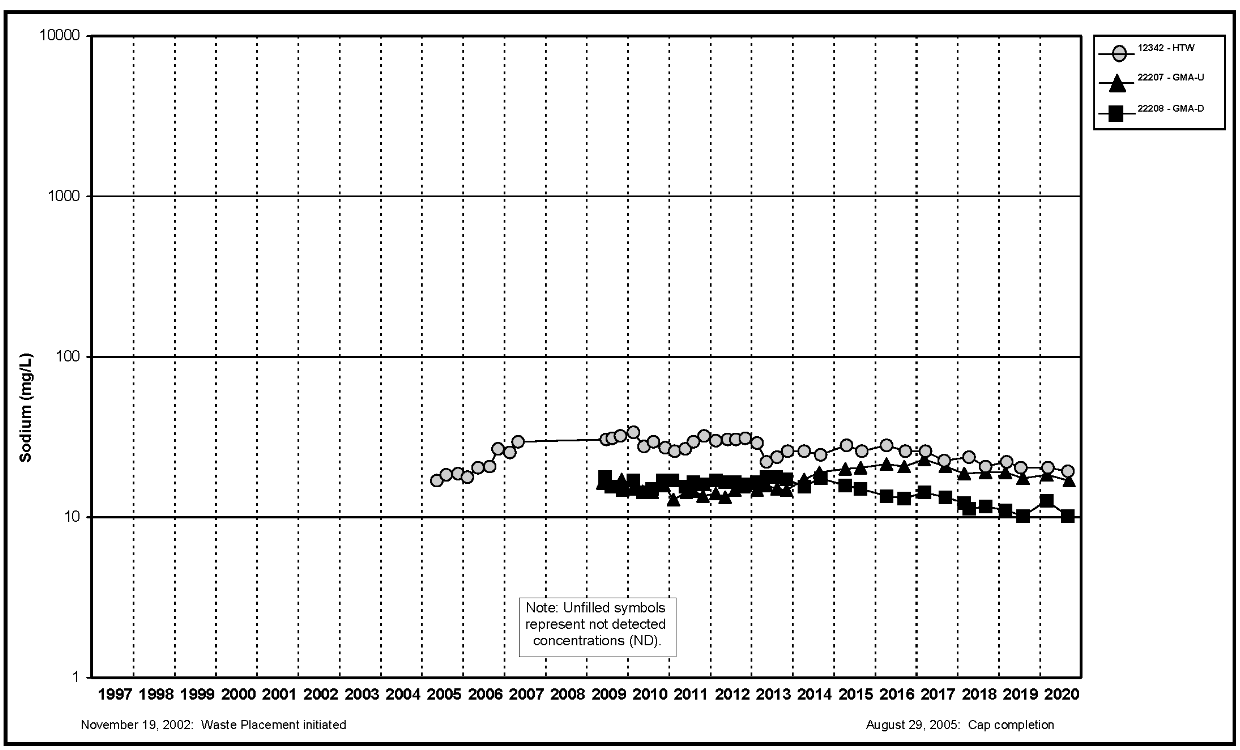

Figure A.5.5-7B. Cell 5 Sodium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

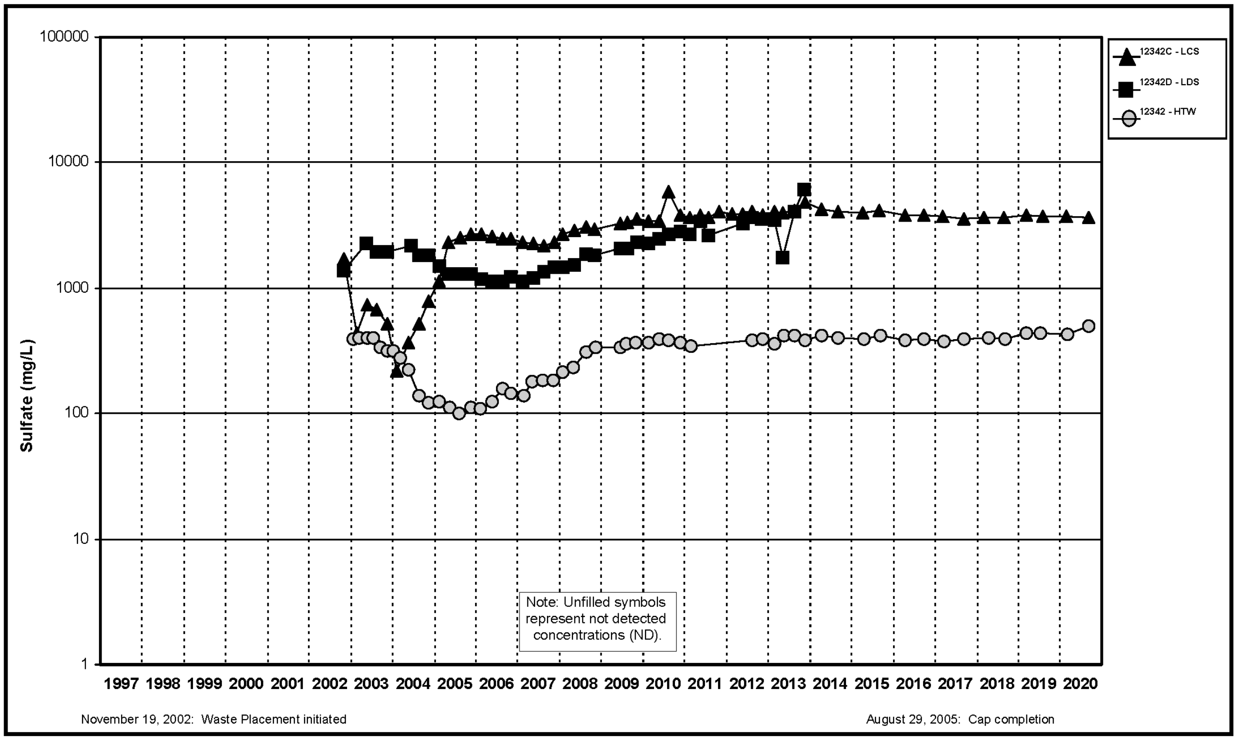

Figure A.5.5-8A. Cell 5 Sulfate Concentration Versus Time Plot for LCS, LDS, and HTW

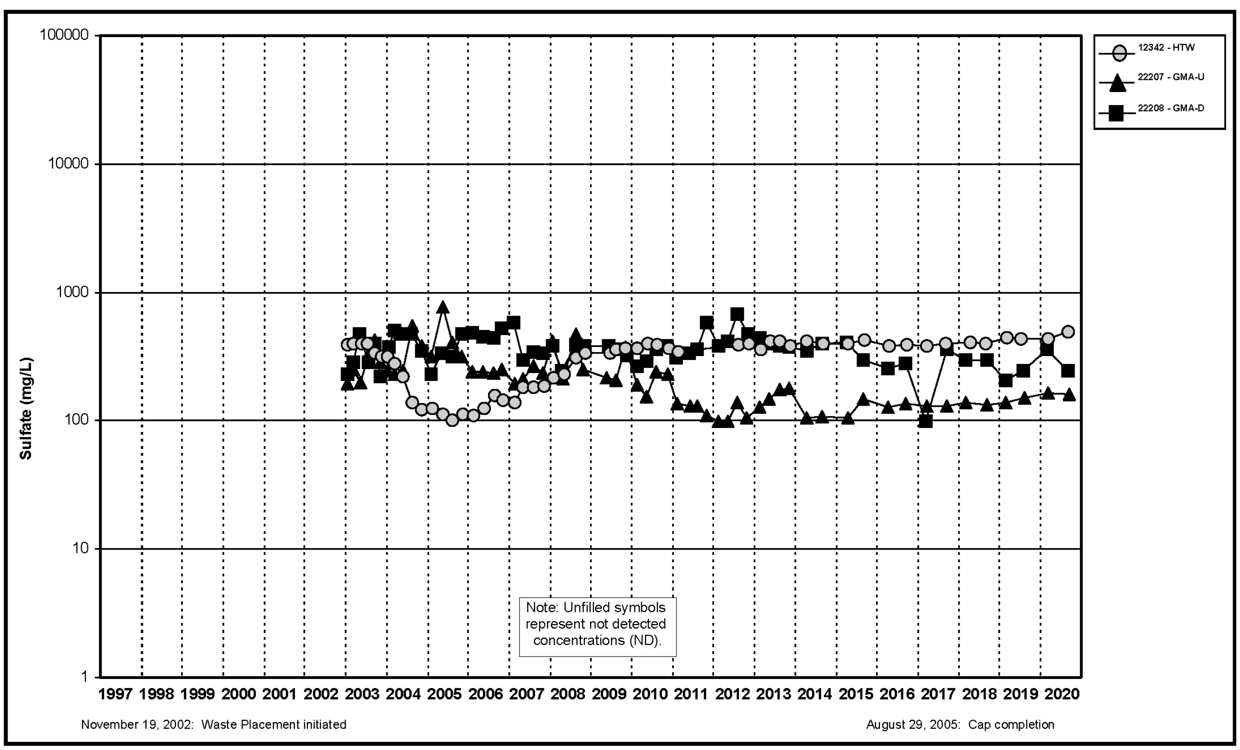

Figure A.5.5-8B. Cell 5 Sulfate Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

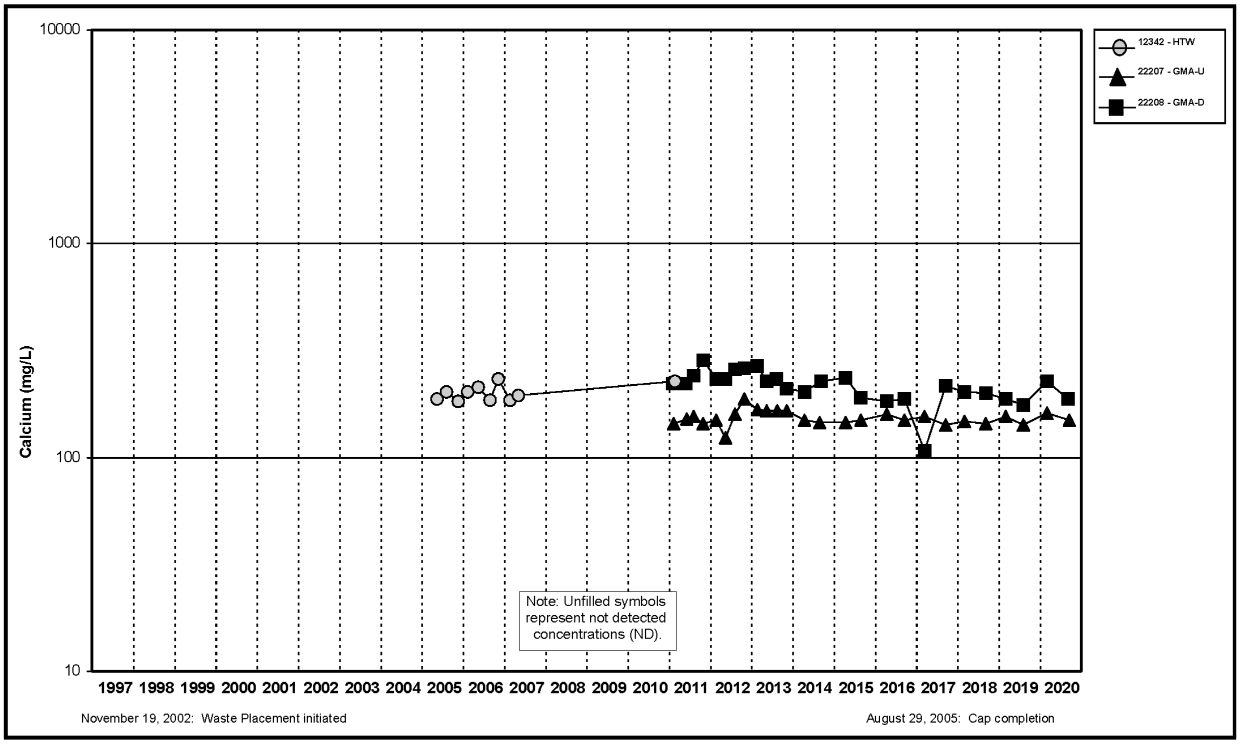

Figure A.5.5-9. Cell 5 Calcium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

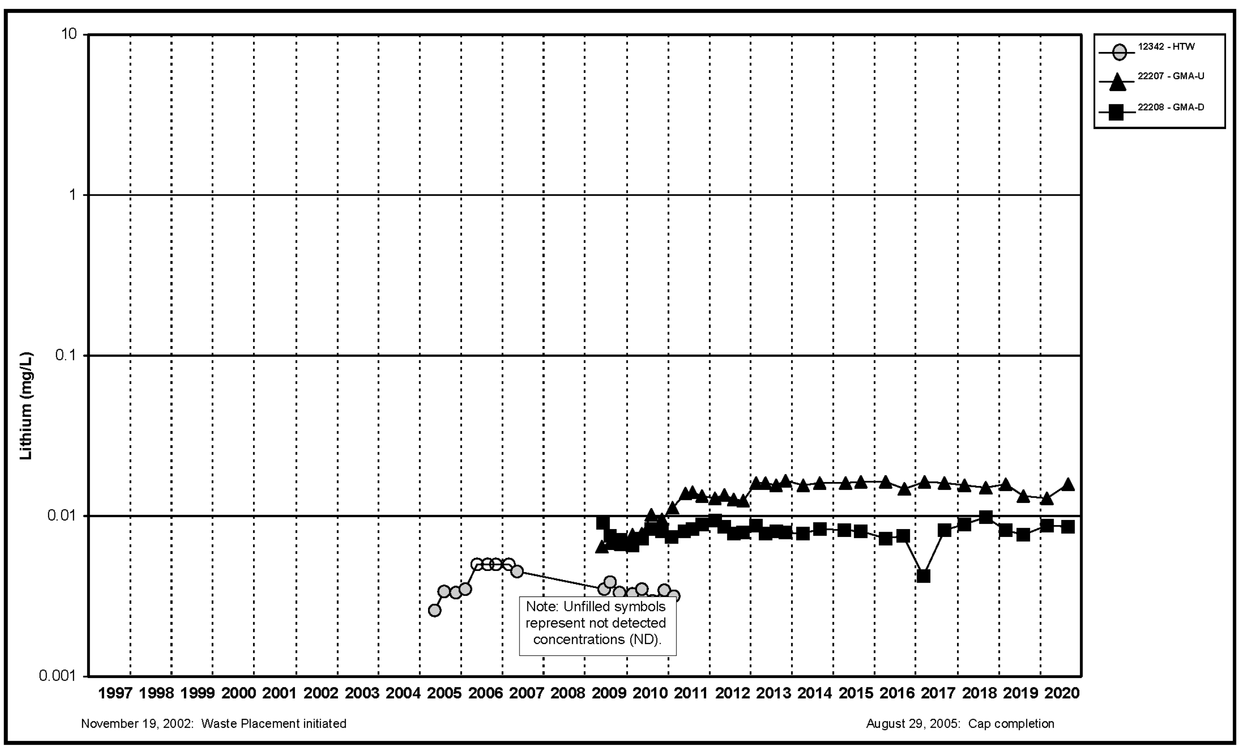

Figure A.5.5-10. Cell 5 Lithium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

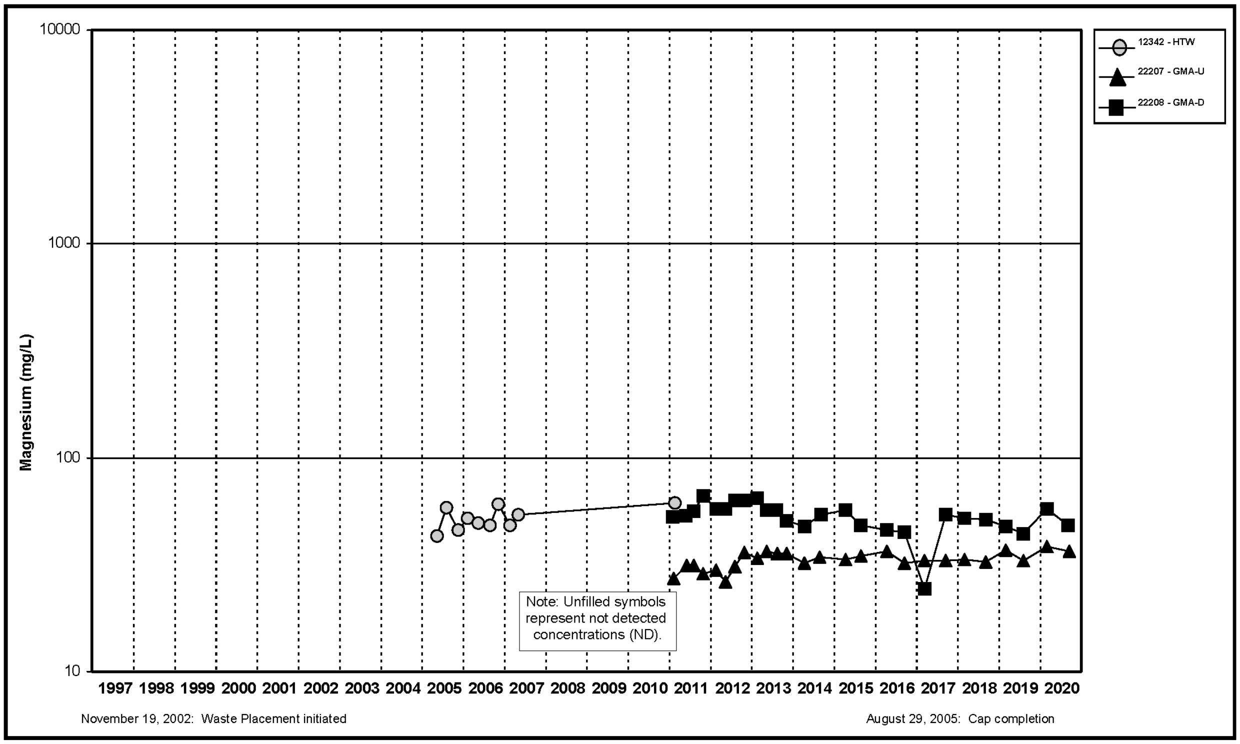

Figure A.5.5-11. Cell 5 Magnesium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

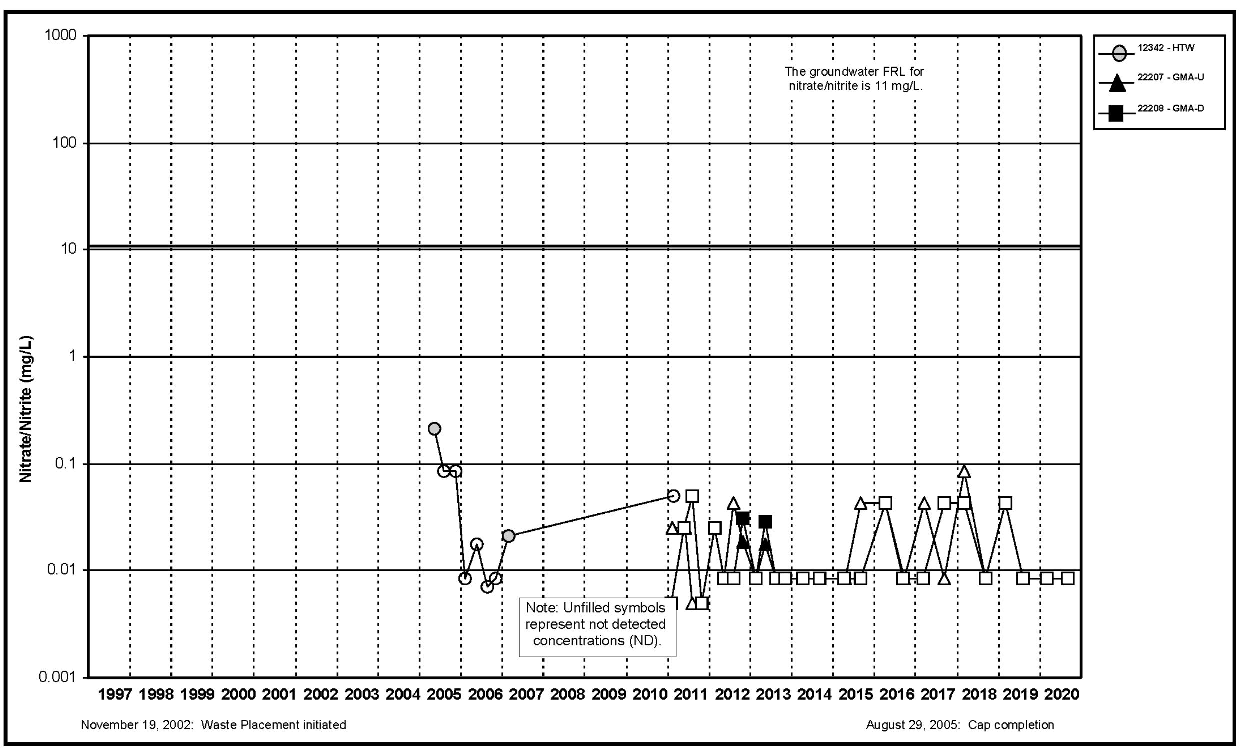

Figure A.5.5-12. Cell 5 Nitrate + Nitrate as Nitrogen Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

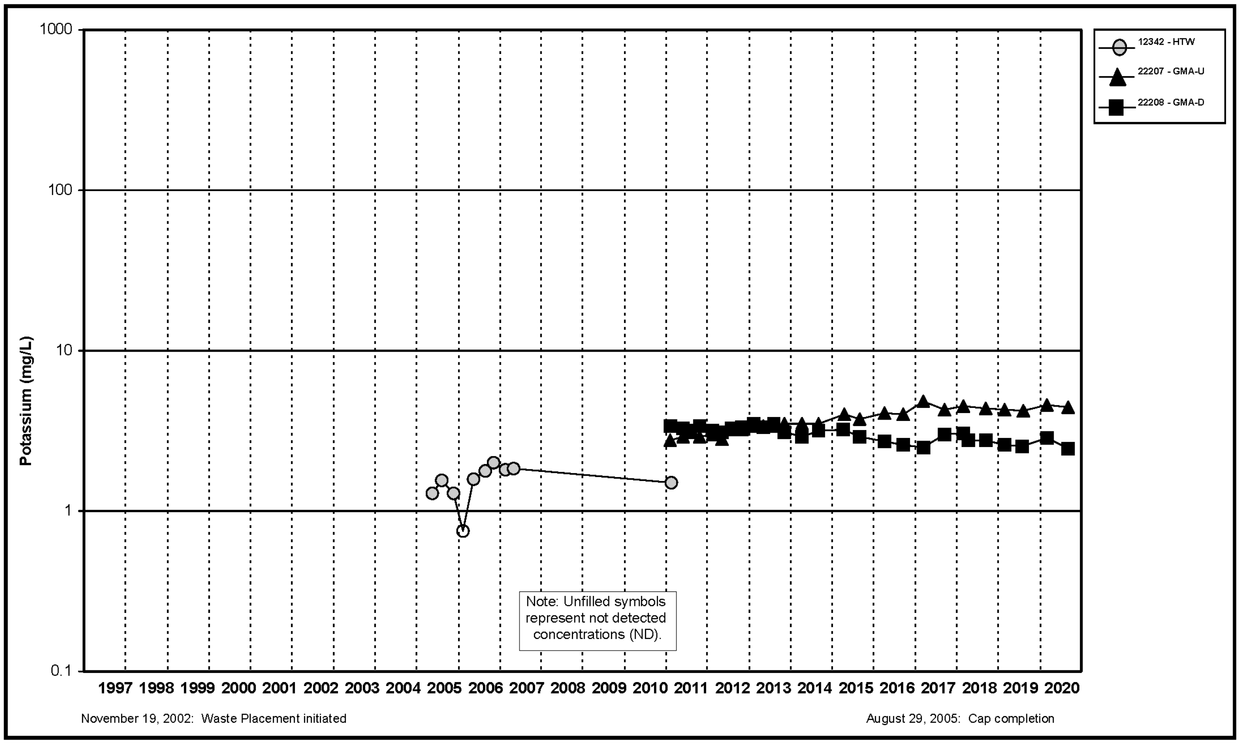

Figure A.5.5-13. Cell 5 Potassium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

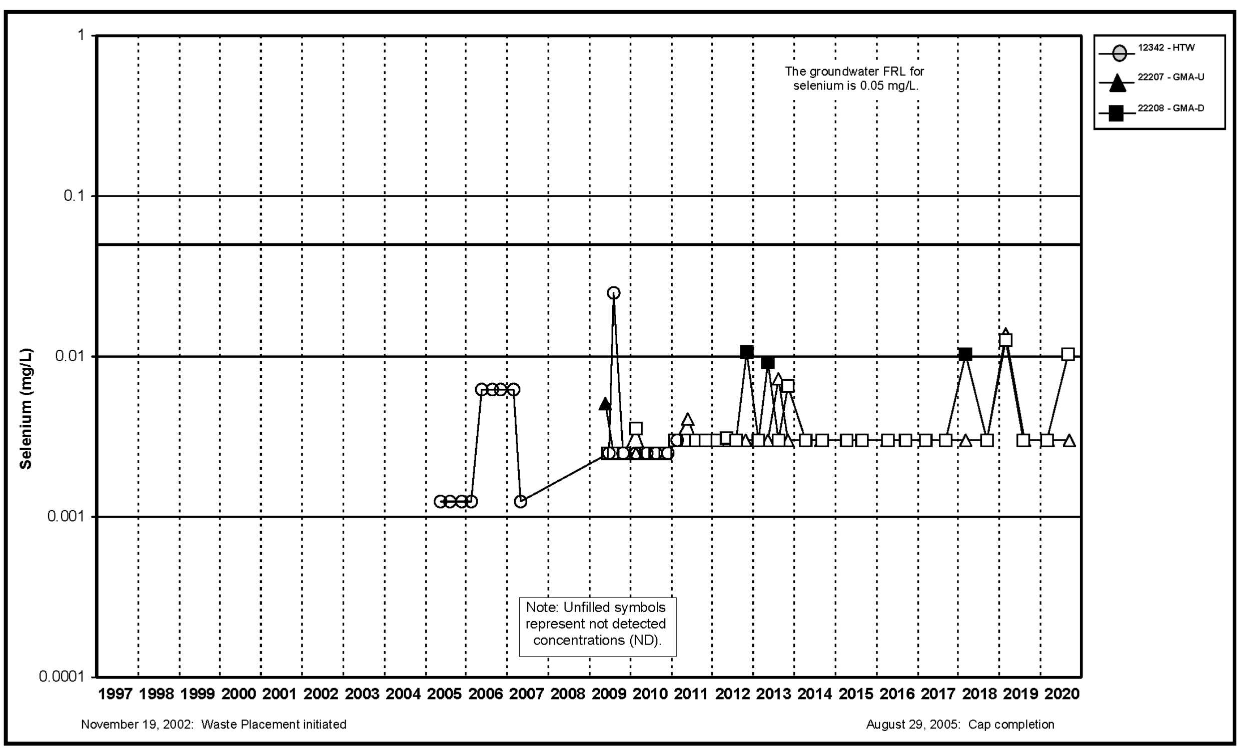

Figure A.5.5-14. Cell 5 Selenium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

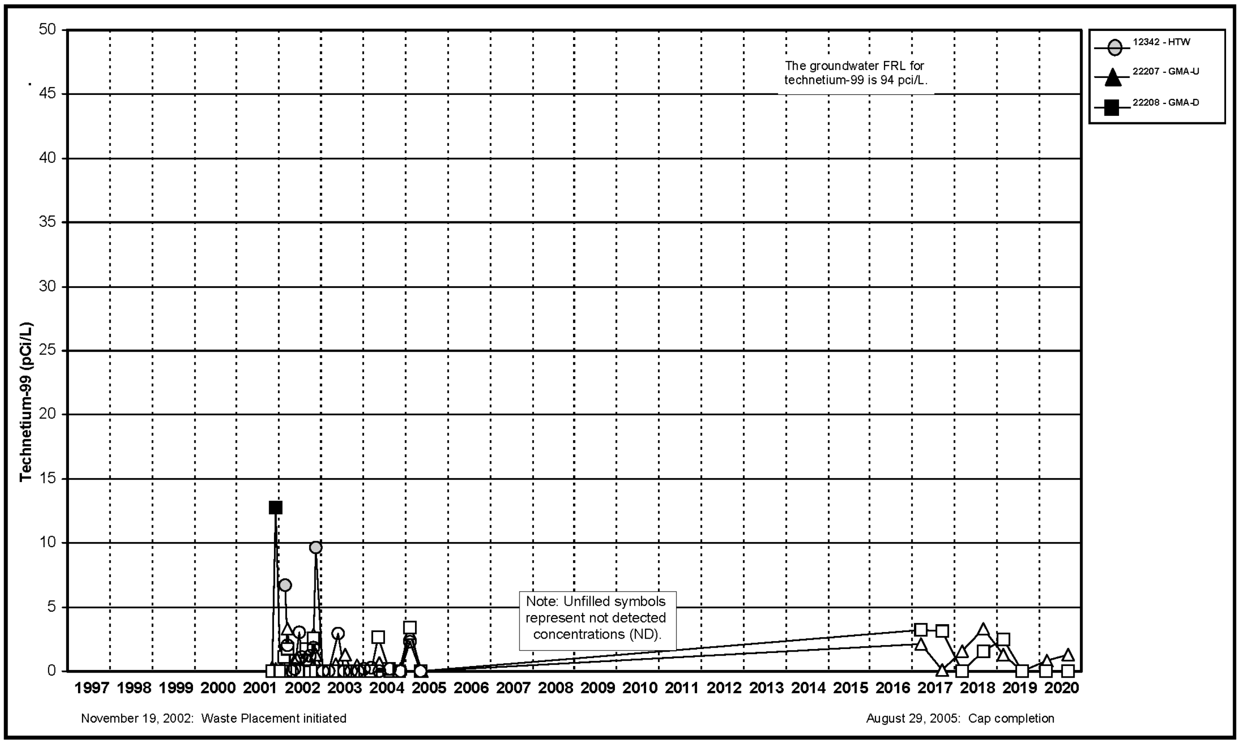

Figure A.5.5-15. Cell 5 Technetium-99 Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

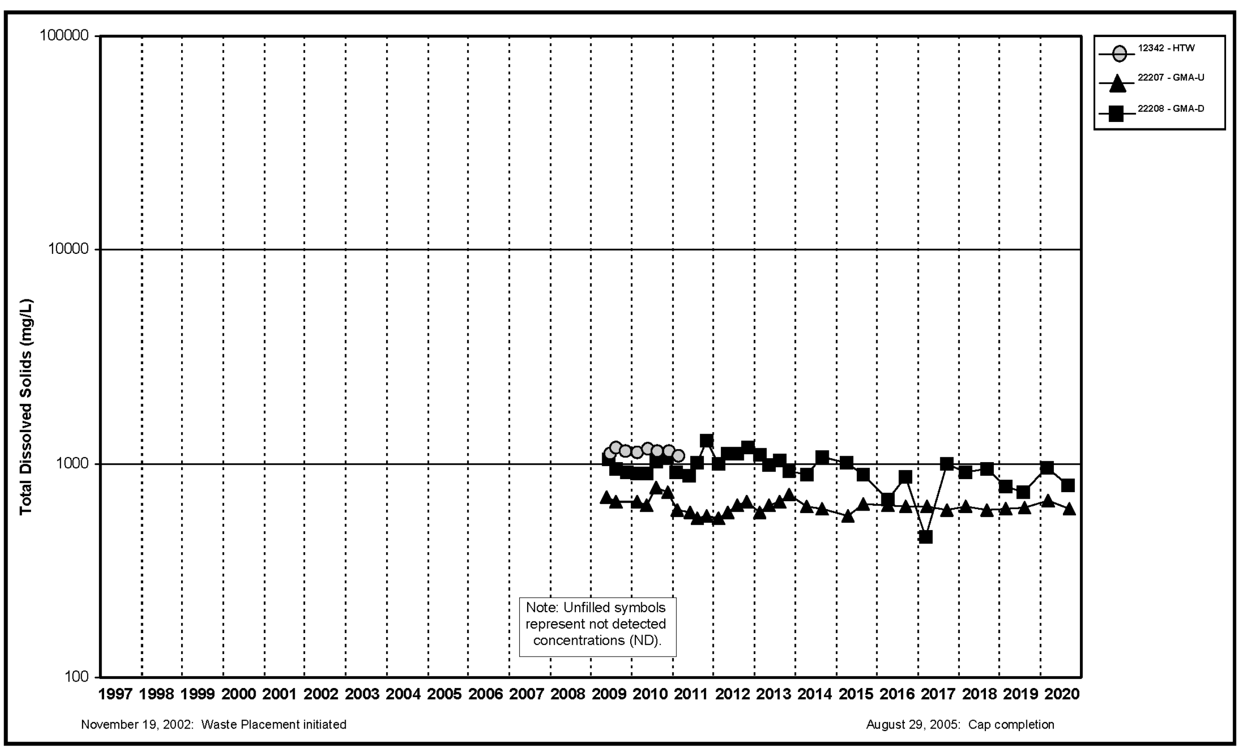

Figure A.5.5-16. Cell 5 Total Dissolved Solids Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

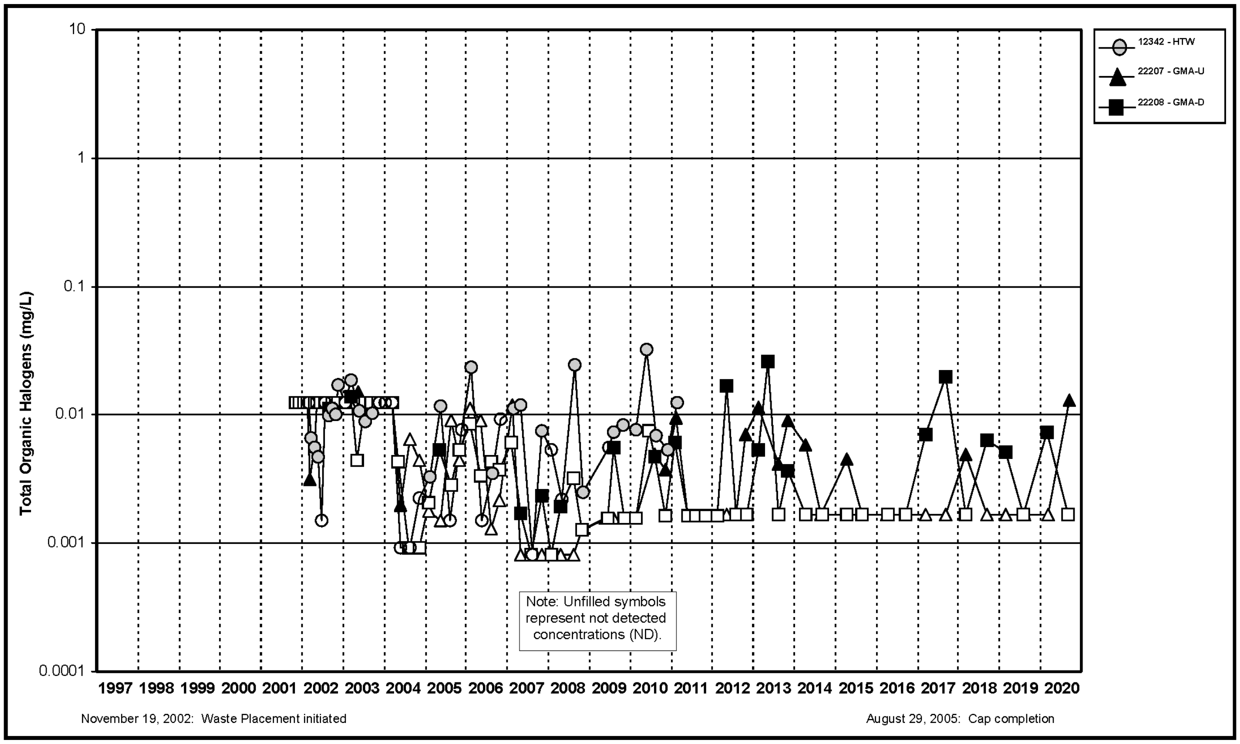

Figure A.5.5-17. Cell 5 Total Organic Halogens Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

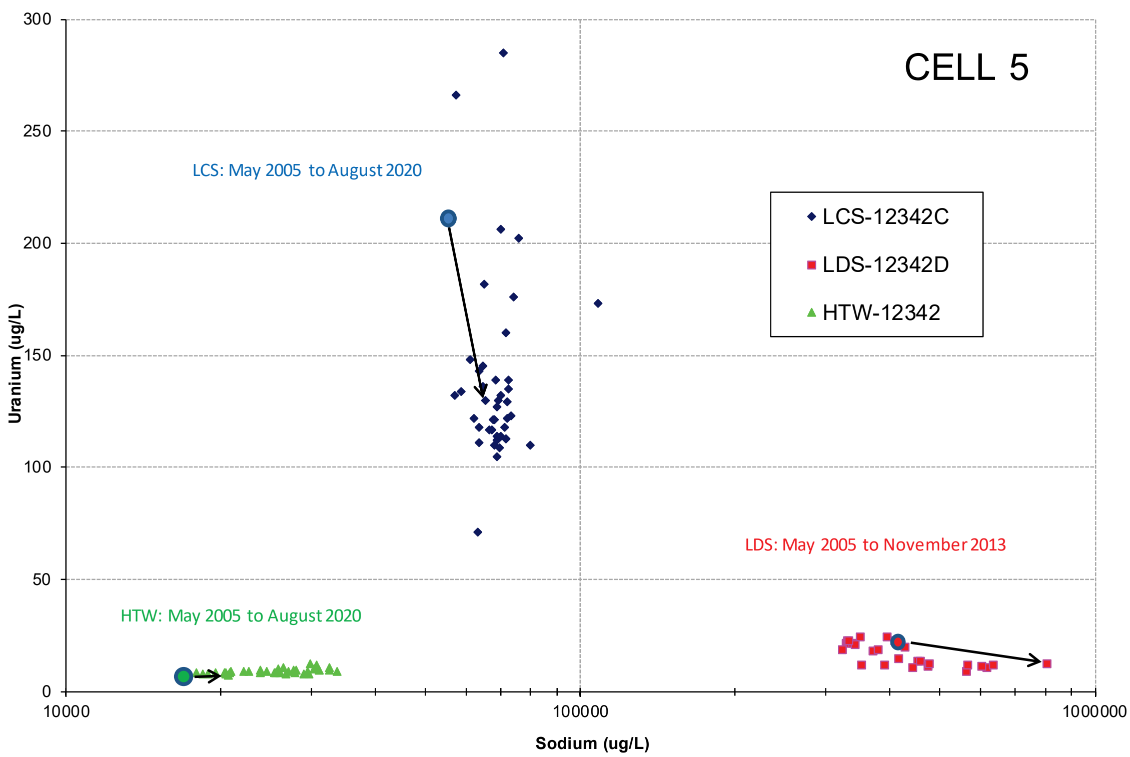

Figure A.5.5-18. Cell 5 Bivariate Plot for Uranium and Sodium

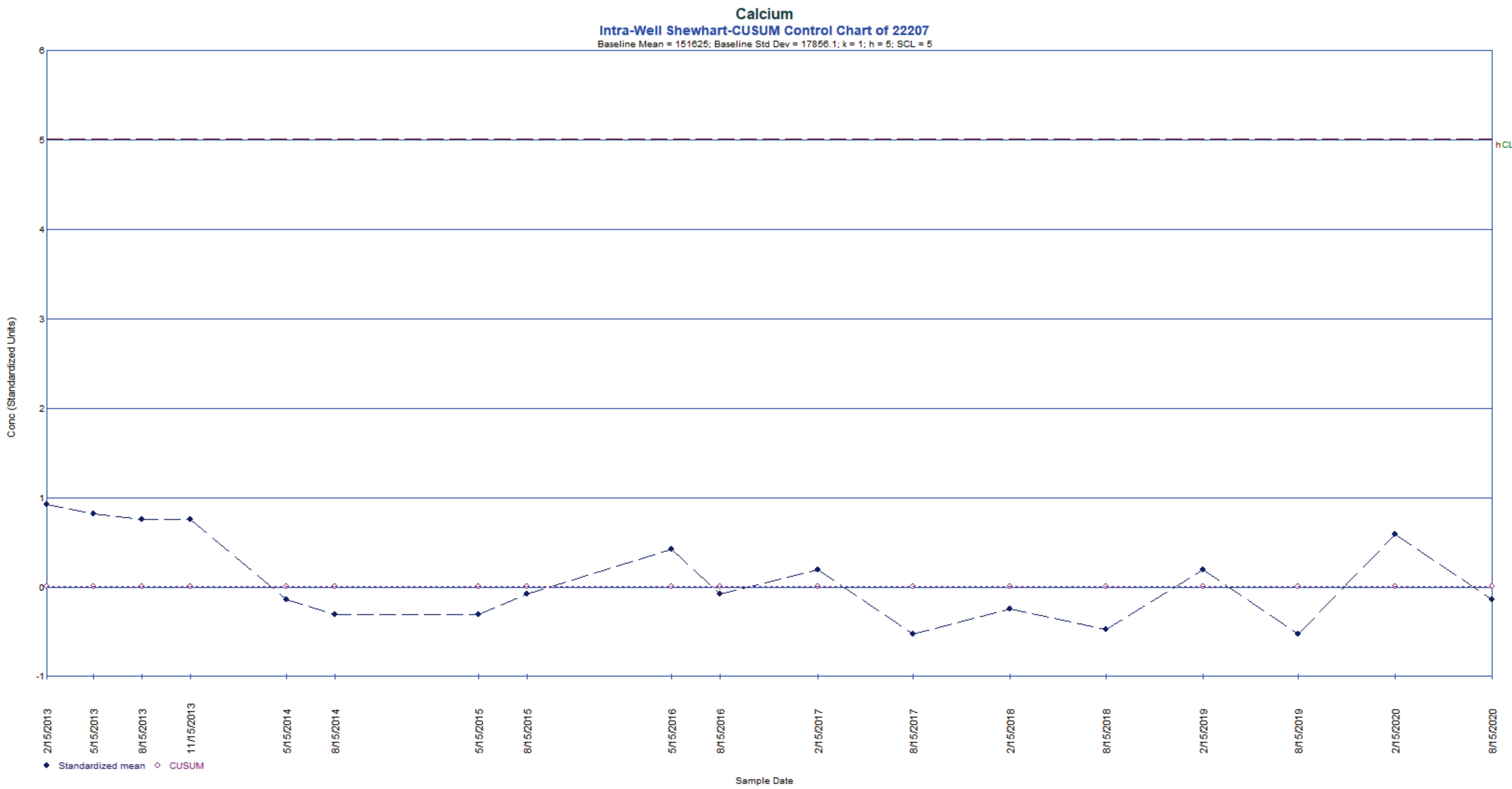

Figure A.5.5-19. Intrawell Shewhart-CUSUM Control Chart for Calcium in Monitoring Well 22207

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Subattachment A.5.6

Cell 6

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Contents

Tables

Figures

Abbreviations

CUSUM	Shewhart-cumulative sum
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
GMA	Great Miami Aquifer
GMA-D	Great Miami Aquifer–downgradient
GMA-U	Great Miami Aquifer–upgradient
HTW	horizontal till well
LCS	leachate collection system
LDS	leak detection system
Ohio EPA	Ohio Environmental Protection Agency
OSDF	On-Site Disposal Facility
SCL	Shewhart control limit

Measurement Abbreviations

amsl	above mean sea level
µg/L	micrograms per liter
mg/L	milligrams per liter

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This subattachment provides the following information about the On-Site Disposal Facility (OSDF) Cell 6:

- Semiannual monitoring summary statistics (refer to Table A.5.6-1)
- Leachate collection system (LCS) monthly accumulation volumes (refer to Figure A.5.6-1)
- Leak detection system (LDS) monthly accumulation volumes (refer to Figure A.5.6-2)
- OSDF horizontal till well (HTW) 12343 water yield (refer to Table A.5.6-2)
- Great Miami Aquifer (GMA) water levels and total uranium concentration versus time (refer to Figures A.5.6-3 and A.5.6-4)
- Plots of concentration versus time (refer to Figures A.5.6-5A through A.5.6-17)
- A bivariate plot for uranium–sodium (refer to Figure A.5.6-18)
- Control charts (refer to Figures A.5.6-19 through A.5.6-22)

A.5.6.1 Water Quality Monitoring Results

Water quality within the cell is sampled in the LCS and LDS. Water quality beneath the cell is sampled in the HTW and GMA wells. Concentration-versus-time plots, bivariate plots, and control charts are used to help interpret and present the results.

