LMS/TUB/S08999

# Annual Groundwater Report April 2011 Through March 2012 Tuba City, Arizona, Disposal Site

July 2012

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# Abbreviations

| | |
|---|---|
| CFR | *Code of Federal Regulations* |
| DOE | U.S. Department of Energy |
| ft | feet |
| GCAP | Groundwater Compliance Action Plan |
| gpm | gallons per minute |
| lb | pounds |
| MCL | maximum concentration limit |
| mg/L | milligrams per liter |
| NNEPA | Navajo Nation Environmental Protection Agency |
| TDS | total dissolved solids |

# Executive Summary

This report evaluates the progress of groundwater remediation at the U.S. Department of Energy (DOE) Office of Legacy Management Tuba City, Arizona, Disposal Site for the period April 2011 through March 2012, and cumulatively since the start of remediation in 2002. The progress of water quality restoration is evaluated and reported annually.

The site is within the Navajo Nation and near Hopi Reservation land. A uranium-ore processing mill operated at the site from 1956 until 1966. DOE conducted surface remedial actions, consisting of encapsulating all solid waste within an onsite engineered disposal cell, between 1988 and 1990. A remnant plume of groundwater contamination, presumed to have originated from process water stored in solar evaporation ponds and slurry-impounded tailings during mill operation, extends beneath and off the site approximately 1,500 feet to the south and southeast in the underlying sandstone aquifer.

The primary contaminants in the groundwater are nitrate, uranium, and sulfate. DOE constructed a pump-and-treat remediation system, operational by mid-2002, to remove these and other site-related contaminants from the aquifer with the objective of achieving water quality restoration goals established in the groundwater compliance action plan (GCAP; DOE 1999). The plan indicated that removal of two pore volumes of groundwater within the contaminant plume, over 20 years of active remediation, would possibly suffice to meet those goals. However, the plan also identifies potential limitations to pump-and-treat technology based on geochemical flow-related factors.

During the current review period (April 2011 through March 2012), close to 9 million gallons of contaminated groundwater were treated, yielding a total cumulative treatment volume of 360 million gallons, or about 30 percent of the total estimated volume of uranium-contaminated groundwater prior to remedial action. Major findings through the period are summarized below:

- Operation of the remediation system was suspended in October 2010 to allow upgrading and replacement of treatment system components. At that time, DOE also updated the preventive maintenance program and operating procedures. The remediation system resumed operation in September 2011 but has since operated intermittently (only 64 days during this review period) due to equipment malfunctions.
- Historically (excluding the recent shutdown and intermittent operational period), the treatment plant has, overall, operated effectively and as intended. Treatment rate, distillate quality, and return flow to the aquifer have met or exceeded design objectives during normal operation.
- When the extraction system is fully operational, its current configuration captures the lateral region of maximum groundwater contamination and the full vertical extent to meet design objectives. Although the treatment plant was not operating for the bulk of this review period, as has been the case in previous years, plume expansion into uncontaminated regions is not evident.
- As concluded in previous annual reports (e.g., DOE 2010, 2011a), after more than 9 years of operation, significant and widespread decreases in contaminant concentrations are not apparent. This is despite the measureable progress in groundwater treatment, as indicated by cumulative contaminant mass and volumes extracted from the aquifer.

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# 1.0 Introduction

## 1.1 Background Information

This report evaluates the progress of groundwater remediation at the U.S. Department of Energy (DOE) Office of Legacy Management (LM) Tuba City, Arizona, Disposal Site for the period April 2011 through March 2012, as well as cumulatively since the start of remediation in 2002. The progress of water quality restoration is evaluated and reported annually.

The site is located near Tuba City, Arizona, within the Navajo Nation and near Hopi Reservation land (Figure 1). A uranium-ore processing mill operated at the site from 1956 until 1966. DOE conducted surface remedial actions, consisting of encapsulating all solid waste within an onsite engineered disposal cell, between 1988 and 1990. A remnant plume of groundwater contamination, presumed to have originated from process water stored in solar evaporation ponds and slurry-impounded tailings during mill operation, extends beneath and off the site approximately 1,500 feet (ft) to the south and southeast in the underlying sandstone aquifer.

The primary contaminants in the groundwater are nitrate, uranium, and sulfate. DOE constructed a pump-and-treat remediation system, operational by mid-2002, to remove these and other site-related contaminants from the aquifer with the objective of meeting water quality restoration goals established in the groundwater compliance action plan (DOE 1999). The action plan did not define a specific duration of active groundwater remediation to meet those goals.

## 1.2 Groundwater Remediation System

The groundwater remediation system currently comprises 37 extraction wells completed within the contaminated region of the aquifer. The extracted water is conveyed in underground piping to an onsite treatment plant, where it is distilled following ion exchange softener pretreatment. A lined solar evaporation pond receives the waste liquid (brine) and the softener regeneration waste. An infiltration trench located upgradient of the contaminant plume receives the treated water (distillate), where it is returned to the aquifer.

Six injection wells (wells 1003 through 1008; see Figure 2a for well locations), originally intended to create a hydraulic barrier downgradient of the contaminant plume by injecting a portion of the treated water, remain unused for that purpose because contamination does not extend to the area of those wells. Of the 37 extraction wells, eight wells (wells 1126 through 1133) were installed in fall 2004 to expand the capture zone of the original 25 wells (wells 1101 through 1125, installed in 1999). Monitoring wells 935, 936, 938, and 942 were converted to extraction wells in summer 2005.

Numerous monitoring wells that are used to track water quality and water level trends are situated within and surrounding the network of extraction wells. Figures 2a through 2c depict the locations of extraction and monitoring wells and the primary features of the site. Figure 2a shows all well locations, Figure 2b shows monitoring wells only, and Figure 2c shows treatment system wells only. (These figures are referred to collectively as Figure 2.) Corresponding well completion information is provided in Appendix A in tabular and schematic form.

Figures 2a and 2b also include the locations of monitoring wells installed by the Navajo Nation Environmental Protection Agency (NNEPA) in September 2010 (iiná bá/DOE 2011). DOE sampled several of these wells in in February 2011 and February 2012 to further assess water quality and flow direction in the west and north-northwest areas of the site along with the regularly scheduled biannual sampling of the DOE monitoring wells. Monitoring results for the NNEPA wells are included in the analysis of groundwater contamination extent and groundwater flow direction presented in Section 3.0 of this report.

Operation of the remediation system was suspended in October 2010 to allow upgrading and replacement of treatment system components. At that time, DOE also updated the preventive maintenance program and operating procedures. The remediation system resumed operation in September 2011 but has since operated intermittently due to equipment malfunctions.

## 1.3 Groundwater Compliance Strategy

The groundwater compliance strategy for the Tuba City site, as defined in the *Phase I Ground Water Compliance Action Plan for the Tuba City, Arizona, UMTRA Site* (DOE 1999), is to achieve applicable cleanup levels through active remediation of those portions of the aquifer affected by previous site activities. Cleanup levels for the aquifer consist of restoration standards (requirements of Title 40 *Code of Federal Regulations* Part 192 [40 CFR 192], "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings") and restoration goals (cleanup levels requested by the Navajo Nation but not required by 40 CFR 192).

Groundwater contaminants requiring active remediation at the site are molybdenum, nitrate, selenium, sulfate, and uranium (DOE 1999). The focus of the figures and data analyses presented in this report are nitrate, uranium, and sulfate, because these contaminants are most widespread and contribute most to potential risk. Restoration standards correspond to a maximum concentration limit (MCL) in groundwater as established by Subpart A of 40 CFR 192. Sulfate is not regulated by 40 CFR 192; however, a restoration standard was adopted for this constituent because it is present in site groundwater at concentrations that could cause excess potential risk (DOE 1999). Groundwater remediation targets for the site are presented in Table 1.

*Table 1. Groundwater Remediation Targets*

| Constituent/Property | Cleanup Level | Baseline Concentrations in Plume |
|---|---|---|
| Nitrate[a] as $NO_3$ | 44 mg/L as $NO_3$ | 840–1,500 mg/L as $NO_3$ |
| Molybdenum[a] | 0.10 mg/L | 0.01–0.58 mg/L |
| Selenium[a] | 0.01 mg/L | 0.01–0.10 mg/L |
| Uranium[a] | 30 pCi/L (0.044 mg/L) U-234 + U-238 | 0.3–0.6 mg/L |
| Sulfate[a] | 250 mg/L | 1,700–3,500 mg/L |
| Total Dissolved Solids (TDS)[b] | 500 mg/L | 3,500–10,000 mg/L |
| Chloride[b] | 250 mg/L | 20–440 mg/L |
| pH[b] | 6.5–8.5 | 6.3–7.6 |
| Corrosivity[b] | not corrosive | not applicable |

[a] Restoration standard
[b] Restoration goal
mg/L = milligrams per liter
pCi/L = picocuries per liter

Source: DOE 1999

## 1.4 Performance Monitoring and Reporting

The effectiveness of the remediation system in removing contaminants from the aquifer and progressing toward cleanup levels is evaluated yearly, mainly on the basis of groundwater monitoring conducted in July or August and February of each year. During these events, samples are collected at monitoring wells for water quality analysis and water levels are measured. The data are then compared to baseline conditions determined between 1998 and March 2002 (DOE 2003) to evaluate the capture zone of the extraction system, to evaluate plume movement within the aquifer, and to evaluate contaminant removal rates and concentration trends.

The extraction wells are sampled during the July–August event. This is also the case for several distal monitoring wells that have no history of contamination. Other information used in evaluating the effectiveness of the groundwater remediation system includes monitoring data collected during routine operation of the treatment plant, such as (1) continuous flow metering for each extraction well, (2) continuous flow metering of the bulk influent and all outflow streams, (3) approximately weekly determination of bulk inflow and distillate composition through composite sampling, and (4) approximately monthly analysis of groundwater composition at each extraction well.

## 1.5 Hydrogeologic Setting

### 1.5.1 Site Conceptual Model and Groundwater Flow

The Tuba City site lies on the middle of three alluvial terraces formed during ancestral flow in Moenkopi Wash. The wash is located about 1.5 miles southeast of the former processing site (see Figure 2 for location of Moenkopi Wash). The terraces are composed of thin (≤20 ft) surface deposits of coarse, indurated, Quaternary alluvium. Loose dune sand and silt mantle the terraces at most locations. The terrace and dune deposits unconformably overlie the regionally extensive Navajo Sandstone, a massively cross-bedded, friable, fine-grained to very fine-grained sandstone and siltstone of Jurassic age. Escarpments that separate the terraces are formed by cliffs of the Navajo Sandstone. The regional dip of the bedrock is about 1 degree to the northeast.

At about 200 ft below ground, the massive eolian dune deposits typifying "classic" Navajo Sandstone become interbedded with fine-grained alluvium more typical of the deeper Kayenta Formation. This "intertonguing interval" is 400 to 450 ft thick. Occasional thin (≤2 ft), resistant limestone beds, which are deposits from relict playa lakes, are interspersed throughout both the classic and intertonguing intervals. The Kayenta Formation consists primarily of 100 ft or more of less-resistant, thin-bedded, red silt and fine sand and lacks the characteristic cross-beds of the Navajo Sandstone. Figure A−1 in Appendix A depicts a conceptual model of the site hydrogeology to illustrate the relationship of surface topography, subsurface geology, and groundwater flow.

Groundwater beneath the Tuba City site occurs in the regionally extensive "N" multiple-aquifer (Cooley et al. 1969), which in the site area comprises the classic and intertonguing intervals of the Navajo Sandstone. Because of the fine-grained composition of the Kayenta Formation locally, it is not water bearing and is considered the base of the N-aquifer in the site area. The local water table occurs within the Navajo Sandstone; the terrace and dune deposits in the site area are not saturated. Groundwater saturation extends from the water table, about 50 to 60 ft

below ground surface on the upper and middle terraces, to the contact with the Kayenta Formation, accounting for a saturated thickness on the order of 500 ft.

Except for the local effects of groundwater withdrawal at the site, groundwater flow is generally south to Moenkopi Wash. At Moenkopi Wash, the Navajo Sandstone is fully penetrated and regional aquifer discharge occurs, expressed as a laterally extensive (10–20 miles) spring zone near the exposed base of the intertonguing interval. Local discharge of groundwater from higher in the formation occurs in some areas, as evidenced by scattered bands of desert phreatophytes that typically occur near the base of the escarpment between the middle and lower terraces. One such area is noted in Figure 2 as the "greasewood area," where the depth to water is approximately 20 ft.

### 1.5.2 Vertical Discretization of the N-Aquifer

In the absence of laterally continuous stratigraphic marker beds in the Navajo Sandstone, the subsurface at the site is discretized into 50-ft intervals, or "horizons," each with a letter designation. This designation provides a reference system for evaluating site hydrogeology and extent of contamination in the vertical dimension. Ground surface of the middle terrace, nominally 5,050 ft in elevation, marks the top of the uppermost horizon, Horizon A (Figure A–1, Appendix A). Horizons A, B, C, and possibly D span the interval of classic Navajo Sandstone beneath the site. The depths of Horizons E through J vertically span the intertonguing interval. The stratigraphic relationships to aquifer horizons are shown in Figure A−1 of Appendix A.

Horizons K, L, and M include the lower intertonguing interval and possibly the upper portion of the Kayenta Formation. Because of surface topography, the uppermost horizon on the lower terrace progresses from Horizon C to D, north to south. The steep topography at Moenkopi Wash intersects Horizons E through G. Contamination of the aquifer is limited in depth to Horizons A, B, and C; therefore, groundwater remediation at the site focuses primarily on the upper 150 ft of the bedrock aquifer. Deeper horizons are also affected by remedial actions and so continue to be monitored.

In Figure 2, color-coding identifies the corresponding horizon in which the midpoint of the well screen is located for extraction wells (round symbols) and monitoring wells (square symbols). Well screen depth in relation to aquifer horizon and elevation for all project wells is shown schematically in Figure A−2 of Appendix A. Table A−1 of Appendix A includes additional well completion information such as screen length and screen intake elevations.

# 2.0 Treatment and Extraction Systems

## 2.1 Bulk Treatment Parameters

The remediation system resumed operation in September 2011 after an approximate year-long shutdown in October 2010. Between that time and early January 2012 (a period of plant troubleshooting), the remediation system operated intermittently. Full-time operation resumed on January 10, 2012, and continued until March 11, 2012, when the plant was shut down again for repairs. The plant resumed operation again on April 2, 2012 (shortly after the end of this reporting period).

During the current review period of April 2011 through March 2012, the treatment plant operated for 64 of 365 total days[1], yielding a net on-stream factor of 17.5 percent. This estimate includes the period between Fall 2011 (when the plant operated only very intermittently and the volume of water pumped was minimal) and March 11, 2012 (see above). This on-stream percentage is comparable to that reported last year (2010–2011), during which period the plant operated for 79 days (net on-stream factor of 21.6 percent).

Approximately 9 million gallons of water were extracted and treated or placed in the evaporation pond during this period, resulting in an average operating rate of 97.4 gallons per minute (gpm). The effective rate (downtime included) was 17.1 gpm. Aquifer yield generally limits the extraction rate to about 90 to 100 gpm. For comparison, corresponding values reported for 2010–2011 were 11.9 million gallons extracted (also reflecting extended plant shutdown), and average operating and effective rates of 105 and 22.6 gpm, respectively.

Total groundwater treatment as of April 1, 2012, was approximately 360 million gallons, equivalent to about 30.0 percent of the total estimated volume of uranium-contaminated groundwater prior to remedial action (see Section 4.0 for a discussion of contaminant removal rates). Corresponding values reported for 2010–2011 were 350.3 million gallons (cumulative treated volume), corresponding to 29.2 percent of the total contaminated groundwater volume.

Figures 3 and 4 show the feed rate to the treatment plant and the corresponding concentration of nitrate, sulfate, and uranium determined from weekly composite samples since the start of remediation. These figures indicate that, prior to the plant shutdown in October 2010, the bulk extraction rate (represented by inflow), although sometimes highly variable week to week, was relatively steady at rates of between 80 and 100 gpm. Since then, these rates are attainable when the plant is fully operating.

As was the case last year (DOE 2011a), contaminant masses extracted during the current review period were about 30 to 35 percent of those reported historically (when the plant was fully operational). Extracted masses of nitrate, sulfate, and uranium, estimated from the weekly monitoring of bulk inflow to the treatment plant, were (rounded) 30,800 pounds (lb), 98,400 lb, and 23 lb, respectively (Table 2).

[1] This estimate only reflects those periods when the plant was in service and returning treated water to the aquifer. If the plant was operating for only a portion of the day—e.g., for 12 (vs. 24) hours—that was counted as 0.5 day.

*Table 2. Treatment System Performance Summary, April 2011−March 2012*

| Contaminant | Mass Removed During Review Period (lb) | Typical Feed Concentration (mg/L) | Average Distillate Concentration (mg/L) |
|---|---|---|---|
| Nitrate (as $NO_3$) | 30,798 | 545 | 7.5 |
| Sulfate | 98,377 | 1651 | 28.6 |
| Uranium | 23 | 0.48 | 0.0091 |

mg/L = milligrams per liter
The masses removed in 2010–2011 were 43,120 lb; 127,750 lb; and 30 lb for nitrate, sulfate, and uranium, respectively. Typical feed concentrations for 2010–2011 were 428 mg/L; 1,269 mg/L; and 0.3 mg/L; average distillate concentrations were 3.8 mg/L; 15.4 mg/L; and 0.002 mg/L.

## 2.2 Distillate Quality

Figures 5a and 5b plot average weekly concentrations of nitrate, sulfate, uranium, chloride, and total dissolved solids (TDS) in the distillate over time. Except for increases in 2007 and 2008, distillate quality has remained relatively stable since 2005. During this review period, concentrations of nitrate, sulfate, and uranium in the distillate averaged 7.5, 28.6, and 0.009 milligram per liter (mg/L), respectively.

Chloride concentrations in the distillate ranged from 1 to 7 mg/L (2.6 mg/L average), and TDS concentrations ranged from 10 to 100 mg/L (41 mg/L average). For all parameters, contaminant removal is very effective and water of high quality is returned to the aquifer.

## 2.3 Treatment System Water Budget

About 5.6 million gallons (62 percent) of the total feed to the treatment system was returned to the aquifer at the infiltration trench. Treatment system wastewater sent to the evaporation pond normally comprises about 5 percent of the total inflow as brine and about 5 percent as loss for softener regeneration. Approximately 14% of the feed water extracted during this period was added to the evaporation pond to suppress wind transport of residue within the pond while the treatment plant was not in operation.

## 2.4 Groundwater Extraction Wells

In Figure 2c, the extraction wells labeled 1101 to 1125 are constructed of 6-inch-diameter Schedule 40 PVC solid casing and 6-inch, continuous V-wrap stainless-steel screen (0.017-inch slot). A filter pack of 20−40 mesh silica sand fills the 2-inch annulus to 30 or 40 ft above the screen slots. Screen lengths are 150 ft, extending from the bottom half of Horizon B to the mid-depth of Horizon E, except for wells 1116, 1117, and 1118, which have 100-ft screens to a depth near the base of Horizon D. Extraction wells 1126 to 1133 are constructed of 4-inch-diameter casing and screen. These wells have a 30-ft to 50-ft screen that is placed across most of Horizon B. These wells became operational in August 2005, as did former monitoring wells 935, 936, 938, and 942 (4-inch wells). The extraction well pumps are generally positioned 10 to 15 ft above the bottom of the well. Pumps in wells 935, 936, 938, and 942 are at the bottom of the well because these wells are much shallower and so have much less potential drawdown. Refer also to Table A–1 and Figure A–2 in Appendix A for well completion details.

### 2.4.1 Infiltration Trench

The infiltration trench is constructed into bedrock along the north side of the site (see Figure 2). Distillate enters at the midpoint of the trench and flows toward each end in 8-inch diameter perforated pipe that is embedded in a 3-ft-thick gravel pack. The trench is approximately 4 feet wide and extends to a depth of about 6 feet below ground surface. In-line valves allow regulation of flow to either end of the trench to optimize infiltration. Monitoring wells 284 and 285 are paired with wells 946 and 943, respectively, to monitor water table conditions at the contact between the terrace deposits and the Navajo Sandstone immediately downgradient of the trench (see Figure 2b). Monitoring is also conducted at several other locations near the trench to evaluate local effects of infiltration on the water table and water quality (for example, at wells 686, 687, 688, 945, and 947).

# 3.0 Groundwater Capture Analysis

## 3.1 Extent of Groundwater Contamination

The "a" series figures in Figures 6a through 14a illustrate the concentrations of nitrate (as $NO_3$), sulfate, and uranium in groundwater in the respective aquifer horizons before the start of remediation (baseline period). The "b" series figures in Figures 6b through 14b show contaminant distribution in August 2011 or February 2012 for the respective contaminant and aquifer horizon. Corresponding analytical results are tabulated in Appendix B for August 2011, February 2012, and the baseline period. Most of the baseline period data are from sample collection in March 2002, but data for some locations are from 1999 or 2001. In addition to the primary contaminants, Appendix B also documents analytical results for molybdenum and selenium. Additional information, including time-concentration graphs for all site monitoring and extraction wells, is provided in data validation reports for the August 2011 and February 2012 sampling events (DOE 2011b; DOE 2012). Validation of laboratory analytical data is performed and documented in these reports as a routine quality-control function within LM.

In Figures 6 through 14, each well location sampled for the respective period is shown, but a concentration value is posted only when the applicable remediation goal or standard was exceeded. In comparing the "a" series figures (representing baseline conditions) with the "b" series counterparts (plotting the most recent results), the area of contamination in the various horizons does not appear significantly different from that established for baseline conditions, indicating no expansion (or shrinkage) of the contaminant plume. (Additional information regarding contaminant concentration trends is provided in Section 4.1.)

Prior to and since groundwater treatment began, the depth of groundwater contamination beneath the middle terrace was and is generally limited to Horizons A, B, and C. Except for nitrate and sulfate in lower terrace well 1003 (see discussion below), contamination of Horizon D is confined to the disposal cell and evaporation pond area where groundwater extraction is most focused (Figures 7b, 10b, and 13b). Apparent contamination in Horizon D at monitoring wells in these areas may be an effect of downward migration of contaminated groundwater in response to groundwater withdrawal at nearby extraction wells. Apparent contamination in Horizons C and D at the extraction wells in these areas is attributed to long screen lengths (approximately

150 ft) that are centered in either Horizon C or D but which intercept contaminated groundwater in Horizons A and B.

Contamination in Horizon E (see Figures 8b, 11b, and 14b) on the middle terrace is still limited to the location of well 268. At that location, contamination was limited to the occurrence of nitrate (as $NO_3$) in the range of about 70 to 100 mg/L. However, in February 2012, nitrate concentrations in this well increased markedly (to 210 mg/L), as did sulfate (from 100–150 mg/L to 360 mg/L) and uranium (from typical values of 0.02 mg/L to approximately 0.08 mg/L).[2] These increases are anomalous because significant plume migration to this depth and at this single location is unlikely (even accounting for the extended plant shutdown). Instead, a compromised annular seal is suspected, which would allow downward movement of contaminated water from Horizons A and B. Except for well 268, contamination is absent in the deeper horizons (Horizons F, G, and I) beneath the middle terrace.

Groundwater contamination beneath the lower terrace is also generally absent—with few exceptions, constituent concentrations are still below remediation goals (as was the case for baseline conditions; see "a" series figures). However, nitrate continues to exceed the 44 mg/L (as $NO_3$) restoration standard at several locations (Figures 7a and 7b)—nominally at Horizon C wells 903 (58 mg/L) and 930 (77.5 mg/L), and more significantly in Horizon C well 691 (285 mg/L) and paired (Horizon D) well 1003 (270 mg/L; refer to Section 4.0 for a discussion of corresponding time trends). These paired wells (wells 691 and 1003) are the only locations on the lower terrace where the sulfate restoration goal has been and is presently exceeded (499–520 mg/L; Figure 10b).

Historically, uranium has exceeded the 0.044 mg/L restoration standard on the lower terrace only at well 691. Exceedances have been slight (historical maximum of 0.071 mg/L); 0.052 and 0.071 mg/L uranium was measured, respectively, in the August 2011 and February 2012 samples. As discussed in Section 4.1, time-concentration trends in wells 691 and 1003 have not been stable for all key site contaminants (see Section 4.1 for additional trending information).

To complement Figures 6b through 14b, which display contaminant distributions as “spot plots,” Figures C−1, C−2, and C−3 are provided in Appendix C to represent the distributions of nitrate, sulfate, and uranium during the current review period as plume maps using concentration contours. The contours were generated by computer interpolation of the monitoring results. As has been the case for the last several reporting periods, the plume geometry and magnitude of the contour intervals has not changed significantly. For all constituents, contamination is still generally confined to the middle terrace and within the upper horizons.

Some of the conclusions drawn above regarding contaminant plume containment and geometry were recently confirmed in an independent investigation conducted by NNEPA (iiná bá/DOE 2011). In September 2010, in cooperation with DOE, NNEPA installed nine groundwater monitoring wells (shallow and deep) into the aquifer west and north of the site; six of these wells (wells NMW-1A, -6S, -7D, -8S, and -9D; immediately adjacent to the site to the west; see Figure 2b for well locations) were sampled by DOE in February 2011 and 2012. Results of this sampling indicate that no site-related contaminants exceeded respective MCLs or

[2] For additional information, refer to Section 4.1, “Contaminant Concentration Trends at Monitoring Wells,” and Appendix E, Figures E–13 through E–15.

NNEPA aquifer restoration goals and that water quality at those locations is consistent with background conditions (see Figures 6b, 7b, 9b, 10b, 12b, and 13b).

These results confirm closure of the western margin of the contaminant plumes. Background conditions were also confirmed at wells NMW-2A, -3A, and -4A for samples collected by iiná bá in September 2010 and February 2011 and by DOE in February 2012, indicating that there was no mill-related activity that adversely impacted groundwater to the north of the LM site.

## 3.2 Water Table Configuration

### 3.2.1 Water Table Contours

Figure 15 shows the estimated water table for the baseline period (August 2001) using water levels in Horizons A and B monitoring wells for the middle terrace and Horizon C wells for the lower terrace. On the middle terrace, water levels at deeper wells are not representative of water table conditions because of pronounced vertical hydraulic gradients (see Section 3.5) and so are not appropriate for constructing a water table map. On the lower terrace, the water table occurs within Horizon C nearest the escarpment and progresses to deeper horizons, mimicking land surface topography eastward. The horizontal direction of groundwater flow was predominantly south during the baseline period. A steeper hydraulic gradient at the escarpment (Figure 15), separating the middle and lower terraces, also mimics ground surface topography.

Figure 16 shows the estimated water table for February 2012. The monitoring wells and corresponding water table elevations used to generate the water table contours are identified in the figure. In previous annual reports, prior to the temporary cessation of active groundwater treatment in October 2010, comparison of Figures 15 and 16 indicated that operation of the extraction wells had significantly depressed the water table within the central regions of extraction to the south and east of the disposal cell. The February 2012 water table depicted in Figure 16 reflects a transient condition in response to intermittent resumption of groundwater extraction, which started in October 2011 and continued through the remainder of the reporting period (i.e., through March 2012).

The February 2012 water table depicted in Figure 16 includes data obtained at six monitoring wells installed to the north and east of the disposal cell by NNEPA in September 2010. These wells were installed because of NNEPA's concern that the existing monitoring network did not fully characterize the direction of groundwater flow and the extent of groundwater contamination west of the disposal cell. Water level data obtained from these wells indicates a southerly to southeast flow direction. These results, in addition to those obtained for water quality analyses (see Section 3.1), dispelled concerns about potential contaminant migration from the disposal cell to the west and confirmed that contamination at the site is of limited and finite extent.

Also evident in similar water table maps in previous annual reports (e.g., Figure 16 in DOE 2010) was an elongate groundwater mound and increased hydraulic gradients along the north edge of the disposal cell caused by infiltration of distillate at the trench. Figure 16 in this report shows that, although a symmetric groundwater mound along the length of the trench is still apparent, the mound and increased gradients have diminished in magnitude since operation

of the remediation system was discontinued in October 2010 and through the subsequent period of intermittent operation since October 2011 (also see Section 3.2.2).

Wells 284 and 285 are paired with wells 946 and 943, respectively, to monitor water table conditions at the contact between the terrace deposits and the Navajo Sandstone immediately downgradient of the trench (see Figure 2b). Wells 284 and 285, completed with screen intakes that straddle the alluvium/sandstone contact, have remained dry since installation in 2004, indicating that mounding has not over-topped the trench to saturate the alluvium. The water table before groundwater treatment was suspended was closest to alluvium/sandstone contact at well 946, rising to within about 6 ft of the contact. The water table elevation at this location has since decreased by about 20 ft since October 2010. Water level hydrographs for wells completed in the aquifer in the area of the trench are presented as Figure D−1 in Appendix D.

## 3.3 Water Level Drawdown

Figure 17 illustrates the effect of groundwater extraction and infiltration by showing the difference in water levels in Horizons A and B between the baseline period and February 2012. Figures 18 and 19 plot the water level differences between the same periods for the deeper horizons. Positive values identify locations where the water level in February 2012 is less than the baseline value. Negative values, such as those at the wells surrounding the infiltration trench (Figure 17), indicate that water levels at the respective locations are presently higher than during the baseline period.

Prior to October 2010, when active treatment was suspended, and as presented in previous annual reports, the pattern of water level drawdown in the area of groundwater extraction reflected three-dimensional converging flow to the extraction wells: the greatest drawdown (as much as 70 ft) was observed at the monitoring wells nearest to the extraction well intakes, both horizontally and vertically. That pattern is also reflected in Figures 17, 18, and 19 for February 2012, although the effect is less pronounced because of the recent history of intermittent groundwater extraction.

The drawdown data for February 2012, and as presented in previous annual reports, indicate significant water level drawdown at a great distance from the extraction wells. For example, drawdowns of 7 to 8 feet are indicated at several lower terrace wells (Figure 17) at distances of 500 to 1,000 feet from the nearest extraction well. Greater drawdowns were recorded at these locations before the interruption of groundwater extraction. The pattern of large drawdowns extending over large distances at a relatively low extraction rate suggests an aquifer with properties of low hydraulic conductivity and low storage capacity.

Well hydrographs provided in Appendix D depict water level variation over time at selected monitoring wells. These hydrographs indicate that, since the start of groundwater remediation and through 2007 and 2008, the predominantly downward trend in groundwater levels indicated an expanding groundwater capture zone (for example, see Figures D-2 and D-3). Subsequent water level increases through most of 2011 then demonstrate aquifer response to the increased frequency of operational shutdown periods (for system repairs). Declining water levels since the end of 2011 reflect the increased duration of plant operation.

Between October 2010 and late 2011, when the treatment system was not in operation, water levels in the areas of maximum drawdown recovered by 10 to 20 feet, or approximately by 50 percent of the drawdown observed during peak operation of the plant. The rate of water level recovery during and since that time may be augmented by a regional rise in water levels of several feet as indicated at background monitoring wells 901, 910, and 947 (Figure D-1).

## 3.4 Horizontal Capture

Figure 20 depicts the estimated zone of groundwater capture in lateral extent in Horizons A and B, where the bulk of contamination resides. In this figure (which was generated using groundwater elevation data obtained before the remediation system was shut down in October 2010), all groundwater within the blue line, the approximate extent of plume capture, is predicted to flow to an extraction well. This prediction is based on slope analysis of the water table using the computer program SURFER. The analysis calculates a vector that describes the direction and magnitude of the water table slope within each user-specified grid cell used in computing the water table contours. The blue capture line in Figure 20 corresponds to a horizontal flow divide between the vectors that converge on the extraction wells and those that do not.

The slope analysis indicated that the full width of the contaminant plume along the south edge of the disposal cell was within the capture zone, suggesting that flow of contaminated groundwater from the site was eliminated by the remediation system. The capture zone encompasses the region of greatest contamination; however, the area encompassing extraction wells 1126 through 1129 apparently escapes capture. As reported in 2010 and previously, water level drawdown in this area is significant and was increasing before the remediation system was shut down (Figures D−4, D−5, and D−6 in Appendix D). Contamination in this area is limited in vertical extent to Horizons A and B and is generally at lower concentrations than within the primary capture zone shown in Figure 20.

Cessation of groundwater extraction and treatment beginning in October 2010 and intermittent operations since September 2011 is not expected to have resulted in a significant breach in plume containment. This is because: (1) plume development occurred over a much longer period relative to the shutdown period and under conditions of much greater aquifer recharge from process water; (2) the low hydraulic conductivity of the aquifer does not promote rapid groundwater movement; and (3) significant residual drawdown remained in the plume capture area, allowing water to return to storage rather than flow farther downgradient.

## 3.5 Vertical Capture

Hydrographs included in Appendix D for selected sets of co-located monitoring wells illustrate that, at a given location, the hydraulic head in the aquifer is a function of well-intake depth. This relationship, whereby the hydraulic head measurably differs in adjacent wells screened at different depths, identifies vertical flow components throughout the monitored thickness of the aquifer, both before and since the start of groundwater remediation, and during the recent period of plant shutdown. As in the horizontal plane, the potential for vertical groundwater flow is directed from high to low hydraulic head.

With few exceptions, vertical flow potentials were downward during the baseline period. Since that time, until remediation was suspended in October 2010, the magnitude of downward flow in Horizons A, B, and C generally increased, as exemplified by the greater vertical separation in the hydrographs for the respective locations of well pairs 263/264, 265/266, 909/932, and 908/912 since about mid-2002 (see Figures D−4 through D−7 in Appendix D). In the main region of contamination, the increased gradients during active remediation imply capture of groundwater from the upper, most contaminated horizons of the aquifer (Horizons A, B, and C).

In the deeper horizons, vertical gradients are generally upward to the extraction well intakes in response to groundwater extraction. For example, the vertical flow potentials reversed to upward between Horizons M, I, and E at co-located wells 268/256/257 (Figure D−8; wells 256 and 257 were decommissioned in August 2005). A similar trend for Horizons E and I is apparent at the location of wells 251/252 (see Figure D−9) until active remediation was suspended in October 2010, at which time pre-remediation gradients resulted.

A downward flow potential was present between Horizon I and M into 2005 at paired wells 254/255 (Figure D−10; wells 254 and 255 were decommissioned in August 2005). Groundwater elevation data for well 273, installed in August 2004 near the location of former wells 254 and 255, implies vertically upward flow from Horizon I to D (Figure D−10). Groundwater extraction has reduced but not reversed the downward flow gradient between Horizons D and G at wells 915 and 916 (Figure D−11); however, this region of the aquifer is not contaminated.

Because the observed vertical influence of the extraction wells extends deeper than the presumed depth of contamination (Horizons A, B, and C, and to a lesser extent Horizon D), it is likely that the remediation system captures the full vertical extent of the contaminant plume. Flow potentials in lower terrace groundwater remain strongly downward, extending possibly through Horizon I, as indicted at the lower terrace well cluster identified in Figure D−12. The effect of pumping at that location has been to increase the downward hydraulic gradient between Horizons C and E and decrease the potential between Horizons E and I (Figure D−12). Despite the downward flow potential remaining on the lower terrace, the slight amount of contamination in lower terrace groundwater is limited primarily to Horizon C.

Temporary and intermittent cessation of groundwater extraction since October 2010 is not of concern with respect to plume containment at depth for the same reasons stated in Section 3.4 regarding horizontal plume capture.

# 4.0 Remediation Progress

## 4.1 Contaminant Concentration Trends at Monitoring Wells

Appendix E contains time series graphs of nitrate, sulfate, and uranium concentrations in groundwater at selected monitoring wells located throughout the project area. In the main region of groundwater contamination (Horizons A and B), nitrate concentrations in most Horizon A/B wells have risen since the baseline period (Figure E–1). Similar trending is not apparent for sulfate or uranium, for which trending is generally absent (Figures E–2 and E–3). Some of the highest uranium concentrations have been measured in wells 262 and 906, where trends have been erratic (Figure E–3). In general, however, persistent and widespread contaminant trending, upward or downward, is not evident.

Horizon A, B, and C wells 271, 683, 684, 914, and 929 are located beyond but near the downgradient or crossgradient extent of contamination (Figure 2). At these "sentinel" wells, groundwater has generally not been contaminated since monitoring began in 1999 (Figures E−4 through E−6). The only exception is found at well 929, where minor nitrate contamination of about 1.5 to 2 times the remediation target remains. As shown in Figure E–4, nitrate levels in this well have varied widely.

On the middle terrace, contaminant concentrations remain stable and below remediation standards in all Horizon C and D wells except one—well 912, located at the southwestern site boundary (Figures E–7 through E–9; see Figure 2b for locations). These results indicate that the plume is not expanding southward at this depth in the aquifer. In Figures E−7 and E−8, historically elevated nitrate and sulfate concentrations at well 912 (Horizon C) appeared to be trending downward over time (between 2002 and 2006), but have risen slightly since then.

As presented in Section 3.1, groundwater contamination beneath the lower terrace is very limited in extent and, where present, does not greatly exceed the remediation standards. Figures E–10 through E–12 show time-series plots for nitrate, sulfate, and uranium at selected lower-terrace wells. Concentrations of these constituents are shown to be relatively stable before and after the start of groundwater remediation, except at paired well 691 and 1003 (discussed in Section 3.1), where contaminant concentrations continue to vary widely. The most recent (February 2012) uranium result for well 691, 0.071 mg/L, is the historical maximum.

Contaminant concentrations at monitoring wells screened below Horizon D on both the middle and lower terrace remain stable and below remediation standards, except at well 268 (refer to Appendix E, Figures E−13 through E−15). At well 268 (Horizon E), located in an area of extensive water level drawdown (see Figures 16 and 19), contaminant concentrations increased between 2004 and 2006, remained stable until August 2011, but then increased markedly based on the February 2012 sampling results. For all primary contaminants, the most recent results (210, 363, and 0.084 mg/L for nitrate, sulfate, and uranium, respectively) exceed corresponding remediation standards. As discussed in Section 3.1, the results for well 268 are anomalously high and will be investigated further.

## 4.2 Breakthrough from the Infiltration Trench

The arrival of distillate from the infiltration trench to the extraction wells may eventually be important in evaluating the aquifer flushing process and time requirement for restoration of water quality. Breakthrough of the distillate is expected to be evident as a relatively abrupt decline in dissolved solids and contaminant concentrations at monitoring and extraction wells nearest the downgradient side of the disposal cell. Such a decline is not yet apparent.

Darcy's Law predicts that the travel time from the infiltration trench to well 940 is about 17 years, based on the inferred water table gradient beneath the disposal cell (0.04 ft/ft), a hydraulic conductivity of 1 ft per day (from DOE 1998), and 25 percent porosity. With these inputs, the average linear flow velocity computes to about 60 ft/yr. Based on this calculation, the estimated travel time (17 years) exceeds the cumulative remediation period to date. This means that, assuming that dispersion is negligible during advective transport, breakthrough of the distillate is not yet expected.

## 4.3 Contaminant Concentration Trends at Extraction Wells

Figures 21 to 23 illustrate concentration trends at the extraction wells for nitrate, sulfate, and uranium. Each figure comprises three separate time series plots to show the trends in different areas of the extraction well field. The well field is separated into the area east of the disposal cell (figure "a"), the area immediately south of the disposal cell (figure "b"), and the area encompassing the southernmost portion of the plume (figure "c").

Figures 21a and 22a indicate no significant temporal trends for nitrate or sulfate in the eastern area of the extraction well field. Between February 2003 and 2007, nitrate concentrations in many of these wells declined, but later rebounded (Figure 21a). Only wells 1121 and 1123 show notable declines approaching the 44 mg/L remediation standard; nitrate concentrations have been nominal in well 1125 historically. Nitrate concentrations in remaining eastern area extraction wells range between approximately 200 and 800 mg/L, averaging about 350 mg/L (well above the remediation goal).

Although sulfate concentrations in some eastern area extraction wells (1103, 1123, 1124) decreased shortly after the baseline monitoring period, since 2008 levels in these wells have rebounded to pre-remediation levels (Figure 22a). Sulfate concentrations in most of these wells now range between 2,000 and 2,500 mg/L, about an order of magnitude above the 250 mg/L remediation goal.

Uranium concentrations in eastern area extraction wells have decreased relative to baseline conditions—from a global average of 0.5 mg/L (baseline) to about 0.25 mg/L (Figure 23a). However, uranium levels have remained stable in most of these wells since 2007. The most significant decreases are apparent in well 1120 (from about 1.6 mg/L to 0.5 mg/L), but this decline were evident earlier (in 2000) and may not necessarily be attributable to active treatment. Similar trends are evident in wells 1121 and 1122.

As has been the case historically, contaminant concentrations are much more variable in the area immediately south of the disposal cell (Figures 21b, 22b, and 23b). Nitrate and sulfate concentrations rose slightly in the southernmost portion of the extraction field at the onset of

remediation, but have since stabilized in most wells (Figures 21b, 22b). Exceptions are found in well 936, where nitrate and sulfate concentrations have significantly decreased (from 3,300 to 800 mg/L for nitrate, and from 4,800 to about 1,000 mg/L for sulfate). The opposite (increasing) trend is apparent in wells 935 and 938, where nitrate concentrations appear to be increasing (Figure 21b). However, overall, there is very little difference between nitrate and sulfate concentrations in these boundary extraction wells when comparing baseline to current conditions, and concentrations remain well above remediation goals.

Uranium concentrations in this area have been mostly stable, with most wells ranging between about 0.1 and 0.4 mg/L (Figure 23b). Exceptions are wells 1105 and 1132, where uranium concentrations have varied widely. For example, uranium concentrations in well 1132 increased significantly (from 0.5 mg/L to 3.4 mg/L) between 2008 and August 2011, but declined again (to 1.5 mg/L) based on the February 2012 result. Other exceptions are apparent for wells 1104 and 1106, where uranium concentrations increased during the 2010–2011 plant shutdown period. However, it is difficult to determine whether these increases are actually attributable to cessation of pumping given the limited data for that period.

Contaminant concentration trends in most southernmost extraction wells (Figures 21c, 22c, and 23c) have also been relatively stable. In contrast to previous years, exceptions are found for extraction wells 1129 and, in particular, 1130, where concentrations of nitrate, sulfate, and uranium, increased during the non-pumping (plant shutdown) period.

In summary, as is the case for most site monitoring wells (Section 4.1), except for declines in nitrate and uranium concentrations in the eastern area of the extraction well field, no temporal trends are evident in most extraction wells. Table 3 lists the extraction wells where a primary contaminant concentration was below the remediation standard in the extract during this reporting period. For this review period, 1116 and 1125 were the only extraction wells where all three primary contaminants were below corresponding remediation standards. This has not been the case historically for southern well 1116, where previously nitrate concentrations have always exceeded the remediation standard. However, contaminant concentrations have always been low in well 1125, located at the eastern margin of the contaminant plume. This well should be considered for intermittent use in the future.

*Table 3. Pumping Wells Where a Contaminant Concentration Is Below the Remediation Standard in the Extract, as of February 2012*

| Extraction Well[a] | Nitrate | Sulfate | Uranium |
|---|---|---|---|
| 1113 | | X | X |
| 1116 | X | X | X |
| 1117 | | | X |
| 1118 | | | X |
| 1125 | X | X | X |
| 1133 | | X | |

[a] This table shows only those extraction wells where the remediation standard was not exceeded for at least one contaminant.

## 4.4 Contaminant Mass Removal and Restoration Progress

Table 4 lists the cumulative amounts of nitrate, sulfate, and uranium removed from the aquifer through March 2012, reflecting over 9 years of groundwater extraction and treatment (accounting for the recent shutdown). For comparison, Table 4 also provides the estimated quantities of contamination initially present in the aquifer and the amount of contaminant removed as a percent of the initial quantity. Calculation methods for these estimates of initial contaminant mass were provided in previous annual reports (e.g., see DOE 2010, Appendix G [Calculation Set 1]). An estimate of the initial volume of contaminated groundwater is also presented in Table 4 based on these calculation sets.

*Table 4. Summary of Cumulative Mass and Volume Recovery as of April 1, 2012*

| Contaminant | Initial Mass (lb) | Cumulative Mass Removed (lb) | Cumulative Percent Mass Reduction | Initial Volume (gallons) | Cumulative Volume Treated (gallons) | Percent Plume Volume Reduction |
|---|---|---|---|---|---|---|
| Nitrate | 9,500,000 | 1,209,567 | 12.7 | $1.2 \times 10^9$ | $3.6 \times 10^8$ | 30.0 |
| Sulfate | 20,150,000 | 3,088,650 | 15.3 | $1.2 \times 10^9$ | $3.6 \times 10^8$ | 30.0 |
| Uranium | 2,300 | 774 | 33.7 | $1.2 \times 10^9$ | $3.6 \times 10^8$ | 30.0 |

Masses are rounded above, but percent mass reduction and plume volume reduction calculations used non-rounded values. For the preceding review period (ending April 1, 2011), cumulative mass reductions were 12.4, 14.8, and 32.6 percent, respectively, for nitrate, sulfate, and uranium.

Table 5 summarizes similar information (cumulative masses and volumes removed), but for all preceding review periods and for uranium only. Restoration projections previously documented (e.g., see calculation sets in Appendix G of DOE 2010) have predicted complete mass removal of uranium within 25 years of active remediation. The corresponding volume of groundwater extracted after 25 years, assuming constant withdrawal of 85 gpm (equivalent to about a 3.6 percent reduction in plume volume per year), is 1 billion gallons, which is slightly less than one estimated pore volume of the contaminant plume.

*Table 5. Historical Annual Cumulative Mass and Volume Recovery of Uranium*

| Year Ending (April)[a] | Cumulative Mass Removed, Uranium[b] (lb) | Cumulative Percent Mass Reduction | Cumulative Volume Treated[c] (million gallons) | Percent Plume Volume Reduction |
|---|---|---|---|---|
| 2003 | 132 | 6 | 50 | 4 |
| 2004 | 234 | 10 | 92 | 8 |
| 2005 | 325 | 14 | 136 | 11 |
| 2006 | 412 | 18 | 180 | 15 |
| 2007 | 493 | 21 | 224 | 19 |
| 2008 | 574 | 25 | 266 | 22 |
| 2009 | 650 | 28 | 307 | 26 |
| 2010 | 721 | 31 | 338 | 28 |
| 2011 | 751 | 33 | 350 | 29 |
| 2012 | 774 | 34 | 360 | 30 |

[a] Values reported from the end of each annual reporting period; (all values are rounded).
[b] Initial mass: 2,300 lb
[c] Initial volume: 1,200 million gallons

Review of historical biannual monitoring data indicates that trends in contaminant concentrations at monitoring wells and extraction wells are generally absent. This suggests that, despite an extraction system that effectively targets the main region of contamination, close to 10 years of groundwater capture, treatment, and reinjection has not significantly improved groundwater quality. As recognized in the GCAP (DOE 1999), the progress of water quality restoration at the site may be limited by matrix and geochemical effects (dual-domain mass transfer and kinetically controlled release mechanisms in the subsurface). These effects could explain why—despite the measureable progress in extracting contaminant mass (e.g., see Table 5)—persistent and significant downward trending in contaminant concentrations at monitoring locations is not apparent.

# 5.0 Year in Review Summary

During the current review period of April 2011 through March 2012, close to 9 million gallons of contaminated groundwater were treated, yielding a total cumulative treatment volume of 360 million gallons, or about 30 percent of the total estimated volume of uranium-contaminated groundwater prior to remedial action. Major findings are summarized below:

- Operation of the remediation system was suspended in October 2010 to allow upgrading and replacement of treatment system components. At that time, DOE also updated the preventive maintenance program and operating procedures. The remediation system resumed operation in September 2011 but has since operated intermittently (only 64 days during this review period) due to equipment malfunctions.
- Historically (excluding the recent shutdown and intermittent operational period), the treatment plant has, overall, operated effectively and as intended. Treatment rate and efficiency, distillate quality, and return flow to the aquifer have met or exceeded design objectives during normal operation.
- When the extraction system is fully operational, its current configuration captures the lateral region of maximum groundwater contamination and the full vertical extent to meet design objectives.
- The most recent groundwater monitoring results (from August 2011 or February 2012) indicate no significant contaminant concentration rebound, expansion of the contaminant plume, or anomalous data in response to the suspension of remediation activity.
- On the middle terrace, contamination is generally limited to the upper 100 ft of the aquifer (Horizons A–C).
- Contamination in Horizon E on the middle terrace (south of the disposal cell and the extraction well field) is still limited to well 268, located just south of the evaporation pond. Monitoring results at this well were anomalously high in February 2012, exceeding remediation targets for nitrate, sulfate, and uranium. Significant plume migration to this depth and at a single location is unlikely. Instead, a compromised annular seal is suspected to allow downward movement of contaminated water from Horizons A and B. This well will be sampled again in August 2012 to confirm the February 2012 results. At that time, the integrity of well 268 will be inspected using a down-hole camera for evidence of annular seal failure or damaged casing.

- Contamination is absent in the deeper horizons (Horizons F, G, and I) beneath the middle terrace.
- In general, contamination of groundwater beneath the lower terrace is absent—with few exceptions, constituent concentrations are still below remediation goals, as was the case for baseline conditions. Paired wells 691 and 1003 are the only locations in this area where restoration goals have been exceeded.
- In September 2010, in cooperation with DOE, NNEPA installed nine groundwater monitoring wells (shallow and deep) into the local groundwater aquifer west and north of the site. DOE sampled six of these wells (immediately adjacent to the site to the west) in 2011 and again in February 2012. Results of both sampling efforts were comparable to background; no site-related contaminants exceeded respective MCLs or NNEPA aquifer restoration goals in these wells.
- Between October 2010 and late 2011, when the treatment system was not in operation, water levels in the areas of maximum drawdown recovered by 10 to 20 feet, or approximately by 50 percent of the drawdown observed during peak operation of the plant. The rate of water level recovery during and since that time may be augmented by a regional rise in water levels of several feet.
- As concluded in previous annual reports (e.g., DOE 2010, DOE 2011a), after more than 9 years of operation, significant and widespread decreases in contaminant concentrations are not apparent. This is despite the measureable progress in groundwater treatment, as indicated by cumulative contaminant mass and volumes extracted from the aquifer.
- The absence of widespread decreases are not considered to be an effect of limitations in extraction and treatment, but rather are more likely related to geochemical and hydrogeologic factors.

