ERDF-00100
Revision 0

# Groundwater, Leachate, Lysimeter, Monitoring and Sampling at the Environmental Restoration Disposal Facility, Calendar Year 2018

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
Plateau Remediation Company

**P.O. Box 1600**
**Richland, Washington 99352**

Approved for Public Release;
Further Dissemination Unlimited

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Release Approval Date

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# Executive Summary

This document reports the findings of the groundwater, leachate, and lysimeter monitoring and sampling at the Environmental Restoration Disposal Facility (ERDF) for calendar year (CY) 2018. ERDF is a Hanford Site low-level mixed waste disposal facility that was brought into service on July 1, 1996. Baseline sampling and analytical data obtained from monitoring wells and the ERDF leachate collection system were used to determine contaminants of concern (COCs) and background conditions for long-term monitoring, as described in BHI-00079, *Groundwater Protection Plan for the Environmental Restoration Disposal Facility*,[1] and to meet the requirements of EPA, 1995, *Record of Decision, U.S. DOE Hanford Environmental Restoration Disposal Facility, Hanford Site, Benton County, Washington*[2] (hereinafter called the ERDF record of decision [ROD]).

The purpose of this annual monitoring report is to evaluate the conditions of and identify trends for groundwater beneath ERDF and report leachate results in fulfillment of the requirements specified in the ERDF ROD and EPA, 1999, *U.S. Department of Energy Environmental Restoration Disposal Facility, Hanford Site - 200 Area, Benton County, Washington, Amended Record of Decision, Decision Summary and Responsiveness Summary*.[3] The overall objective of the groundwater monitoring program is to determine whether ERDF has impacted the groundwater. This objective is complicated by the fact that ERDF is situated downgradient of numerous groundwater contamination plumes originating from the 200 West Area.

Each of the ERDF cells is constructed with a double-liner system for the purpose of collecting liquids or leachate that may travel through the waste materials stored at the disposal site. These liquids are typically generated from natural precipitation and the application of dust control water that percolates downward through the disposed waste materials and collects on the surface of the lining material. The primary liners and the

[1] BHI-00079, 1996, *Groundwater Protection Plan for the Environmental Restoration Disposal Facility*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

[2] EPA, 1995, *Record of Decision*, *U.S. DOE Hanford Environmental Restoration Disposal Facility, Hanford Site, Benton County, Washington*, U.S. Environmental Protection Agency, U.S. Department of Energy, and Washington State Department of Ecology. Available at: https://pdw.hanford.gov/arpir/pdf.cfm?accession=D196041064.

[3] EPA, 1999, *U.S. Department of Energy Environmental Restoration Disposal Facility, Hanford Site - 200 Area, Benton County, Washington*, *Amended Record of Decision, Decision Summary and Responsiveness Summary*, U.S. Environmental Protection Agency, Region 10, Seattle, Washington. Available at: https://pdw.hanford.gov/arpir/pdf.cfm?accession=D199122784.

secondary liners each are designed to deliver leachate to sump areas. Sumps for the primary liners are independent from the sumps associated with the secondary liners. The primary and secondary sumps at each of the cells are routinely evacuated, and the leachate is stored in holding tanks prior to transfer to the 200 West Pump and Treat (P&T) Facility.

The leachate in the storage tanks is sampled quarterly to (1) provide data to maintain leachate delisting status, (2) provide confirmation that the approved treatment facility acceptance criteria are continuing to be met, and (3) assess whether additional COCs should be added to the routine ERDF groundwater monitoring program.

ERDF has been expanded from its original 2 cells to currently 10 cells. Beginning with construction of cells 5 and 6, gravity collection basin lysimeters (lysimeters) were included in response to DOE/RL-2003-31, *Study of Vadose Zone Monitoring at the Hanford Site, Task 1, Use in New Cells at the Environmental Restoration Disposal Facility*.[4] The lysimeters are installed under the ERDF cells. Lysimeter liquids are collected via a perforated pipe laid on top of a geomembrane below all engineered components of the cells. All subsequent cells have had basin lysimeters installed. The lysimeters are dewatered and sampled annually.

The ERDF groundwater monitoring program is integrated with the larger Hanford Site groundwater monitoring program, in which groundwater sampling is conducted across the entire Hanford Site. Groundwater samples are collected semi-annually from four monitoring wells in the vicinity of ERDF. The monitoring well network consists of one upgradient well (699-36-70A) and three downgradient wells (699-37-66, 699-35-66A, and 699-36-66B). Wells 699-37-66 and 699-36-66B were constructed in 2007 and 2008 to replace two wells (699-36-67 and 699-37-68) removed due to the ERDF expansion. Groundwater monitoring wells in the ERDF well network have exhibited a gradual rate of decline in water levels since monitoring was initiated in September 1995.

The following summary is offered based on the CY 2018 analytical results; the statistical analysis of monitoring data; an evaluation of the groundwater, leachate, and lysimeter monitoring data; and a review of the water-level measurement data.

[4] DOE/RL-2003-31, 2003, *Study of Vadose Zone Monitoring at the Hanford Site, Task 1, Use in New Cells at the Environmental Restoration Disposal Facility*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

## Groundwater

Nitrate, carbon tetrachloride, gross beta, gross alpha, technetium-99, iodine-129, and uranium present in groundwater samples collected from ERDF monitoring wells are due to the migration of upgradient contaminants in the aquifer from non-ERDF sources in the 200 West Area. Two replacement groundwater wells (699-37-66 and 699-36-66B) have been constructed within the existing groundwater contamination plumes that have been moving slowly in the downgradient direction beneath ERDF. These two replacement wells were placed farther downgradient than the original wells. This may extend the time for contaminant peaks from historical releases in the 200 West Area to pass the downgradient wells due to the increased travel time of the groundwater between monitoring locations. The seven 200 West Area source contaminant peaks from sources immediately upgradient to ERDF appear to have passed the upgradient well between CY 2000 and CY 2005. In general, the contamination levels have been trending downward in the upgradient well; however, the CY 2018 results for uranium show an increase over values found from CY 2008 through CY 2016.

Groundwater activities from gross beta have varied from a long-term upward trend in each of the downgradient wells to showing a recent decline in wells 699-36-70A and 699-36-66B. Well 699-36-70A was below the upper tolerance limits for CY 2018, while wells 699-36-66B, 699-35,-66A, and 699-37-66 were above the upper tolerance limit. Gross alpha activities are typically nondetect; however, multiple detections were noted in CY 2018, three of which exceeded the upper tolerance limit at wells 699-36-70A, 699-36-66B, and 699-35-66A in the March 2018 sampling event.

Groundwater activity from uranium and iodine-129 has remained stable with a general long-term downward trend. Both uranium and iodine-129 concentrations increased in CY 2018, but each well is below the upper tolerance limit. Levels of technetium-99 in all wells except 699-35-66A remained essentially stable in CY 2018. Technetium-99 is the primary contributor to the measured gross beta activity in the ERDF wells. Uranium, technetium-99, gross alpha, and gross beta will continue to be monitored in future sampling to evaluate the data for adverse impacts from the ERDF leachate to the groundwater at this location.

Nitrate concentrations have remained stable to slightly decreasing, and all values were below the upper tolerance limits in CY 2018. Carbon tetrachloride concentrations remain low, below the upper tolerance limit in CY 2018.

Additional radionuclides and chemical constituents are monitored in routine analyses. In general, concentrations remain stable to slightly decreasing.

Historical analysis has shown periodic spikes in the groundwater data for arsenic. CY 2018 arsenic results indicated a potential upward trend in the upgradient well but a downward trend with the downgradient wells. Both spring and fall sample results from well 699-36-70A exceeded the upper tolerance limit. No Hanford Site-derived sources for arsenic have been identified for potential impact in the groundwater under ERDF. Pre-Hanford use of arsenic in agriculture may be the source of this contamination.

Chromium levels in downgradient well 699-35-66A have historically been elevated and remain above the upper tolerance limit. Well 699-36-70A chromium levels decreased significantly in the fall 2016 sampling, to a level similar to the wells below the upper tolerance limit. Between the 2016 spring and fall sampling, the pump in well 699-36-70A was replaced. The fall analysis showed a significant drop to levels comparable with downgradient wells 699-37-66 and 699-36-66B. It is likely that the elevated chromium levels seen were associated with the older pump. All other wells are stable at a level below the upper tolerance limit. Chromium levels and other corrosion products will continue to be monitored in future sampling.