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 was 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.

With EPA and Ohio EPA concurrence, DOE reduced the number of parameters sampled from 24 to 13 beginning in January 2017. All 13 parameters are sampled in the GMA wells; 4 of the 13 parameters (total uranium, boron, sodium, and sulfate) are sampled in the LCS, LDS, and HTW of each cell. The annual sampling in the LCS of each cell for the abbreviated list of Appendix I parameters and polychlorinated biphenyls listed in *Ohio Administrative Code* 3745-27-10 was also eliminated beginning in January 2017 with EPA and Ohio EPA concurrence (DOE 2017).

A.5.6.1.1 LCS and LDS Results

As shown in Table A.5.6-1 and summarized below, four parameters (total uranium, boron, sodium, and sulfate) have upward trends in the LCS and/or LDS based on the Mann-Kendall test for trend. In 2020, sufficient water was present in the LDS tank of Cell 6 to sample the tank twice. A new high boron concentration 1.37 milligrams per liter (mg/L) was measured in the LCS tank of Cell 6 in 2020. The previous high was 1.04 mg/L. Two new concentration highs were measured in the LDS tank of Cell 6 in 2020 (uranium and sulfate). The new high for uranium in the LDS was 144 micrograms per liter (µg/L). The previous high was 115 µg/L. The new high for sulfate in the LDS was 6,510 mg/L. The previous high was 5,230 mg/L.

Parameters with Upward Concentration Trends in the LCS and LDS of Cell 6[a]

Parameter	LCS 12343C 2020 Trend	LDS 12343D 2020 Trend
Total Uranium		Up
Boron		Up
Sodium	Up	Up
Sulfate	Up	Up

[a] No entry indicates that the trend was not up.

A.5.6.1.2 HTW and Monitoring Well Results

As shown in Table A.5.6-1 and summarized below, six parameters (total uranium, boron, sulfate, lithium, magnesium, and selenium) have upward trends in the HTW and/or GMA wells based on the Mann-Kendall test for trend.

Parameters with Upward Concentration Trends in the HTW and GMA Wells of Cell 6[a]

Parameter	HTW 12343	GMA-U[b] 22209	GMA-D[b] 22210
Total Uranium	Up		
Boron		Up	Up
Sulfate	Up		Up
Lithium		Up	
Magnesium		Up	
Selenium			Up

[a] No entry indicates that the trend was not up.
[b] GMA-U = upgradient Great Miami Aquifer, GMA-D = downgradient Great Miami Aquifer, HTW = horizontal till well.

A.5.6.1.3 Discussion

The uranium–sodium bivariate plot for the Cell 6 LCS, LDS, and HTW is provided in Figure A.5.6-18. On the figure, the first sample ever collected from the monitoring horizon is circled. An arrow leads from the first sample to the location of the most recent sample. The plot shows that the chemical signatures for uranium and sodium in the LCS, LDS, and HTW are separate and distinct, indicating that mixing between the horizons is not occurring; therefore, upward concentration trends measured beneath the cells in GMA wells are attributed to fluctuating ambient concentrations beneath the cell and are not related to cell performance.

The new high uranium and sulfate concentrations measured in the LDS are not attributed to communication with the LCS. They are attributed to the impact that decreasing flow can have on the concentrations left in water remaining in the LDS, as the LDS dries up. An additional discussion of this is presented in Attachment A.5, Section A.5.2.2.

A.5.6.2 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.

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 "not in 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. Usually, two parameters are used to compute standardized limits—the decision value (h) and the Shewhart control limit (SCL).

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 eight samples were selected for control charts. By default, the ChemStat software plots both a CUSUM control limit (h) and an SCL on the control chart. The software recommends a value of 5 for the CUSUM control limit and a value of 4.5 for the SCL.

EPA Statistical Analysis 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 is not needed. The ChemStat software though, by default, plots both the SCL and CUSUM control limit on the charts. To address this issue, the SCL was defined as 5 to equal the recommended CUSUM (h) limit. This combined limit is identified as hCL on the control charts. For interpretation purposes, the hCL value will be regarded as the CUSUM (h) limit.

As shown in Table A.5.6-1 in gray shading and as summarized below, four parameters in the HTW or GMA wells of Cell 6 (total uranium, calcium, lithium, and potassium) meet the criteria for control charts (i.e., at least eight samples, normal or lognormal distribution, no trend, and no serial correlation), resulting in four control charts (Figures A.5.6-19 through A.5.6-22). All of the control charts exhibit "in control" conditions.

Parameter	Monitoring Point[a]	Well Number	Assessment	Figure Number
Total Uranium	GMA-D	22210	In Control	A.5.6-19
Calcium	GMA-U	22209	In Control	A.5.6-20
Lithium	GMA-D	22210	In Control	A.5.6-21
Potassium	GMA-U	22209	In Control	A.5.6-22

[a] GMA-U = upgradient Great Miami Aquifer; GMA-D = downgradient Great Miami Aquifer.

A.5.6.3 Summary and Conclusions

- Four parameters monitored semiannually have an upward concentration trend in the LCS and/or LDS of Cell 6: total uranium, boron, sodium, and sulfate.
- A new high boron concentration 1.37 mg/L was measured in the LCS tank of Cell 6 in 2020. The previous high was 1.04 mg/L.
- Sufficient water was present in the LDS tank of Cell 6 to sample the tank twice in 2020. Two new concentration highs were measured in the LDS tank of Cell 6 in 2020 (uranium

and sulfate). The new high for uranium was 144 µg/L. The previous high was 115 µg/L). The new high for sulfate was 6,510 mg/L. The new high uranium and sulfate concentrations measured in the LDS are not attributed to communication with the LCS. They are attributed to the impact that decreasing flow can have on the concentrations left in water remaining in the LDS, as the LDS dries up. An additional discussion of this is presented in Attachment A.5, Section A.5.2.2.

- Six parameters monitored semiannually have an upward concentration trend in the HTW or GMA wells of Cell 6: total uranium, boron, sulfate, lithium, magnesium, and selenium. Separate and distinct chemical signatures for uranium and sodium in the LCS, LDS, and HTW of Cell 6 indicate that water is not mixing between the horizons. Therefore, upward concentration trends beneath Cell 6 (i.e., HTW or GMA wells) are attributed to fluctuating ambient concentrations beneath the cell and not to cell performance.
- Four control charts were constructed for Cell 6 parameters. All control charts exhibit “in control” conditions.

A.5.6.4 References

DOE (U.S. Department of Energy), 2017. *Fernald Preserve 2016 Site Environmental Report*, LMS/FER/S15232, Office of Legacy Management, Cincinnati, Ohio, May.

EPA (U.S. Environmental Protection Agency), 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities—Unified Guidance*, EPA 530/R-09-007, March.

OAC 3745-27-10. “Ground Water Monitoring Program for a Sanitary Landfill Facility,” *Ohio Administrative Code.*

Table A.5.6-1. Summary Statistics for Cell 6

Parameter	Horizon[a]	Location	Number of Detected Samples	Total Number of Samples	Percent Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[d]	Distribution Type[d,e]	Trend[d,f] (Year Last Sampled)	Serial Correlation[d,g]	Outliers[h,i]
Total Uranium (µg/L)	LCS	12343C	54	54	100	43.3	276	127	34	Undefined	Down (2020)	Detected	
	LDS	12343D	54	54	100	3.10	144	28.5	30.4	Undefined	Up (2020)	Detected	
	HTW	12343	54	54	100	6.32	16.9	11.4	2.2	Normal	Up (2020)	Detected	24.2 (Q1-07); 21.4 (Q2-11)
	GMA-U	22209	53	58	91.4	ND	2.43	0.491	0.387	Undefined	Down (2020)	Not Detected	
	GMA-D	22210	63	65	96.9	ND	0.994	0.660	0.157	Normal	None (2020)	Not Detected	0.0095 (Q2-05)
Boron (mg/L)	LCS	12343C	54	54	100	0.0566	1.37	0.740	0.195	Undefined	Down (2020)	Detected	
	LDS	12343D	54	54	100	0.289	1.22	0.415	0.143	Undefined	Up (2020)	Detected	2.38 (Q3-04)
	HTW	12343	33	37	89.2	ND	0.124	0.0918	0.0193	Undefined	None (2020)	Detected	
	GMA-U	22209	53	58	91.4	ND	0.0668	0.0382	0.0087	Undefined	Up (2020)	Detected	
	GMA-D	22210	55	58	94.8	ND	0.0616	0.0367	0.0087	Undefined	Up (2020)	Detected	0.0086 Q3-05)
Sodium (mg/L)	LCS	12343C	45	45	100	23.1	107	70.2	14.9	Undefined	Up (2020)	Detected	
	LDS	12343D	43	43	100	109	819	500	126	Normal	Up (2020)	Detected	
	HTW	12343	41	41	100	18.6	66.0	40.8	13.5	Normal	Down (2020)	Detected	
	GMA-U	22209	33	33	100	14.5	22.9	18.6	2.3	Normal	None (2020)	Detected	
	GMA-D	22210	34	34	100	11.7	20.4	17.2	2.2	Undefined	Down (2020)	Detected	
Sulfate (mg/L)	LCS	12343C	54	54	100	491	4800	3440	1050	Undefined	Up (2020)	Detected	
	LDS	12343D	53	53	100	1300	6510	3350	1350	Undefined	Up (2020)	Detected	
	HTW	12343	48	49	98.0	ND	716	496	98	Normal	Up (2020)	Detected	
	GMA-U	22209	57	57	100	2.07	406	162	68	Undefined	Down (2020)	Detected	
	GMA-D	22210	57	57	100	127	392	278	72	Normal	Up (2020)	Detected	578 (Q1-07)
Calcium (mg/L)	GMA-U	22209	26	26	100	136	184	151	12	Ln Normal	None (2020)	Not Detected	242 (Q3-11); 231 (Q3-13)
	GMA-D	22210	26	26	100	181	239	211	17	Normal	Down (2020)	Detected	
Lithium (mg/L)	GMA-U	22209	33	33	100	0.00486	0.00865	0.00630	0.00095	Normal	Up (2020)	Detected	
	GMA-D	22210	33	33	100	0.00631	0.00865	0.00738	0.00057	Normal	None (2020)	Not Detected	
Magnesium (mg/L)	GMA-U	22209	26	26	100	27.0	39.7	33.2	3.0	Normal	Up (2020)	Detected	55.4 (Q3-13)
	GMA-D	22210	26	26	100	41.5	58.3	51.0	4.3	Normal	Down (2020)	Detected	
Nitrate + Nitrite, as Nitrogen (mg/L)	GMA-U	22209	2	27	7.4	ND	0.500	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
	GMA-D	22210	1	26	3.8	ND	0.0425	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
Potassium (mg/L)	GMA-U	22209	26	26	100	3.00	3.78	3.31	0.18	Normal	None (2020)	Not Detected	
	GMA-D	22210	27	27	100	2.80	3.62	3.20	0.22	Normal	Down (2020)	Detected	
Selenium (mg/L)	GMA-U	22209	3	33	9.1	ND	0.00925	0.00376	Insufficient	Insufficient	Insufficient	Insufficient	
	GMA-D	22210	4	33	12.1	ND	0.0122	0.00300	0.00232	Undefined	Up (2020)	Detected	
Technitium-99 (pCi/L)	GMA-U	22209	1	19	5.3	ND	8.61	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
	GMA-D	22210	1	19	5.3	ND	6.61	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
Total Dissolved Solids (mg/L)	GMA-U	22209	33	33	100	550	718	631	41	Normal	Down (2020)	Not Detected	876 (Q3-11)
	GMA-D	22210	33	33	100	746	1020	905	73	Normal	Down (2020)	Detected	
Total Organic Halogens (mg/L)	GMA-U	22209	18	58	31.0	ND	0.0208	0.00166	0.00494	Undefined	None (2020)	Detected	0.0365 (Q3-06); 0.0377 (Q1-11); 0.0432 (Q1-13)
	GMA-D	22210	16	58	27.6	ND	0.0590	0.0020	0.0085	Undefined	None (2020)	Not Detected	

Note 1: Shading identifies a horizontal till well or Great Miami Aquifer well, with at least eight samples, Normal or Ln Normal distribution, no trend (None), and no serial correlation (Not Detected). These wells achieve control chart criteria.

Note 2: Data used in this table has been standardized to quarterly.

[a]LCS = leachate collection system; LDS = leak detection system; HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; and GMA-D = downgradient Great Miami Aquifer

[b]ND = not detected; NA = not applicable

[c]Averages were determined based on the distribution assumption.

[d]Insufficient is used for Distribution Type, Trend, or Serial Correlation whenever there is not enough data to run the test.

[e]Data distribution based on the Shapiro-Wilk statistic.

Normal: Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the Ln Normal assumption.

Ln Normal: Ln Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the Normal assumption.

Undefined: Normal and Lognormal Distribution assumptiions are both rejected or there are less than 25 percent detected values. "Average" is defined as the Median of the data.

[f]Trend based on nonparametric Mann-Kendall procedure.

[g]Serial correlation based on Rank Von Neumann test.

[h]Outliers determined by Rosner's (for sample sizes greater than 25) or Dixon procedure (for sample sizes less than or equal to 25).

[i]Q = quarter

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Table A.5.6-2. Horizontal Till Well 12343 Water Yield

Year	Total Volume Purged (gallons)	Number of Months Purged	Average Volume Purged (gallons)
2003	9,940	10	994
2004	760	6	127
2005	925	5	185
2006	565	4	141
2007	355	4	89
2008	510	4	128
2009	550	4	183
2010	935	4	234
2011	1,175	4	294
2012	1,065	4	266
2013	1,130	4	283
2014	475	2	238
2015	725	2	363
2016	600	2	300
2017	720	2	360
2018	815	2	408
2019	690	2	345
2020	740	2	370

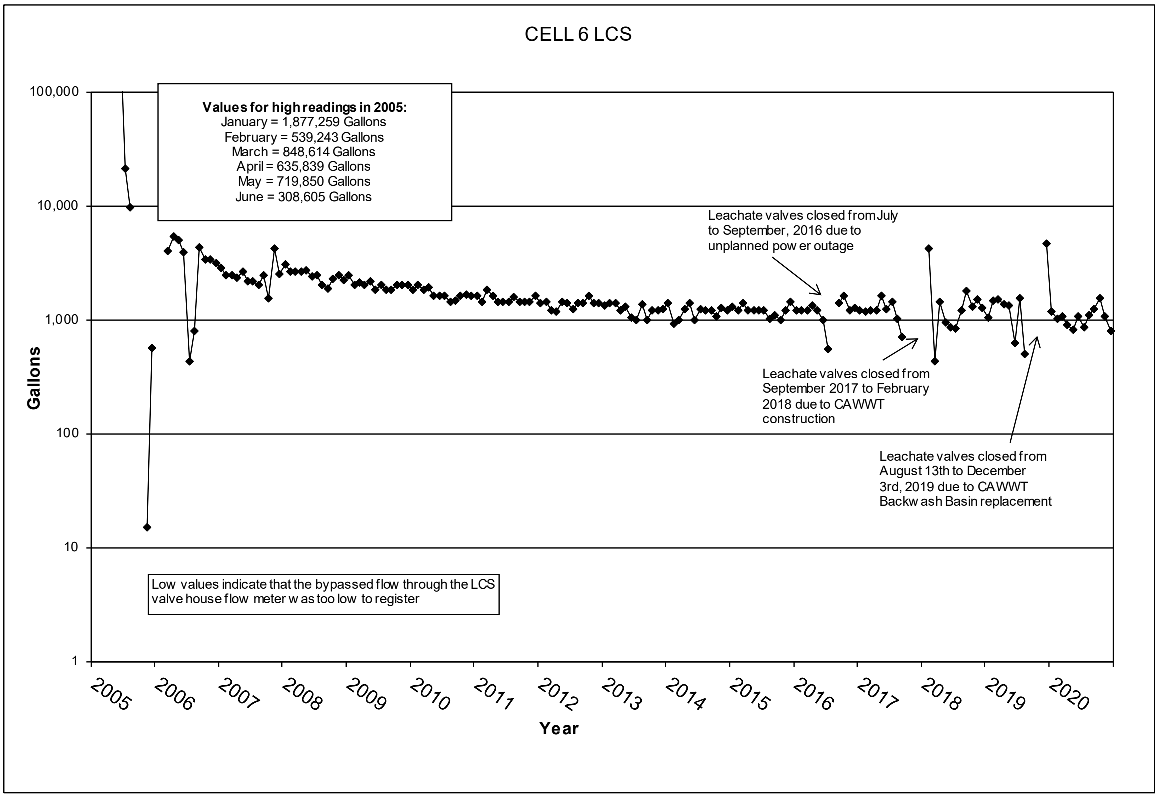

Figure A.5.6-1. Monthly Accumulation Volumes for Cell 6 LCS

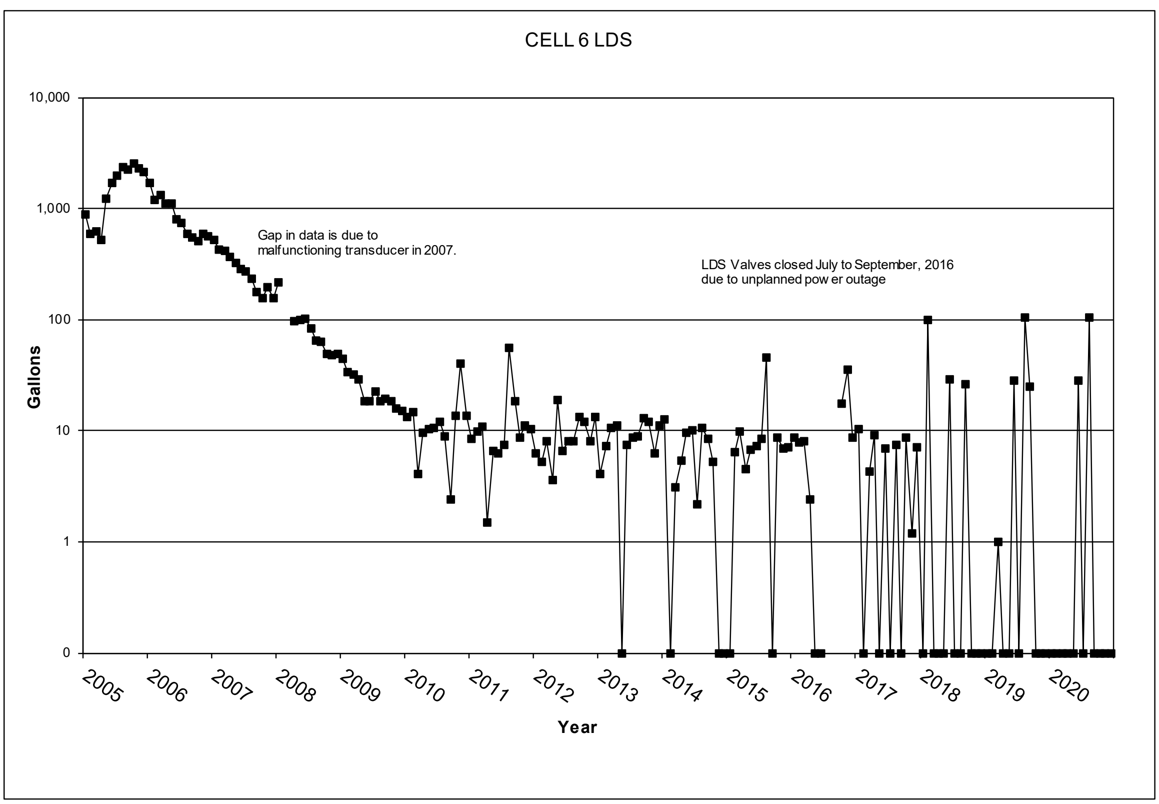

Figure A.5.6-2. Monthly Accumulation Volumes for Cell 6 LDS

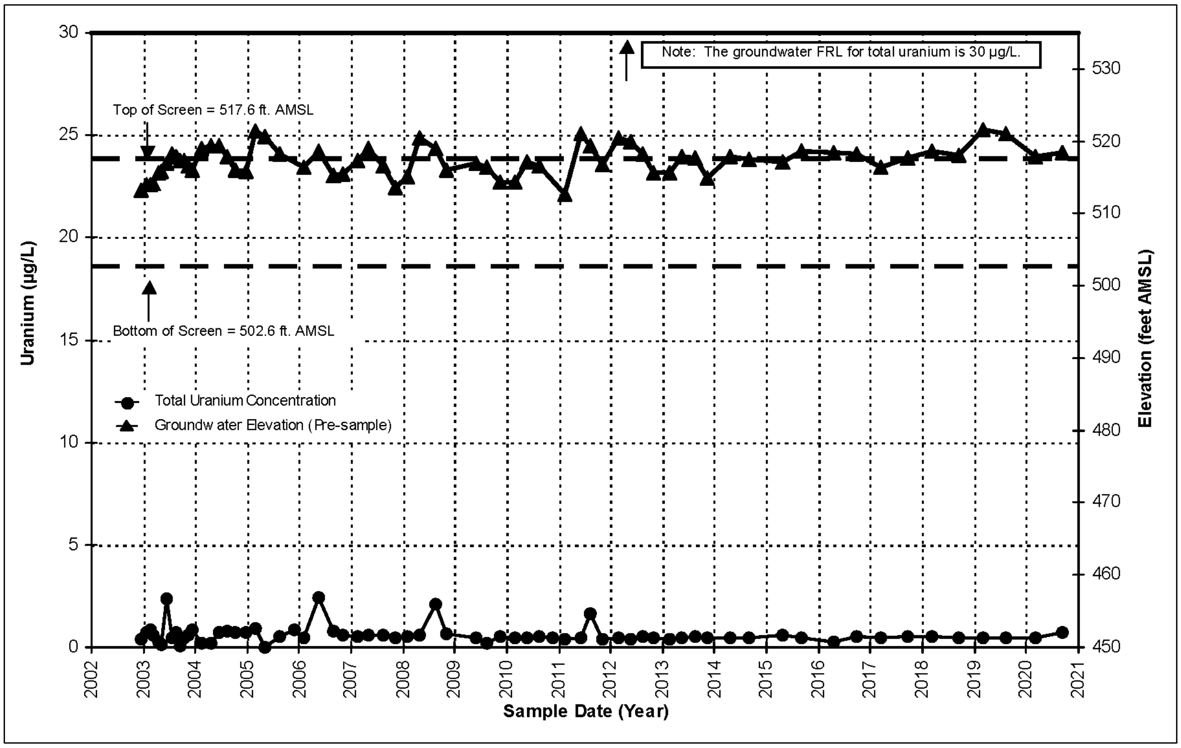

Figure A.5.6-3. Total Uranium Concentration and Groundwater Elevation Versus Time Plot for Cell 6 Upgradient Monitoring Well 22209

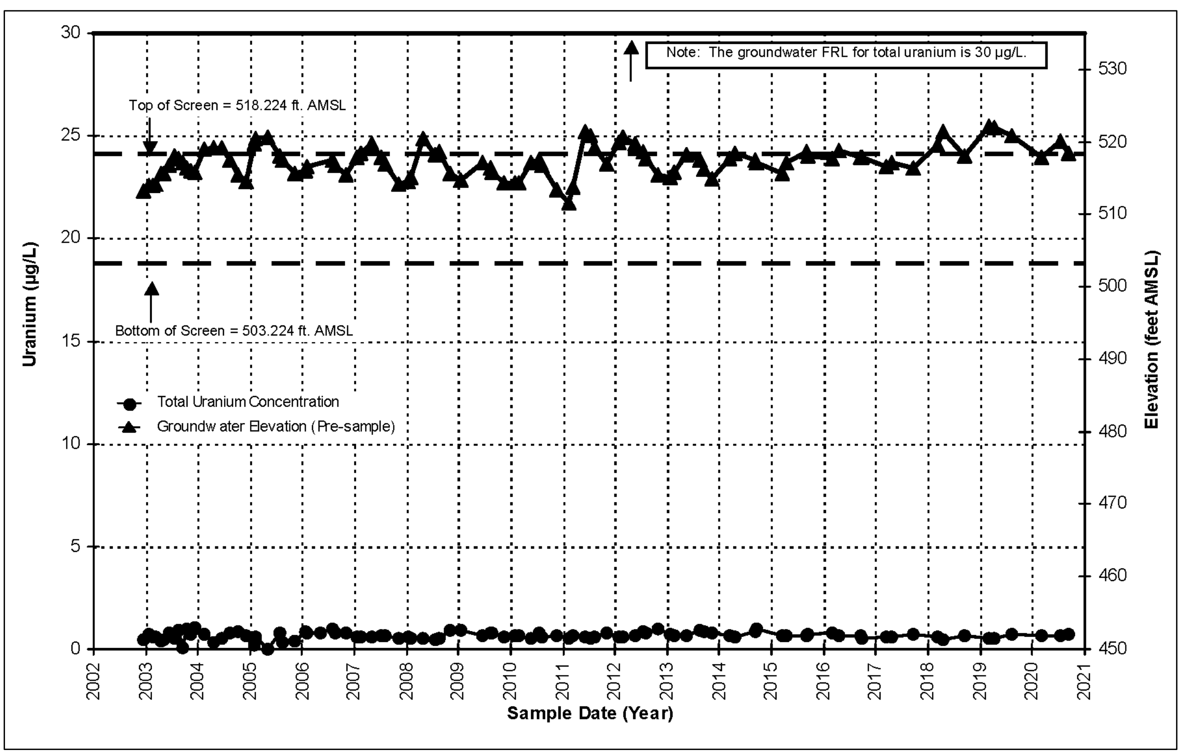

Figure A.5.6-4. Total Uranium Concentration and Groundwater Elevation Versus Time Plot for Cell 6 Downgradient Monitoring Well 22210

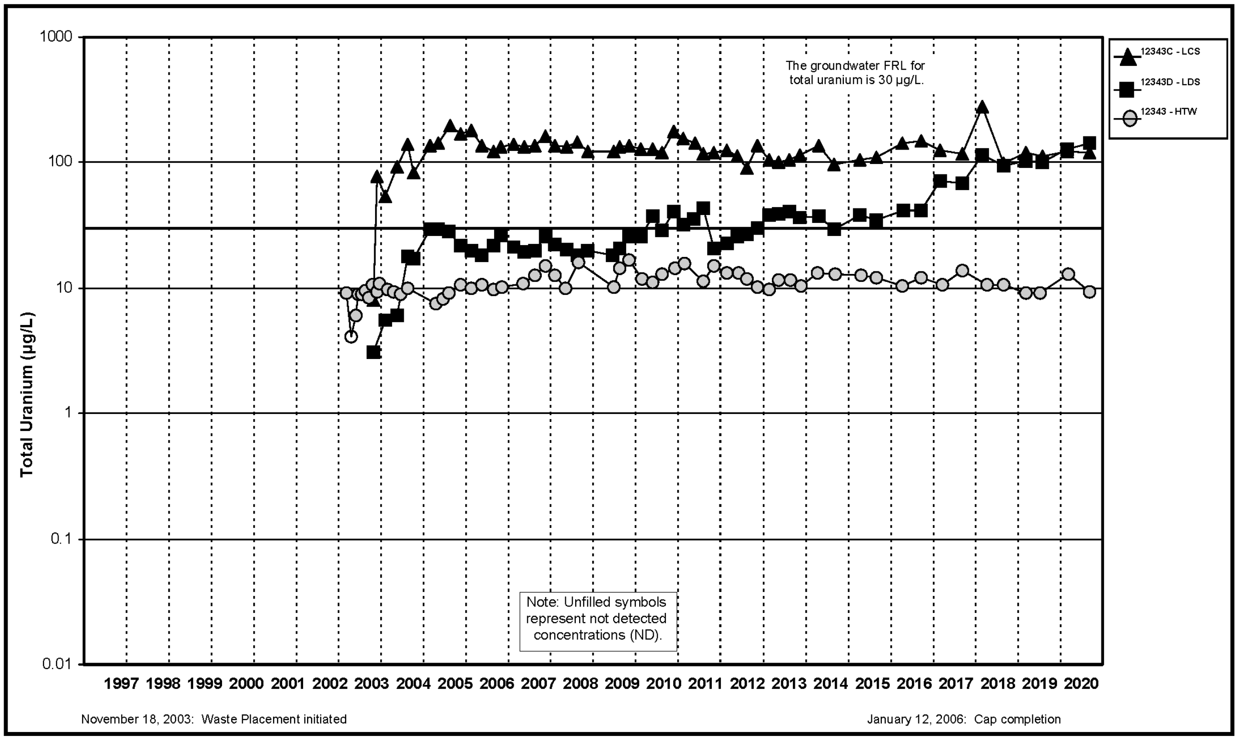

Figure A.5.6-5A. Cell 6 Total Uranium Concentration Versus Time Plot for LCS, LDS, and HTW

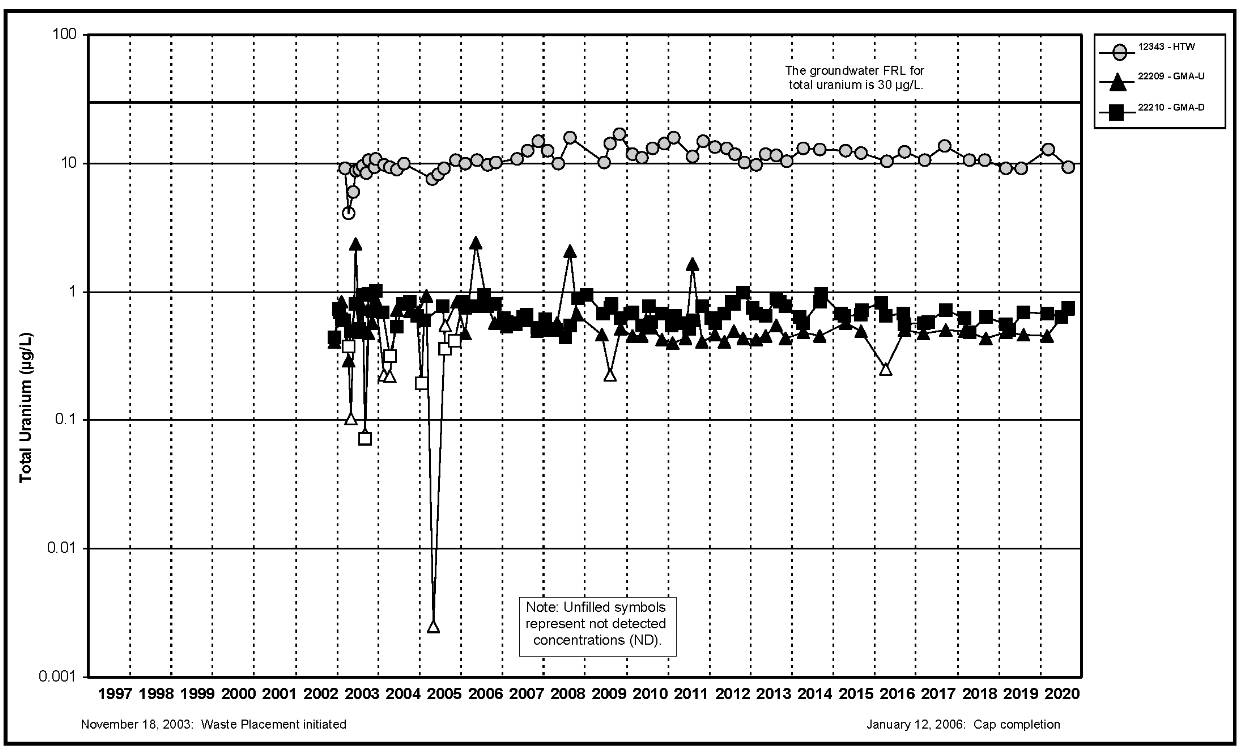

Figure A.5.6-5B. Cell 6 Total Uranium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

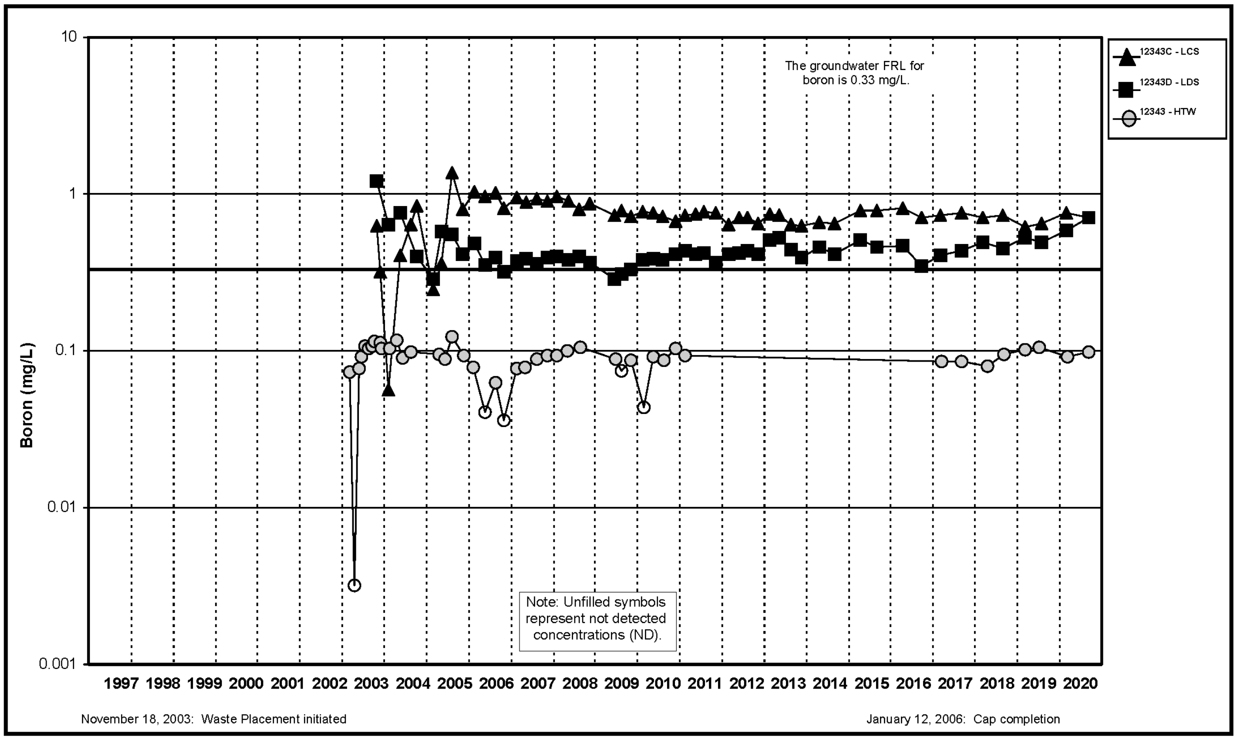

Figure A.5.6-6A. Cell 6 Boron Concentration Versus Time Plot for LCS, LDS, and HTW

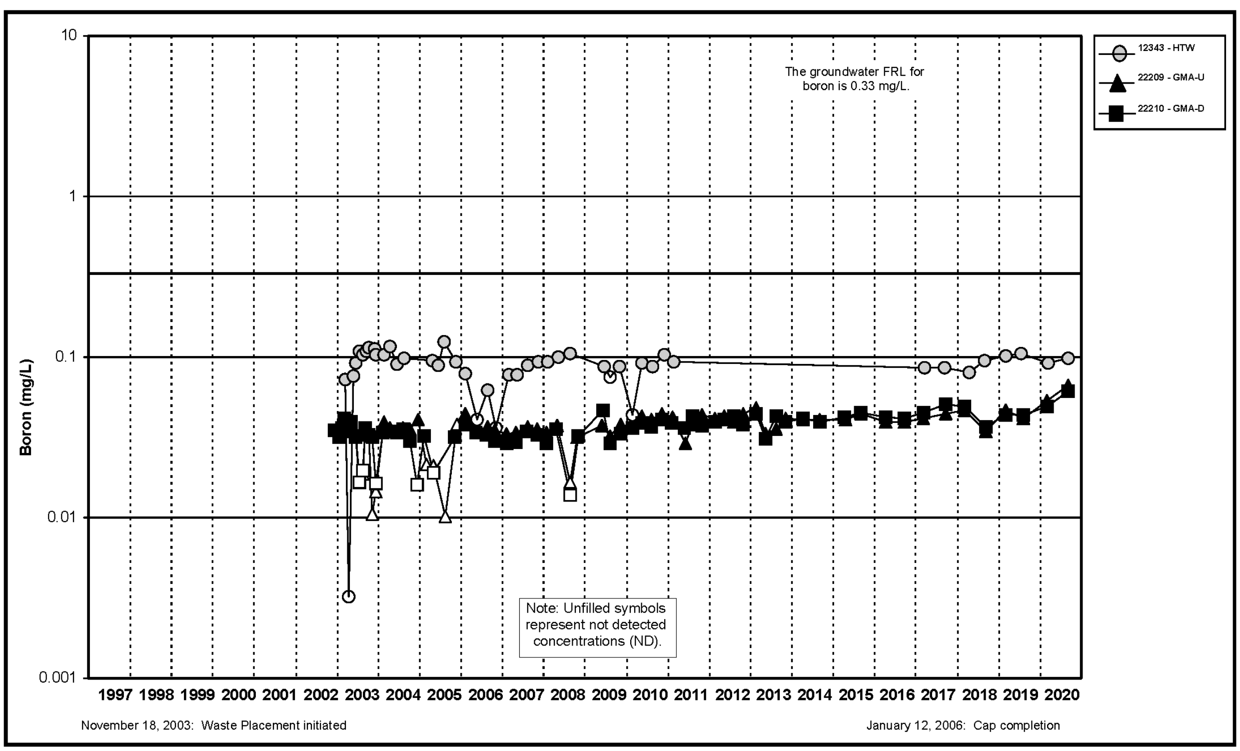

Figure A.5.6-6B. Cell 6 Boron Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

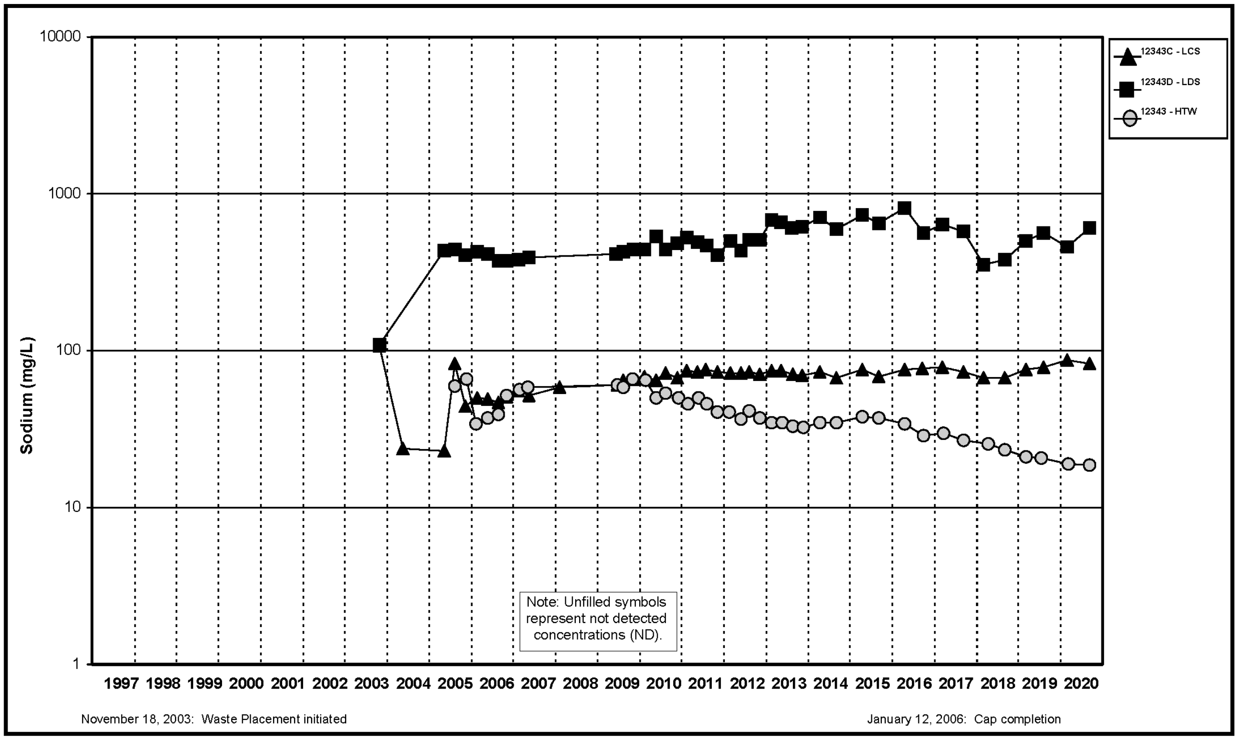

Figure A.5.6-7A. Cell 6 Sodium Concentration Versus Time Plot for LCS, LDS, and HTW

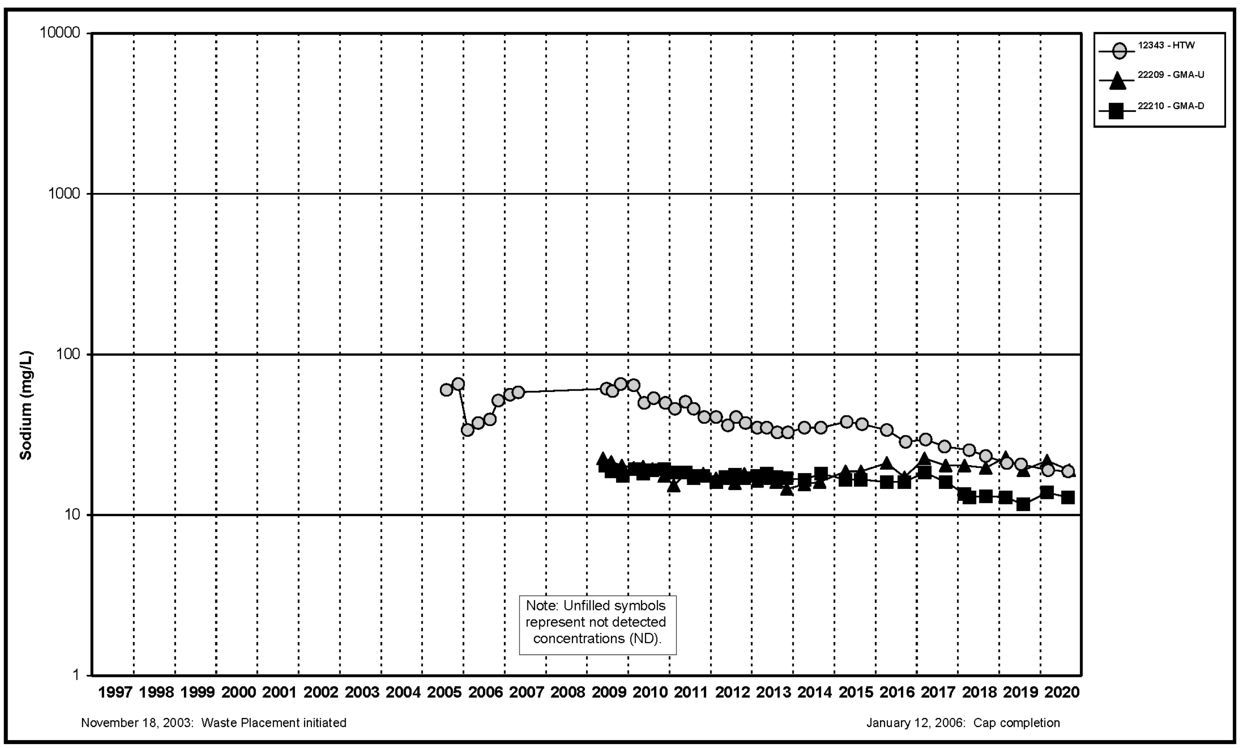

Figure A.5.6-7B. Cell 6 Sodium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