# 6.0 References

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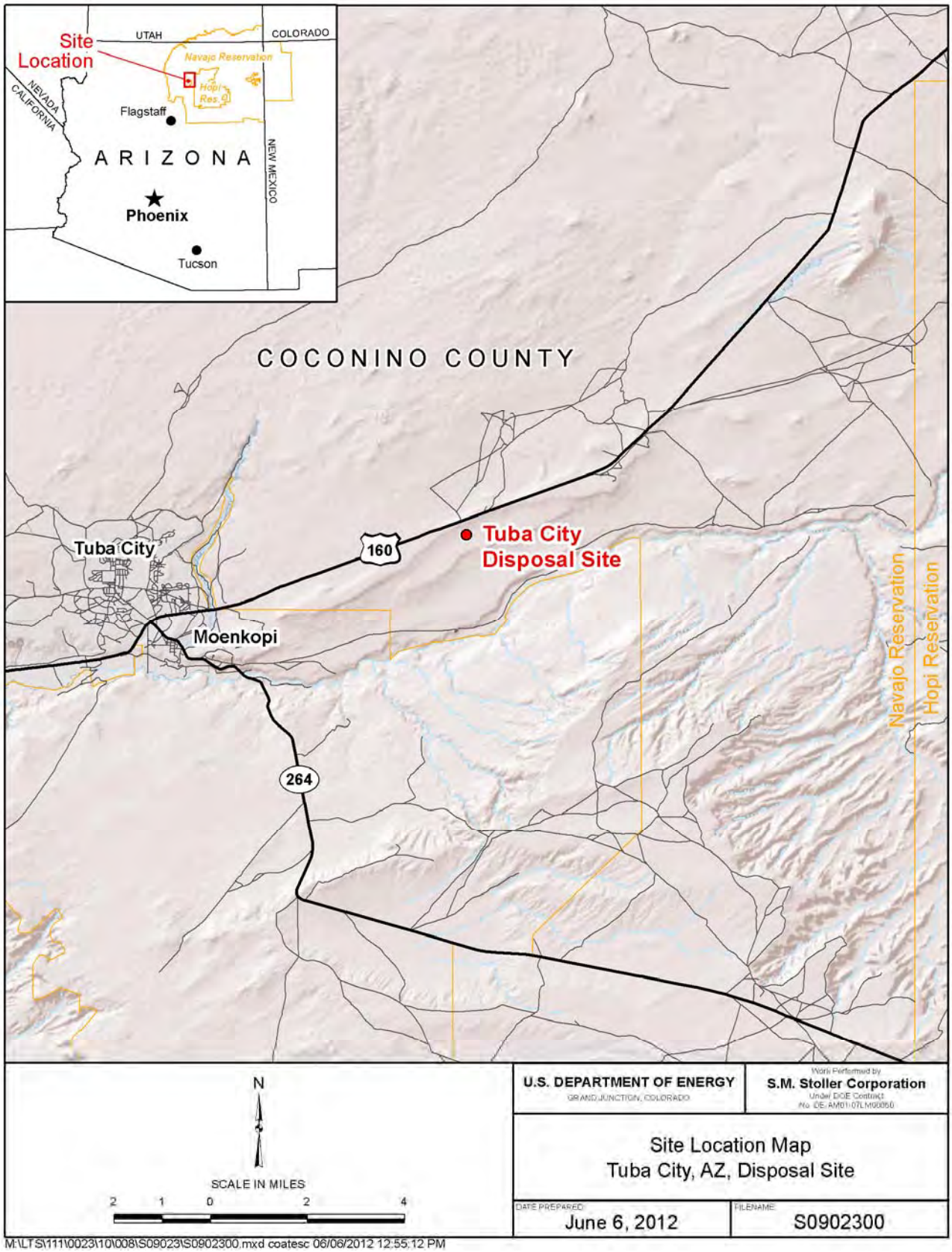


*Figure 1. Tuba City Site Location*

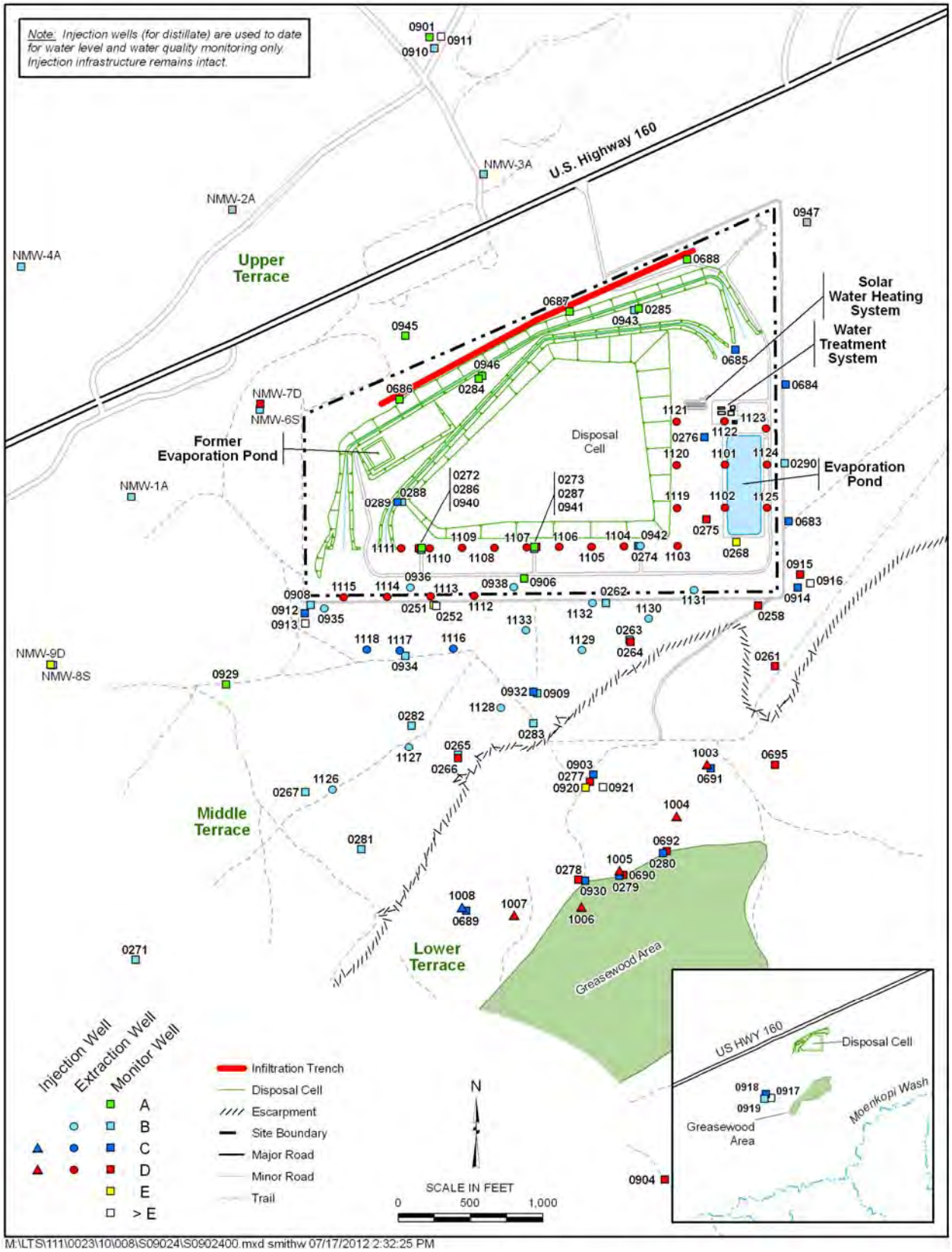


*Figure 2a. Tuba City Site Features and Well Locations*

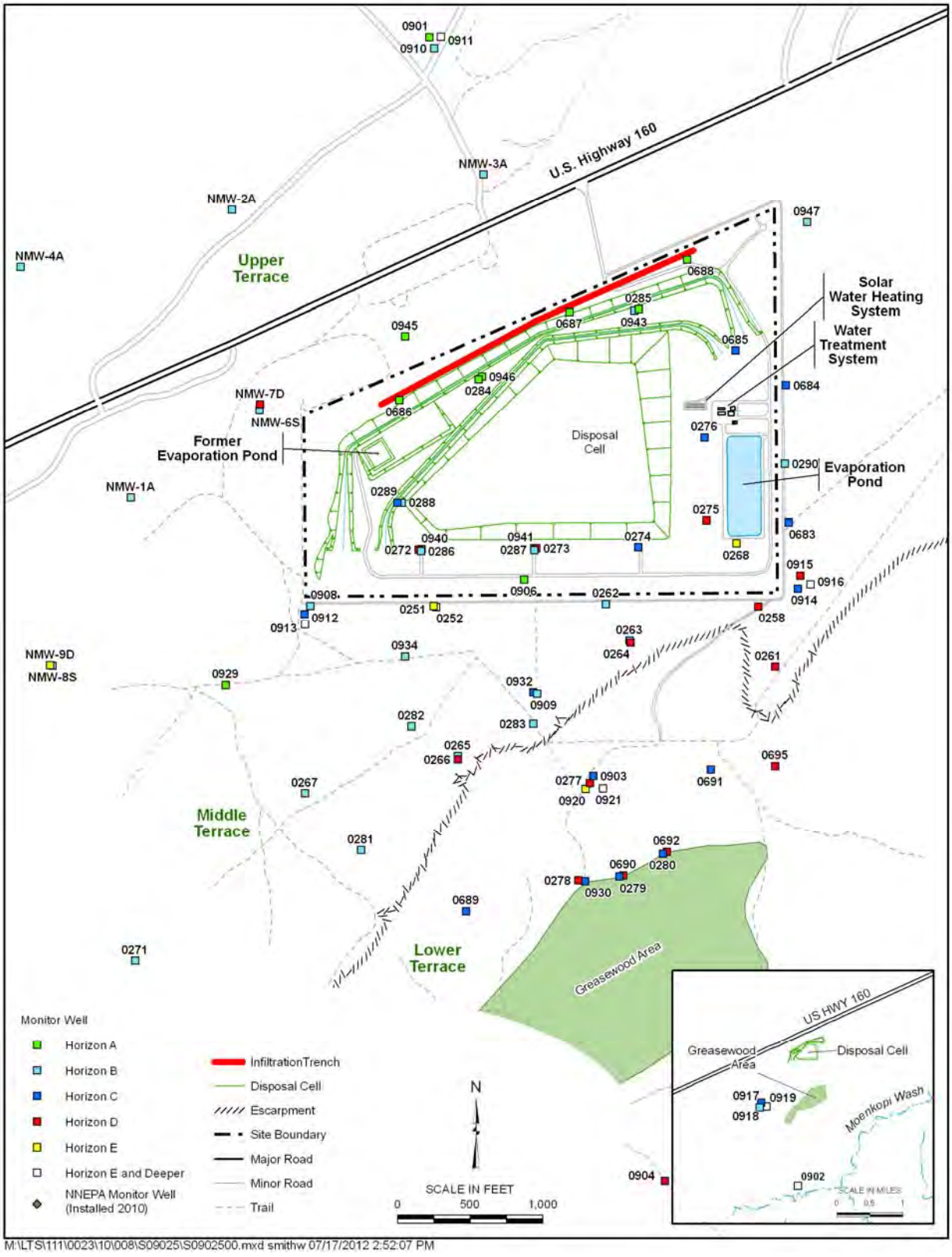


*Figure 2b. Tuba City Site Features and Well Locations—Monitoring Wells Only*

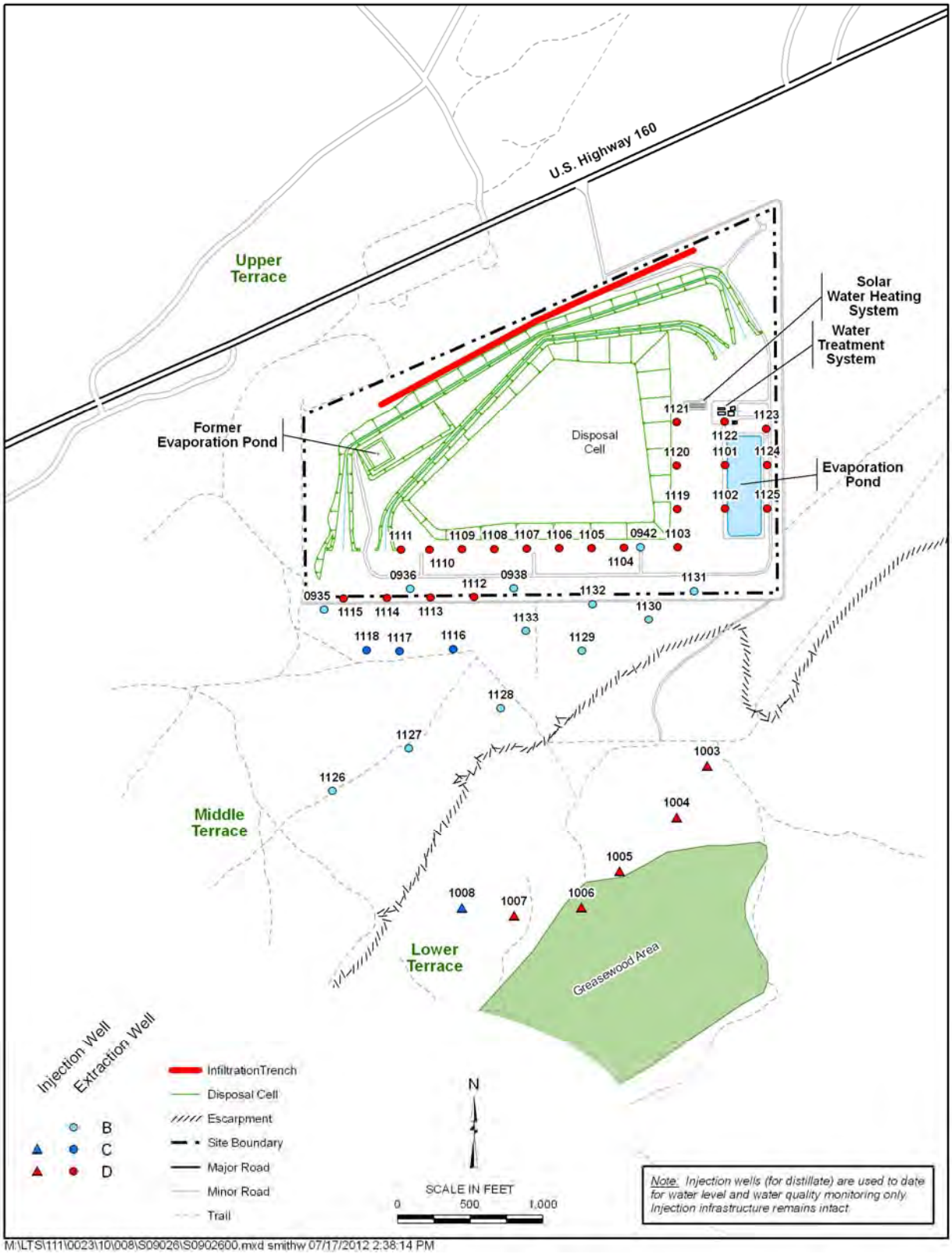


*Figure 2c. Tuba City Site Features and Well Locations—Treatment System Wells Only*

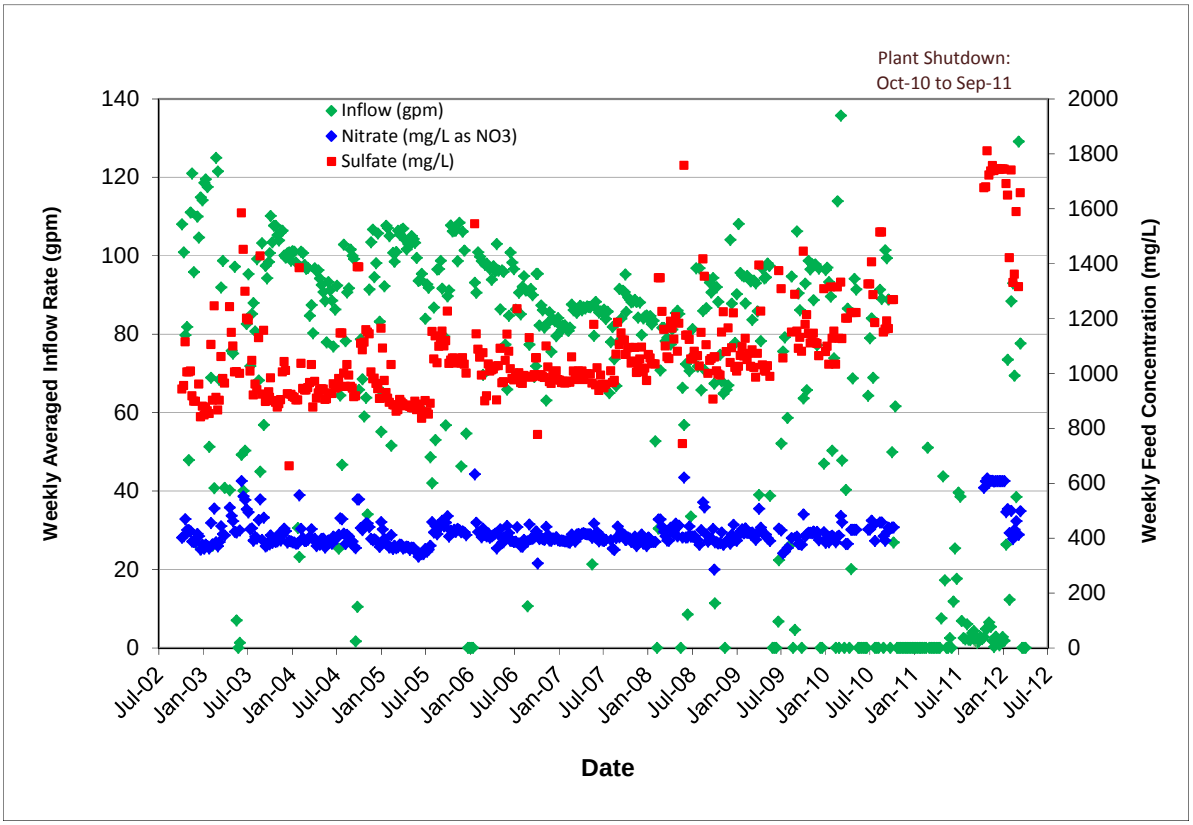


*Figure 3. Treatment Plant Inflow Rate and Nitrate and Sulfate Concentrations*

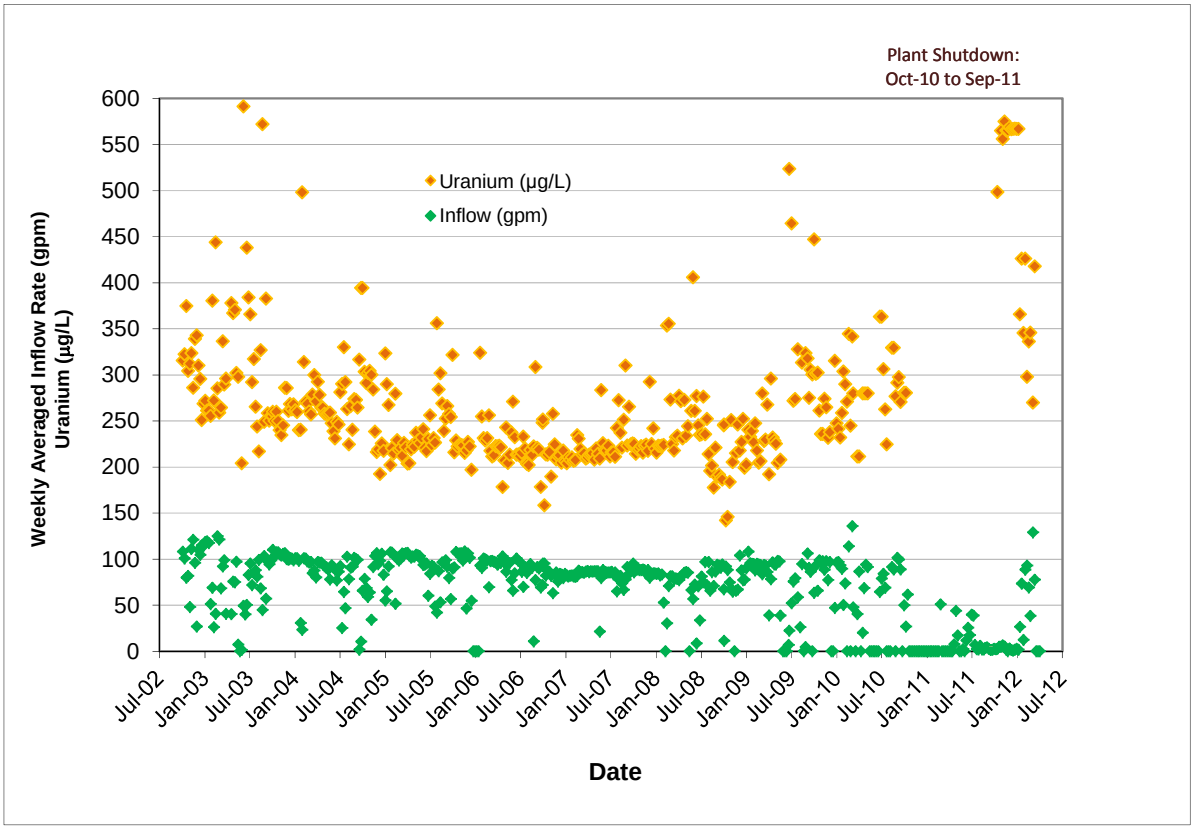


*Figure 4. Treatment Plant Inflow Rate and Uranium Concentration*

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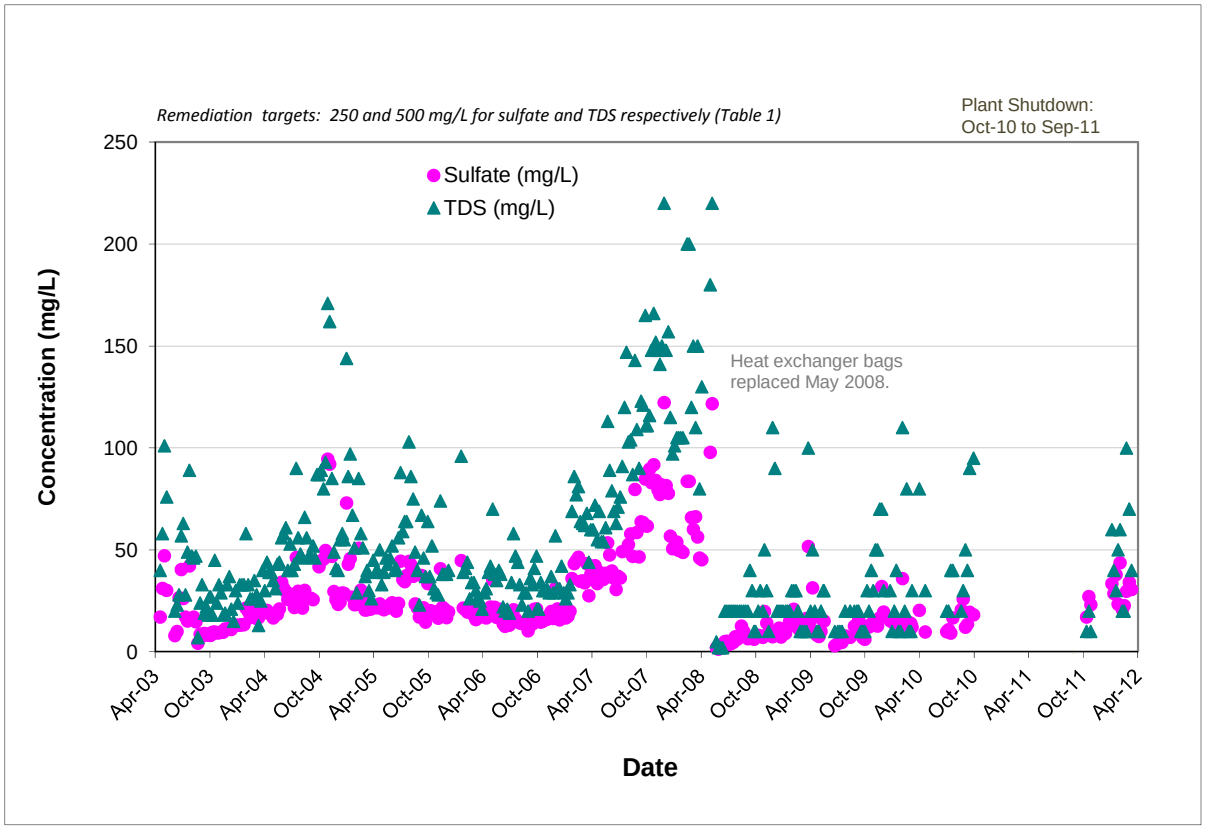


*Figure 5a. Treatment Plant Distillate Quality—Sulfate and TDS*

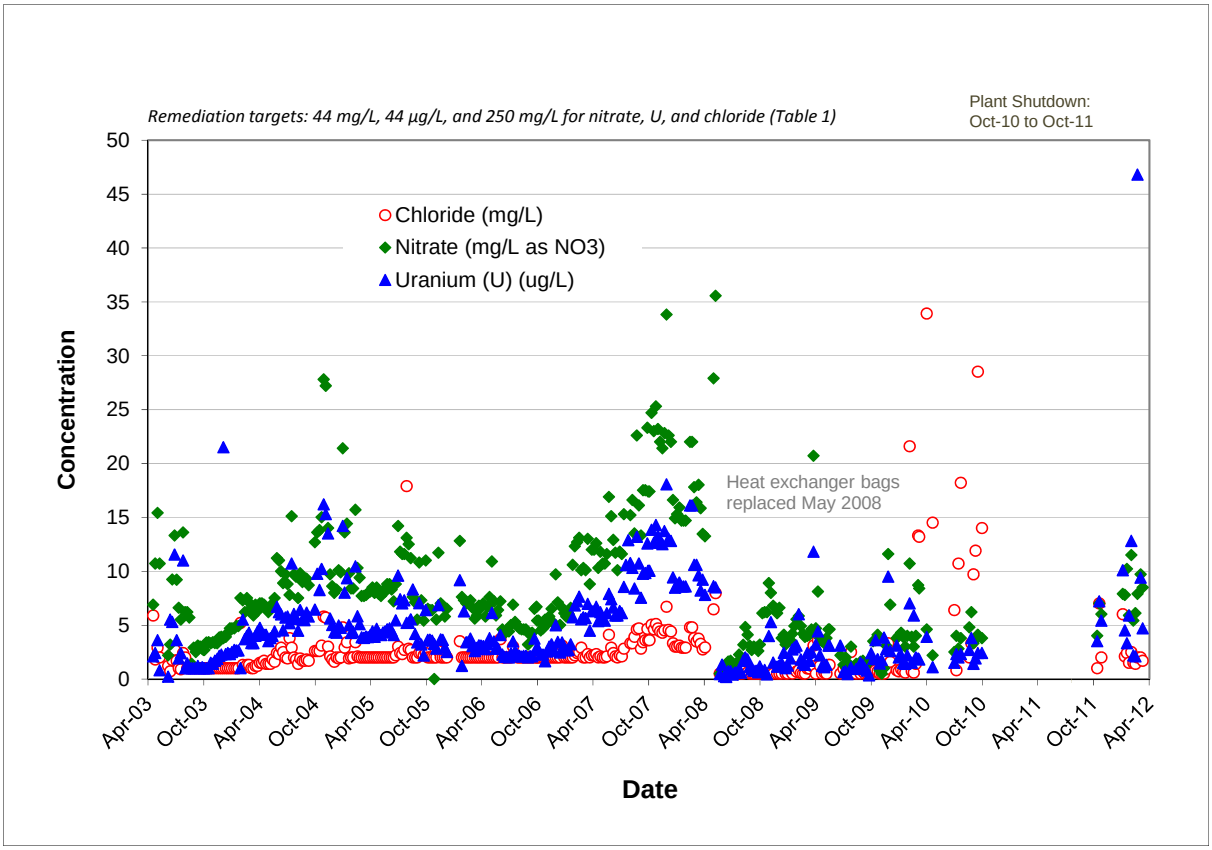


*Figure 5b. Treatment Plant Distillate Quality—Nitrate, Uranium, and Chloride*

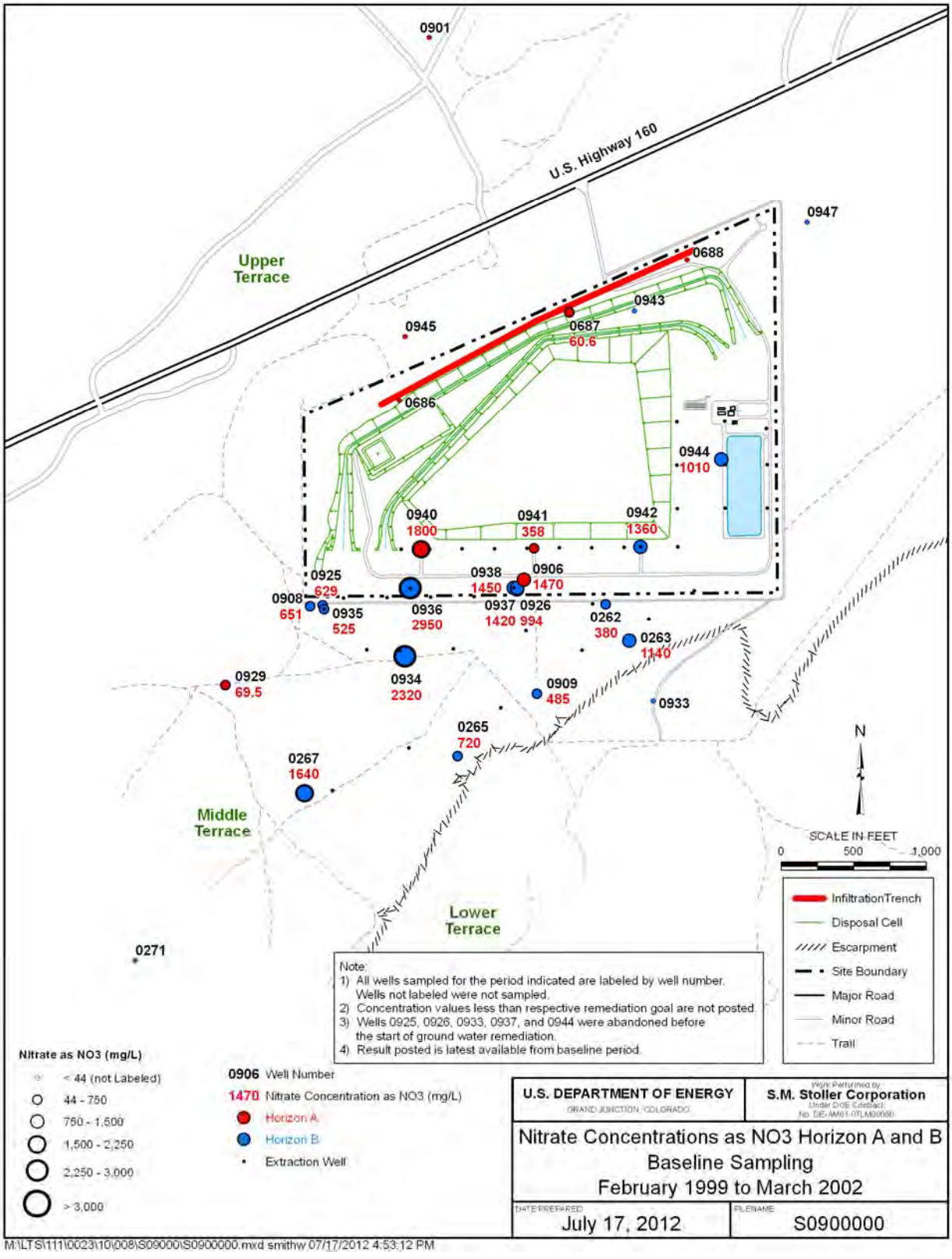


*Figure 6a. Nitrate Concentrations as $NO_3$, Horizons A and B, Baseline Period*

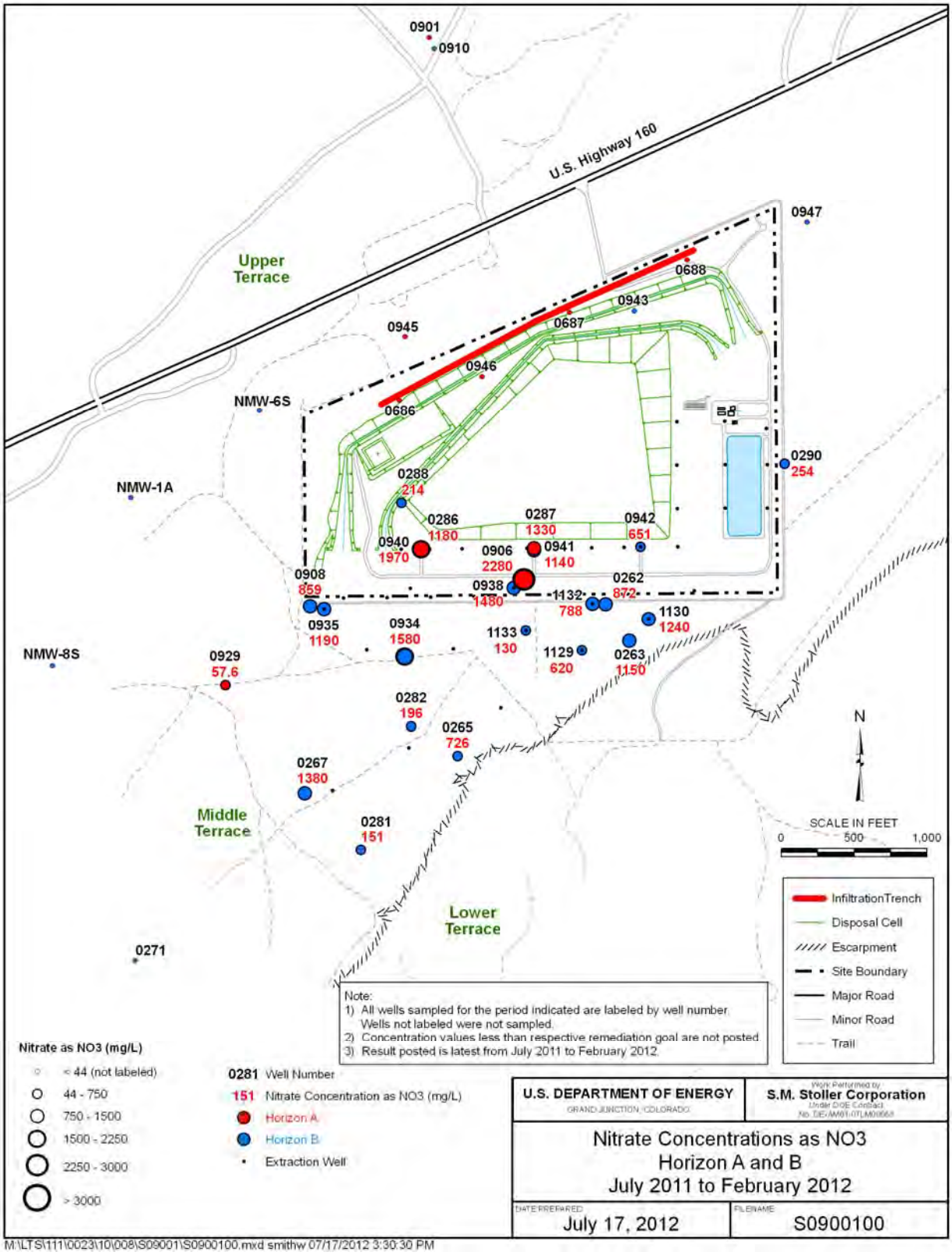


*Figure 6b. Nitrate Concentrations as $NO_3$, Horizons A and B, February 2012*

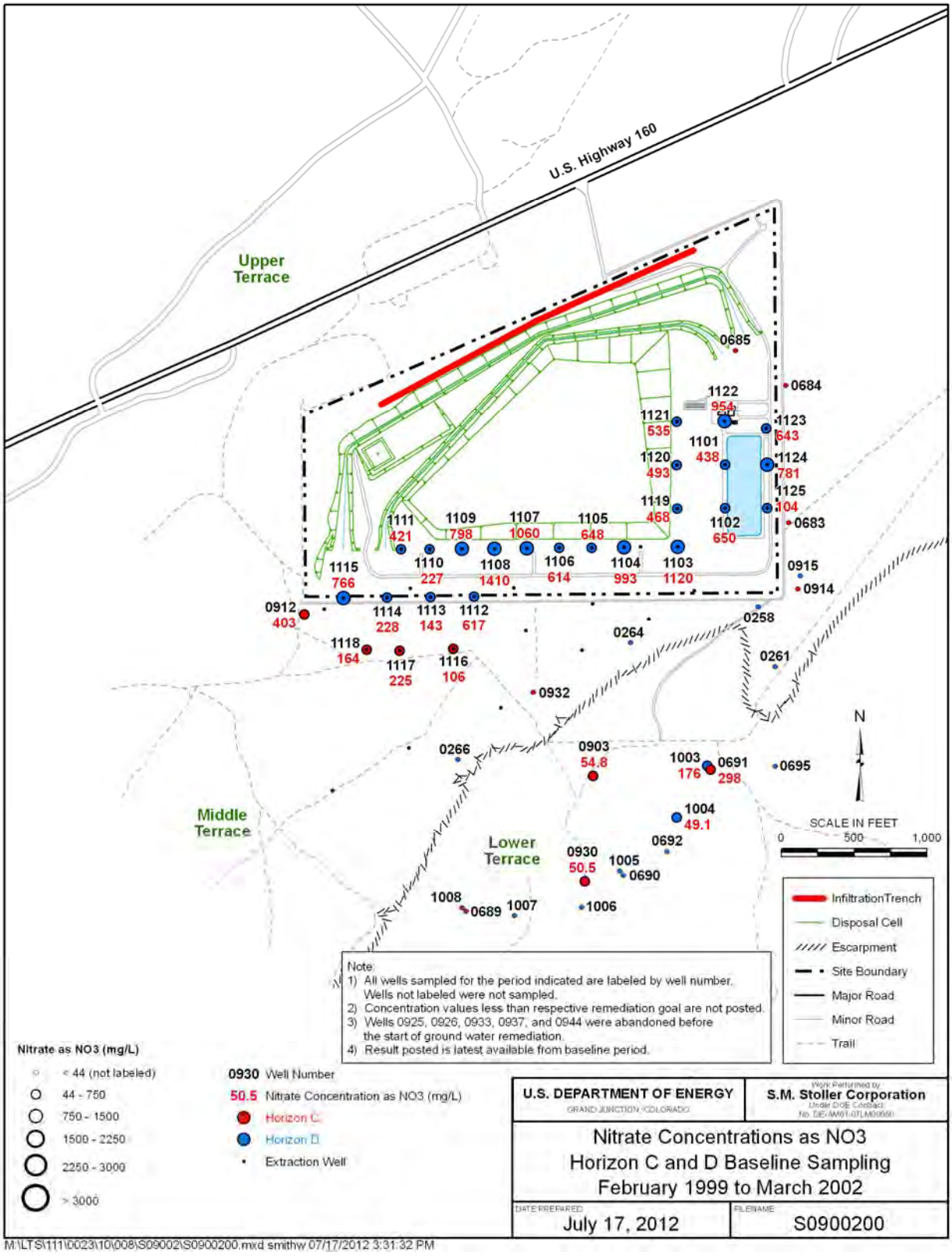


*Figure 7a. Nitrate Concentrations as $NO_3$, Horizons C and D, Baseline Period*

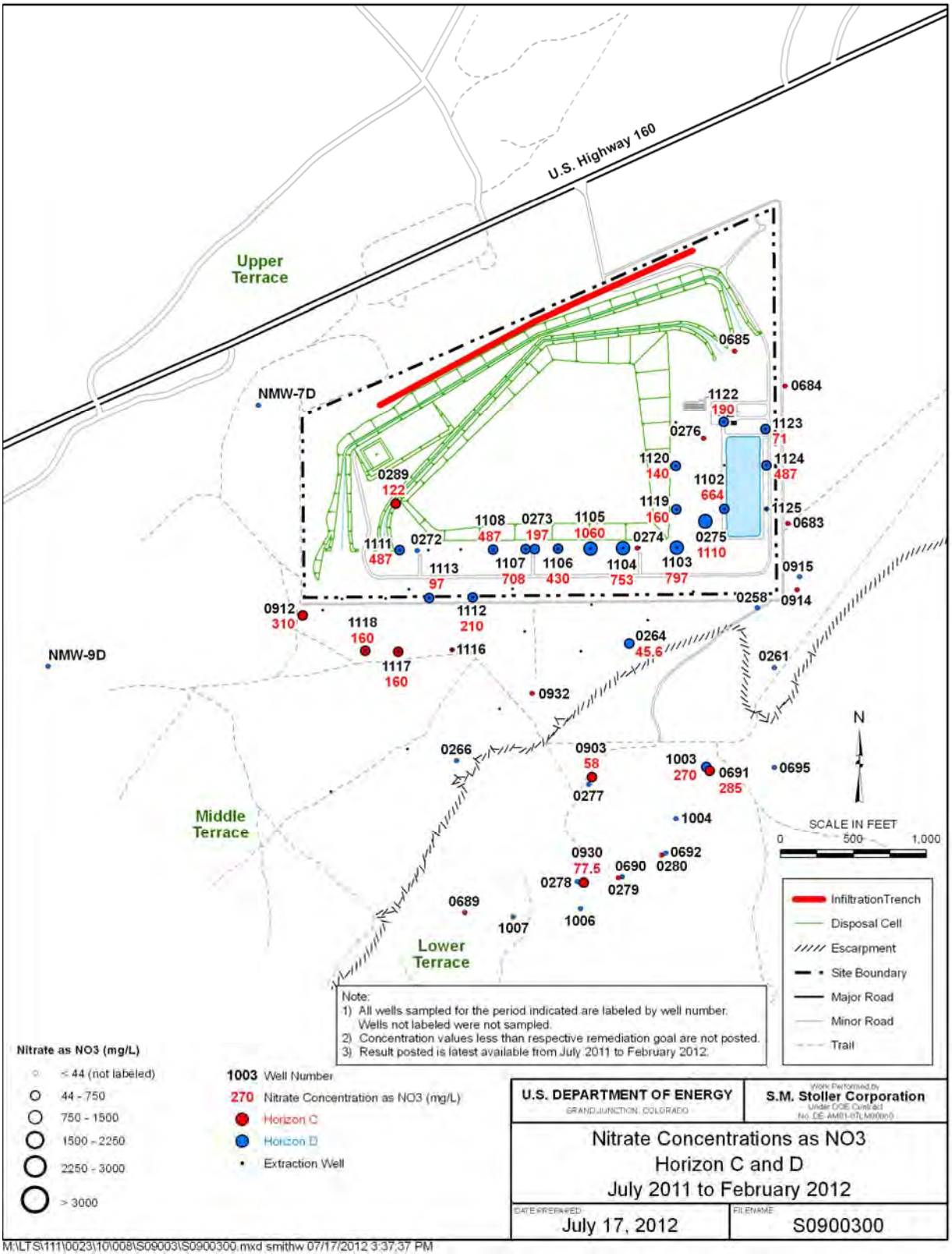


*Figure 7b. Nitrate Concentrations as $NO_3$, Horizons C and D, February 2012*

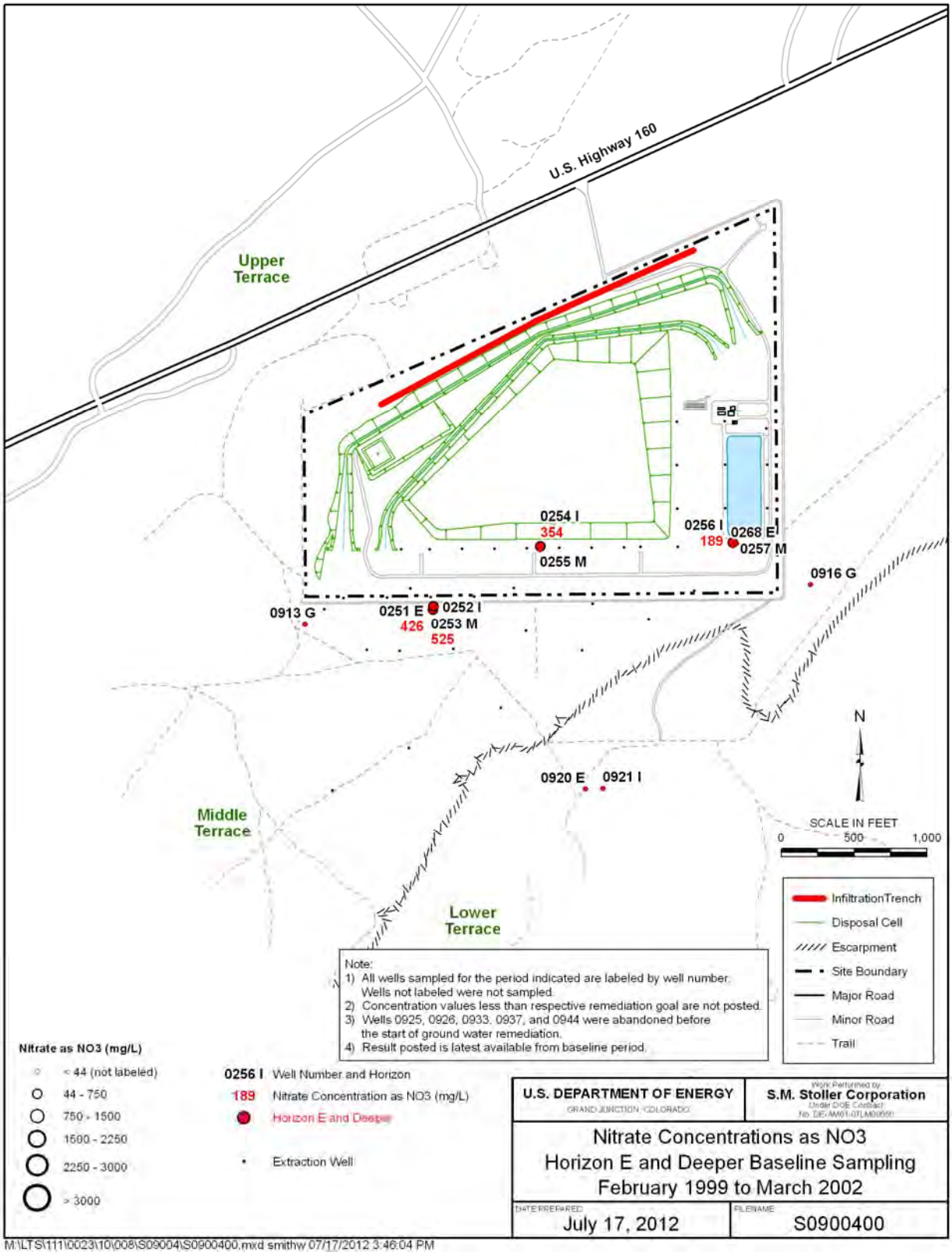


*Figure 8a. Nitrate Concentrations as $NO_3$, Horizons E and Deeper, Baseline Period*

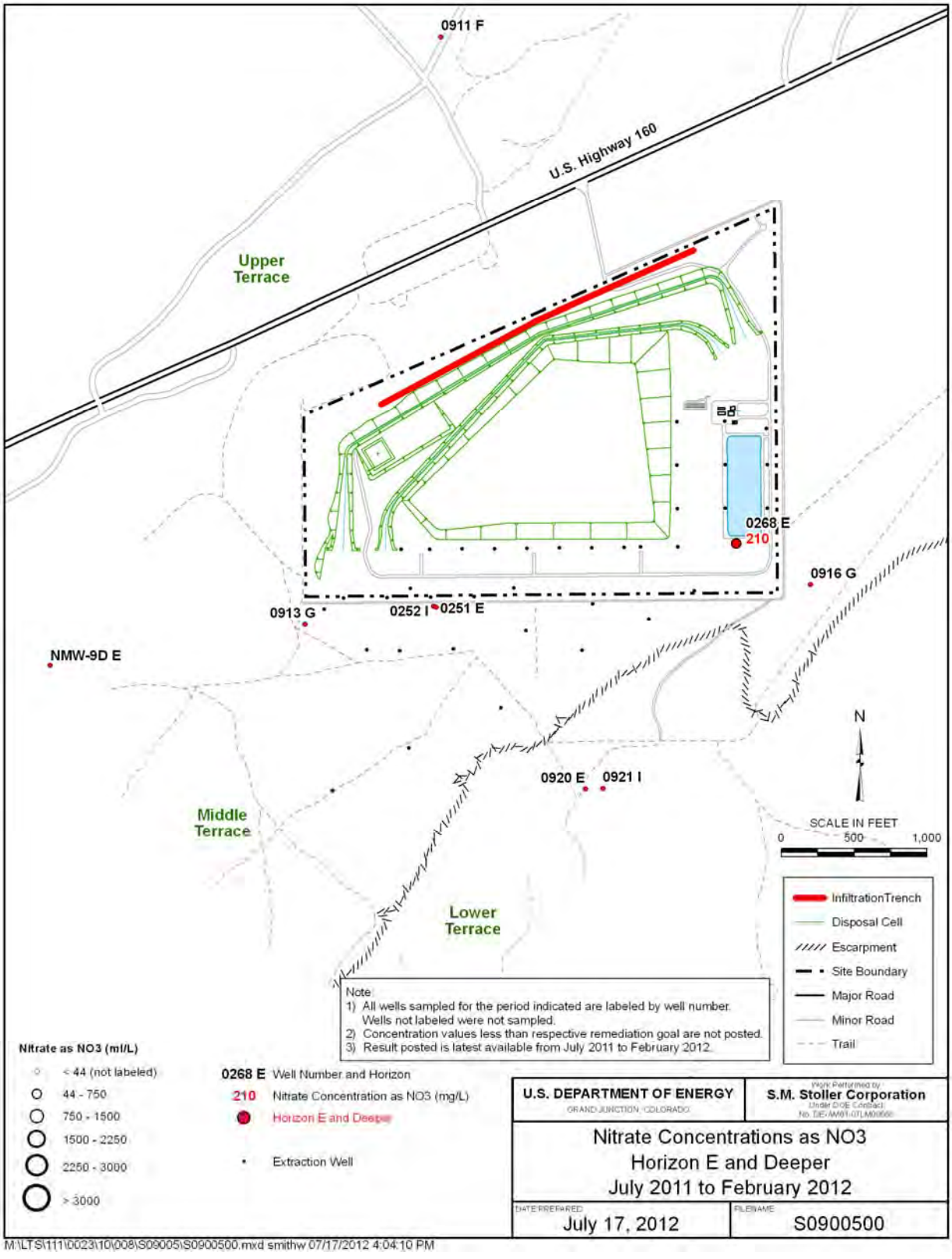


*Figure 8b. Nitrate Concentrations as $NO_3$, Horizons E and Deeper, February 2012*