Total organic halide concentrations have historically and significantly spiked in the ERDF wells. Most recently, all wells spiked in CY 2012 and CY 2013. Two groundwater wells (699-37-66 and 699-36-66B) appear to have been placed within the existing groundwater contamination plume that has been slowly moving in the downgradient direction beneath ERDF. Analysis has shown periodic spikes in the groundwater data in the past. No correlations have been determined between total organic halide results and the volatile organic analyses performed at the same time (volatile organic analyses have reported unexpected detections of chlorinated organics, the most likely contributor to total organic halide results). Total organic halide analysis is only an indicator analysis. In rcent years, samples have been mostly upward indicating. Concentrations in each ERDF wells were above the upper tolerance limit in either the spring or fall sampling. Well 699-37-66 has stayed above the upper tolerance limit since CY 2017. Any future indication of consistent contamination will be evaluated to establish the source and composition of the compounds.

The CY 2018 concentration results for selenium were steady with none of the sample results exceeding the upper tolerance limit. The hydrogen ion concentration (pH) for all wells remains within the tolerance limit range for the CY 2018 sampling; monitoring will continue.

## Leachate

Historically, leachate samples were routinely collected during March and September of each year. Beginning in 2016, sampling was increased to quarterly to provide additional data for the treatment facility. The composition of the leachate will reflect the contamination levels of the wastes being disposed. The samples are analyzed for the routine list of approximately 50 constituents.

The upward trend for chromium (total and hexavalent) noted previously, peaked in June 2017 and remained above the one-tenth hexavalent chromium delisting value. The only other analyte detected at concentrations greater than one-tenth of the delisting value was nitrate. All nitrate values to date have exceeded one-tenth of the delisting values. No significant changes were noted for the remaining routine analytes.

Based on the evaluation of the CY 2018 data, there has been no correlation between leachate COC levels and groundwater COC levels that would indicate the leachate is impacting the groundwater under ERDF. Therefore, no additional analytes are recommended for the groundwater monitoring program or the routine leachate sampling.

## Lysimeters

The source of the liquid within the lysimeters is from the vadose zone located beneath the ERDF cell liner and is made up of compaction moisture (construction water, consolidation water, and/or condensation water) from the admix layer located immediately above the lysimeter. The absence of technetium-99 within the lysimeter liquid is a good indicator that the leachate collection system located above the lysimeters is not leaking liquid into the lysimeters. This is based on the presence of technetium-99 in the leachate and the high solubility and mobility of technetium-99 through soils; Additional supporting evidence is the high sulfate concentration in the lysimeter liquid in comparison to the leachate, indicating there is no effective dilution of the lysimeter liquid.

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# Terms

| | |
|---|---|
| CERCLA | *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* |
| COC | contaminant of concern |
| CY | calendar year |
| EPA | U.S. Environmental Protection Agency |
| ERDF | Environmental Restoration Disposal Facility |
| e-tape | electronic tape measure |
| GPP | groundwater protection plan |
| P&T | pump and treat |
| pH | hydrogen ion concentration |
| RCRA | *Resource Conservation and Recovery Act of 1976* |
| ROD | record of decision |
| SAP | sampling and analysis plan |

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# 1 Introduction

The Environmental Restoration Disposal Facility (ERDF) is a Hanford Site low-level mixed waste disposal facility that was brought into service on July 1, 1996. Baseline sampling and analytical data obtained from monitoring wells and the ERDF leachate collection system were used to determine contaminants of concern (COCs) and background conditions for long-term monitoring, as described in the initial BHI-00079, *Groundwater Protection Plan for the Environmental Restoration Disposal Facility,* and to meet the requirements of EPA, 1995, *Record of Decision, U.S. DOE Hanford Environmental Restoration Disposal Facility, Hanford Site, Benton County, Washington* (hereinafter called the ERDF record of decision [ROD]). Based on about 10 years of the ERDF monitoring activities and statistical evaluations of the data, the original groundwater protection plan (BHI-00079) was revised (CP-60092, *Groundwater Protection Plan for the Environmental Restoration Disposal Facility, formerly WCH-198, Rev. 1*, hereinafter called the ERDF groundwater protection plan [GPP]), and a new plan (CP-60070, *Environmental Restoration Disposal Facility Leachate Sampling and Analysis Plan, formerly WCH-173 Rev. 2*, hereinafter called the ERDF sampling and analysis plan [SAP]), was approved. The ERDF SAP was revised in 2015, and the ERDF GPP (CP-60092) was revised in 2016. Any new requirements or changes in evaluation that were recommended by the revised ERDF SAP (CP-60070) are included in this report. Future reports will incorporate changes or revisions to the ERDF GPP (CP-60092). Ongoing groundwater and leachate monitoring are performed to meet the requirements of the ERDF ROD, DOE O 435.1, *Radioactive Waste Management,* and the ERDF Performance Assessment (CP-60152, *Performance Assessment Monitoring Plan for the Environmental Restoration Disposal Facility, formerly WCH-579 Rev. 1*); details of the monitoring program are described in the revised ERDF GPP (CP-60092) and EPA, 1999, *U.S. Department of Energy Environmental Restoration Disposal Facility, Hanford Site - 200 Area, Benton County, Washington Amended Record of Decision, Decision Summary and Responsiveness Summary* (hereinafter called the ERDF Amended ROD).

## 1.1 Purpose and Objectives

The purpose of this annual monitoring report is to evaluate the conditions of and identify trends for groundwater beneath ERDF, and to report leachate results in fulfillment of the requirements specified in the ERDF ROD and the ERDF Amended ROD. The objectives of this report are as follows:

- Review routine groundwater sampling data to evaluate if there have been changes in COC concentrations over time that may be attributed to the ERDF operations.
- Assess conditions that may indicate the presence of encroaching groundwater contaminant plumes originating from upgradient sources in the 200 West Area.
- Assess data from routine ERDF leachate sampling to determine if additional constituents should be added to the ERDF groundwater monitoring COCs list and to confirm that leachate concentrations do not exceed delisting levels specified in the ERDF Amended ROD.
- Evaluate the groundwater levels in the ERDF monitoring wells to determine if the existing wells need to be modified or replaced.
- Biennially evaluate waste streams disposed at ERDF as part of the delisting criteria for the leachate.

- Describe and evaluate the conditions and identify trends of the ERDF lysimeter system as related to the vadose zone monitoring and changes in the volume of liquid in the lysimeters.
- Describe and evaluate the sample data, identify changes or trends in the data, and incorporate a summary of the results.

Appendix A shows analytical results for groundwater samples that were collected from the ERDF monitoring well network from calendar year (CY) 1996 through CY 2018.

Appendix B graphically shows trends in the monitoring data resulting from routine groundwater sampling in the ERDF well network.

The most recent 3 years of leachate analytical results for samples collected from CY 2016 through CY 2018 are presented in Appendix C. Leachate data collected from CY 1996 through CY 2017 are contained in previous ERDF groundwater and leachate monitoring reports:

- BHI-01382, *Groundwater Monitoring and Sampling at the Environmental Restoration Disposal Facility, Calendar Year 1996 Through 1999*
- BHI-01641, *Groundwater Monitoring and Sampling at the Environmental Restoration Disposal Facility, Calendar Year 2001*
- BHI-01684, *Groundwater and Leachate Monitoring and Sampling at the Environmental Restoration Disposal Facility, Calendar Year 2002*
- BHI-01738, *Groundwater and Leachate Monitoring and Sampling at the Environmental Restoration Disposal Facility, Calendar Year 2003*
- BHI-01777, *Groundwater and Leachate Monitoring and Sampling at the Environmental Restoration Disposal Facility, Calendar Year 2004*
- WCH-88, *Groundwater and Leachate Monitoring and Sampling at the Environmental Restoration Disposal Facility, Calendar Year 2005*
- WCH-189, *Groundwater and Leachate Monitoring and Sampling at ERDF, CY 2006*
- WCH-295, *Groundwater and Leachate Monitoring and Sampling at ERDF, CY 2007*
- WCH-315, *Groundwater and Leachate Monitoring and Sampling at ERDF, CY 2008*
- WCH-399, *Groundwater and Leachate Monitoring and Sampling at ERDF, CY 2009*
- WCH-455, *Groundwater and Leachate Monitoring and Sampling at ERDF, CY 2010*
- WCH-536, *Groundwater and Leachate Monitoring and Sampling at the Environmental Restoration Disposal Facility, Calendar Year (CY) 2011*
- WCH-564, *Groundwater, Leachate, and Lysimeter Monitoring and Sampling at the Environmental Restoration Disposal Facility, Calendar Year (CY) 2012*
- WCH-590, *Groundwater, Leachate, and Lysimeter Monitoring and Sampling at the Environmental Restoration Disposal Facility, Calendar Year 2013*
- WCH-613, *Groundwater, Leachate, and Lysimeter Monitoring and Sampling at the Environmental Restoration Disposal Facility, Calendar Year 2014*

- WCH-633, *Groundwater, Leachate, and Lysimeter Monitoring and Sampling at the Environmental Restoration Disposal Facility, Calendar Year 2015*
- ERDF-00050, *Groundwater, Leachate, and Lysimeter Monitoring and Sampling at the Environmental Restoration Disposal Facility, Calendar Year 2016*
- ERDF-00075, *Groundwater, Leachate, and Lysimeter Monitoring and Sampling at the Environmental Restoration Disposal Facility, Calendar Year 2017*

Appendix D graphically shows trends in monitoring data from routine sampling in the ERDF leachate samples.