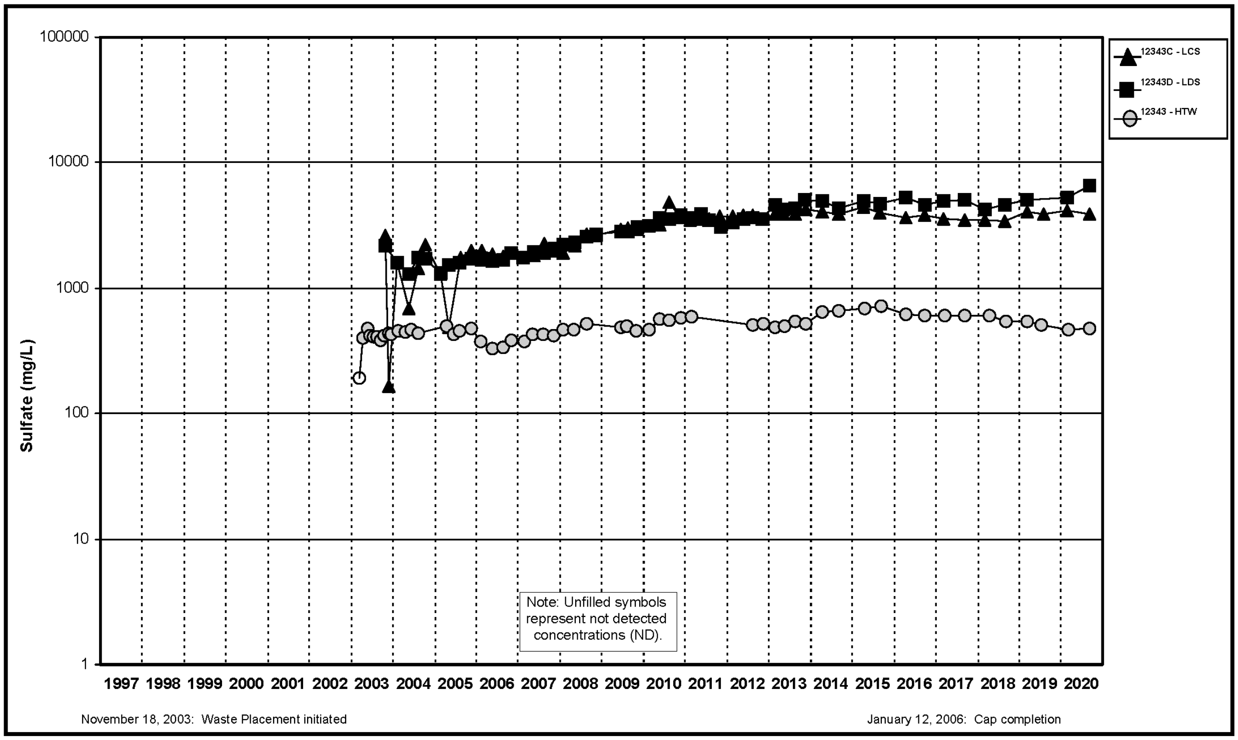

Figure A.5.6-8A. Cell 6 Sulfate Concentration Versus Time Plot for LCS, LDS, and HTW

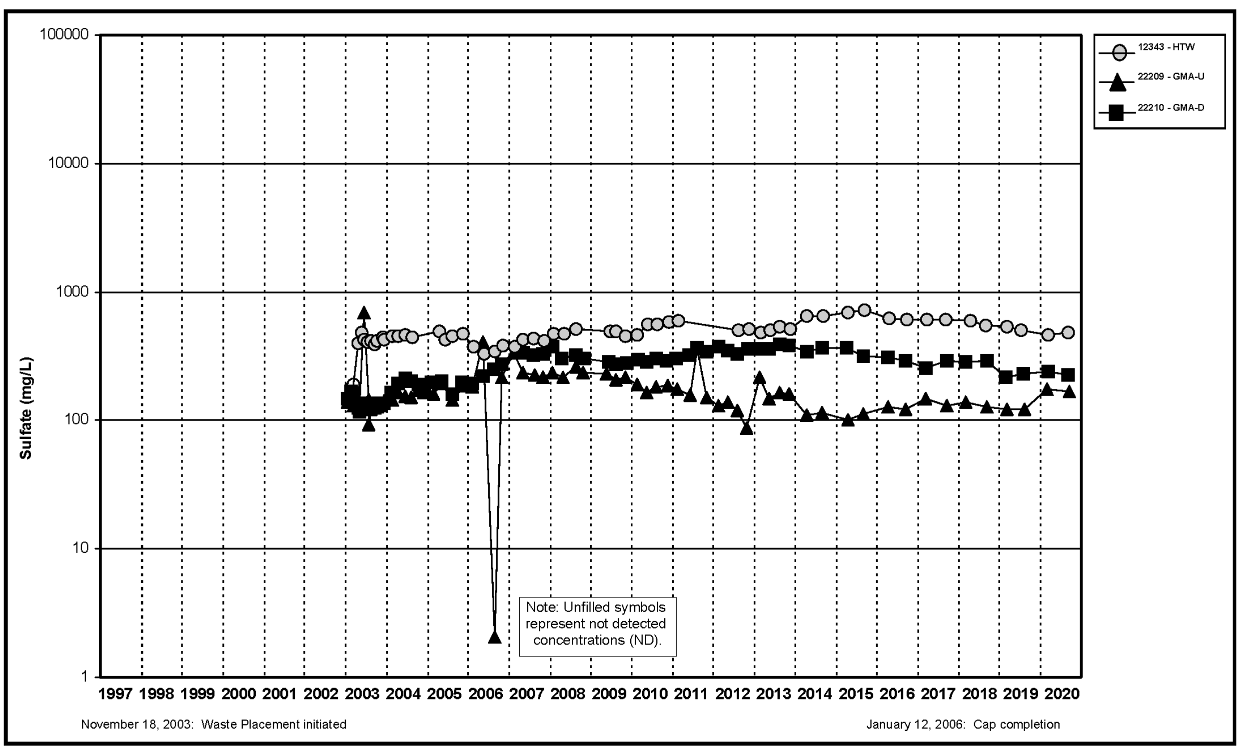

Figure A.5.6-8B. Cell 6 Sulfate Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

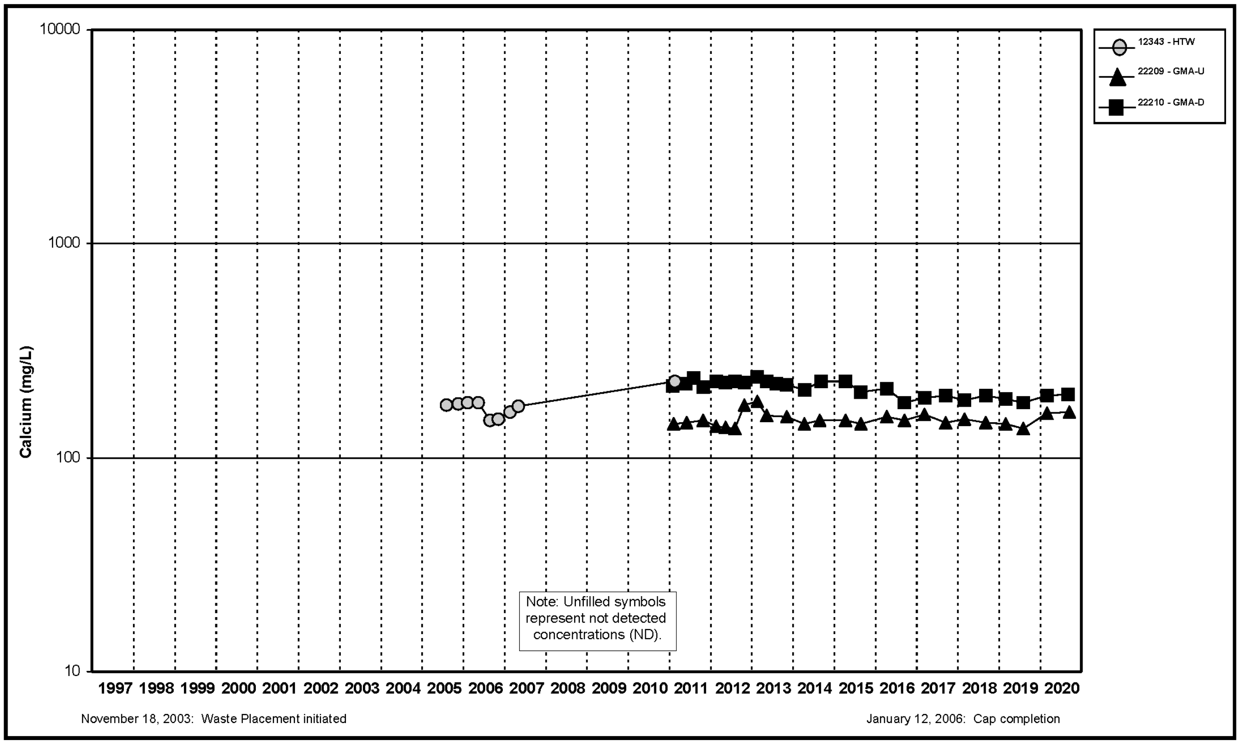

Figure A.5.6-9. Cell 6 Calcium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

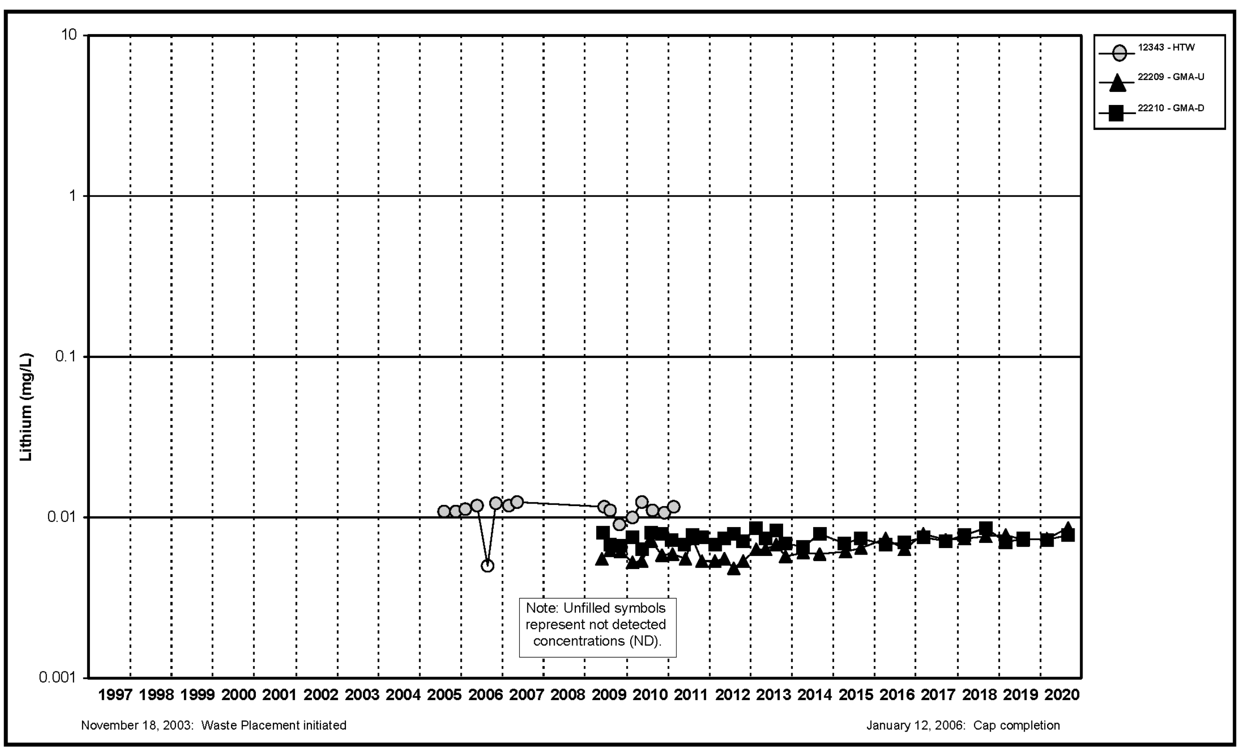

Figure A.5.6-10. Cell 6 Lithium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

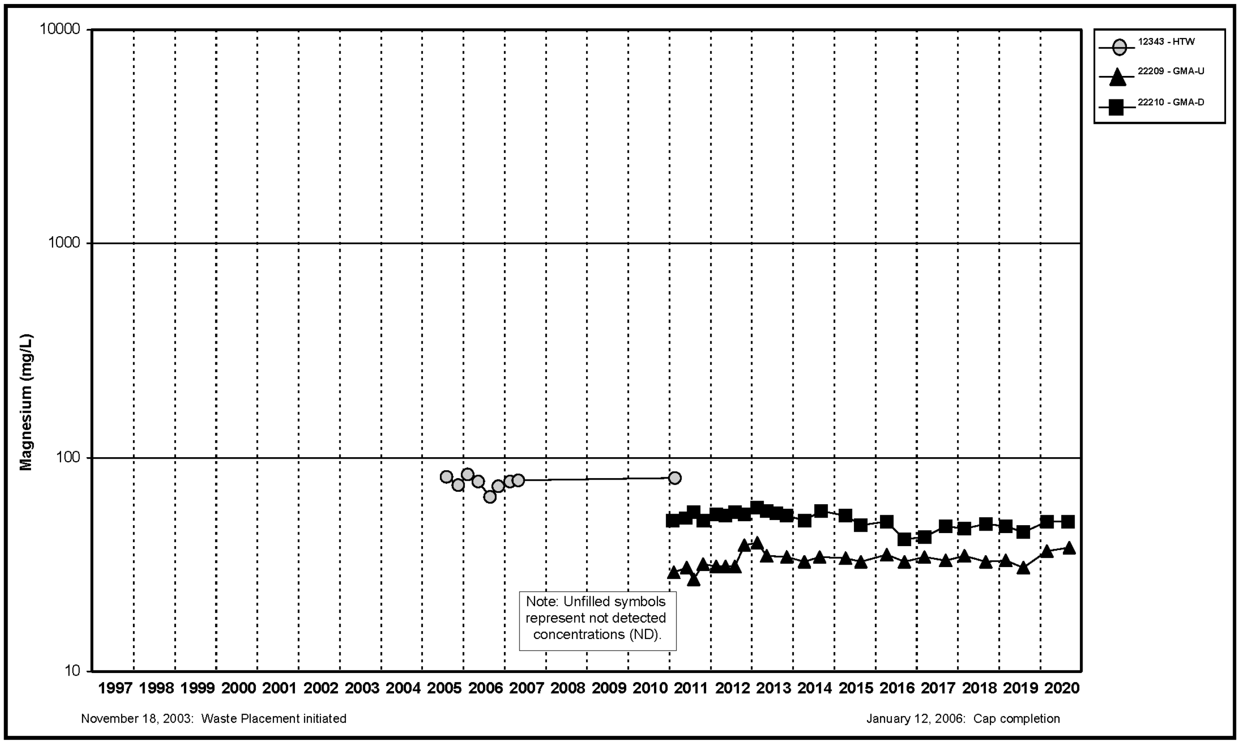

Figure A.5.6-11. Cell 6 Magnesium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

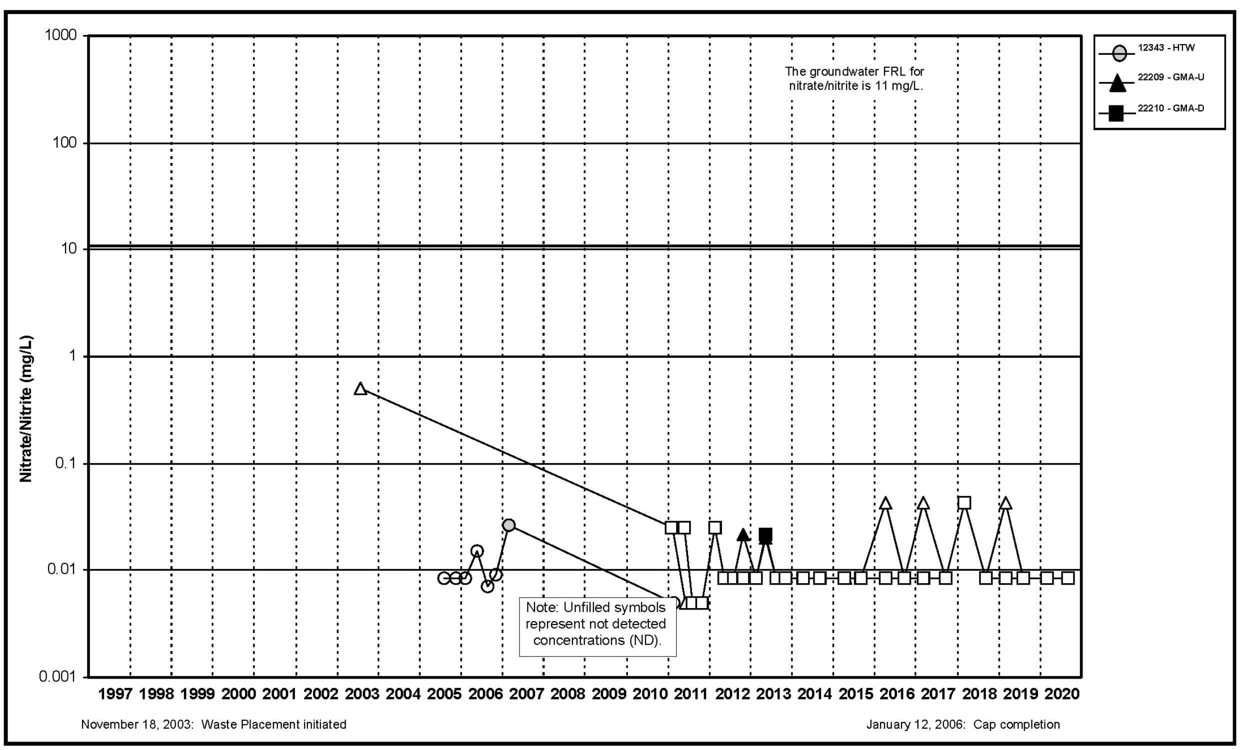

Figure A.5.6-12. Cell 6 Nitrate + Nitrite as Nitrogen Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

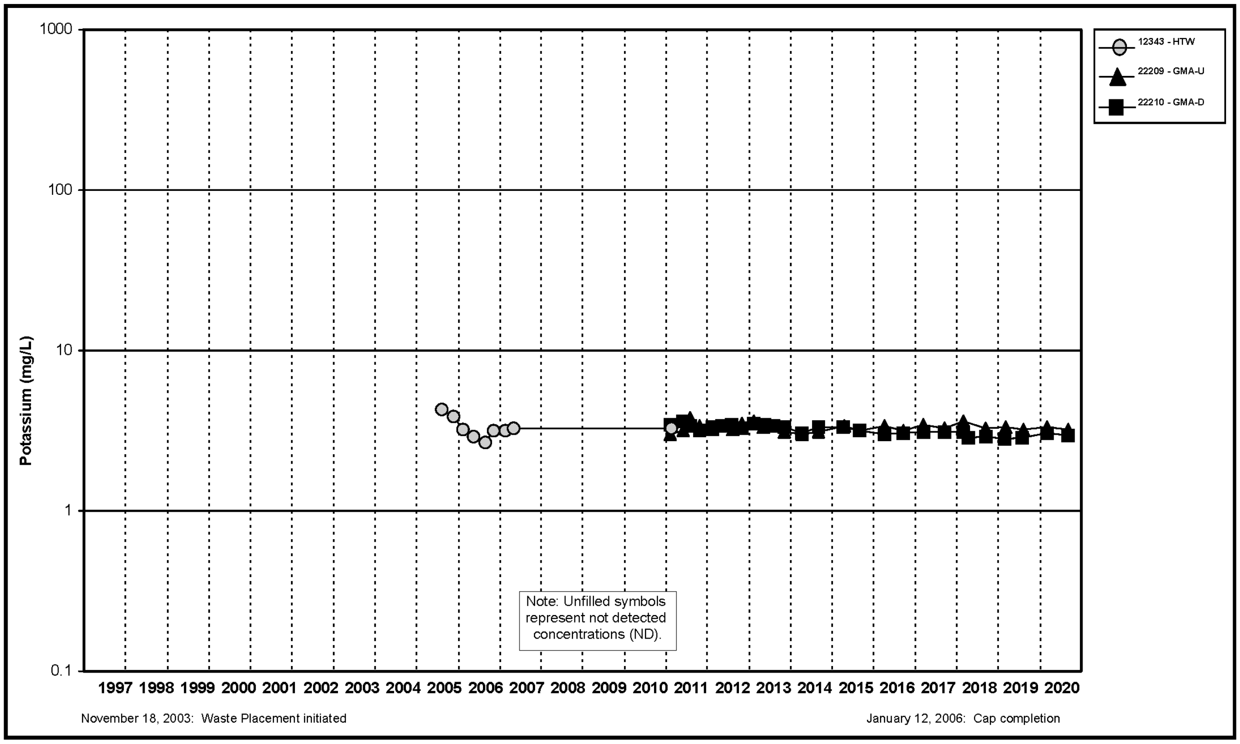

Figure A.5.6-13. Cell 6 Potassium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

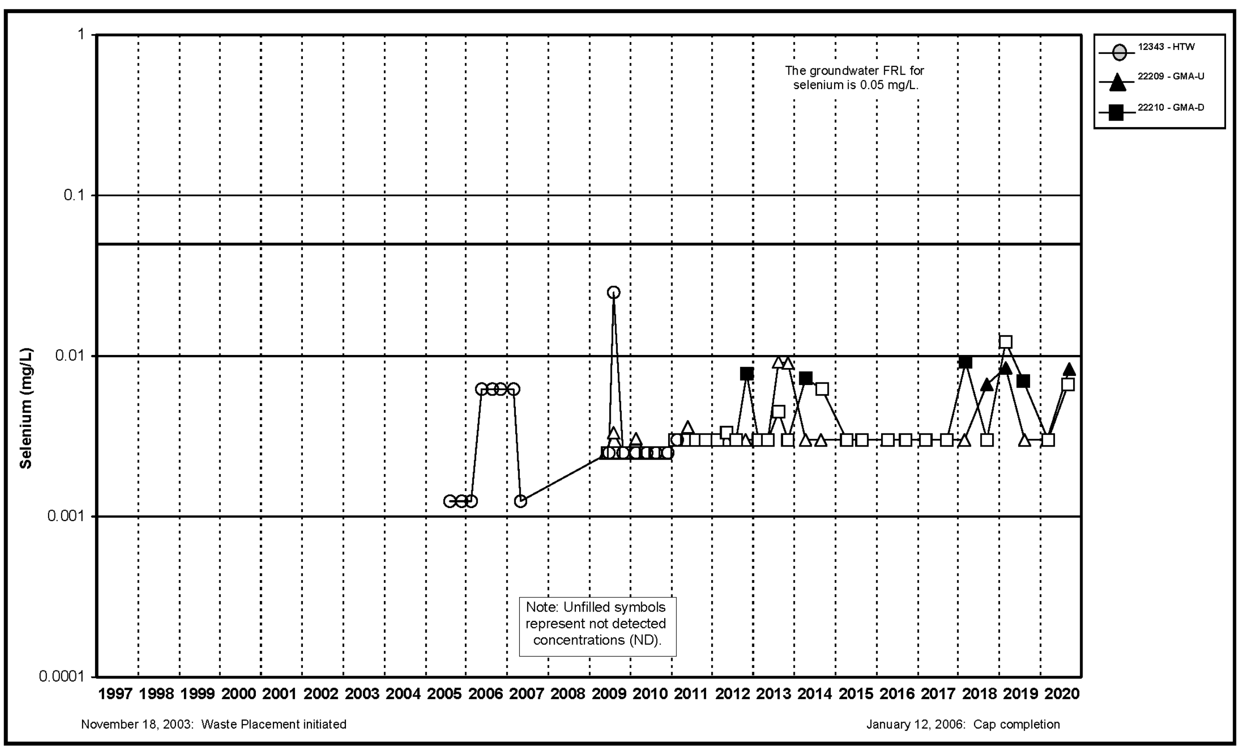

Figure A.5.6-14. Cell 6 Selenium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

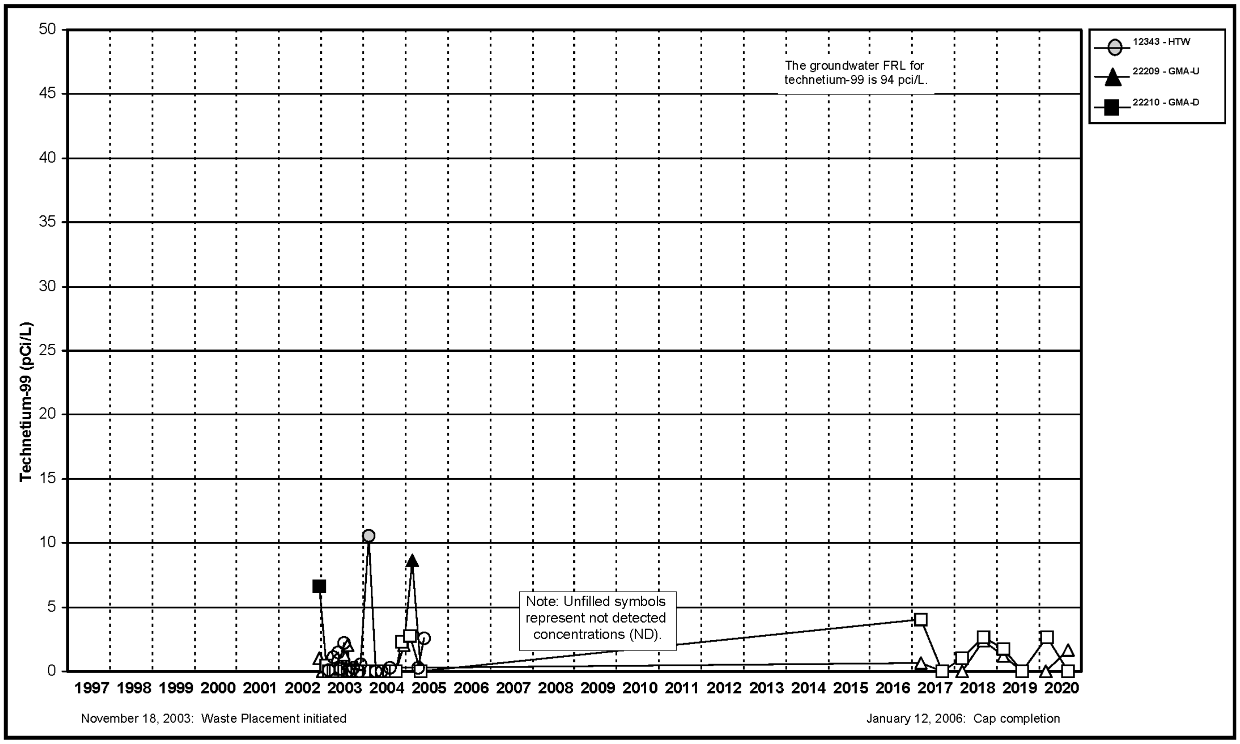

Figure A.5.6-15. Cell 6 Technetium-99 Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

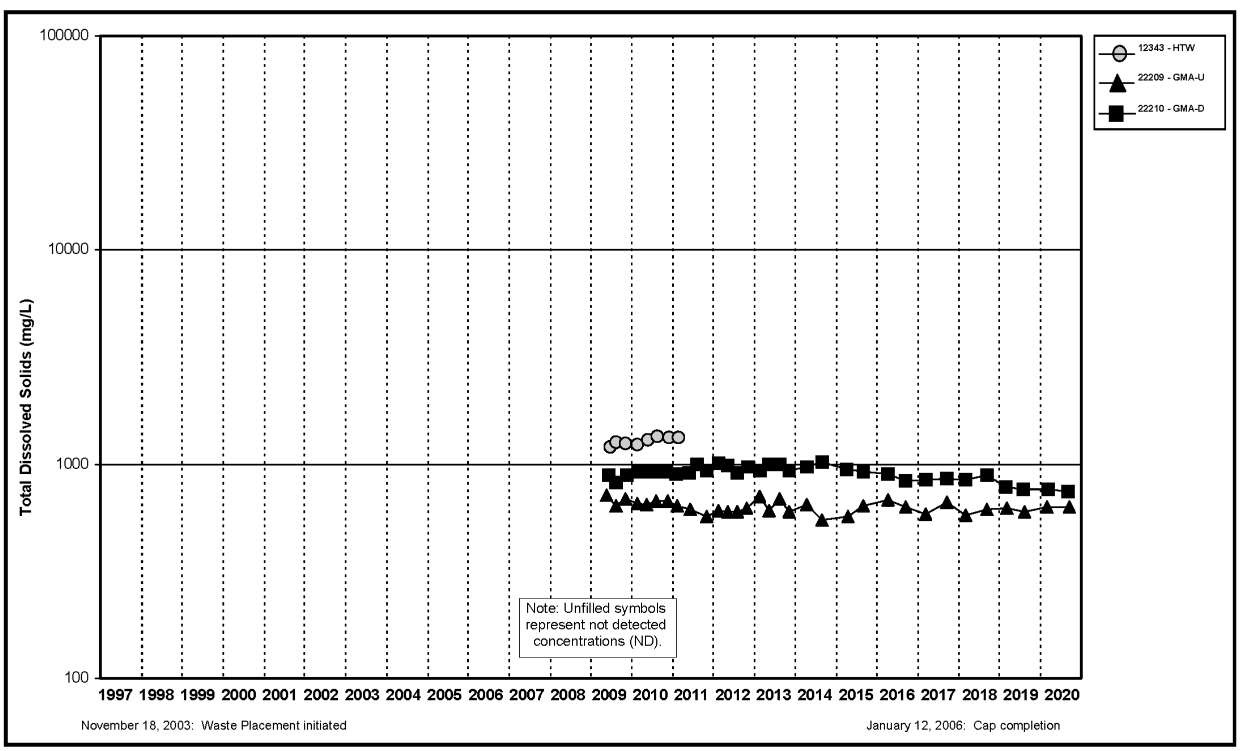

Figure A.5.6-16. Cell 6 Total Dissolved Solids Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

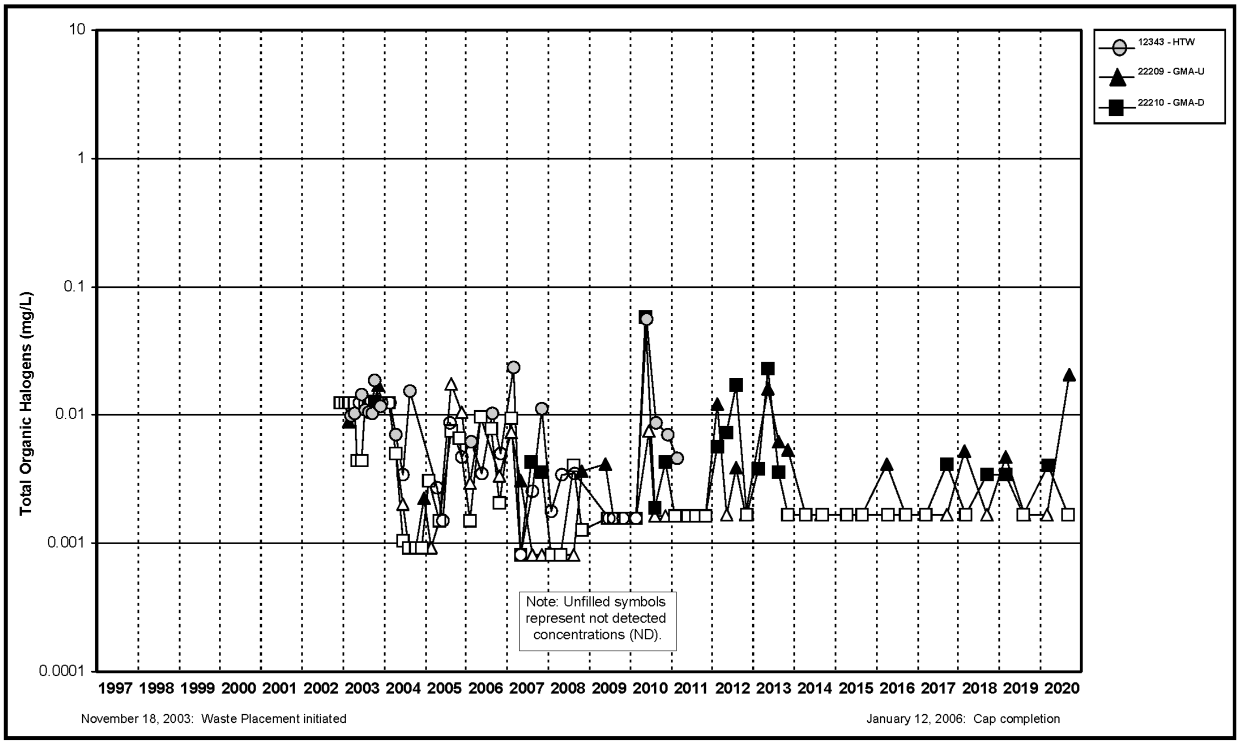

Figure A.5.6-17. Cell 6 Total Organic Halogens Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

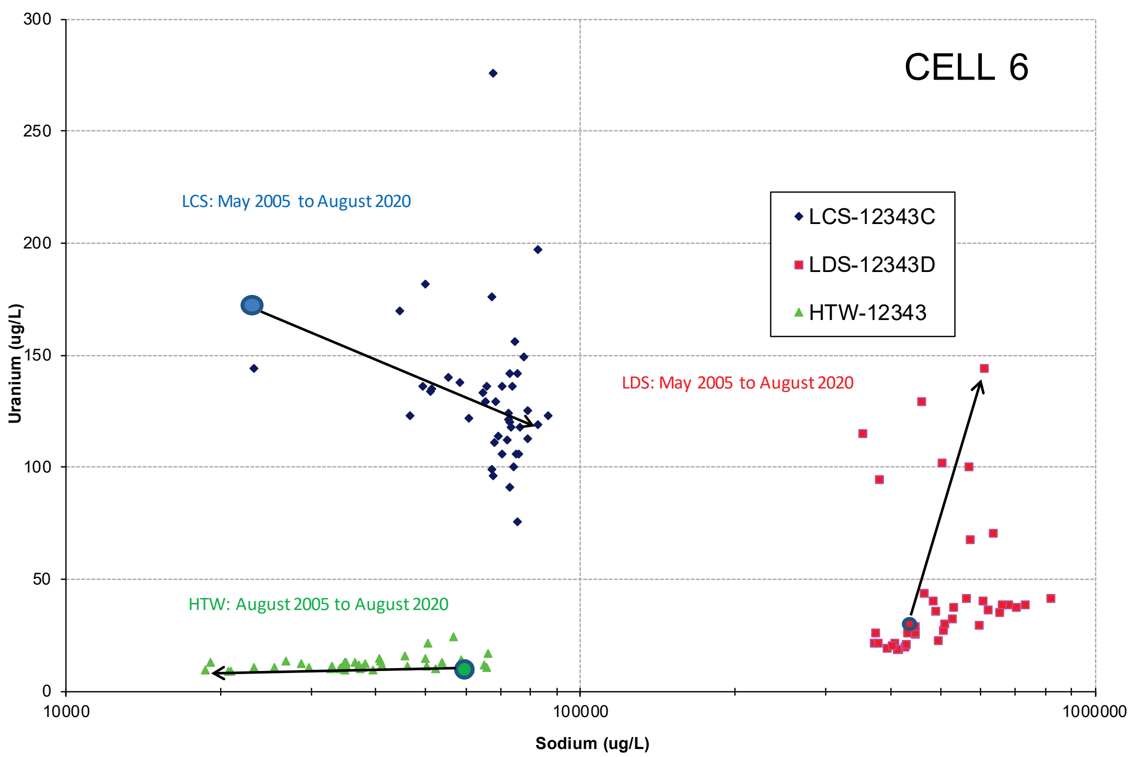

Figure A.5.6-18. Cell 6 Bivariate Plot for Uranium and Sodium

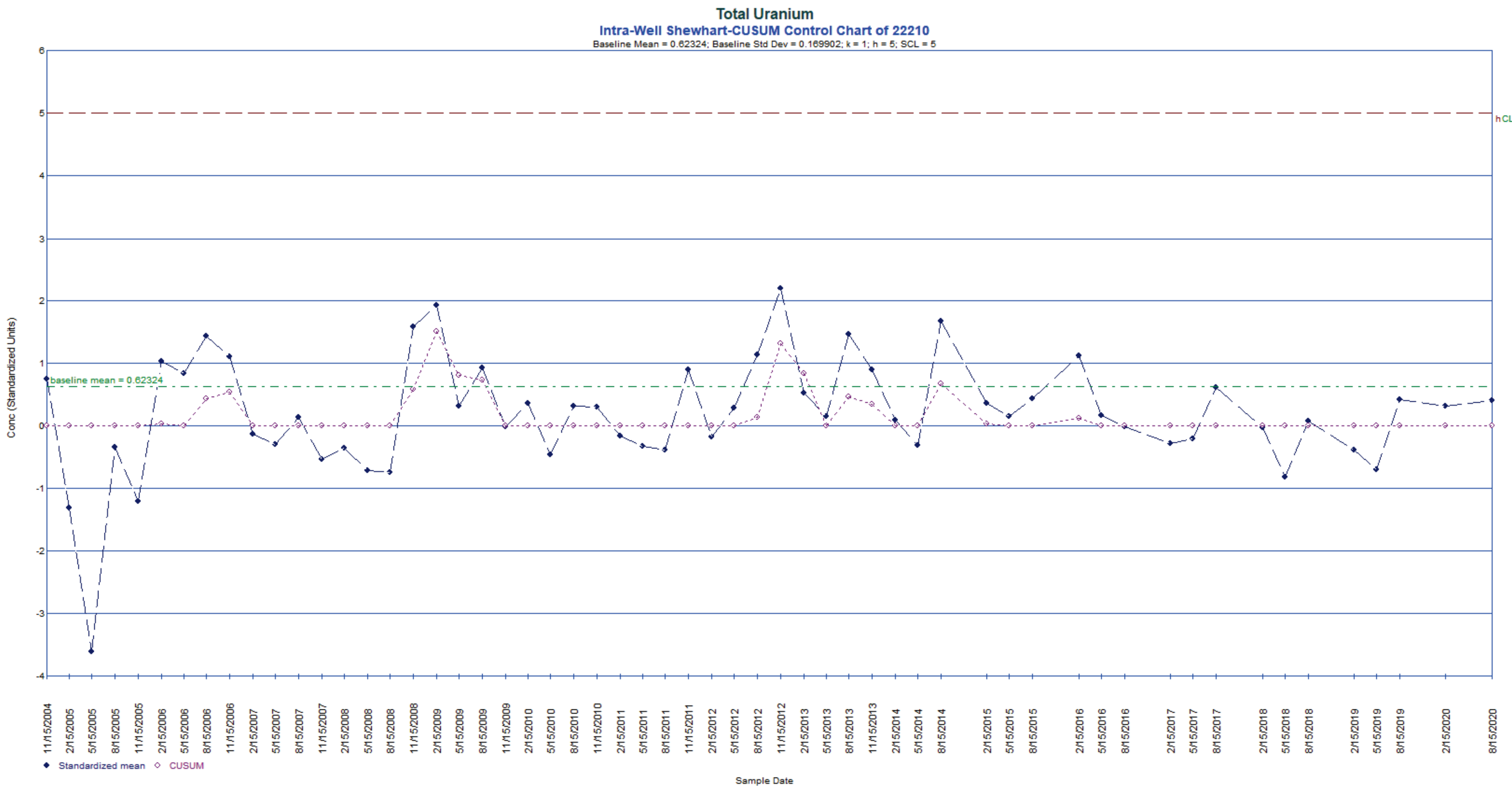

Figure A.5.6-19. Intrawell Shewhart-CUSUM Control Chart for Uranium in Monitoring Well 22210

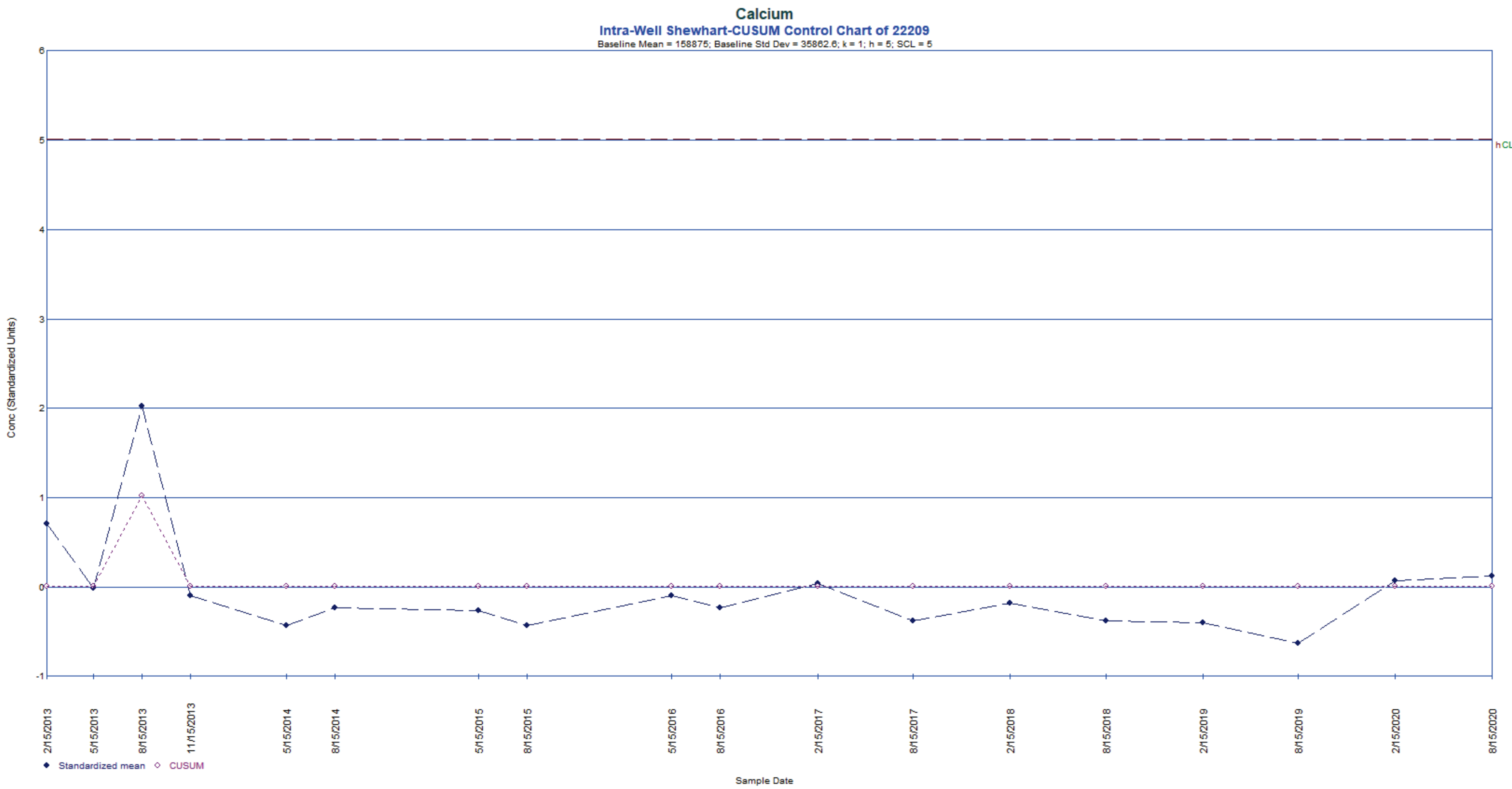

Figure A.5.6-20. Intrawell Shewhart-CUSUM Control Chart for Calcium in Monitoring Well 22209