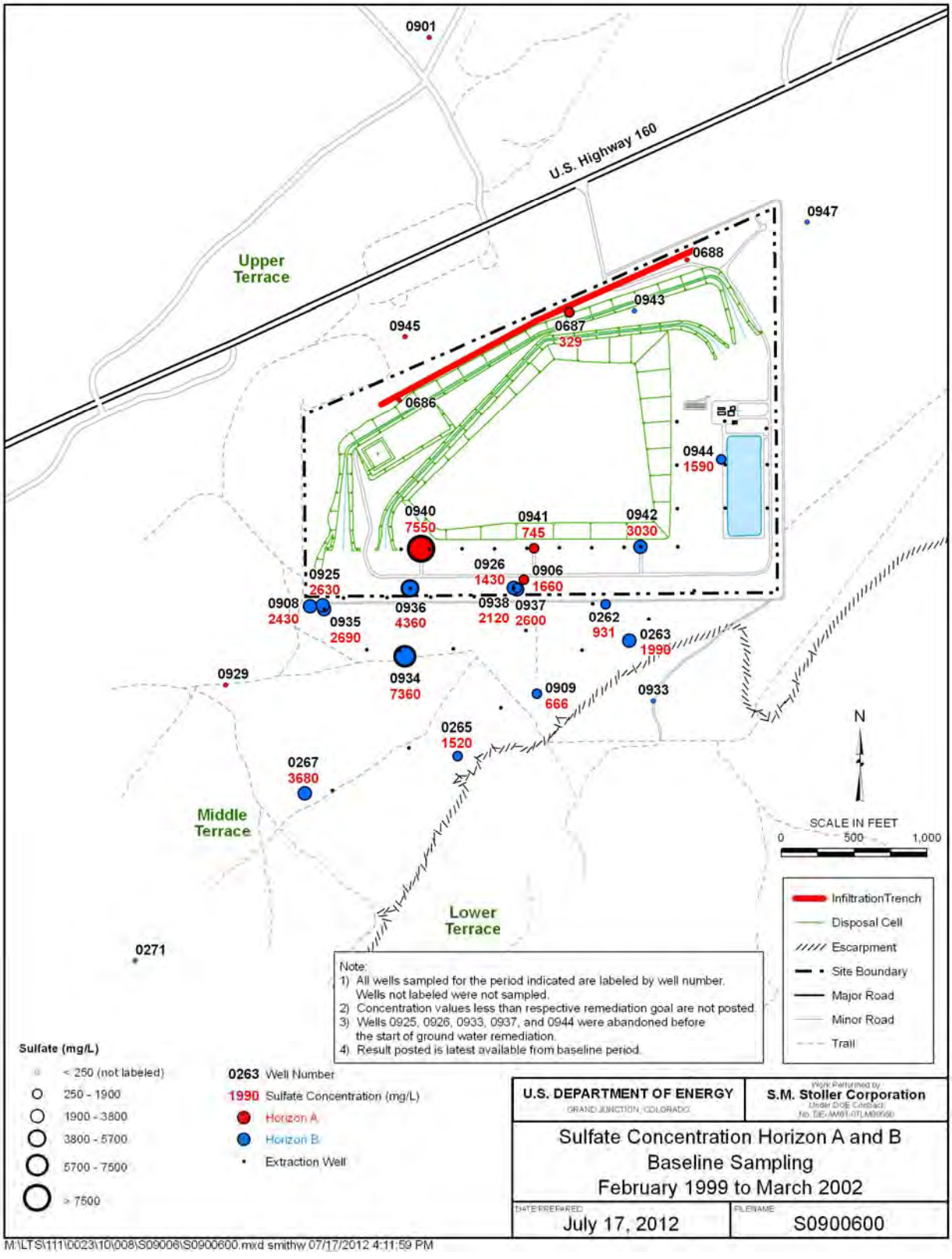


*Figure 9a. Sulfate Concentrations in Groundwater, Horizons A and B, Baseline Period*

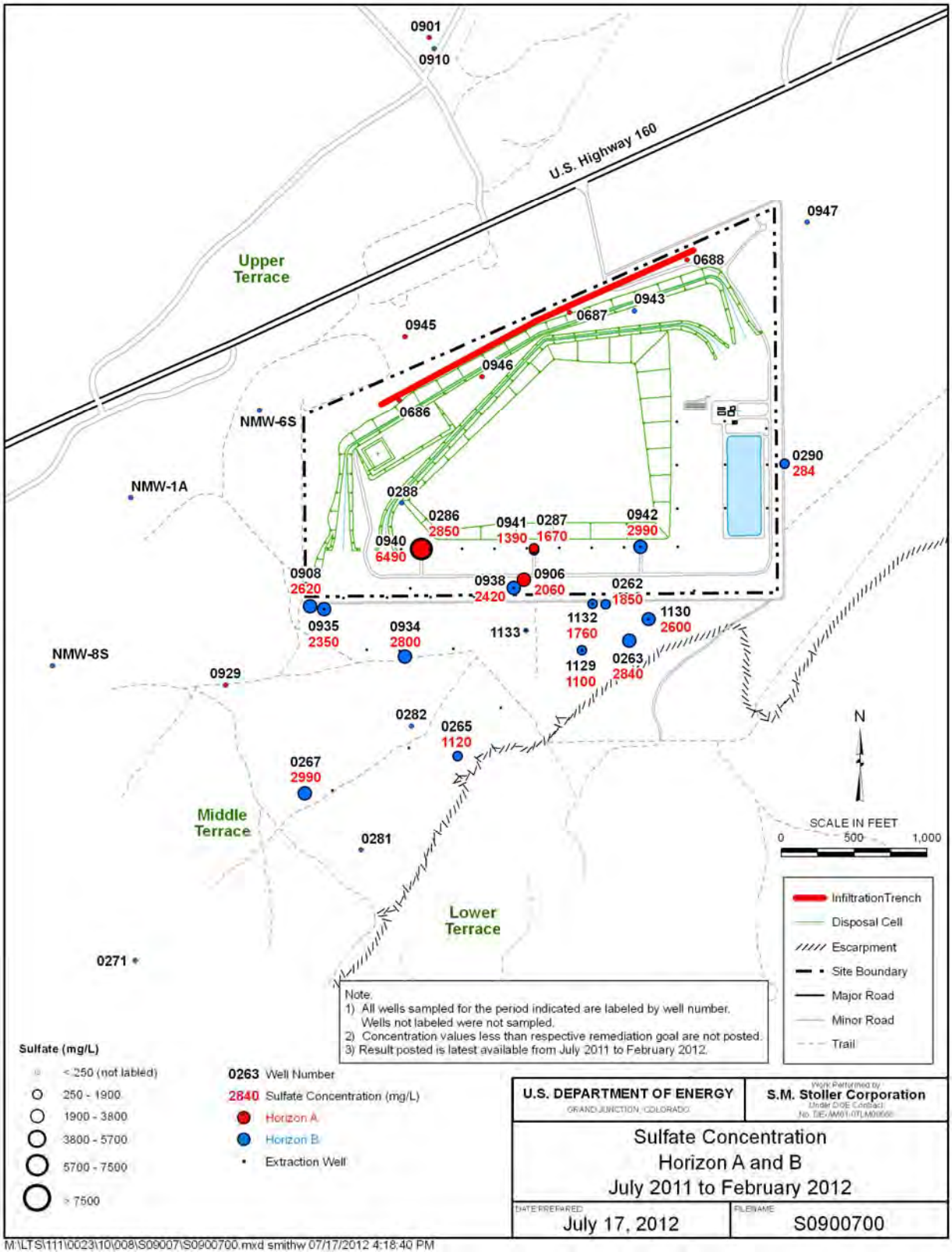


*Figure 9b. Sulfate Concentrations in Groundwater, Horizons A and B, February 2012*

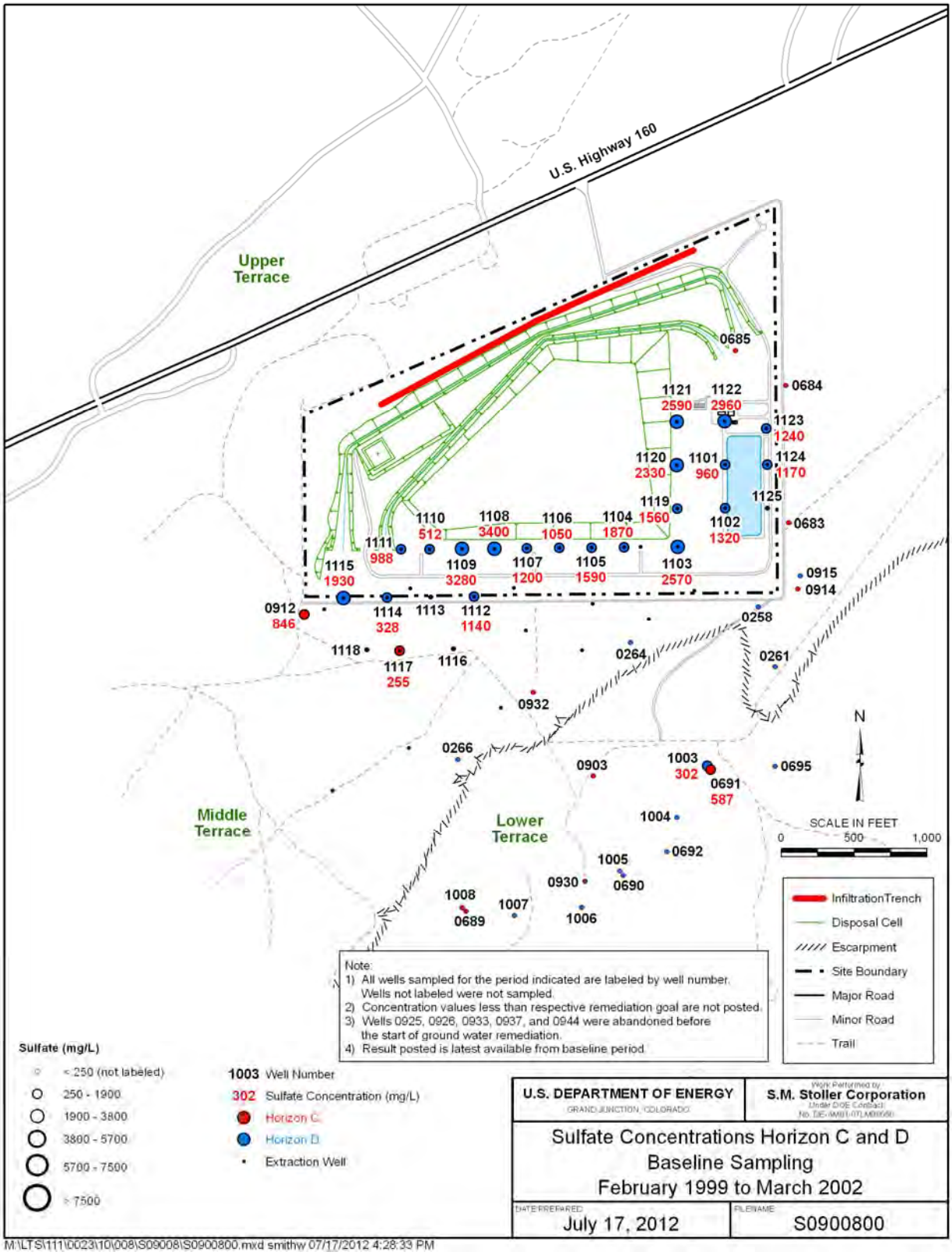


*Figure 10a. Sulfate Concentrations in Groundwater, Horizons C and D, Baseline Period*

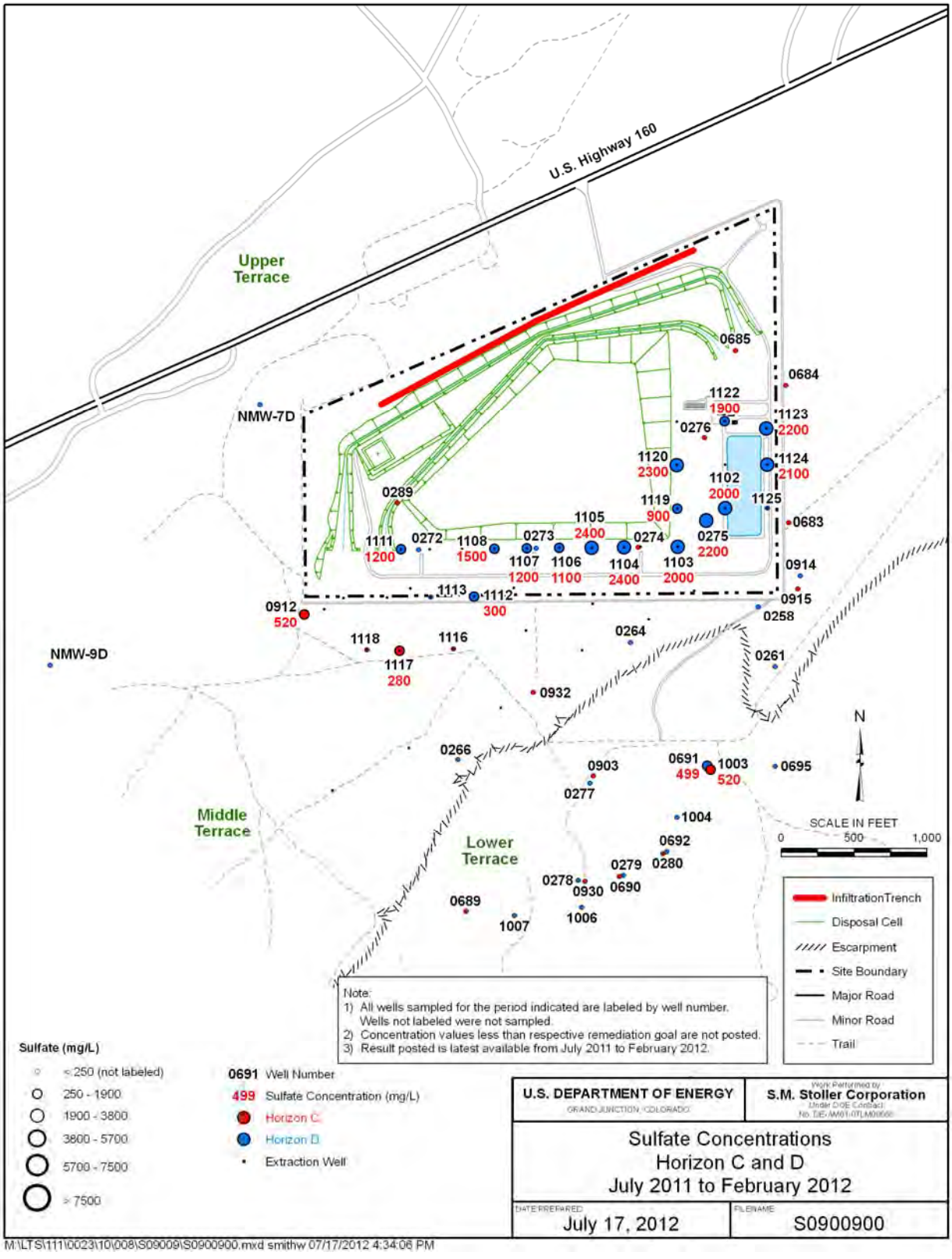


*Figure 10b. Sulfate Concentrations in Groundwater, Horizons C and D, February 2012*

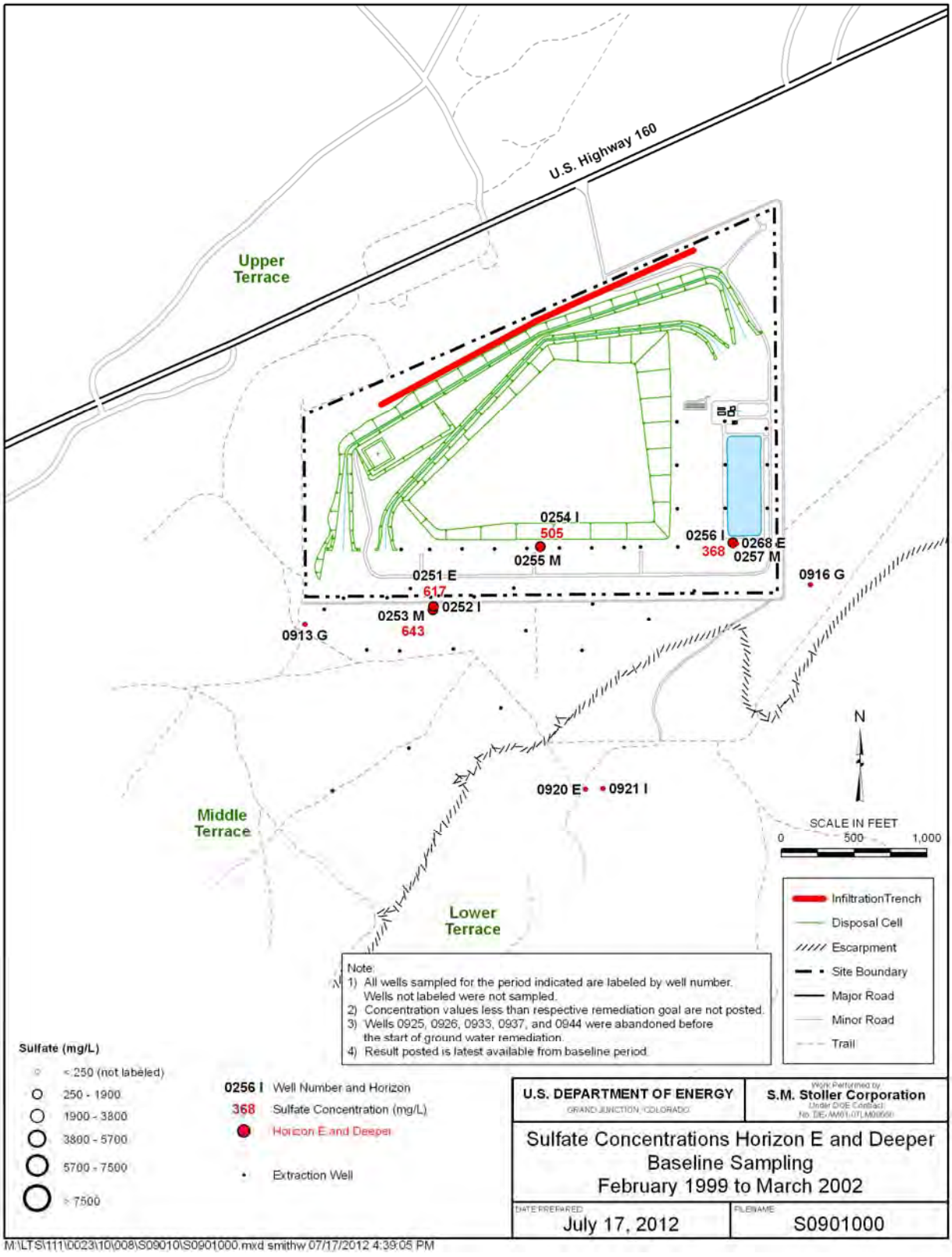


*Figure 11a. Sulfate Concentrations in Groundwater, Horizons E and Deeper, Baseline Period*

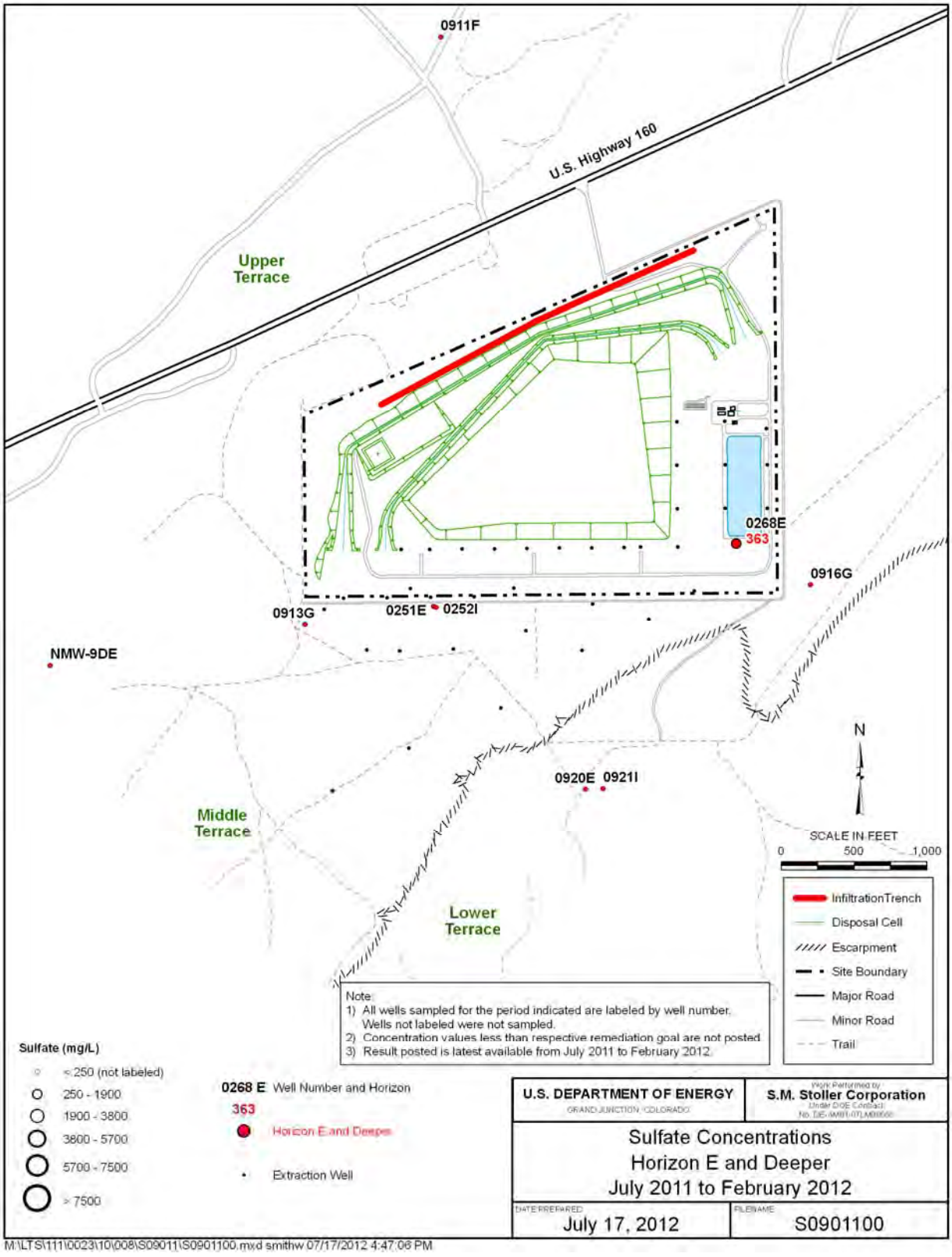


*Figure 11b. Sulfate Concentrations in Groundwater, Horizons E and Deeper, February 2012*

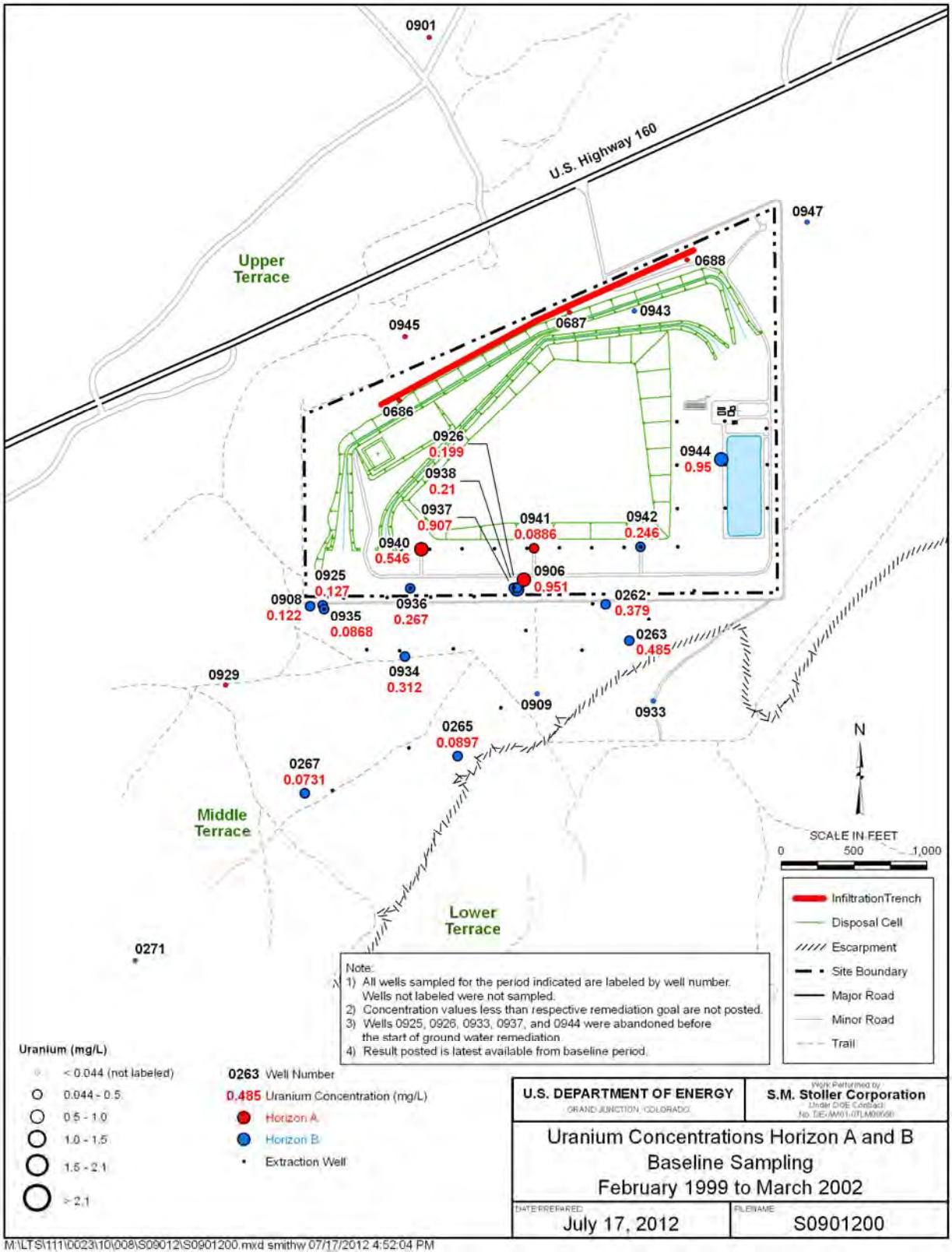


*Figure 12a. Uranium Concentrations in Groundwater, Horizons A and B, Baseline Period*

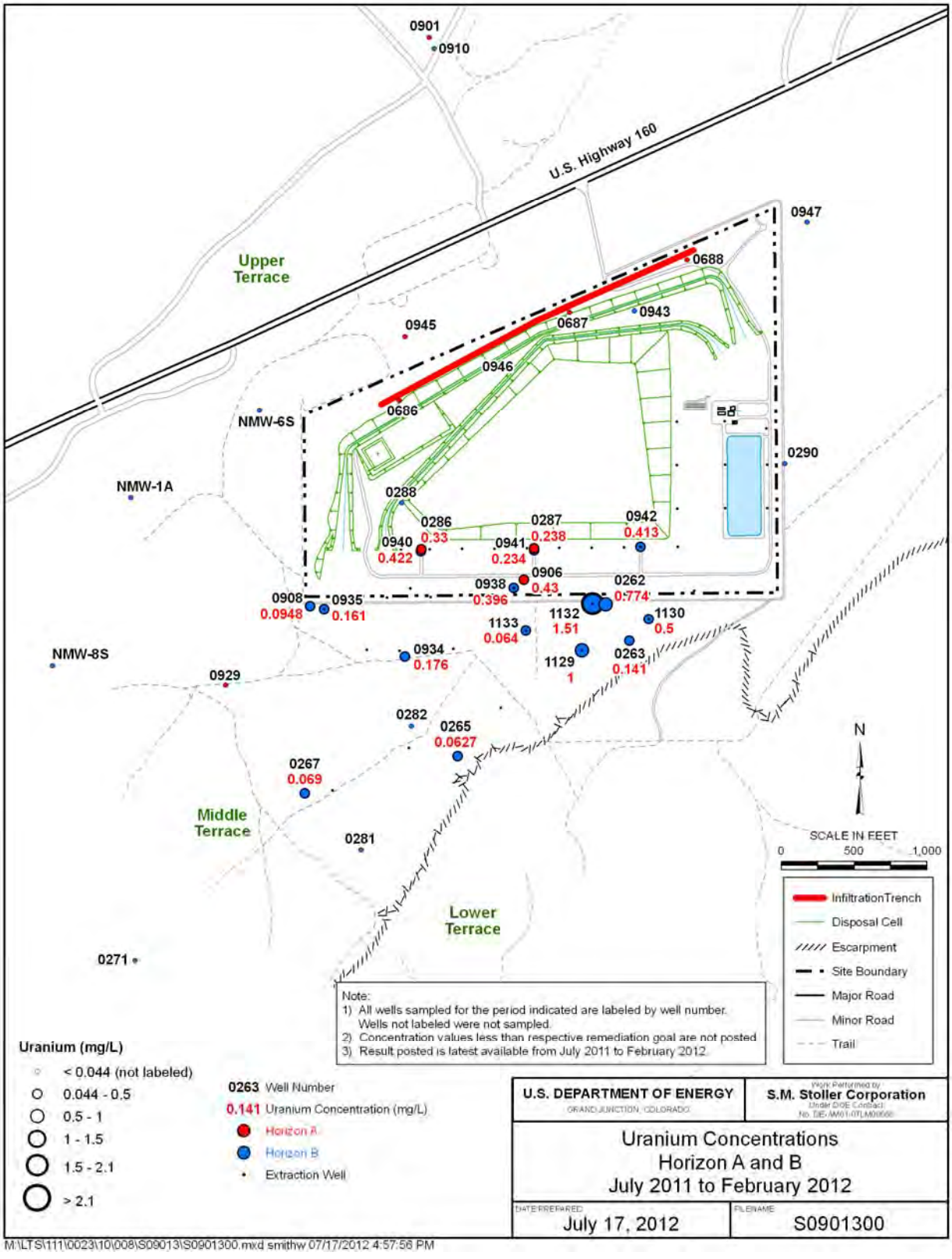


*Figure 12b. Uranium Concentrations in Groundwater, Horizons A and B, February 2012*

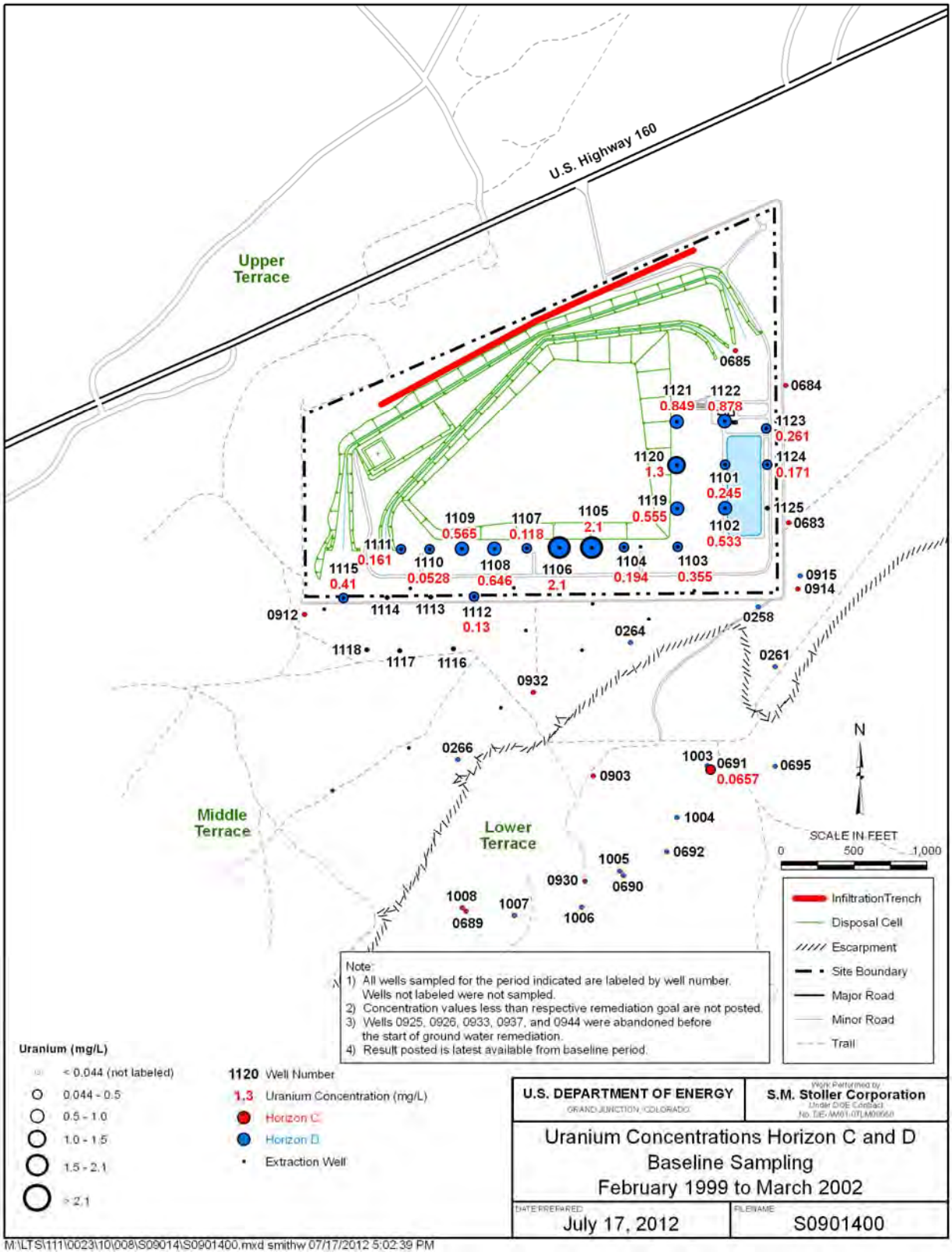


*Figure 13a. Uranium Concentrations in Groundwater, Horizons C and D, Baseline Period*

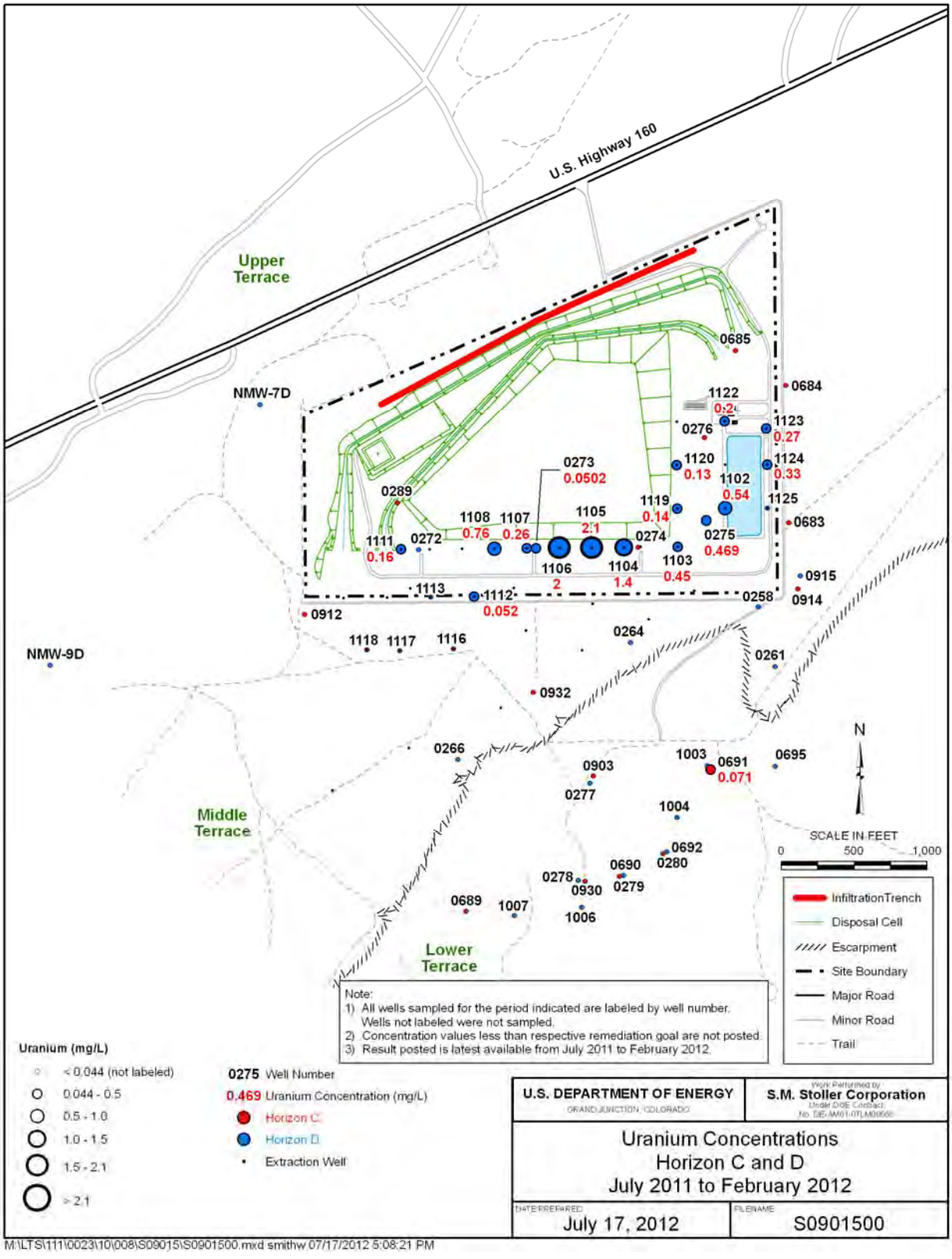


*Figure 13b. Uranium Concentrations in Groundwater, Horizons C and D, February 2012*

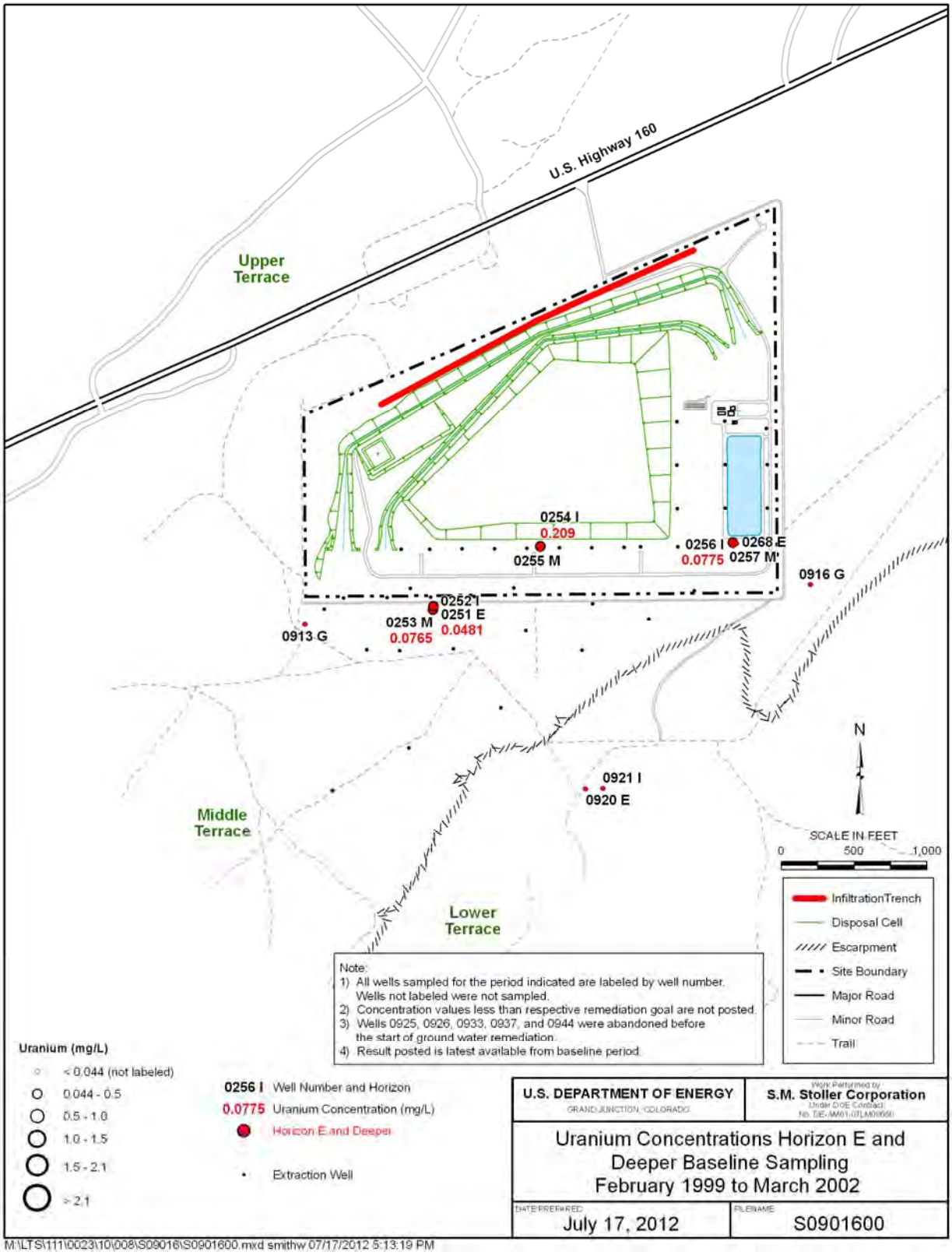


*Figure 14a. Uranium Concentrations in Groundwater, Horizons E and Deeper, Baseline Period*

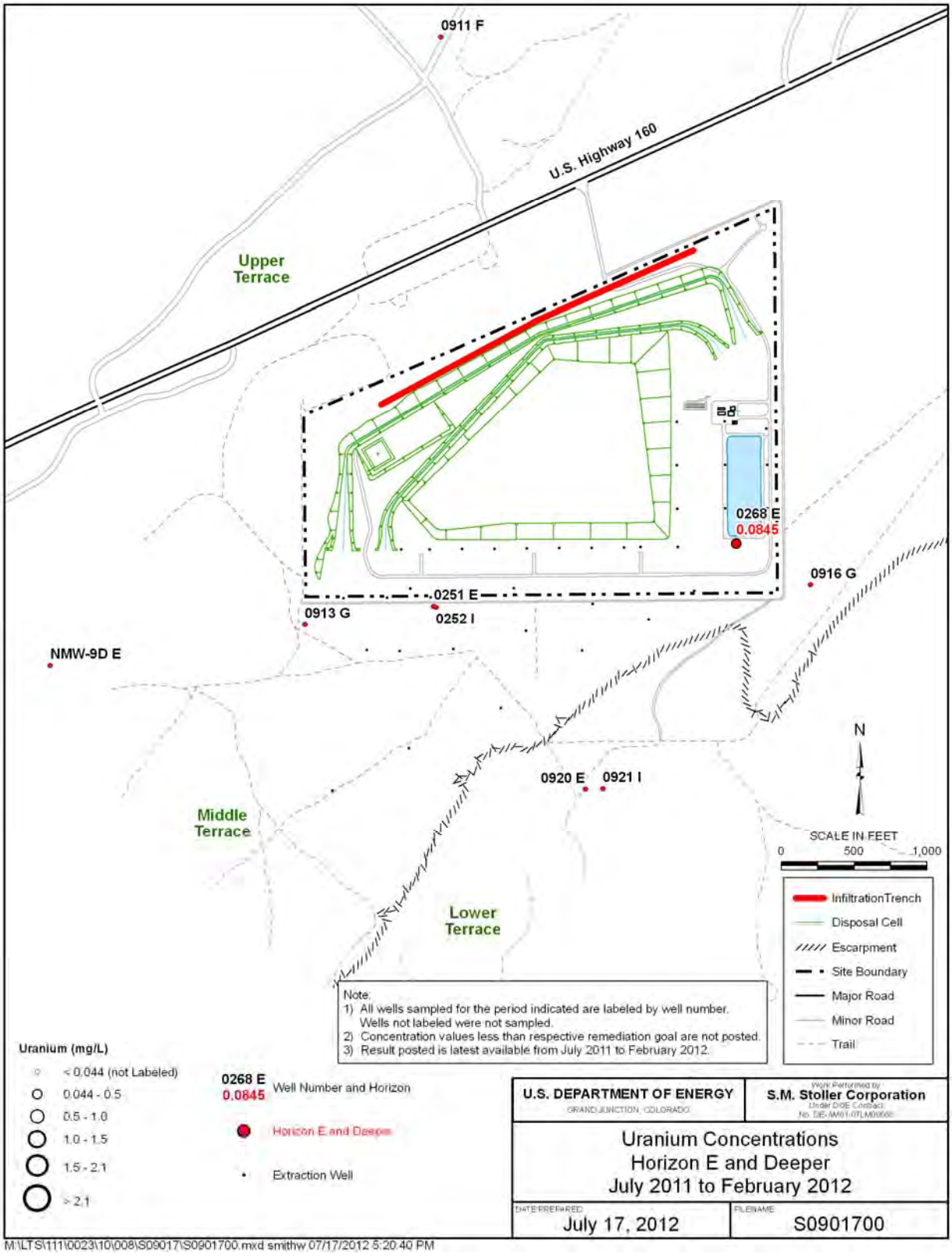


*Figure 14b. Uranium Concentrations in Groundwater, Horizons E and Deeper, February 2012*