Appendix E contains CY 2018 analytical data for the lysimeter sampling. Lysimeter data collected from CY 1996 through CY 2010 are contained in previous ERDF lysimeter monitoring reports:

- WCH-42, *Annual Report for Gravity Collection Lysimeter Monitoring Plan – ERDF Cells 5 and 6*
- WCH-335, *Annual Report for Gravity Collection Lysimeter Monitoring Plan – ERDF Cells 5 and 6, CY 2008*
- WCH-400, *Annual Report for Gravity Collection Lysimeter Monitoring in ERDF Cells 5, 6, 7, and 8, CY 2009*
- WCH-454, *Annual Report for Gravity Collection Lysimeter Monitoring in ERDF Cells 5, 6, 7, and 8, CY 2010*

Lysimeter data for CY 2011 through CY 2017 were combined with the ERDF groundwater and leachate monitoring reports (WCH-536, WCH-564, WCH-590, WCH-613, WCH-633, ERDF-00050, and ERDF-00075).

# 2 Background

## 2.1 General Description

The ERDF site is located between the 200 East and 200 West Areas of the Hanford Site (Figure 1). This location was selected for ERDF because of the depth to groundwater in this area, its location above pre-existing groundwater plumes, the relatively flat topography in this area, and the compatibility of this location with stakeholder recommendations.

The ERDF landfill is authorized under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). The landfill was designed to meet the *Resource Conservation and Recovery Act of 1976* (RCRA) minimum technology requirements; however, ERDF is not permitted as a RCRA facility. Wastes disposed at ERDF contain elevated levels of radionuclides and hazardous constituents originating from the 100, 200, and 300 Area waste sites.

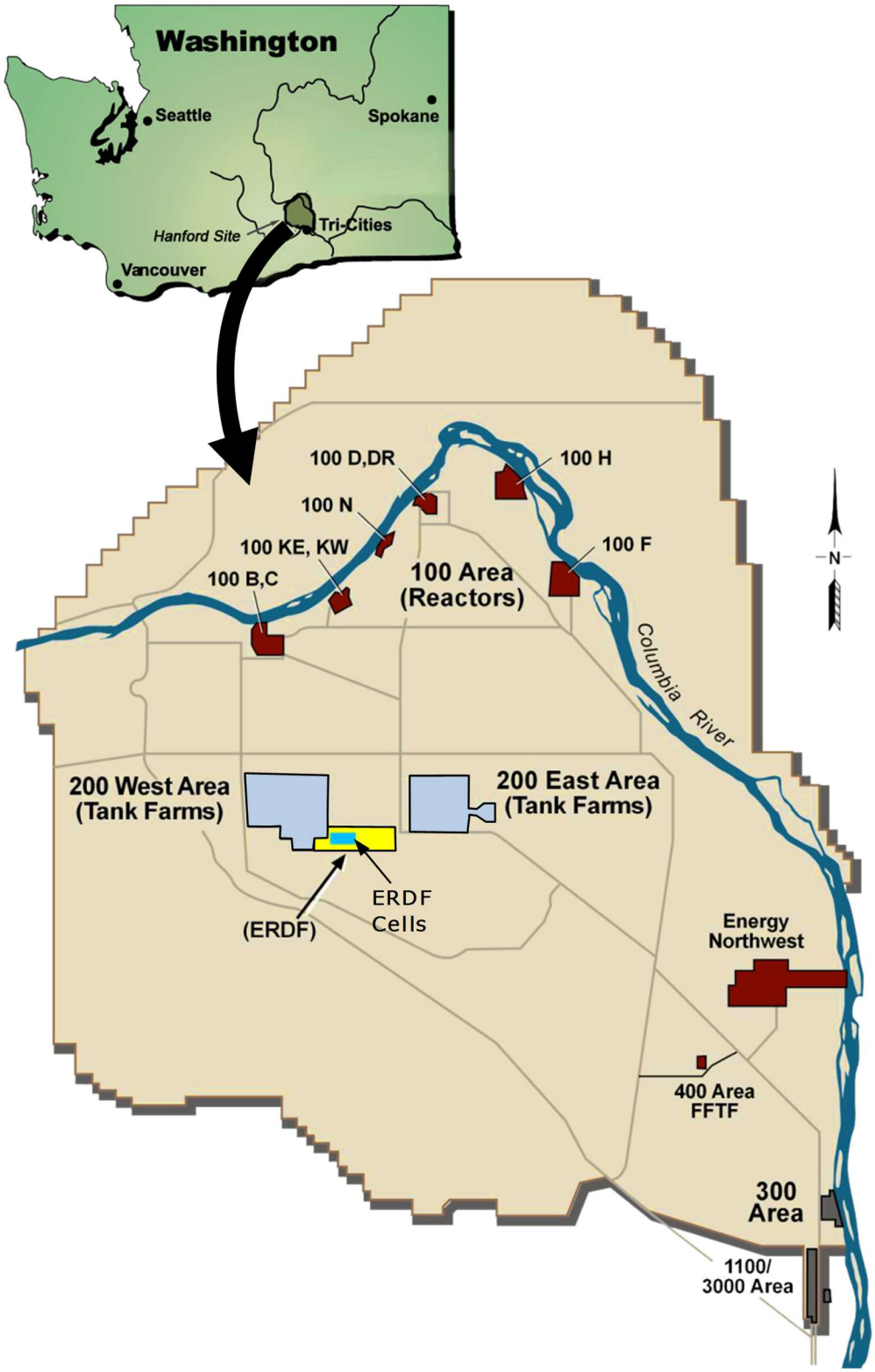


**Figure 1. Location of the Environmental Restoration Disposal Facility**

## 2.2 Environmental Restoration Disposal Facility

ERDF is a landfill for disposal of wastes generated from remediation of waste sites within the Hanford Site. To support ongoing remedial actions, ERDF was constructed on the Central Plateau of the Hanford Site between the 200 West and 200 East Areas, well away from the Columbia River. The ERDF cells are designed to expand in disposal volume as necessary. As of CY 2018, 10 ERDF cells have been constructed (Figure 2). The initial disposal cells were completed and began receiving waste in July 1996. Since the beginning of operations, cells 1 through 4 have been filled and was covered with an interim cover, cells 5 and 6 were filled, and cells 7 through 10 are nearly filled. Additional disposal capacity was added with the approval of a vertical expansion in 2015. The vertical expansion added approximately 2.2 million cubic yards of capacity by placing waste lifts over the top of previously disposed waste, increasing the total height of the waste column. The vertical expansion design is documented in WCH-632, *ERDF Vertical Expansion Design*. Throughout CY 2018, approximately 175,807 metric tons (193,794 U.S. tons) of waste was disposed at the facility.

### 2.2.1 Leachate System

Each of the ERDF cells was constructed with a double-liner system for the purpose of collecting liquids or leachate that may travel through the waste materials stored at the disposal site. These liquids are primarily generated from natural precipitation and the application of dust control water that percolates downward through the disposed waste materials and collects on the surface of the lining material. The primary (upper) and secondary (lower) liners each are designed to deliver leachate to sump areas. Sumps for the upper liners are independent from the sumps associated with the lower liners. The upper and lower sumps at each of the cells are routinely evacuated, and the leachate is stored in holding tanks prior to transfer to the 200 West Pump and Treat (P&T) Facility. A summary of recent annual leachate generation volumes is included in Appendix C.

### 2.2.2 Lysimeter System

Gravity collection lysimeters (basin lysimeters) were constructed in response to DOE/RL-2003-31, *Study of Vadose Zone Monitoring at the Hanford Site, Task 1, Use in New Cells at the Environmental Restoration Disposal Facility*. This study was performed by Fluor Hanford for the U.S. Department of Energy, Richland Operations Office. The purpose of the study was to report on the status of vadose zone monitoring and to recommend measures that could be taken at the Hanford Site to further develop the technology of vadose zone monitoring. Lysimeters were installed beginning with the construction of cells 5 and 6 and continued with all subsequent cell construction.