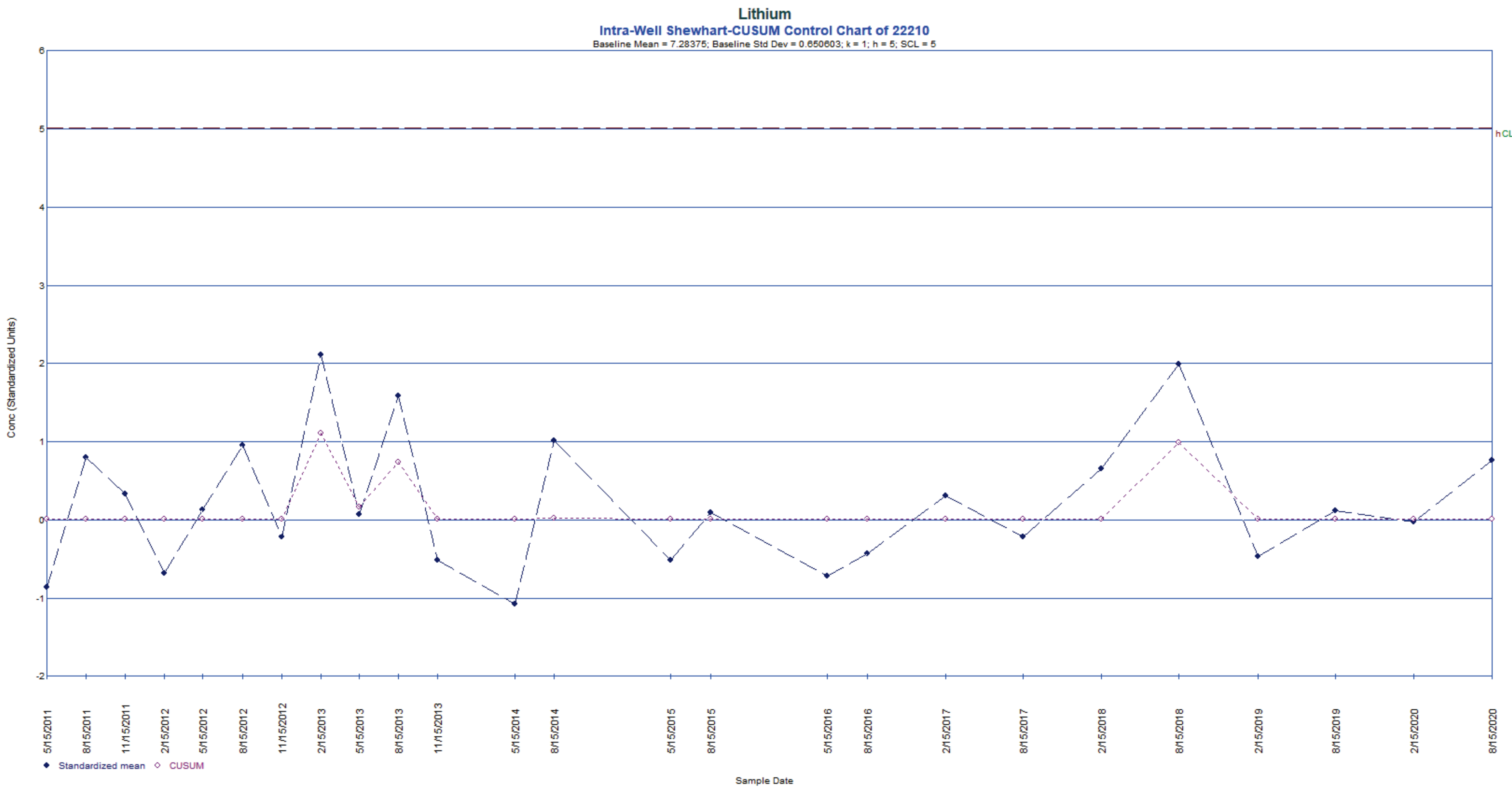

Figure A.5.6-21. Intrawell Shewhart-CUSUM Control Chart for Lithium in Monitoring Well 22210

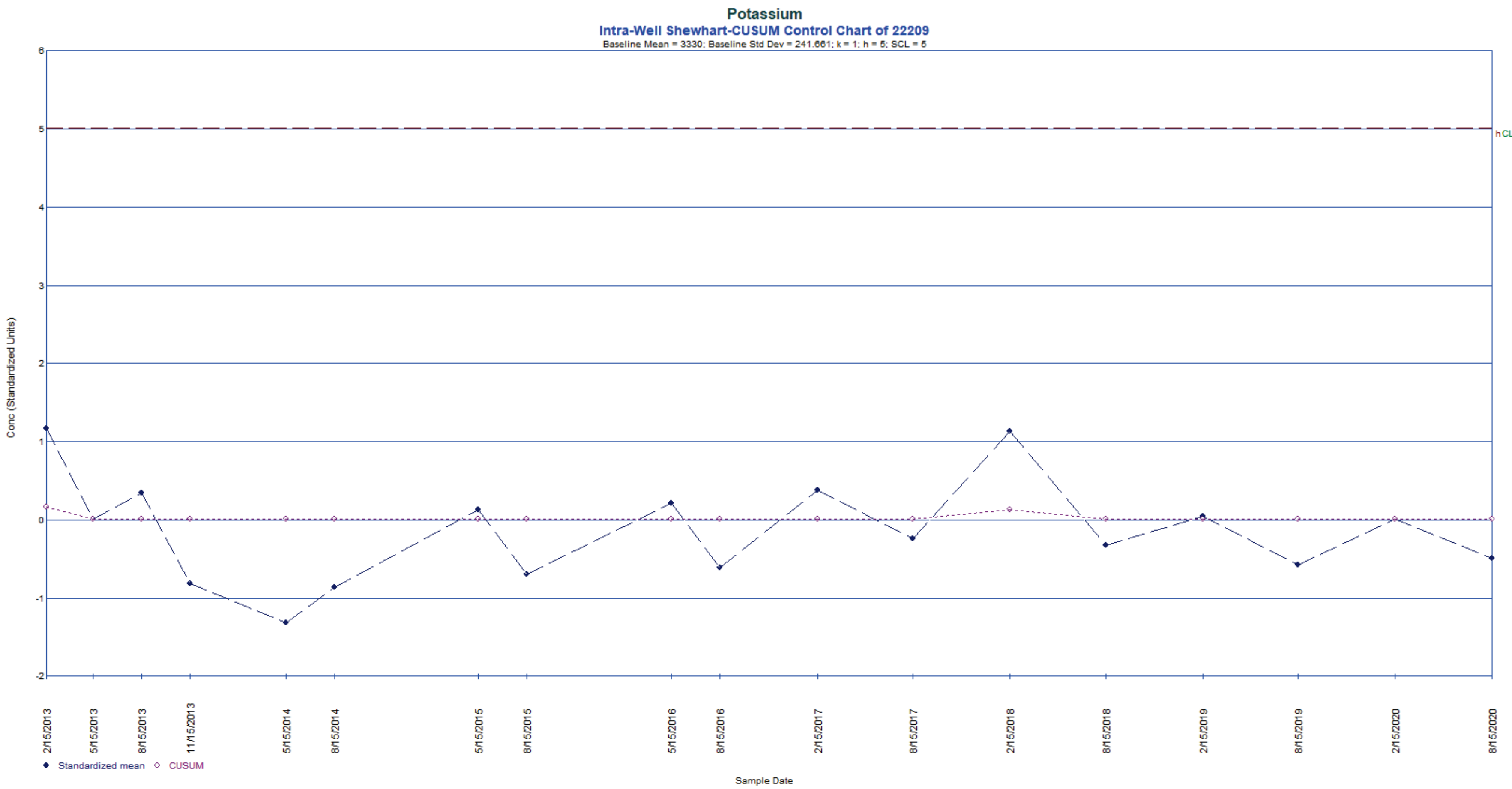

Figure A.5.6-22. Intrawell Shewhart-CUSUM Control Chart for Potassium in Monitoring Well 22209

Subattachment A.5.7

Cell 7

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Contents

Tables

Figures

Abbreviations

CUSUM	Shewhart-cumulative sum
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
GMA	Great Miami Aquifer
GMA-D	Great Miami Aquifer–downgradient
GMA-U	Great Miami Aquifer–upgradient
HTW	horizontal till well
LCS	leachate collection system
LDS	leak detection system
Ohio EPA	Ohio Environmental Protection Agency
OSDF	On-Site Disposal Facility
SCL	Shewhart control limit

Measurement Abbreviations

amsl	above mean sea level
µg/L	micrograms per liter
mg/L	milligrams per liter
pCi/L	picocuries per liter

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This subattachment provides the following information about the On-Site Disposal Facility (OSDF) Cell 7:

- Semiannual monitoring summary statistics (refer to Table A.5.7-1)
- Leachate collection system (LCS) monthly accumulation volumes (refer to Figure A.5.7-1)
- Leak detection system (LDS) monthly accumulation volumes (refer to Figure A.5.7-2)
- OSDF horizontal till well (HTW) 12344 water yield (refer to Table A.5.7-2)
- Great Miami Aquifer (GMA) water levels and total uranium concentration versus time (refer to Figures A.5.7-3 and A.5.7-4)
- Plots of concentration versus time (refer to Figures A.5.7-5A through A.5.7-17)
- A bivariate plot for uranium–sodium (refer to Figure A.5.7-18)
- Control charts (refer to Figures A.5.7-19 through A.5.7-24)

A.5.7.1 Water Quality Monitoring Results

Water quality within the cell is sampled in the LCS and LDS. Water quality beneath the cell is sampled in the HTW and GMA wells. Concentration-versus-time plots, bivariate plots, and control charts are used to help interpret and present the results.

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.

With EPA and Ohio EPA concurrence, DOE reduced the number of parameters sampled from 24 to 13 beginning in January 2017. All 13 parameters are sampled in the GMA wells; 4 of the 13 parameters (total uranium, boron, sodium, and sulfate) are sampled in the LCS, LDS, and HTW of each cell. The annual sampling in the LCS of each cell for the abbreviated list of Appendix I parameters and polychlorinated biphenyls listed in *Ohio Administrative Code* 3745-27-10 (OAC 3745-27-10) was also eliminated beginning in January 2017 with EPA and Ohio EPA concurrence (DOE 2017).

A.5.7.1.1 LCS and LDS Results

As shown in Table A.5.7-1 and summarized below, four parameters (total uranium, boron, sodium, and sulfate) have upward concentration trends in the LCS and/or LDS based on the Mann-Kendall test for trend. No new high concentrations were measured in the LCS of Cell 7 in 2020.The volume of water in the LDS tank of Cell 7 was insufficient to collect a sample in 2012 and 2013. Enough water was present to collect a sample in 2014 and 2015, but since 2015 the volume of water in the LDS tank of Cell 7 has been insufficient to collect a sample.

Parameters with Upward Concentration Trends in the LCS and LDS of Cell 7[a]

Parameter	LCS 12344C 2020 Trend	LDS 12344D Trend (Year Last Sampled)
Total Uranium		Up (2015)
Boron		Up (2015)
Sodium	Up	Up (2015)
Sulfate	Up	Up (2015)

[a] No entry indicates that the trend was not up.

A.5.7.1.2 HTW and Monitoring Well Results

As shown in Table A.5.7-1 and summarized below, five parameters (total uranium, boron, sodium, sulfate, and selenium) have upward concentration trends in the HTW and/or GMA wells based on the Mann-Kendall test for trend.

Parameters with Upward Concentration Trends in the HTW and GMA Wells of Cell 7[a]

Parameter	HTW 12344	GMA-U[b] 22212	GMA-D[b] 22211
Total Uranium	Up		
Boron		Up	Up
Sodium	Up		Up
Sulfate	Up		
Selenium		Up	

[a] No entry indicates that the trend was not up.
[b] GMA-U = upgradient Great Miami Aquifer; GMA-D = downgradient Great Miami Aquifer.

A.5.7.1.3 Discussion

The uranium–sodium bivariate plot for the Cell 7 LCS, LDS, and HTW is provided in Figure A.5.7-18. On the figure, the first sample ever collected from the monitoring horizon is circled. An arrow leads from the first sample to the location of the most recent sample. The plot shows that the chemical signatures for uranium and sodium in the LCS, LDS, and HTW are separate and distinct, indicating that mixing between the horizons is not occurring; therefore, upward concentration trends measured beneath the cells in GMA wells are attributed to fluctuating ambient concentrations beneath the cell and are not related to cell performance.

A.5.7.2 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. 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 “not in 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. Usually, two parameters are used to compute standardized limits—the decision value (*h*) and the Shewhart control limit (SCL).

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 eight samples were selected for control charts. By default, the ChemStat software plots both a CUSUM control limit (*h*) and an SCL on the control chart. The software recommends a value of 5 for the CUSUM control limit and a value of 4.5 for the SCL.

EPA Statistical Analysis 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 is not needed. The ChemStat software though, by default, plots both the SCL and CUSUM control limit on the charts. To address this issue, the SCL was defined as 5 to equal the recommended CUSUM (*h*) limit. This combined limit is identified as *h*CL on the control charts. For interpretation purposes, the *h*CL value will be regarded as the CUSUM (*h*) limit.

As shown in Table A.5.7-1 in gray shading and as summarized below, six parameters in the HTW and/or GMA wells of Cell 7 (total uranium, boron, calcium, lithium, magnesium, and potassium) meet the criteria for control charts (i.e., at least eight samples, normal or lognormal distribution, no trend, and no serial correlation), resulting in six control charts (Figures A.5.7-19 through A.5.7-24). All of the control charts exhibit “in control” conditions.

Parameter	Monitoring Point[a]	Monitoring Well	Assessment	Figure Number
Total Uranium	GMA-U	22212	In Control	A.5.7-19
Boron	HTW	12344	In Control	A.5.7-20
Calcium	GMA-U	22212	In Control	A.5.7-21
Lithium	GMA-D	22211	In Control	A.5.7-22
Magnesium	GMA-U	22212	In Control	A.5.7-23
Potassium	GMA-U	22212	In Control	A.5.7-24

[a] GMA-U = upgradient Great Miami Aquifer; GMA-D = downgradient Great Miami Aquifer, HTW = Horizontal Till Well.

A.5.7.3 Summary and Conclusions

- Two parameters monitored semiannually in 2020 have an upward concentration trend in the LCS of Cell 7: sodium and sulfate. No new high concentrations were measured in the LCS of Cell 7 in 2020.
- The volume of water in the LDS tank of Cell 7 was insufficient to collect a sample in 2020.
- Five parameters monitored semiannually have an upward concentration trend in the HTW or GMA wells of Cell 7: total uranium, boron, sodium, sulfate, and selenium. Separate and distinct chemical signatures for total uranium and sodium in the LCS, LDS, and HTW of Cell 7 indicate that water is not mixing between the horizons. Therefore, upward concentration trends beneath Cell 7 (i.e., HTW and/or GMA wells) are attributed to fluctuating ambient concentrations beneath the cell, and not to cell performance.
- Six control charts were constructed for Cell 7 parameters. All of the control charts exhibit “in control” conditions.

A.5.7.4 References

DOE (U.S. Department of Energy), 2017. *Fernald Preserve 2016 Site Environmental Report*, LMS/FER/S15232, Office of Legacy Management, Cincinnati, Ohio, May.

EPA (U.S. Environmental Protection Agency), 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities—Unified Guidance*, EPA 530/R-09-007, March.

OAC 3745-27-10. "Ground Water Monitoring Program for a Sanitary Landfill Facility," *Ohio Administrative Code.*

Table A.5.7-1. Summary Statistics for Cell 7

Parameter	Horizon[a]	Location	Number of Detected Samples	Total Number of Samples	Percent Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[d]	Distribution Type[d,e]	Trend[d,f] (Year Last Sampled)	Serial Correlation[d,g]	Outliers[h,i]
Total Uranium (µg/L)	LCS	12344C	51	51	100	36.2	264	160	44	Normal	Down (2020)	Not Detected	4.72 (Q3-04); 355 (Q3-07)
	LDS	12344D	31	31	100	12.2	37.6	25.7	26.4	Normal	Up (2015)	Detected	169 (Q2-14)
	HTW	12344	51	51	100	2.00	8.61	3.73	1.53	Undefined	Up (2020)	Detected	12.1 (Q4-13)
	GMA-U	22212	48	53	90.6	ND	0.634	0.432	0.101	Normal	None (2020)	Not Detected	1.64 (Q1-04); 4.46 (Q1-05); 1.70 (Q1-07); 1.73 (Q3-10); 5.53 (Q3-11)
	GMA-D	22211	56	60	93.3	ND	4.06	0.347	0.677	Undefined	None (2020)	Not Detected	
Boron (mg/L)	LCS	12344C	51	51	100	0.0625	1.35	1.12	0.33	Undefined	Down (2020)	Detected	
	LDS	12344D	31	31	100	0.168	2.10	0.360	0.425	Undefined	Up (2015)	Detected	
	HTW	12344	27	35	77.1	ND	0.0750	0.0252	0.0122	Ln Normal	None (2020)	Not Detected	
	GMA-U	22212	51	53	96.2	ND	0.0486	0.0376	0.00560	Normal	Up (2020)	Detected	0.0151 (Q3-08); 0.0607 (Q3-20)
	GMA-D	22211	50	53	94.3	ND	0.0622	0.0329	0.0088	Undefined	Up (2020)	Detected	
Sodium (mg/L)	LCS	12344C	44	44	100	51.8	121	95.1	16.5	Normal	Up (2020)	Detected	18.1 (Q2-05); 19.4 (Q3-05); 26.8 (Q4-05)
	LDS	12344D	24	24	100	186	1590	587	374	Undefined	Up (2015)	Detected	
	HTW	12344	39	39	100	19.8	37.9	33.5	5.9	Undefined	Up (2020)	Detected	
	GMA-U	22212	33	33	100	15.5	27.0	20.2	3.0	Normal	Down (2020)	Detected	
	GMA-D	22211	34	34	100	10.1	19.2	14.3	2.5	Normal	Up (2020)	Detected	
Sulfate (mg/L)	LCS	12344C	51	51	100	122	5070	3630	1260	Undefined	Up (2020)	Detected	
	LDS	12344D	31	31	100	1280	7370	1770	1880	Undefined	Up (2015)	Detected	
	HTW	12344	46	46	100	80.4	765	400	261	Undefined	Up (2020)	Detected	
	GMA-U	22212	53	53	100	96.6	731	179	114	Undefined	None (2020)	Detected	
	GMA-D	22211	53	53	100	117	572	302	118	Ln Normal	None (2020)	Detected	3,640 (Q3-12)
Calcium (mg/L)	GMA-U	22212	26	26	100	140	177	155	10	Ln Normal	None (2020)	Not Detected	377 (Q3-11)
	GMA-D	22211	26	26	100	136	263	189	37	Normal	Down (2020)	Detected	
Lithium (mg/L)	GMA-U	22212	33	33	100	0.00474	0.00732	0.00556	0.00058	Normal	None (2020)	Detected	0.00892 (Q3-10); 0.00810 (Q3-11)
	GMA-D	22211	33	33	100	0.00555	0.00930	0.00702	0.00088	Normal	None (2020)	Not Detected	
Magnesium (mg/L)	GMA-U	22212	26	26	100	28.6	41.5	34.9	2.6	Normal	None (2020)	Not Detected	54.6 (Q3-11)
	GMA-D	22211	26	26	100	34.6	64.7	47.1	8.6	Normal	Down (2020)	Not Detected	
Nitrate + Nitrite, as Nitrogen (mg/L)	GMA-U	22212	2	26	7.8	ND	0.0425	Insuffficient	Insufficient	Insufficient	Insufficient	Insufficient	
	GMA-D	22211	3	26	11.5	ND	0.0425	0.0173	Insufficient	Insufficient	Insufficient	Insufficient	
Potassium (mg/L)	GMA-U	22212	26	26	100	3.05	3.81	3.47	0.17	Normal	None (2020)	Not Detected	4.81 (Q3-11)
	GMA-D	22211	27	27	100	2.42	3.65	2.93	0.32	Normal	Down (2020)	Detected	
Selenium (mg/L)	GMA-U	22212	5	33	15.2	ND	0.0140	0.00300	0.00327	Undefined	Up (2020)	Detected	
	GMA-D	22211	2	33	6.1	ND	0.00893	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
Technitium-99 (pCi/L)	GMA-U	22212	1	18	5.6	ND	11.0	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
	GMA-D	22211	0	18	0	ND	NA	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
Total Dissolved Solids (mg/L)	GMA-U	22212	33	33	100	519	854	652	63	Normal	None (2020)	Detected	1,130 (Q2-10); 1,270 (Q3-10); 1,510 (Q3-11)
	GMA-D	22211	33	33	100	583	1350	897	214	Normal	Down (2020)	Detected	
Total Organic Halogens (mg/L)	GMA-U	22212	20	53	37.7	ND	0.0125	0.00313	0.00283	Undefined	None (2020)	Not Detected	0.0500 (Q2-10); 0.0190 (Q2-13)
	GMA-D	22211	17	53	32.1	0.000620	0.023	0.00166	0.00410	Undefined	None (2020)	Not Detected	0.0540 (Q2-10)

Note 1: Shading identifies a horizontal till well or Great Miami Aquifer well, with at least eight samples, Normal or Ln Normal distribution, no trend (None), and no serial correlation (Not Detected). These wells achieve control chart criteria.

Note 2: Data used in this table has been standardized to quarterly.

[a]LCS = leachate collection system; LDS = leak detection system; HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; and GMA-D = downgradient Great Miami Aquifer

[b]ND = not detected; NA = not applicable

[c]Averages were determined based on the distribution assumption.

[d]Insufficient is used for Distribution Type, Trend, or Serial Correlation whenever there is not enough data to run the test.

[e]Data distribution based on the Shapiro-Wilk statistic.

Normal: Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the Ln Normal assumption.

LN Normal: Ln Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the Normal assumption.

Undefined: Normal and Lognormal Distribution assumptiions are both rejected or there are less than 25 percent detected values. "Average" is defined as the Median of the data.

[f]Trend based on nonparametric Mann-Kendall procedure.

[g]Serial correlation based on Rank Von Neumann test.

[h]Outliers determined by Rosner's (for sample sizes greater than 25) or Dixon procedure (for sample sizes less than or equal to 25).

[i]Q = quarter

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Table A.5.7-2. Horizontal Till Well 12344 Water Yield

Year	Total Volume Purged (gallons)	Number of Months Purged	Average Volume Purged (gallons)
2004	2,380	6	264
2005	2,475	5	495
2006	2,375	4	594
2007	1,300	4	325
2008	2,800	4	700
2009	825	4	275
2010	675	4	169
2011	675	4	169
2012	815	4	204
2013	1,125	4	281
2014	455	2	228
2015	650	2	325
2016	665	2	333
2017	720	2	360
2018	955	2	478
2019	1520	2	760
2020	960	2	480

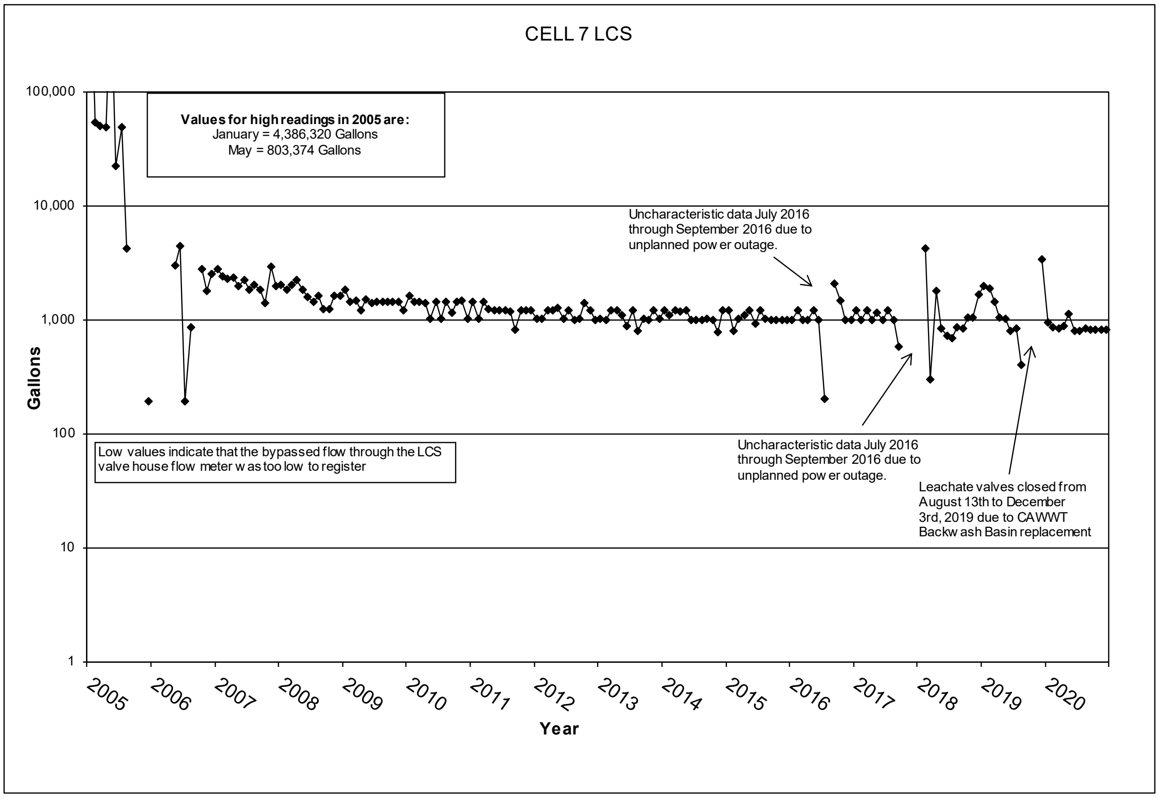

Figure A.5.7-1. Monthly Accumulation Volumes for Cell 7 LCS

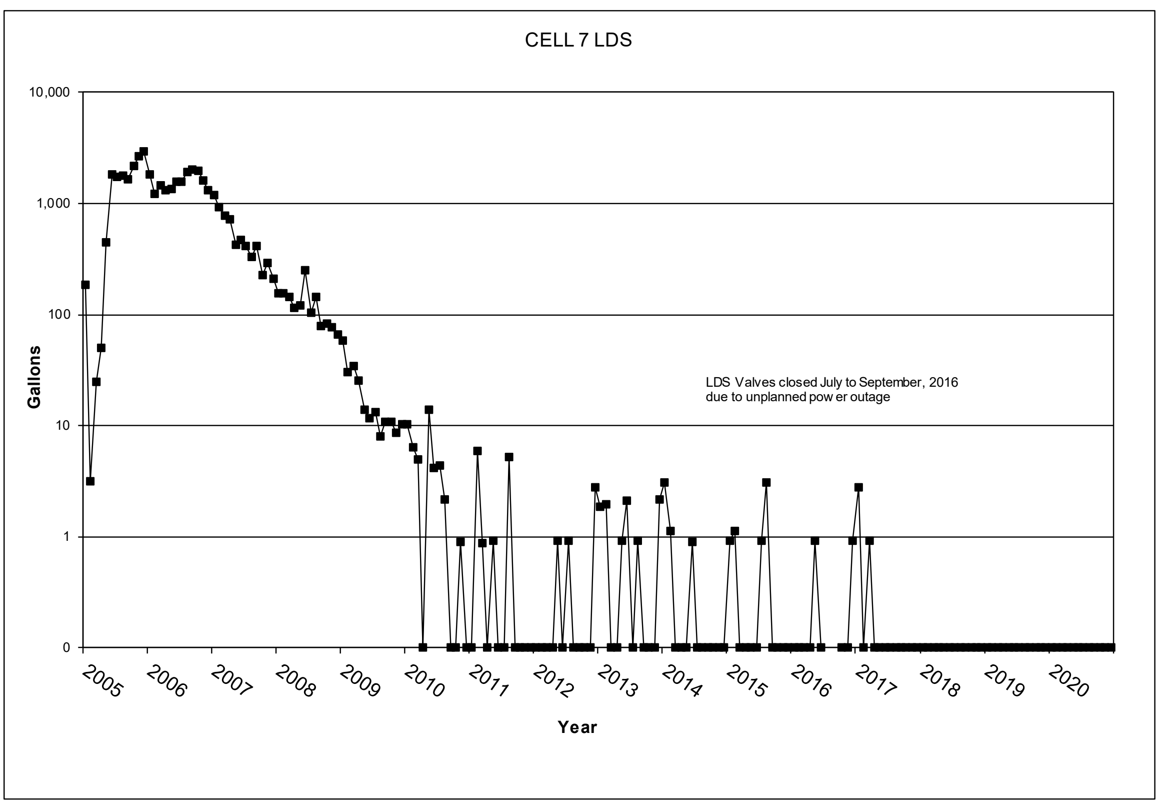

Figure A.5.7-2. Monthly Accumulation Volumes for Cell 7 LDS

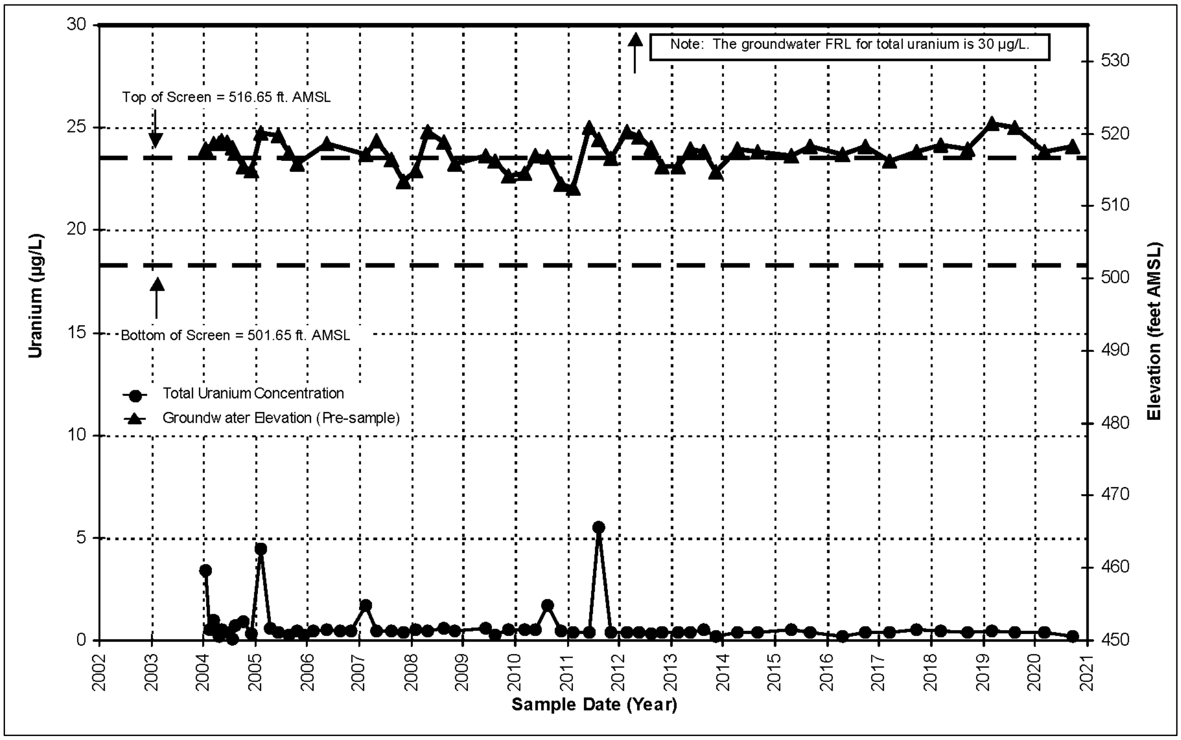

Figure A.5.7-3. Total Uranium Concentration and Groundwater Elevation Versus Time Plot for Cell 7 Upgradient Monitoring Well 22212

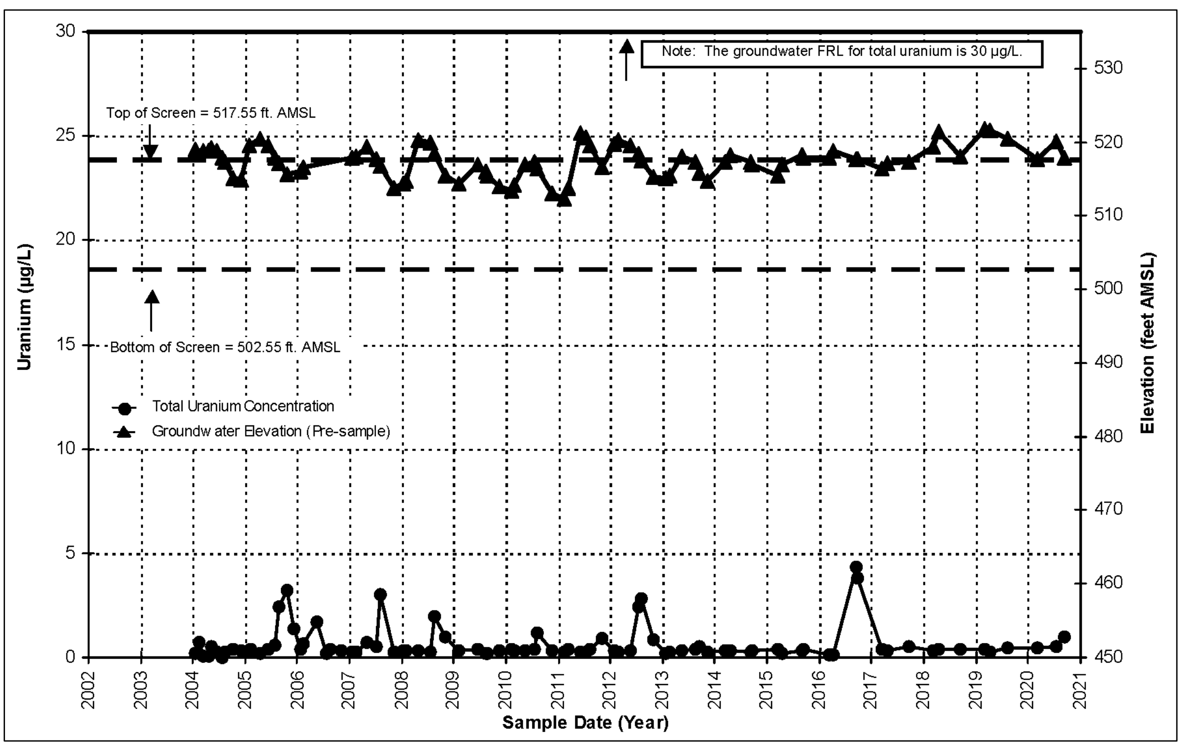

Figure A.5.7-4. Total Uranium Concentration and Groundwater Elevation Versus Time Plot for Cell 7 Downgradient Monitoring Well 22211

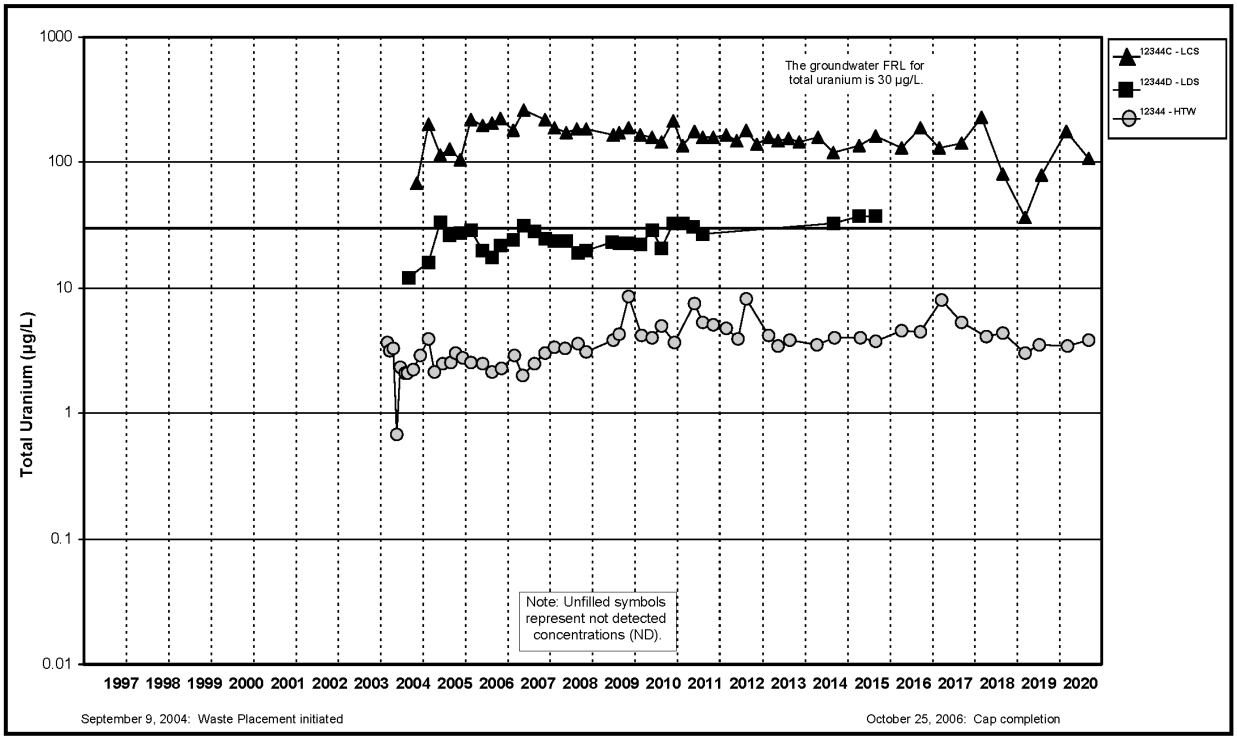

Figure A.5.7-5A. Cell 7 Total Uranium Concentration Versus Time Plot for LCS, LDS, and HTW

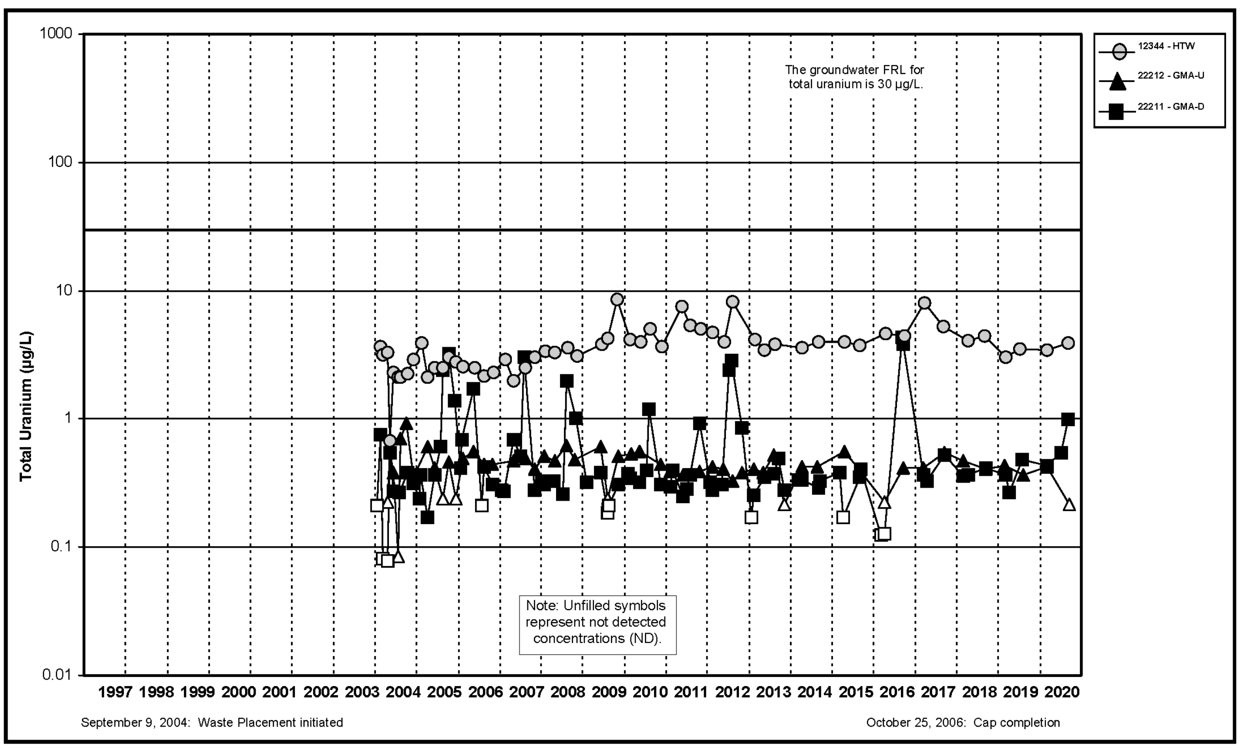

Figure A.5.7-5B. Cell 7 Total Uranium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