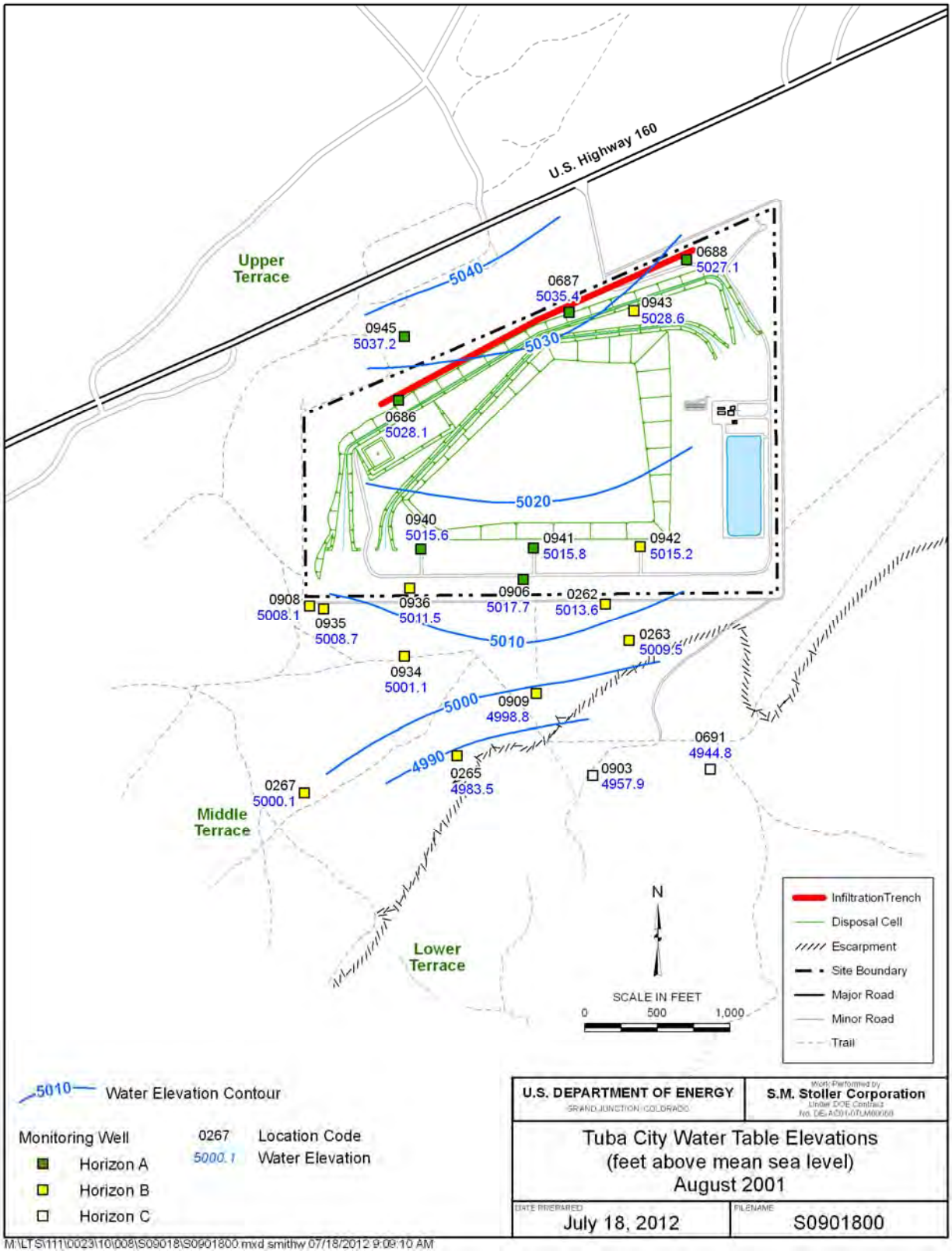


*Figure 15. Water Table Elevations, Tuba City Site, August 2001*

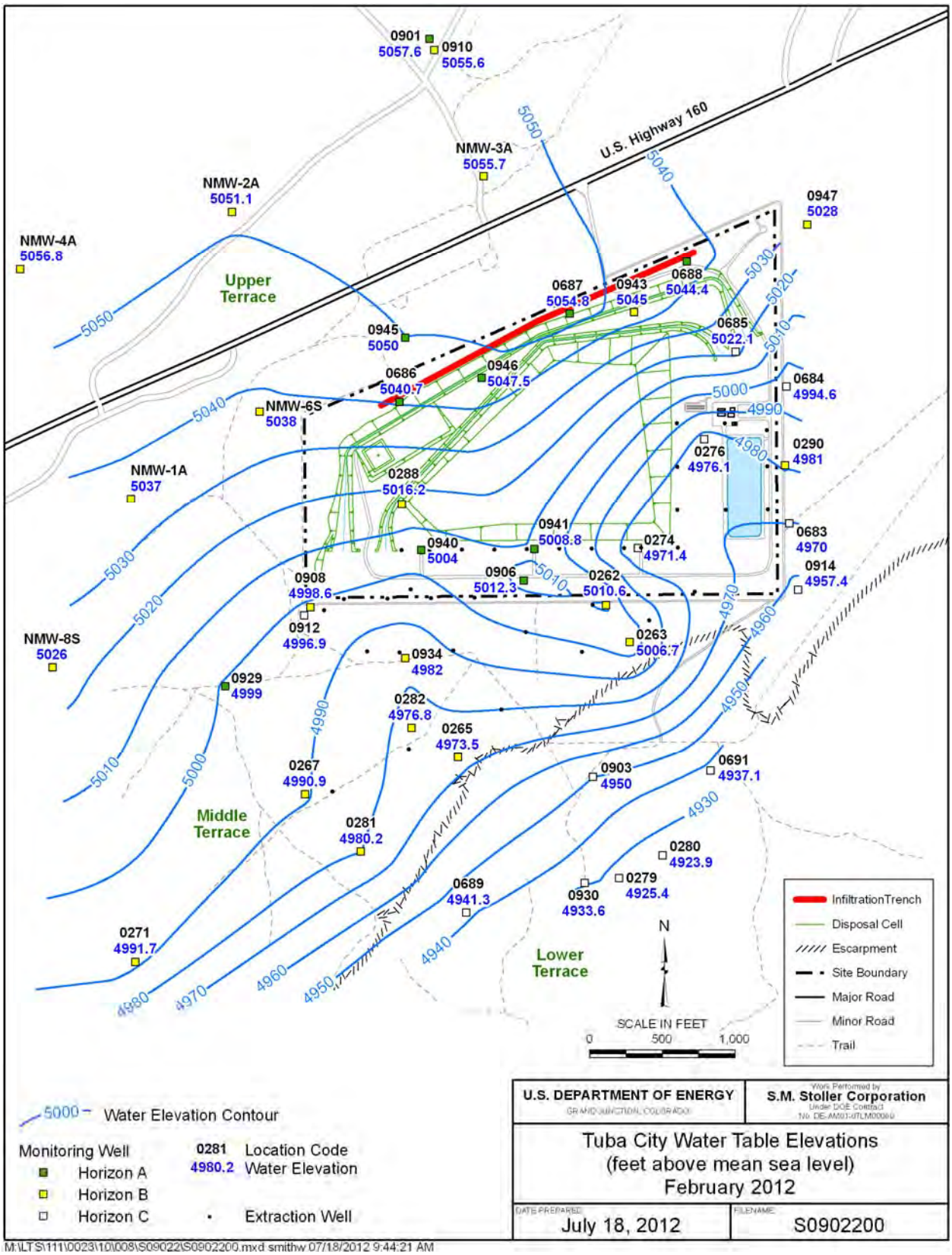


*Figure 16. Water Table Contour Map, Tuba City Site, February 2012*

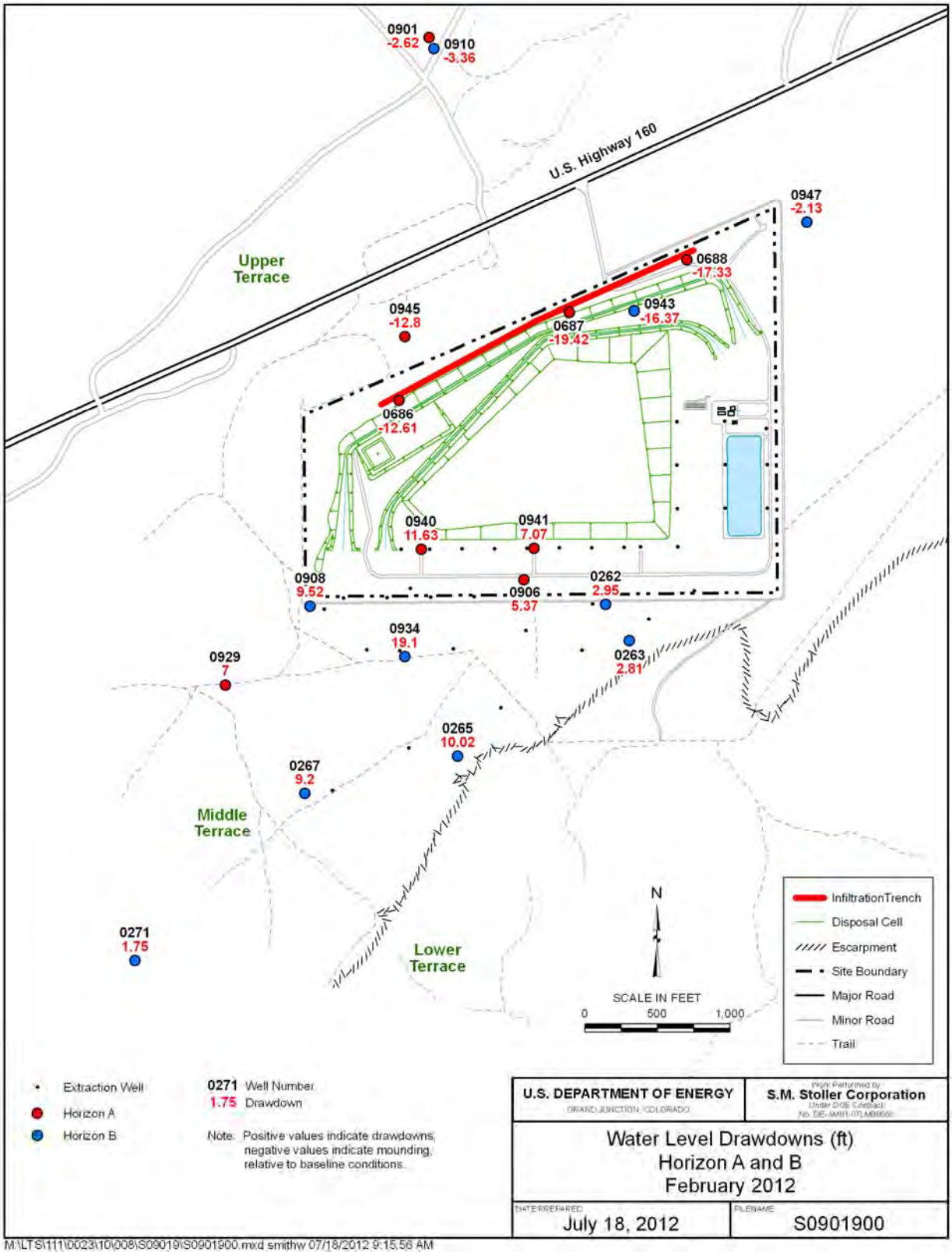


*Figure 17. Water Level Drawdowns, Horizons A and B, February 2012*

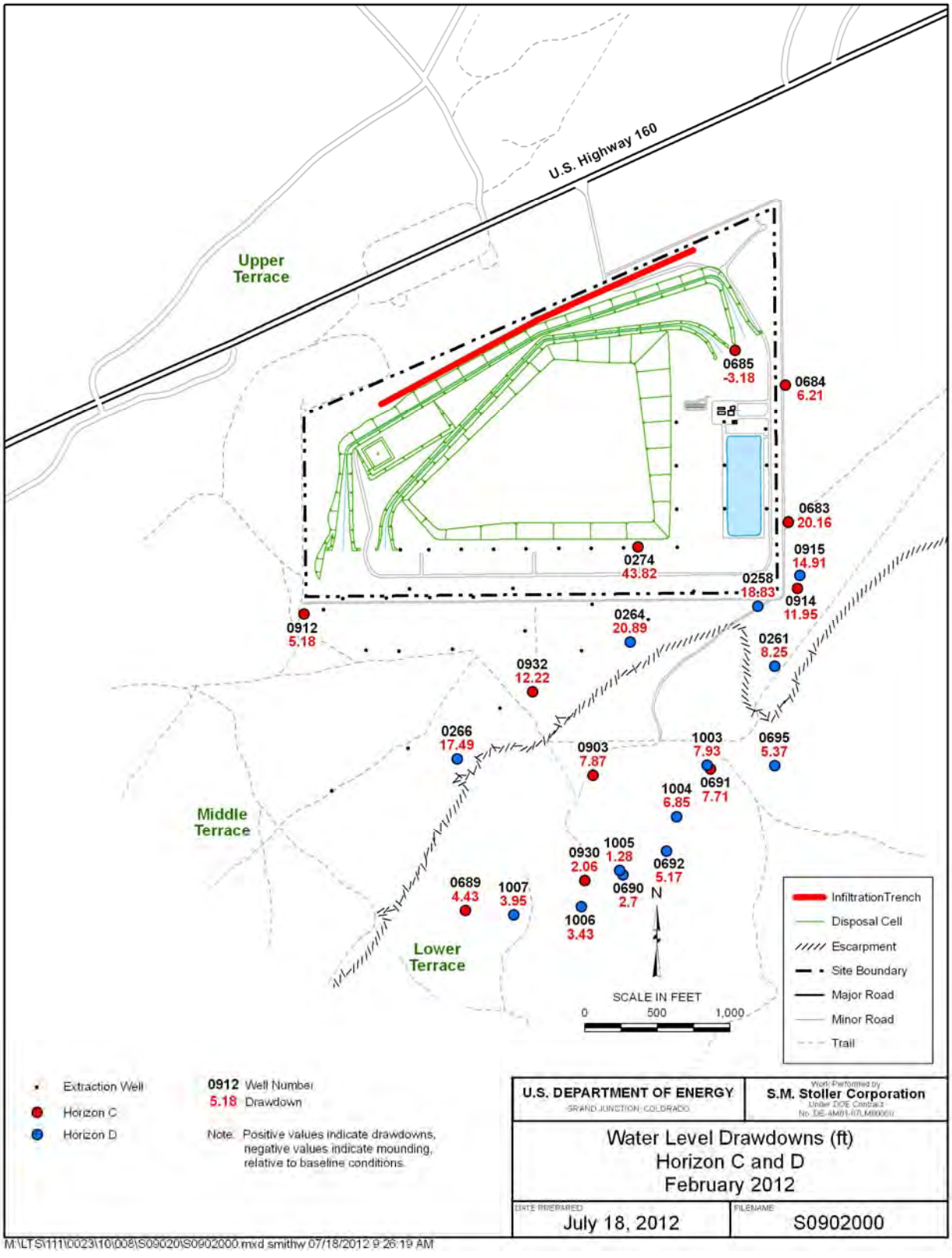


*Figure 18. Water Level Drawdowns, Horizons C and D, February 2012*

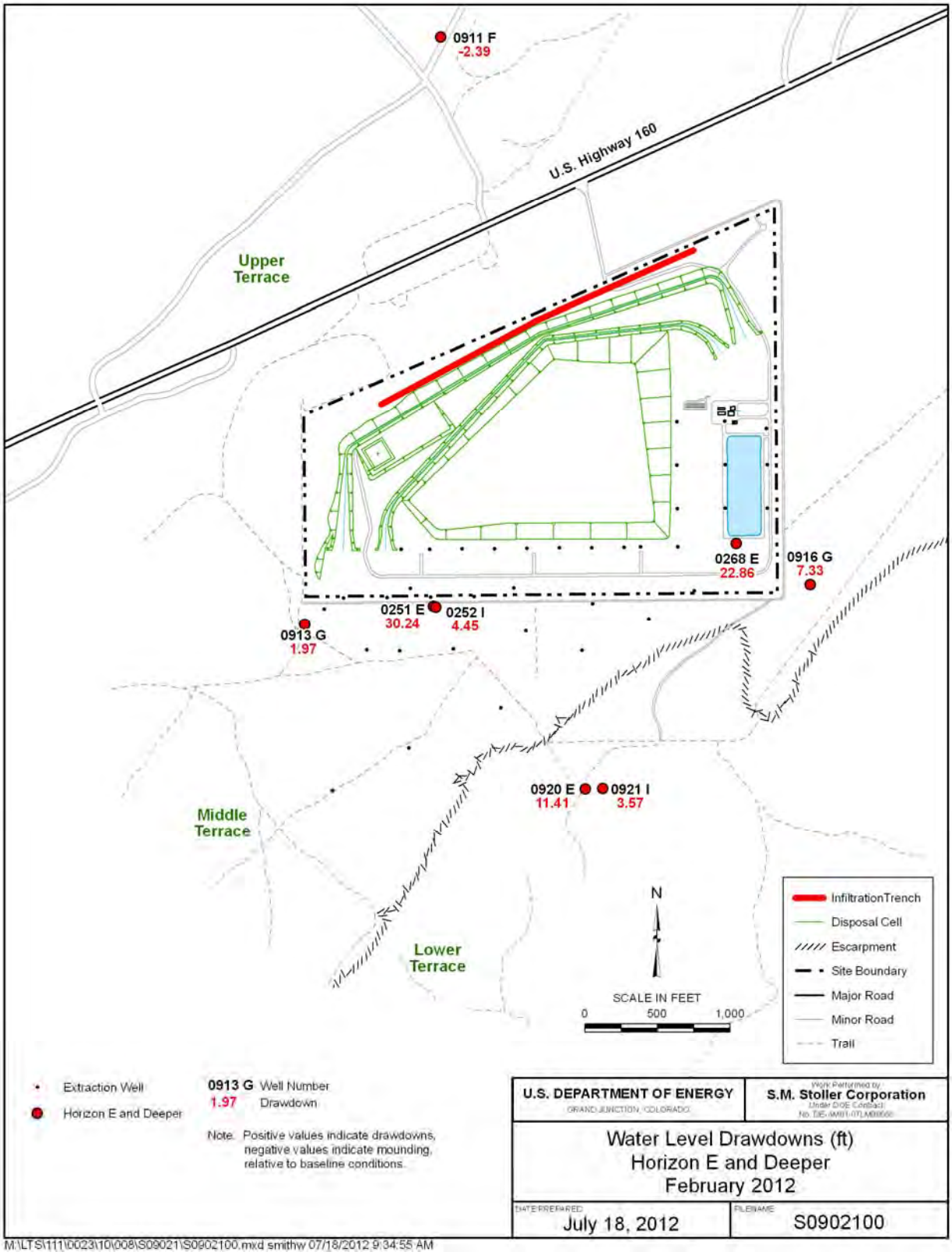


*Figure 19. Water Level Drawdowns, Horizons E, F, G, I, and M, February 2012*

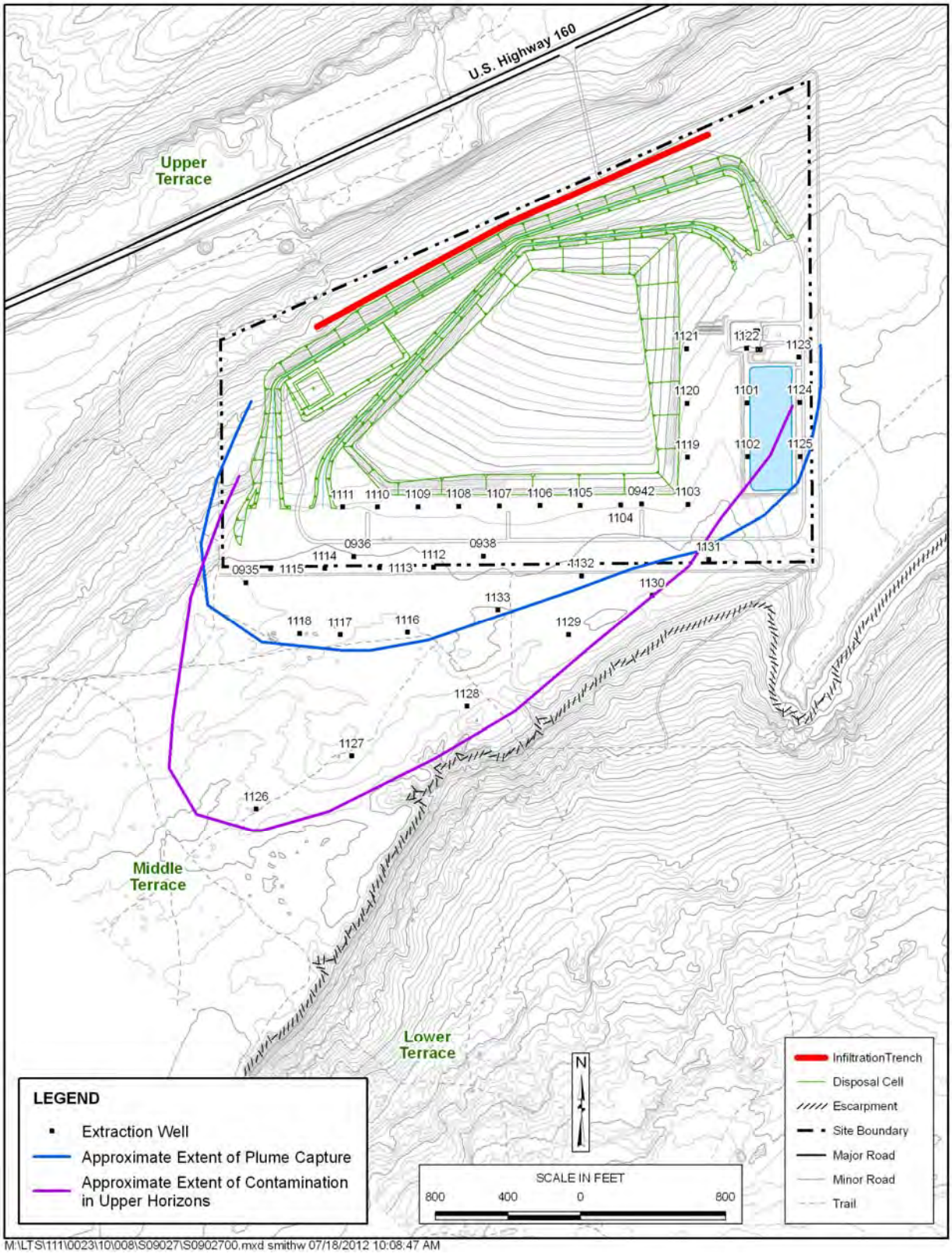


*Figure 20. Approximate Extent of Groundwater Contamination and Extraction System Capture Zone, Horizons A and B*

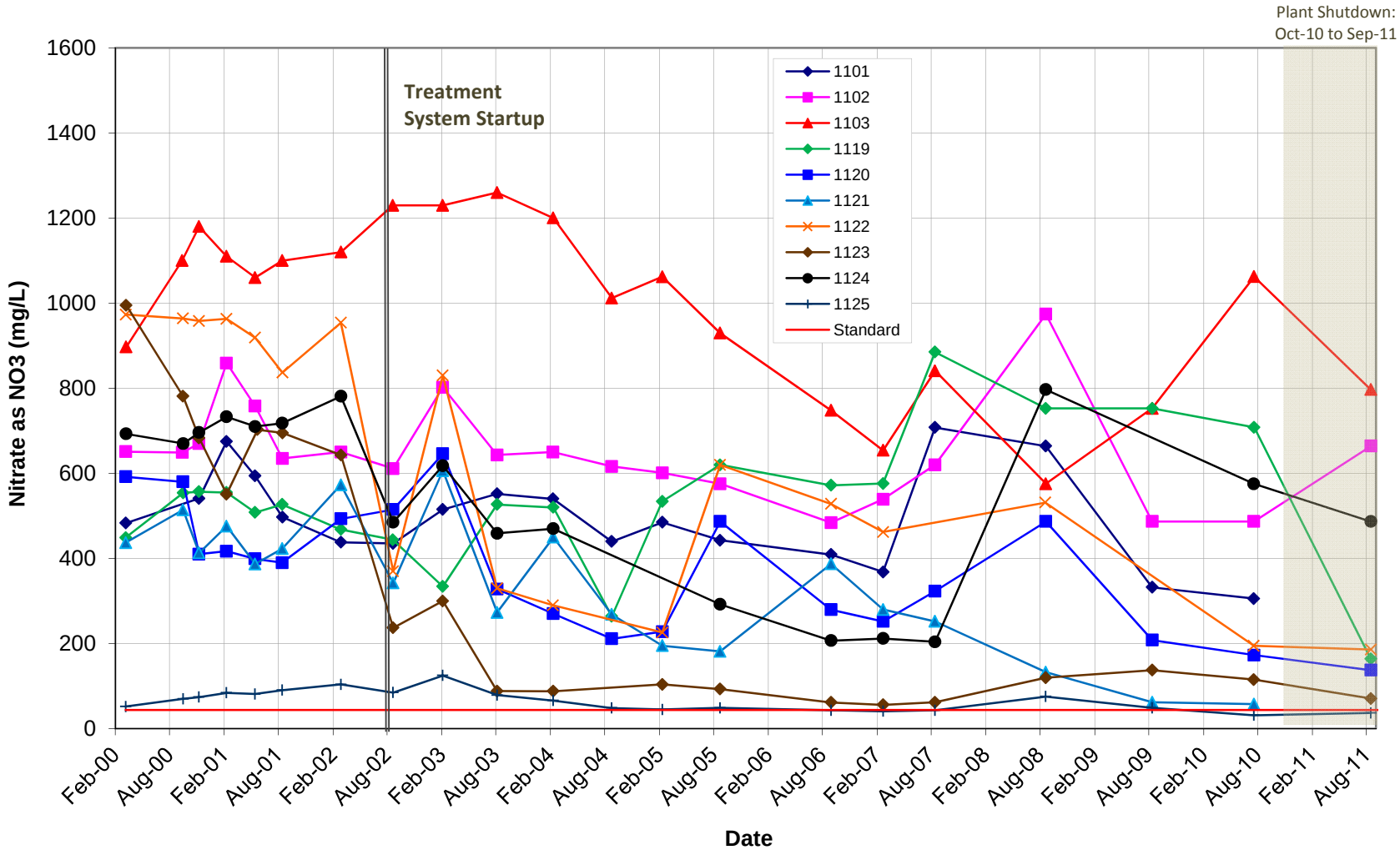


*Figure 21a. Nitrate Concentration Trends at Extraction Wells 1101–1103, 1119–1125 (East of Disposal Cell)*

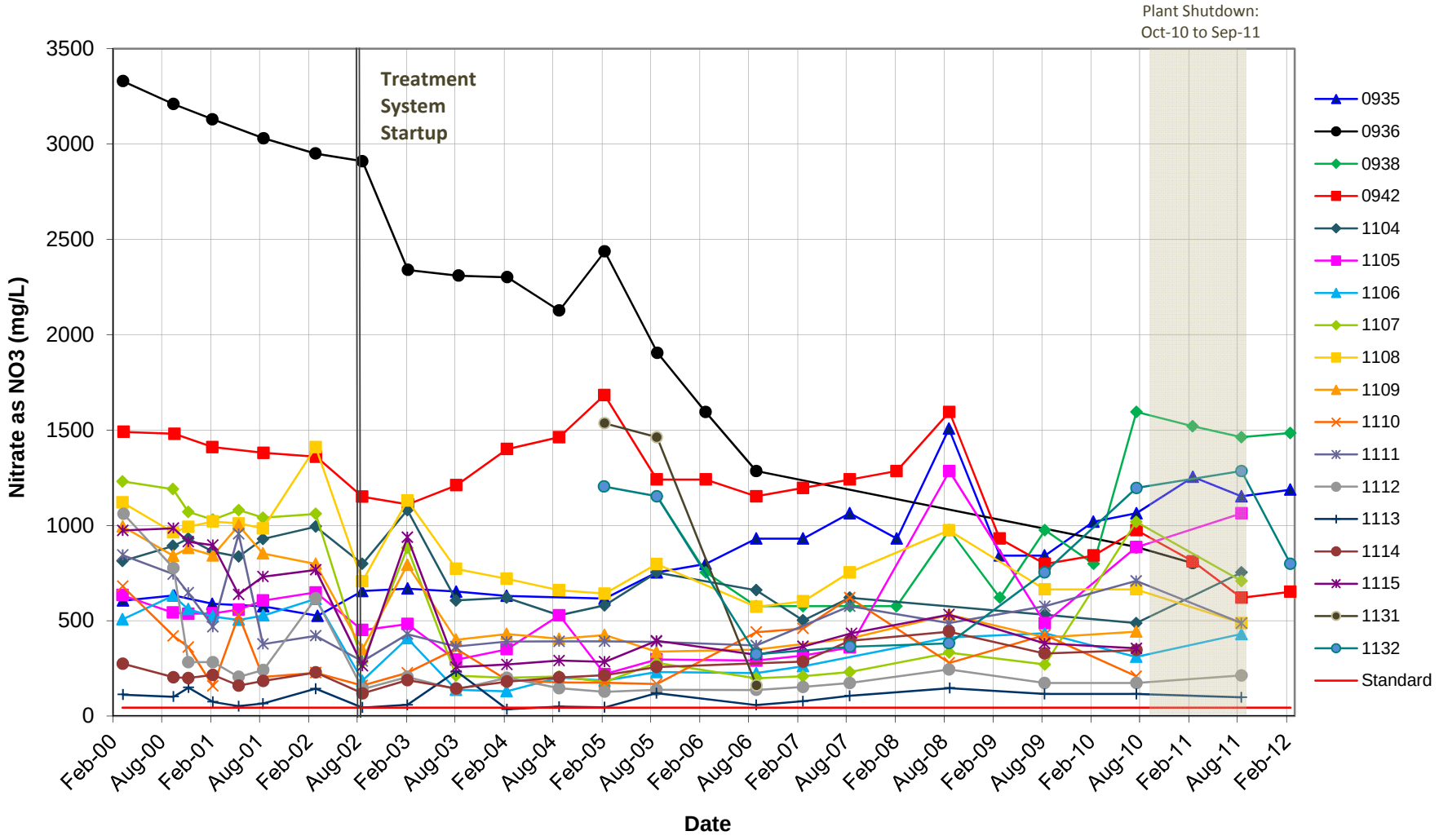


*Figure 21b. Nitrate Concentration Trends at Extraction Wells 935–936, 938, 942, 1104–1115, 1131–1132 (South of Disposal Cell at or within Site Boundary)*

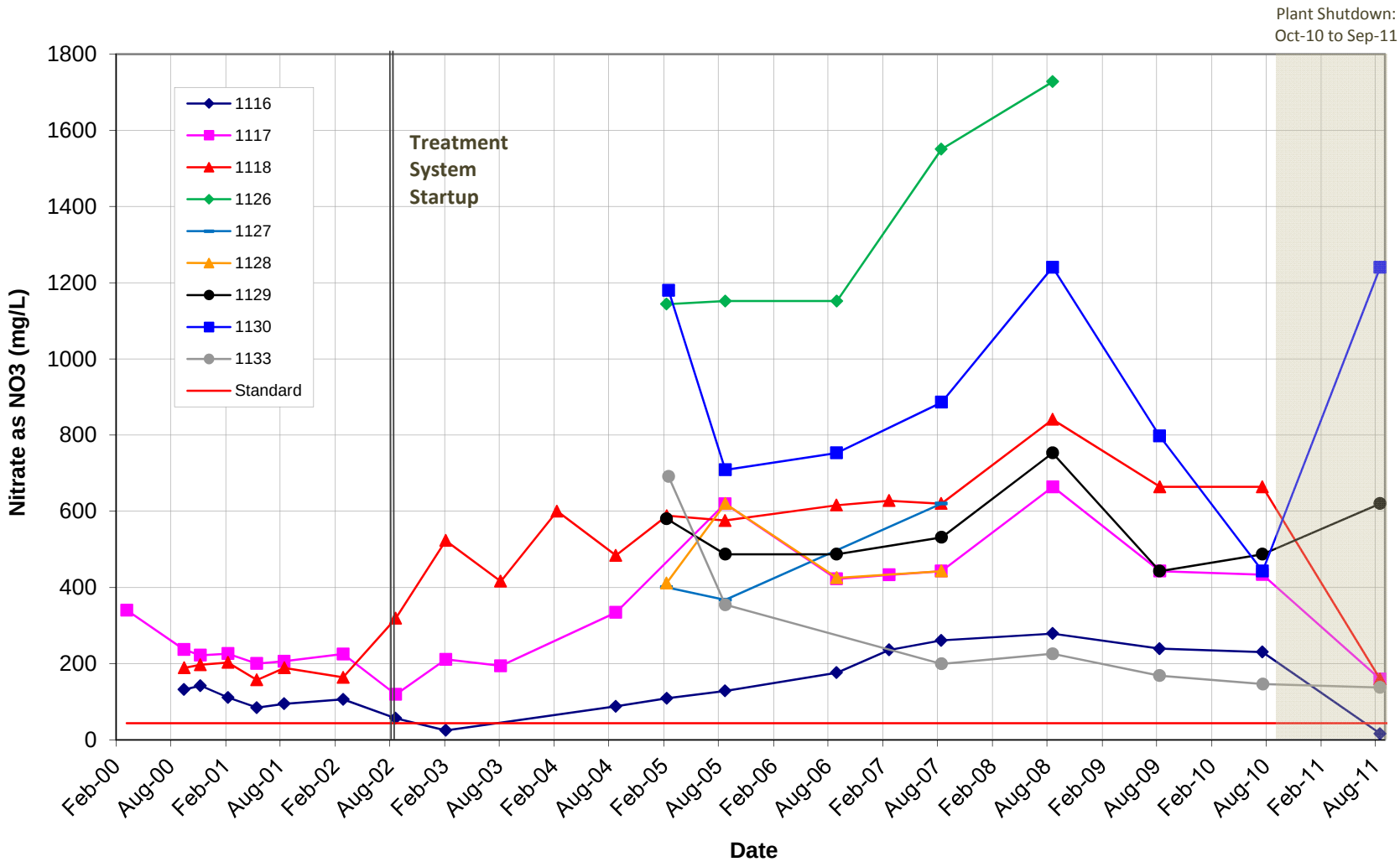


*Figure 21c. Nitrate Concentration Trends at Southernmost Extraction Wells 1116–1118, 1126–1130, 1133*

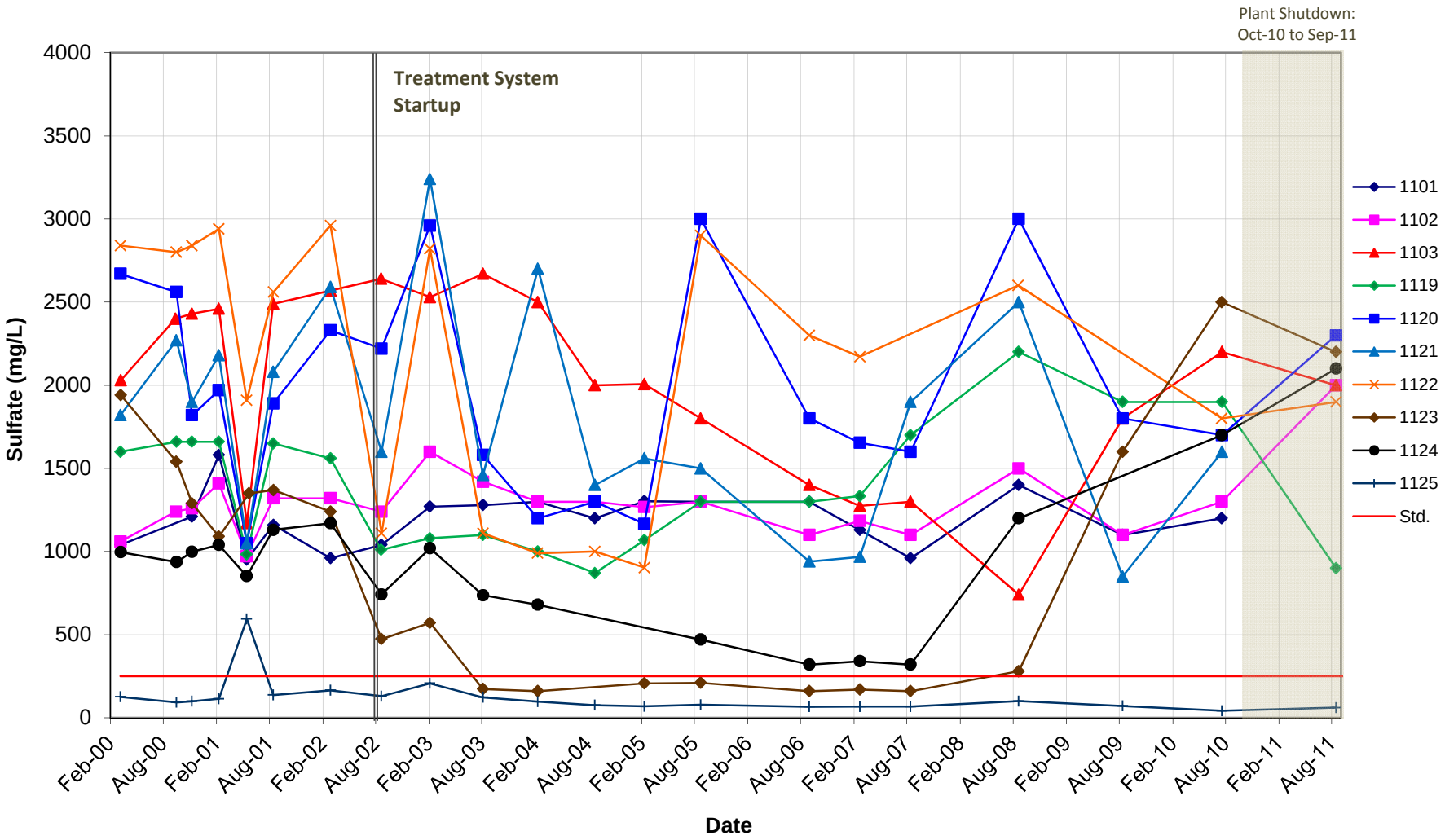


*Figure 22a. Sulfate Concentration Trends at Extraction Wells 1101–1103, 1119–1125 (East of Disposal Cell)*

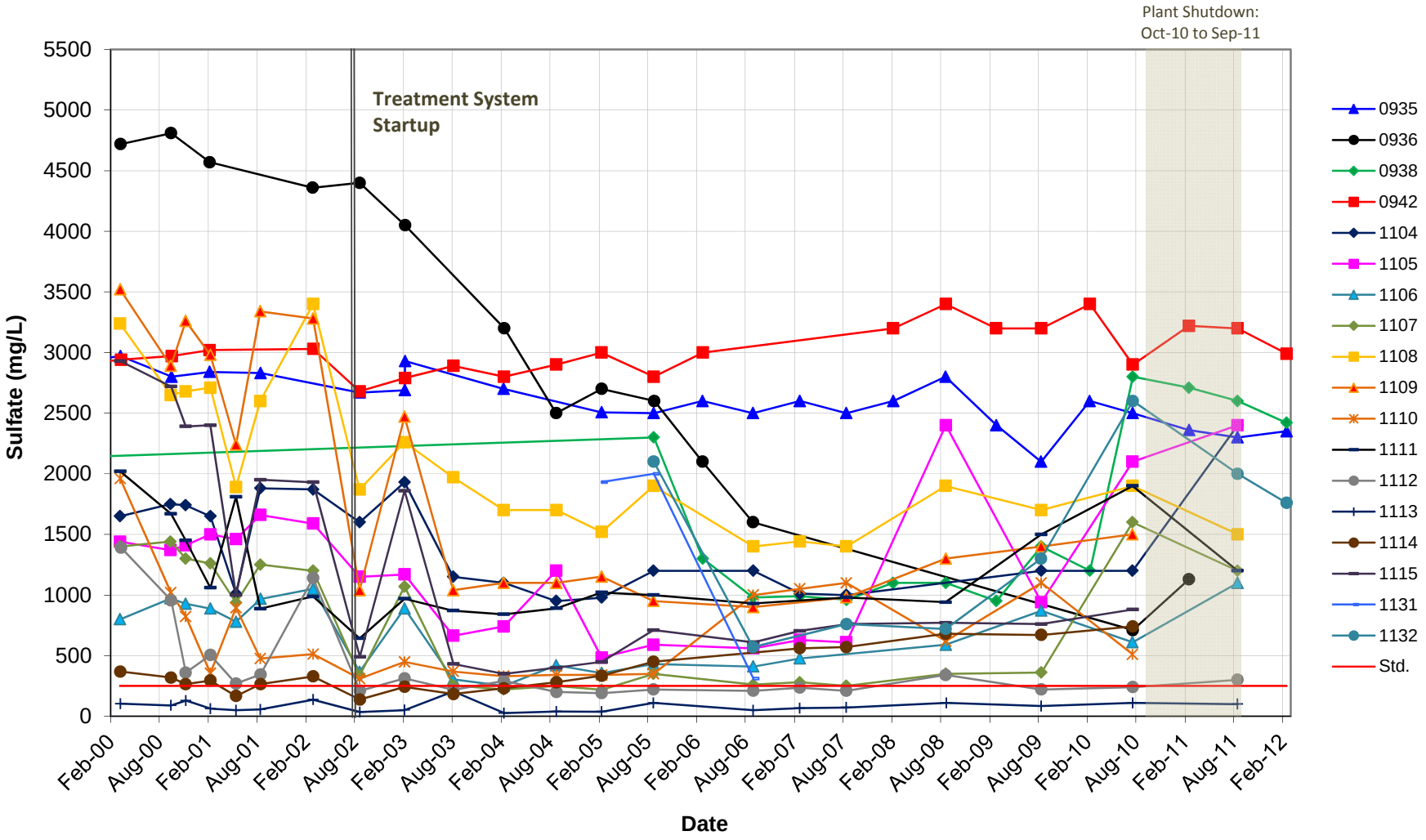


*Figure 22b. Sulfate Concentration Trends at Extraction Wells 935–936, 938, 942, 1104–1115, 1131–1132 (South of Disposal Cell at or within Site Boundary)*

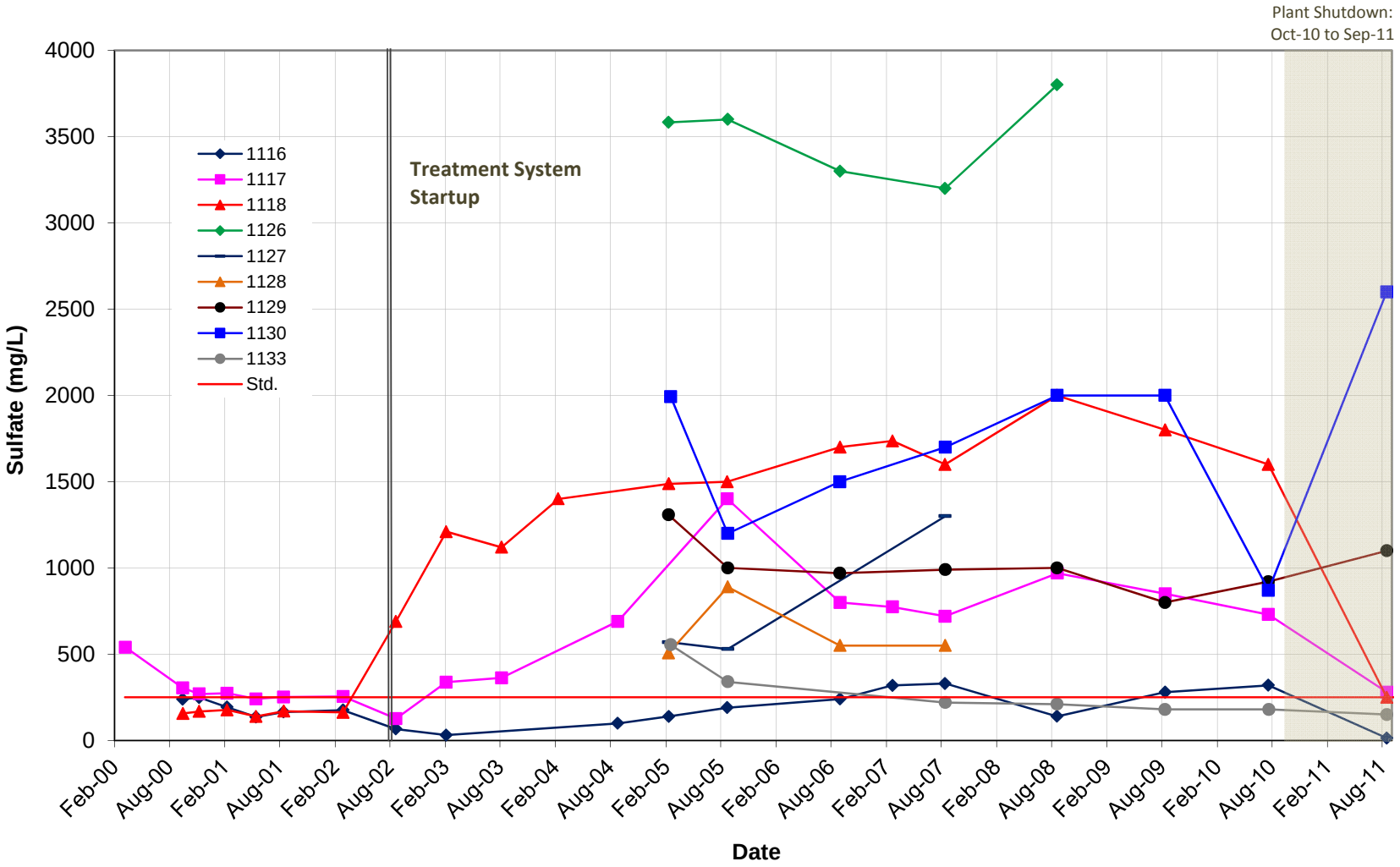


*Figure 22c. Sulfate Concentration Trends at Southernmost Extraction Wells 1116–1118, 1126–1130, 1133*

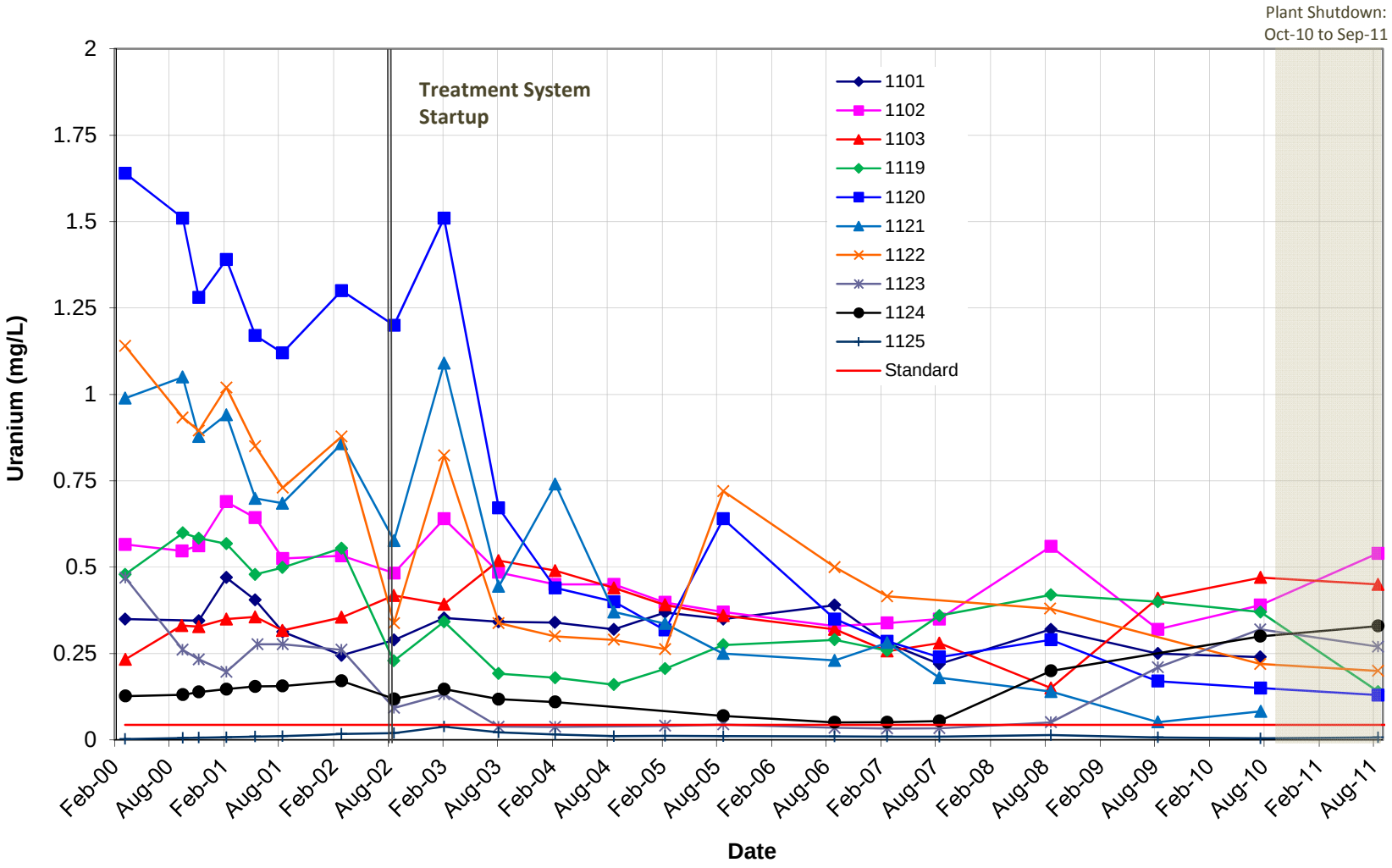


*Figure 23a. Uranium Concentration Trends at Extraction Wells 1101–1103, 1119–1125 (East of Disposal Cell)*

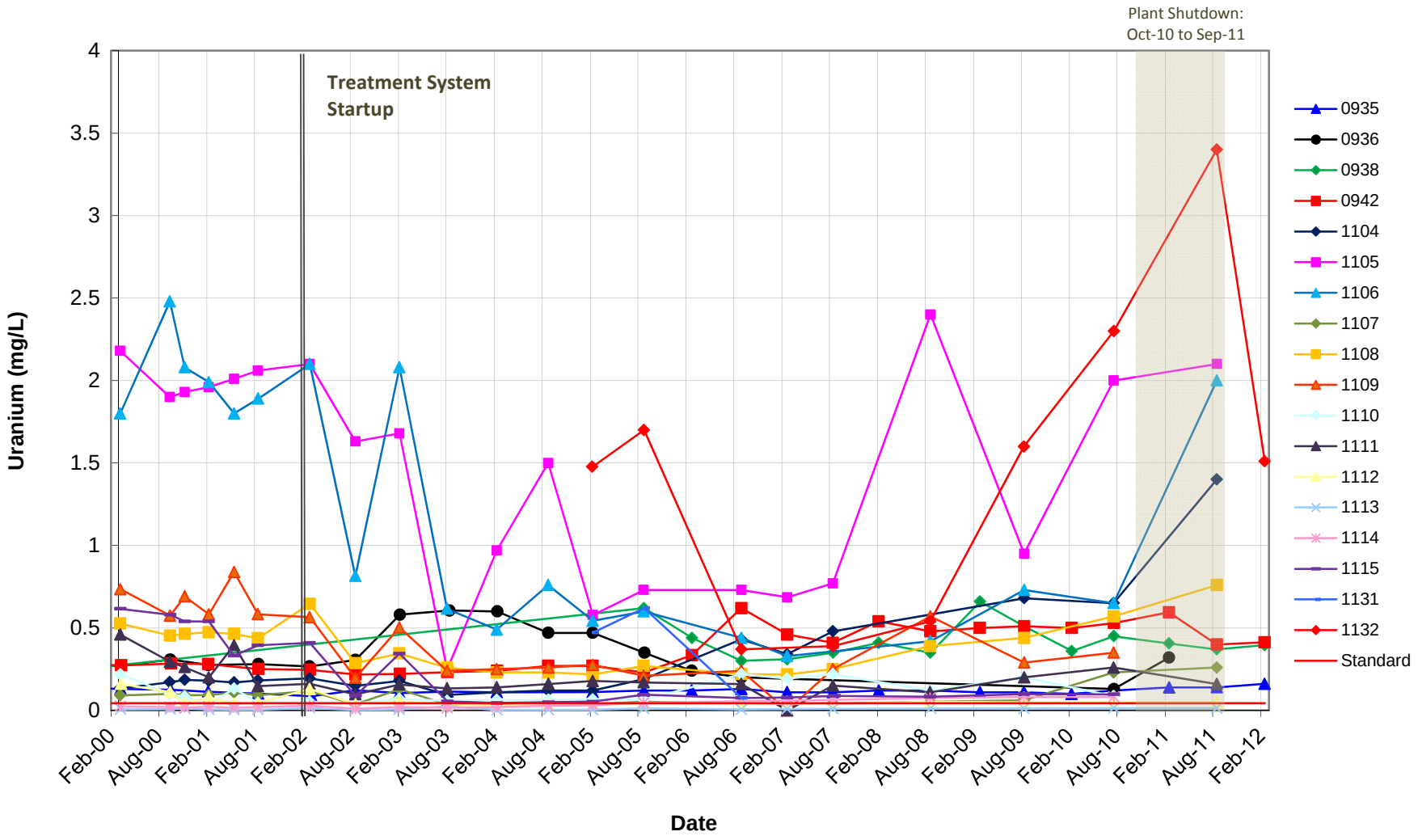


*Figure 23b. Uranium Concentration Trends at Extraction Wells 935–936, 938, 942, 1104–1115, 1131–1132 (South of Disposal Cell at or within Site Boundary)*

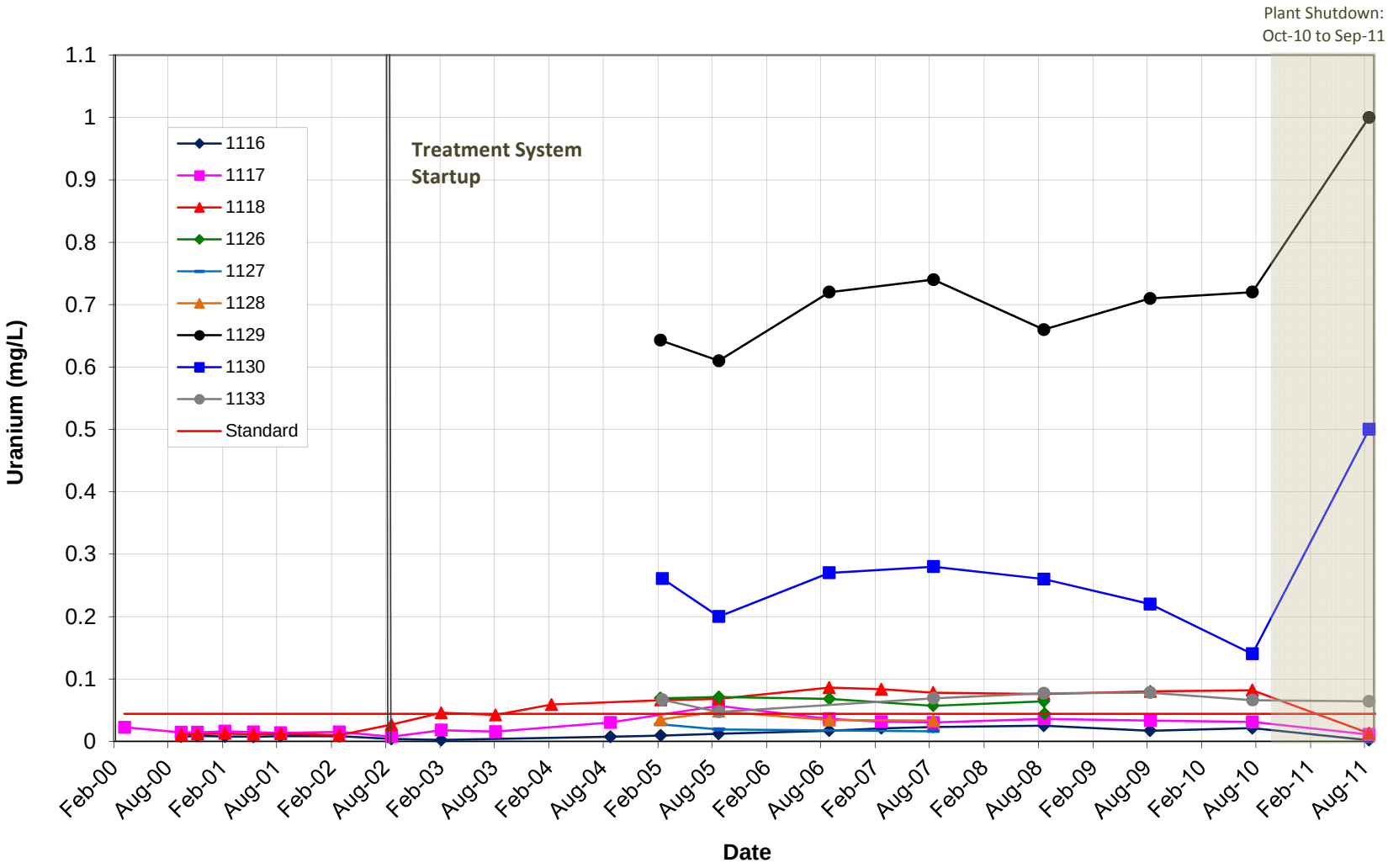


*Figure 23c. Uranium Concentration Trends at Southernmost Extraction Wells 1116–1118, 1126–1130, 1133*