The lysimeter design selected from the study for installation under the ERDF cells was a basin lysimeter. This type of lysimeter is not configured to detect small increases in liquid accumulation. These are constructed by excavating a sloping recession within the cell sub-grade beneath the composite liner system and installing a liner into the area. A thick-walled, 15 cm (6 in.) diameter pipe is laid flat on the bottom of a collection area of approximately 50.7 $m^2$ (546 $ft^2$), increasing to 380.9 $m^2$ (4,100 $ft^2$) at the top of the lysimeter. The lysimeter has an approximate capacity to contain 181,699 L (48,000 gal) within the available pore space of the gravel.

The vadose zone monitoring activities are expected to continue until after the final landfill cap is installed and the annual quantity of leachate collected in the secondary leachate collection and removal system is shown to be insignificant (i.e., less than the amount needed to activate the removal pumps).

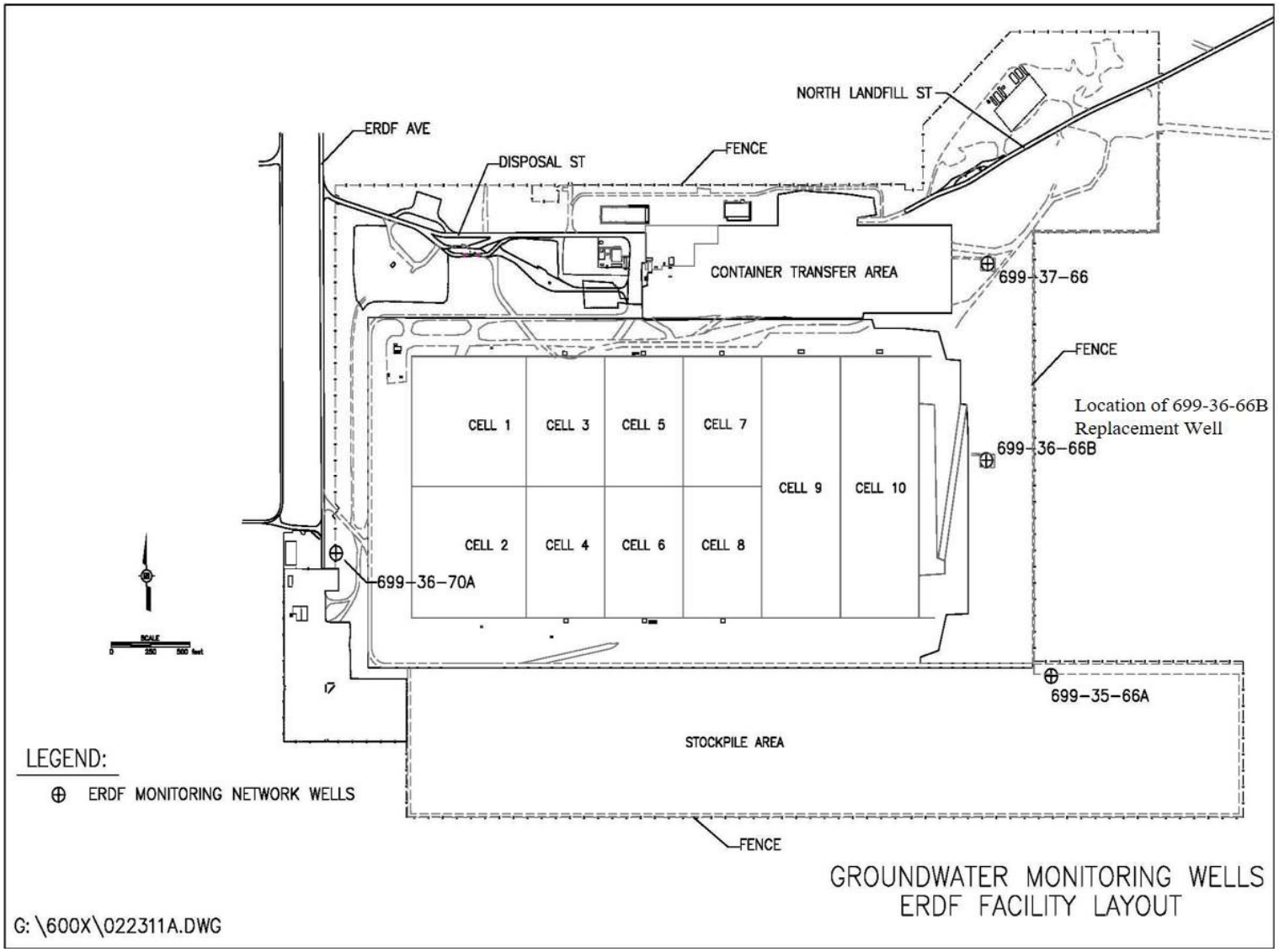


**Figure 2. The ERDF Monitoring Well Location Map**

# 3 Groundwater and Leachate Monitoring

The groundwater and leachate monitoring program is described in the ERDF GPP (CP-60092). This chapter provides an overview of these monitoring requirements.

## 3.1 Groundwater Sampling

Groundwater samples are collected semi-annually from four monitoring wells in the vicinity of ERDF. This monitoring well network is scheduled for routine sampling during the first and third quarters of each year. The monitoring well network consists of one upgradient well (699-36-70A) and three downgradient wells (699-37-66, 699-35-66A, and 699-36-66B). During CY 2018, groundwater sampling was completed at all of the ERDF monitoring wells in March and September. Well locations are shown in Figure 2.

The COCs for routine monitoring were determined based on the results of preoperational baseline sampling conducted from March 1996 through September 1997 and known contaminant plumes beneath ERDF. Additional COCs may be added to the groundwater monitoring program if analytical results from leachate sampling indicate it is warranted. To date, no additional COCs have been identified for addition to the groundwater lists based on leachate analysis results. Table 1 lists the analytes, acceptance criteria, and target maximum practical quantitation limits for the groundwater monitoring program.

**Table 1. Analytes, Acceptance Criteria, and Target Maximum Practical Quantitation Limit for Groundwater Samples**

| Analyte/Method | Target PQL | QC Element and Acceptance Criteria |
|---|---|---|
| **General Chemical Parameters** | | |
| **Alkalinity – 2320[a]** | 5 mg/L | Field Duplicate – ±20% RPD[b]<br>Field Blanks[d] – <MDL or <5% Sample Concentration<br>Method Blank – <MDL or <5% Sample Concentration<br>Laboratory Control Sample – 80-120% Recovery<br>Lab Duplicate – ±20% RPD[b]<br>Matrix Spike – 75-125% Recovery (not applicable for TDS) |
| **Total Organic Halides – 9020[c]** | 10 µg/L | |
| **Total Dissolved Solids – 2540C[a]** | 10 mg/L | |
| **Anions by IC – 9056 [c] or 300.0[e]** | | |
| Chloride | 0.4 mg/L | |
| Fluoride | 5 mg/L | |
| Sulfate | 0.55 mg/L | |
| **N in Nitrate/Nitrite – 353.2[f]** | 0.1 mg/L | |
| **Metals** | | |
| **Metals ICP-6010[c] or ICP/MS-6020[c]** | | Field Duplicate – ±20% RPD[b]<br>Field Blanks[d] – <MDL or <5% Sample Concentration<br>Method Blank – <MDL or <5% Sample Concentration<br>Laboratory Control Sample – 80-120% Recovery<br>Matrix Spike – 75-125% Recovery<br>Matrix Spike Duplicate – ±20% RPD[b] |
| Arsenic | 5 µg/L | |
| Barium | 5 µg/L | |
| Chromium | 10 µg/L | |
| Lead | 3 µg/L | |
| Selenium | 5 µg/L | |
| Tin | 5 µg/L | |
| Vanadium | 10 µg/L | |
| Zinc | 10 µg/L | |

**Table 1. Analytes, Acceptance Criteria, and Target Maximum Practical Quantitation Limit for Groundwater Samples**

| Analyte/Method | Target PQL | QC Element and Acceptance Criteria |
|---|---|---|
| **Volatile Organic Compounds** | | |
| **Volatiles by GC/MS –8260[c]** | | Field Duplicate – ±20% RPD[b]<br>Field Blanks[d] – <MDL or <5% Sample Concentration<br>Method Blank – <MDL or <5% Sample Concentration<br>Laboratory Control Sample – 70-130% recovery<br>Matrix Spike – 70-130% Recovery<br>Matrix Spike Duplicate – ±20% RPD[b]<br>Surrogates – 70-130% Recovery |
| Carbon Tetrachloride | 3 µg/L | |
| **Radionuclides** | | |
| Carbon-14 – LSC[g] | 50 pCi/L | Field Duplicate – ±20% RPD[b]<br>Field Blanks[d] – <MDL or 5% Sample Concentration<br>Method Blank – <MDC or 5% Sample Activity Concentration<br>Laboratory Control Sample – 80-120% Recovery<br>Lab Duplicate – ±20% RPD[b]<br>Matrix Spike – 75-125% Recovery for C-14, Tc-99, and Total Uranium<br>Tracer – 30-105% Recovery for I-129, Sr-90<br>Carrier – 40-110% Recovery for Total Radium Alpha, Sr-90 |
| Iodine-129 – LEPS, LSC, GPC[g] | 1 pCi/L | |
| Technetium-99 – LSC[g] | 50 pCi/L | |
| Total Radium Alpha – GPC[g] | 1 pCi/L | |
| Gross Alpha – GPC[g] | 3 pCi/L | |
| Gross Beta – GPC[g] | 4 pCi/L | |
| Total Uranium – 6020 | 1.0 mg/L | |
| **Field Parameters** | | |
| pH | 0.1 pH unit | As per manufacturer's instructions. |
| Specific Conductance | 25 µS/cm | |
| Turbidity | 0.5 NTU | |
| Temperature | ±1°C | |

a. APHA/AWWA/WEF 2012, *Standard Methods for the Examination of Water and Wastewater*.