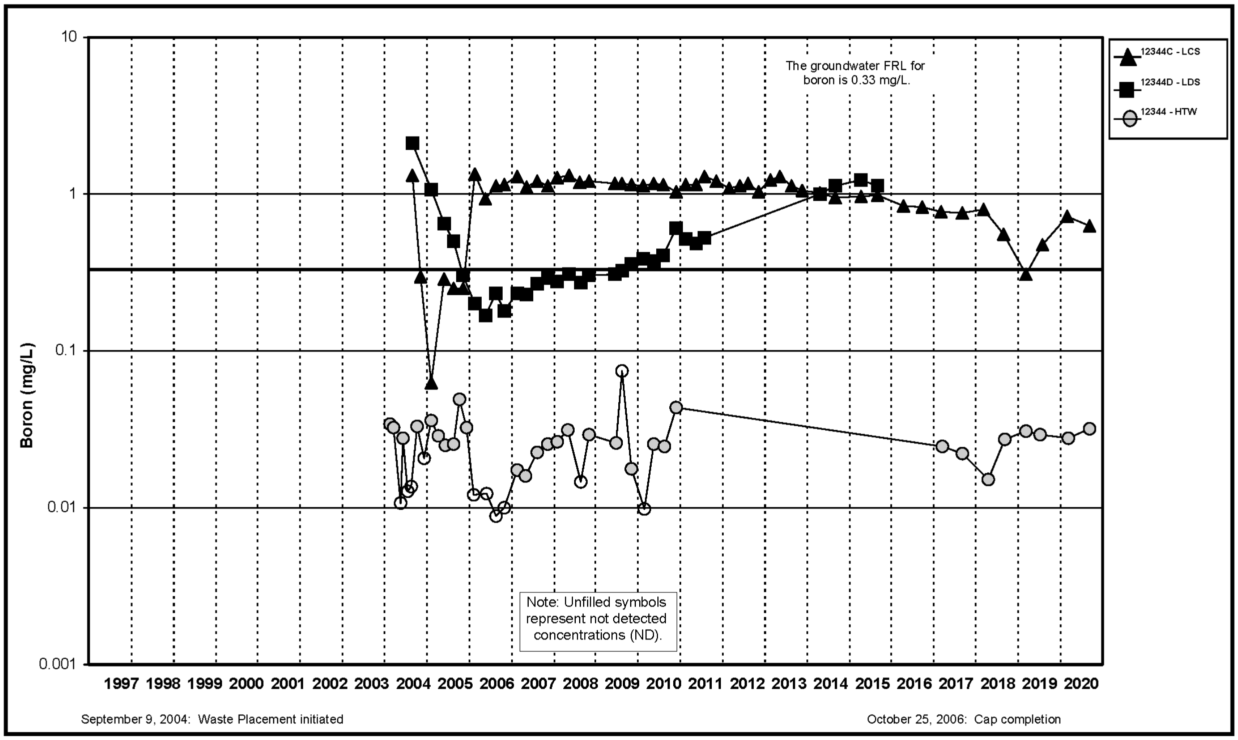

Figure A.5.7-6A. Cell 7 Boron Concentration Versus Time Plot for LCS, LDS, and HTW

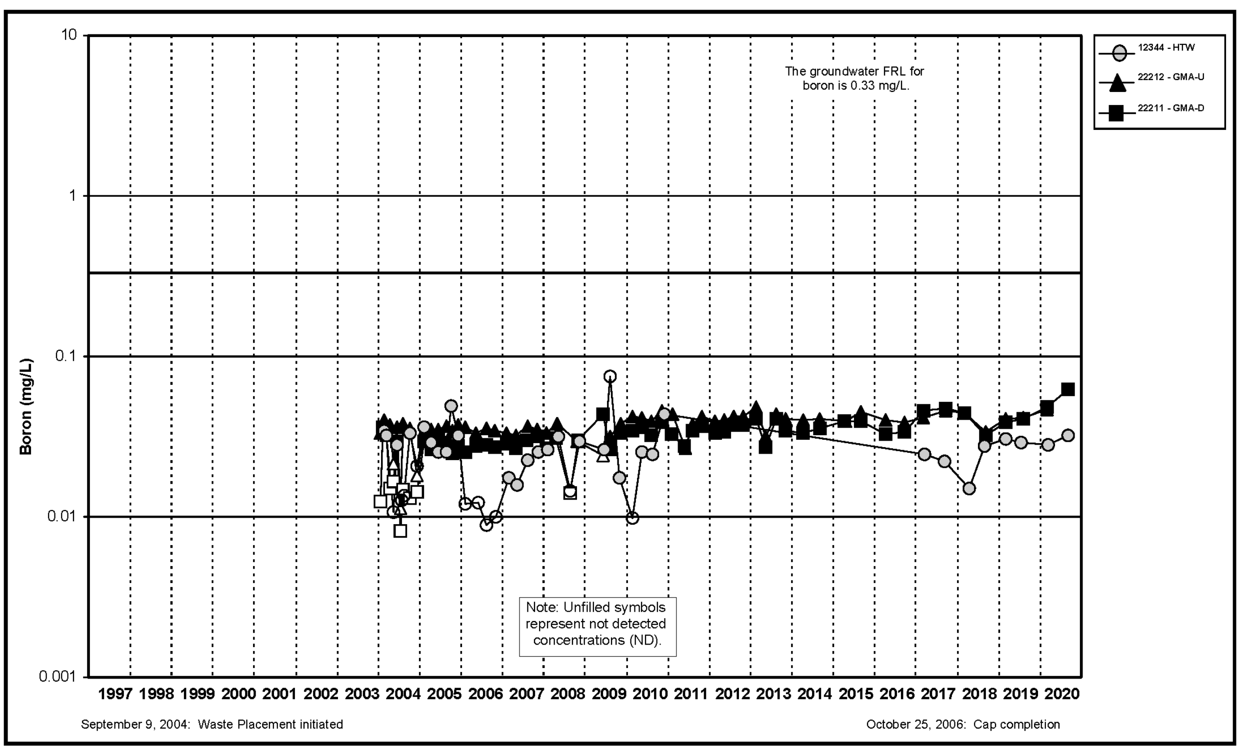

Figure A.5.7-6B. Cell 7 Boron Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

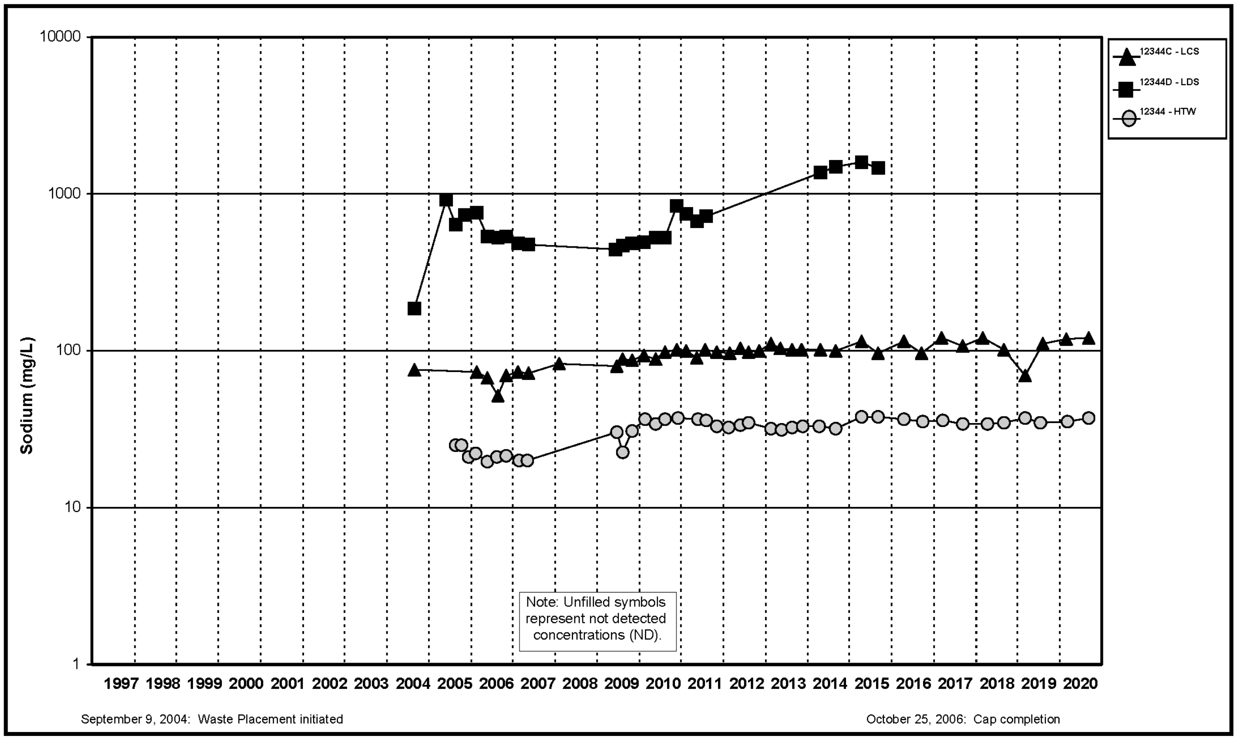

Figure A.5.7-7A. Cell 7 Sodium Concentration Versus Time Plot for LCS, LDS, and HTW

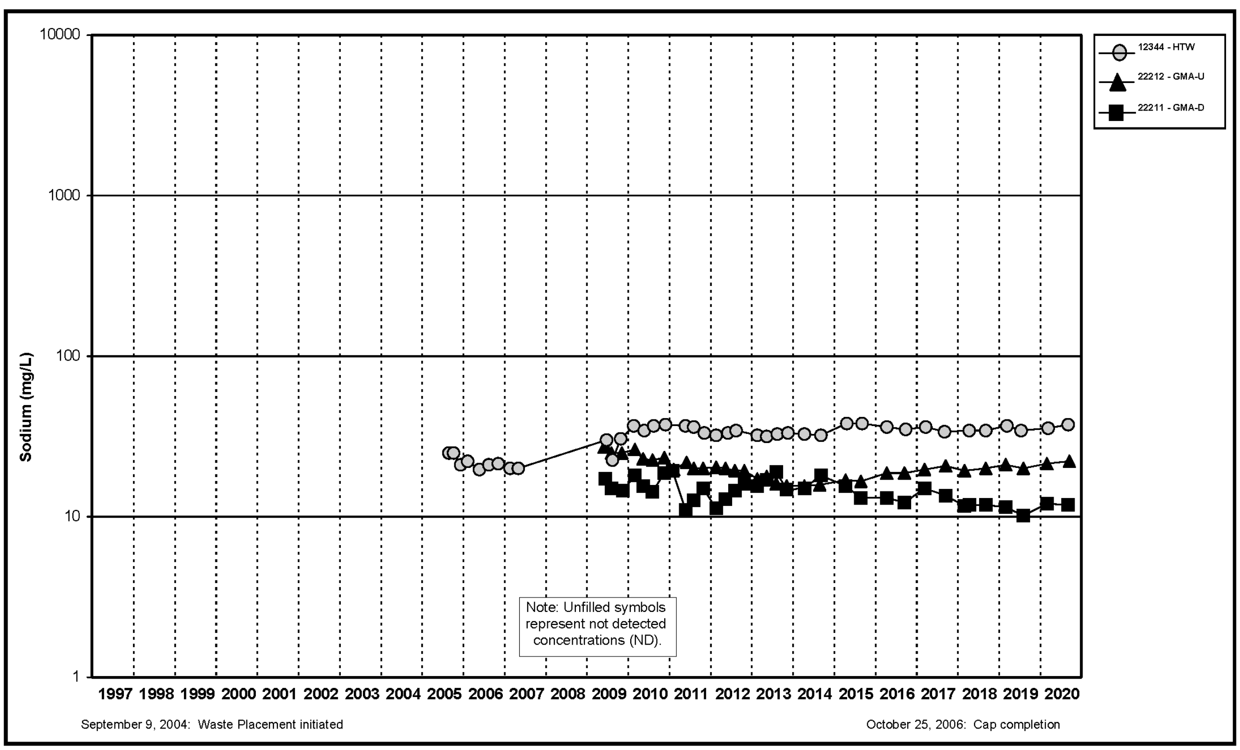

Figure A.5.7-7B. Cell 7 Sodium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

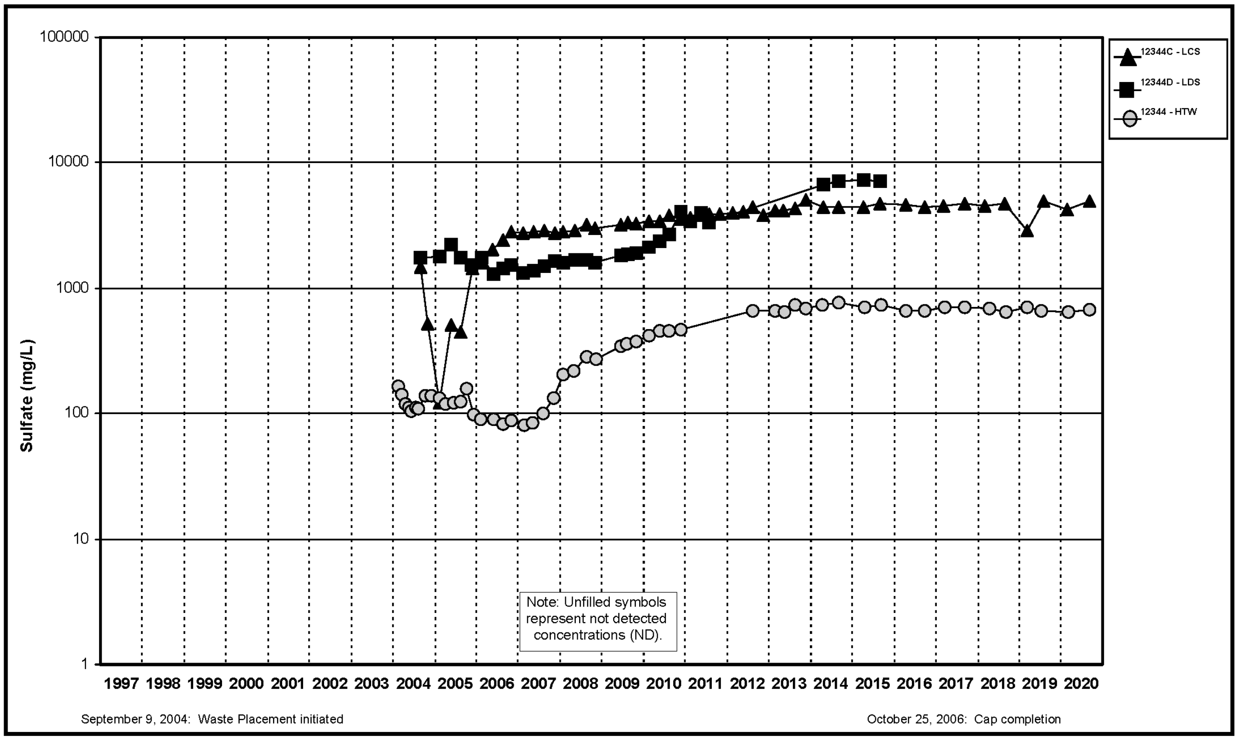

Figure A.5.7-8A. Cell 7 Sulfate Concentration Versus Time Plot for LCS, LDS, and HTW

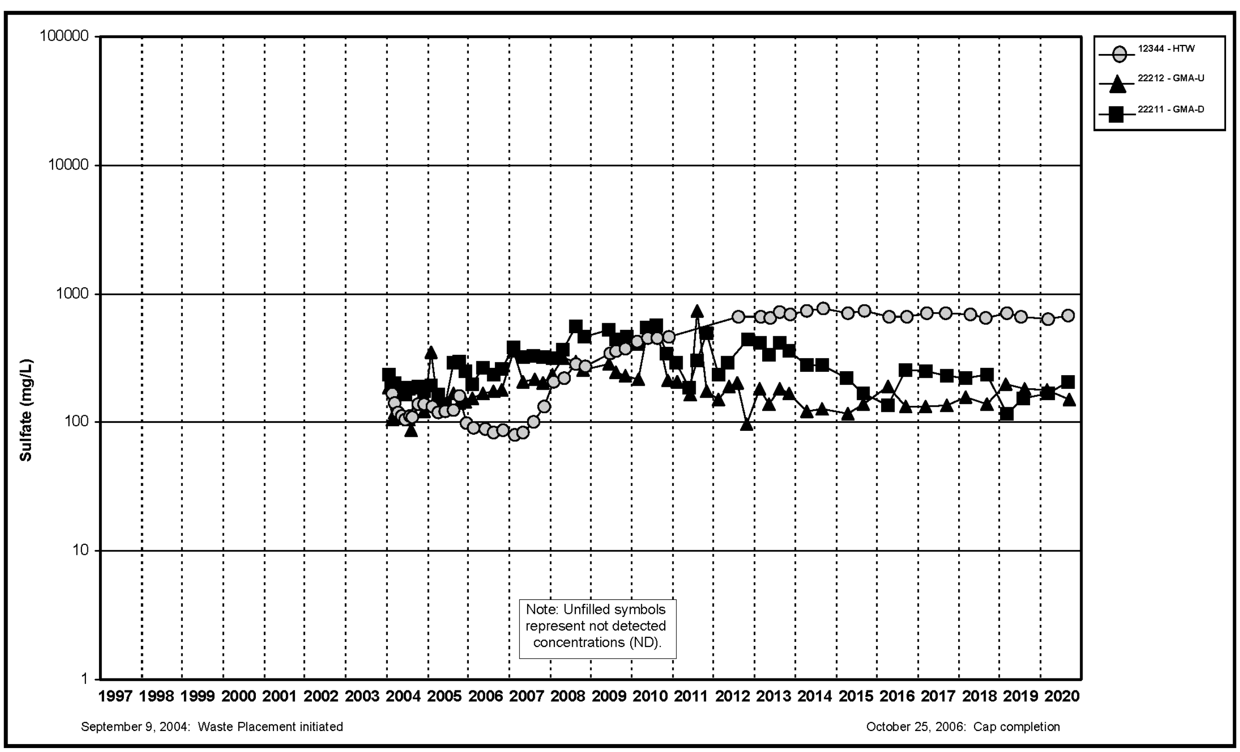

Figure A.5.7-8B. Cell 7 Sulfate Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

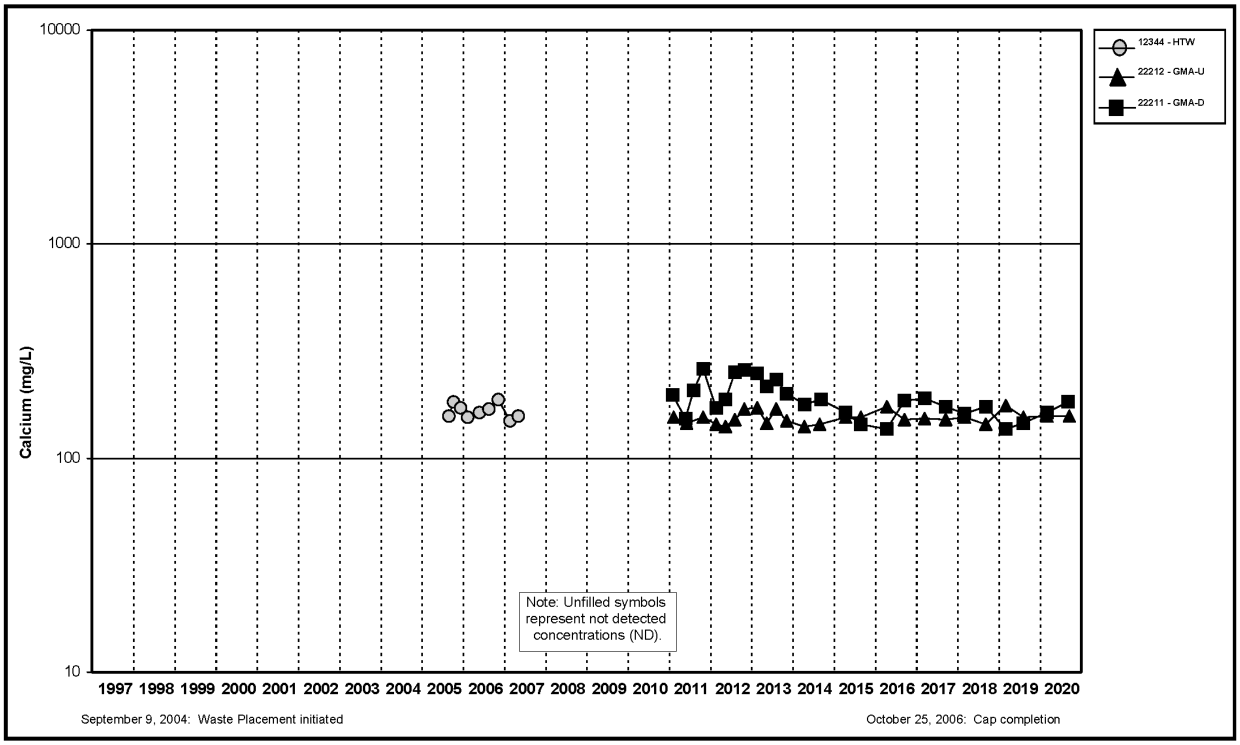

Figure A.5.7-9. Cell 7 Calcium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

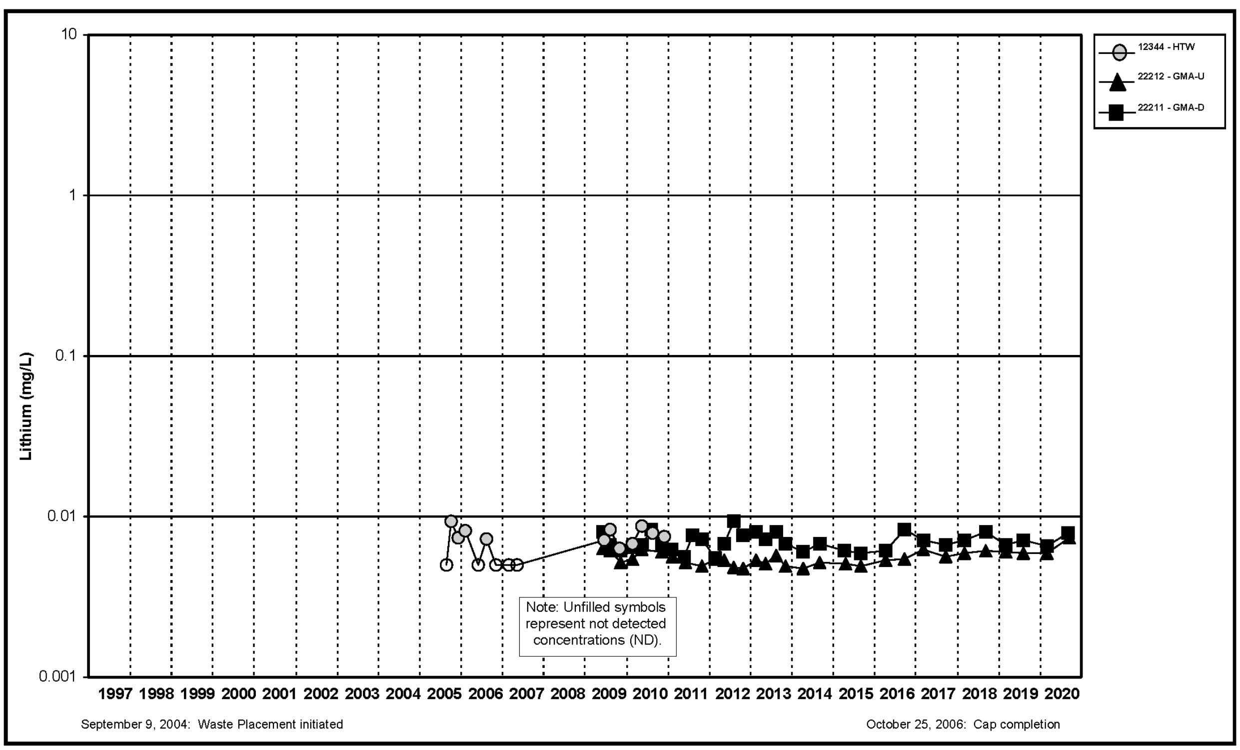

Figure A.5.7-10. Cell 7 Lithium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

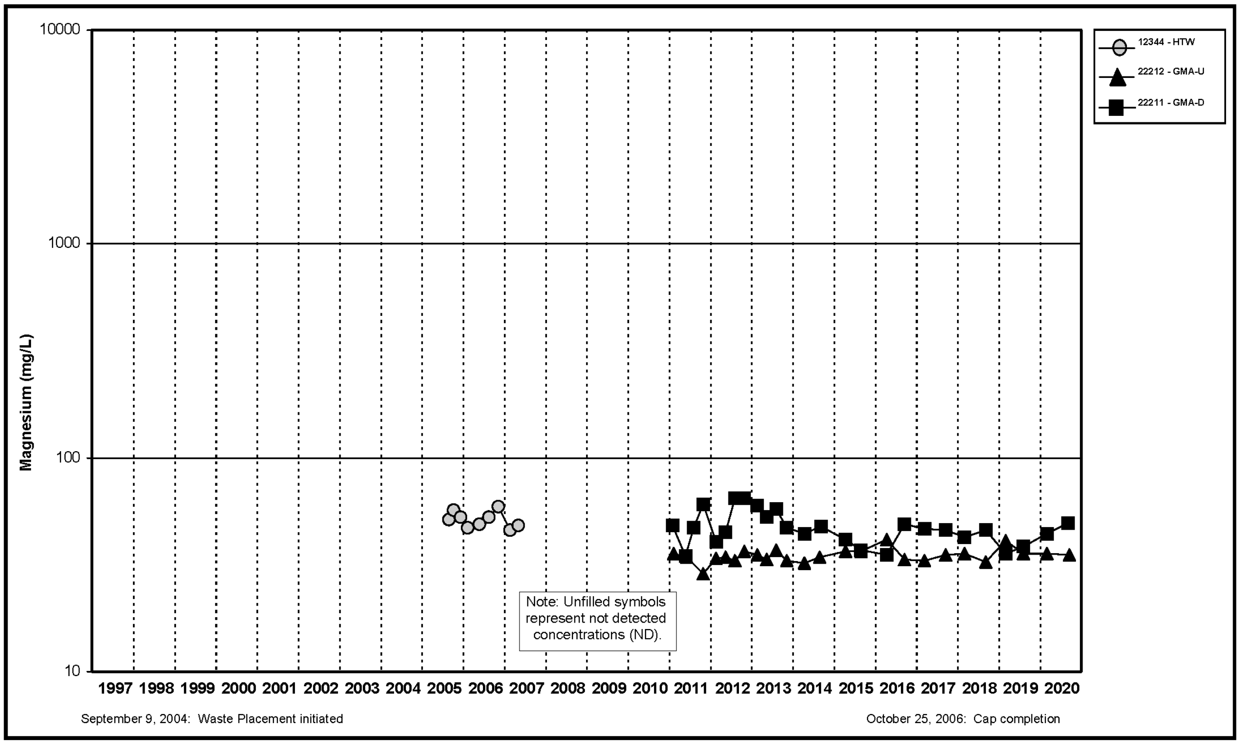

Figure A.5.7-11. Cell 7 Magnesium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

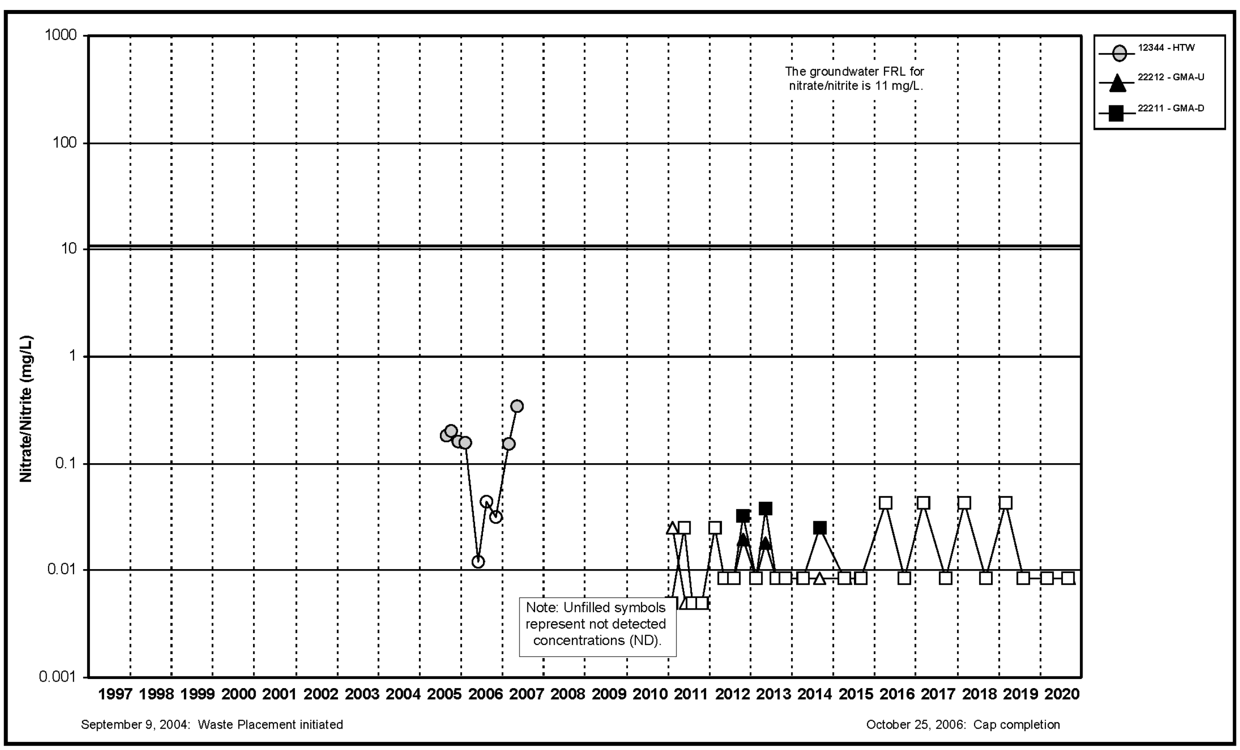

Figure A.5.7-12. Cell 7 Nitrate + Nitrite as Nitrogen Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

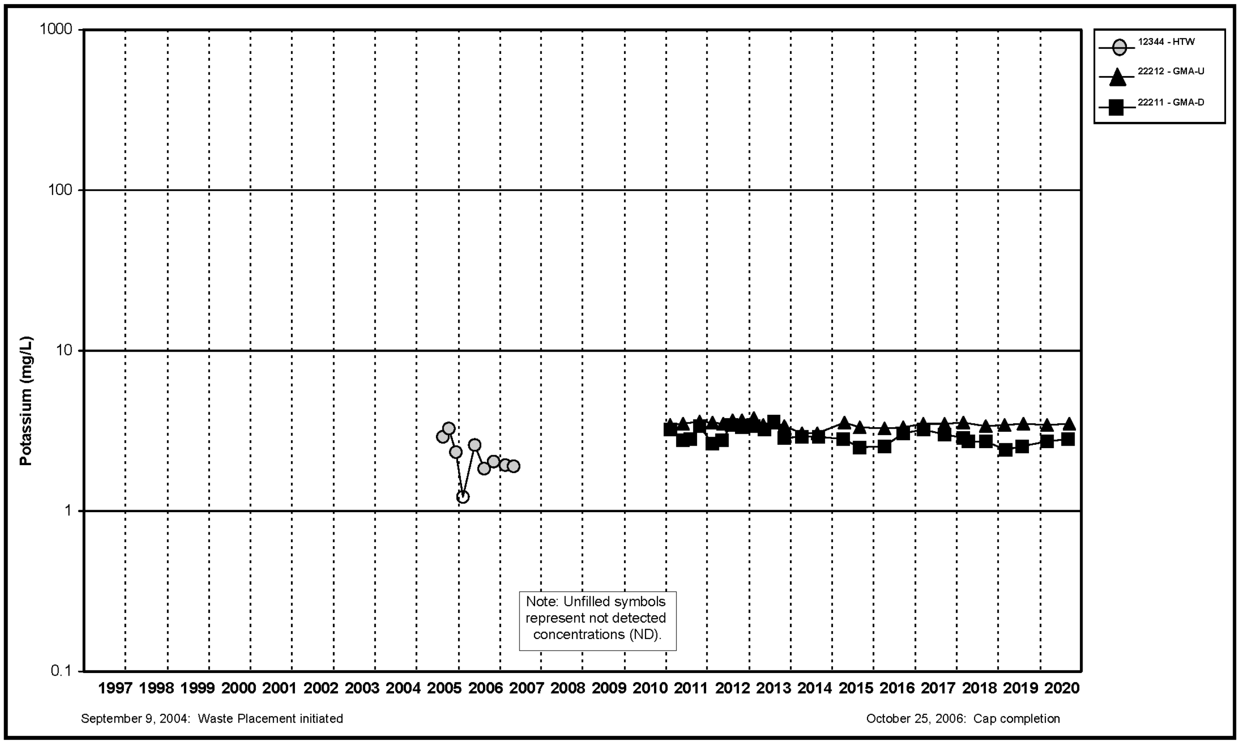

Figure A.5.7-13. Cell 7 Potassium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

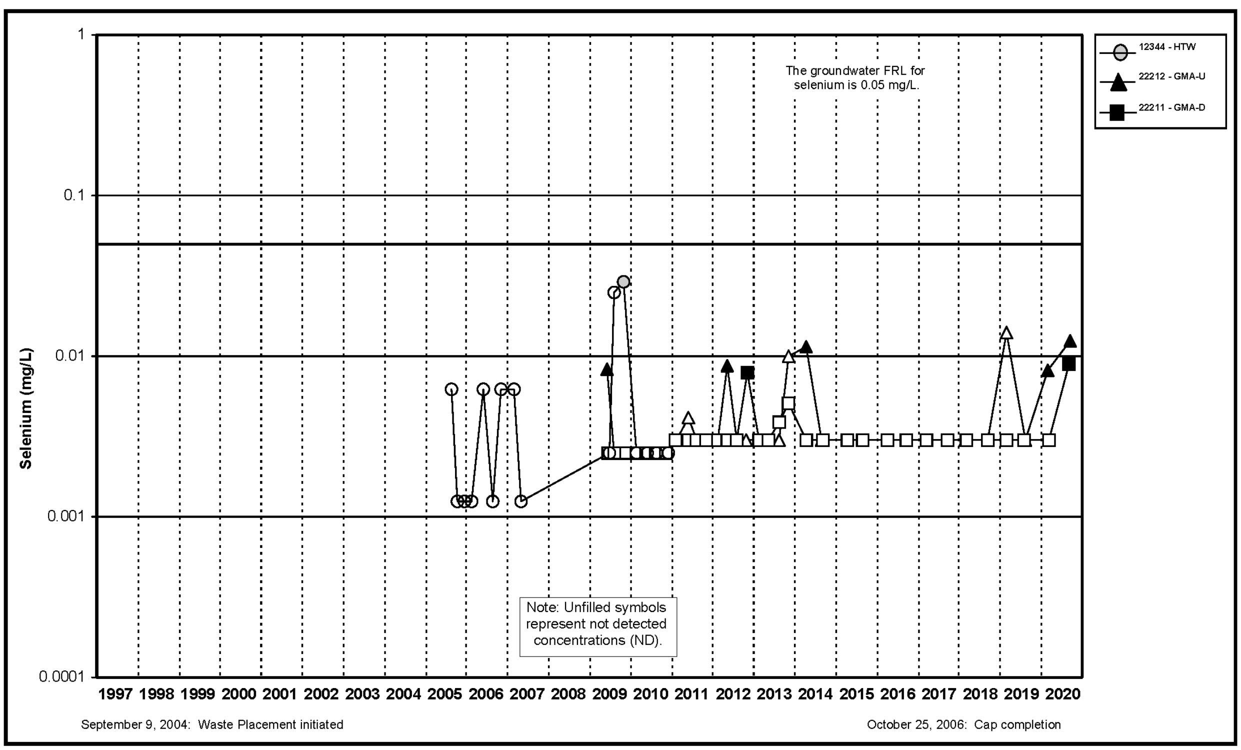

Figure A.5.7-14. Cell 7 Selenium Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

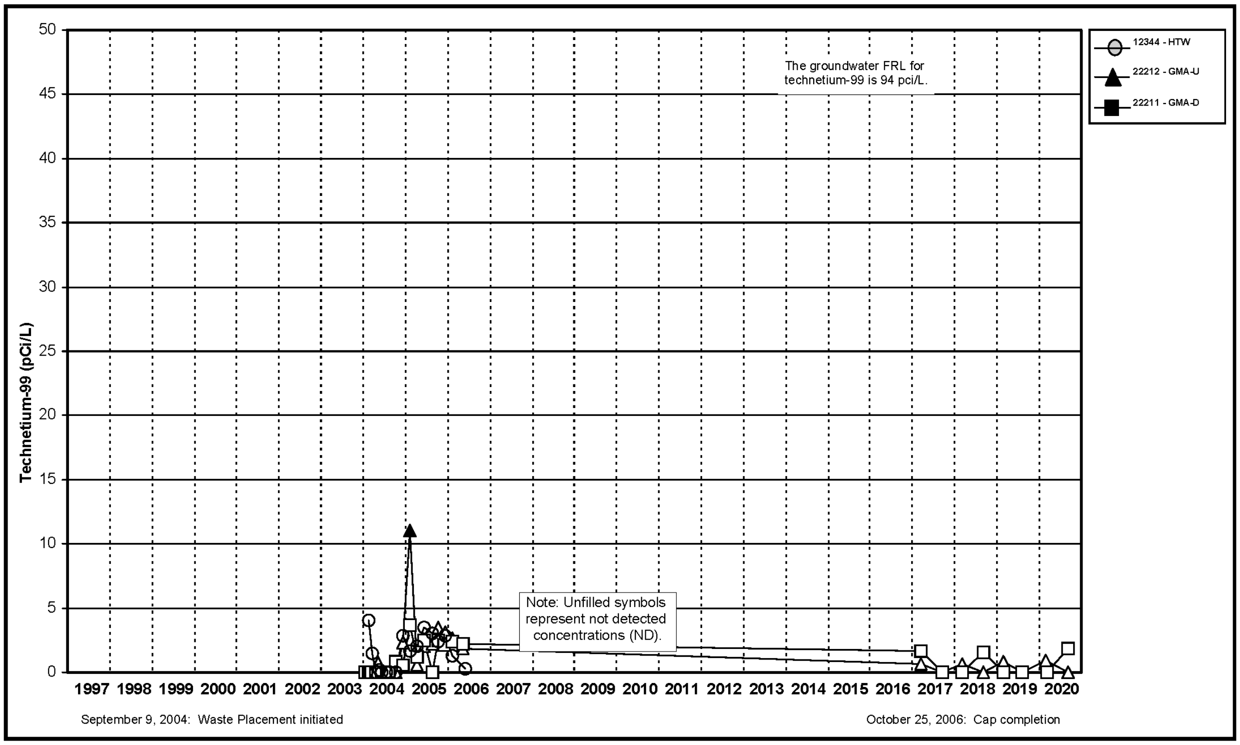

Figure A.5.7-15. Cell 7 Technetium-99 Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

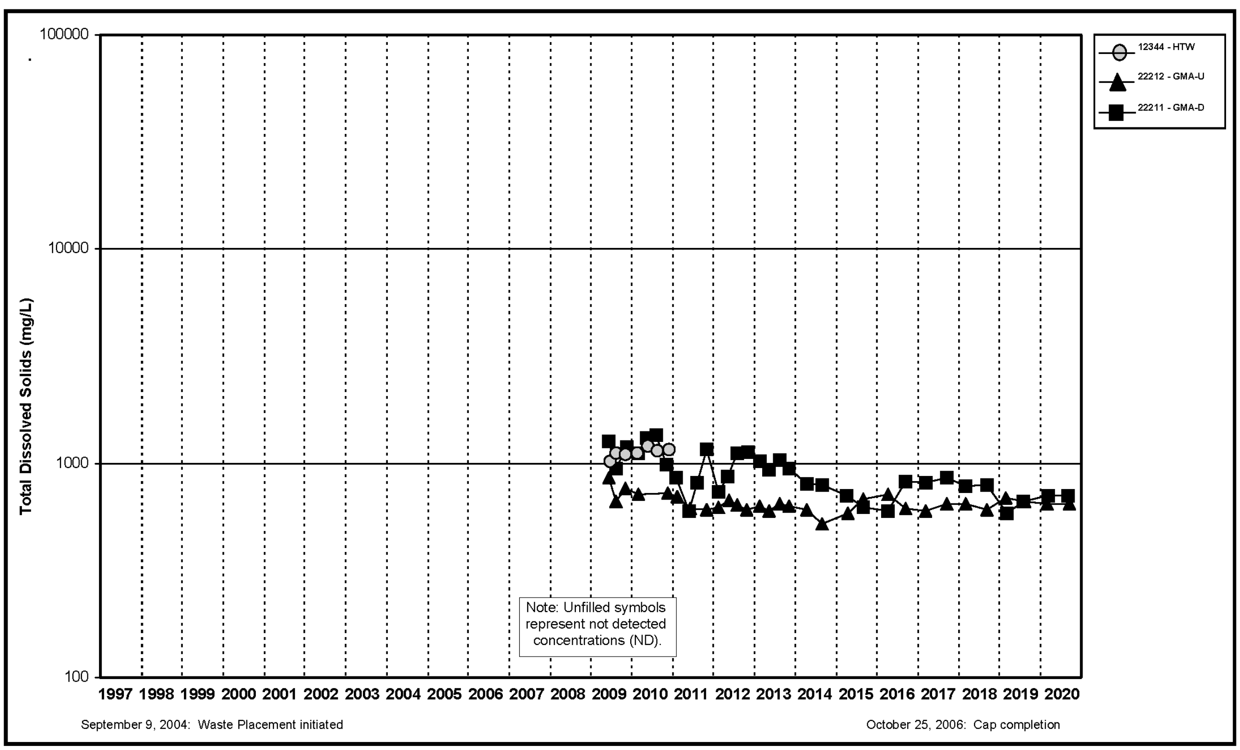

Figure A.5.7-16. Cell 7 Total Dissolved Solids Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

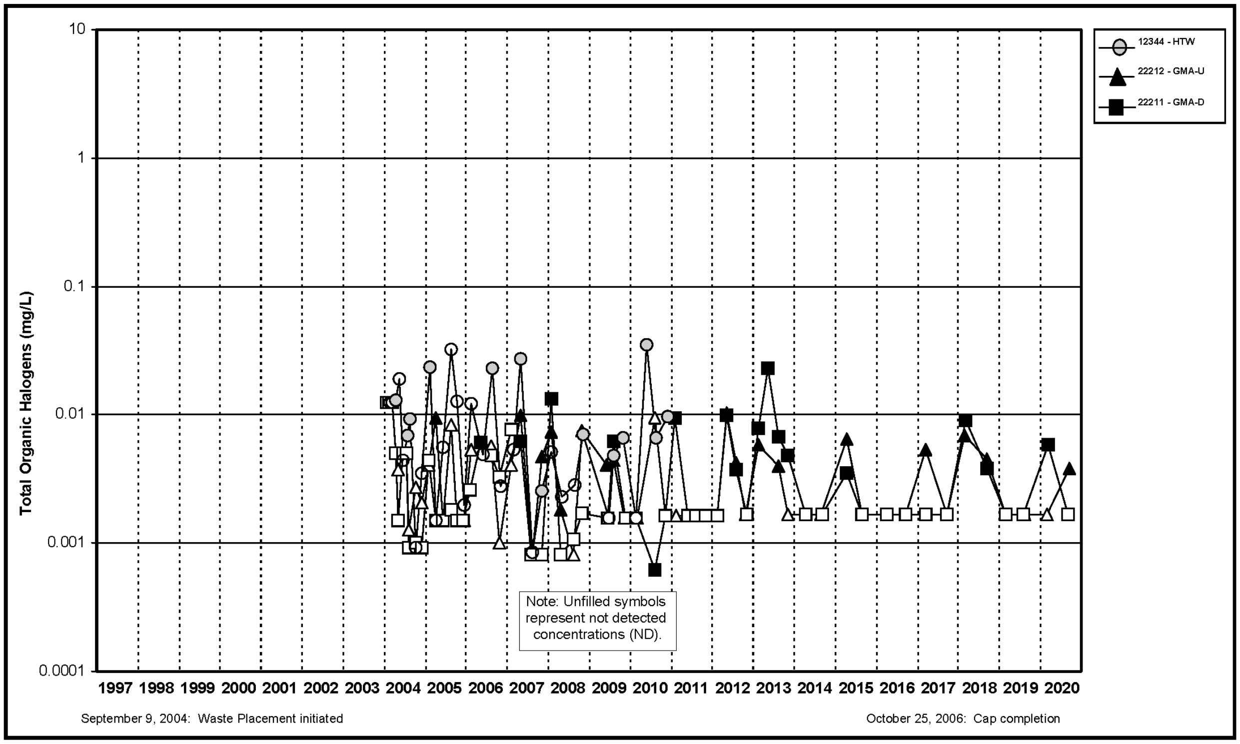

Figure A.5.7-17. Cell 7 Total Organic Halogens Concentration Versus Time Plot for HTW, GMA-U Well, and GMA-D Well