# Appendix A

# Well Completion Information and Conceptual Site Model

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# Figures



# Table

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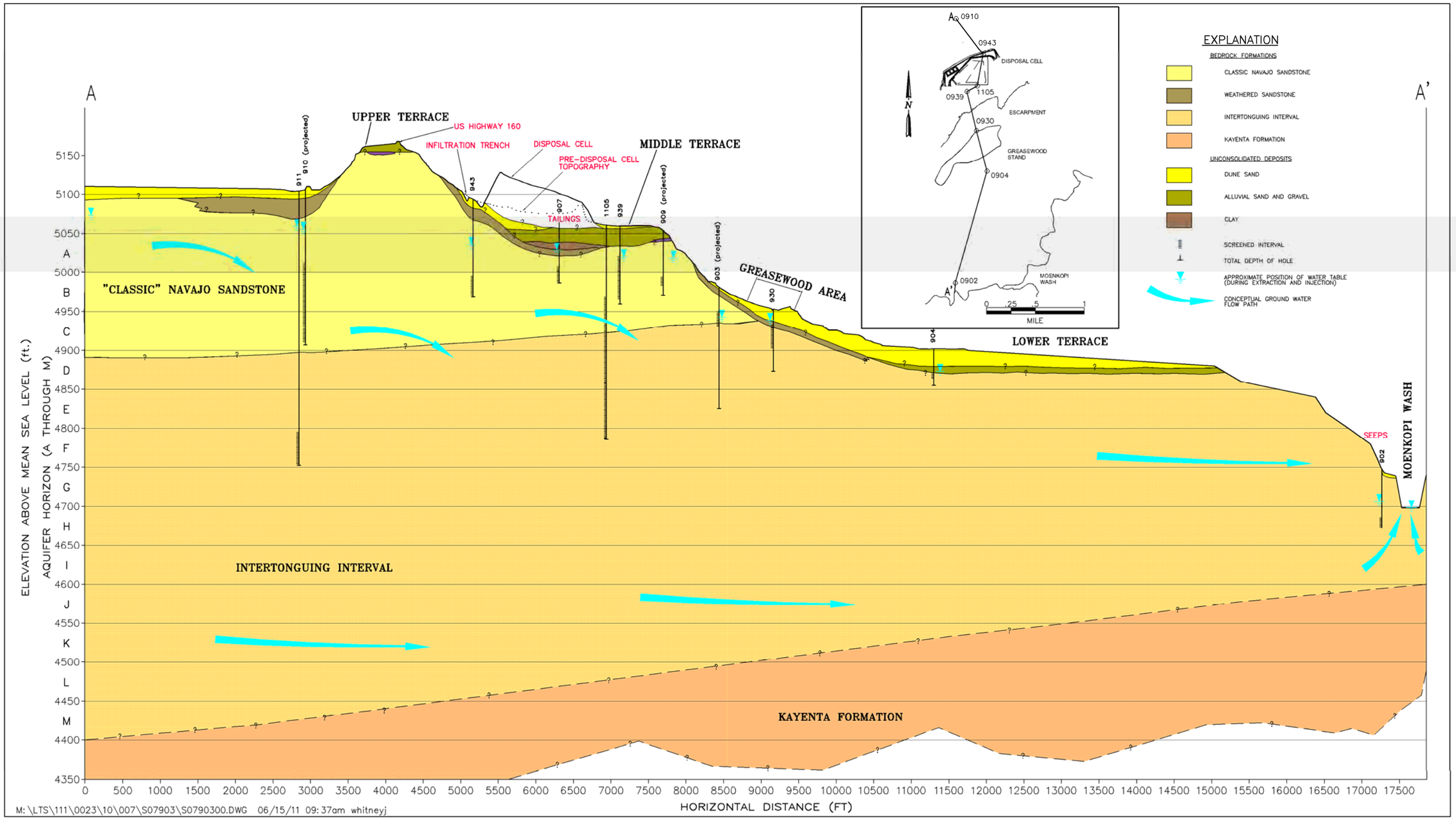


*Figure A−1. Conceptual Model of the Site Hydrogeology*

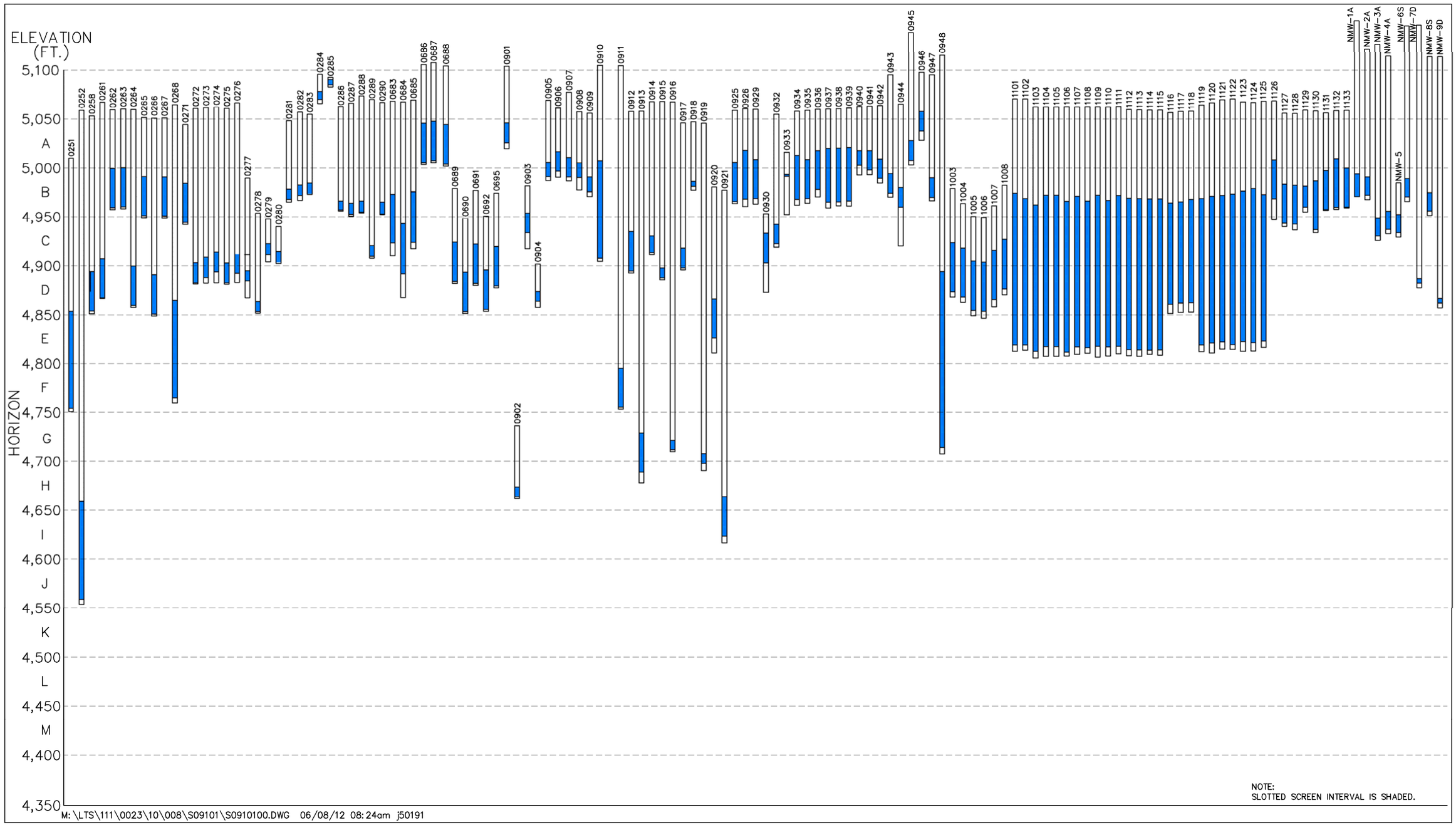


*Figure A−2. Well Completions Schematic*

*Table A−1. Well Completion Information*

| Well | Type | Horizon | Top Of Screen Elev. | Mid Screen Elev. | Bottom of Screen Elev. | Top of Screen Depth | Mid Screen Depth | Bottom of Screen Depth | Screen Length | Sump Length | Well Depth | Top of Casing Elev. | | Ground Elev. | | Well Diameter | Boring Started | Decommission Date | State Plane East | State Plane North |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0284 | MW | A | 5079.8 | 5074.8 | 5069.8 | 16.5 | 21.5 | 26.5 | 10.0 | 1.5 | 28.0 | 5098.72 | | 5096.3 | | 2 | 16-Aug-04 | | 730525 | 1873562 |
| 0285 | MW | A | 5090.8 | 5088.3 | 5085.8 | 3.0 | 5.5 | 8.0 | 5.0 | 0.1 | 8.1 | 5096.47 | | 5093.8 | | 2 | 16-Aug-04 | | 731629 | 1874042 |
| 0686 | MW | A | 5045.5 | 5025.5 | 5005.5 | 60.0 | 80.0 | 100.0 | 40.0 | 0.3 | 100.3 | 5107.97 | | 5105.5 | | 2 | 28-Mar-00 | | 729978 | 1873416 |
| 0687 | MW | A | 5047.6 | 5027.6 | 5007.6 | 60.0 | 80.0 | 100.0 | 40.0 | 0.3 | 100.3 | 5109.82 | | 5107.6 | | 2 | 29-Mar-00 | | 731152 | 1874024 |
| 0688 | MW | A | 5044.1 | 5024.1 | 5004.1 | 60.0 | 80.0 | 100.0 | 40.0 | 0.3 | 100.3 | 5106.98 | | 5104.1 | | 2 | 29-Mar-00 | | 731961 | 1874385 |
| 0901 | MW | A | 5045.8 | 5035.8 | 5025.8 | 58.0 | 68.0 | 78.0 | 20.0 | 2.0 | 80.0 | 5105.46 | | 5103.8 | | 2 | 16-Oct-84 | | 730185 | 1875918 |
| 0906 | MW | A | 5016.9 | 5006.9 | 4996.9 | 44.0 | 54.0 | 64.0 | 20.0 | 2.0 | 66.0 | 5062.10 | | 5060.9 | | 2 | 19-Nov-84 | | 730838 | 1872181 |
| 0907 | MW | A | 5010.7 | 5000.7 | 4990.7 | 66.5 | 76.5 | 86.5 | 20.0 | | | 5079.17 | | 5077.2 | | 2 | 30-Nov-84 | 19-Apr-88 | 731252 | 1872920 |
| 0928 | MW | A | 5022.1 | 5009.6 | 4997.1 | 30.0 | 42.5 | 55.0 | 25.0 | 3.0 | 58.0 | 5053.99 | | 5052.1 | | 4 | 20-Oct-95 | 24-May-00 | 729401 | 1870814 |
| 0929 | MW | A | 5010.4 | 4990.4 | 4970.4 | 48.2 | 68.2 | 88.2 | 40.0 | | | 5060.82 | | 5058.6 | | 4 | | | 728780 | 1871453 |
| 0940 | MW | A | 5017.9 | 5010.4 | 5002.9 | 45.0 | 52.5 | 60.0 | 15.0 | 3.0 | 68.0 | 5064.77 | | 5062.9 | | 4 | 01-Nov-95 | | 730130 | 1872391 |
| 0941 | MW | A | 5018.0 | 5008.0 | 4998.0 | 45.0 | 55.0 | 65.0 | 20.0 | 3.0 | 68.0 | 5065.97 | | 5063.0 | | 4 | 10-Nov-95 | | 730908 | 1872398 |
| 0945 | MW | A | 5028.1 | 5018.1 | 5008.1 | 110.0 | 120.0 | 130.0 | 20.0 | 3.0 | 133.0 | 5140.49 | | 5138.1 | | 4 | 11-Oct-95 | | 730019 | 1873857 |
| 0946 | MW | A | 5057.6 | 5047.6 | 5037.6 | 40.0 | 50.0 | 60.0 | 20.0 | 3.3 | 63.3 | 5100.50 | | 5097.6 | | 4 | 02-Nov-95 | | 730547 | 1873582 |
| NMW-1A | MW | B | 4980.7 | 4970 | 4960.7 | 167.5 | 177.5 | 187.5 | 20.0 | 5.0 | 192.50 | 5150.95 | | 5148.20 | | 4 | 25-Sep-10 | | 728130 | 1872744 |
| NMW-2A | MW | B | 4978.7 | 4968 | 4958.7 | 140.5 | 150.5 | 160.5 | 20.0 | 5.0 | 165.46 | 5121.69 | | 5119.15 | | 4 | 27-Sep-10 | | 728826 | 1874729 |
| NMW-3A | MW | B | 4975.1 | 4965 | 4955.1 | 190.6 | 200.6 | 210.6 | 20.0 | 5.0 | 215.62 | 5168.51 | | 5165.73 | | 4 | 10-Oct-10 | | 730559 | 1874974 |
| NMW-4A | MW | B | 4964.2 | 4954 | 4944.2 | 170.5 | 180.5 | 190.5 | 20.0 | 5.0 | 195.46 | 5137.44 | | 5134.68 | | 4 | 7-Oct-10 | | 727368 | 1874332 |
| NMW-6S | MW | B | 4975.1 | 4965 | 4955.1 | 167.6 | 177.6 | 187.6 | 20.0 | 5.0 | 192.62 | 5145.93 | | 5142.74 | | 4 | 23-Sep-10 | | 729015 | 1873349 |
| NMW-8S | MW | B | 4962.4 | 4952 | 4942.4 | 149.4 | 159.4 | 169.4 | 20.0 | 5.0 | 174.43 | 5114.87 | | 5112.30 | | 4 | 6-Oct-10 | | 727588 | 1871585 |
| 0262 | MW | B | 4999.2 | 4979.2 | 4959.2 | 60.0 | 80.0 | 100.0 | 40.0 | 0.3 | 100.3 | 5061.99 | | 5059.2 | | 2 | 03-Apr-00 | | 731402 | 1872012 |
| 0263 | MW | B | 5000.2 | 4980.2 | 4960.2 | 60.0 | 80.0 | 100.0 | 40.0 | 0.3 | 100.3 | 5063.10 | | 5060.2 | | 2 | 04-Apr-00 | | 731565 | 1871757 |
| 0265 | MW | B | 4991.1 | 4971.1 | 4951.1 | 60.0 | 80.0 | 100.0 | 40.0 | 0.3 | 100.3 | 5053.88 | | 5051.1 | | 2 | 16-Apr-00 | | 730382 | 1870964 |
| 0267 | MW | B | 4990.8 | 4970.8 | 4950.8 | 60.0 | 80.0 | 100.0 | 40.0 | 0.3 | 100.3 | 5053.40 | | 5050.8 | | 2 | 14-Apr-00 | | 729329 | 1870707 |
| 0271 | MW | B | 4984.0 | 4964.0 | 4944.0 | 60.0 | 80.0 | 100.0 | 40.0 | 0.3 | 100.3 | 5046.72 | | 5044.0 | | 2 | 29-Apr-00 | | 728160 | 1869555 |
| 0281 | MW | B | 4977.8 | 4972.8 | 4967.8 | 70.5 | 75.5 | 80.5 | 10.0 | 1.5 | 82.0 | 5051.00 | | 5048.3 | | 2 | 11-Aug-04 | | 729714 | 1870315 |
| 0282 | MW | B | 4983.3 | 4978.3 | 4973.3 | 74.1 | 79.1 | 84.1 | 10.0 | 1.5 | 85.6 | 5060.04 | | 5057.4 | | 2 | 10-Aug-04 | | 730062 | 1871168 |
| 0283 | MW | B | 4984.8 | 4979.8 | 4974.8 | 70.5 | 75.5 | 80.5 | 10.0 | 1.5 | 82.0 | 5057.97 | | 5055.3 | | 2 | 03-Aug-04 | | 730901 | 1871185 |
| 0286 | MW | B | 4968.84 | 4963.8 | 4958.84 | 93.2 | 98.2 | 103.2 | 10.0 | 0.4 | 103.6 | 5063.99 | | 5062.0 | | 2 | 13-Mar-07 | | 730128 | 1872377 |
| 0287 | MW | B | 4962.29 | 4957.3 | 4952.29 | 100.7 | 105.7 | 110.7 | 10.0 | 0.4 | 111.1 | 5065.65 | | 5063.0 | | 2 | 15-Mar-07 | | 730908 | 1872386 |
| 0288 | MW | B | 4965.86 | 4960.9 | 4955.86 | 104.0 | 109.0 | 114.0 | 10.0 | 0.5 | 114.5 | 5072.54 | | 5069.9 | | 2 | 18-Mar-07 | | 729995 | 1872709 |
| 0290 | MW | B | 4964.33 | 4959.3 | 4954.33 | 102.7 | 107.7 | 112.7 | 10.0 | 0.4 | 113.1 | 5068.91 | | 5067.0 | | 2 | 17-Mar-07 | | 732633 | 1872979 |
| 0905 | MW | B | 5006.0 | 4998.5 | 4991.0 | 63.0 | 70.5 | 78.0 | 15.0 | 2.0 | 80.0 | 5072.80 | | 5069.0 | | 2 | 14-Nov-84 | 24-May-00 | 732933 | 1873200 |
| 0908 | MW | B | 5005.3 | 4997.8 | 4990.3 | 52.0 | 59.5 | 67.0 | 15.0 | 2.0 | 69.0 | 5058.14 | | 5057.3 | | 2 | 17-Nov-84 | | 729366 | 1871999 |
| 0909 | MW | B | 4990.8 | 4983.3 | 4975.8 | 65.0 | 72.5 | 80.0 | 15.0 | 2.0 | 82.0 | 5057.17 | | 5055.8 | | 2 | 18-Nov-84 | | 730927 | 1871393 |
| 0910 | MW | B | 5007.6 | 4957.6 | 4907.6 | 97.0 | 147.0 | 197.0 | 100.0 | 1.0 | 198.0 | 5106.70 | | 5104.6 | | 4 | 26-Jul-85 | | 730219 | 1875840 |
| 0918 | MW | B | 4986.2 | 4983.7 | 4981.2 | 61.0 | 63.5 | 66.0 | 5.0 | 2.0 | 68.0 | 5049.63 | | 5047.2 | | 4 | 15-Aug-85 | | 727294 | 1868724 |
| 0925 | EXT | B | 5005.8 | 4985.8 | 4965.8 | 53.0 | 73.0 | 93.0 | 40.0 | 0.5 | 93.5 | 5060.87 | | 5058.8 | | 6 | 21-Oct-95 | 24-May-00 | 729452 | 1872006 |
| 0926 | EXT | B | 5018.3 | 4993.3 | 4968.3 | 42.2 | 67.2 | 92.2 | 50.0 | 3.0 | 95.2 | 5062.85 | | 5060.5 | | 6 | 25-Oct-95 | 17-May-00 | 730790 | 1872126 |
| 0933 | MW | B | 4993.3 | 4992.3 | 4991.3 | 23.0 | 24.0 | 25.0 | 2.0 | | | 5018.03 | | 5016.3 | | 4 | 18-Oct-95 | 24-May-00 | 731727 | 1871341 |
| 0934 | MW | B | 5013.0 | 4990.5 | 4968.0 | 45.0 | 67.5 | 90.0 | 45.0 | 3.0 | 93.0 | 5059.73 | | 5058.0 | | 4 | 02-Nov-95 | | 730018 | 1871649 |
| 0935 | MW/EXT | B | 5008.8 | 4988.8 | 4968.8 | 50.0 | 70.0 | 90.0 | 40.0 | 3.0 | 93.0 | 5061.50 | | 5058.8 | | 4 | 28-Oct-95 | * | 729461 | 1871978 |
| 0936 | MW/EXT | B | 5017.9 | 4997.9 | 4977.9 | 42.0 | 62.0 | 82.0 | 40.0 | 3.0 | 85.0 | 5062.30 | | 5059.9 | | 6 | 26-Oct-95 | * | 730055 | 1872121 |

*Table A−1 (continued). Well Completion Information*

| Well | Type | Horizon | Top Of Screen Elev. | Mid Screen Elev. | Bottom of Screen Elev. | Top of Screen Depth | Mid Screen Depth | Bottom of Screen Depth | Screen Length | Sump Length | Well Depth | Top of Casing Elev. | | Ground Elev. | | Well Diameter | Boring Started | Decommission Date | State Plane East | State Plane North |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0937 | MW | B | 5020.2 | 4992.7 | 4965.2 | 40.0 | 67.5 | 95.0 | 55.0 | 3.0 | 98.0 | 5062.80 | | 5060.2 | | 4 | 09-Nov-95 | 24-May-00 | 730790 | 1872116 |
| 0938 | MW/EXT | B | 5020.4 | 4992.9 | 4965.4 | 40.0 | 67.5 | 95.0 | 55.0 | 3.0 | 98.0 | 5063.64 | | 5060.4 | | 4 | 26-Oct-95 | * | 730769 | 1872124 |
| 0939 | EXT | B | 5021.1 | 4993.6 | 4966.1 | 40.0 | 67.5 | 95.0 | 55.0 | 3.0 | 98.0 | 5063.23 | | 5061.1 | | 6 | 23-Oct-95 | 16-May-00 | 731403 | 1872132 |
| 0942 | MW/EXT | B | 5009.5 | 4999.5 | 4989.5 | 54.0 | 64.0 | 74.0 | 20.0 | 3.0 | 77.0 | 5066.45 | | 5063.5 | | 4 | 03-Nov-95 | * | 731642 | 1872409 |
| 0943 | MW | B | 4994.1 | 4984.1 | 4974.1 | 101.0 | 111.0 | 121.0 | 20.0 | 3.0 | 124.0 | 5098.05 | | 5095.1 | | 4 | 13-Oct-95 | | 731596 | 1874034 |
| 0944 | MW | B | 4979.9 | 4969.9 | 4959.9 | 85.0 | 95.0 | 105.0 | 20.0 | 2.0 | 107.0 | 5067.00 | | 5064.9 | | 4 | 04-Nov-95 | 28-Jul-99 | 732199 | 1873007 |
| 0947 | MW | B | 4990.0 | 4980.0 | 4970.0 | 105.0 | 115.0 | 125.0 | 20.0 | 3.3 | 128.3 | 5097.01 | | 5095.0 | | 4 | 03-Nov-95 | | 732786 | 1874642 |
| 1126 | EXT | B | 4991.9 | 4971.9 | 4951.9 | 60.0 | 80.0 | 100.0 | 40.0 | 3.3 | 103.3 | *5051.9* | ** | *5051.9* | ** | 4 | 09-Sep-04 | | 729517 | 1870728 |
| 1127 | EXT | B | 4984.2 | 4964.2 | 4944.2 | 72.7 | 92.7 | 112.7 | 40.0 | 3.3 | 116.0 | *5056.9* | ** | *5056.9* | ** | 4 | 11-Sep-04 | | 730044 | 1871022 |
| 1128 | EXT | B | 4982.3 | 4962.3 | 4942.3 | 72.7 | 92.7 | 112.7 | 40.0 | 3.3 | 116.0 | *5055.0* | ** | *5055.0* | ** | 4 | 12-Sep-04 | | 730679 | 1871294 |
| 1129 | EXT | B | 4990.9 | 4975.9 | 4960.9 | 68.2 | 83.2 | 98.2 | 30.0 | 3.3 | 101.5 | *5059.1* | ** | *5059.1* | ** | 4 | 30-Aug-04 | | 731237 | 1871690 |
| 1130 | EXT | B | 4987.3 | 4962.3 | 4937.3 | 71.7 | 96.7 | 121.7 | 50.0 | 3.3 | 125.0 | *5059.0* | ** | *5059.0* | ** | 4 | 29-Jul-04 | | 731699 | 1871907 |
| 1131 | EXT | B | 4998.1 | 4978.1 | 4958.1 | 59.7 | 79.7 | 99.7 | 40.0 | 3.3 | 103.0 | *5057.8* | ** | *5057.8* | ** | 4 | 08-Sep-04 | | 732011 | 1872106 |
| 1132 | EXT | B | 5009.1 | 4984.1 | 4959.1 | 49.7 | 74.7 | 99.7 | 50.0 | 3.3 | 103.0 | *5058.8* | ** | *5058.8* | ** | 4 | 31-Aug-04 | | 731310 | 1872015 |
| 1133 | EXT | B | 4999.4 | 4979.4 | 4959.4 | 59.7 | 79.7 | 99.7 | 40.0 | 3.3 | 103.0 | *5059.1* | ** | *5059.1* | ** | 4 | 02-Sep-04 | | 730850 | 1871827 |
| NMW-5 | MW | C | 4948.2 | 4938 | 4928.2 | 35.0 | 45.0 | 55.0 | 20.0 | 5.0 | 59.95 | 4985.85 | | 4983.10 | | 4 | 8-Oct-10 | | 715095 | 1867920 |
| 0274 | MW | C | 4913.6 | 4903.6 | 4893.6 | 149.0 | 159.0 | 169.0 | 20.0 | 1.5 | 170.5 | 5064.42 | | 5062.6 | | 2 | 30-Aug-04 | | 731623 | 1872403 |
| 0276 | MW | C | 4910.0 | 4900.0 | 4890.0 | 154.5 | 164.5 | 174.5 | 20.0 | 1.5 | 176.0 | 5067.55 | | 5064.5 | | 2 | 01-Sep-04 | | 732081 | 1873158 |
| 0279 | MW | C | 4922.1 | 4917.1 | 4912.1 | 26.5 | 31.5 | 36.5 | 10.0 | 1.5 | 38.0 | 4951.04 | | 4948.6 | | 2 | 15-Aug-04 | | 731494 | 1870132 |
| 0280 | MW | C | 4922.6 | 4917.6 | 4912.6 | 26.5 | 31.5 | 36.5 | 10.0 | 1.5 | 38.0 | 4951.52 | | 4949.1 | | 2 | 15-Aug-04 | | 731794 | 1870289 |
| 0289 | MW | C | 4920.3 | 4915.3 | 4910.3 | 148.3 | 153.3 | 158.3 | 10.0 | 0.4 | 163.0 | 5070.82 | | 5068.6 | | 6 | 28-Mar-07 | | 729965 | 1872709 |
| 0683 | MW | C | 4973.2 | 4948.2 | 4923.2 | 95.0 | 120.0 | 145.0 | 50.0 | 3.0 | 148.0 | 5070.64 | | 5068.2 | | 6 | 31-Aug-99 | | 732661 | 1872574 |
| 0684 | MW | C | 4943.1 | 4917.4 | 4891.8 | 124.2 | 149.9 | 175.5 | 51.3 | 2.5 | 178.0 | 5070.05 | | 5067.3 | | 6 | 20-Aug-99 | | 732642 | 1873521 |
| 0685 | MW | C | 4975.6 | 4949.7 | 4923.8 | 93.7 | 119.6 | 145.5 | 51.8 | 2.5 | 148.0 | 5072.44 | | 5069.3 | | 6 | 19-Aug-99 | | 732295 | 1873760 |
| 0689 | MW | C | 4923.9 | 4903.9 | 4883.9 | 55.0 | 75.0 | 95.0 | 40.0 | 0.3 | 95.3 | 4981.63 | | 4978.9 | | 2 | 31-Mar-00 | | 730439 | 1869893 |
| 0691 | MW | C | 4921.9 | 4901.9 | 4881.9 | 55.0 | 75.0 | 95.0 | 40.0 | 0.3 | 95.3 | 4979.41 | | 4976.9 | | 2 | 30-Mar-00 | | 732124 | 1870872 |
| 0903 | MW | C | 4953.5 | 4943.5 | 4933.5 | 28.0 | 38.0 | 48.0 | 20.0 | 2.0 | 50.0 | 4983.33 | | 4981.5 | | 2 | 30-Oct-84 | | 731314 | 1870829 |
| 0912 | MW | C | 4934.7 | 4914.7 | 4894.7 | 123.0 | 143.0 | 163.0 | 40.0 | 2.0 | 165.0 | 5059.97 | | 5057.7 | | 4 | 12-Aug-85 | | 729324 | 1871942 |
| 0914 | MW | C | 4930.3 | 4921.8 | 4913.3 | 137.2 | 145.7 | 154.2 | 17.0 | 2.0 | 156.2 | 5070.10 | | 5067.5 | | 4 | 16-Aug-85 | | 732723 | 1872119 |
| 0917 | MW | C | 4917.8 | 4907.8 | 4897.8 | 128.0 | 138.0 | 148.0 | 20.0 | 2.0 | 150.0 | 5048.02 | | 5045.8 | | 4 | 14-Aug-85 | | 727255 | 1868642 |
| 0930 | MW | C | 4933.0 | 4918.0 | 4903.0 | 20.0 | 35.0 | 50.0 | 30.0 | 3.0 | 53.0 | 4954.96 | | 4953.0 | | 4 | 23-Oct-95 | | 731257 | 1870099 |
| 0932 | MW | C | 4942.3 | 4932.3 | 4922.3 | 112.5 | 122.5 | 132.5 | 20.0 | 2.7 | 135.2 | 5057.32 | | 5054.8 | | 4 | 29-Oct-95 | | 730900 | 1871401 |
| 1008 | INJ | C | 4926.8 | 4901.6 | 4876.4 | 55.6 | 80.8 | 106.0 | 50.4 | 2.5 | 108.5 | 4980.52 | | 4982.3 | | 6 | 23-Jul-99 | | 730410 | 1869916 |
| 1116 | EXT | C | 4964.1 | 4912.5 | 4861.0 | 92.4 | 143.9 | 195.5 | 103.1 | 2.5 | 198.0 | 5053.74 | | 5056.5 | | 6 | 08-Aug-99 | | 730350 | 1871702 |
| 1117 | EXT | C | 4965.3 | 4913.7 | 4862.1 | 92.3 | 143.9 | 195.5 | 103.2 | 2.5 | 198.0 | 5054.95 | | 5057.6 | | 6 | 11-Aug-99 | | 729981 | 1871688 |
| 1118 | EXT | C | 4967.9 | 4915.1 | 4862.3 | 89.9 | 142.7 | 195.5 | 105.6 | 2.5 | 198.0 | 5055.11 | | 5057.8 | | 6 | 12-Aug-99 | | 729756 | 1871695 |
| NMW-7D | MW | D | 4865.7 | 4863 | 4860.7 | 278.2 | 280.7 | 283.2 | 5.0 | 5.0 | 288.19 | 5147.13 | | 5143.92 | | 4 | 21-Sep-10 | | 729017 | 1873387 |
| 0258 | MW | D | 4894.0 | 4874.0 | 4854.0 | 159.0 | 179.0 | 199.0 | 40.0 | 0.3 | 199.3 | 5055.56 | | 5053.0 | | 2 | 13-Apr-00 | | 732452 | 1871996 |
| 0261 | MW | D | 4907.0 | 4887.0 | 4867.0 | 160.0 | 180.0 | 200.0 | 40.0 | 0.3 | 200.3 | 5069.69 | | 5067.0 | | 2 | 01-Apr-00 | | 732565 | 1871578 |
| 0264 | MW | D | 4899.6 | 4879.6 | 4859.6 | 160.0 | 180.0 | 200.0 | 40.0 | 0.3 | 200.3 | 5062.19 | | 5059.6 | | 2 | 03-Apr-00 | | 731569 | 1871746 |
| 0266 | MW | D | 4890.6 | 4870.6 | 4850.6 | 160.0 | 180.0 | 200.0 | 40.0 | 0.3 | 200.3 | 5053.32 | | 5050.6 | | 2 | 15-Apr-00 | | 730380 | 1870941 |
| 0272 | MW | D | 4902.8 | 4892.8 | 4882.8 | 159.1 | 169.1 | 179.1 | 20.0 | 1.5 | 180.6 | 5064.24 | | 5061.9 | | 2 | 28-Aug-04 | | 730112 | 1872389 |
| 0273 | MW | D | 4909.4 | 4899.4 | 4889.4 | 153.0 | 163.0 | 173.0 | 20.0 | 1.5 | 174.5 | 5064.74 | | 5062.4 | | 2 | 29-Aug-04 | | 730922 | 1872397 |
| 0275 | MW | D | 4903.0 | 4893.0 | 4883.0 | 158.2 | 168.2 | 178.2 | 20.0 | 1.5 | 179.7 | 5062.64 | | 5061.2 | | 2 | 01-Sep-04 | | 732092 | 1872586 |

*Table A−1 (continued). Well Completion Information*

| Well | Type | Horizon | Top Of Screen Elev. | Mid Screen Elev. | Bottom of Screen Elev. | Top of Screen Depth | Mid Screen Depth | Bottom of Screen Depth | Screen Length | Sump Length | Well Depth | Top of Casing Elev. | | Ground Elev. | | Well Diameter | Boring Started | Decommission Date | State Plane East | State Plane North |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0277 | MW | D | 4884.0 | 4879.0 | 4874.0 | 95.7 | 100.7 | 105.7 | 10.0 | 1.5 | 107.2 | 4982.35 | | 4979.7 | | 2 | 12-Aug-04 | | 731290 | 1870777 |
| 0278 | MW | D | 4862.9 | 4857.9 | 4852.9 | 90.5 | 95.5 | 100.5 | 10.0 | 1.5 | 102.0 | 4956.09 | | 4953.4 | | 2 | 14-Aug-04 | | 731210 | 1870104 |
| 0690 | MW | D | 4893.3 | 4873.3 | 4853.3 | 55.0 | 75.0 | 95.0 | 40.0 | 0.3 | 95.3 | 4950.87 | | 4948.3 | | 2 | 30-Mar-00 | | 731521 | 1870140 |
| 0692 | MW | D | 4895.6 | 4875.6 | 4855.6 | 55.0 | 75.0 | 95.0 | 40.0 | 0.3 | 95.3 | 4953.31 | | 4950.6 | | 2 | 05-Apr-00 | | 731821 | 1870303 |
| 0695 | MW | D | 4919.3 | 4899.3 | 4879.3 | 55.0 | 75.0 | 95.0 | 40.0 | 0.3 | 95.3 | 4976.83 | | 4974.3 | | 2 | 06-Apr-00 | | 732566 | 1870896 |
| 0904 | MW | D | 4873.8 | 4868.8 | 4863.8 | 28.0 | 33.0 | 38.0 | 10.0 | 2.0 | 40.0 | 4904.11 | | 4901.8 | | 2 | 07-Nov-84 | | 731808 | 1868036 |
| 0915 | MW | D | 4897.8 | 4892.8 | 4887.8 | 170.0 | 175.0 | 180.0 | 10.0 | 2.0 | 182.0 | 5070.84 | | 5067.8 | | 4 | 24-Aug-85 | | 732740 | 1872209 |
| 1003 | INJ | D | 4923.4 | 4898.4 | 4873.4 | 55.5 | 80.5 | 105.5 | 50.0 | 2.5 | 108.0 | 4976.58 | | 4978.9 | | 6 | 26-Jul-99 | | 732101 | 1870898 |
| 1004 | INJ | D | 4918.1 | 4893.1 | 4868.1 | 45.5 | 70.5 | 95.5 | 50.0 | 2.5 | 98.0 | 4961.55 | | 4963.6 | | 6 | 27-Jul-99 | | 731892 | 1870544 |
| 1005 | INJ | D | 4904.7 | 4879.7 | 4854.7 | 45.5 | 70.5 | 95.5 | 50.0 | 2.5 | 98.0 | 4947.83 | | 4950.2 | | 6 | 25-Jul-99 | | 731496 | 1870168 |
| 1006 | INJ | D | 4903.7 | 4878.7 | 4853.7 | 45.7 | 70.7 | 95.7 | 50.0 | 2.5 | 98.2 | 4947.08 | | 4949.5 | | 6 | 24-Jul-99 | | 731233 | 1869918 |
| 1007 | INJ | D | 4915.6 | 4890.5 | 4865.4 | 45.8 | 70.9 | 96.0 | 50.2 | 2.5 | 98.5 | 4958.56 | | 4961.4 | | 6 | 23-Jul-99 | | 730770 | 1869861 |
| 1101 | EXT | D | 4974.2 | 4896.5 | 4818.9 | 96.1 | 173.8 | 251.5 | 155.4 | 2.5 | 254.0 | 5067.29 | | 5070.4 | | 6 | 24-Aug-99 | | 732223 | 1872970 |
| 1102 | EXT | D | 4968.8 | 4893.8 | 4818.8 | 101.5 | 176.5 | 251.5 | 150.0 | 2.5 | 254.0 | 5066.76 | | 5070.3 | | 6 | 24-Aug-99 | | 732225 | 1872670 |
| 1103 | EXT | D | 4962.3 | 4887.3 | 4812.3 | 100.0 | 175.0 | 250.0 | 150.0 | 2.5 | 252.5 | 5059.56 | | 5062.3 | | 6 | 30-Jul-99 | | 731896 | 1872407 |
| 1104 | EXT | D | 4972.3 | 4894.8 | 4817.3 | 90.0 | 167.5 | 245.0 | 155.0 | 3.0 | 248.0 | 5059.57 | | 5062.3 | | 6 | 01-Aug-99 | | 731527 | 1872404 |
| 1105 | EXT | D | 4972.1 | 4894.6 | 4817.1 | 90.0 | 167.5 | 245.0 | 155.0 | 3.0 | 248.0 | 5059.33 | | 5062.1 | | 6 | 02-Aug-99 | | 731304 | 1872401 |
| 1106 | EXT | D | 4966.0 | 4888.7 | 4811.4 | 96.5 | 173.8 | 251.1 | 154.6 | 2.9 | 254.0 | 5059.73 | | 5062.5 | | 6 | 03-Aug-99 | | 731081 | 1872400 |
| 1107 | EXT | D | 4971.2 | 4894.0 | 4816.8 | 91.1 | 168.3 | 245.5 | 154.4 | 2.5 | 248.0 | 5059.51 | | 5062.3 | | 6 | 03-Aug-99 | | 730858 | 1872398 |
| 1108 | EXT | D | 4966.1 | 4891.1 | 4816.1 | 96.3 | 171.3 | 246.3 | 150.0 | 2.5 | 248.8 | 5059.62 | | 5062.4 | | 6 | 03-Aug-99 | | 730634 | 1872396 |
| 1109 | EXT | D | 4972.1 | 4894.7 | 4817.3 | 90.3 | 167.7 | 245.1 | 154.8 | 2.9 | 248.0 | 5059.64 | | 5062.4 | | 6 | 04-Aug-99 | | 730410 | 1872394 |
| 1110 | EXT | D | 4966.8 | 4891.8 | 4816.8 | 95.5 | 170.5 | 245.5 | 150.0 | 2.5 | 248.0 | 5059.47 | | 5062.3 | | 6 | 07-Aug-99 | | 730187 | 1872392 |
| 1111 | EXT | D | 4971.9 | 4894.7 | 4817.5 | 90.7 | 167.9 | 245.1 | 154.4 | 2.5 | 247.6 | 5059.87 | | 5062.6 | | 6 | 06-Aug-99 | | 729993 | 1872392 |
| 1112 | EXT | D | 4969.1 | 4891.6 | 4814.1 | 90.5 | 168.0 | 245.5 | 155.0 | 2.5 | 248.0 | 5057.08 | | 5059.6 | | 6 | 17-Aug-99 | | 730494 | 1872064 |
| 1113 | EXT | D | 4968.7 | 4891.2 | 4813.7 | 90.5 | 168.0 | 245.5 | 155.0 | 2.5 | 248.0 | 5058.54 | | 5059.2 | | 6 | 17-Aug-99 | | 730196 | 1872061 |
| 1114 | EXT | D | 4968.5 | 4891.0 | 4813.6 | 90.6 | 168.0 | 245.5 | 154.9 | 2.5 | 248.0 | 5056.25 | | 5059.1 | | 6 | 11-Aug-99 | | 729896 | 1872057 |
| 1115 | EXT | D | 4968.6 | 4891.2 | 4813.7 | 90.5 | 168.0 | 245.5 | 155.0 | 2.5 | 248.0 | 5056.36 | | 5059.2 | | 6 | 07-Aug-99 | | 729596 | 1872055 |
| 1119 | EXT | D | 4968.7 | 4893.7 | 4818.7 | 95.3 | 170.3 | 245.3 | 150.0 | 2.5 | 247.8 | 5061.19 | | 5064.0 | | 6 | 31-Jul-99 | | 731894 | 1872667 |
| 1120 | EXT | D | 4971.0 | 4896.0 | 4821.0 | 95.5 | 170.5 | 245.5 | 150.0 | 2.5 | 248.0 | 5063.60 | | 5066.5 | | 6 | 28-Jul-99 | | 731891 | 1872967 |
| 1121 | EXT | D | 4972.0 | 4897.0 | 4822.0 | 97.5 | 172.5 | 247.5 | 150.0 | 2.5 | 250.0 | 5066.61 | | 5069.5 | | 6 | 28-Jul-99 | | 731889 | 1873267 |
| 1122 | EXT | D | 4973.4 | 4896.3 | 4819.2 | 96.9 | 174.0 | 251.1 | 154.2 | 2.9 | 254.0 | 5067.31 | | 5070.3 | | 6 | 26-Aug-99 | | 732221 | 1873269 |
| 1123 | EXT | D | 4976.2 | 4899.2 | 4822.2 | 91.0 | 168.0 | 245.0 | 154.0 | 3.0 | 248.0 | 5064.54 | | 5067.2 | | 6 | 02-Sep-99 | | 732508 | 1873222 |
| 1124 | EXT | D | 4978.7 | 4899.9 | 4821.1 | 87.9 | 166.7 | 245.5 | 157.6 | 2.5 | 248.0 | 5063.86 | | 5066.6 | | 6 | 23-Aug-99 | | 732512 | 1872972 |
| 1125 | EXT | D | 4972.8 | 4897.8 | 4822.8 | 95.5 | 170.5 | 245.5 | 150.0 | 2.5 | 248.0 | 5065.47 | | 5068.3 | | 6 | 25-Aug-99 | | 732515 | 1872671 |
| NMW-9D | MW | E | 4847.6 | 4845 | 4842.6 | 265.5 | 268 | 270.5 | 5.0 | 5.0 | 275.52 | 5115.92 | | 5113.14 | | 4 | 4-Oct-10 | | 727573 | 1871587 |
| 0251 | MW | E | 4858.9 | 4808.9 | 4758.9 | 200.0 | 250.0 | 300.0 | 100.0 | 0.3 | 300.3 | 5061.25 | | 5058.9 | | 2 | 28-Apr-00 | | 730215 | 1871999 |
| 0268 | MW | E | 4864.5 | 4814.5 | 4764.5 | 200.0 | 250.0 | 300.0 | 100.0 | 0.3 | 300.3 | 5067.24 | | 5064.5 | | 2 | 15-May-00 | | 732301 | 1872430 |
| 0920 | MW | E | 4866.0 | 4846.0 | 4826.0 | 114.4 | 134.4 | 154.4 | 40.0 | 2.0 | 156.4 | 4982.97 | | 4980.4 | | 4 | 30-Jul-85 | | 731262 | 1870737 |
| 0948 | EXDS | E | 4893.9 | 4803.9 | 4713.9 | 221.5 | 311.5 | 401.5 | 180.0 | 5.0 | 406.5 | 5117.80 | | 5115.4 | | 4 | 17-Oct-95 | | 733915 | 1875516 |
| 0911 | MW | F | 4795.2 | 4775.2 | 4755.2 | 309.4 | 329.4 | 349.4 | 40.0 | 2.0 | 351.4 | 5106.96 | | 5104.6 | | 4 | 18-Jul-85 | | 730265 | 1875920 |
| 0913 | MW | G | 4729.2 | 4709.2 | 4689.2 | 328.7 | 348.7 | 368.7 | 40.0 | 2.0 | 370.7 | 5060.16 | | 5057.9 | | 4 | 02-Aug-85 | | 729327 | 1871871 |
| 0916 | MW | G | 4721.7 | 4716.7 | 4711.7 | 345.7 | 350.7 | 355.7 | 10.0 | 2.0 | 357.7 | 5070.00 | | 5067.4 | | 4 | 22-Aug-85 | | 732811 | 1872146 |
| 0919 | MW | G | 4707.9 | 4702.9 | 4697.9 | 337.7 | 342.7 | 347.7 | 10.0 | 2.0 | 349.7 | 5048.56 | | 5045.6 | | 4 | 26-Aug-85 | | 727353 | 1868654 |
| 0902 | MW | H | 4673.7 | 4668.7 | 4663.7 | 63.0 | 68.0 | 73.0 | 10.0 | 2.0 | 75.0 | 4737.42 | | 4736.7 | | 2 | 02-Dec-84 | | 730179 | 1862292 |

*Table A−1 (continued). Well Completion Information*

| Well | Type | Horizon | Top Of Screen Elev. | Mid Screen Elev. | Bottom of Screen Elev. | Top of Screen Depth | Mid Screen Depth | Bottom of Screen Depth | Screen Length | Sump Length | Well Depth | Top of Casing Elev. | | Ground Elev. | | Well Diameter | Boring Started | Decommission Date | State Plane East | State Plane North |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0252 | MW | I | 4658.9 | 4608.9 | 4558.9 | 400.0 | 450.0 | 500.0 | 100.0 | 0.4 | 500.4 | 5061.30 | | 5058.9 | | 4 | 26-Apr-00 | | 730232 | 1871993 |
| 0254 | MW | I | 4662.7 | 4612.7 | 4562.7 | 400.0 | 450.0 | 500.0 | 100.0 | 0.4 | 500.4 | 5065.38 | | 5062.7 | | 4 | 03-May-00 | 13-Aug-05 | 730951 | 1872411 |
| 0256 | MW | I | 4664.0 | 4614.0 | 4564.0 | 400.0 | 450.0 | 500.0 | 100.0 | 0.4 | 500.4 | 5066.58 | | 5064.0 | | 4 | 13-May-00 | 14-Aug-05 | 732277 | 1872437 |
| 0921 | MW | I | 4663.7 | 4643.7 | 4623.7 | 313.2 | 333.2 | 353.2 | 40.0 | 2.0 | 355.2 | 4979.08 | | 4976.9 | | 4 | 22-Jul-85 | | 731379 | 1870742 |
| 0253 | MW | M | 4458.8 | 4408.8 | 4358.8 | 600.0 | 650.0 | 700.0 | 100.0 | 0.4 | 700.4 | 5061.11 | | 5058.8 | | 4 | 18-Apr-00 | 11-Apr-01 | 730213 | 1871974 |
| 0255 | MW | M | 4462.3 | 4412.3 | 4362.3 | 600.0 | 650.0 | 700.0 | 100.0 | 0.4 | 700.4 | 5064.89 | | 5062.3 | | 4 | 01-May-00 | 12-Aug-05 | 730947 | 1872387 |
| 0257 | MW | M | 4463.4 | 4413.4 | 4363.4 | 600.0 | 650.0 | 700.0 | 100.0 | 0.4 | 700.4 | 5066.40 | | 5063.4 | | 4 | 11-May-00 | 11-Aug-05 | 732278 | 1872414 |
| 0968 | EXDS | NA | 5000.4 | 4699.9 | 4399.4 | 106.0 | 406.5 | 707.0 | 601.0 | 0.0 | 707.0 | 5107.00 | | 5106.4 | | 10 | 1-Feb-55 | | 730180 | 1875689 |
| 0970 | EXDS | NA | 5007.7 | 4705.2 | 4402.7 | 100.0 | 402.5 | 705.0 | 605.0 | 0.0 | 705.0 | 5109.53 | | 5107.7 | | 10 | 1-Sep-55 | | 730653 | 1876567 |
| 0971 | EXDS | NA | 4985.3 | 4693.8 | 4402.3 | 117.0 | 408.5 | 700.0 | 583.0 | 0.0 | 700.0 | 5104.00 | | 5102.3 | | 10 | 1-Nov-55 | | 731590 | 1878306 |
| 0972 | EXDS | NA | 5039.7 | 4724.7 | 4409.7 | 100.0 | 415.0 | 730.0 | 630.0 | 0.0 | 730.0 | 5141.07 | | 5139.7 | | 10 | 1-Jun-56 | | 728031 | 1877986 |
| | | | | | | | | | | | | | | | | | | | | |
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All dimensions in feet except well diameter in inches.
All depths are relative to ground surface.
* = Converted to extraction well in August 2005.
MW = monitoring well.
EXT = Groundwater remediation extraction well.
INJ = Groundwater remediation injection well.
EXDS = Extraction well domestic supply, completed in Navajo Sandstone. Four wells, previously owned by Rare Metals—0968, 0970, 0971, and 0972 (sampled in 1982 and 1985 only)—are located north of the site, near upgradient monitoring wells 0901, 0910, and 0911.
NMW = Wells owned by NNEPA
Well 0948 (single sampling in 1995), located about 1,500 ft east of the site, is used to supply the Tuba City site treatment facility with domestic non-potable water. Water levels are still measured annually at wells 0948, 0968, and 0970.
** = Approximate.