b. RPD Applies only in cases where one or both results are >5 times the detection limit.

c. EPA SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, as updated.

d. Field blanks typically consist of equipment blanks, full trip blanks. Organic analysis may include a field transfer blank.

e. EPA Method 300.0 (EPA-600/4-84-017, *Determination of Inorganic Anions by Ion Chromatography*).

f. EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*, March 1979 and revised March 1983. For N in nitrate/nitrite, specific method may change with laboratory.

g. Laboratory developed procedures.

| | | | | | |
|---|---|---|---|---|---|
| GC/MS | = | gas chromatography/mass spectrometry | MDL | = | method detection limit |
| GPC | = | gas proportional counting | MS | = | mass spectrometry |
| IC | = | ion chromatography | NTU | = | nephelometric turbidity units |
| ICP | = | inductively coupled plasma | pH | = | hydrogen ion concentration |
| KPA | = | kinetic phosphorescence analysis | PQL | = | practical quantitation limit |
| LEPS | = | low-energy photon spectrometry | QC | = | quality control |
| LSC | = | liquid scintillation counting | RPD | = | relative percent difference |
| MDC | = | minimum detectable concentration | TDS | = | total dissolved solids |

Routine groundwater sampling has been conducted since the ERDF operations commenced. Sampling at the ERDF groundwater wells was not completed during March 2000 due to a Hanford Site moratorium on groundwater sampling. Well 699-37-68 was not sampled during September 2000 because of problems with a dedicated monitoring well pump (BHI-01738). Groundwater wells 699-37-68 and 699-36-67 were decommissioned in 2007 due to construction of the ERDF waste cells 7 and 8. Groundwater wells 699-37-66 and 699-36-66B were installed as replacement downgradient wells.

### 3.1.1 General Approach to Evaluating Results

Groundwater samples collected from the ERDF monitoring well network were analyzed in accordance with the requirements of the U.S. Environmental Protection Agency (EPA) in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, using industry standard or laboratory-specific test methods (Table 1). Laboratory results for these samples were entered into the Hanford Environmental Information System, a Hanford Site database that contains environmental analytical data. Groundwater monitoring data were evaluated to identify the analytical results needed for inclusion in this report. The following data selections and evaluation criteria were applied:

- Quality assurance/quality control data were evaluated for the purpose of identifying potential collection or analytical problems. However, unless a problem with the data was identified during this review, the results or discussions regarding the quality assurance/quality control data were not included in this report.
- All data qualifiers were recorded.
- If the relative percent difference between values reported for main and duplicate samples was greater than 20%, the samples were flagged in the data spreadsheet and the data evaluated to determine their applicability.
- Data acceptance based on a less than 20% relative difference criterion was relaxed for analytical results reported at or near the method detection limit (e.g., typically within five times the detection limit). This allows for an expected increased analytical error when values are close to the detection limit.
- Only analytical results for metals from filtered groundwater samples were used for metals evaluation.

### 3.1.2 Statistical Approach to Evaluating Results

The statistical analysis of ERDF groundwater monitoring data is based on the ERDF GPP (CP-60092) and PNNL-13080, *Hanford Site Groundwater Monitoring: Setting, Sources, and Methods*. The initial groundwater protection plan (BHI-00079) required that background water quality be established from four consecutive groundwater sampling events using one of two methods. Groundwater quality background conditions can be determined using either facility-wide data or historical data from each well in the monitoring network. The first approach (facility-wide) results in a single background value for the site for each constituent to which subsequent groundwater quality data are compared; this approach is referred to as an interwell comparison (PNNL-13080).

The second approach (historical) results in background water quality data for each well group to which the subsequent groundwater quality data are compared; this approach is referred to as an intrawell comparison (PNNL-13080).

The interwell approach was selected and used for the ERDF groundwater monitoring program. This method allows for the consideration of impacts from non-ERDF sources.

For each analyte of interest identified in the ERDF GPP (CP-60092), data from the four pre-operational sampling events at each of the four ERDF monitoring wells were grouped together into data sets. The average concentration, activity, or other appropriate measure for each analyte was determined, and the tolerance limit for each analyte was calculated. Data from the subsequent semi-annual monitoring events are compared to background levels and tolerance limits. Those constituents observed to have levels outside of the tolerance limits are evaluated to determine whether the deviation may be related to an ERDF or non-ERDF source(s).

Where analytical results report a nondetect, the detection limit value is used in this assessment. If a current measurement exceeds a tolerance limit based on nondetection (i.e., the reported detection limit), it is not considered to be a confirmed exceedance and is discussed qualitatively.

### 3.1.3 Determination of Tolerance Limits

The tolerance limit represents a concentration range that contains a specified proportion of the population with a specified probability (PNNL-13080). Both the upper and lower bounds of the interval (two-sided) were initially calculated. The parametric tolerance limit was determined using the following equation:

$$TI = X_b + k * S_b \text{ (two-sided)}$$

where:

- $k$ = normal tolerance factor, which depends on the number of background samples (n), coverage (P%), and the confidence level (Y)
- $X_b$ = mean of background concentrations
- $S_b$ = sample standard deviation
- $TI$ = tolerance limit.

Coverage of 95% and a confidence level of 95% were used to determine the parametric tolerance limit. Application of this equation assumes that a normal (or lognormal) distribution is a reasonable approximation of the background concentrations.

In the original statistical approach, two-sided tolerance limits were calculated for all constituents. Two-sided tolerance limits are appropriate when exceeding either the upper or the lower limit could indicate changes (or contamination) in groundwater quality. An example of a constituent exhibiting these characteristics is the hydrogen ion concentration (pH), which can be significantly higher (more basic) or lower (more acidic) than the baseline concentration. For the other constituents identified for monitoring, a one-sided or upper tolerance limit is more appropriate.

A revised statistical approach for groundwater monitoring at ERDF was developed for CP-60092. The approach of using tolerance levels was maintained; however, with the exception of pH, one-sided tolerance limits were used. The general approach was to determine an upper tolerance limit for each analyte. The assumption that the pre-operational baseline data can be pooled into a single data set for each analyte was maintained. The revised tolerance limits have been used since 2007.

## 3.2 Summary of Groundwater Analyses

The groundwater results were used to measure analytical and statistical variability. The statistical basis for comparison of the groundwater analysis results is presented in Section 3.1.2 . Analytical results reported for groundwater samples collected from the ERDF monitoring well network are presented in Appendix A. The analyte trend plots summarizing groundwater monitoring results are included in Appendix B and have been revised to reflect the new tolerance limits for CY 2007 data onward

(CP-60092). The tolerance limits show an overlap in the graphical presentations in Appendix B to better show changes. The original tolerance limits apply to pre-2007 sampling; the new tolerance limits apply only to CY 2007 and later sampling. A supplemental zinc trend graph has been added to Appendix B. The original tolerance limit for zinc was impacted by corrosion of galvanized components in two of the original wells. One well (699-37-68) was repaired in 2000. The other well (699-36-67) was never fully repaired, yielding high zinc concentrations until removal in 2008. The supplemental trend graph shows well concentrations without the results impacted by well component corrosion. This trend graph is more useful for evaluation of recent trends.

Groundwater monitoring results and apparent trends based on CY 2018 data are summarized in Table 2.