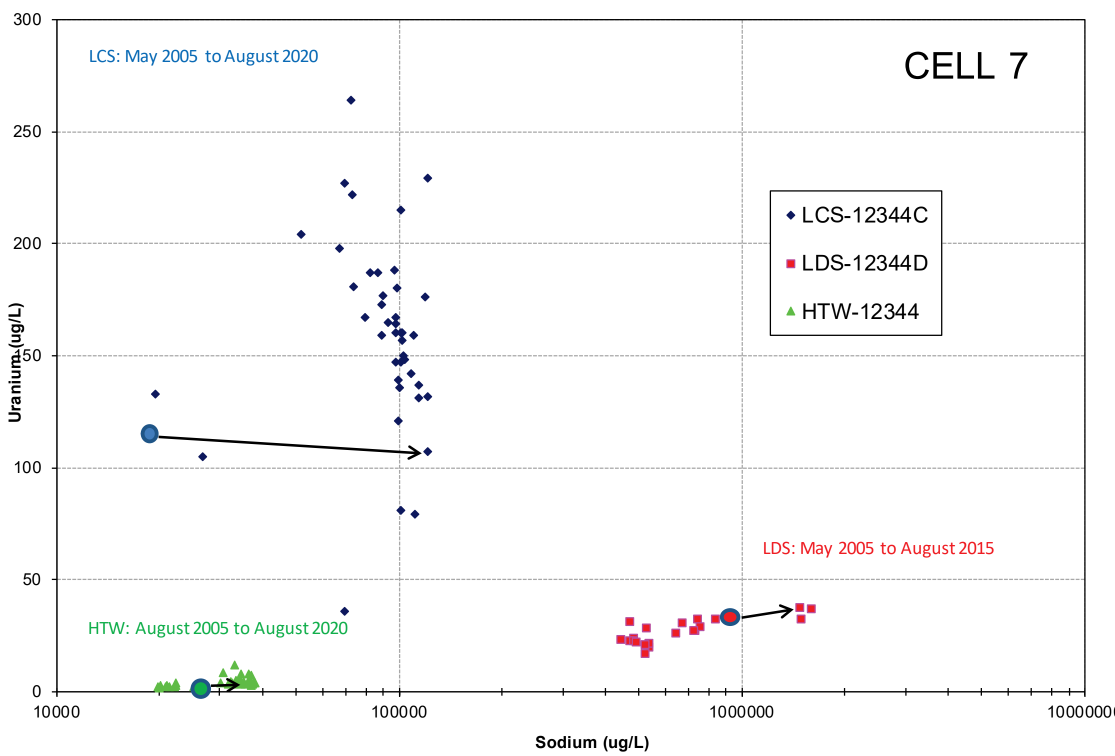

Figure A.5.7-18. Cell 7 Bivariate Plot for Uranium and Sodium

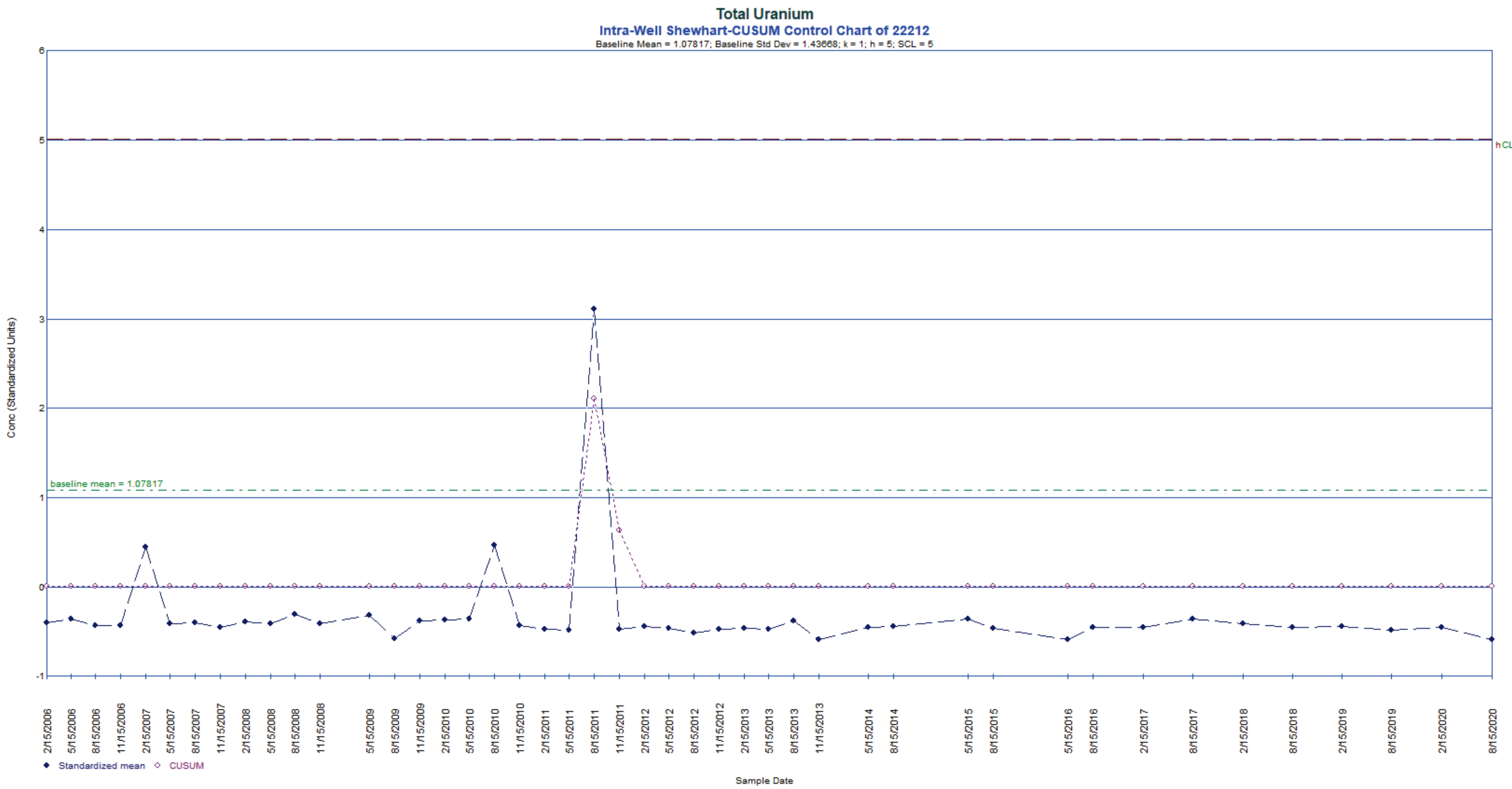

Figure A.5.7-19. Intrawell Shewhart-CUSUM Control Chart for Uranium in Monitoring Well 22212

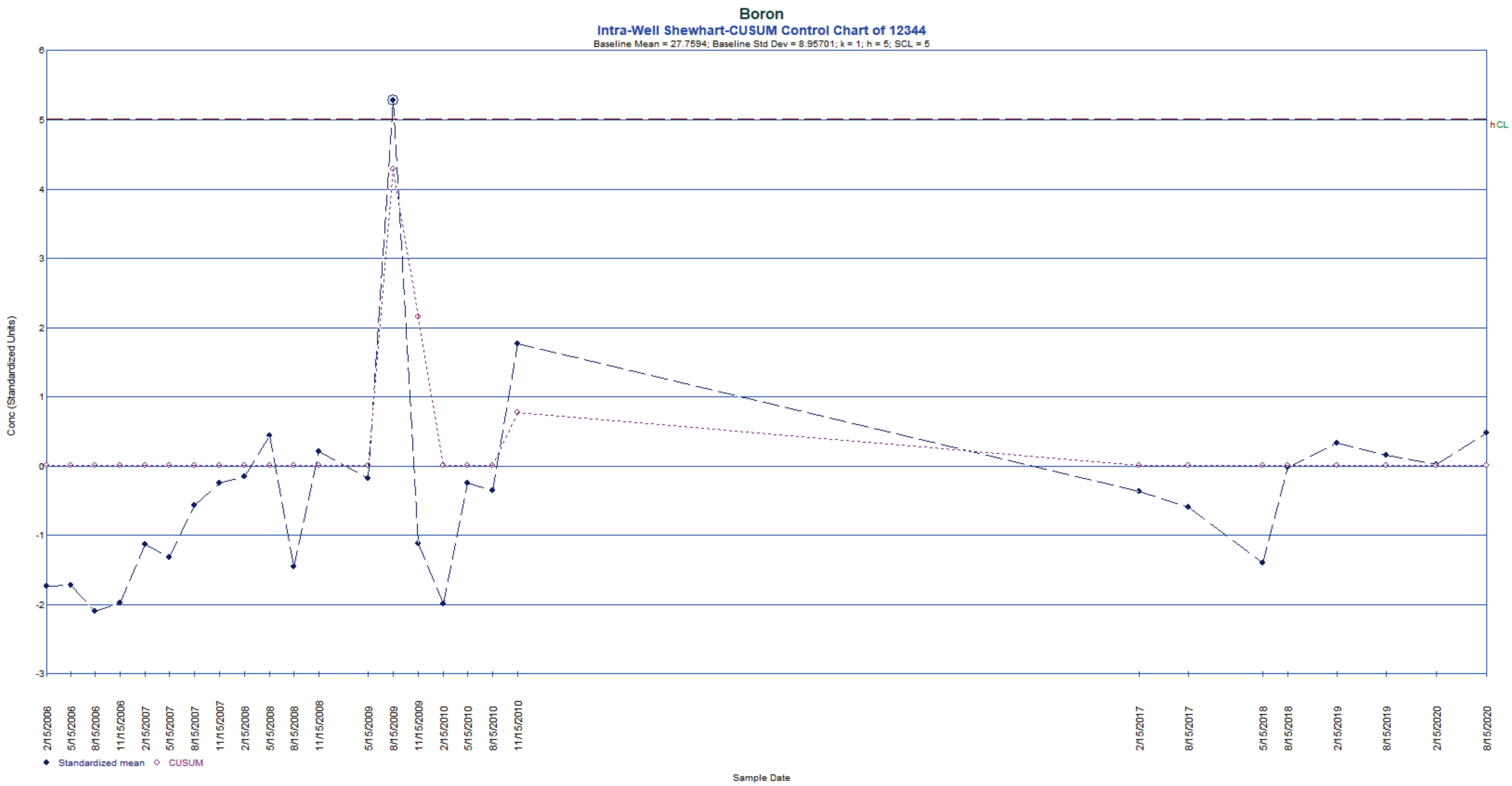

Figure A.5.7-20. Intrawell Shewhart-CUSUM Control Chart for Boron in Monitoring Well 12344

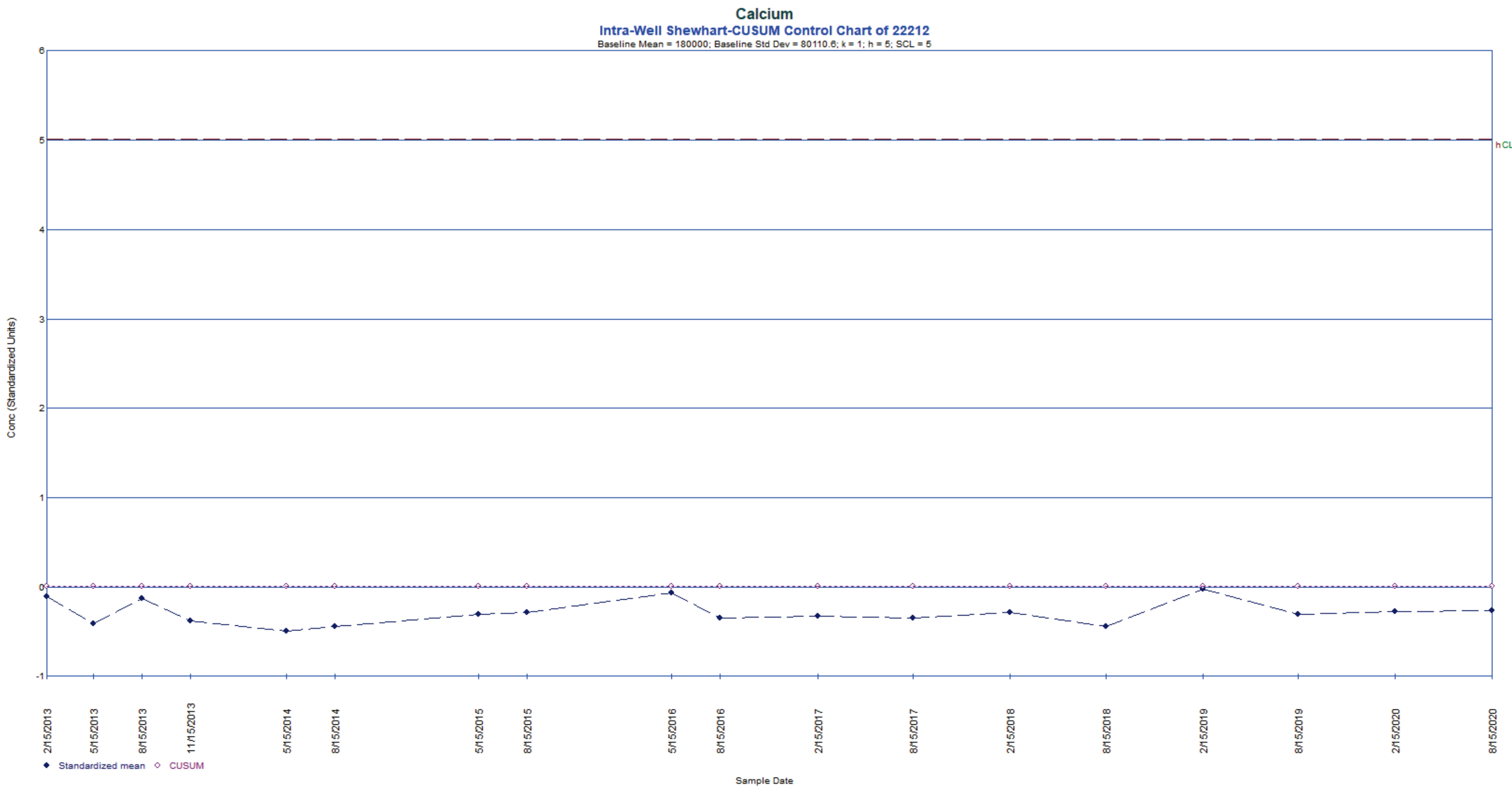

Figure A.5.7-21. Intrawell Shewhart-CUSUM Control Chart for Calcium in Monitoring Well 22212

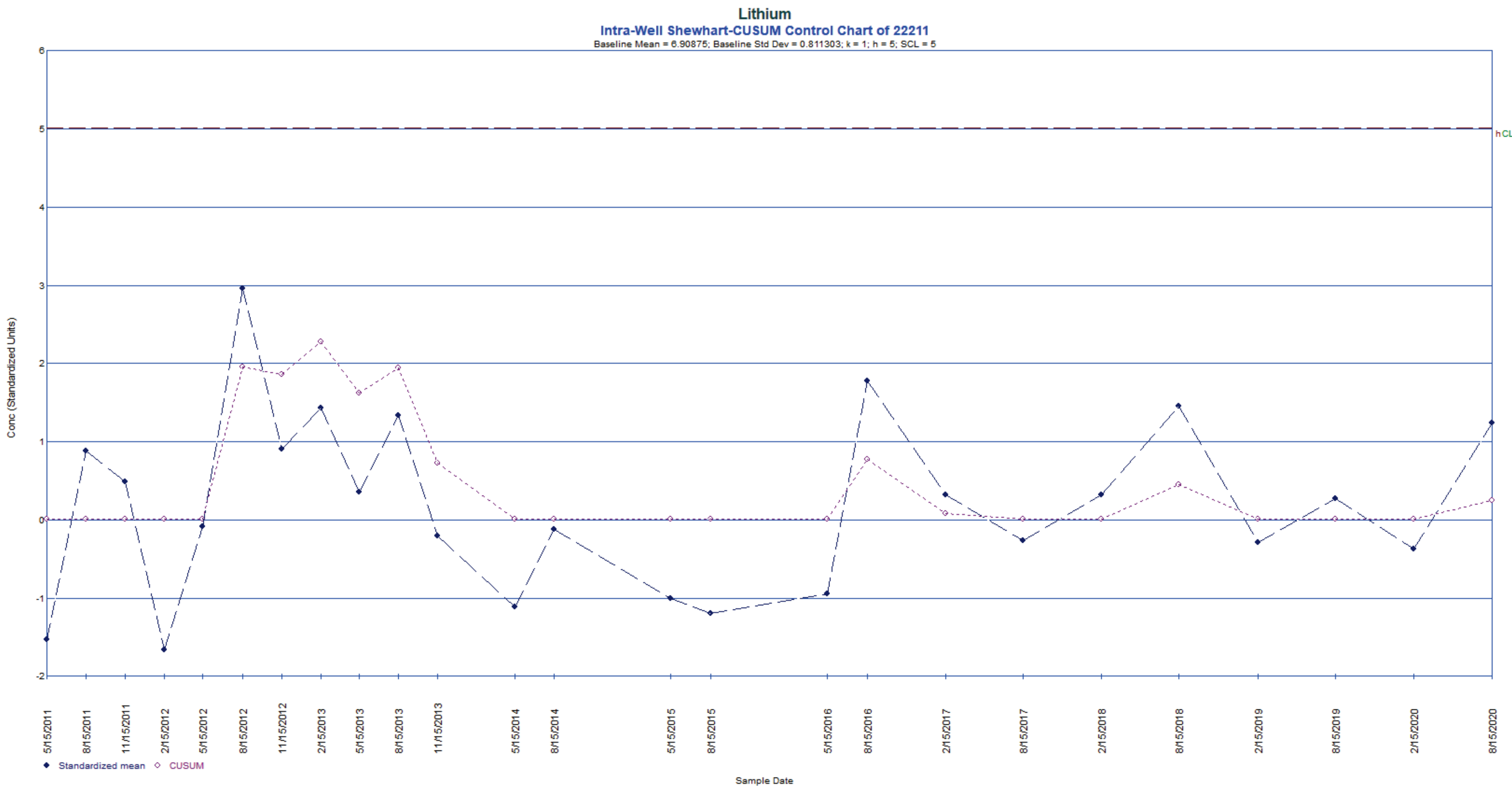

Figure A.5.7-22. Intrawell Shewhart-CUSUM Control Chart for Lithium in Monitoring Well 22211

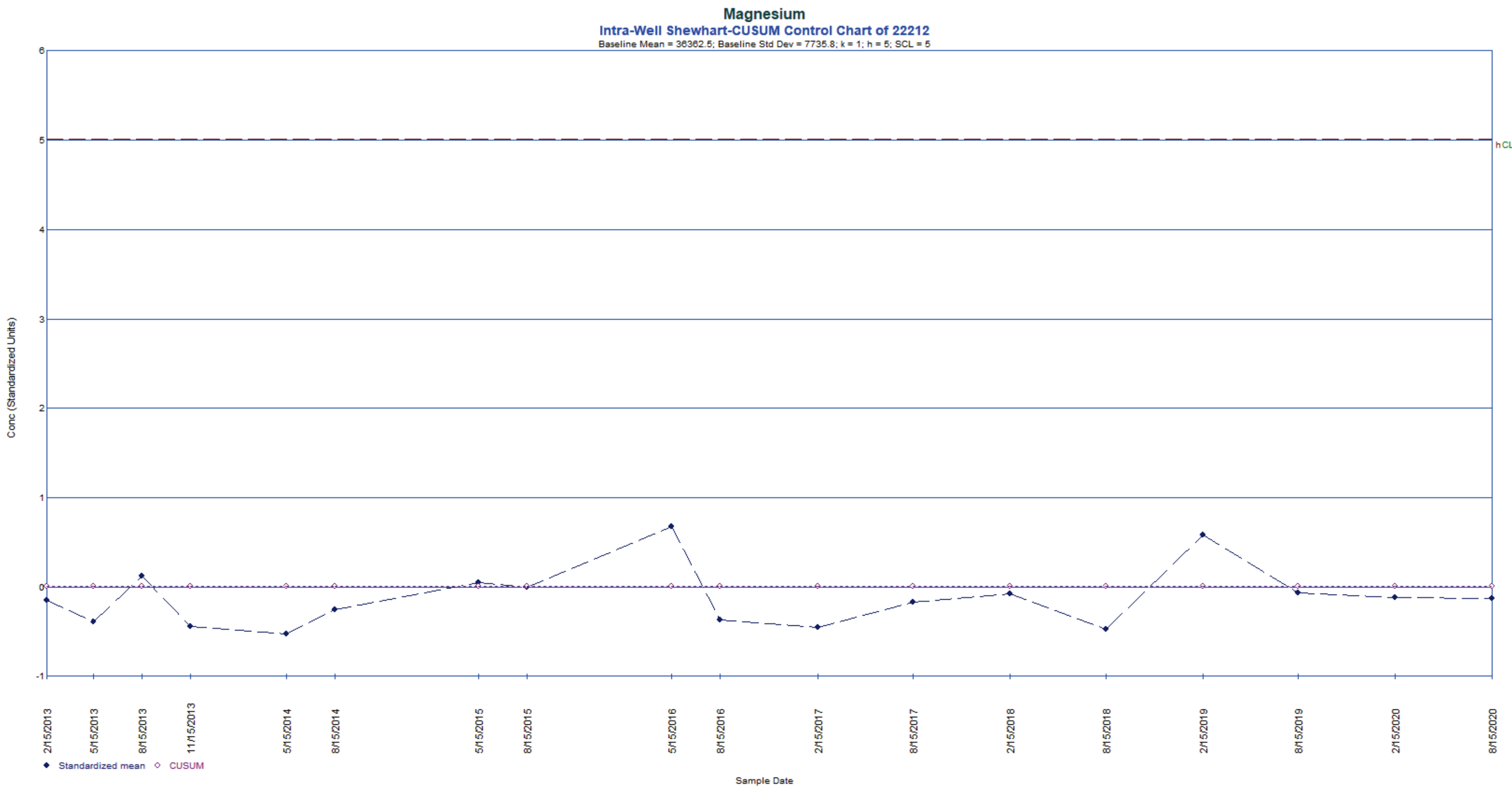

Figure A.5.7-23. Intrawell Shewhart-CUSUM Control Chart for Magnesium in Monitoring Well 22212

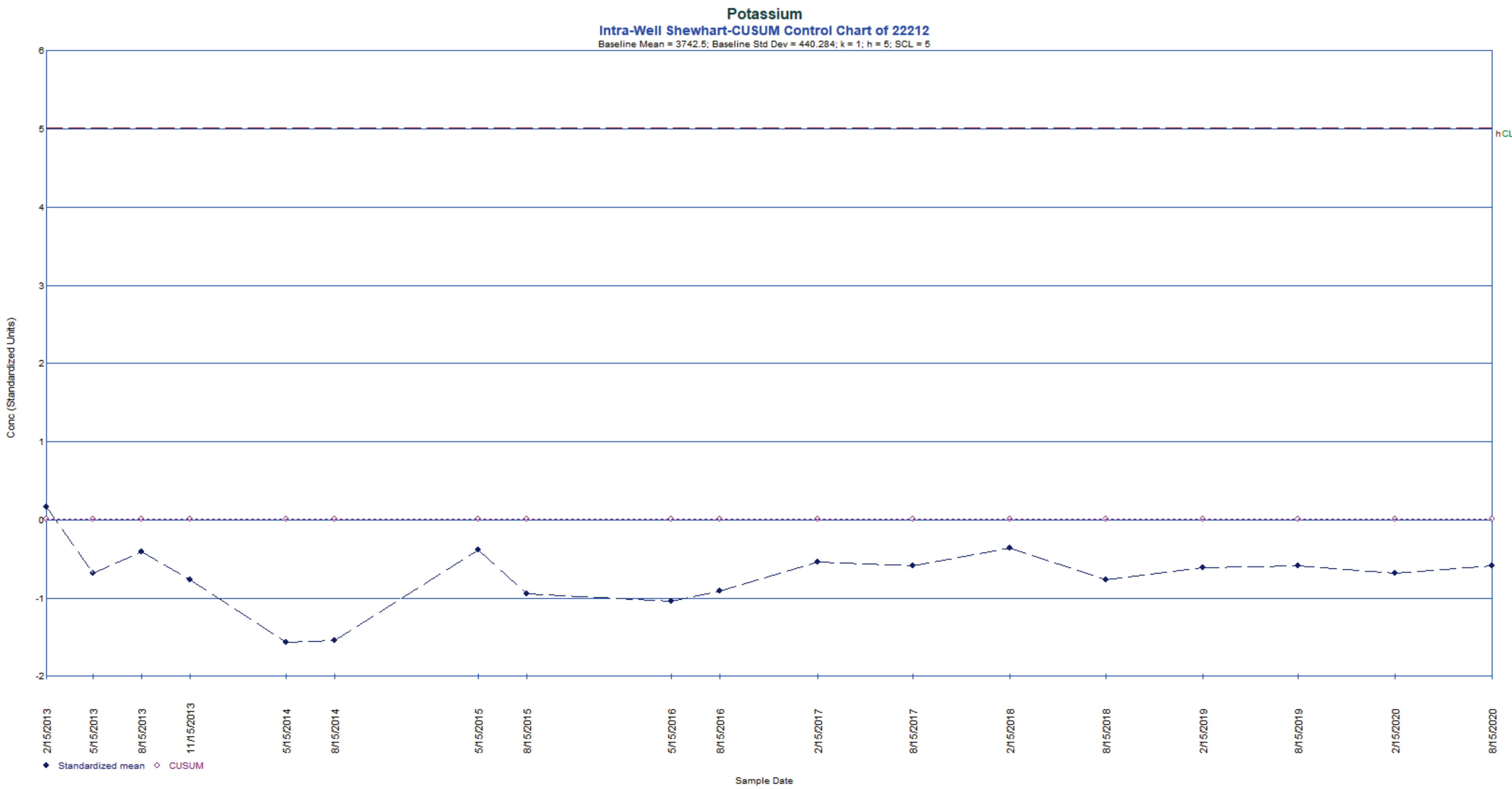

Figure A.5.7-24. Intrawell Shewhart-CUSUM Control Chart for Potassium in Monitoring Well 22212

Subattachment A.5.8

Cell 8

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Contents

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Abbreviations

CUSUM	Shewhart-cumulative sum
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
GMA	Great Miami Aquifer
GMA-D	Great Miami Aquifer–downgradient
GMA-SE	Great Miami Aquifer–southeast
GMA-SW	Great Miami Aquifer–southwest
GMA-U	Great Miami Aquifer–upgradient
HTW	horizontal till well
LCS	leachate collection system
LDS	leak detection system
Ohio EPA	Ohio Environmental Protection Agency
OSDF	On-Site Disposal Facility
SCL	Shewhart control limit
TDS	total dissolved solids

Measurement Abbreviations

amsl	above mean sea level
µg/L	micrograms per liter
mg/L	milligrams per liter
pCi/L	picocuries per liter

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This subattachment provides the following information about the On-Site Disposal Facility (OSDF) Cell 8:

- Semiannual monitoring summary statistics (refer to Table A.5.8-1)
- Leachate collection system (LCS) monthly accumulation volumes (refer to Figure A.5.8-1)
- Leak detection system (LDS) monthly accumulation volumes (refer to Figure A.5.8-2)
- OSDF horizontal till well (HTW) 12345 water yield (refer to Table A.5.8-2)
- Great Miami Aquifer (GMA) water levels and total uranium concentration versus time (refer to Figures A.5.8-3 through A.5.8-6)
- Plots of concentration versus time (refer to Figures A.5.8-7A through A.5.8-19)
- Bivariate plots for uranium–sodium and uranium–sulfate (refer to Figure A.5.8-20 and A.5.8-21)
- Control charts (refer to Figures A.5.8-22 through A.5.8-23)

A.5.8.1 Water Quality Monitoring Results

Water quality within the cell is sampled in the LCS and LDS. Water quality beneath the cell is sampled in the HTW and GMA wells. Concentration-versus-time plots, bivariate plots, and control charts are used to help interpret and present the results.

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.

With EPA and Ohio EPA concurrence, DOE reduced the number of parameters sampled from 24 to 13 beginning in January 2017. All 13 parameters are sampled in the GMA wells; 4 of the 13 parameters (total uranium, boron, sodium, and sulfate) are sampled in the LCS, LDS, and HTW of each cell. The annual sampling in the LCS of each cell for the abbreviated list of Appendix I parameters and polychlorinated biphenyls listed in *Ohio Administrative Code* 3745-27-10 was also eliminated beginning in January 2017 with EPA and Ohio EPA concurrence (DOE 2017).

A.5.8.1.1 LCS and LDS Results

As shown in Table A.5.8-1, and summarized below, four parameters (total uranium, boron, sodium, and sulfate) have upward concentration trends in the LCS and/or LDS based on the Mann-Kendall test for trend. Enough water was present in the LDS of Cell 8 to collect semiannual samples twice in 2020. Two new high total uranium concentrations were measured in the LDS of Cell 8 in 2020. The total uranium concentration measured in the first half of 2020 was 120 micrograms per liter (µg/L). The total uranium concentration measured in the second half of 2020 was 209 µg/L). The previous high of 102 µg/L was measured in the second half of 2019.

Parameters with Upward Concentration Trends in the LCS and LDS of Cell 8[a]

Parameter	LCS 12345C 2020 Trend	LDS 12345D 2020 Trend
Total Uranium		Up
Boron		Up
Sodium	Up	Up
Sulfate	Up	Up

[a] No entry indicates that the trend was not up.

A.5.8.1.2 HTW and Monitoring Well Results

As shown in Table A.5.8-1 and summarized below, nine parameters (total uranium, boron, sodium, sulfate, lithium, magnesium, selenium, total dissolved solids [TDS], and total organic halogens) have upward concentration trends in the HTW and/or GMA wells based on the Mann-Kendall test for trend. Cell 8 is unique in that it has four GMA wells (GMA-U, GMA-D, GMA-SW, and GMA-SE). The Cell 8 HTW did not contain enough water to collect a sample in 2020.

Parameters with Upward Concentration Trends in the HTW and GMA Wells of Cell 8[a]

Parameter	HTW 12345 Trend (Year Last Sampled)	GMA-U[b] 22213	GMA-D[b] 22214	GMA-SW[b] 22215	GMA-SE[b] 22217
Total Uranium	Up (2008)	Up			
Boron		Up		Up	
Sodium			Up	Up	
Sulfate	Up (2008)	Up		Up	
Lithium				Up	
Magnesium				Up	
Selenium		Up	Up	Up	
Total Dissolved Solids				Up	
Total Organic Halogens					Up

[a] No entry indicates that the trend was not up. Magnesium, selenium, total dissolved solids, and total organic halogen are not horizontal till well parameters.
[b] GMA-U = upgradient Great Miami Aquifer, GMA-D = downgradient Great Miami Aquifer; GMA-SW = southwest Great Miami Aquifer; GMA-SE = southeast Great Miami Aquifer, HTW = horizontal till well.

A.5.8.1.3 Discussion

Two bivariate plots are used to illustrate that the LCS, LDS, and HTW of Cell 8 have separate and distinct chemical signatures. A uranium–sodium bivariate plot for the Cell 8 LCS, LDS, and HTW is provided in Figure A.5.8-20, and a uranium–sulfate bivariate plot for the Cell 8 LCS, LDS, and HTW is provided in Figure A.5.8-21. On the figures, the first sample collected from the monitoring horizon is circled. An arrow leads from the first sample to the location of the most recent sample. Both plots show that the chemical signatures for uranium and sodium and for uranium and sulfate in the LCS are separate and distinct from the signatures seen in the LDS and HTW. The uranium–sulfate plot illustrates more clearly than the uranium–sodium plot that the chemical signatures in the LDS and HTW are also separate and distinct. Separate and distinct horizons. Therefore, the increasing concentrations measured beneath Cell 8 (i.e., HTW and GMA wells) are attributed to fluctuating ambient concentrations beneath the cell and are not related to cell performance.

The new high uranium concentration measured in the LDS is not attributed to communication with the LCS. The new high uranium concentration measured in the LDS is attributed to the impact that decreasing flow can have on the uranium concentration left in water remaining in the LDS, as the LDS dries up. An additional discussion of this is presented in Section A.5.8.2.

A.5.8.2 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. 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 "not in 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. Usually, two parameters are used to compute standardized limits—the decision value (*h*) and the Shewhart control limit (SCL).

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 eight samples were selected for control charts. By default, the ChemStat software plots both a CUSUM control limit (*h*) and an SCL on the control chart. The software recommends a value of 5 for the CUSUM control limit and a value of 4.5 for the SCL.

EPA Statistical Analysis 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 is not needed. The ChemStat software though, by default, plots both the SCL and CUSUM control limit on the charts. To address this issue, the SCL was defined as 5 to equal the recommended CUSUM (*h*) limit. This combined limit is identified as *h*CL on the control charts. For interpretation purposes, the *h*CL value will be regarded as the CUSUM (*h*) limit.

As shown in Table A.5.8-1 in gray shading and as summarized below, two parameters in the HTW or GMA wells of Cell 8 meet the criteria for control charts (i.e., at least eight samples, normal or lognormal distribution, no trend, and no serial correlation), resulting in two control charts (Figures A.5.8-22 and A.5.8-23) which exhibit "in control" conditions.

Parameter	Monitoring Point[a]	Monitoring Well	Assessment	Figure Number
Boron	HTW	12345	In Control	A.5.8-22
Calcium	GMA-U	22213	In Control	A.5.8-23

[a] GMA-U = upgradient Great Miami Aquifer; GMA-SE = southeast Great Miami Aquifer, HTW = horizontal till well.

A.5.8.3 Summary and Conclusions

- Four parameters monitored semiannually have an upward concentration trend in the LCS and/or LDS of Cell 8: total uranium, boron, sodium, and sulfate.
- Two new high total uranium concentrations were measured in the LDS of Cell 8 in 2020. The total uranium concentration measured in the first half of 2020 was 120 µg/L. The total uranium concentration measured in the second half of 2020 was 209 µg/L. The previous high total uranium concentration of 102 µg/L was measured in the second half of 2019. The new high uranium concentrations measured in the LDS are not attributed to communication with the LCS and are attributed to the impact that decreasing flow can have on the uranium concentration left in water remaining in the LDS, as the LDS dries up.
- The Cell 8 HTW did not contain enough water to collect a sample in 2020.
- Nine parameters monitored semiannually are increasing in either the HTW or GMA wells of Cell 8 (total uranium, boron, sodium, sulfate, lithium, magnesium, selenium, TDS, and total organic halogens). The chemical signatures for uranium–sodium and uranium–sulfate in the LCS of Cell 8 are separate and distinct from the signatures seen in the LDS and HTW. The signature for uranium–sodium in the HTW is also separate and distinct from the LDS signature, but low total uranium concentrations in both horizons have the clusters closer than what is seen in the other seven cells. The signature for uranium–sulfate in the HTW is separate and distinct from the LDS signature. Separate and distinct chemical signatures in the LCS, LDS, and HTW indicate that water is not mixing between the horizons. Concentration increases in the HTW and GMA wells of Cell 8 are attributed to fluctuating ambient concentrations beneath the cell and not to cell performance. The HTW of Cell 8 has been dry since the third quarter of 2008, providing additional evidence that the secondary liner is not leaking.
- Two control charts were constructed for Cell 8 parameters. Both exhibit “in control” conditions.

A.5.8.4 References

DOE (U.S. Department of Energy), 2017. *Fernald Preserve 2016 Site Environmental Report*, LMS/FER/S15232, Office of Legacy Management, Cincinnati, Ohio, May.

EPA (U.S. Environmental Protection Agency), 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities—Unified Guidance*, EPA 530/R-09-007, March.

OAC 3745-27-10. “Ground Water Monitoring Program for a Sanitary Landfill Facility,” *Ohio Administrative Code.*

Table A.5.8-1. Summary Statistics for Cell 8

Parameter	Horizon[a]	Location	Number of Detected Samples	Total Number of Samples	Percent Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[d]	Distribution Type[d,e]	Trend[d,f] (Year Last Sampled)	Serial Correlation[d,g]	Outliers[h,i]
Total Uranium (µg/L)	LCS	12345C	50	50	100	1.51	335	169	60	Normal	None (2020)	Detected	
	LDS	12345D	45	45	100	9.38	209	24.5	36.6	Undefined	Up (2020)	Detected	
	HTW	12345	16	16	100	3.67	7.30	5.02	0.99	Normal	Up (2008)	Not Detected	
	GMA-U	22213	46	53	86.8	ND	0.717	0.394	0.119	Normal	Up (2020)	Detected	
	GMA-D	22214	57	60	95.0	ND	2.37	0.404	0.496	Undefined	Down (2020)	Not Detected	
	GMA-SW	22215	43	47	91.5	ND	0.847	0.480	0.123	Undefined	None (2020)	Not Detected	16.4 (Q2-11); 7.08 (Q3-11); 5.51 (Q1-19)
	GMA-SE	22217	43	43	100	0.898	18.3	6.99	4.25	Normal	Down (2020)	Detected	
Boron (mg/L)	LCS	12345C	50	50	100	0.0681	0.776	0.612	0.168	Undefined	None (2020)	Detected	
	LDS	12345D	45	45	100	0.582	7.02	1.33	1.06	Undefined	Up (2020)	Detected	
	HTW	12345	15	15	100	0.0683	0.0978	0.0834	0.0079	Normal	None (2008)	Not Detected	
	GMA-U	22213	50	53	94.3	ND	0.0583	0.0384	0.0071	Undefined	Up (2020)	Detected	
	GMA-D	22214	51	53	96.2	ND	0.0524	0.0288	0.0068	Undefined	None (2020)	Not Detected	
	GMA-SW	22215	45	47	95.7	ND	0.0498	0.0342	0.0053	Normal	Up (2020)	Not Detected	0.0132 (Q3-08); 0.0746 (Q4-13)
	GMA-SE	22217	41	43	95.4	ND	0.0447	0.0274	0.0058	Normal	None (2020)	Detected	
Sodium (mg/L)	LCS	12345C	42	42	100	16.8	148	115	35	Undefined	Up (2020)	Detected	
	LDS	12345D	36	36	100	72.8	2260	488	427	Undefined	Up (2020)	Detected	
	HTW	12345	7	7	100	277	385	334	45	Normal	Down (2007)	Not Detected	
	GMA-U	22213	33	33	100	18.3	30.3	21.9	3.8	Undefined	Down (2020)	Detected	
	GMA-D	22214	34	34	100	9.83	16.8	12.4	1.6	Normal	Up (2020)	Detected	
	GMA-SW	22215	33	33	100	13.5	26.0	18.5	2.6	Normal	Up (2020)	Detected	
	GMA-SE	22217	33	33	100	11.0	17.6	13.6	1.8	Undefined	Down (2020)	Detected	
Sulfate (mg/L)	LCS	12345C	50	50	100	146	4020	2870	980	Undefined	Up (2020)	Detected	
	LDS	12345D	45	45	100	1730	20,900	3690	3300	Undefined	Up (2020)	Detected	
	HTW	12345	15	15	100	95.5	152	116	18	Normal	Up (2008)	Detected	
	GMA-U	22213	53	53	100	90.2	284	182	54	Normal	Up (2020)	Detected	
	GMA-D	22214	53	53	100	76.1	457	218	92	Normal	Down (2020)	Detected	
	GMA-SW	22215	46	47	97.9	ND	911	251	173	Ln Normal	Up (2020)	Detected	
	GMA-SE	22217	43	43	100	113	1320	367	211	Ln Normal	Down (2020)	Detected	
Calcium (mg/L)	GMA-U	22213	26	26	100	142	186	161	11	Normal	None (2020)	Not Detected	
	GMA-D	22214	26	26	100	89.8	230	142	41	Ln Normal	Down (2020)	Detected	
	GMA-SW	22215	26	26	100	127	446	192	72	Undefined	None (2020)	Not Detected	
	GMA-SE	22217	26	26	100	121	334	196	53	Normal	Down (2020)	Detected	
Lithium (mg/L)	GMA-U	22213	33	33	100	0.00434	0.00728	0.00541	0.00061	Normal	None (2020)	Detected	
	GMA-D	22214	33	33	100	0.00372	0.00718	0.00498	0.00086	Ln Normal	Down (2020)	Detected	0.00858 (Q1-17)
	GMA-SW	22215	33	33	100	0.00467	0.00828	0.00590	0.00085	Ln Normal	Up (2020)	Detected	
	GMA-SE	22217	33	33	100	0.00432	0.00799	0.00591	0.00099	Normal	Down (2020)	Detected	
Magnesium (mg/L)	GMA-U	22213	26	26	100	31.7	42.0	36.6	2.5	Normal	None (2020)	Detected	
	GMA-D	22214	26	26	100	22.0	53.2	33.5	8.8	Normal	Down (2020)	Detected	
	GMA-SW	22215	26	26	100	32.5	74.5	44.2	9.6	Undefined	Up (2020)	Not Detected	
	GMA-SE	22217	26	26	100	27.5	63.3	42.1	9.0	Normal	Down (2020)	Detected	
Nitrate + Nitrite, as Nitrogen (mg/L)	GMA-U	22213	0	26	0	ND	NA	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
	GMA-D	22214	1	26	3.8	ND	0.0500	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
	GMA-SW	22215	2	26	7.7	ND	0.0850	Insufficient	Insufficient	Undefined	None (2020)	Not Detected	
	GMA-SE	22217	5	26	19.2	ND	0.0850	0.0850	0.0186	Undefined	None (2020)	Not Detected	
Potassium (mg/L)	GMA-U	22213	26	26	100	3.36	4.14	3.69	0.18	Normal	Down (2020)	Detected	
	GMA-D	22214	27	27	100	2.14	3.23	2.53	0.30	Normal	Down (2020)	Detected	
	GMA-SW	22215	26	26	100	2.30	5.01	3.53	0.48	Undefined	None (2020)	Not Detected	
	GMA-SE	22217	26	26	100	2.36	4.09	3.02	0.43	Normal	Down (2020)	Detected	

Table A.5.8-1. Summary Statistics for Cell 8 (continued)

Parameter	Horizon[a]	Location	Number of Detected Samples	Total Number of Samples	Percent Detects	Minimum[b]	Maximum[b]	Average[c,d]	Standard Deviation[d]	Distribution Type[d,e]	Trend[d,f] (Year Last Sampled)	Serial Correlation[d,g]	Outliers[h,i]
Selenium (mg/L)	GMA-U	22213	2	33	6.1	ND	0.0193	Insufficient	Insufficient	Undefined	Up (2020)	Detected	
	GMA-D	22214	4	33	12.1	ND	0.0194	0.00300	0.00346	Undefined	Up (2020)	Detected	
	GMA-SW	22215	7	33	21.2	ND	0.0140	0.00300	0.00292	Undefined	Up (2020)	Detected	
	GMA-SE	22217	3	33	9.1	ND	0.0174	0.00416	Insufficient	Insufficient	Insufficient	Insufficient	
Technitium-99 (pCi/L)	GMA-U	22213	6	44	13.6	ND	24.8	0.450	4.37	Undefined	Down (2020)	Detected	
	GMA-D	22214	4	44	9.1	ND	11.8	0.0150	2.46	Undefined	None (2020)	Not Detected	
	GMA-SW	22215	0	38	0	ND	NA	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
	GMA-SE	22217	0	34	0	ND	NA	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	
Total Dissolved Solids (mg/L)	GMA-U	22213	33	33	100	429	843	679	85	Undefined	Down (2020)	Detected	
	GMA-D	22214	33	33	100	386	1020	620	165	Normal	Down (2020)	Detected	
	GMA-SW	22215	33	33	100	457	1800	821	276	Undefined	Up (2020)	Detected	
	GMA-SE	22217	33	33	100	514	1550	892	259	Normal	Down (2020)	Detected	
Total Organic Halogens (mg/L)	GMA-U	22213	11	53	20.8	ND	0.0560	0.00166	0.00847	Undefined	None (2020)	Not Detected	
	GMA-D	22214	11	53	20.8	ND	0.0590	0.00166	0.00895	Undefined	None (2020)	Not Detected	
	GMA-SW	22215	13	47	27.7	ND	0.0460	0.00166	0.00803	Undefined	None (2020)	Not Detected	
	GMA-SE	22217	16	43	37.2	ND	0.0730	0.00166	0.0114	Undefined	Up (2020)	Not Detected	

Note 1: Shading identifies a horizontal till well or Great Miami Aquifer well, with at least eight samples, Normal or Ln Normal distribution, no trend (None), and no serial correlation (Not Detected). These wells achieve control chart criteria.