# Appendix B

# Groundwater Sample Results for Contaminants of Concern: August 2011, February 2012, and the Baseline Period

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# Contents

## Tables

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*Table B−1. Baseline, August 2011, and February 2012 Molybdenum Concentrations*

| Well Number | Horizon | Baseline Molybdenum Concentration (mg/L) | Year Sampled, Baseline | August 2011 Molybdenum Concentration (mg/L) | February 2012 Molybdenum Concentration (mg/L) |
|---|---|---|---|---|---|
| 0686 | A | 0.0015U | 2002 | 0.0015 | |
| 0687 | A | 0.0113 | 2002 | 0.0026 | |
| 0688 | A | 0.0015U | 2002 | 0.002 | |
| 0901 | A | 0.00078 | 2001 | 0.00054 | 0.000857BN |
| 0906 | A | 0.0137 | 2002 | 0.0018 | 0.00913N |
| 0929 | A | 0.0015U | 2002 | 0.00029 | 0.000551BN |
| 0940 | A | 0.0015U | 2002 | 0.0015 | 0.00163BN |
| 0941 | A | 0.0284 | 2002 | 0.026 | 0.0358N * |
| 0945 | A | 0.0015U | 2002 | 0.00062 | |
| 0946 | A | | | 0.00032 | |
| 0262 | B | 0.432 | 2001 | 0.75 | 0.839 |
| 0263 | B | 0.192 | 2001 | 0.041 | 0.0476 |
| 0265 | B | 0.00046 | 2001 | 0.00016U | 0.000206B |
| 0267 | B | 0.0015U | 2002 | 0.00032U | 0.000267B |
| 0271 | B | 0.0015U | 2002 | 0.00028 | |
| 0281 | B | | | 0.00055 | 0.00152B |
| 0282 | B | | | 0.00041 | 0.000529B |
| 0286 | B | | | 0.00058B | 0.00124B |
| 0287 | B | | | 0.12 | 0.134 |
| 0288 | B | | | 0.00011 | 0.000232B |
| 0290 | B | | | 0.00022 | 0.000549BN |
| 0908 | B | 0.0015U | 2002 | 0.00039B | 0.000522BN |
| 0909 | B | 0.0015U | 2002 | | |
| 0910 | B | | | 0.00045 | 0.000765BN |
| 0934 | B | 0.0015U | 2002 | 0.0013 | 0.00292BN |
| 0935 | B | 0.0015U | 2002 | 0.00032U | 0.000165NU |
| 0936 | B | 0.0015U | 2002 | | |
| 0938 | B | 0.001U | 1999 | 0.0034 | 0.0112N |
| 0942 | B | 0.021 | 2002 | 0.0051 | 0.00931N |
| 0943 | B | 0.0015U | 2002 | 0.00051 | |
| 0947 | B | 0.0015U | 2002 | 0.00041 | |
| 1129 | B | | | 1.1 | |
| 1130 | B | | | 0.051 | |
| 1132 | B | | | 2.8 | 1.96N |
| 1133 | B | | | 0.012 | |
| NMW-1A | B | | | | 0.000643BU |
| NMW-2A | B | | | | 0.000611BU |
| NMW-3A | B | | | | 0.00047BU |
| NMW-4A | B | | | | 0.00039BU |
| NMW-6S | B | | | | 0.000601BU |
| NMW-8S | B | | | | 0.000431BU |
| 0274 | C | | | 0.00039 | 0.000507BU |
| 0276 | C | | | 0.00043 | 0.000556BU |
| 0279 | C | | | 0.00078 | |
| 0280 | C | | | 0.00046 | |
| 0289 | C | | | 0.00037 | 0.000938BNU |
| 0683 | C | 0.0015U | 2002 | 0.00046 | |
| 0684 | C | 0.0015U | 2002 | 0.00042 | |
| 0685 | C | 0.0015U | 2002 | 0.00035 | |
| 0689 | C | 0.0015U | 2002 | 0.00035 | |

*Table B−1 (continued). Baseline, August 2011, and February 2012 Molybdenum Concentrations*

| Well Number | Horizon | Baseline Molybdenum Concentration (mg/L) | Year Sampled, Baseline | August 2011 Molybdenum Concentration (mg/L) | February 2012 Molybdenum Concentration (mg/L) |
|---|---|---|---|---|---|
| 0691 | C | 0.0015U | 2002 | 0.00016U | 0.000285BN |
| 0903 | C | 0.0015U | 2002 | 0.00023 | |
| 0912 | C | 0.0003U | 2001 | 0.000055B | |
| 0914 | C | 0.00081 | 2001 | 0.00085 | |
| 0917 | C | 0.0013 | 2001 | | |
| 0930 | C | 0.0015U | 2002 | 0.00016 | 0.000591BU |
| 0932 | C | 0.0018U | 2002 | 0.00029 | 0.000592BN |
| 1008 | C | 0.0015U | 2002 | | |
| 1116 | C | 0.0015U | 2002 | 0.00021 | |
| 1117 | C | 0.0015U | 2002 | 0.00033 | |
| 1118 | C | 0.00063 | 2000 | 0.00016 | |
| NMW-5 | C | | | | 0.00113B |
| 0258 | D | 0.0026 | 2001 | | |
| 0261 | D | 0.0031 | 2001 | 0.00042 | 0.000639B |
| 0264 | D | 0.00058 | 2001 | 0.00047 | |
| 0266 | D | | | 0.00032 | 0.000526B |
| 0272 | D | | | 0.0002 | 0.00044B |
| 0273 | D | | | 0.00022 | 0.000361BU |
| 0275 | D | | | 0.02 | 0.025 |
| 0277 | D | | | 0.00032U | 0.000398BU |
| 0278 | D | 0.0015U | 2002 | 0.00017 | |
| 0690 | D | 0.0015U | 2002 | 0.0003 | |
| 0692 | D | 0.0015U | 2002 | 0.00032 | |
| 0695 | D | 0.00077 | 2001 | 0.0003 | |
| 0904 | D | 0.00054 | 2001 | 0.00056 | |
| 0915 | D | 0.0004U | 2000 | 0.00067 | |
| 1003 | D | 0.0004U | 2000 | 0.00056 | |
| 1004 | D | 0.0004U | 2000 | 0.00014 | |
| 1005 | D | 0.0004U | 2000 | 0.00035 | |
| 1006 | D | 0.0015U | 2002 | | |
| 1007 | D | 0.0015U | 2002 | 0.00029 | |
| 1101 | D | 0.0015U | 2002 | | |
| 1102 | D | 0.0916 | 2002 | 0.00032U | |
| 1103 | D | 2.96 | 2002 | 0.005 | |
| 1104 | D | 1.26 | 2002 | 0.029 | |
| 1105 | D | 0.16 | 2002 | 1 | |
| 1106 | D | 0.0015U | 2002 | 0.092 | |
| 1107 | D | 0.0015U | 2002 | 0.097 | |
| 1108 | D | 0.0015U | 2002 | 0.00043B | |
| 1109 | D | 0.0015U | 2002 | | |
| 1110 | D | 0.0015U | 2002 | | |
| 1111 | D | 0.0015U | 2002 | 0.00032U | |
| 1112 | D | 0.0027 | 2002 | 0.00024B | |
| 1113 | D | 0.0015U | 2002 | 0.00037 | |
| 1114 | D | 0.0053 | 2002 | | |
| 1115 | D | 0.0815 | 2002 | | |
| 1119 | D | 0.105 | 2002 | 0.0027 | |
| 1120 | D | 0.0003U | 2001 | 0.037 | |
| 1121 | D | 0.00081 | 2001 | | |
| 1122 | D | 0.0015U | 2002 | 0.00076B | |
| 1124 | D | 0.0015U | 2002 | 0.00032U | |

*Table B−1 (continued). Baseline, August 2011, and February 2012 Molybdenum Concentrations*

| Well Number | Horizon | Baseline Molybdenum Concentration (mg/L) | Year Sampled, Baseline | August 2011 Molybdenum Concentration (mg/L) | February 2012 Molybdenum Concentration (mg/L) |
|---|---|---|---|---|---|
| 1125 | D | 0.0015U | 2002 | 0.00032 | |
| NMW-7D | D | | | | 0.000707BU |
| 0251 | E | 0.0015U | 2002 | 0.00019 | 0.000437B |
| 0268 | E | 0.0015U | 2002 | 0.00024 | 0.000484BU * |
| 0920 | E | 0.0003U | 2001 | 0.00023 | |
| NMW-9D | E | | | | 0.00259B |
| 0911 | F | | | 0.0002 | |
| 0913 | G | 0.0003U | 2001 | 0.00011 | |
| 0916 | G | 0.00096 | 2001 | 0.00096 | |
| 0252 | I | 0.0015U | 2002 | 0.00012 | 0.00031B |
| 0921 | I | 0.0003U | 2001 | 0.00017 | |

B = Result between instrument detection limit and contract required detection limit.
U = Analytical result below detection limit.

Values in red exceed the corresponding groundwater remediation target for molybdenum, 0.1 mg/L (see Table 1 of main report). Well numbers with groundwater concentrations greater than the remediation target during this reporting period are also listed in red.

* Denotes filtered sample. Samples are generally not filtered (as reflected above), except in cases when turbidity is greater than 10 nephelometric turbidity units (NTUs).

*Table B−2. Baseline, August 2011, and February 2012 Nitrate Concentrations (as $NO_3$)*

| Well Number | Horizon | Baseline Nitrate Concentration (mg/L) | Year Sampled, Baseline | August 2011 Nitrate Concentration (mg/L) | February 2012 Nitrate Concentration (mg/L) |
|---|---|---|---|---|---|
| 0686 | A | 32.2 | 2002 | 12 | |
| 0687 | A | 60.6 | 2002 | 9 | |
| 0688 | A | 35.1 | 2002 | 21 | |
| 0901 | A | 13 | 2001 | 16 | 14.2 |
| 0906 | A | 1470 | 2002 | 1550 | 2280 |
| 0929 | A | 69.5 | 2002 | 66 | 57.6 |
| 0940 | A | 1800 | 2002 | 1950 | 1970 |
| 0941 | A | 358 | 2002 | 1110 | 1140 * |
| 0945 | A | 12.7 | 2002 | 20 | |
| 0946 | A | | | 7.1 | |
| 0262 | B | 380 | 2001 | 841 | 872 |
| 0263 | B | 1140 | 2001 | 1020 | 1150 |
| 0265 | B | 720 | 2001 | 664 | 726 |
| 0267 | B | 1640 | 2002 | 1330 | 1380 |
| 0271 | B | 15.6 | 2002 | 19 | |
| 0281 | B | | | 150 | 151 |
| 0282 | B | | | 180 | 196 |
| 0286 | B | | | 841 | 1180 |
| 0287 | B | | | 1240 | 1330 |
| 0288 | B | | | 220 | 214 |
| 0290 | B | | | 170 | 254 |
| 0908 | B | 651 | 2002 | 797 | 859 |
| 0909 | B | 485 | 2002 | | |
| 0910 | B | | | 14 | 13.9 |
| 0934 | B | 2320 | 2002 | 1590 | 1580 |
| 0935 | B | 525 | 2002 | 1150 | 1190 |
| 0936 | B | 2950 | 2002 | | |
| 0938 | B | 1450 | 1999 | 1460 | 1480 |
| 0942 | B | 1360 | 2002 | 620 | 651 |
| 0943 | B | 22.1 | 2002 | 9 | |
| 0947 | B | 12.5 | 2002 | 13 | |
| 1129 | B | | | 620 | |
| 1130 | B | | | 1240 | |
| 1132 | B | | | 1280 | 797 |
| 1133 | B | | | 140 | |
| NMW-1A | B | | | | 14.3 |
| NMW-2A | B | | | | 13.7 |
| NMW-3A | B | | | | 13.6 |
| NMW-4A | B | | | | 15.4 |
| NMW-6S | B | | | | 15.4 |
| NMW-8S | B | | | | 15.4 |
| 0274 | C | | | 16 | 14.8 |
| 0276 | C | | | 15 | 14.3 |
| 0279 | C | | | 42 | |
| 0280 | C | | | 11 | |
| 0289 | C | | | 170 | 122 |
| 0683 | C | 14.1 | 2002 | 14 | |
| 0684 | C | 13.9 | 2002 | 14 | |
| 0685 | C | 14.3 | 2002 | 15 | |
| 0689 | C | 14.3 | 2002 | 12 | |

*Table B−2 (continued). Baseline, August 2011, and February 2012 Nitrate Concentrations (as $NO_3$)*

| Well Number | Horizon | Baseline Nitrate Concentration (mg/L) | Year Sampled, Baseline | August 2011 Nitrate Concentration (mg/L) | February 2012 Nitrate Concentration (mg/L) |
|---|---|---|---|---|---|
| 0691 | C | 298 | 2002 | 270 | 285 |
| 0903 | C | 54.8 | 2002 | 58 | |
| 0912 | C | 403 | 2001 | 310 | |
| 0914 | C | 13 | 2001 | 12 | |
| 0917 | C | 15.7 | 2001 | | |
| 0930 | C | 50.9 | 2002 | 66 | 79.7H |
| 0932 | C | 25.3 | 2002 | 30 | 28.6 |
| 1008 | C | 15.7 | 2000 | | |
| 1116 | C | 106 | 2002 | 17 | |
| 1117 | C | 225 | 2002 | 160 | |
| 1118 | C | 164 | 2002 | 160 | |
| NMW-5 | C | | | | 11.4 |
| 0258 | D | 15 | 2000 | 15 | 14.4 |
| 0261 | D | 14 | 2001 | 15 | |
| 0264 | D | 24.3 | 2001 | 44 | 45.6 |
| 0266 | D | 14 | 2001 | 15 | 14.2 |
| 0272 | D | | | 17 | 17.6 |
| 0273 | D | | | 190 | 197 |
| 0275 | D | | | 1110 | 1110 |
| 0277 | D | | | 14 | |
| 0278 | D | | | 14 | |
| 0690 | D | 12.5 | 2002 | 14 | |
| 0692 | D | 12.5 | 2002 | 10 | |
| 0695 | D | 25.4 | 2002 | 32 | |
| 0904 | D | 5.13 | 2001 | 4 | |
| 0915 | D | 14.1 | 2001 | 14 | |
| 1003 | D | 176 | 2000 | 270 | |
| 1004 | D | 49.1 | 2000 | 29 | |
| 1005 | D | 14.5 | 2000 | | |
| 1006 | D | 14.1 | 2000 | 10 | |
| 1007 | D | 15.3 | 2000 | 15 | |
| 1101 | D | 438 | 2002 | | |
| 1102 | D | 650 | 2002 | 664 | |
| 1103 | D | 1120 | 2002 | 797 | |
| 1104 | D | 993 | 2002 | 753 | |
| 1105 | D | 648 | 2002 | 1060 | |
| 1106 | D | 614 | 2002 | 430 | |
| 1107 | D | 1060 | 2002 | 708 | |
| 1108 | D | 1410 | 2002 | 487 | |
| 1109 | D | 798 | 2002 | | |
| 1110 | D | 227 | 2002 | | |
| 1111 | D | 421 | 2002 | 487 | |
| 1112 | D | 617 | 2002 | 220 | |
| 1113 | D | 143 | 2002 | 100 | |
| 1114 | D | 228 | 2002 | | |
| 1115 | D | 766 | 2002 | | |
| 1119 | D | 468 | 2002 | 160 | |
| 1120 | D | 493 | 2002 | 140 | |
| 1121 | D | 573 | 2002 | | |
| 1122 | D | 954 | 2002 | 190 | |
| 1123 | D | 643 | 2002 | 71 | |

*Table B−2 (continued). Baseline, August 2011, and February 2012 Nitrate Concentrations as ($NO_3$)*

| Well Number | Horizon | Baseline Nitrate Concentration (mg/L) | Year Sampled, Baseline | August 2011 Nitrate Concentration (mg/L) | February 2012 Nitrate Concentration (mg/L) |
|---|---|---|---|---|---|
| 1124 | D | 781 | 2002 | 487 | |
| 1125 | D | 104 | 2002 | 37 | |
| NMW-7D | D | | | | 14 |
| 0251 | E | 426 | 2002 | 14 | 15.1 |
| 0268 | E | 15.4 | 2002 | 75 | 210 * |
| 0920 | E | 14.8 | 2001 | 15 | |
| NMW-9D | E | | | | 7.7 |
| 0911 | F | | | 14 | |
| 0913 | G | 12.4 | 2001 | 13 | |
| 0916 | G | 11.6 | 2001 | 8.4 | |
| 0252 | I | 15.3 | 2002 | 10 | 10.4 |
| 0921 | I | 11 | 2001 | 11 | |

Values in red exceed the corresponding groundwater remediation target for nitrate (as $N0_3$), 44 mg/L (see Table 1 of main report). Well numbers with groundwater concentrations greater than the remediation target during this reporting period are also listed in red.

* Denotes filtered sample. Samples are generally not filtered (as reflected above), except in cases when turbidity is greater than 10 NTUs.

*Table B−3. Baseline, August 2011, and February 2012 Selenium Concentrations*

| Well Number | Horizon | Baseline Selenium Concentration (mg/L) | Year Sampled, Baseline | August 2011 Selenium Concentration (mg/L) | February 2012 Selenium Concentration (mg/L) |
|---|---|---|---|---|---|
| 0686 | A | 0.0088 | 2002 | 0.0047 | |
| 0687 | A | 0.0145 | 2002 | 0.00056 | |
| 0688 | A | 0.0033 | 2002 | 0.0047 | |
| 0901 | A | 0.0024 | 2001 | 0.0029 | 0.00304B |
| 0906 | A | 0.0335 | 2002 | 0.017 | 0.0488 |
| 0929 | A | 0.0028 | 2002 | 0.0023 | 0.00239B |
| 0940 | A | 0.105 | 2002 | 0.064 | 0.0871 |
| 0941 | A | 0.0348 | 2002 | 0.11 | 0.126 * |
| 0945 | A | 0.0035 | 2002 | 0.0037 | |
| 0946 | A | | | 0.00041 | |
| 0262 | B | 0.0621 | 2001 | 0.072 | 0.0963 |
| 0263 | B | 0.0632 | 2001 | 0.043 | 0.0489 |
| 0265 | B | 0.0071 | 2001 | 0.0068 | 0.00579 |
| 0267 | B | 0.0532 | 2002 | 0.049 | 0.0554 |
| 0271 | B | 0.0016 | 2002 | 0.0014 | |
| 0281 | B | | | 0.002 | 0.00167B |
| 0282 | B | | | 0.0016 | 0.0015U |
| 0286 | B | | | 0.027 | 0.0388 |
| 0287 | B | | | 0.098 | 0.0955 |
| 0288 | B | | | 0.0026 | 0.00183B |
| 0290 | B | | | 0.0042 | 0.00795 |
| 0908 | B | 0.0163 | 2002 | 0.024 | 0.0252 |
| 0909 | B | 0.0224 | 2002 | | |
| 0910 | B | | | 0.0015 | 0.00172B |
| 0934 | B | 0.0116 | 2002 | 0.014 | 0.0075 |
| 0935 | B | 0.0195 | 2002 | 0.016 | 0.0172 |
| 0936 | B | 0.0869 | 2002 | | |
| 0938 | B | 0.0432 | 1999 | 0.065 | 0.0767 |
| 0942 | B | 0.0348 | 2002 | 0.055 | 0.0616 |
| 0943 | B | 0.0021 | 2002 | 0.00026 | |
| 0947 | B | 0.0019 | 2002 | 0.0016 | |
| 1129 | B | | | 0.082 | |
| 1130 | B | | | 0.046 | |
| 1132 | B | | | 0.22 | 0.126 |
| 1133 | B | | | 0.015 | |
| NMW-1A | B | | | | 0.0015U |
| NMW-2A | B | | | | 0.0015U |
| NMW-3A | B | | | | 0.0015U |
| NMW-4A | B | | | | 0.0015U |
| NMW-6S | B | | | | 0.0015U |
| NMW-8S | B | | | | 0.00175B |
| 0274 | C | | | 0.0015 | 0.00231B |
| 0276 | C | | | 0.0016 | 0.00236B |
| 0279 | C | | | 0.0023 | |
| 0280 | C | | | 0.002 | |
| 0289 | C | | | 0.0022 | 0.00182B |
| 0683 | C | 0.0022 | 2002 | 0.0018 | |
| 0684 | C | 0.0019 | 2002 | 0.0015 | |
| 0685 | C | 0.0017 | 2002 | 0.0018 | |
| 0689 | C | 0.0014 | 2002 | 0.0012 | |

*Table B−3 (continued). Baseline, August 2011, and February 2012 Selenium Concentrations*

| Well Number | Horizon | Baseline Selenium Concentration (mg/L) | Year Sampled, Baseline | August 2011 Selenium Concentration (mg/L) | February 2012 Selenium Concentration (mg/L) |
|---|---|---|---|---|---|
| 0691 | C | 0.0046 | 2002 | 0.0037 | 0.00341B |
| 0903 | C | 0.0023 | 2002 | 0.0019 | |
| 0912 | C | 0.0137 | 2001 | 0.0066 | |
| 0914 | C | 0.0016 | 2001 | 0.0011 | |
| 0917 | C | 0.0017 | 2001 | | |
| 0930 | C | 0.002 | 2002 | 0.0018 | 0.00249B |
| 0932 | C | 0.0019 | 2002 | 0.0015 | 0.00179B |
| 1008 | C | 0.0015 | 2000 | | |
| 1116 | C | 0.0018 | 2002 | 0.0012 | |
| 1117 | C | 0.0028 | 2002 | 0.0049 | |
| 1118 | C | 0.0028 | 2002 | 0.0039 | |
| NMW-5 | C | | | | 0.00277B |
| 0258 | D | 0.0018 | 2000 | 0.0016 | 0.0015U |
| 0261 | D | 0.0021 | 2001 | 0.0017 | |
| 0264 | D | 0.0018 | 2001 | 0.0018 | 0.00208B |
| 0266 | D | 0.0013 | 2001 | 0.001 | 0.0015U |
| 0272 | D | | | 0.001 | 0.0015U |
| 0273 | D | | | 0.016 | 0.0192 |
| 0275 | D | | | 0.034 | 0.0375 |
| 0277 | D | | | 0.0015 | |
| 0278 | D | | | 0.0011 | |
| 0690 | D | 0.0014 | 2002 | 0.0012 | |
| 0692 | D | 0.0022 | 2002 | 0.0014 | |
| 0695 | D | 0.0019 | 2002 | 0.0017 | |
| 0904 | D | 0.0131 | 2001 | 0.013 | |
| 0915 | D | 0.0019 | 2001 | 0.0016 | |
| 1003 | D | 0.003 | 2000 | 0.0037 | |
| 1004 | D | 0.0021 | 2000 | 0.0017 | |
| 1005 | D | 0.0014 | 2000 | | |
| 1006 | D | 0.0013 | 2000 | 0.0012 | |
| 1007 | D | 0.0013 | 2000 | 0.0013 | |
| 1101 | D | 0.0188 | 2002 | | |
| 1102 | D | 0.0121 | 2002 | 0.037 | |
| 1103 | D | 0.0613 | 2002 | 0.035 | |
| 1104 | D | 0.0344 | 2002 | 0.047 | |
| 1105 | D | 0.0871 | 2002 | 0.071 | |
| 1106 | D | 0.0925 | 2002 | 0.05 | |
| 1107 | D | 0.0903 | 2002 | 0.056 | |
| 1108 | D | 0.0704 | 2002 | 0.034 | |
| 1109 | D | 0.0372 | 2002 | | |
| 1110 | D | 0.0081 | 2002 | | |
| 1111 | D | 0.0172 | 2002 | 0.012 | |
| 1112 | D | 0.0154 | 2002 | 0.0052 | |
| 1113 | D | 0.0025 | 2002 | 0.0024 | |
| 1114 | D | 0.0035 | 2002 | | |
| 1115 | D | 0.0362 | 2002 | | |
| 1119 | D | 0.029 | 2002 | 0.011 | |
| 1120 | D | 0.0563 | 2002 | 0.013 | |
| 1121 | D | 0.0455 | 2002 | | |
| 1122 | D | 0.0558 | 2002 | 0.025 | |
| 1123 | D | 0.0449 | 2002 | 0.014 | |
| 1124 | D | 0.0186 | 2002 | 0.033 | |

*Table B−3 (continued). Baseline, August 2011, and February 2012 Selenium Concentrations*

| Well Number | Horizon | Baseline Selenium Concentration (mg/L) | Year Sampled, Baseline | August 2011 Selenium Concentration (mg/L) | February 2012 Selenium Concentration (mg/L) |
|---|---|---|---|---|---|
| 1125 | D | 0.0025 | 2002 | 0.0023 | |
| NMW-7D | D | | | | 0.0015U |
| 0251 | E | 0.0035 | 2002 | 0.00086 | 0.0015U |
| 0268 | E | 0.0018 | 2002 | 0.002 | 0.00246B * |
| 0920 | E | 0.0014 | 2001 | 0.0013 | |
| NMW-9D | E | | | | 0.00174B |
| 0911 | F | | | 0.00094 | |
| 0913 | G | 0.00063 | 2001 | 0.00091 | |
| 0916 | G | 0.001 | 2001 | 0.00085 | |
| 0252 | I | 0.00092 | 2002 | 0.00072 | 0.0015U |
| 0921 | I | 0.00091 | 2001 | 0.00087 | |

B = Result between instrument detection limit and contract required detection limit.
U = Analytical result below detection limit.

Values in red exceed the corresponding groundwater remediation target for selenium, 0.01 mg/L (see Table 1 of main report). Well numbers with groundwater concentrations greater than the remediation target during this reporting period are also listed in red.

* Denotes filtered sample. Samples are generally not filtered (as reflected above), except in cases when turbidity is greater than 10 NTUs.

*Table B−4. Baseline, August 2011, and February 2012 Sulfate Concentrations*

| Well Number | Horizon | Baseline Sulfate Concentration (mg/L) | Year Sampled, Baseline | August 2011 Sulfate Concentration (mg/L) | February 2012 Sulfate Concentration (mg/L) |
|---|---|---|---|---|---|
| 0686 | A | 98.6 | 2002 | 78 | |
| 0687 | A | 329 | 2002 | 24 | |
| 0688 | A | 40 | 2002 | 110 | |
| 0901 | A | 26.2 | 2001 | 36 | 26.1 |
| 0906 | A | 1660 | 2002 | 1600 | 2060 |
| 0929 | A | 28.1 | 2002 | 26 | 19.9 |
| 0940 | A | 7550 | 2002 | 8200 | 6490 |
| 0941 | A | 745 | 2002 | 1400 | 1390 * |
| 0945 | A | 32.1 | 2002 | 31 | |
| 0946 | A | | | 20 | |
| 0262 | B | 931 | 2001 | 2000 | 1850 |
| 0263 | B | 1990 | 2001 | 2700 | 2840 |
| 0265 | B | 1520 | 2001 | 1100 | 1120 |
| 0267 | B | 3680 | 2002 | 3300 | 2990 |
| 0271 | B | 16.4 | 2002 | 14 | |
| 0281 | B | | | 140 | 132 |
| 0282 | B | | | 82 | 112 |
| 0286 | B | | | 2400 | 2850 |
| 0287 | B | | | 1700 | 1670 |
| 0288 | B | | | 230 | 234 |
| 0290 | B | | | 200 | 284 |
| 0908 | B | 2430 | 2002 | 2800 | 2620 |
| 0909 | B | 666 | 2002 | | |
| 0910 | B | | | 14 | 14.3 |
| 0934 | B | 7360 | 2002 | 2800 | 2800 |
| 0935 | B | 2690 | 2002 | 2400 | 2350 |
| 0936 | B | 4360 | 2002 | | |
| 0938 | B | 2120 | 1999 | 2600 | 2420 |
| 0942 | B | 3030 | 2002 | 3200 | 2990 |
| 0943 | B | 29 | 2002 | 17 | |
| 0947 | B | 18.7 | 2002 | 16 | |
| 1129 | B | | | 1100 | |
| 1130 | B | | | 2600 | |
| 1132 | B | | | 2200 | 1760 |
| 1133 | B | | | 150 | |
| NMW-1A | B | | | | 12.6 |
| NMW-2A | B | | | | 13.4 |
| NMW-3A | B | | | | 11.4 |
| NMW-4A | B | | | | 12.5 |
| NMW-6S | B | | | | 14.8 |
| NMW-8S | B | | | | 13 |
| 0274 | C | | | 15 | 15 |
| 0276 | C | | | 16 | 16.8 |
| 0279 | C | | | 59 | |
| 0280 | C | | | 20 | |
| 0289 | C | | | 190 | 109 |
| 0683 | C | 21.6 | 2002 | 17 | |
| 0684 | C | 18 | 2002 | 15 | |
| 0685 | C | 26.2 | 2002 | 20 | |
| 0689 | C | 13.7 | 2002 | 14 | |

*Table B−4 (continued). Baseline, August 2011, and February 2012 Sulfate Concentrations*

| Well Number | Horizon | Baseline Sulfate Concentration (mg/L) | Year Sampled, Baseline | August 2011 Sulfate Concentration (mg/L) | February 2012 Sulfate Concentration (mg/L) |
|---|---|---|---|---|---|
| 0691 | C | 587 | 2002 | 520 | 499 |
| 0903 | C | 76.5 | 2002 | 66 | |
| 0912 | C | 846 | 2001 | 520 | |
| 0914 | C | 15.6 | 2001 | 12 | |
| 0917 | C | 13.9 | 2001 | | |
| 0930 | C | 59.8 | 2002 | 78 | 91.2 |
| 0932 | C | 30.2 | 2002 | 30 | 23.2 |
| 1008 | C | 13 | 2000 | | |
| 1116 | C | 176 | 2002 | 14 | |
| 1117 | C | 255 | 2002 | 280 | |
| 1118 | C | 163 | 2002 | 250 | |
| NMW-5 | C | | | | 52.6 |
| 0258 | D | 17.4 | 2000 | 17 | 17.1 |
| 0261 | D | 18.2 | 2001 | 17 | |
| 0264 | D | 37.7 | 2001 | 76 | 73.5 |
| 0266 | D | 10.9 | 2001 | 10 | 10.4 |
| 0272 | D | | | 11 | 12.6 |
| 0273 | D | | | 170 | 206 |
| 0275 | D | | | 2800 | 2200 |
| 0277 | D | | | 16 | |
| 0278 | D | | | 12 | |
| 0690 | D | 13.8 | 2002 | 12 | |
| 0692 | D | 20.8 | 2002 | 15 | |
| 0695 | D | 50.4 | 2002 | 40 | |
| 0904 | D | 96.5 | 2001 | 92 | |
| 0915 | D | 17.8 | 2001 | 16 | |
| 1003 | D | 302 | 2000 | 520 | |
| 1004 | D | 66.2 | 2000 | 43 | |
| 1005 | D | 12.7 | 2000 | | |
| 1006 | D | 12.2 | 2000 | 11 | |
| 1007 | D | 11.7 | 2000 | 12 | |
| 1101 | D | 960 | 2002 | | |
| 1102 | D | 1320 | 2002 | 2000 | |
| 1103 | D | 2570 | 2002 | 2000 | |
| 1104 | D | 1870 | 2002 | 2400 | |
| 1105 | D | 1590 | 2002 | 2400 | |
| 1106 | D | 1050 | 2002 | 1100 | |
| 1107 | D | 1200 | 2002 | 1200 | |
| 1108 | D | 3400 | 2002 | 1500 | |
| 1109 | D | 3280 | 2002 | | |
| 1110 | D | 512 | 2002 | | |
| 1111 | D | 988 | 2002 | 1200 | |
| 1112 | D | 1140 | 2002 | 300 | |
| 1113 | D | 136 | 2002 | 100 | |
| 1114 | D | 328 | 2002 | | |
| 1115 | D | 1930 | 2002 | | |
| 1119 | D | 1560 | 2002 | 900 | |
| 1120 | D | 2330 | 2002 | 2300 | |
| 1121 | D | 2590 | 2002 | | |
| 1122 | D | 2960 | 2002 | 1900 | |
| 1123 | D | 1240 | 2002 | 2200 | |

*Table B−4 (continued). Baseline, August 2011, and February 2012 Sulfate Concentrations*

| Well Number | Horizon | Baseline Sulfate Concentration (mg/L) | Year Sampled, Baseline | August 2011 Sulfate Concentration (mg/L) | February 2012 Sulfate Concentration (mg/L) |
|---|---|---|---|---|---|
| 1124 | D | 1170 | 2002 | 2100 | |
| 1125 | D | 165 | 2002 | 61 | |
| NMW-7D | D | | | | 9.68 |
| 0251 | E | 617 | 2002 | 11 | 11.8 |
| 0268 | E | 17.4 | 2002 | 110 | 363 * |
| 0920 | E | 12.7 | 2001 | 12 | |
| NMW-9D | E | | | | 31.7 |
| 0911 | F | | | 8.8 | |
| 0913 | G | 8.43 | 2001 | 7.4 | |
| 0916 | G | 13.5 | 2001 | 8.4 | |
| 0252 | I | 19.2 | 2002 | 6.4 | 6.38 |
| 0921 | I | 8.52 | 2001 | 8.2 | |

Values in red exceed the corresponding groundwater remediation target for sulfate, 250 mg/L (see Table 1 of main report). Well numbers with groundwater concentrations greater than the remediation target during this reporting period are also listed in red.

* Denotes filtered sample. Samples are generally not filtered (as reflected above), except in cases when turbidity is greater than 10 NTUs.

*Table B−5. Baseline, August 2011, and February 2012 Uranium Concentrations*

| Well Number | Horizon | Baseline Uranium Concentration (mg/L) | Year Sampled, Baseline | August 2011 Uranium Concentration (mg/L) | February 2012 Uranium Concentration (mg/L) |
|---|---|---|---|---|---|
| 0686 | A | 0.0021 | 2002 | 0.0014 | |
| 0687 | A | 0.0208 | 2002 | 0.00016 | |
| 0688 | A | 0.002 | 2002 | 0.0021 | |
| 0901 | A | 0.0026 | 2001 | 0.0031 | 0.00353 |
| 0906 | A | 0.951 | 2002 | 0.51 | 0.43 |
| 0929 | A | 0.0012 | 2002 | 0.0015 | 0.00197 |
| 0940 | A | 0.546 | 2002 | 0.39 | 0.422 |
| 0941 | A | 0.0886 | 2002 | 0.23 | 0.234 * |
| 0945 | A | 0.0031 | 2002 | 0.0013 | |
| 0946 | A | | | 0.000084 | |
| 0262 | B | 0.379 | 2001 | 0.81 | 0.774 |
| 0263 | B | 0.485 | 2001 | 0.16 | 0.141 |
| 0265 | B | 0.0897 | 2001 | 0.061 | 0.0627 |
| 0267 | B | 0.0731 | 2002 | 0.077 | 0.069 |
| 0271 | B | 0.0014 | 2002 | 0.0014 | |
| 0281 | B | | | 0.0074 | 0.00875 |
| 0282 | B | | | 0.0048 | 0.00695 |
| 0286 | B | | | 0.4 | 0.33 |
| 0287 | B | | | 0.24 | 0.238 |
| 0288 | B | | | 0.011 | 0.0128 |
| 0290 | B | | | 0.0089 | 0.041 |
| 0908 | B | 0.122 | 2002 | 0.083 | 0.0948 |
| 0909 | B | 0.0389 | 2002 | | |
| 0910 | B | | | 0.0011 | 0.00155 |
| 0934 | B | 0.312 | 2002 | 0.17 | 0.176 |
| 0935 | B | 0.0868 | 2002 | 0.14 | 0.161 |
| 0936 | B | 0.267 | 2002 | | |
| 0938 | B | 0.21 | 1999 | 0.37 | 0.396 |
| 0942 | B | 0.246 | 2002 | 0.4 | 0.413 |
| 0943 | B | 0.0049 | 2002 | 0.0062 | |
| 0947 | B | 0.0024 | 2002 | 0.0012 | |
| 1129 | B | | | 1 | |
| 1130 | B | | | 0.5 | |
| 1132 | B | | | 3.5 | 1.69 |
| 1133 | B | | | 0.064 | |
| NMW-1A | B | | | | 0.00145 |
| NMW-2A | B | | | | 0.00142 |
| NMW-3A | B | | | | 0.0013 |
| NMW-4A | B | | | | 0.00134 |
| NMW-6S | B | | | | 0.0014 |
| NMW-8S | B | | | | 0.00156 |
| 0274 | C | | | 0.0017 | 0.00202 |
| 0276 | C | | | 0.0015 | 0.00191 |
| 0279 | C | | | 0.0019 | |
| 0280 | C | | | 0.0014 | |
| 0289 | C | | | 0.015 | 0.0155 |
| 0683 | C | 0.0012 | 2002 | 0.0012 | |
| 0684 | C | 0.0019 | 2002 | 0.0013 | |
| 0685 | C | 0.0012 | 2002 | 0.0013 | |
| 0689 | C | 0.0011 | 2002 | 0.0012 | |

*Table B−5 (continued). Baseline, August 2011, and February 2012 Uranium Concentrations*

| Well Number | Horizon | Baseline Uranium Concentration (mg/L) | Year Sampled, Baseline | August 2011 Uranium Concentration (mg/L) | February 2012 Uranium Concentration (mg/L) |
|---|---|---|---|---|---|
| 0691 | C | 0.0657 | 2002 | 0.052 | 0.071 |
| 0903 | C | 0.0022 | 2002 | 0.0021 | |
| 0912 | C | 0.0342 | 2001 | 0.024 | |
| 0914 | C | 0.0013 | 2001 | 0.000041 | |
| 0917 | C | 0.0013 | 2001 | | |
| 0930 | C | 0.0023 | 2002 | 0.0033 | 0.00475 |
| 0932 | C | 0.0016 | 2002 | 0.0022 | 0.00215 |
| 1008 | C | 0.001 | 2000 | | |
| 1116 | C | 0.0081 | 2002 | 0.0018 | |
| 1117 | C | 0.0151 | 2002 | 0.011 | |
| 1118 | C | 0.0098 | 2002 | 0.013 | |
| NMW-5 | C | | | | 0.00507 |
| 0258 | D | 0.0018 | 2000 | 0.0013 | 0.00153 |
| 0261 | D | 0.0018 | 2001 | 0.0013 | |
| 0264 | D | 0.0033 | 2001 | 0.0035 | 0.00423 |
| 0266 | D | 0.0019 | 2001 | 0.0015 | 0.00223 |
| 0272 | D | | | 0.0014 | 0.00182 |
| 0273 | D | | | 0.035 | 0.0502 |
| 0275 | D | | | 0.42 | 0.469 |
| 0277 | D | | | 0.0024 | |
| 0278 | D | | | 0.0013 | |
| 0690 | D | 0.0018 | 2002 | 0.0016 | |
| 0692 | D | 0.0015 | 2002 | 0.0017 | |
| 0695 | D | 0.002 | 2002 | 0.002 | |
| 0904 | D | 0.0044 | 2001 | 0.0043 | |
| 0915 | D | 0.0017 | 2001 | 0.0000029U | |
| 1003 | D | 0.0205 | 2000 | 0.039 | |
| 1004 | D | 0.0053 | 2000 | 0.0049 | |
| 1005 | D | 0.0013 | 2000 | | |
| 1006 | D | 0.0014 | 2000 | 0.0013 | |
| 1007 | D | 0.0012 | 2000 | 0.0014 | |
| 1101 | D | 0.245 | 2002 | | |
| 1102 | D | 0.533 | 2002 | 0.54 | |
| 1103 | D | 0.355 | 2002 | 0.45 | |
| 1104 | D | 0.194 | 2002 | 1.4 | |
| 1105 | D | 2.1 | 2002 | 2.1 | |
| 1106 | D | 2.1 | 2002 | 2 | |
| 1107 | D | 0.118 | 2002 | 0.26 | |
| 1108 | D | 0.646 | 2002 | 0.76 | |
| 1109 | D | 0.565 | 2002 | | |
| 1110 | D | 0.0528 | 2002 | | |
| 1111 | D | 0.161 | 2002 | 0.16 | |
| 1112 | D | 0.13 | 2002 | 0.052 | |
| 1113 | D | 0.0149 | 2002 | 0.014 | |
| 1114 | D | 0.0277 | 2002 | | |
| 1115 | D | 0.41 | 2002 | | |
| 1119 | D | 0.555 | 2002 | 0.14 | |
| 1120 | D | 1.3 | 2002 | 0.13 | |
| 1121 | D | 0.857 | 2002 | | |
| 1122 | D | 0.878 | 2002 | 0.2 | |
| 1123 | D | 0.261 | 2002 | 0.27 | |

*Table B−5 (continued). Baseline, August 2011, and February 2012 Uranium Concentrations*

| Well Number | Horizon | Baseline Uranium Concentration (mg/L) | Year Sampled, Baseline | August 2011 Uranium Concentration (mg/L) | February 2012 Uranium Concentration (mg/L) |
|---|---|---|---|---|---|
| 1124 | D | 0.171 | 2002 | 0.33 | |
| 1125 | D | 0.0176 | 2002 | 0.0073 | |
| NMW-7D | D | | | | 0.0011 |
| 0251 | E | 0.0481 | 2002 | 0.0015 | 0.00194 |
| 0268 | E | 0.0014 | 2002 | 0.015 | 0.0845 * |
| 0920 | E | 0.0017 | 2001 | 0.0014 | |
| NMW-9D | E | | | | 0.00147 |
| 0911 | F | | | 0.0013 | |
| 0913 | G | 0.0016 | 2001 | 0.0012 | |
| 0916 | G | 0.0014 | 2001 | 0.000013 | |
| 0252 | I | 0.0024 | 2002 | 0.0019 | 0.00224 |
| 0921 | I | 0.0047 | 2001 | 0.0047 | |

B = Result between instrument detection limit and contract required detection limit.

Values in red exceed the corresponding groundwater remediation target for uranium, 0.044 mg/L (see Table 1 of main report). Well numbers with groundwater concentrations greater than the remediation target during this reporting period are also listed in red.

* Denotes filtered sample. Samples are generally not filtered (as reflected above), except in cases when turbidity is greater than 10 NTUs.

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# Appendix C

# Nitrate, Sulfate, and Uranium Plume Maps

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# Figures

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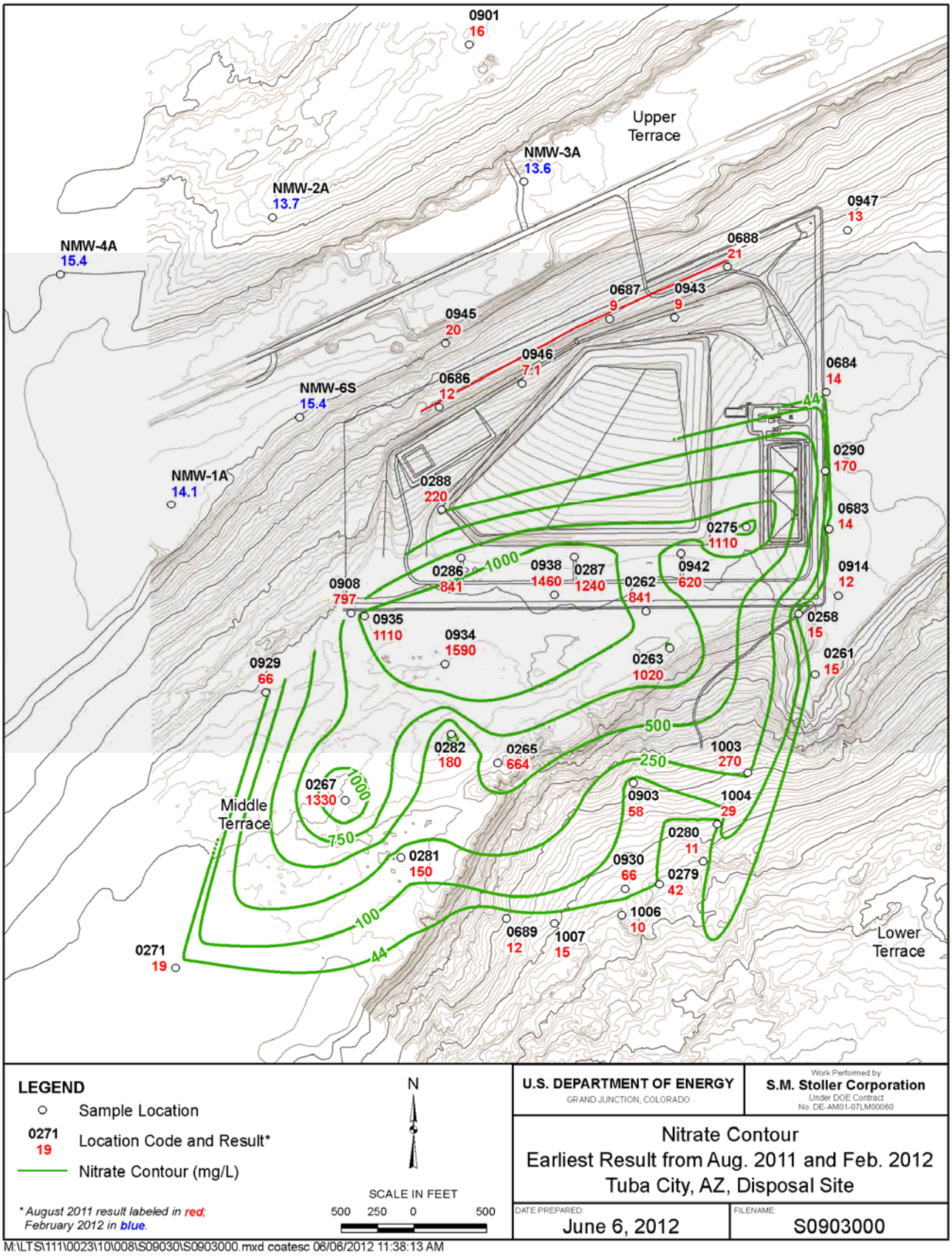


*Figure C−1. Nitrate (mg/L as $NO_3$) Plume Map: August 2011*

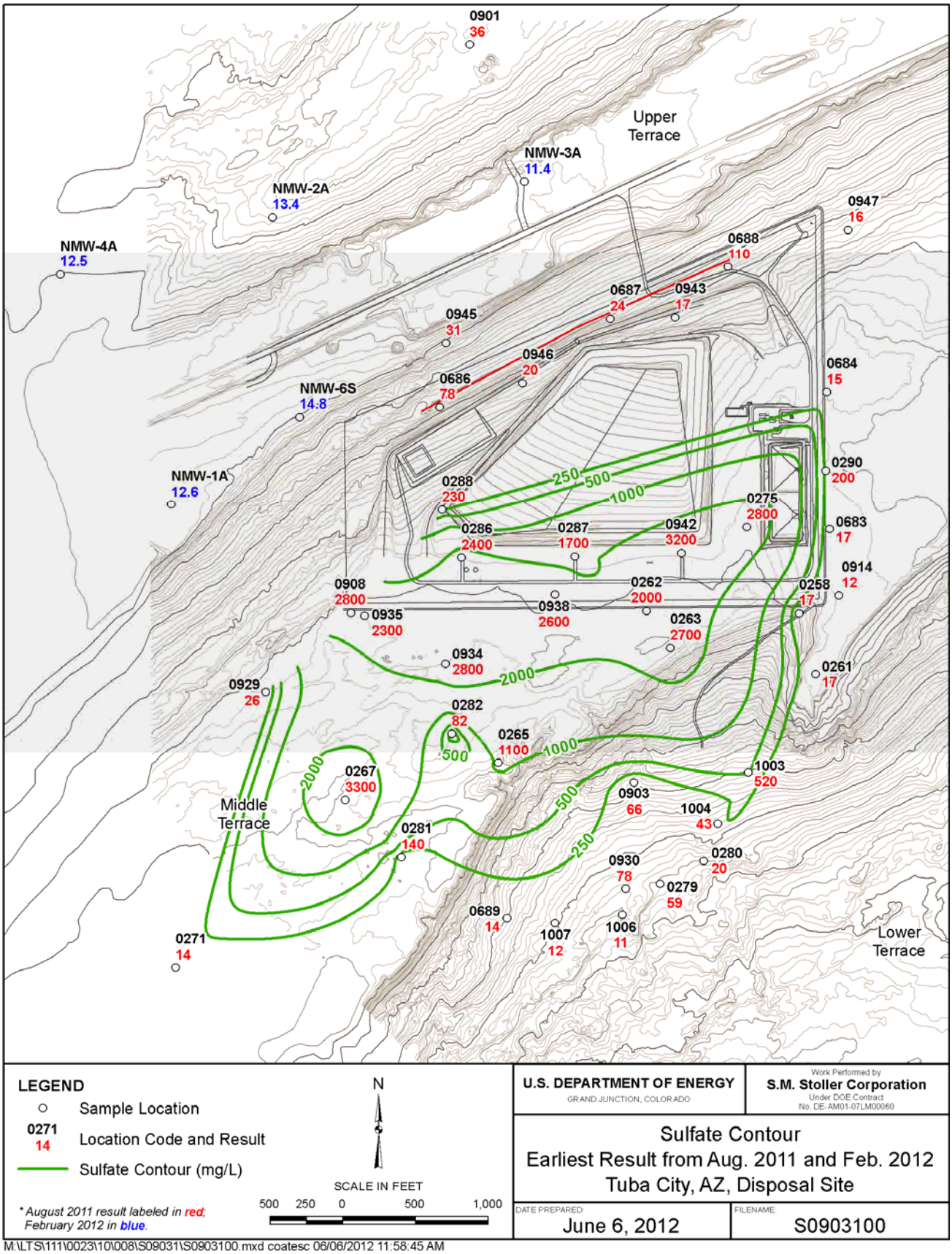


*Figure C−2. Sulfate (mg/L) Plume Map: August 2011*

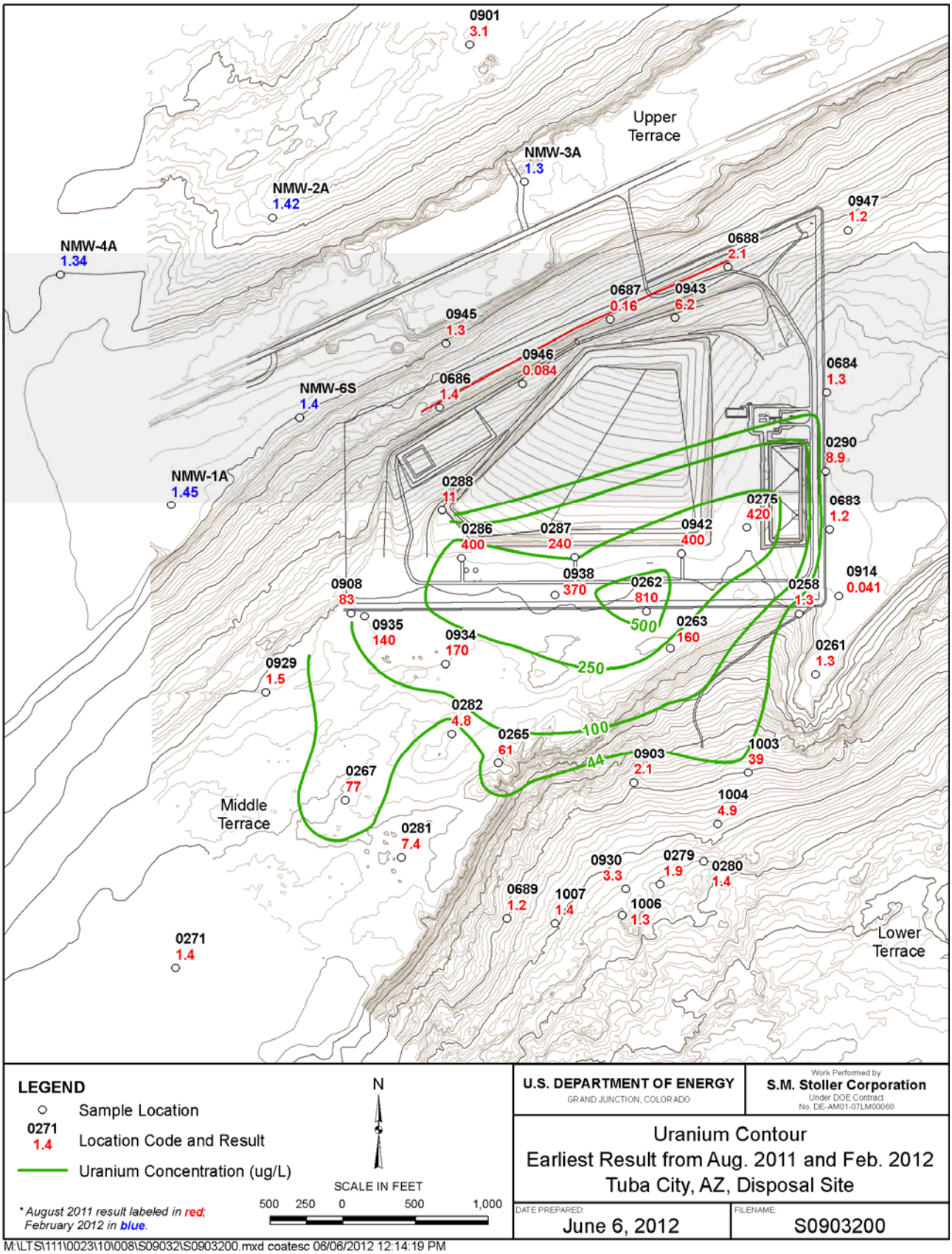


*Figure C−3. Uranium (µg/L) Plume Map: July 2010*

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# Appendix D

# Monitoring Well Water Level Hydrographs

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# Figures

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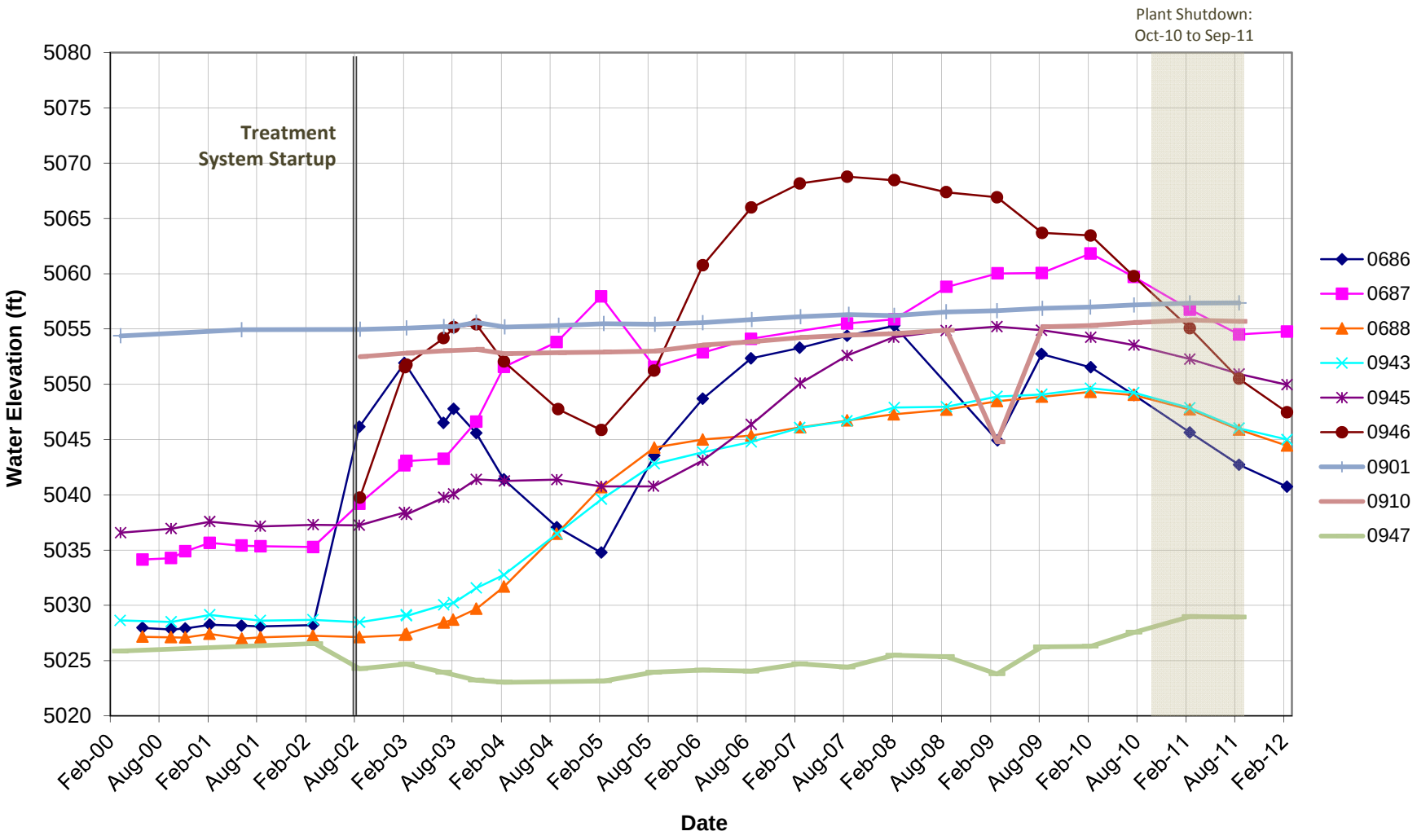