**Table 2. Summary of Tolerance Limits Comparisons and Trends**

| Analyte | Upper Tolerance Limit[a] | Well(s) Exceeding Upper Tolerance Limit in CY 2018[b] | | | | Comments |
|---|---|---|---|---|---|---|
| | | 70A | 66A | 66B | 66 | |
| Arsenic | 4.2 µg/L | Yes | No | No | No | All downgradient wells exhibited arsenic concentrations below the upper tolerance limit. Levels were elevated above the upper tolerance limit in both March and September for upgradient well 699-66-70A. At upgradient well 699-66-70A, concentrations exceeded the upper tolerance limit in both March and September at 4.72 and 5.13 µg/L, respectively. It can be noted that the reported arsenic detects for the ERDF monitoring wells have always remained below the Hanford Site background levels listed in the ERDF GPP (CP-60092) for arsenic (11.8 µg/L). |
| Barium | 122.3 µg/L | No | No | No | No | All wells exhibited barium concentrations below the upper tolerance limit, stable compared to previous years. |
| Chromium | 13.4 µg/L | No | Yes | No | No | Chromium levels in well 699-35-66A are elevated above the upper tolerance limit, but have not changed significantly from previous years. The other wells were all below the upper tolerance limit. Chromium levels in well 699-36-70A have fluctuated significantly for the past 6 years, but the pump was replaced after the March 2016 sampling; the results are now consistent with wells 699-36-66B and 699-37-66. |
| Lead | 5 µg/L | No | No | No | No | Lead concentrations were all nondetected below the upper tolerance limit. |
| Selenium | 5.6 µg/L | No | No | No | No | All wells exhibited selenium concentrations below the upper tolerance limit, stable with regards to previous years. |
| Tin | 10 µg/L | No | No | No | No | Tin concentrations were all non-detected below the upper tolerance limit. |
| Uranium | 3.4 µg/L | No | No | No | No | All wells exhibited uranium concentrations below the upper tolerance limit. |
| Vanadium | 40 µg/L | No | No | No | No | All wells exhibited vanadium concentrations below the upper tolerance limit, stable compared to previous years. |
| Zinc | 26.5 µg/L | No | No | No | No | Zinc concentrations were all nondetected below the upper tolerance limit except for one duplicate, which also was below the upper tolerance limit. |

**Table 2. Summary of Tolerance Limits Comparisons and Trends**

| Analyte | Upper Tolerance Limit[a] | Well(s) Exceeding Upper Tolerance Limit in CY 2018[b] | | | | Comments |
|---|---|---|---|---|---|---|
| | | 70A | 66A | 66B | 66 | |
| Alkalinity | 152.9 mg/L | No | No | Yes | No | All wells exhibited alkalinity concentrations below the upper tolerance limit except for well 699-36-66B in March; in September, the concentration was below the upper tolerance limit, similar to previous years. |
| Chloride | 26 mg/L | No | No | No | No | All wells exhibited chloride concentrations below the upper tolerance limit, with a slight increase compared to previous years. |
| Fluoride | 0.45 mg/L | No | No | No | No | All wells exhibited fluoride concentrations below the upper tolerance limit, generally stable compared to previous years. |
| Sulfate | 37.8 mg/L | No | No | No | No | All wells exhibited sulfate concentrations below the upper tolerance limit, stable compared to previous years. |
| Gross alpha | 2.98 pCi/L | Yes | Yes | Yes | No | All wells except 699-37-66 exhibited gross alpha activity above the upper tolerance limit in March. In September all wells exhibited gross alpha activity below the upper tolerance limit. |
| Gross beta | 31.5 pCi/L | No | Yes | Yes | Yes | The gross beta activity in all wells excluding well 699-36-70A was above the upper tolerance limit in March. September results for well 699-36-66B returned to below the upper tolerance limit as well as the duplicate for well 699-37-66. The maximum gross beta activity was 91.6pCi/L at well 699-35-66A in March. |
| C-14 | 58.1 pCi/L | No | No | No | No | All wells exhibited C-14 concentrations below the upper tolerance limit. All sample results were nondetects except for the September concentration of 47.7 pCi/L for well 99-36-66B. |
| I-129 | 21.1 pCi/L | No | No | No | No | All wells exhibited I-129 concentrations below the upper tolerance limit, generally stable compared to previous years. |
| Tc-99 | 93.8 pCi/L | No | Yes | No | No | Downgradient well 699-35-66A continues a general upward trend and exceeded the upper tolerance limit in September but was below the upper tolerance limit in March. Except for March 2013 and current March 2018 events, this well has exceeded the upper tolerance limit since 2009. All other wells exhibited technetium-99 concentrations below the upper tolerance limit consistent with previous years. Note that for the 200-UP-1 Operable Unit, which underlies ERDF, the cleanup level for Tc-99 in groundwater is 900 pCi/L. |
| Radium | 0.695 pCi/L | No | No | No | No | Radium concentrations were below the upper tolerance limit in all wells. |
| Carbon tetrachloride | 11 µg/L | No | No | No | No | All wells exhibited carbon tetrachloride concentrations below the upper tolerance limit, stable compared to previous years. |
| Nitrate and nitrite (as nitrogen) | 51.1 mg/L | No | No | No | No | All wells exhibited nitrate and nitrite concentrations below the upper tolerance limit and appear stable with regard to previous years. Results were reported for September but not for March, when the laboratory was experiencing equipment calibration errors, which led to hold time errors and not enough sample to conduct a rerun. |

**Table 2. Summary of Tolerance Limits Comparisons and Trends**

| Analyte | Upper Tolerance Limit[a] | Well(s) Exceeding Upper Tolerance Limit in CY 2018[b] | | | | Comments |
|---|---|---|---|---|---|---|
| | | 70A | 66A | 66B | 66 | |
| Total organic halides | 5 µg/L | Yes | Yes | Yes | Yes | In March, total organic halides were not detected in the three downgradient wells, but the detection limit of 7.7 µg/L was greater than the upper tolerance limit; at upgradient well 699-36-70A, the concentration was measured below the upper tolerance limit. In September, all concentrations were below the upper tolerance limit, except at well 699-36-70A, where the upper tolerance limit was slightly exceeded at 5.38 µg/L. |
| Total dissolved solids | 570 mg/L | No | No | No | No | All wells exhibited total dissolved solids concentrations below the upper tolerance limit, stable compared to previous years. |
| Turbidity | 49.8 NTU | No | No | No | No | All wells exhibited turbidity values below the upper tolerance limit, stable compared to previous years. |
| pH | 8.01 units/ 7.48 units[c] | No | No | No | No | All pH values remained within the tolerance range. |
| Specific conductance | 774 µS/m | No | No | No | No | All wells exhibited specific conductance values below the upper tolerance limit, stable, compared to previous years. |

a. New upper tolerance limits have been set for 2007 onward in the revised ERDF GPP (CP-60092, *Groundwater Protection Plan for the Environmental Restoration Disposal Facility, formerly WCH-198, Rev. 1*).

b. Well identification:

70A = upgradient monitoring well 699-36-70A
66A = downgradient monitoring well 699-35-66A
66 = downgradient monitoring well 699-37-66
66B = downgradient monitoring well 699-36-66B

c. pH tolerance limit includes upper and lower limits.

CY = calendar year
ERDF = Environmental Restoration Disposal Facility
ERDF GPP = Groundwater Protection Plan for the Environmental Restoration Disposal Facility
NTU = nephelometric turbidity units
pH = hydrogen ion concentration

Numerous contaminant plumes that originated from past activities in the 200 West Area are beneath the ERDF site. Chemical processing activities involving uranium and plutonium in the 200 West Area are known to have introduced contaminants in the groundwater upgradient from ERDF. Plumes originating from 200 West Area sources detected in the ERDF monitoring wells include nitrogen (nitrate plus nitrite), carbon tetrachloride, gross alpha, gross beta, technetium-99, iodine-129, uranium, and chromium. The sources for these constituents are discussed in DOE/RL-2018-66, *Hanford Site Groundwater Annual Monitoring Report for 2018.* Results from the established monitoring wells indicate the contaminant plumes are migrating eastward. The apparent trends in groundwater concentrations of these constituents are as follows:

- **Nitrate and nitrite (as nitrogen)**. Concentrations in all four wells remain under the upper tolerance limit. The concentrations have remained stable and continue to show a long-term downward trend for upgradient well 699-36-70A. Wells 699-35-66A and 699-36-66B exhibit stable readings. Well 699-37-66 concentrations remain elevated compared to the other wells but shows an overall declining trend.