Note 2: Data used in this table has been standardized to quarterly.

[a]LCS = leachate collection system; LDS = leak detection system; HTW = horizontal till well; GMA-U = upgradient Great Miami Aquifer; and GMA-D = downgradient Great Miami Aquifer

[b]ND = not detected; NA = not applicable

[c]Averages were determined based on the distribution assumption.

[d]Insufficient is used for Distribution Type, Trend, or Serial Correlation whenever there is not enough data to run the test.

[e]Data distribution based on the Shapiro-Wilk statistic.

Normal: Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the Ln Normal assumption.

Ln Normal: Ln Normal assumption could not be rejected at the 5 percent level and has a higher probability value than the Normal assumption.

Undefined: Normal and Lognormal Distribution assumptiions are both rejected or there are less than 25 percent detected values. "Average" is defined as the Median of the data.

[f]Trend based on nonparametric Mann-Kendall procedure.

[g]Serial correlation based on Rank Von Neumann test.

[h]Outliers determined by Rosner's (for sample sizes greater than 25) or Dixon procedure (for sample sizes less than or equal to 25).

[i]Q = quarter

Table A.5.8-2. Horizontal Till Well 12345 Water Yield

Year	Total Volume Purged (gallon)	Number of Months Purged	Average Volume Purged (gallon)
2004	4,020	5	804
2005	1,050	6	175
2006	3,375	4	844
2007	1,000	4	250
2008	135	4	34
2009	0	2	0
2010	0	2	0
2011	0	2	0
2012	0	2	0
2013	0	2	0
2014	0	2	0
2015	0	2	0
2016	0	2	0
2017	0	2	0
2018	0	2	0
2019	0	2	0
2020	0	2	0

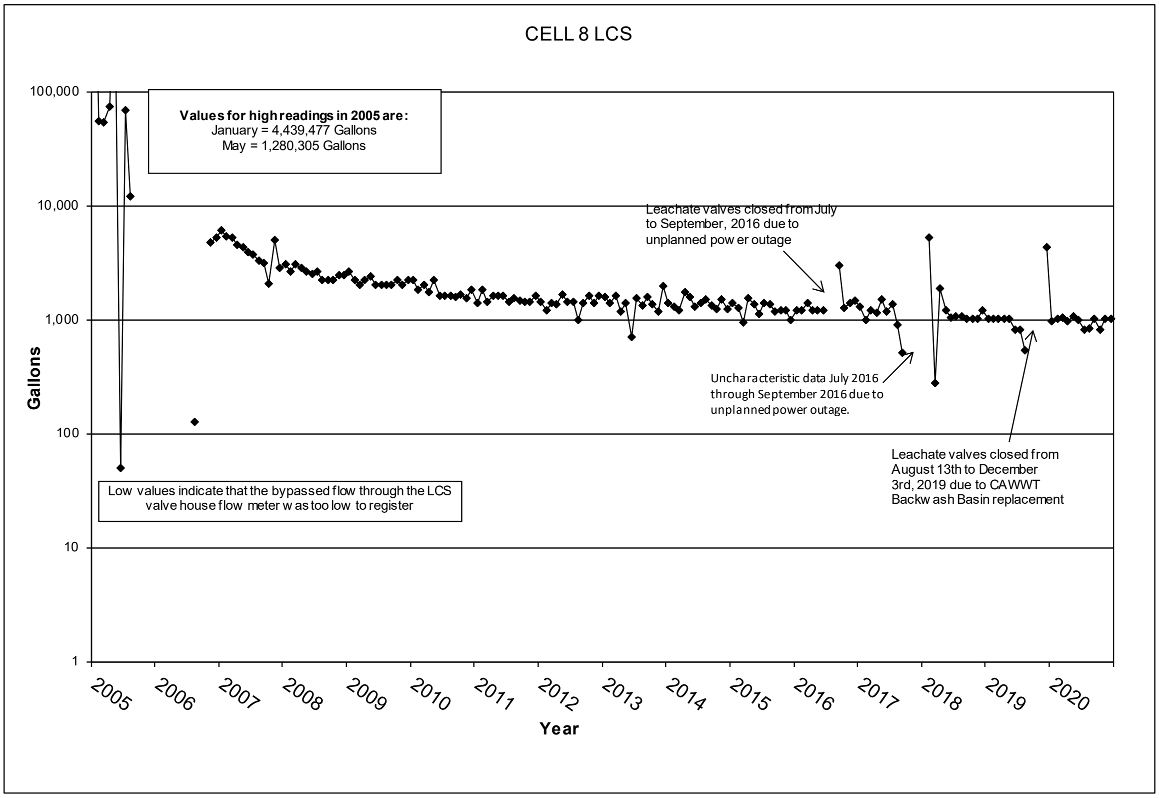


Figure A.5.8-1. Monthly Accumulation Volumes for Cell 8 LCS

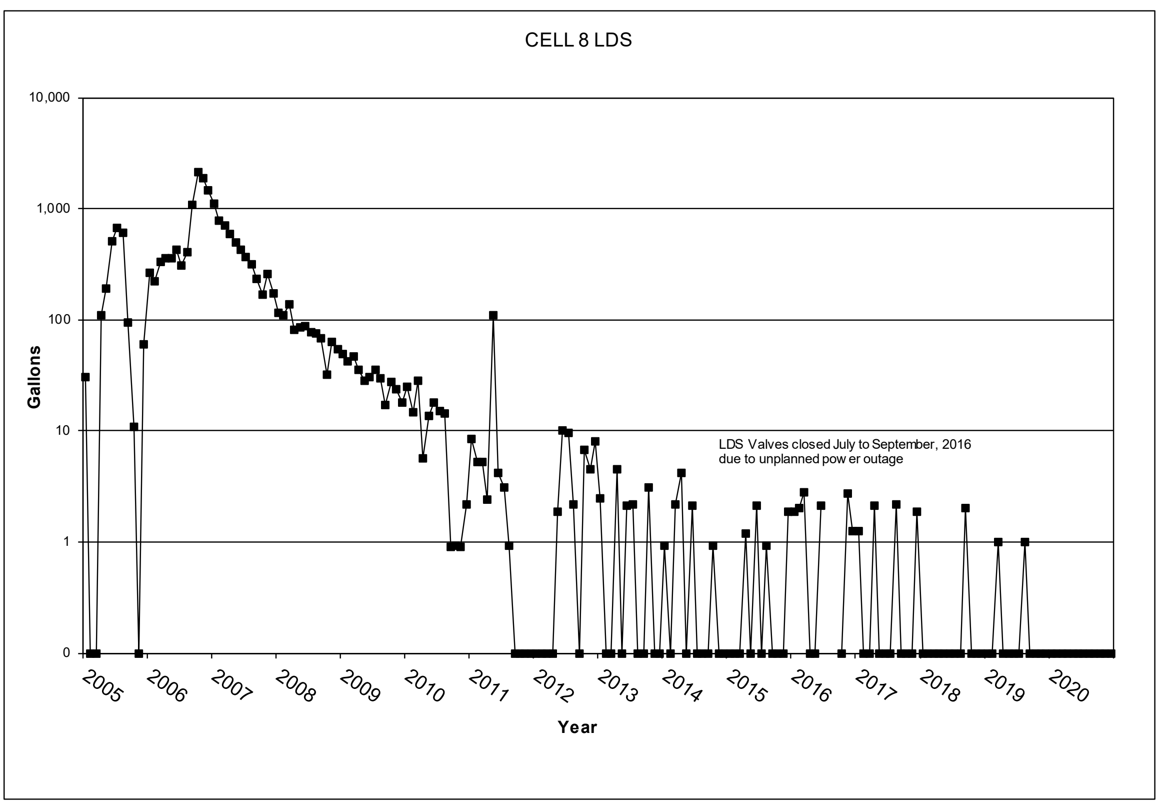


Figure A.5.8-2. Monthly Accumulation Volumes for Cell 8 LDS

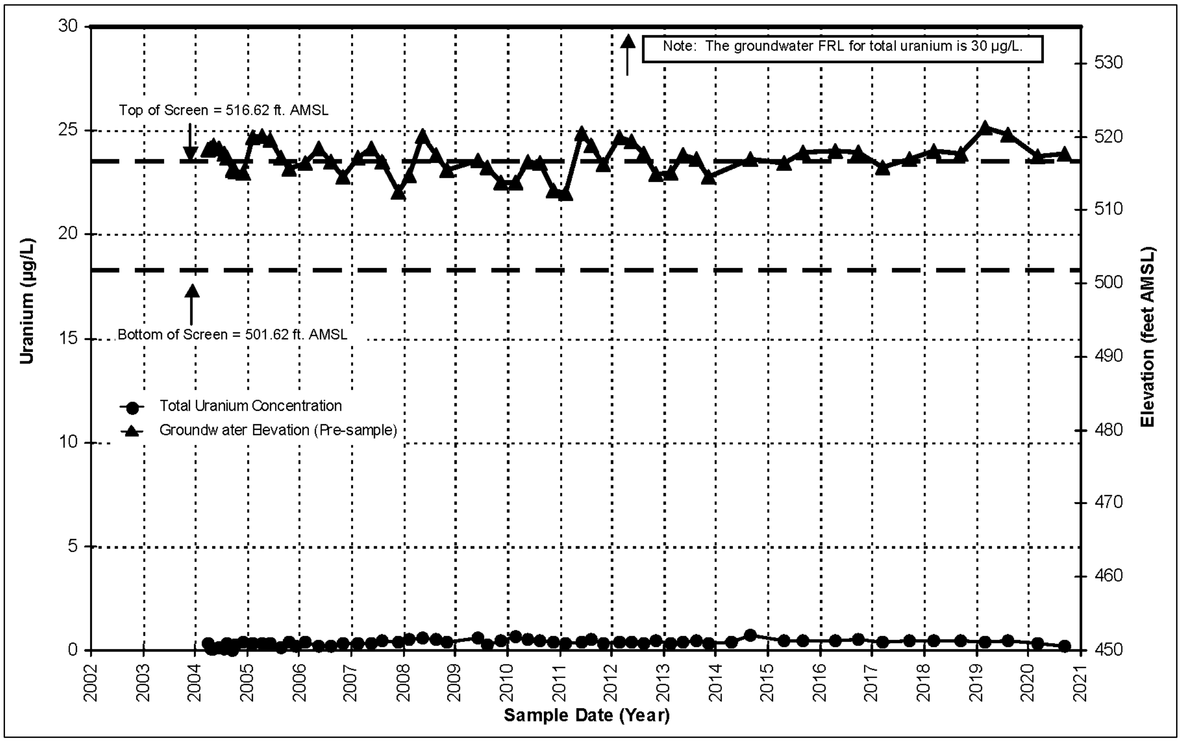


Figure A.5.8-3. Total Uranium Concentration and Groundwater Elevation Versus Time Plot for Cell 8 Upgradient Monitoring Well 22213

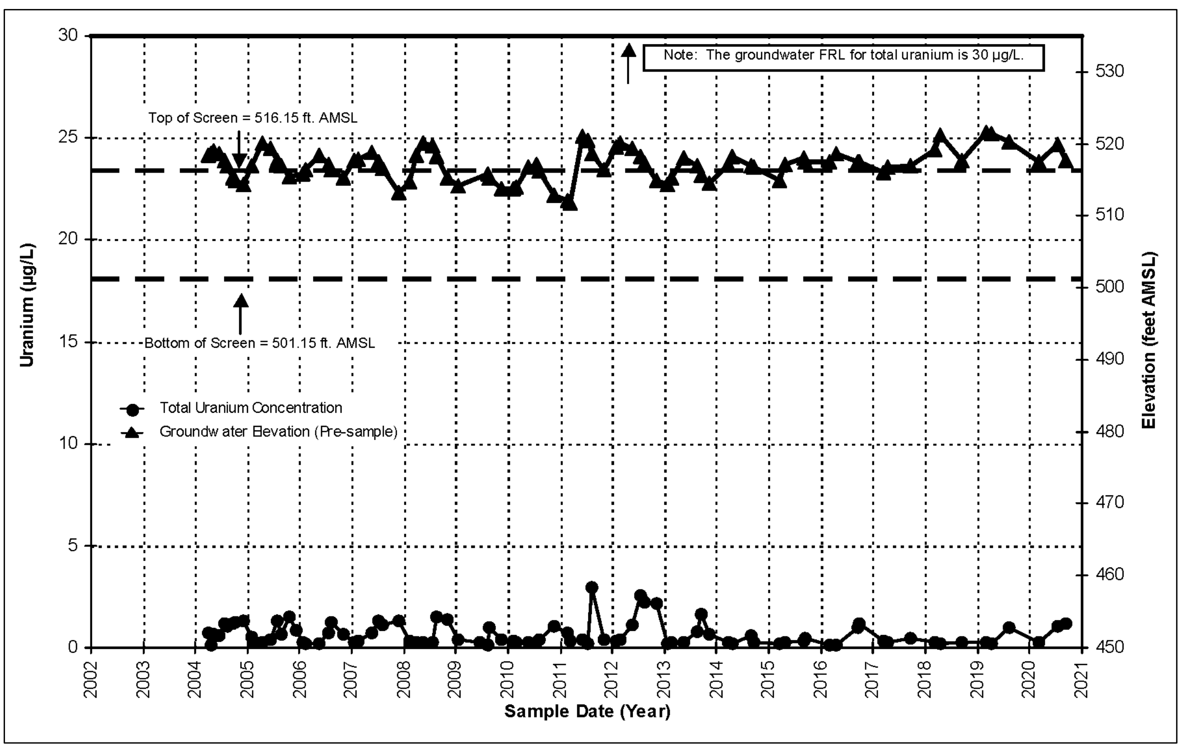


Figure A.5.8-4. Total Uranium Concentration and Groundwater Elevation Versus Time Plot for Cell 8 Downgradient Monitoring Well 22214

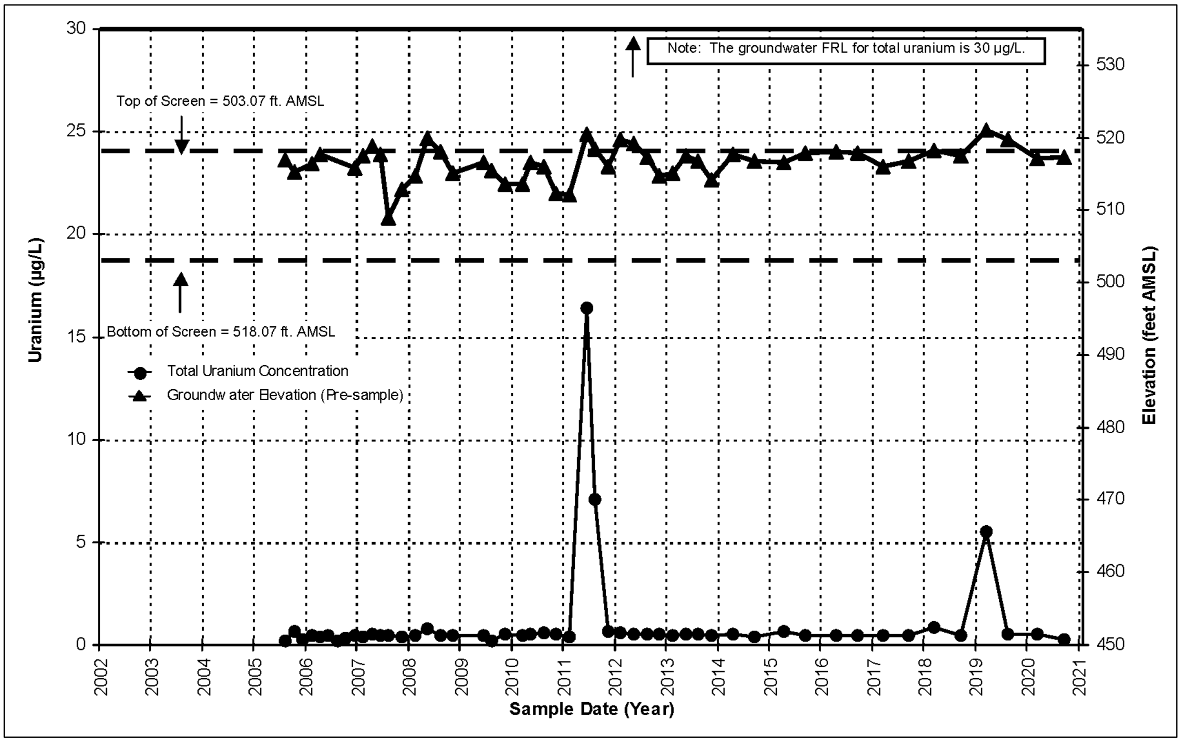


Figure A.5.8-5. Total Uranium Concentration and Groundwater Elevation Versus Time Plot for Cell 8 Downgradient Monitoring Well 22215

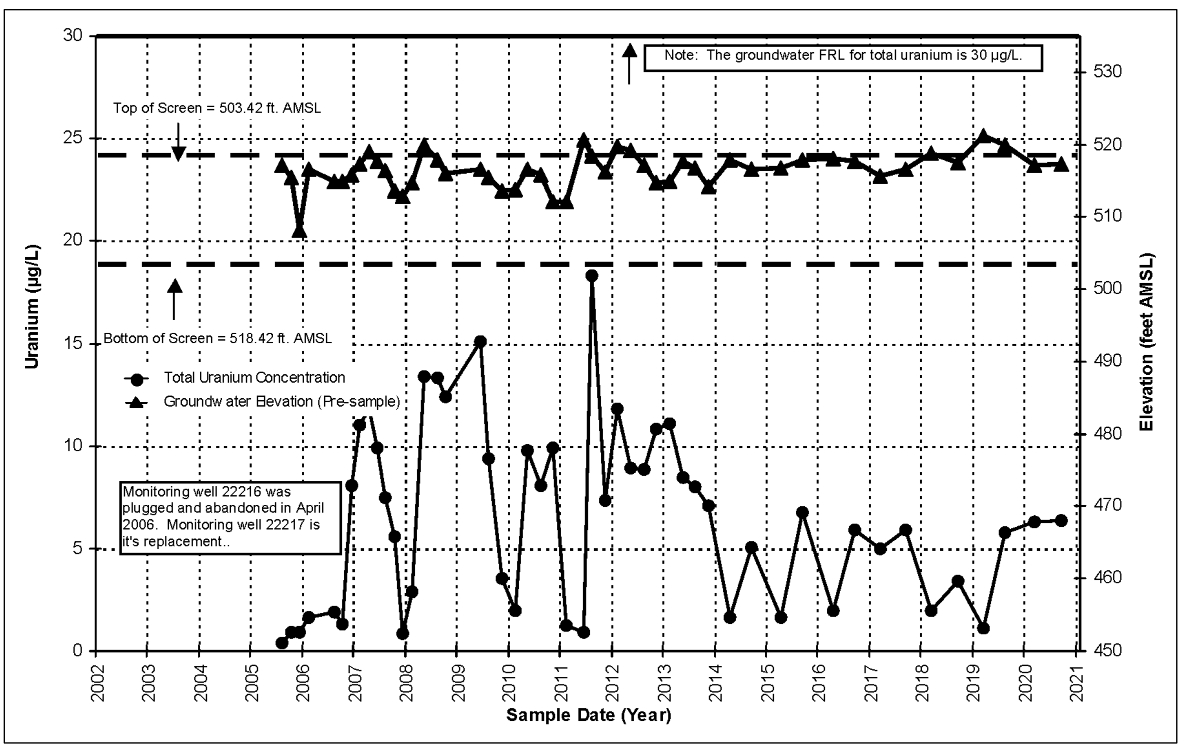


Figure A.5.8-6. Total Uranium Concentration and Groundwater Elevation Versus Time Plot for Cell 8 Downgradient Monitoring Well 22216/22217

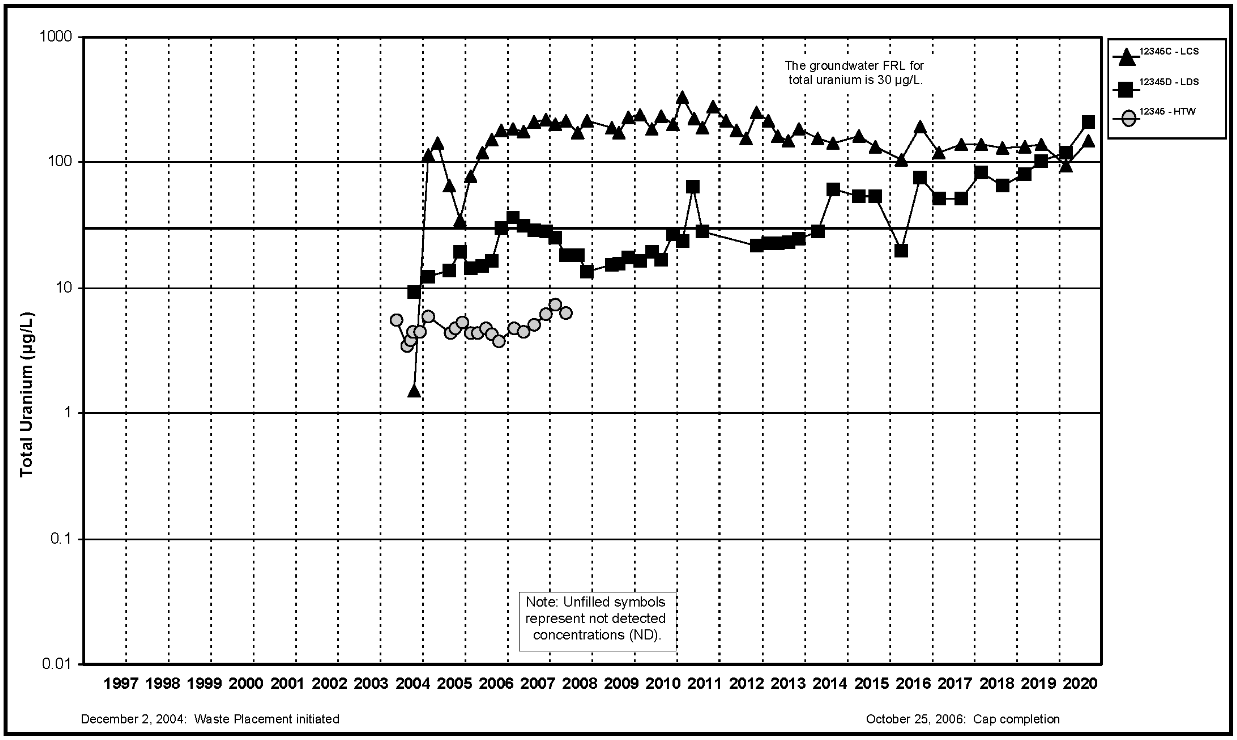


Figure A.5.8-7A. Cell 8 Total Uranium Concentration Versus Time Plot for LCS, LDS, and HTW

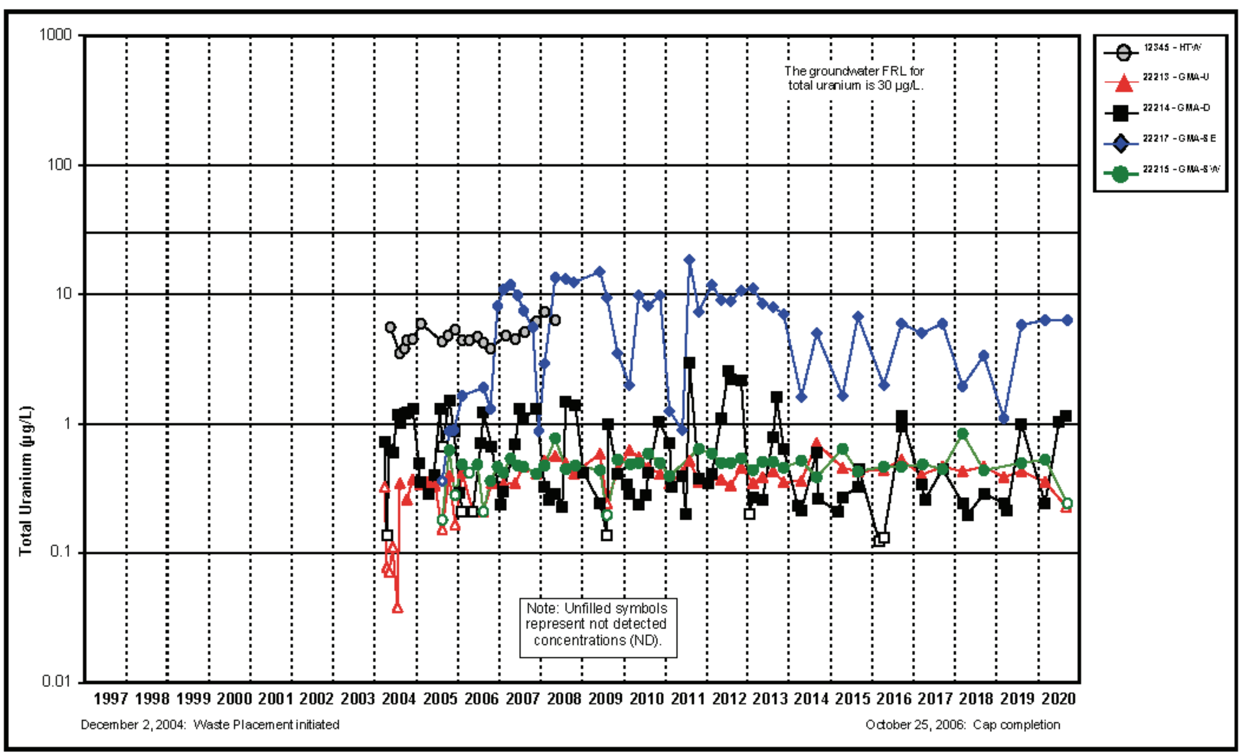


Figure A.5.8-7B. Cell 8 Total Uranium Concentration Versus Time Plot for HTW, GMA-U, GMA-D, GMA-SE, and GMA-SW Wells

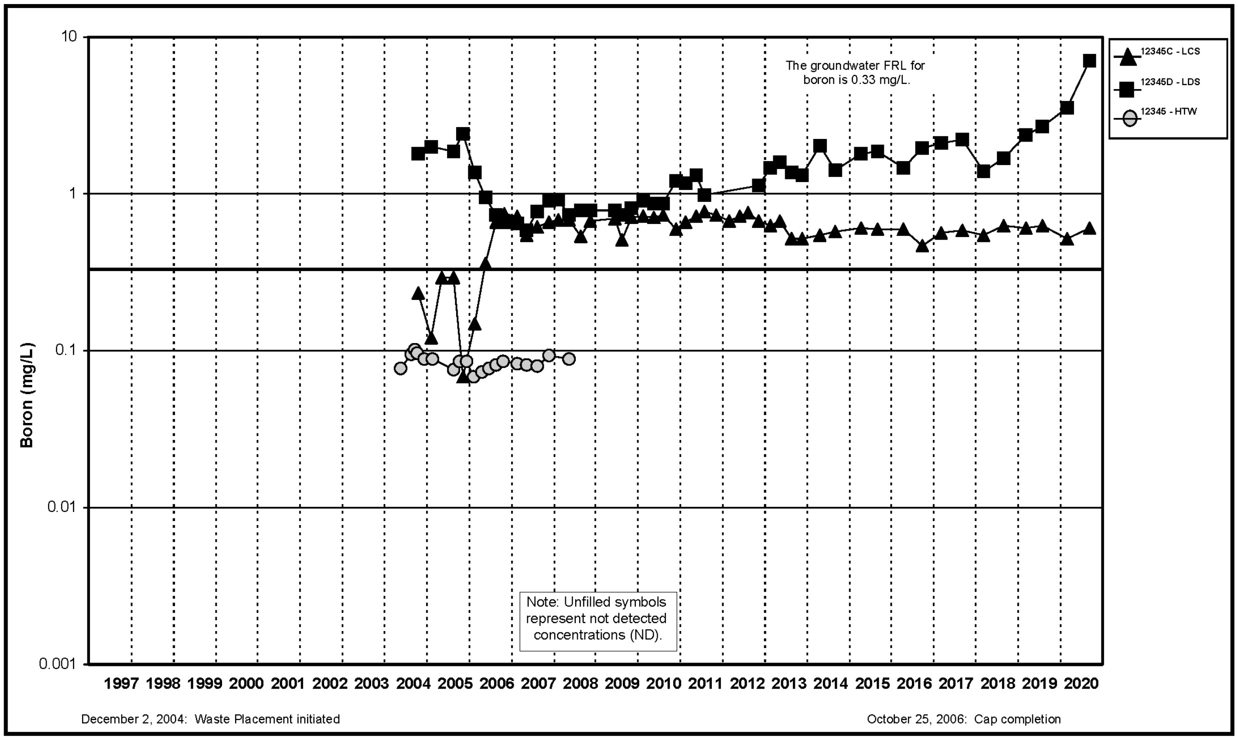


Figure A.5.8-8A. Cell 8 Boron Concentration Versus Time Plot for LCS, LDS, and HTW

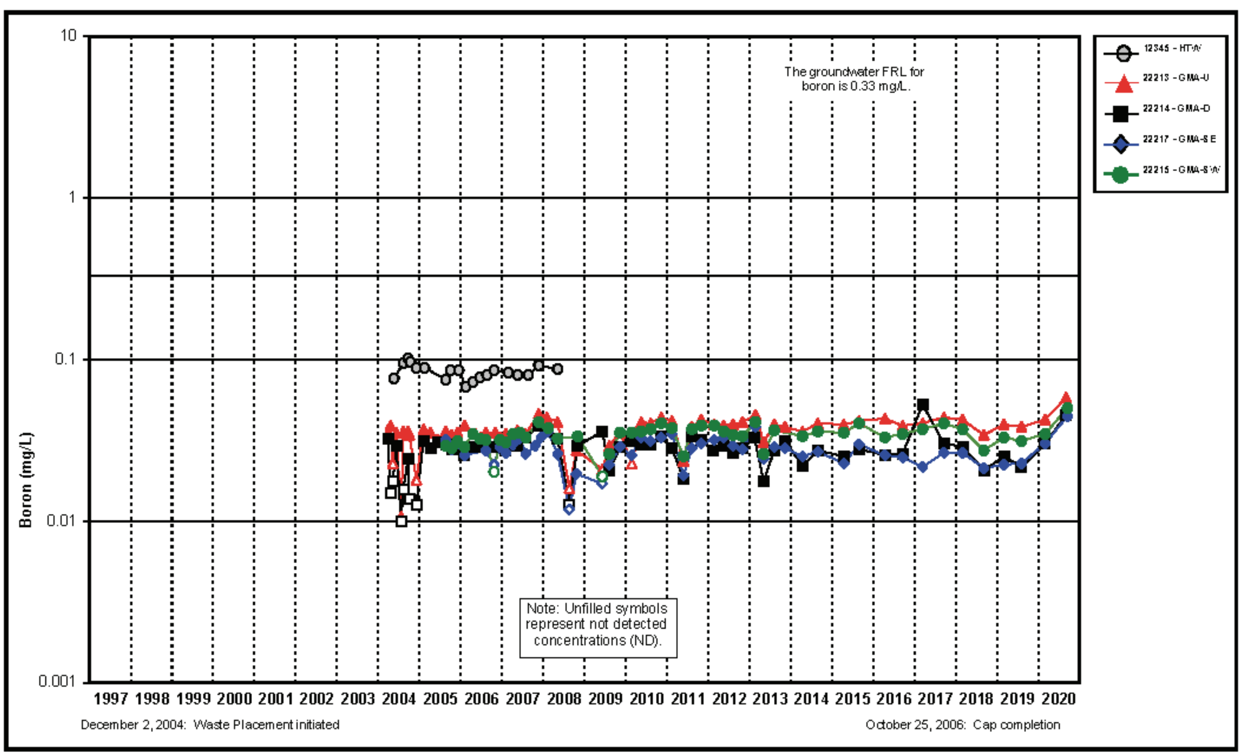


Figure A.5.8-8B. Cell 8 Boron Concentration Versus Time Plot for HTW, GMA-U, GMA-D, GMA-SE, and GMA-SW Wells

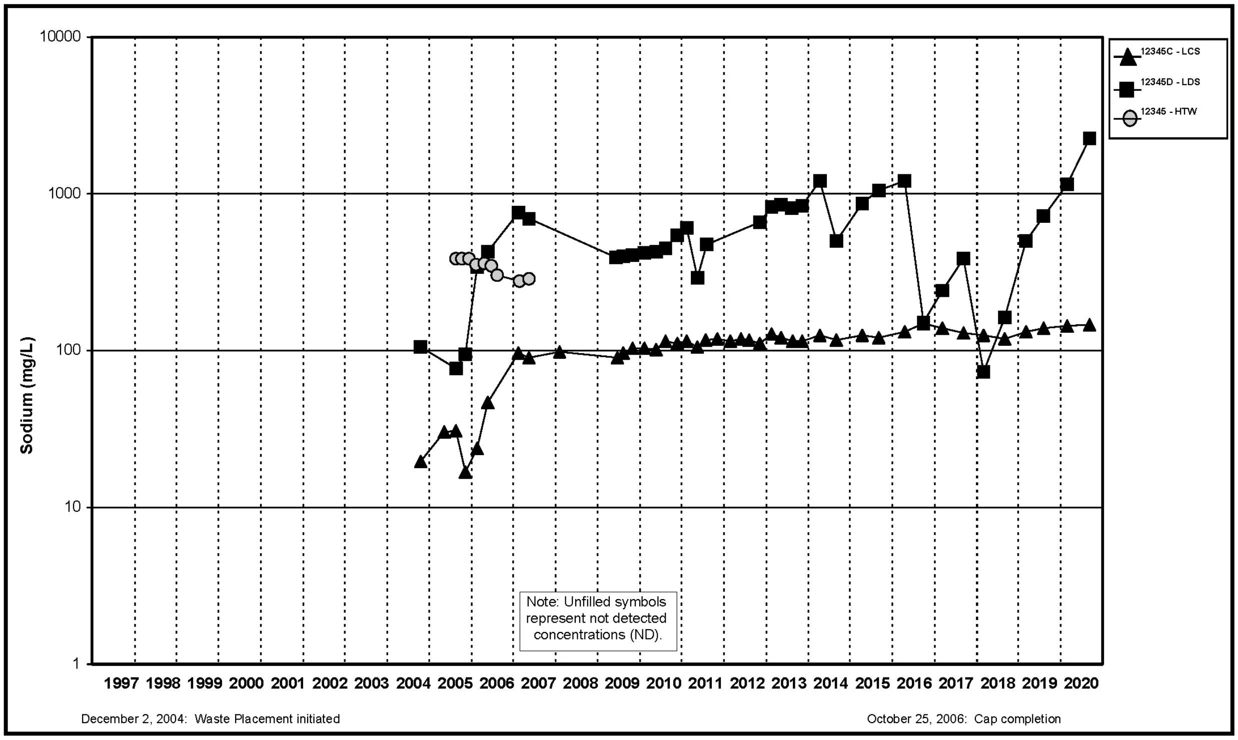


Figure A.5.8-9A. Cell 8 Sodium Concentration Versus Time Plot for LCS, LDS, and HTW

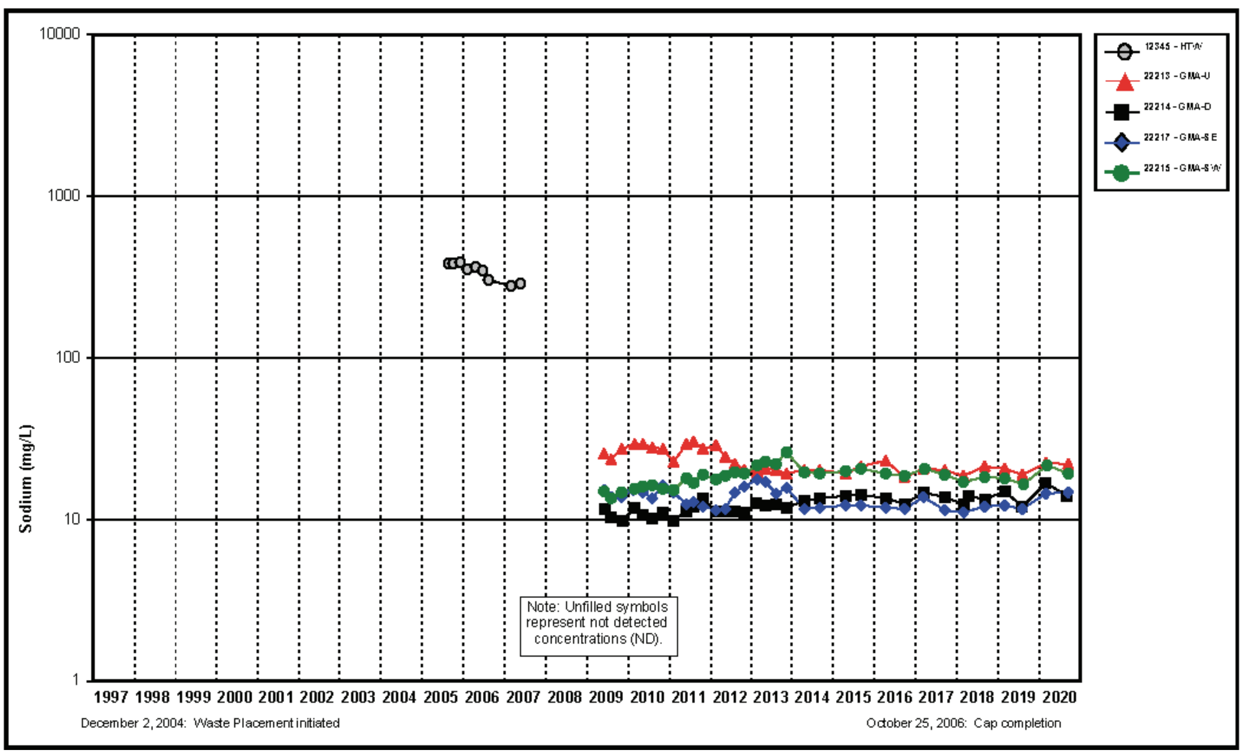


Figure A.5.8-9B. Cell 8 Sodium Concentration Versus Time Plot for HTW, GMA-U, GMA-D, GMA-SE, and GMA-SW Wells

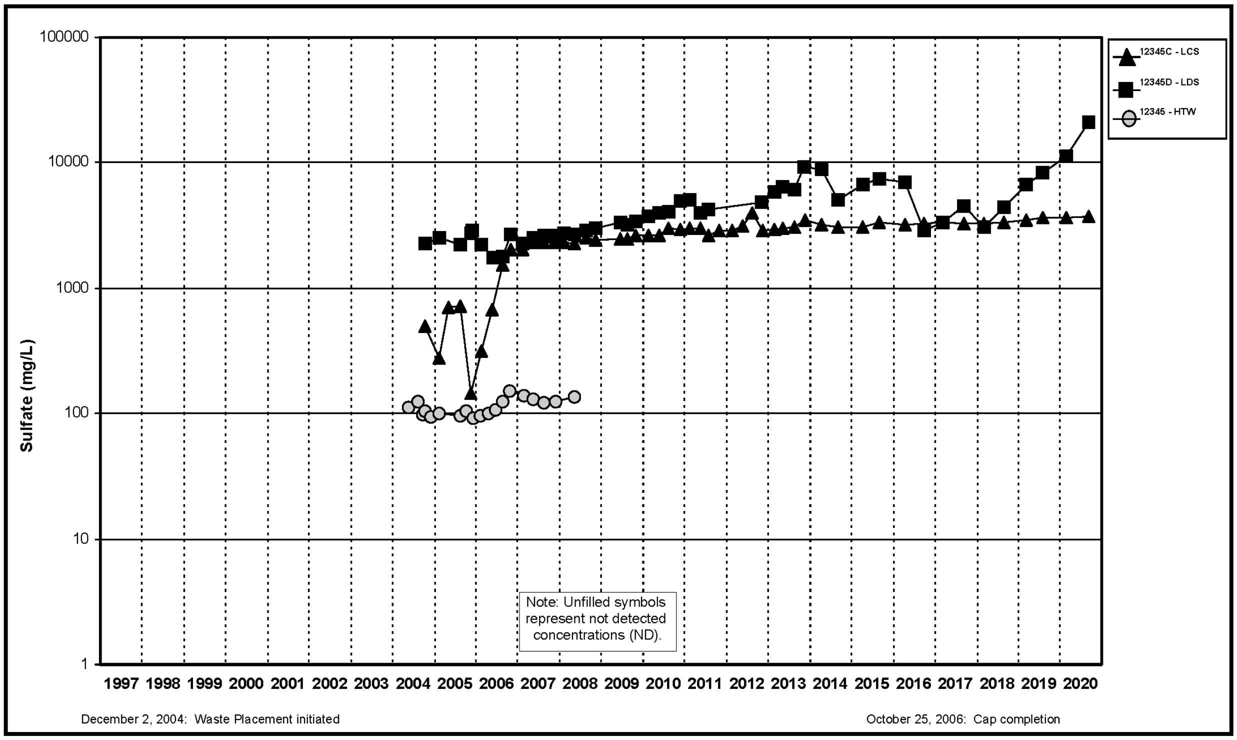


Figure A.5.8-10A. Cell 8 Sulfate Concentration Versus Time Plot for LCS, LDS, and HTW