*Figure D−1. Monitoring Wells at Infiltration Trench (686–688, 943, 945, 946) and Background Wells 901, 910, and 947*

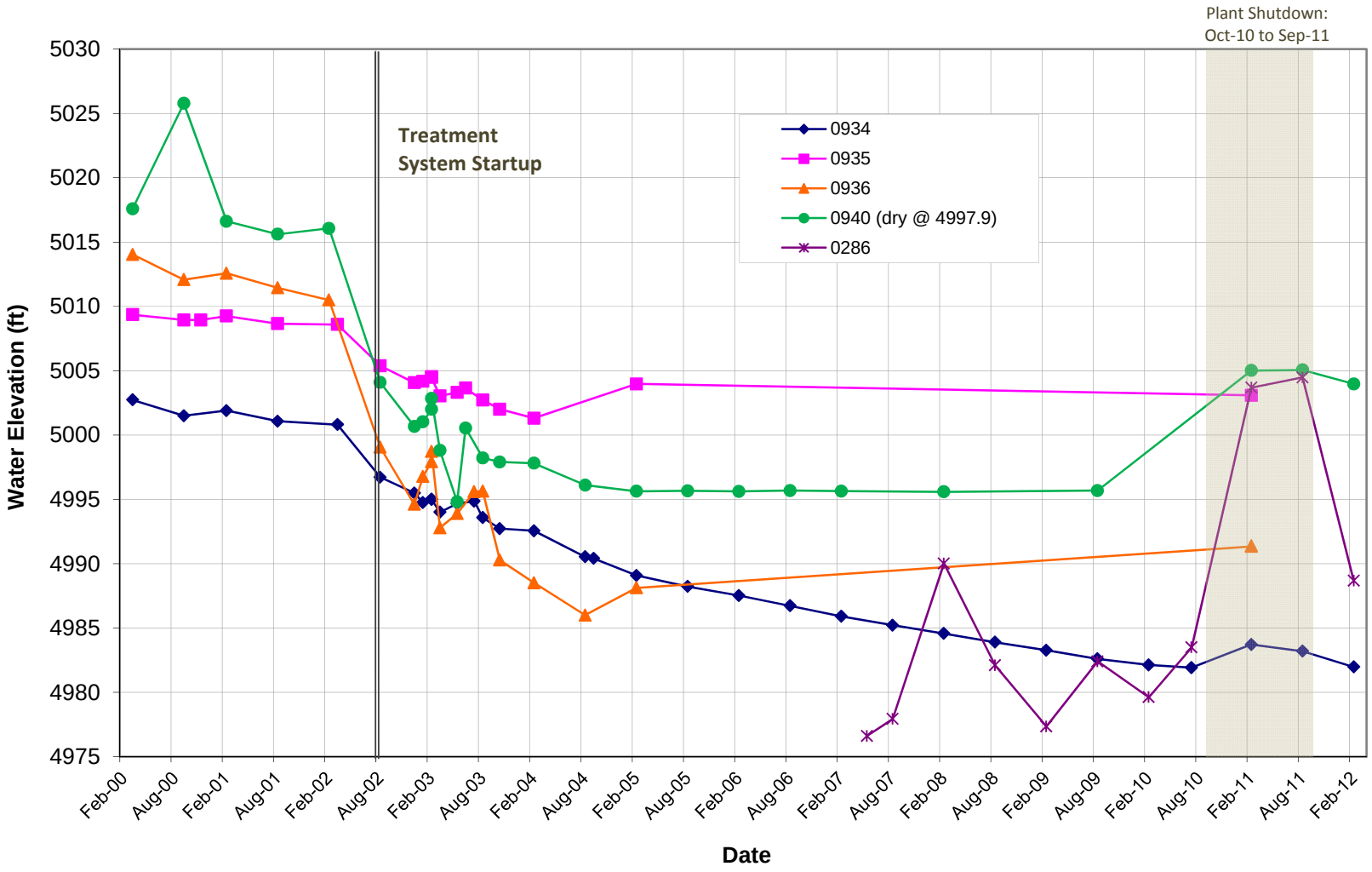


*Figure D−2. Horizon A and B Monitoring Wells 286, 934–936, 940*

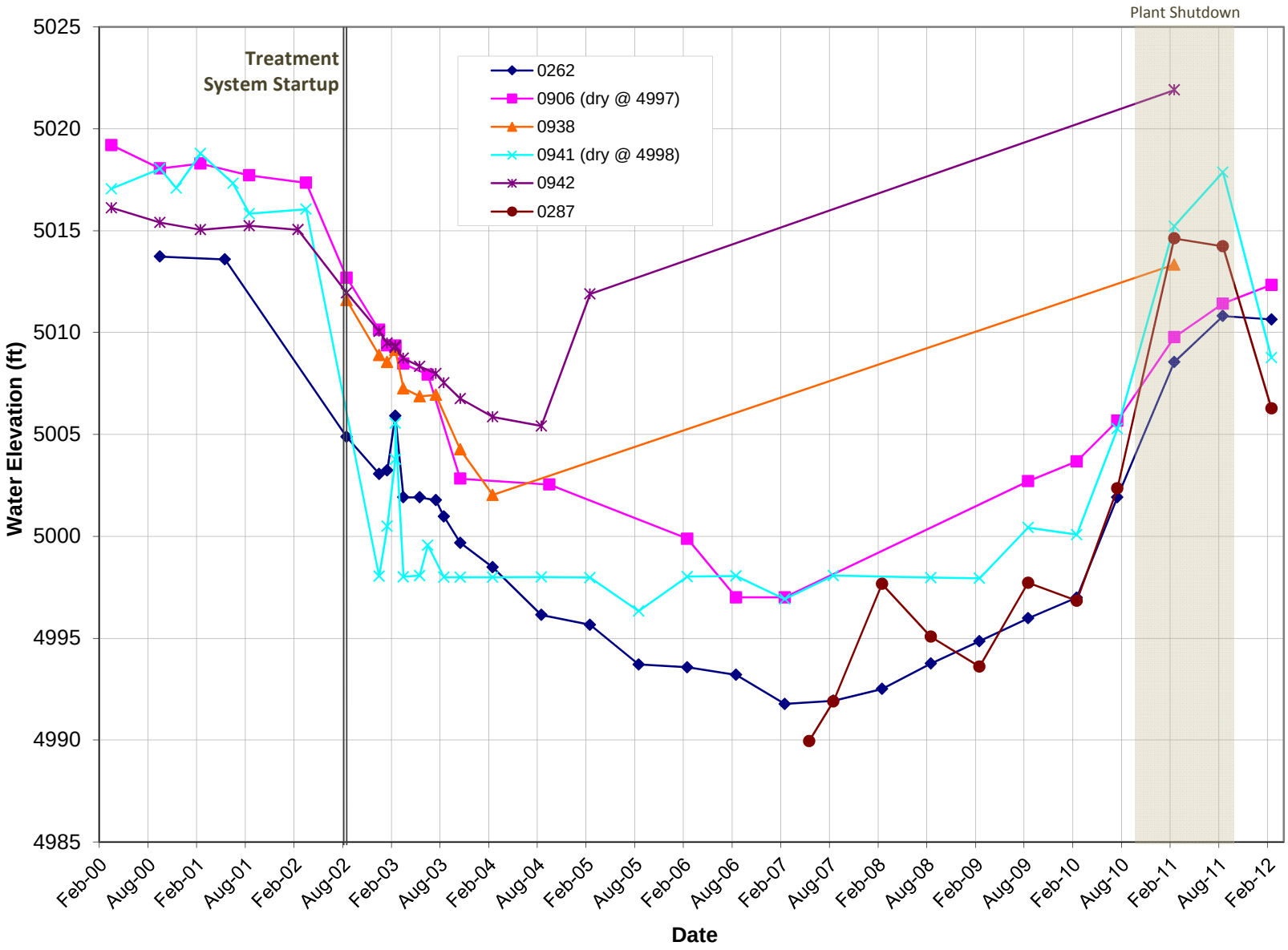


*Figure D−3. Horizon A and B Monitoring Wells 262, 287, 906, 938, 941, 942*

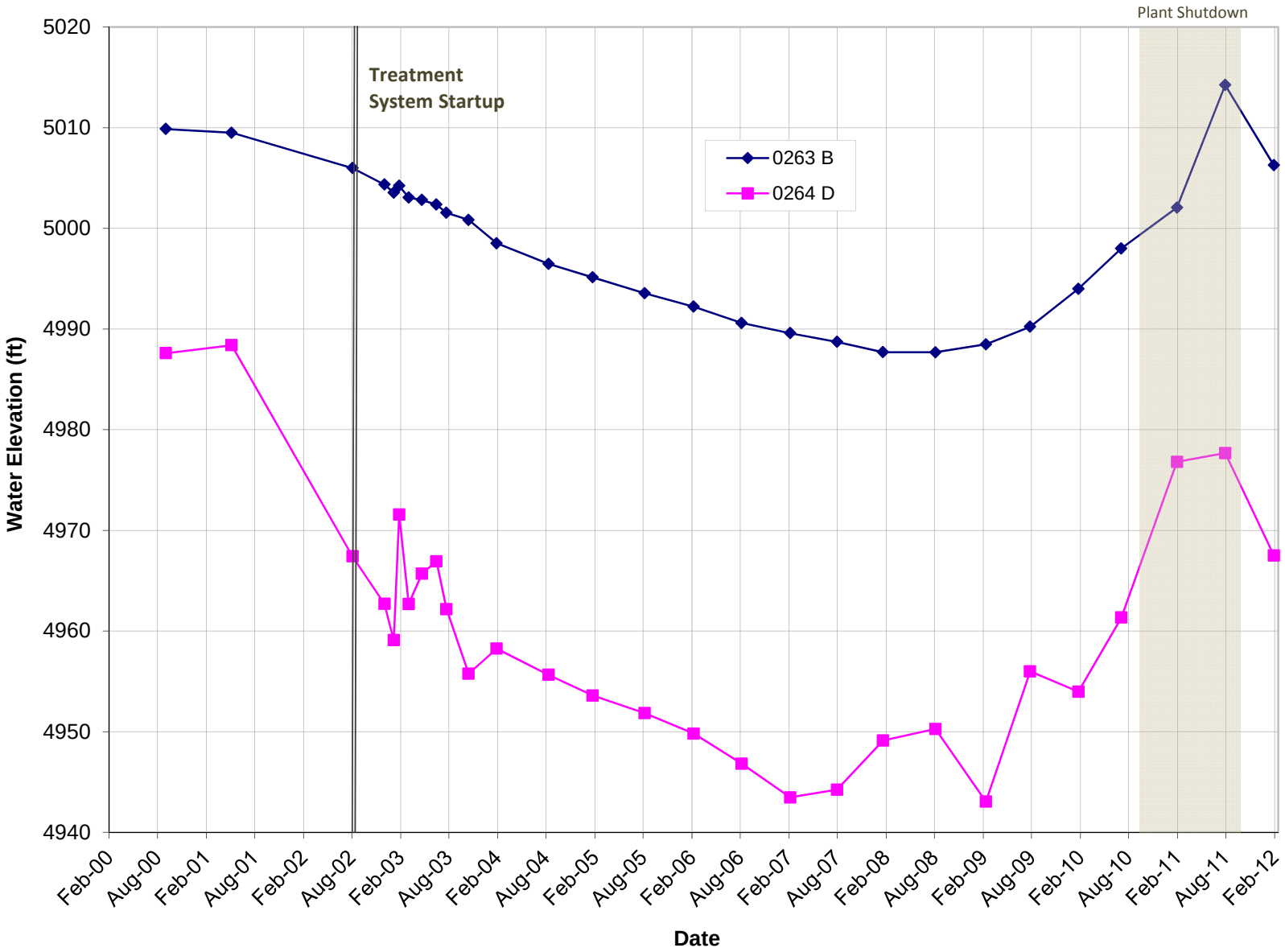


*Figure D−4. Middle Terrace Well Pair 263 and 264*

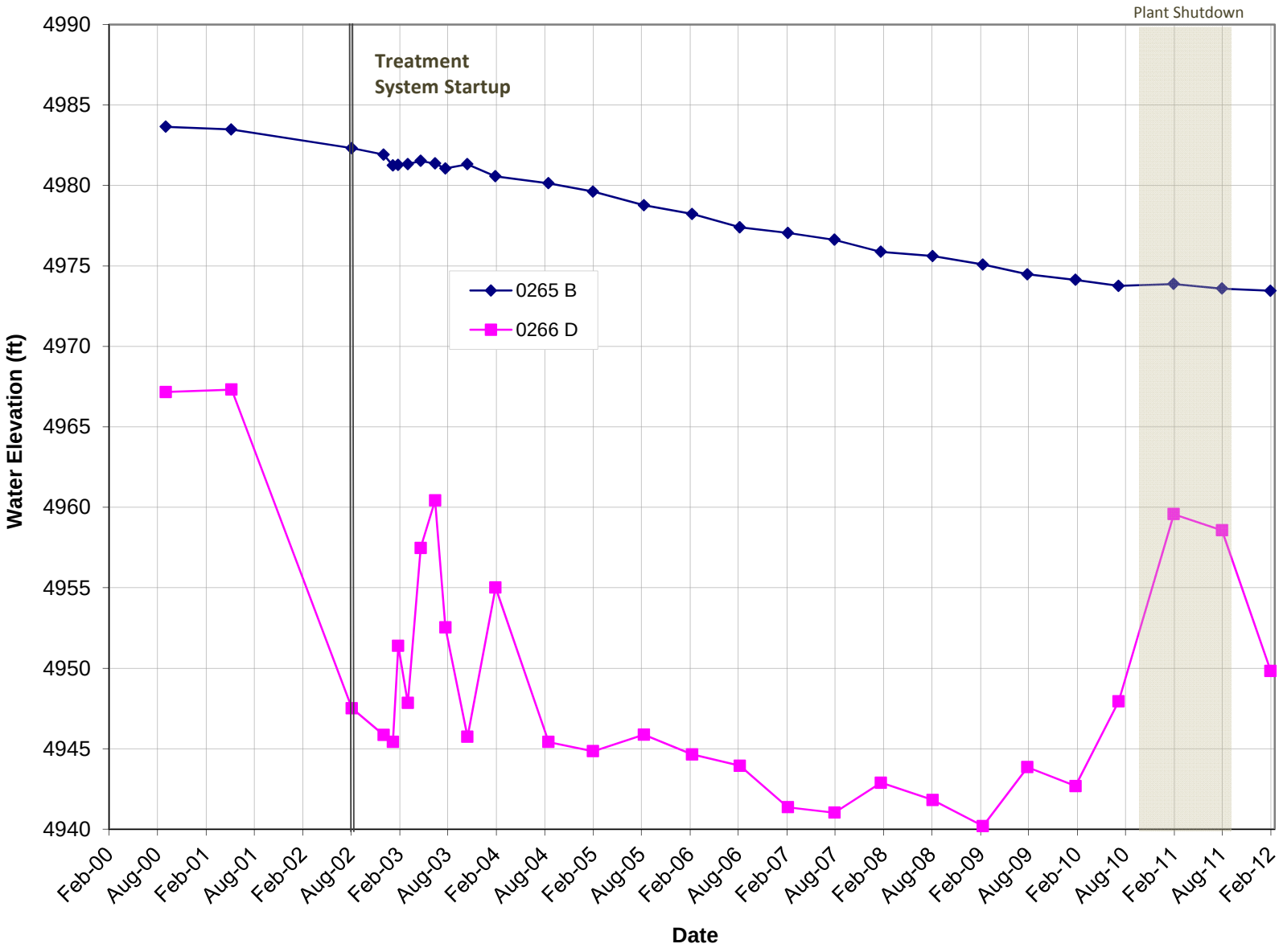


*Figure D−5. Middle Terrace Well Pair 265 and 266*

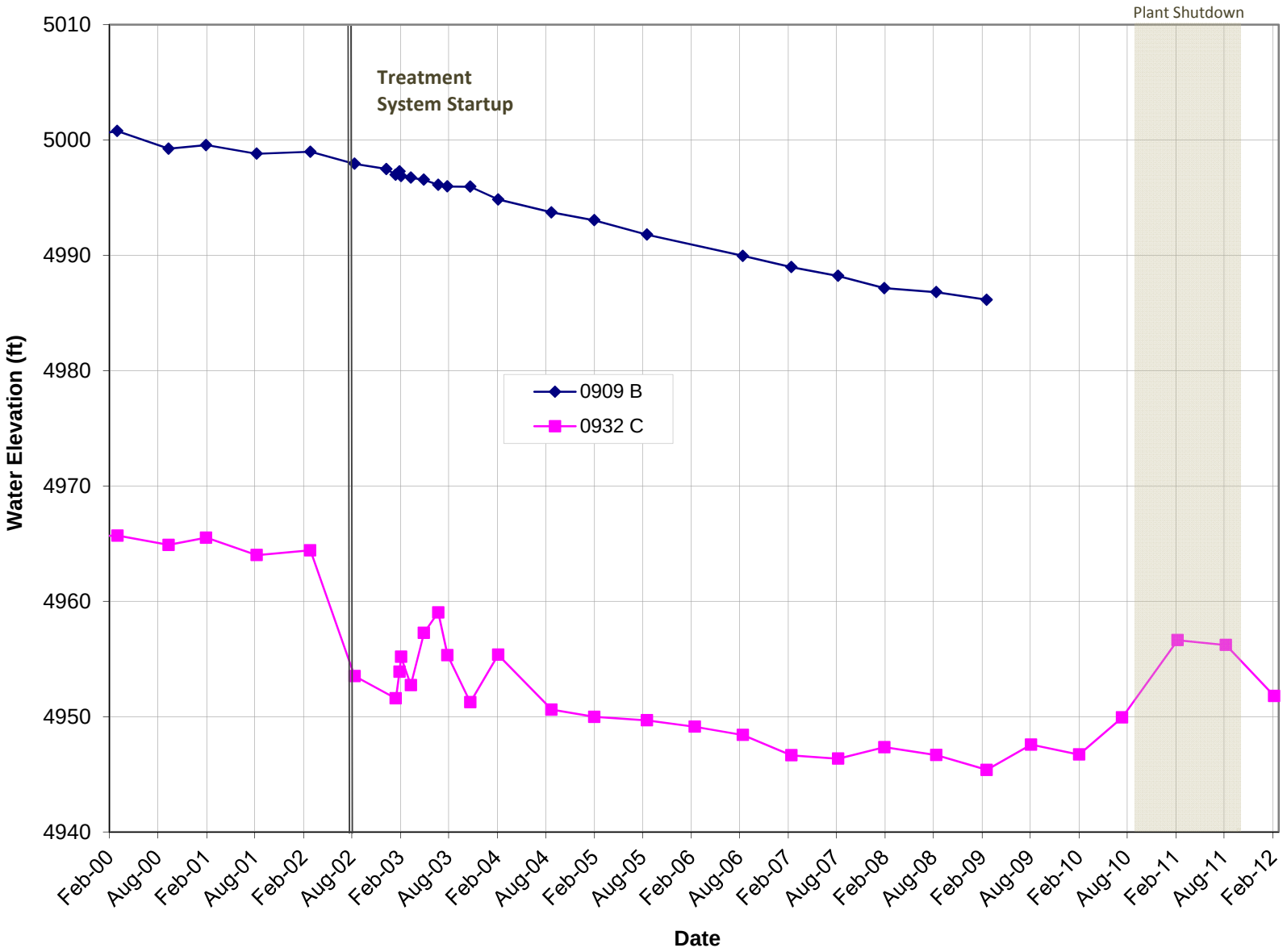


*Figure D−6. Middle Terrace Well Pair 909 and 932*

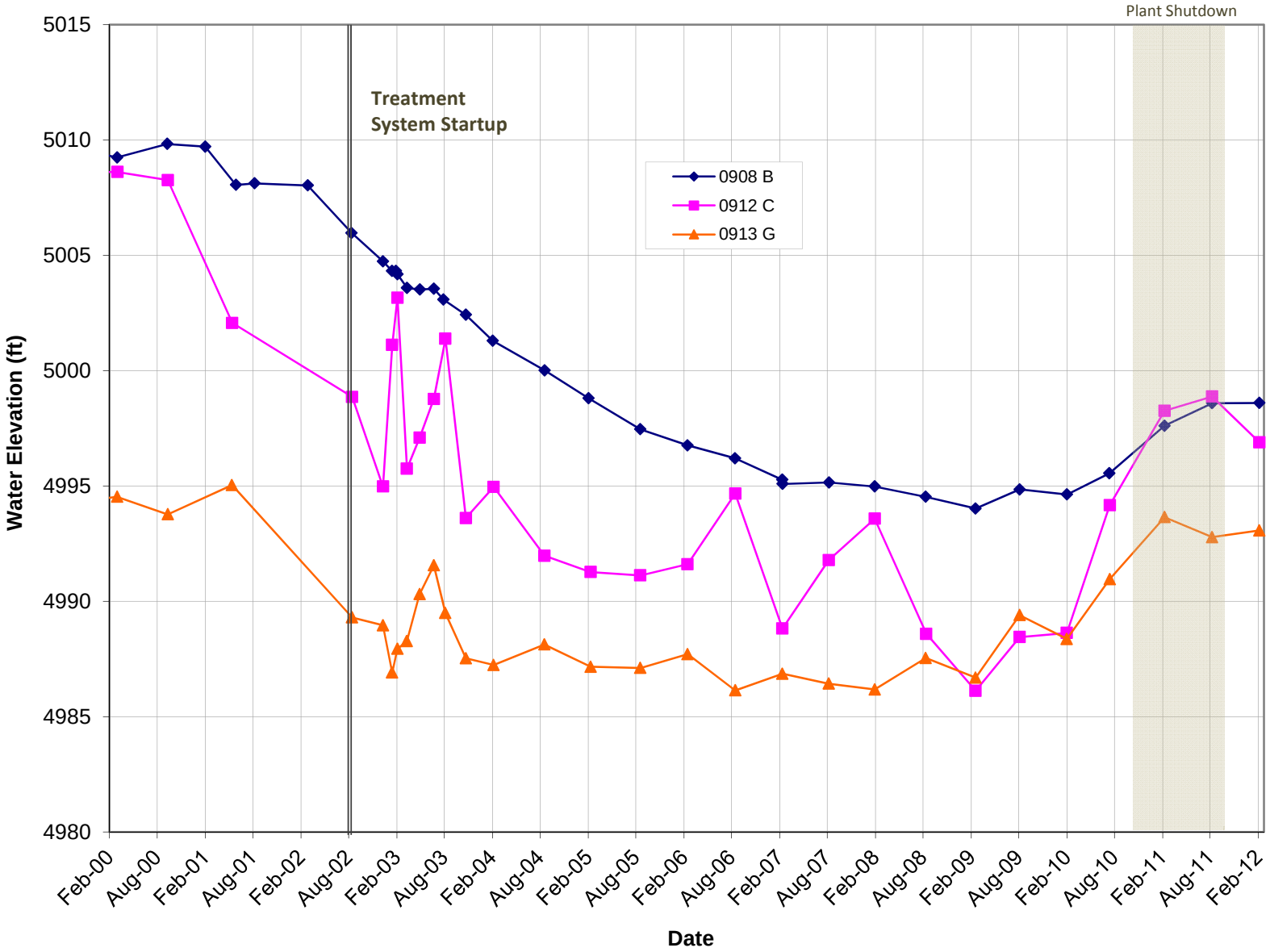


*Figure D−7. Middle Terrace Well Cluster 908, 912, and 913*

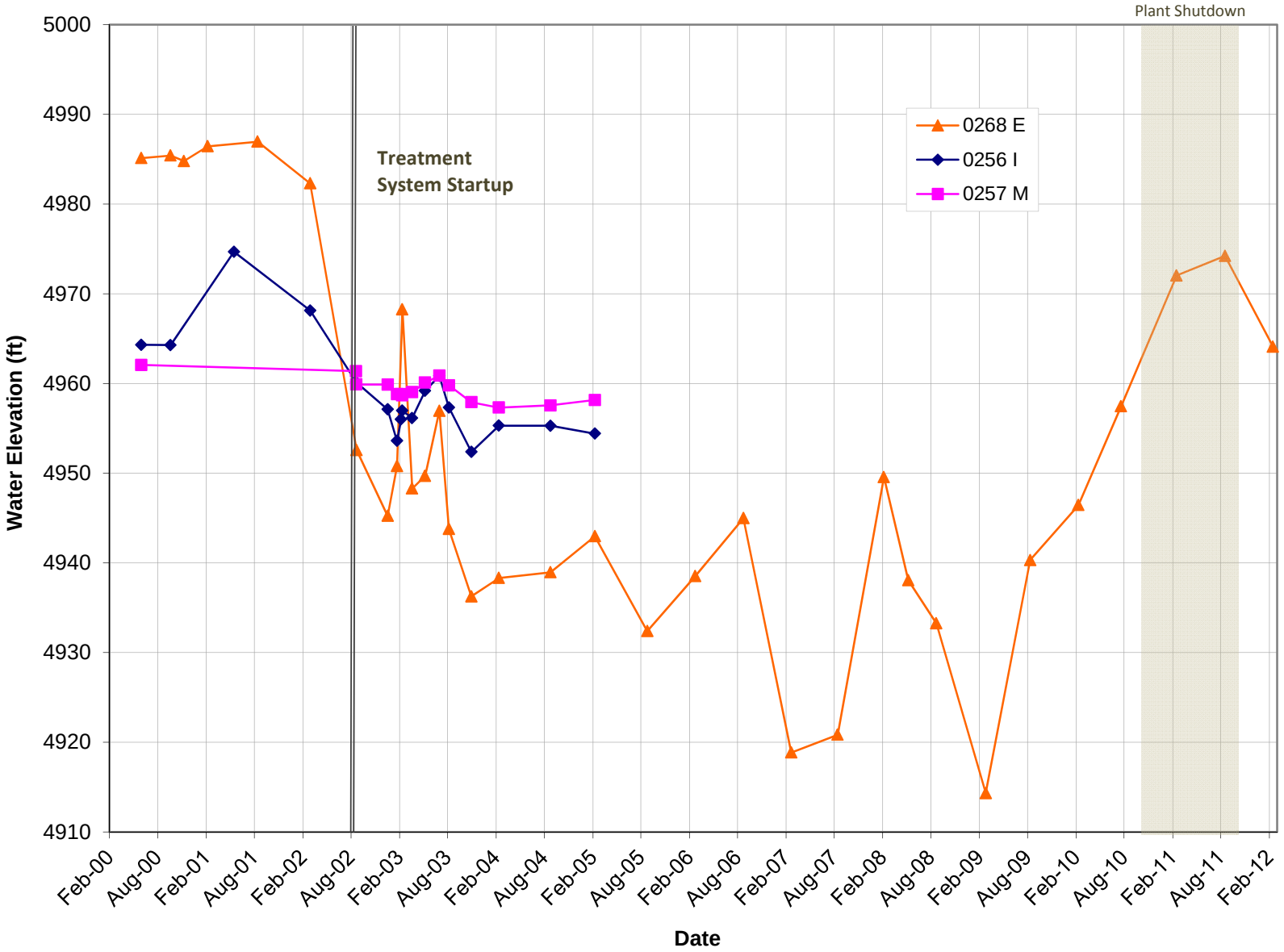


*Figure D−8. Middle Terrace Well Cluster 256, 257, and 268*

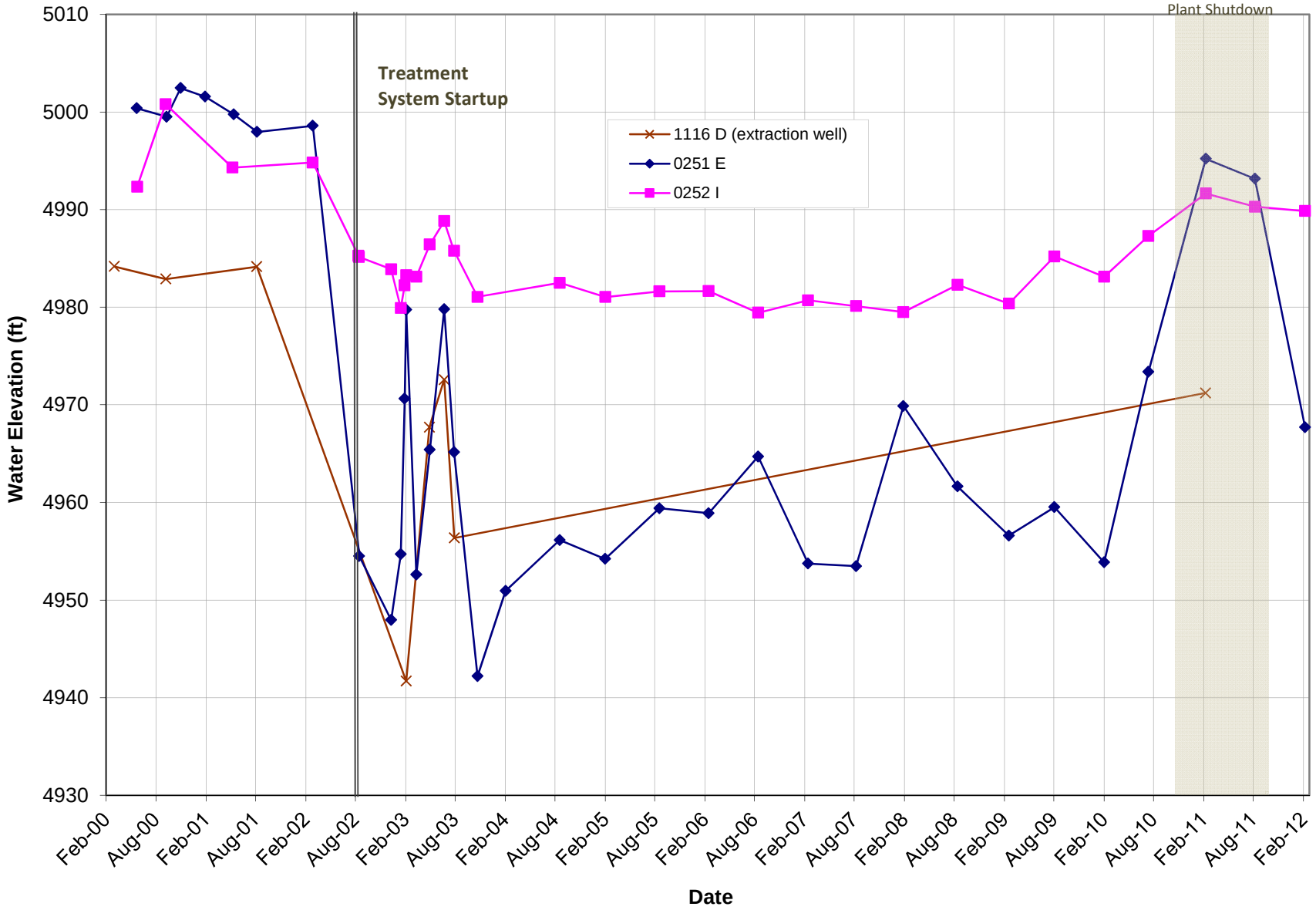


*Figure D−9. Middle Terrace Well Cluster 251, 252, and 1116*

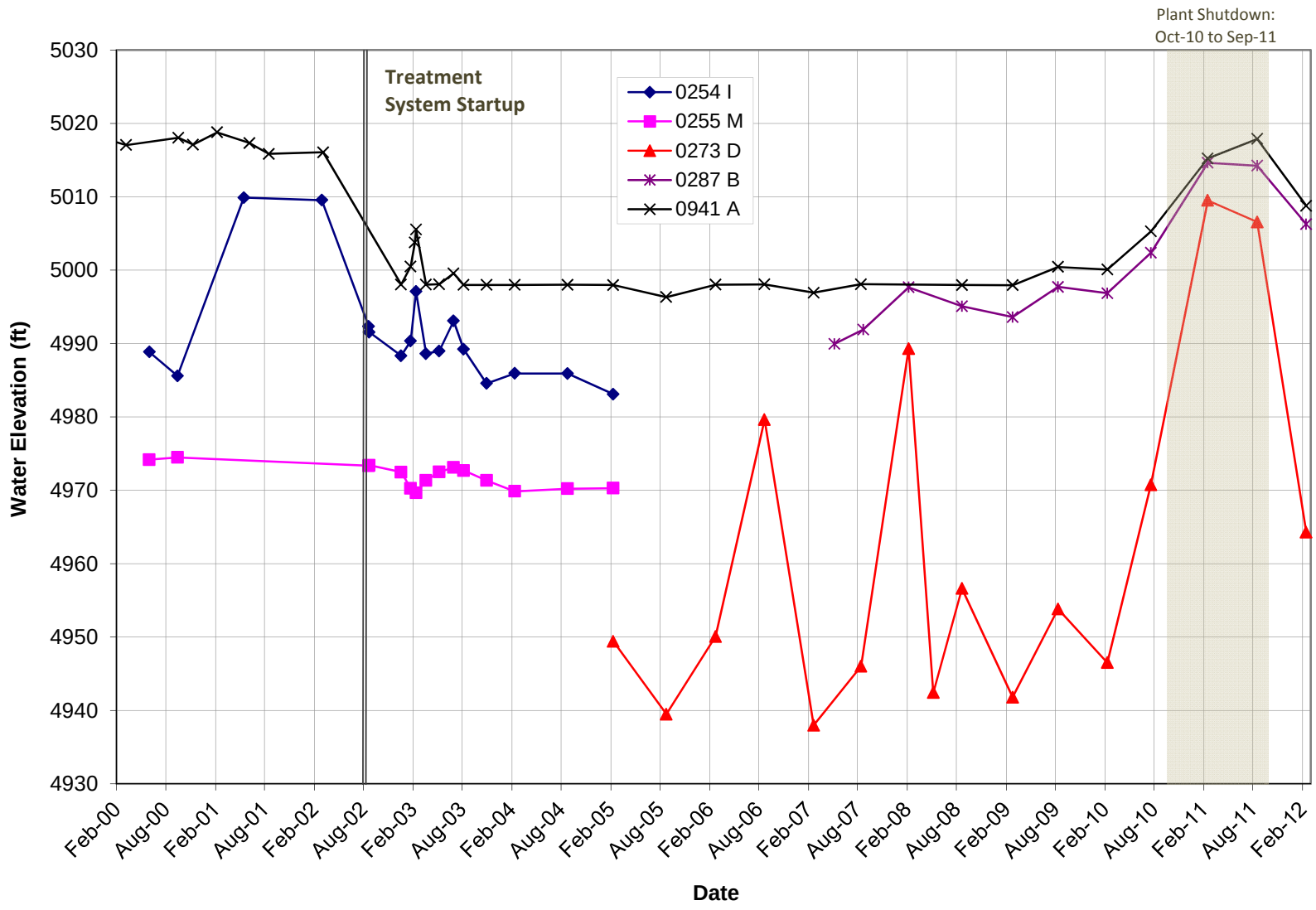


*Figure D−10. Middle Terrace Well Cluster 254, 255, 273, 287, and 941*

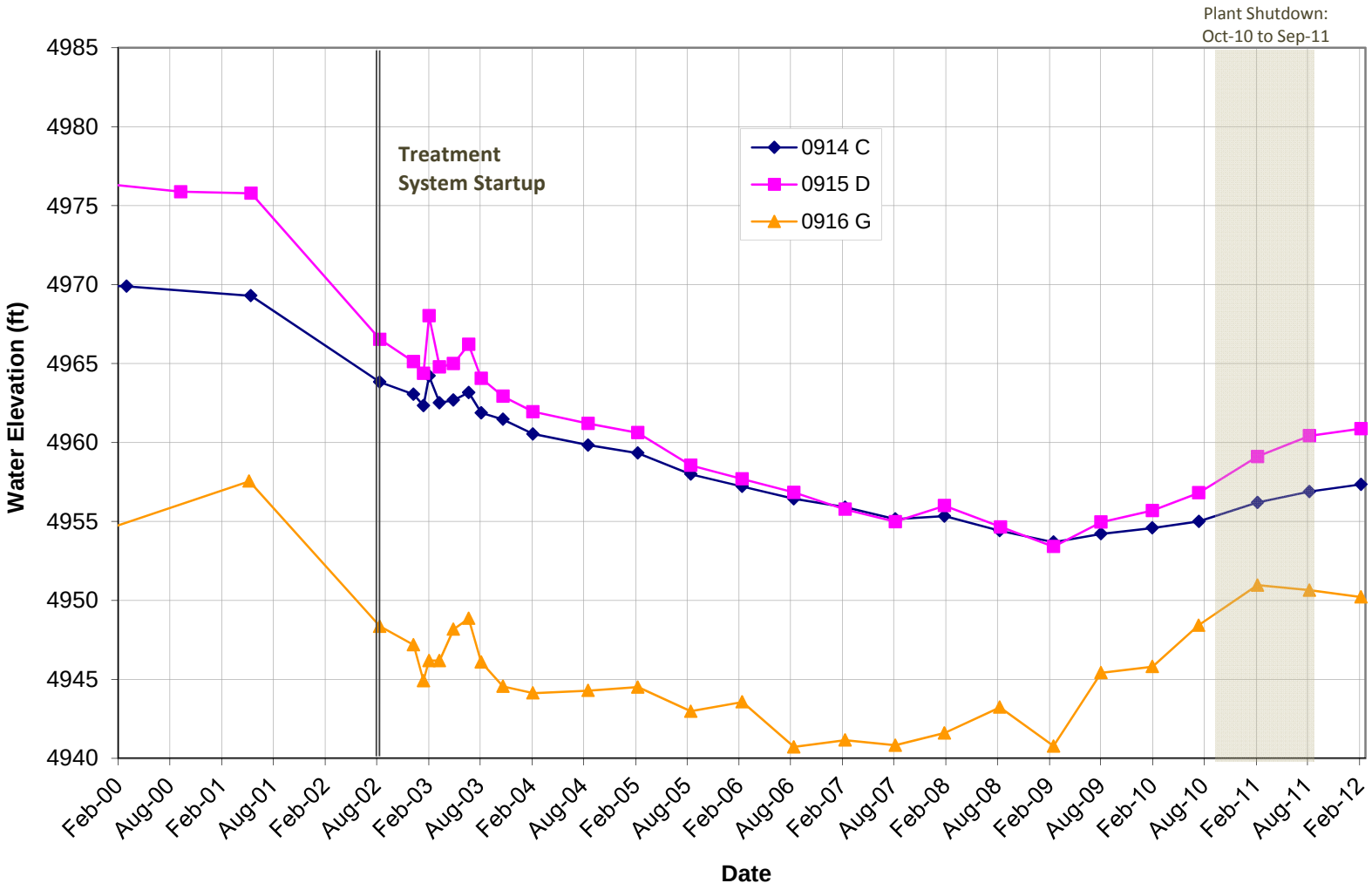


*Figure D−11. Middle Terrace Well Cluster 914, 915, and 916*

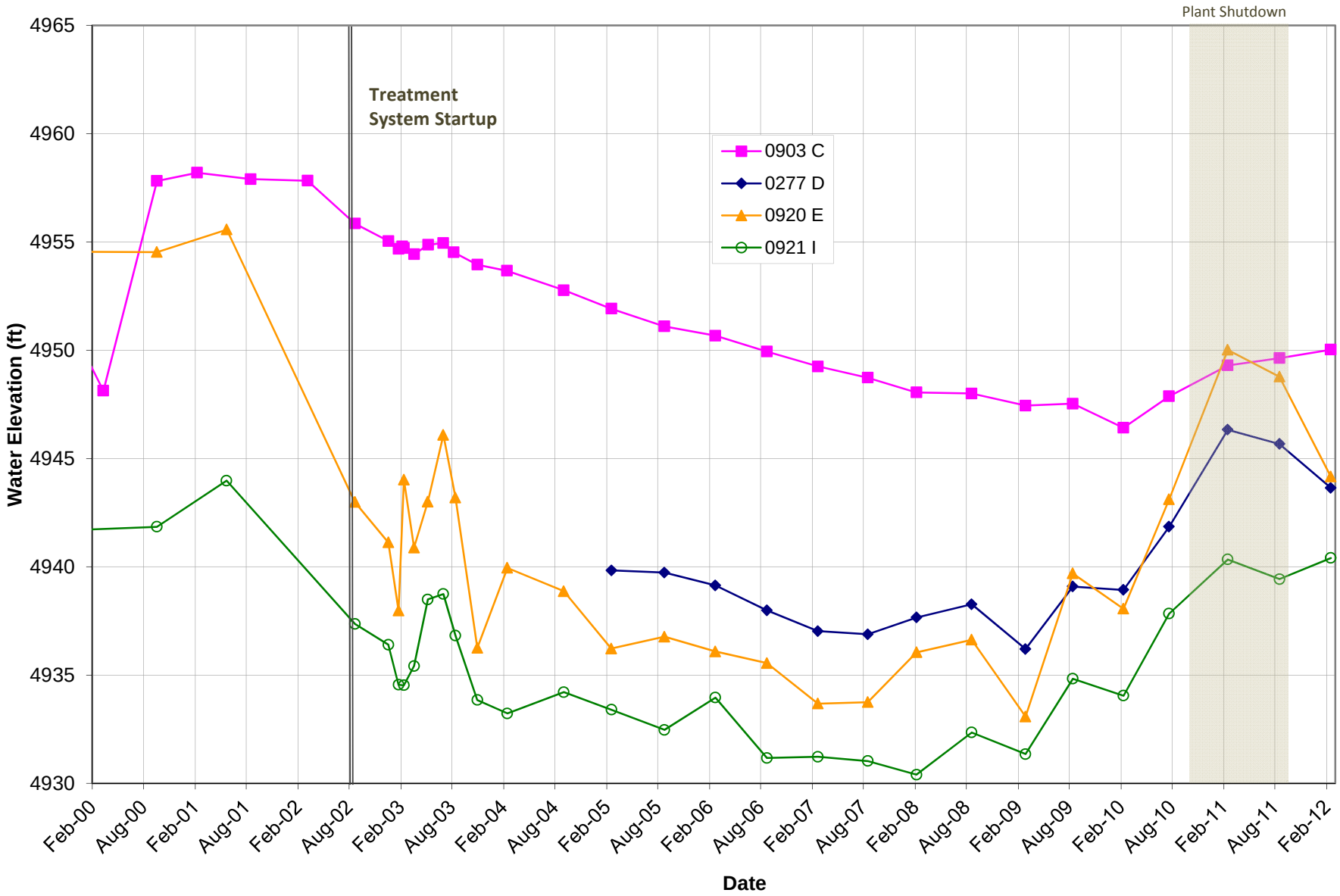


*Figure D−12. Lower Terrace Well Cluster 277, 903, 920, and 921*

# Appendix E

# Contaminant Concentration Trends at Monitoring Wells

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# Figures

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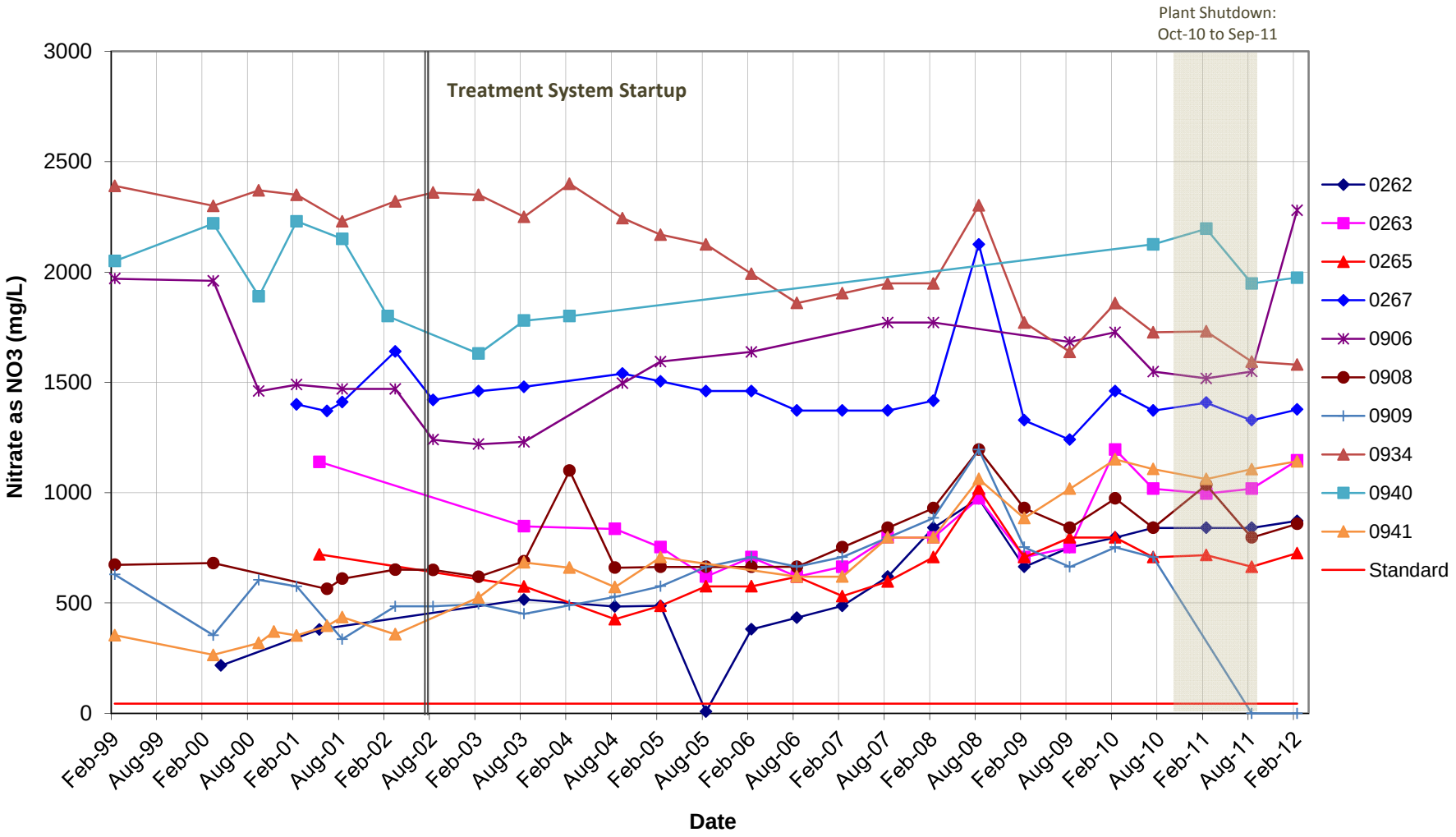


*Figure E−1. Horizons A and B Monitoring Wells, Nitrate as $NO_3$ Concentrations*