- **Carbon tetrachloride**. Carbon tetrachloride concentrations have remained fairly consistent at levels less than half of the upper tolerance limit for at least 10 years. Well 699-36-70A historically had a downward trend through 2007, stabilized through 2012, returned to a downward trend, and appears to have started to stabilize again starting in 2016.
- **Gross alpha activity**. Gross alpha activity concentrations generally have been below the calculated upper tolerance limits since monitoring at the ERDF well network was initiated. However, fluctuations above and below the current upper tolerance limit have been observed at all existing monitoring wells, and detection limits often are near the upper tolerance limit.
- **Gross beta activity**. At upgradient well 699-36-70A, gross beta activity trended downward since the year 2000 from above to below the upper tolerance limit. From 2008 through 2017, gross beta activity also trended downward at two of the downgradient wells (699-36-66B and 699-37-66) but rose above the upper tolerance limit in 2018. At the third downgradient well (699-35-66A), gross beta activity dropped below the upper tolerance limit in 2013 and 2014 but since has trended upward with a maximum spike of 91.6 pCi/L in March 2018.
- **Technetium-99**. Technetium-99 activity in the ERDF monitoring wells has generally been below the upper tolerance limits over the course of the ERDF monitoring activities except at downgradient well 699-35-66A, where technetium-99 activity rose above the upper tolerance limit in 2009 and generally has trended upward since. At the other downgradient wells, technetium-99 activity has been generally stable. Examination of technetium-99 contamination associated with the 200-UP groundwater area described in DOE/RL-2017-66, *Hanford Site Groundwater Monitoring Report for 2017*, shows contamination sources both to the north and west of ERDF with concentrations above the upper tolerance limit established for ERDF.
- **Iodine-129**. Iodine-129 activity has remained relatively stable in all monitoring wells over the course of the ERDF monitoring activities. An upward trend in upgradient well 699-36-70A has been identified; however, no wells have exceeded the upper tolerance limit.
- **Uranium**. Uranium activity in groundwater has generally been stable since CY 2005 in the ERDF monitoring wells. Wells 699-36-66B and 699-36-70A show a slight upward trend beginning in about CY 2016.
- **Chromium**. Chromium levels in downgradient well 699-35-66A have historically been elevated and remain above the upper tolerance limit. Well 699-36-70A chromium levels increased significantly in the September 2013 sampling, just below the upper tolerance limit. The spring 2014 chromium value at this well slightly exceeded the upper tolerance limit but dropped back below in September 2014. The pump in the well was replaced in CY 2016 after the March sampling. After the pump replacement, the September 2016 concentrations dropped significantly and are now consistent with wells 699-36-66B and 699-37-66. All wells remain stable with previous years and wells 699-36-70A, 669-37-66, and 699-36-66B are well below the upper tolerance limit.

Additional radionuclides and chemical constituents are monitored in the routine analyses. In general, concentrations remain stable to slightly decreasing, except for the following:

- **Arsenic**. Historically arsenic was trending upward in all wells, generally trending downward from 2008 through 2014, and has fluctuated since. Arsenic concentrations have been below the upper tolerance limit at all wells since 2012 except well 699-36-70A, where arsenic exceeded the upper tolerance limit in September 2016, March 2018, and September 2018. No Hanford Site-derived sources for arsenic have been identified for potential impact in the groundwater under ERDF. Pre-Hanford Site use of arsenic in agriculture may be the source of this contamination or the arsenic

may be naturally occurring. The ERDF monitoring wells have always remained below the Hanford Site background levels.

- **Selenium**. Selenium concentrations generally have been trending slightly downward and were below the upper tolerance limit in all wells since 2017.
- **pH**. The pH of all wells within the tolerance range for CY 2018.

## 3.3 Groundwater Levels

Water-level measurements were collected from each of the four monitoring wells during the semi-annual groundwater sampling events to determine groundwater accessibility during future monitoring events. Water-level measurements were taken during each routine groundwater monitoring event immediately prior to purging the well for sample collection.

Note: During the September 2005 monitoring event, the exact water level in monitoring well 699-36-67 could not be determined because the electronic tape measure (e-tape) did not appear to reach the top of the water in the well. The e-tape apparently did not sound, indicating that water had been reached, and appeared to be dry when removed from the well. Based on the length of the e-tape used, the water level in this well was more than 3.5 m (11.5 ft) lower than anticipated. Sampling at this well took place as planned, and the well produced a sufficient amount of water for sample collection. This measurement was treated as an anomaly and not used to evaluate water levels and future accessibility. Prior to the decommissioning of well 699-36-67 in 2008, subsequent samples returned to expected levels.

Based on a water-level contour map (Figure 3), groundwater in the vicinity of ERDF generally moves from the west across the site to the east-northeast at approximately 91 m (298.5 ft) below the surface. The hydraulic gradient is estimated at 0.001 m/m (meters of vertical change per meter of horizontal movement) on the west end of ERDF and averages 0.003 m/m across the entire width of ERDF, with the east end having a greater gradient. The average hydraulic gradient for the 200 West Area that includes ERDF is 0.002 m/m. The groundwater table in and near the 200 West Area has been steadily declining since discharges to the 200 West Area ponds, trenches, and cribs stopped during the 1990s.

The current hydrograph for the ERDF monitoring wells presented in Figure 4 indicates an annual decline of less than 0.4 m/yr (1.31 ft/yr), which is consistent with the regional hydrologic changes reported for the area (BHI-01311, *Hydrogeologic Conceptual Model for the Carbon Tetrachloride and Uranium/Technetium Plumes in the 200 West Area: 1994 Through 1999 Update*; PNNL-15070-SUM, *Summary of Hanford Site Groundwater Monitoring for Fiscal Year 2004*).

## 3.4 Summary of Groundwater Monitoring Well Level Measurements

Groundwater monitoring wells in the ERDF well network have exhibited a gradual rate of decline in water levels since monitoring was initiated in September 1995. Overall groundwater level trends will continue to be monitored in conjunction with future sampling events.

Based on the measured water levels in the four ERDF monitoring wells, it was determined that the height of the water column in ERDF upgradient monitoring well 699-36-70A is 1.58 m (5.2 ft). The downgradient monitoring wells had water column levels of 1.86 m (6.1 ft) at well 699-35-66A, 8.11 m (26.6 ft) at well 699-37-66, and 8.01 m (26.3 ft) at well 699-36-66B. At the current average rate of decline, the monitoring wells would be available for use, as they are currently constructed, for approximately 10 to 20 years. Wells 699-36-70A and 699-35-66A will need to be replaced sooner than the other two wells.