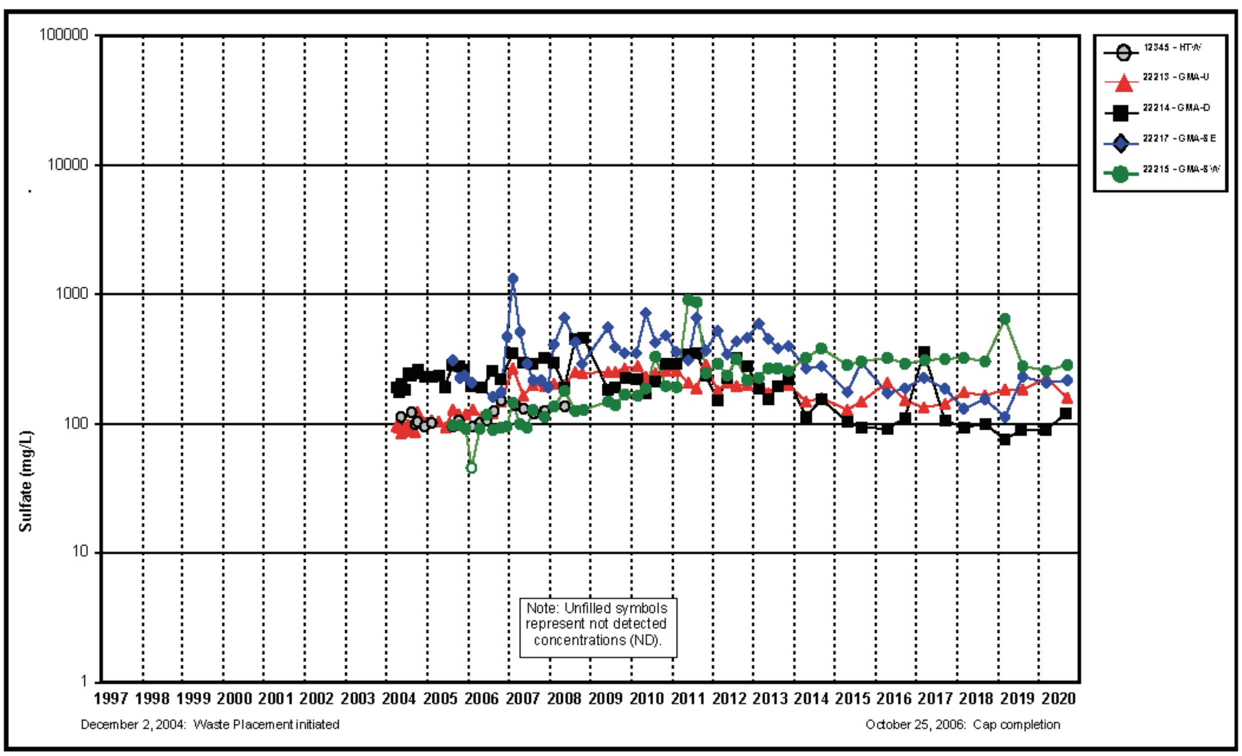


Figure A.5.8-10B. Cell 8 Sulfate Concentration Versus Time Plot for HTW, GMA-U, GMA-D, GMA-SE, and GMA-SW Wells

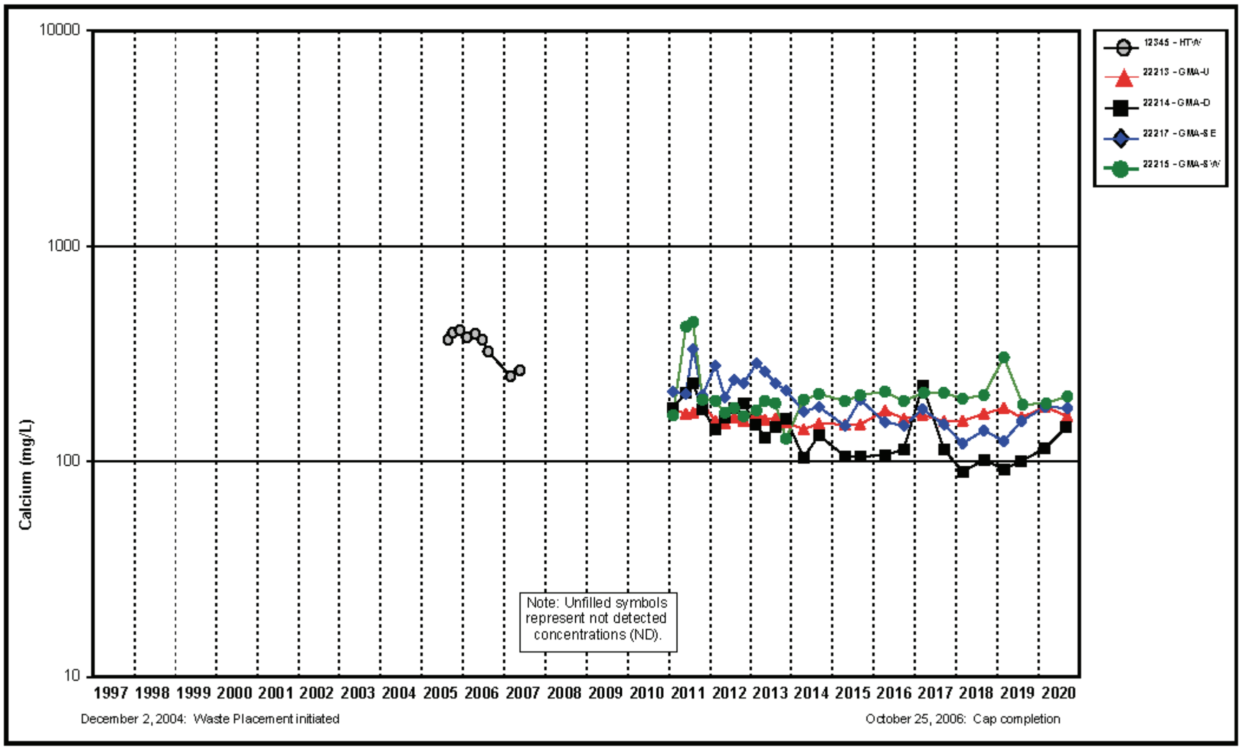


Figure A.5.8-11. Cell 8 Calcium Concentration Versus Time Plot for HTW, GMA-U, GMA-D, GMA-SE, and GMA-SW Wells

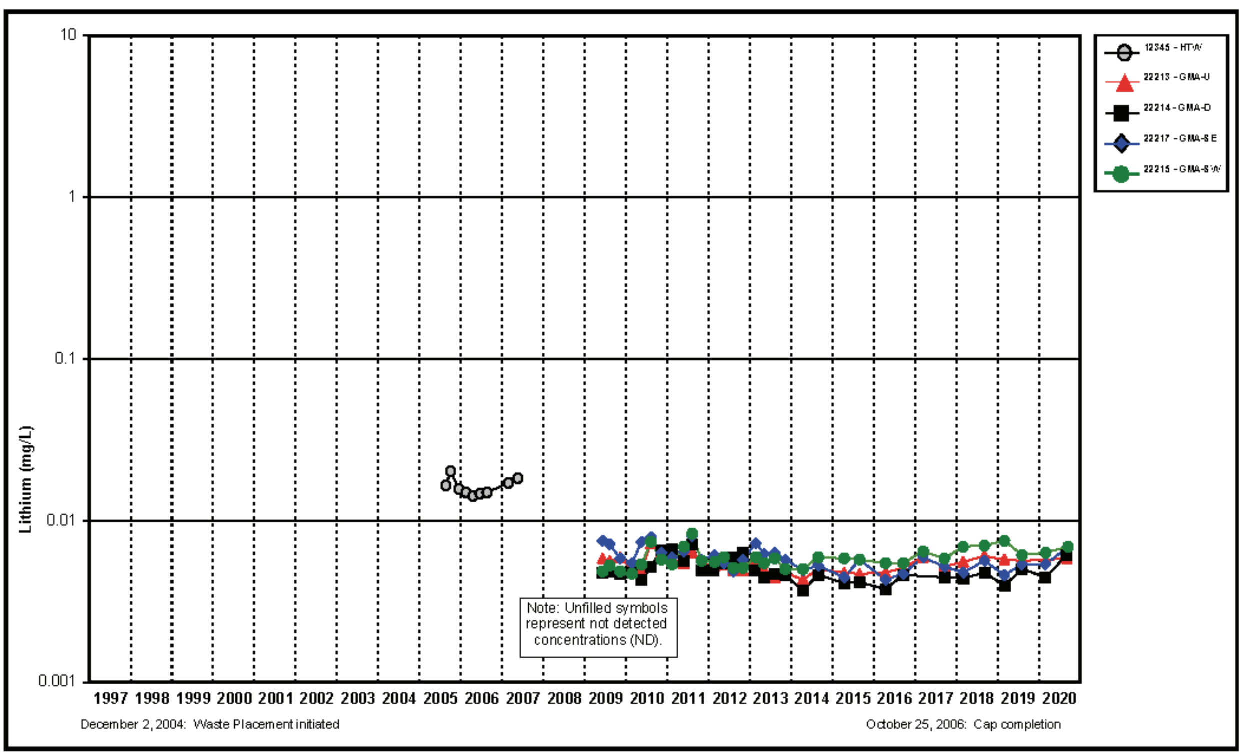


Figure A.5.8-12. Cell 8 Lithium Concentration Versus Time Plot for HTW, GMA-U, GMA-D, GMA-SE, and GMA-SW Wells

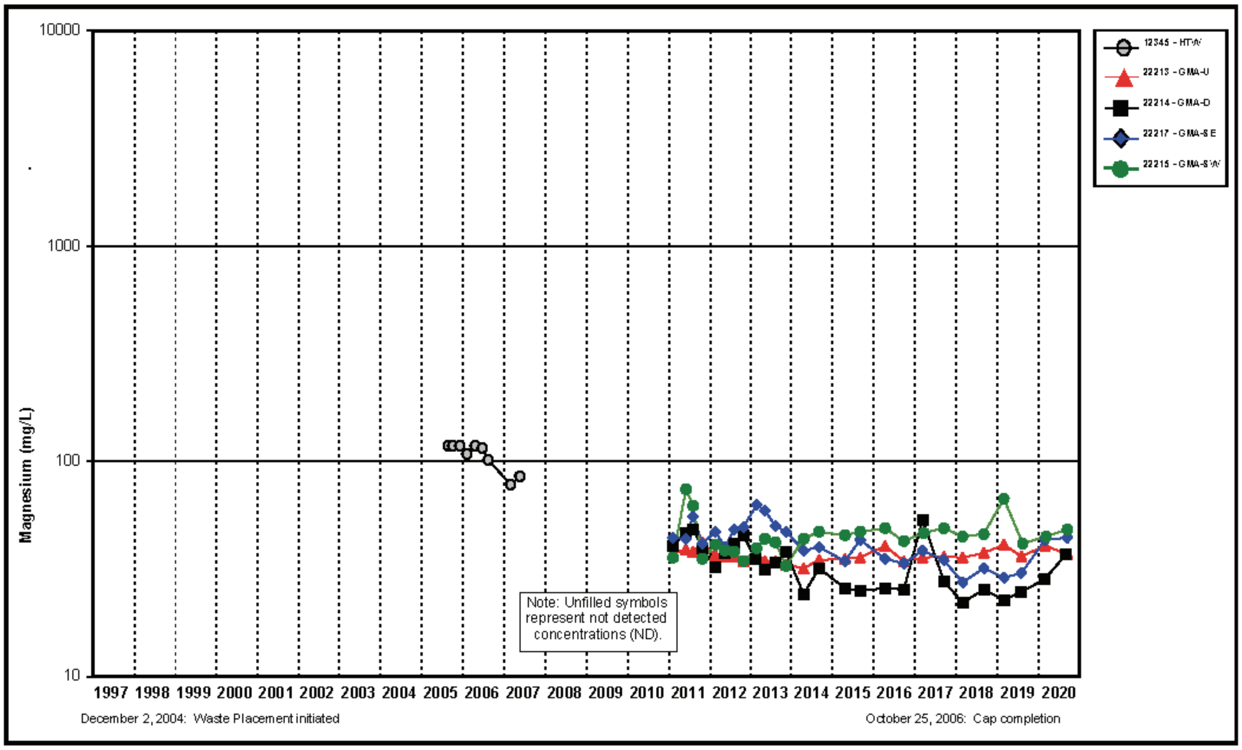


Figure A.5.8-13. Cell 8 Magnesium Concentration Versus Time Plot for HTW, GMA-U, GMA-D, GMA-SE, and GMA-SW Wells

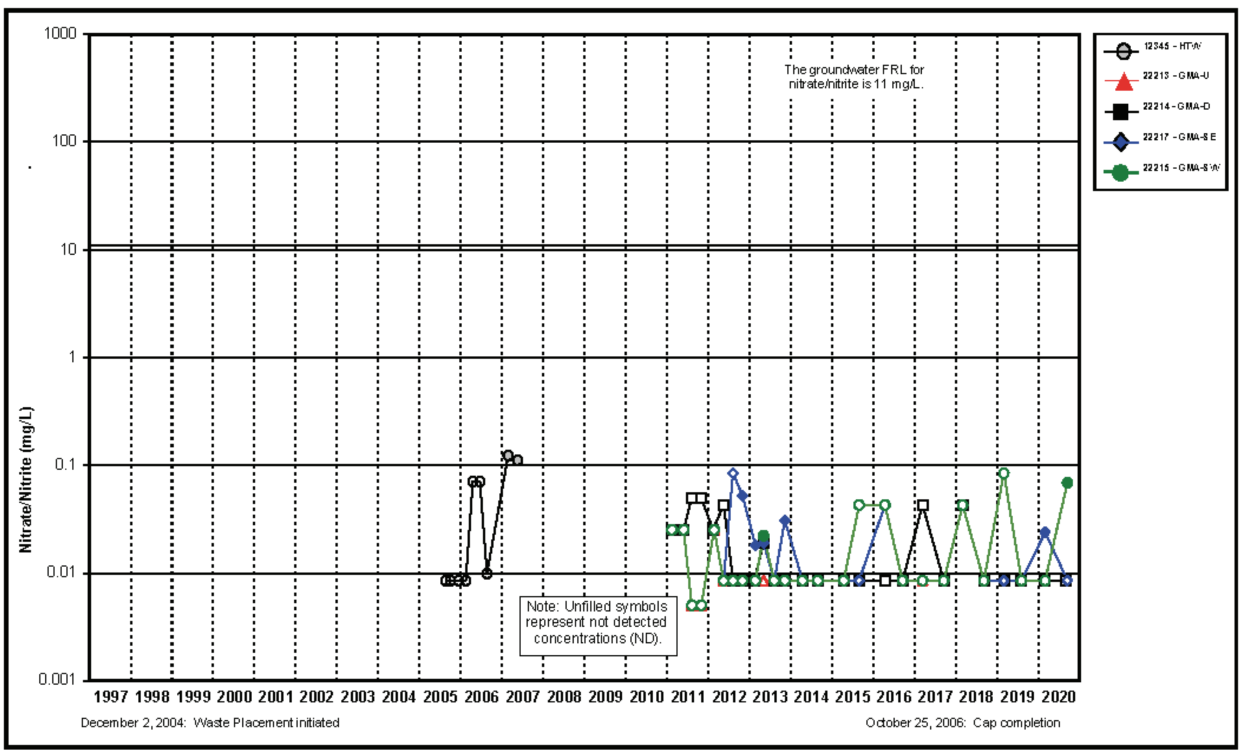


Figure A.5.8-14. Cell 8 Nitrate + Nitrate as Nitrogen Concentration Versus Time Plot for HTW, GMA-U, GMA-D, GMA-SE, and GMA-SW Wells

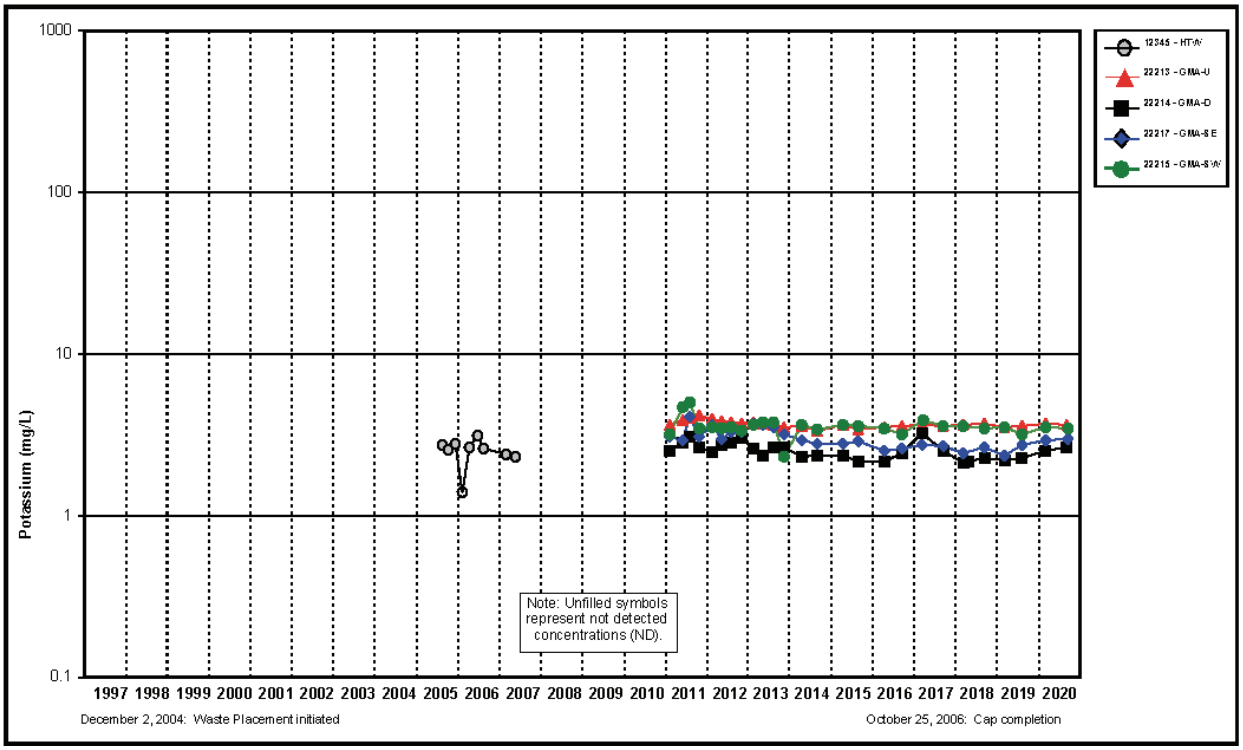


Figure A.5.8-15. Cell 8 Potassium Concentration Versus Time Plot for HTW, GMA-U, GMA-D, GMA-SE, and GMA-SW Wells

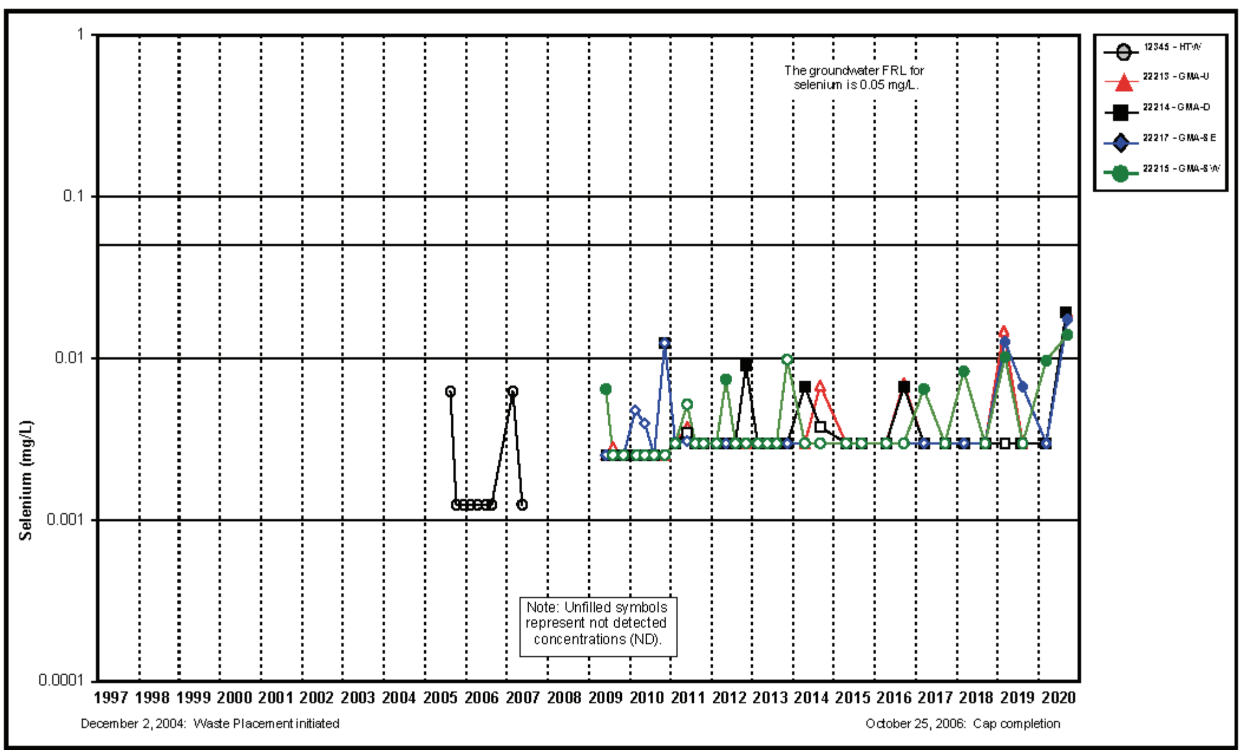


Figure A.5.8-16. Cell 8 Selenium Concentration Versus Time Plot for HTW, GMA-U, GMA-D, GMA-SE, and GMA-SW Wells

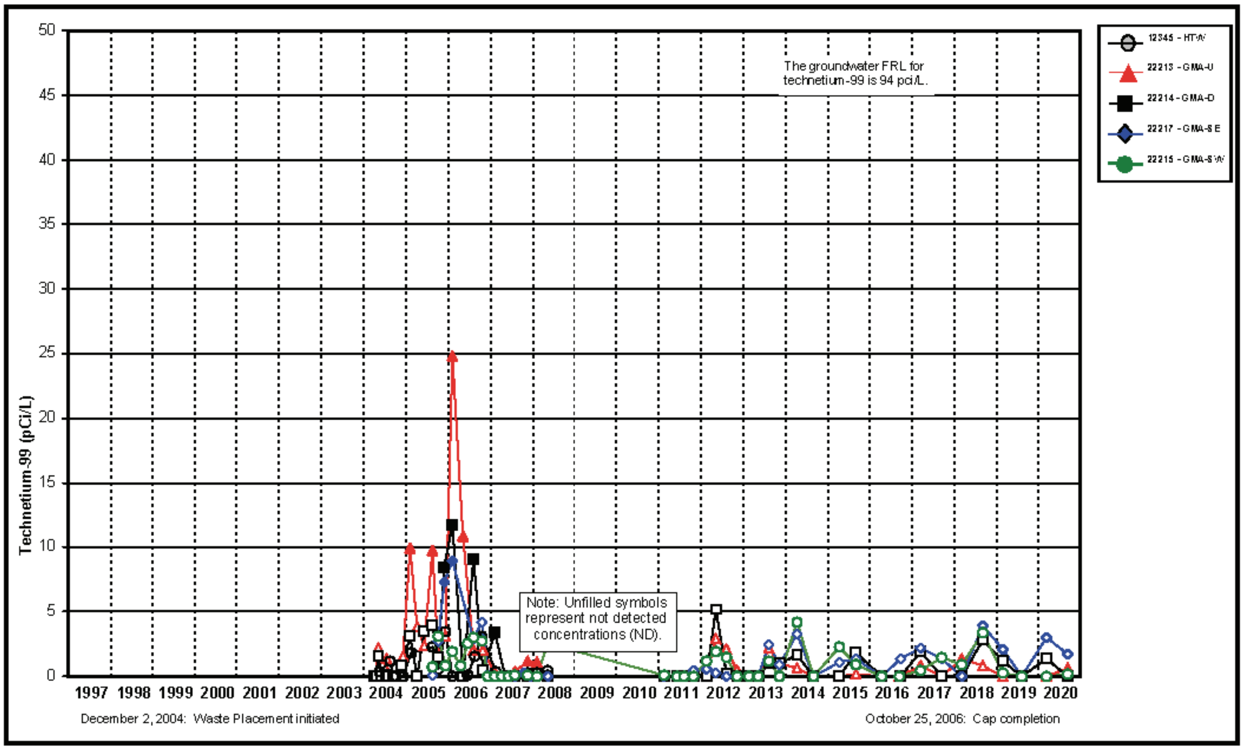


Figure A.5.8-17. Cell 8 Technetium-99 Concentration Versus Time Plot for HTW, GMA-U, GMA-D, GMA-SE, and GMA-SW Wells

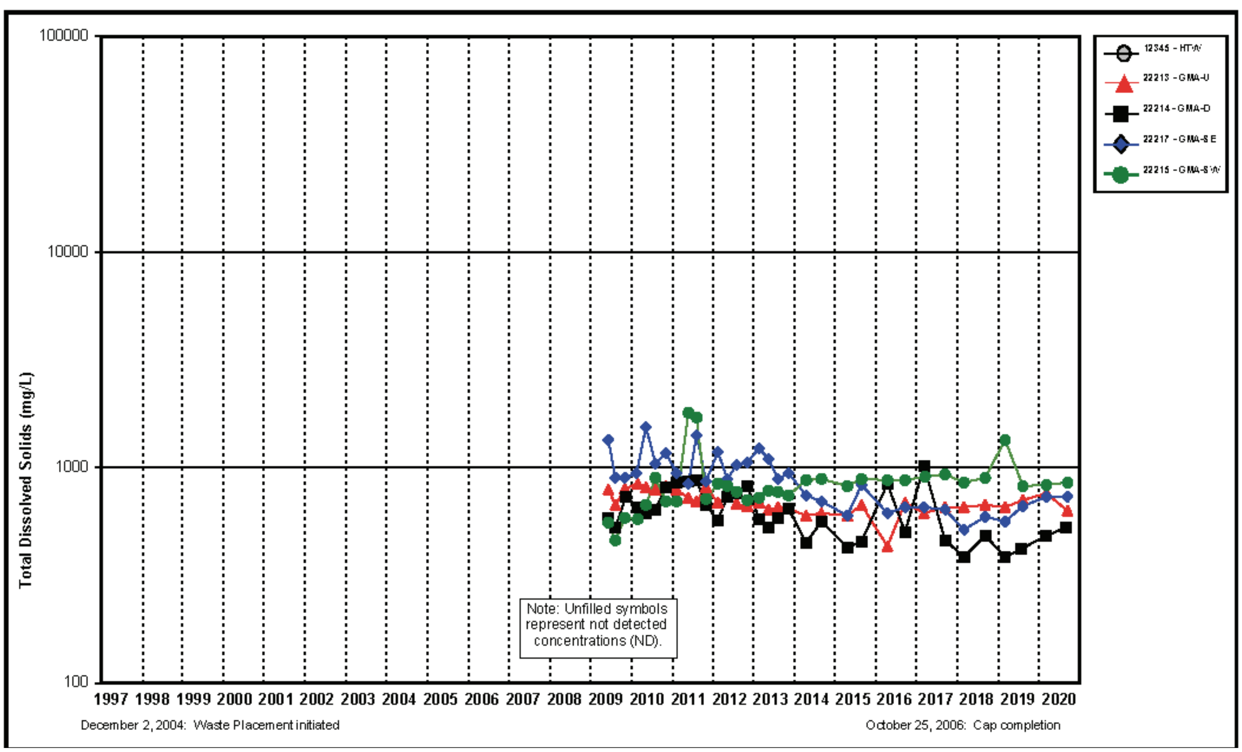


Figure A.5.8-18. Cell 8 Total Dissolved Solids Concentration Versus Time Plot for HTW, GMA-U, GMA-D, GMA-SE, and GMA-SW Wells

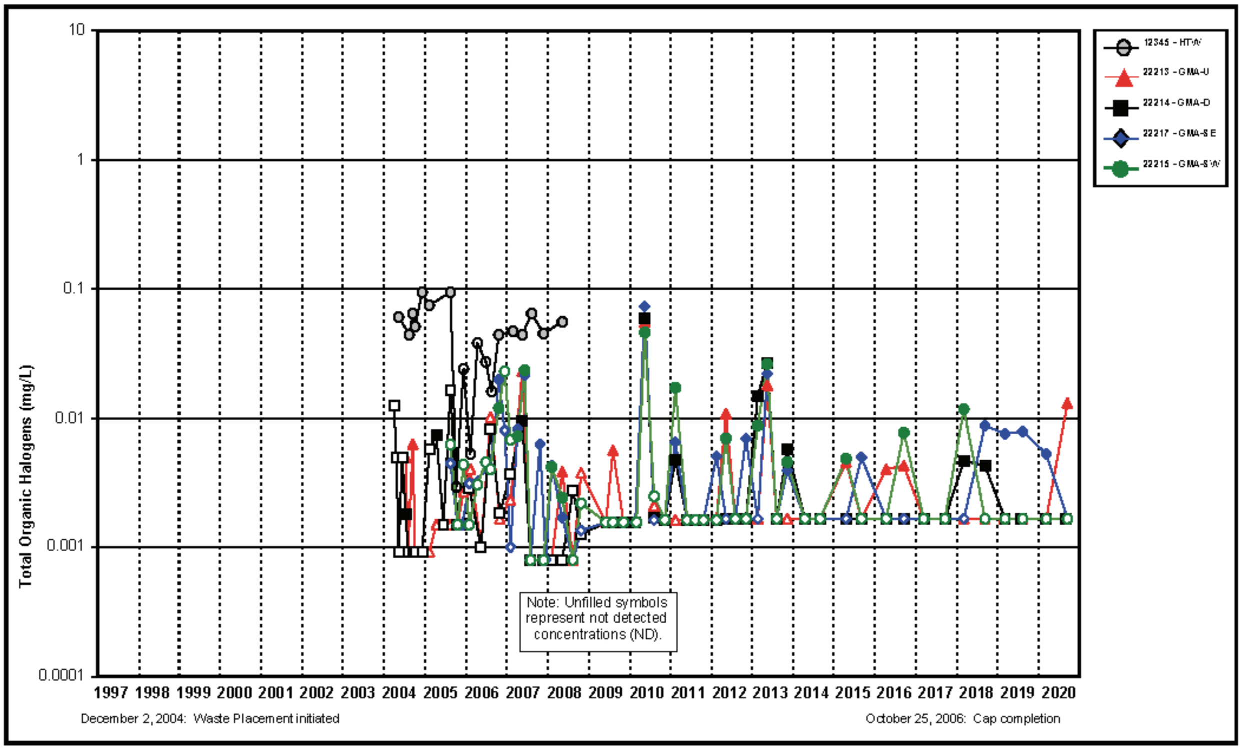


Figure A.5.8-19. Cell 8 Total Organic Halogens Concentration Versus Time Plot for HTW, GMA-U, GMA-D, GMA-SE, and GMA-SW Wells

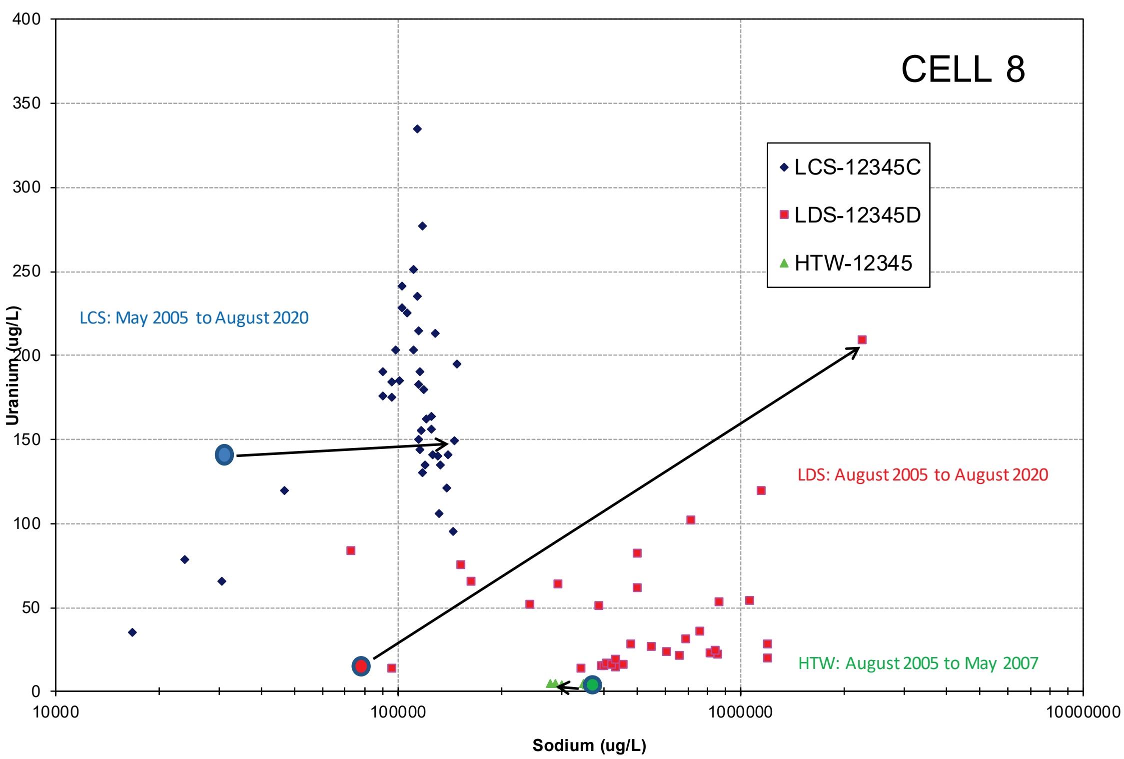


Figure A.5.8-20. Cell 8 Bivariate Plot for Uranium and Sodium

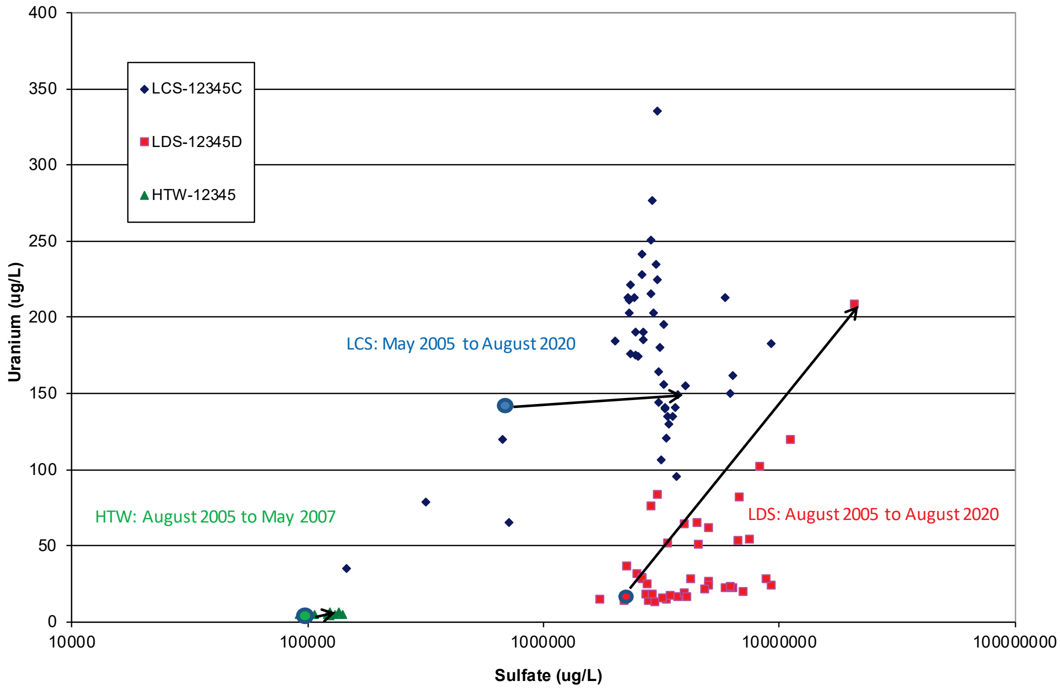


Figure A.5.8-21. Cell 8 Bivariate Plot for Uranium and Sulfate

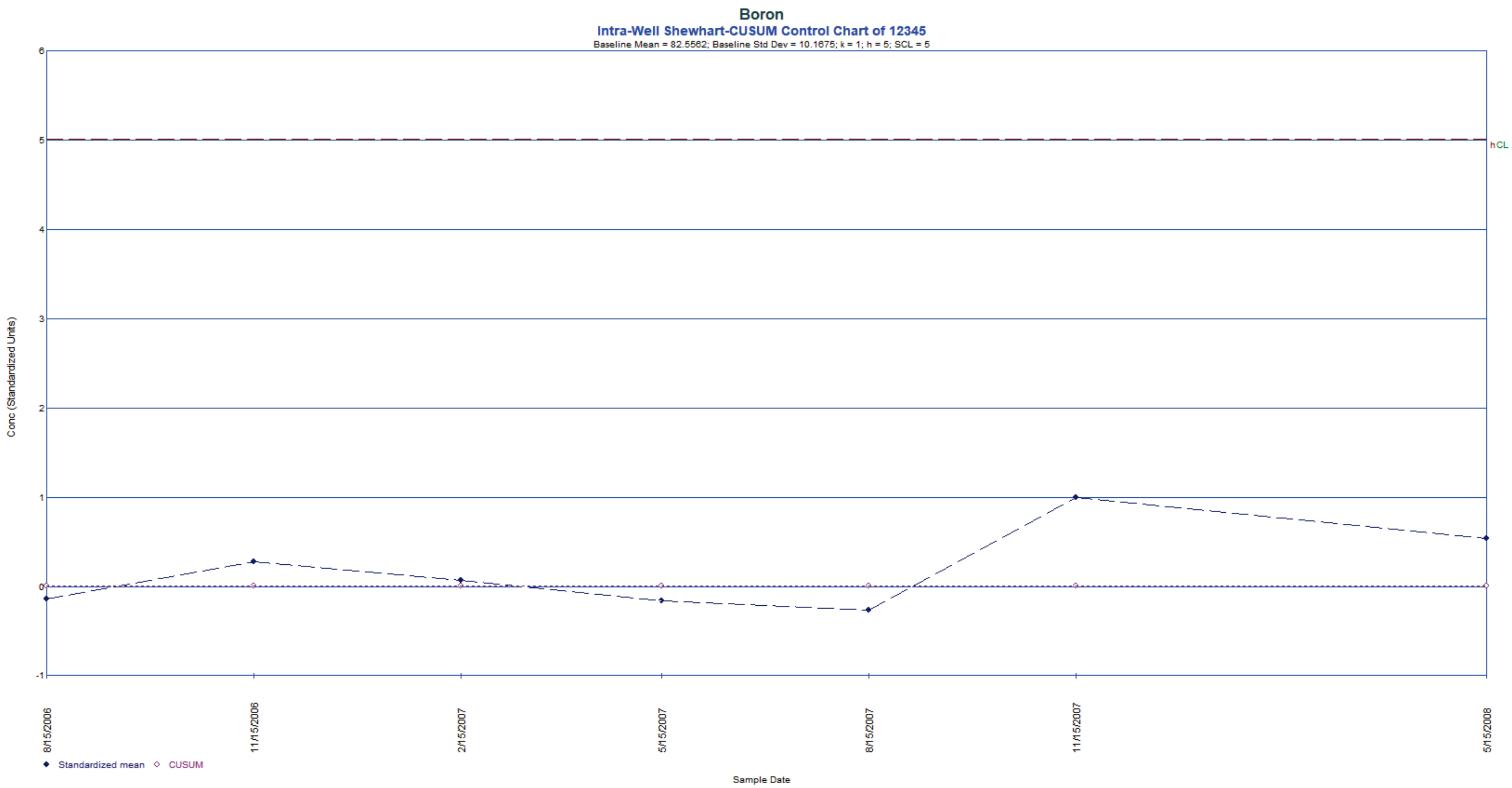
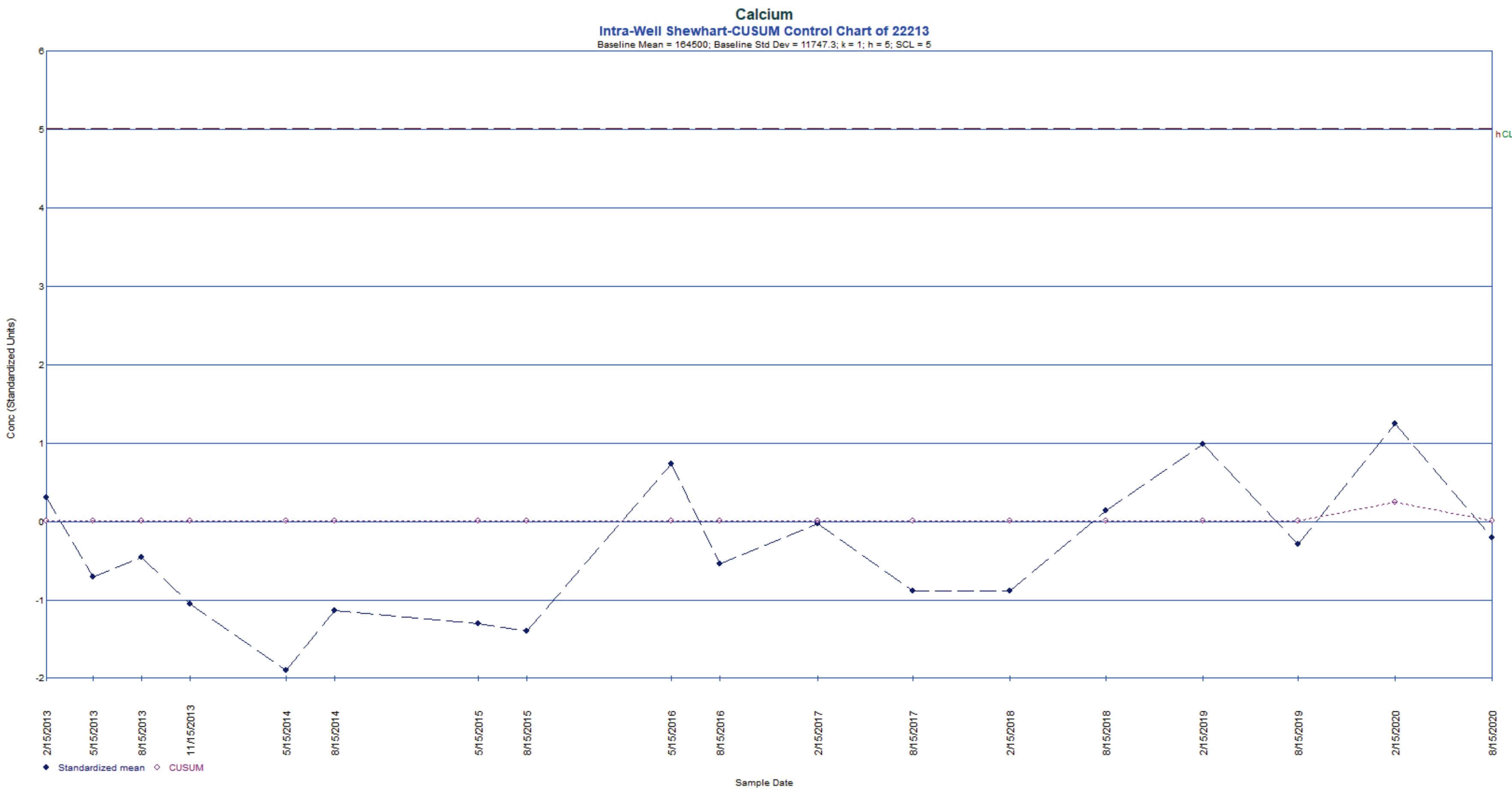


Figure A.5.8-22. Intrawell Shewhart-CUSUM Control Chart for Boron in Monitoring Well 12345



Abbreviation: Conc = concentration

Figure A.5.8-23. Intrawell Shewhart-CUSUM Control Chart for Calcium in Monitoring Well 22213