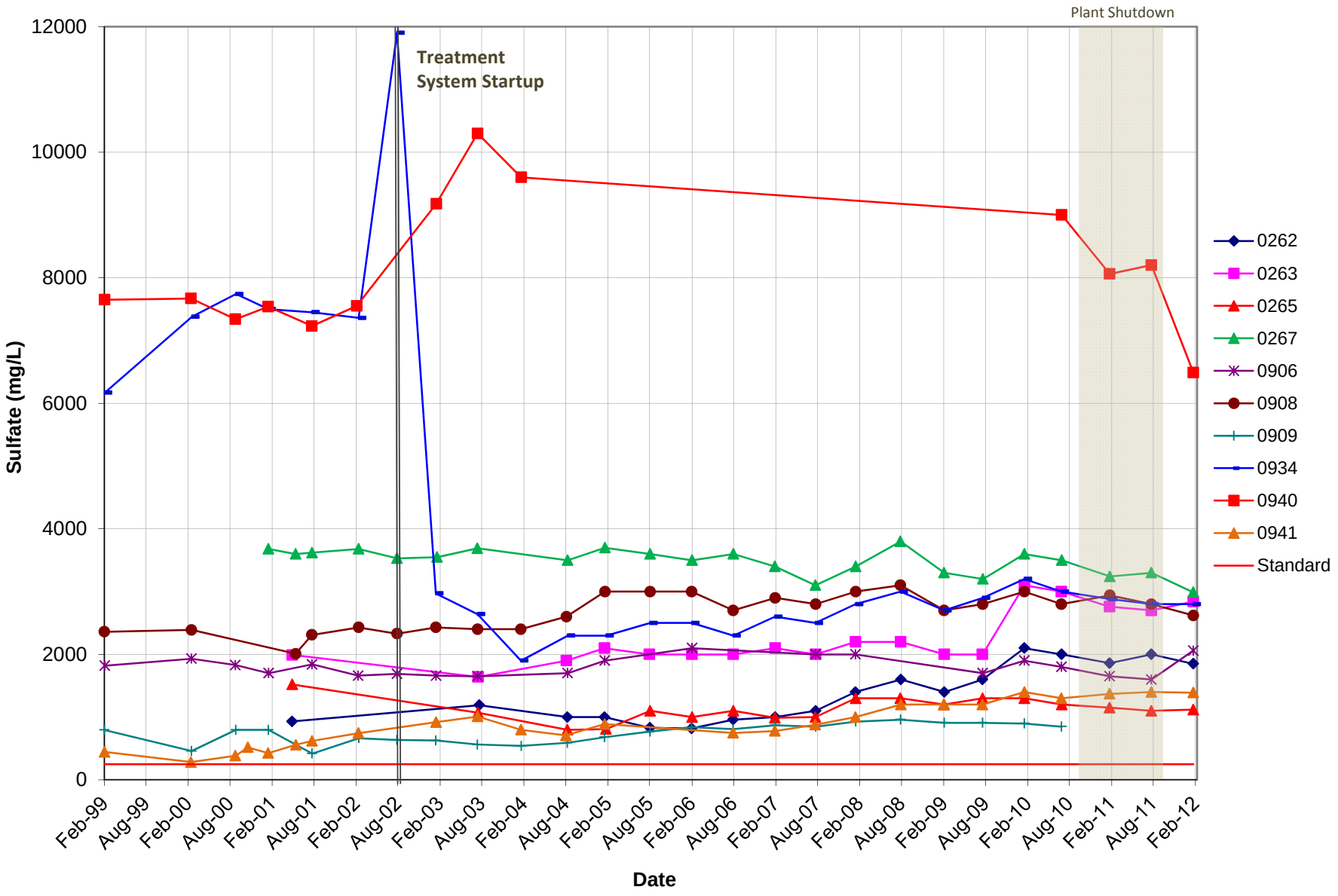


*Figure E−2. Horizons A and B Monitoring Wells, Sulfate Concentrations*

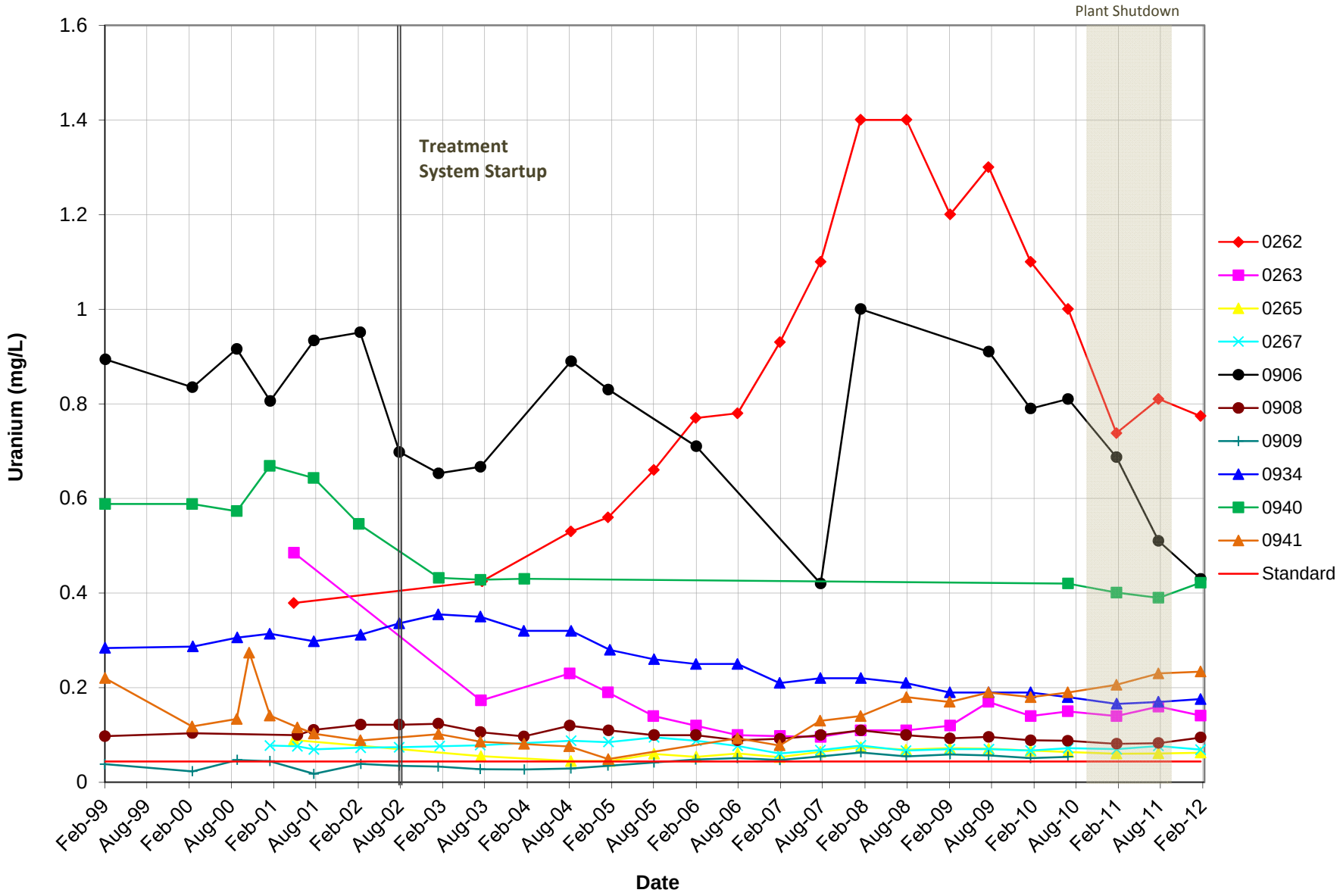


*Figure E−3. Horizons A and B Monitoring Wells, Uranium Concentrations*

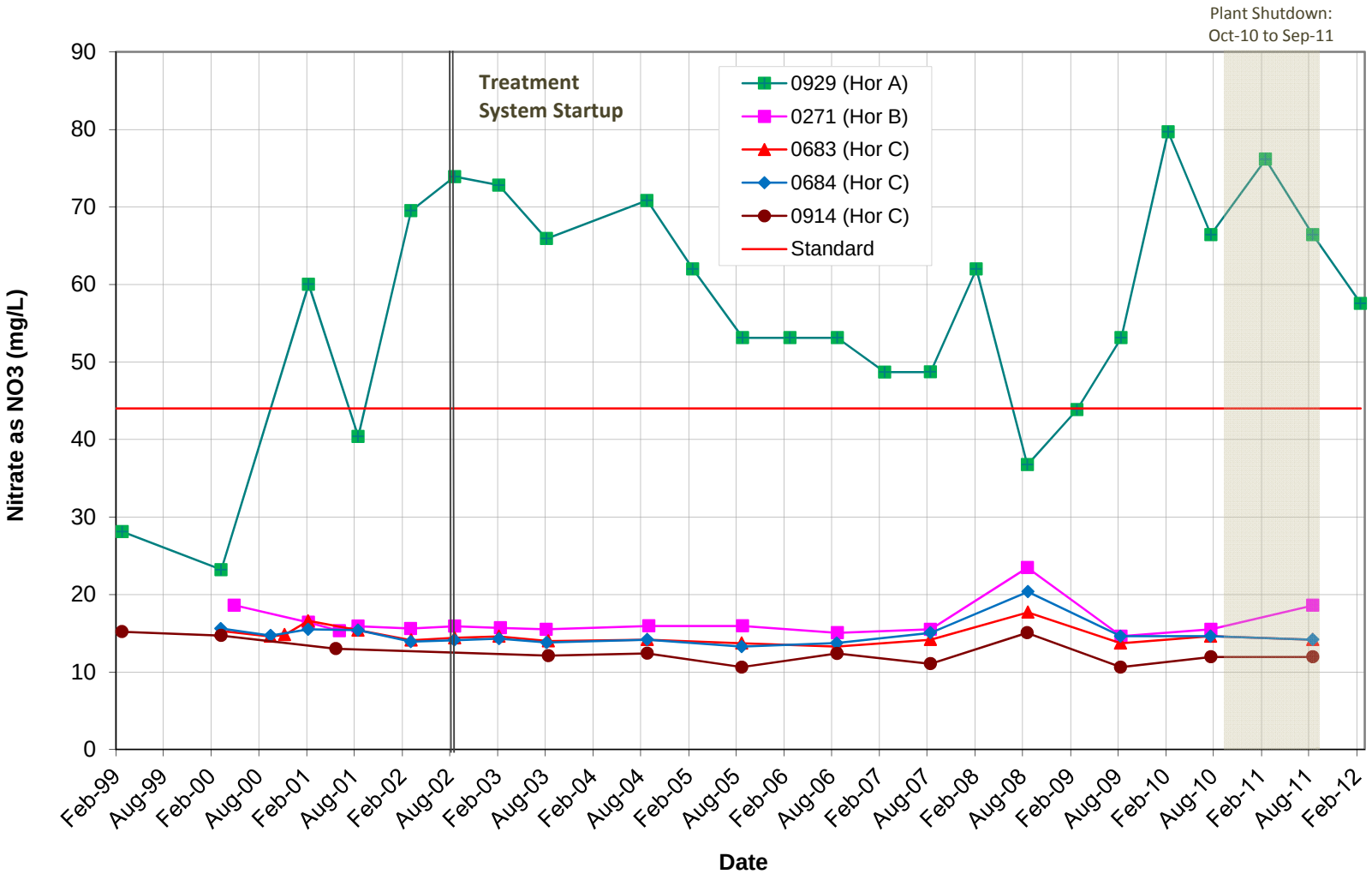


*Figure E−4. Horizons A–C Sentinel Wells, Nitrate as $NO_3$ Concentrations*

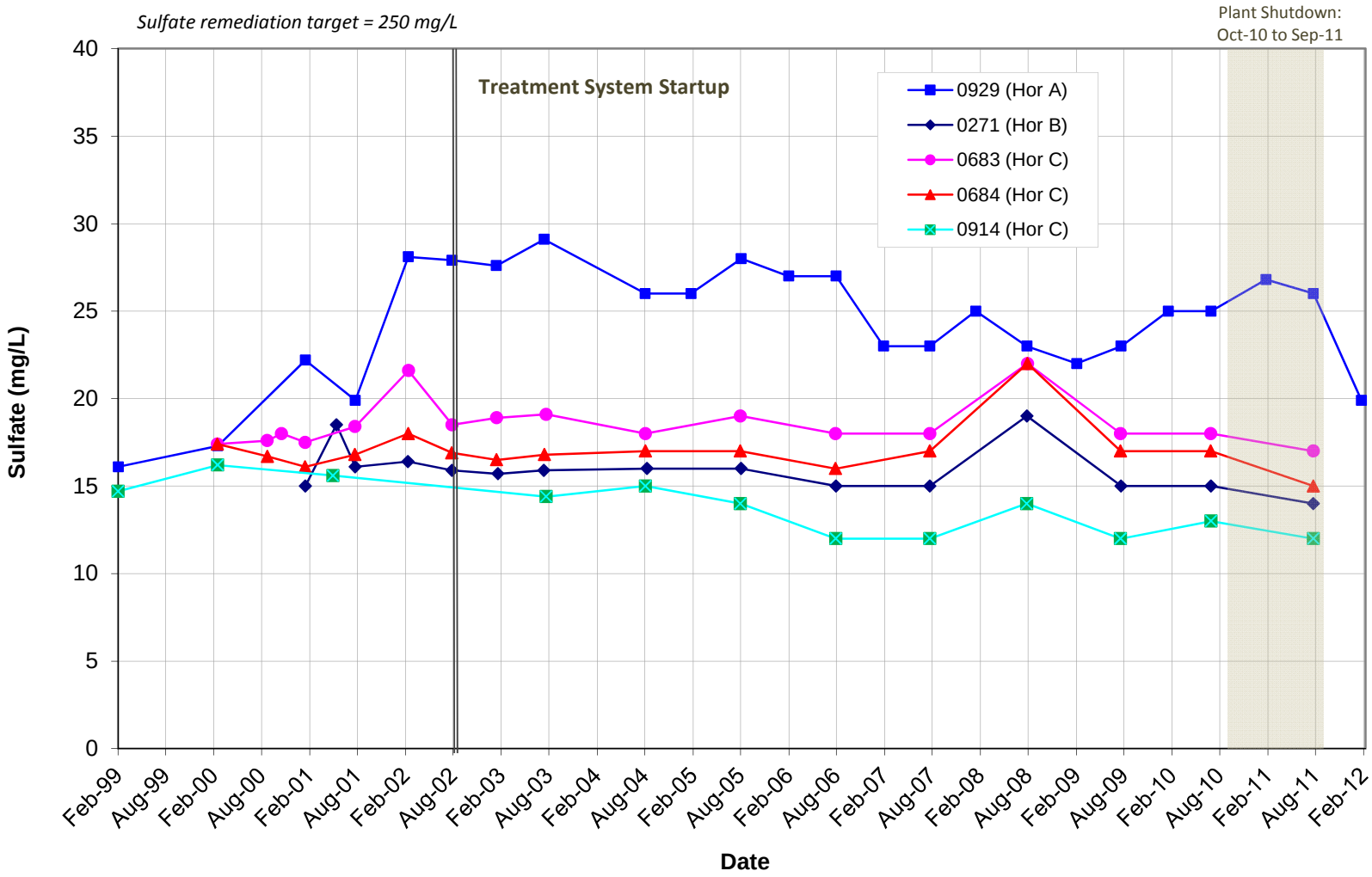


*Figure E−5. Horizons A–C Sentinel Wells, Sulfate Concentrations*

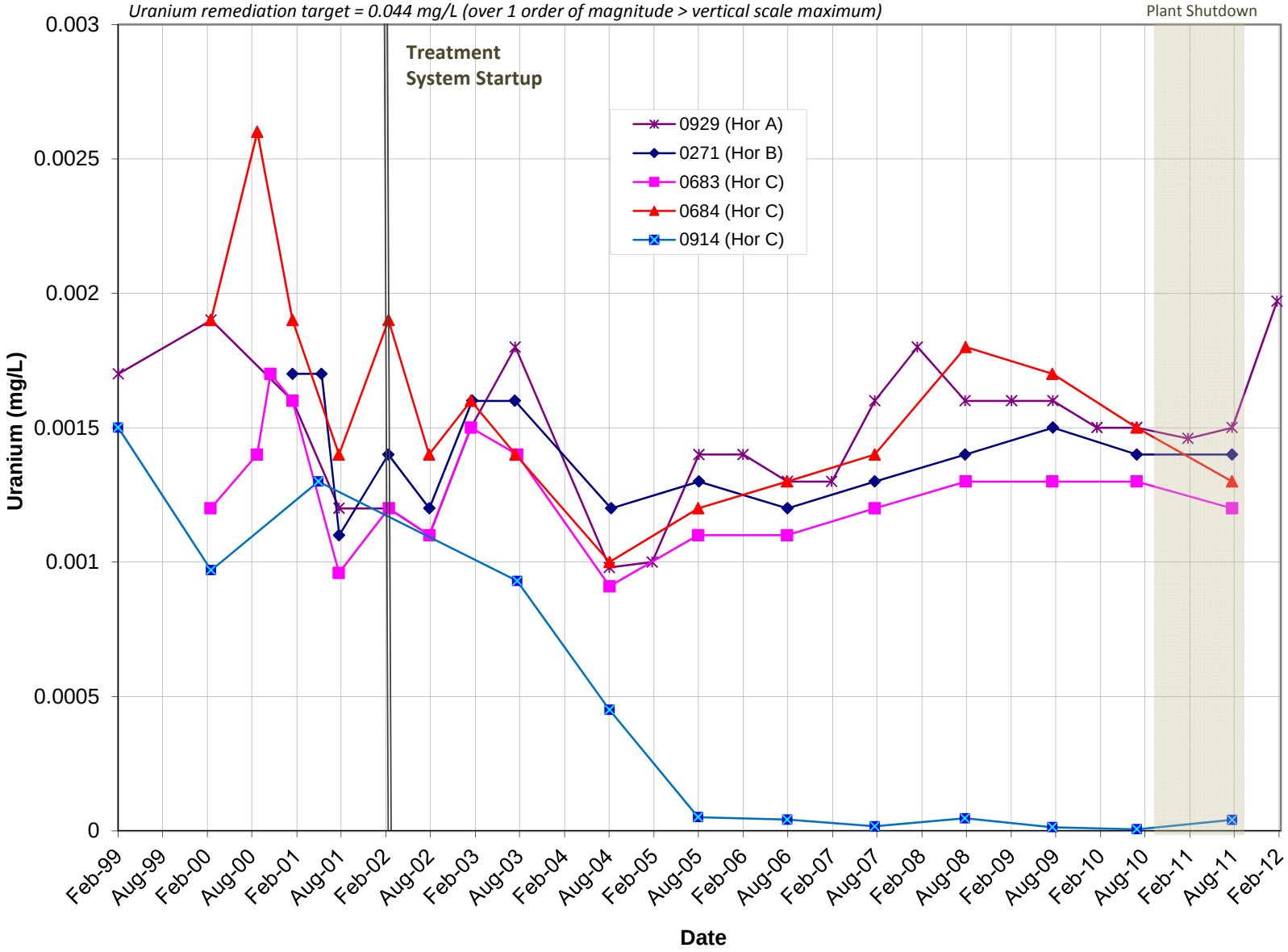


*Figure E−6. Horizons A–C Sentinel Wells, Uranium Concentrations*

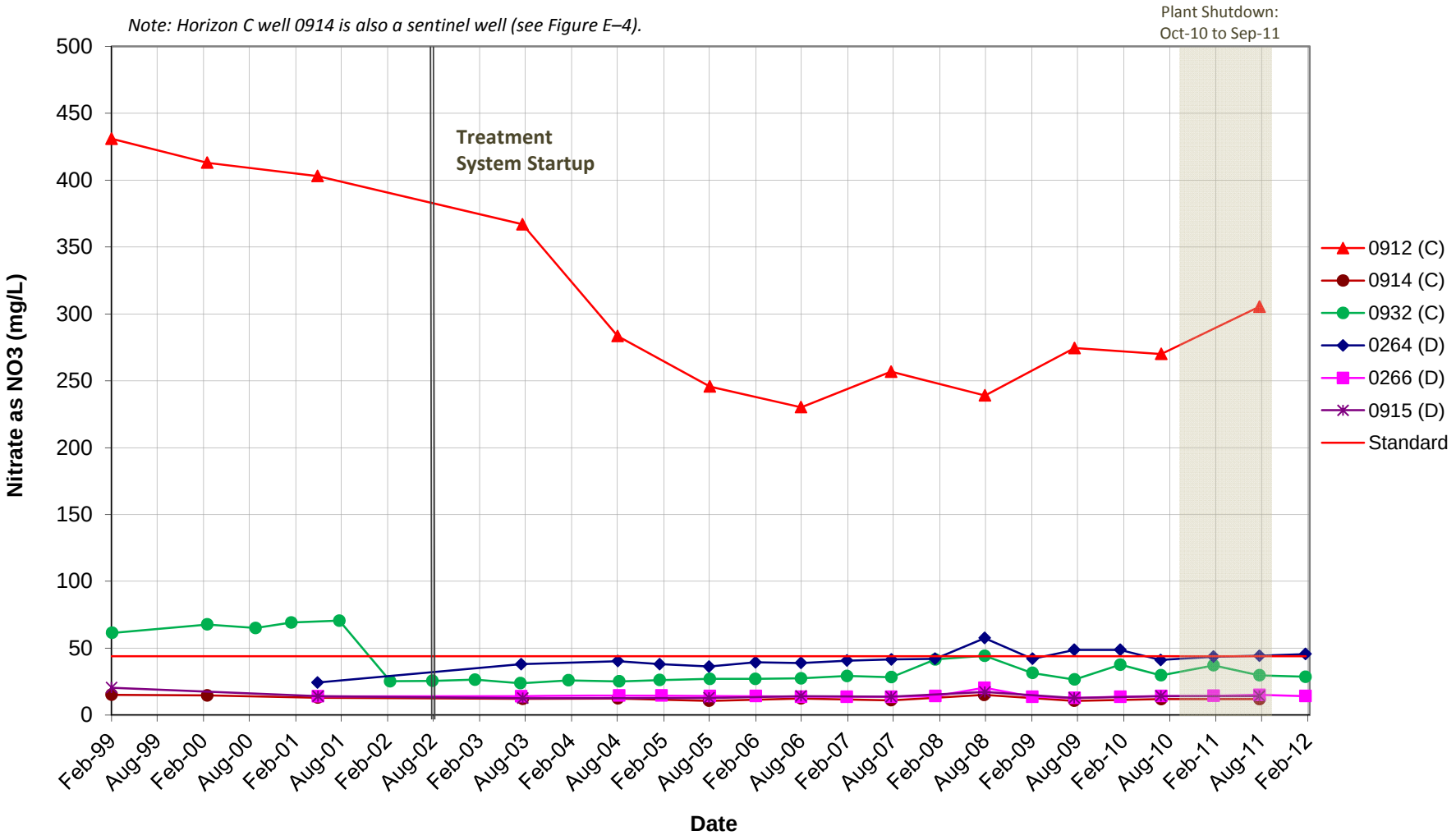


*Figure E−7. Horizons C and D Monitoring Wells, Nitrate as $NO_3$ Concentration*

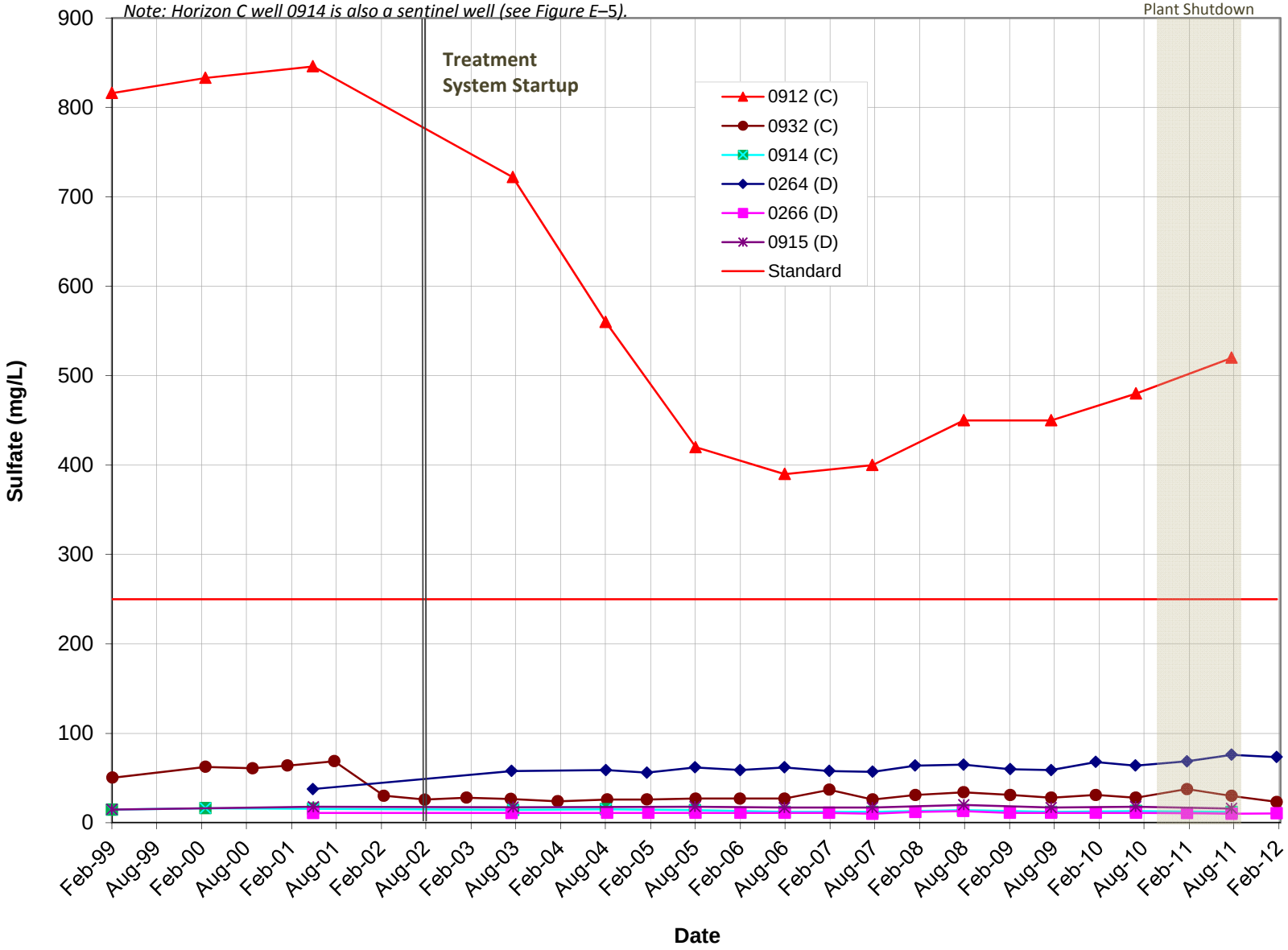


*Figure E−8. Horizons C and D Monitoring Wells, Sulfate Concentration*

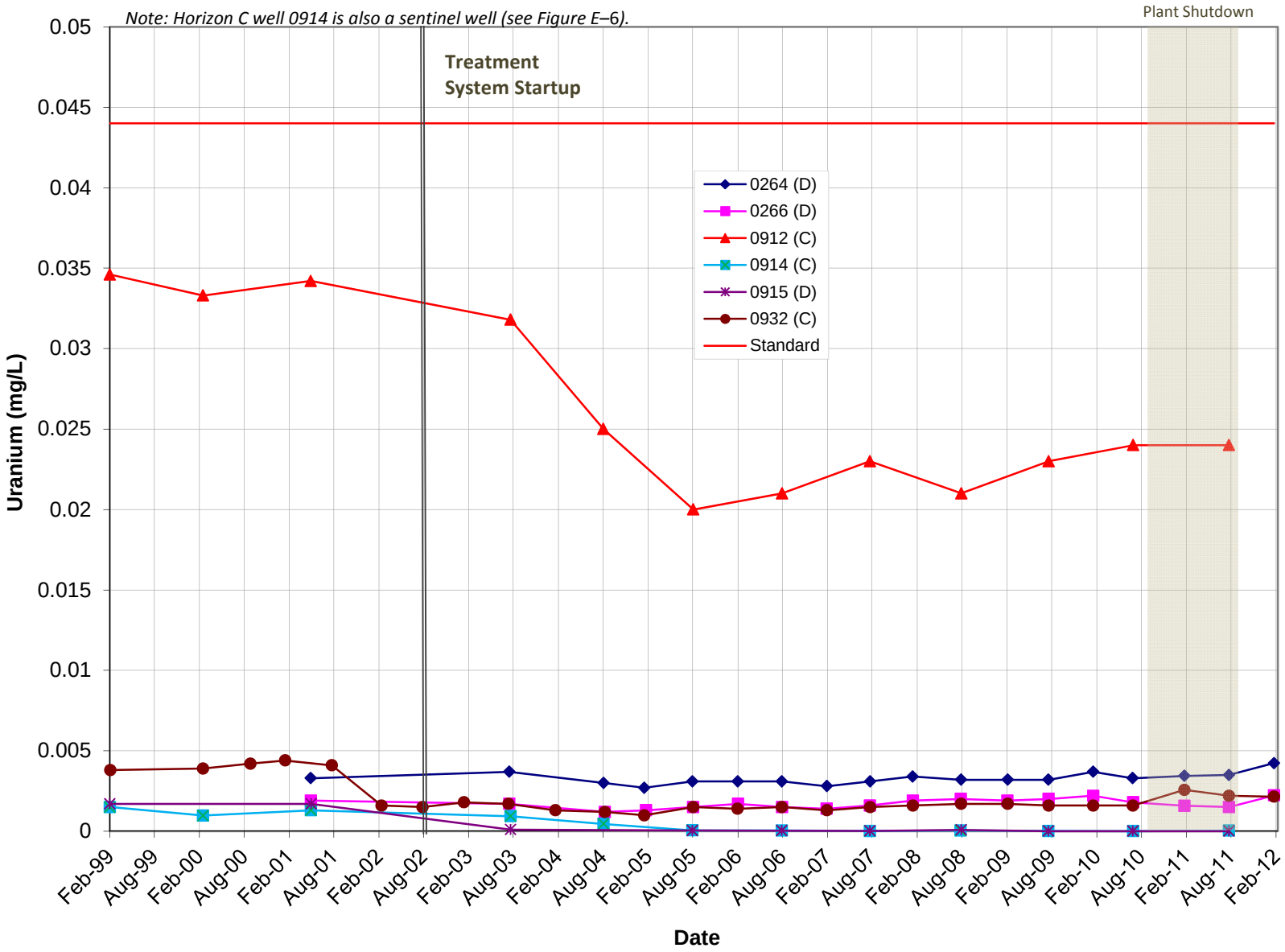


*Figure E−9. Horizons C and D Monitoring Wells, Uranium Concentration*

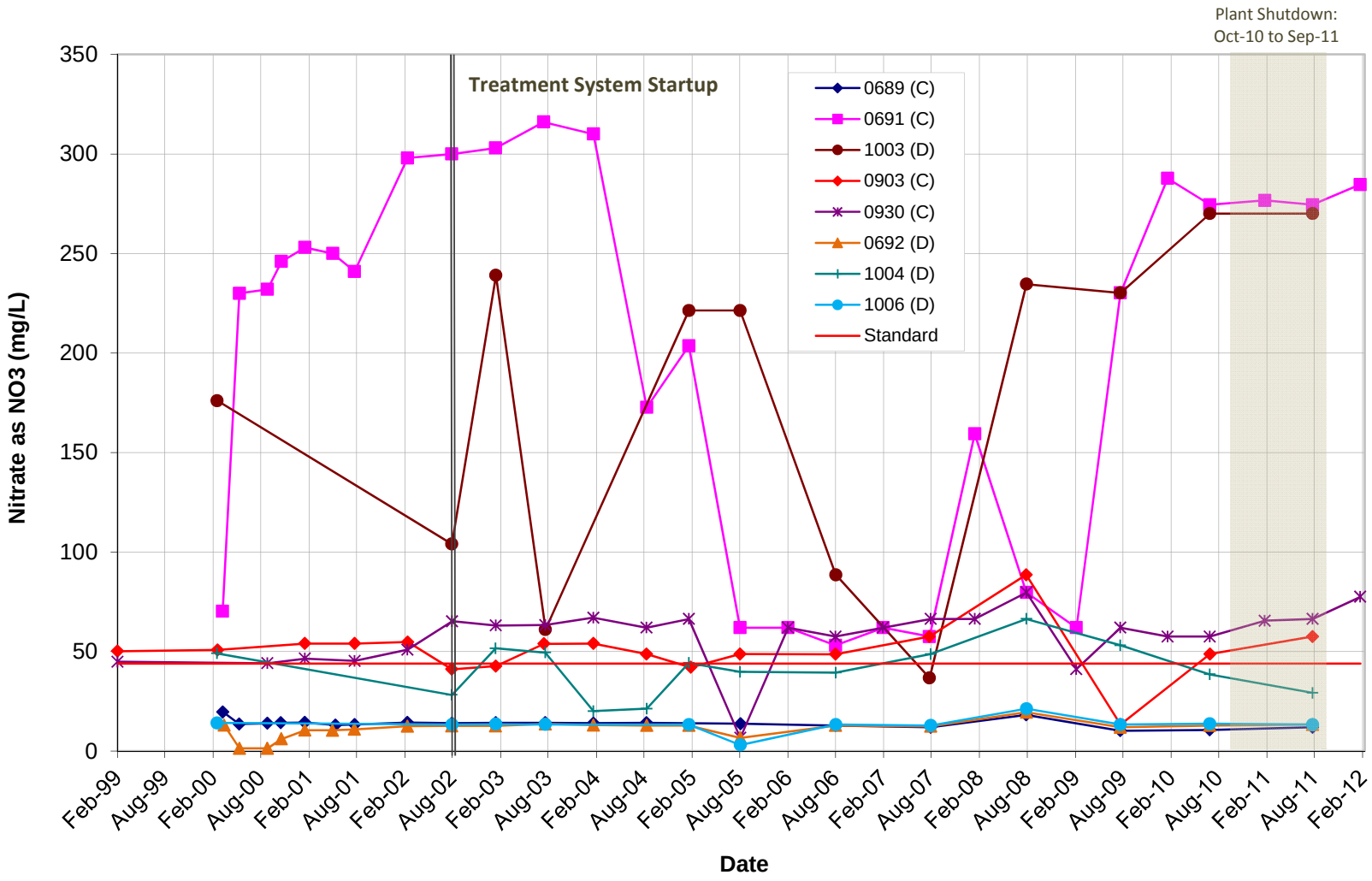


*Figure E−10. Horizons C and D Lower Terrace Monitoring Wells, Nitrate as $NO_3$ Concentration*

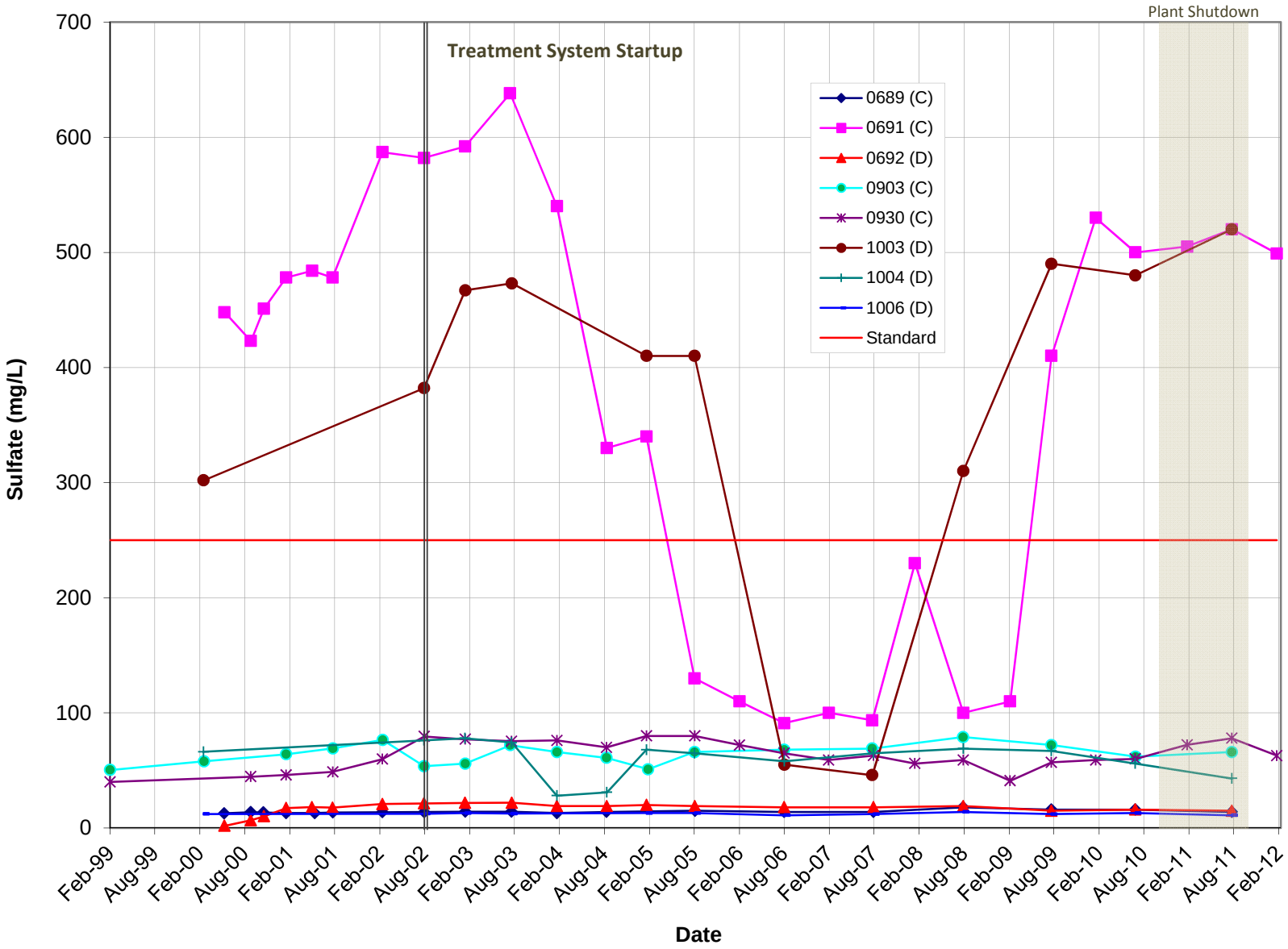


*Figure E−11. Horizons C and D Lower Terrace Monitoring Wells, Sulfate Concentration*

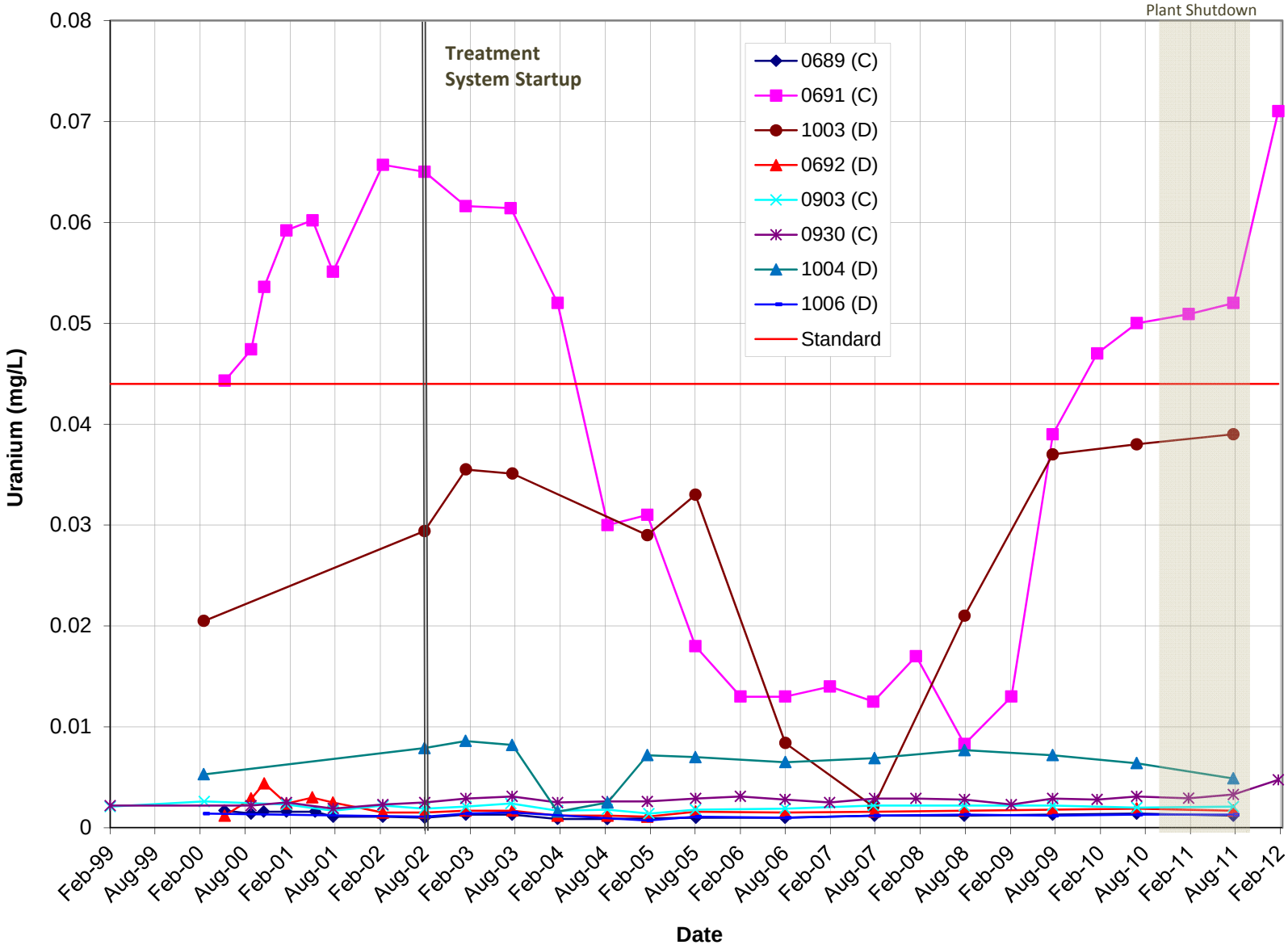


*Figure E−12. Horizons C and D Lower Terrace Monitoring Wells, Uranium Concentration*

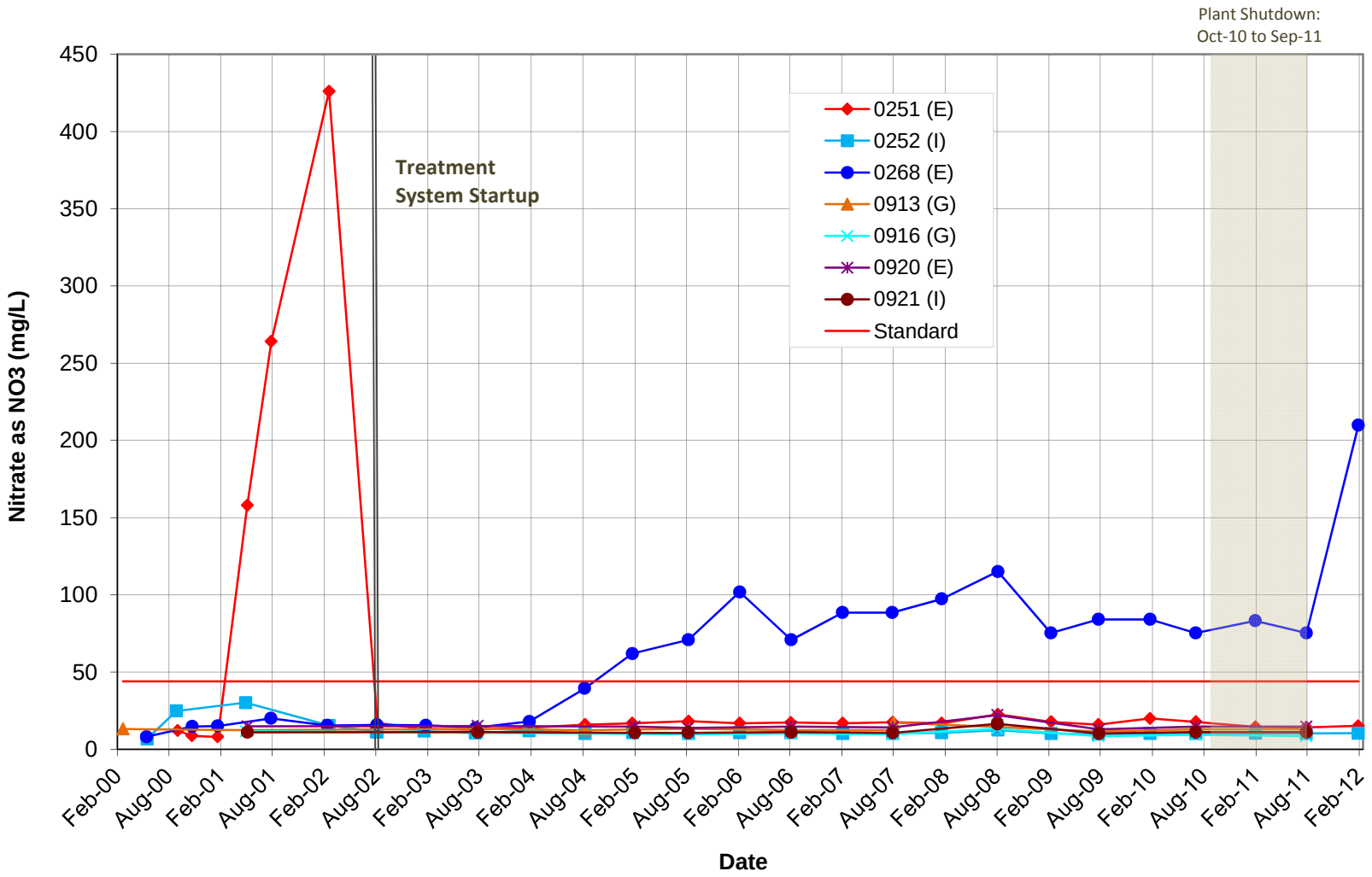


*Figure E−13. Deep Monitoring Wells, Nitrate as $NO_3$ Concentration*

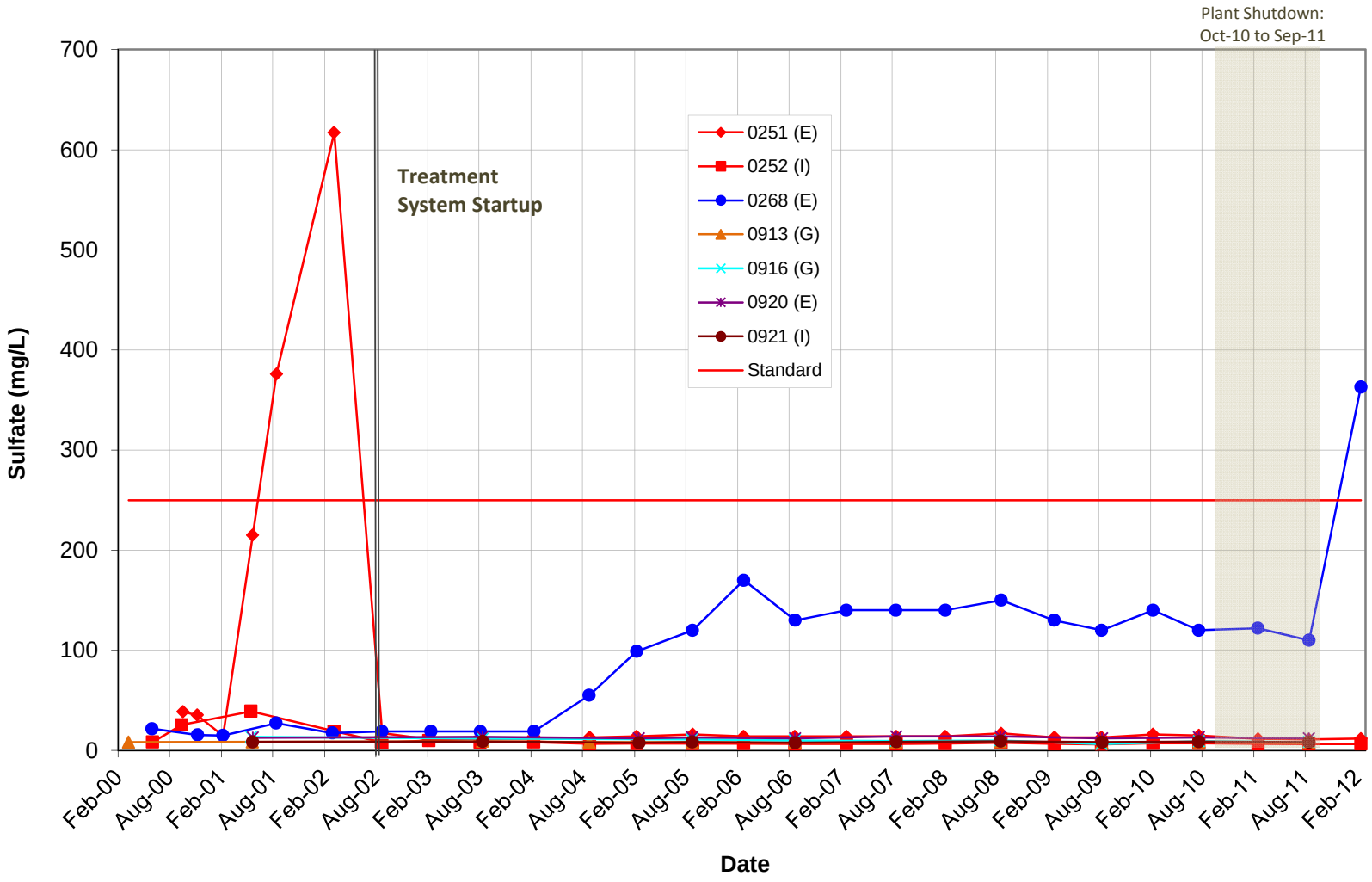


*Figure E−14. Deep Monitoring Wells, Sulfate Concentration*

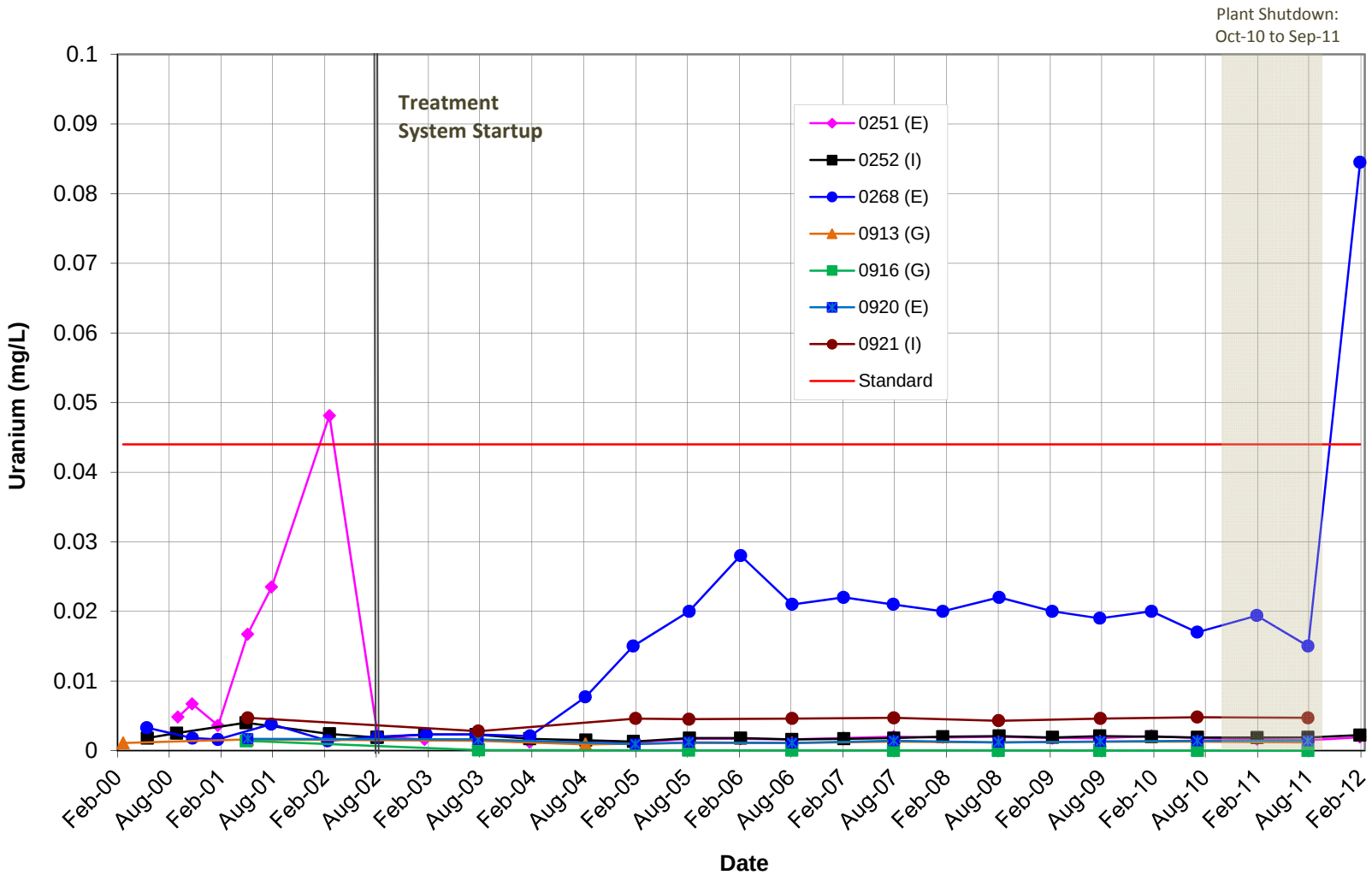


*Figure E−15. Deep Monitoring Wells, Uranium Concentration*

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