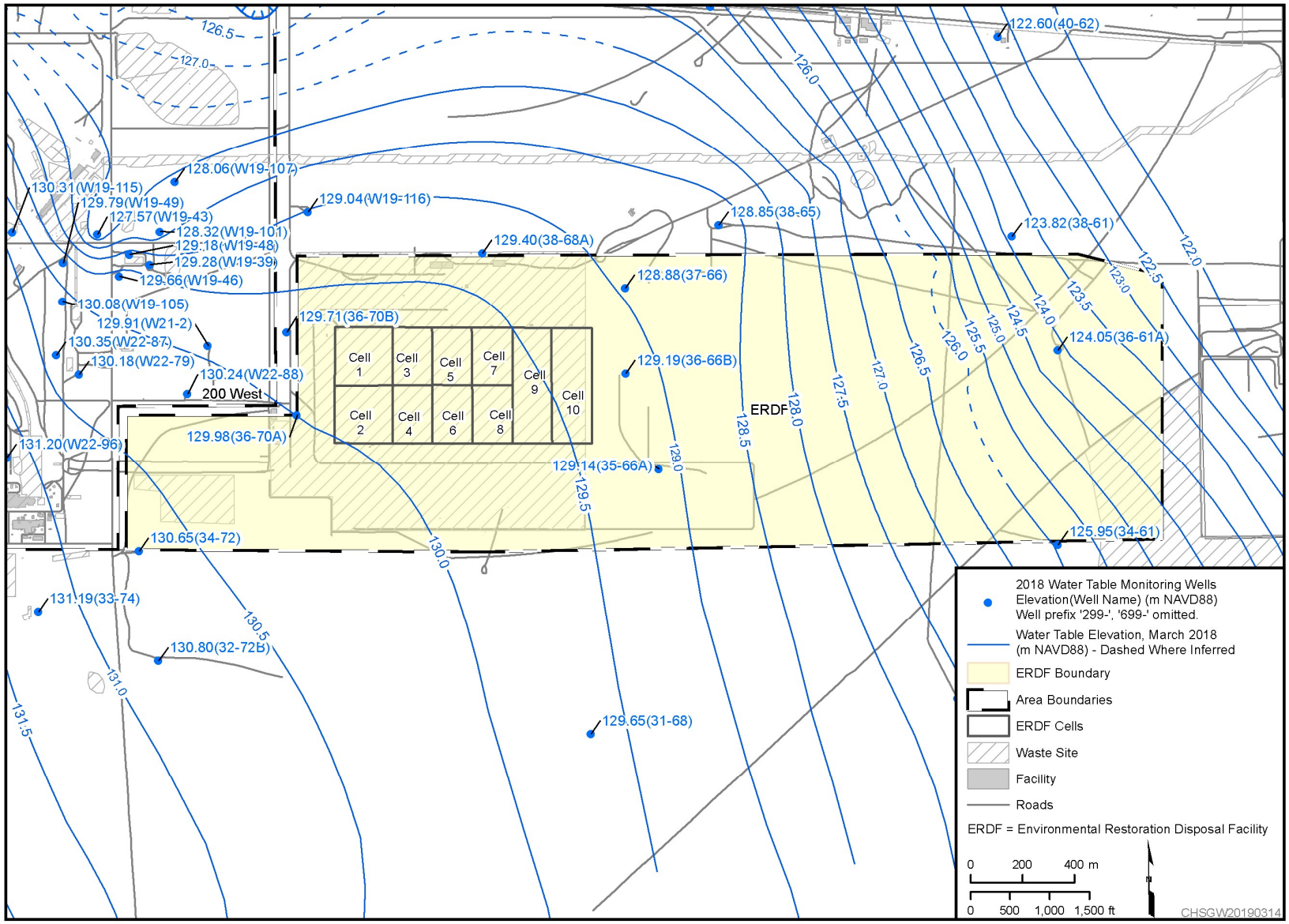


**Figure 3. Water-Level Contour Map**

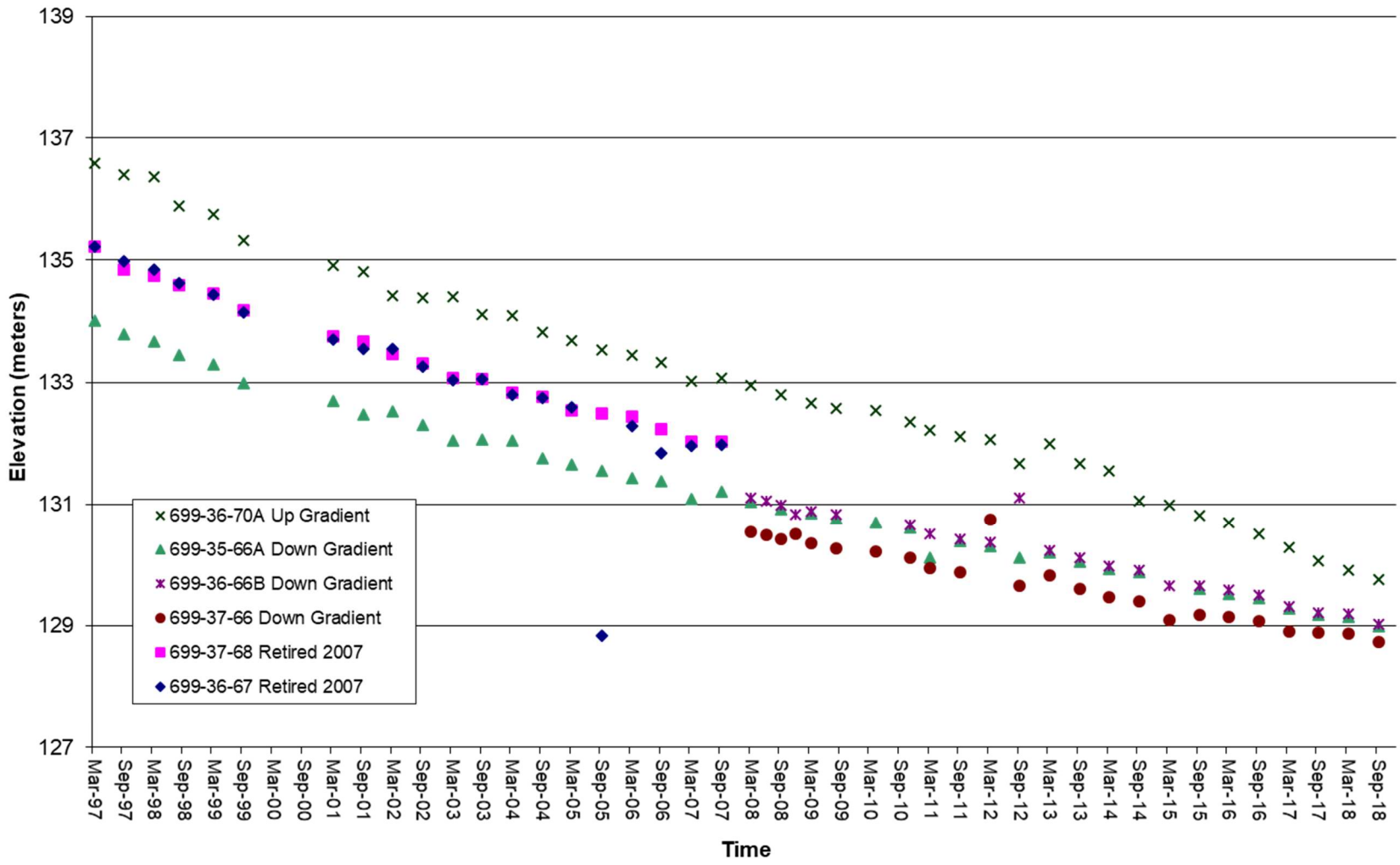


**Figure 4. Hydrograph from the ERDF Groundwater Monitoring Wells**

## 3.5 Leachate Sampling

The leachate was sampled semi-annually to provide data for leachate delisting analyses and to assess whether additional COCs should be added to the routine ERDF groundwater monitoring program. Although separate leachate sampling may also be performed to verify that waste acceptance criteria for the appropriate treatment facility continues to be met, the treatment facility is currently relying on the sampling results to monitor acceptance. The monitoring frequency was increased to quarterly in CY 2016 at the request of the 200 West P&T Facility to assist in transferring leachate treatment to that facility (EPA et al., 2015, *Explanation of Significant Differences for the U.S. Department of Energy, Environmental Restoration Disposal Facility, Hanford Site – 200 Area, Benton County, WA*). The evaluation of any approved treatment facility sampling data for treatment at that facility is outside the scope of this report.

Leachate sampling was performed quarterly during CY 1999 to CY 2000 for an extensive list of analytes, as defined by the ERDF Amended ROD (EPA, 1999). At the end of this initial baseline sampling, a routine analyte list was established (short list), and leachate sampling was reduced to a semi-annual basis through CY 2015.

The leachate sampling program is described in the ERDF SAP (CP-60070). The samples are collected to support routine and confirmatory sampling programs. As identified in the ERDF Amended ROD (EPA, 1999), once every 2 years (biennial) an evaluation of recent waste component additions to ERDF is made to assess the need to add analytes to the long list and sampling of the leachate for the long list of analytes is performed. The current long list of analytes is shown in Appendix C. The current short list of analytes is identified in Appendix C. The samples are collected from varying levels within the leachate storage unit tanks.

The ERDF project continued routine sampling and analysis of landfill leachate during CY 2018 for the short list of analytes. Composite leachate samples for the short and long list of analytes were collected during CY 2018. Data for the current year and from the 2 prior years of leachate sampling (i.e., CY 2016 to CY 2018) are used to identify trends that may indicate if additional laboratory analysis for groundwater samples is warranted.

## 3.6 Summary of Leachate Analysis

Data associated with leachate sampling conducted in CY 2018 are presented in Appendix C. Only analytical results that were reported as significant detects (>1 parts per billion), or are on the routine short list, are included in this report. The results shown in Appendix C have been expanded from previous annual reports to include tungsten, phosphate, ammonia (as nitrogen in ammonia), chemical oxygen demand, and total radioactive strontium at the request of the 200 West P&T Facility. Hexavalent chromium has been added to the routine short list in Appendix C due to concentrations exceeding one-tenth of the delisting level. Leachate sampling trends are presented in Appendix D. Hexavalent chromium results have been added to the chromium trend graph. For new routine analytes, additional trend graphs will be included in future reports.

The composite leachate samples contained detectable concentrations of common metals, anions, and mobile radionuclides.

There were no exceedances of a delisting level during the year.

The following is an update of those constituents of primary interest for which there were detectable concentrations in the CY 2018 sampling results:

- **Chromium**. Except for occasional spikes (typically only one of the two samples in an event), total chromium levels remained below 40 µg/L until March 2013. Concentrations have been on an upward trend since then. Due to levels of total and hexavalent chromium seen in the 2014 sampling, hexavalent chromium was added to the routine list. All chromium and hexavalent chromium values for CY 2018 were greater than one-tenth of the delisting value for hexavalent chromium. Both total and hexavalent chromium results peaked in June 2017 and September 2018, and dropped in December 2018. The similarity of the total and hexavalent chromium results indicates that the bulk of the chromium in the ERDF leachate is present as hexavalent chromium. A line representing one-tenth of the hexavalent chromium delisting level has been included on the chromium trend graph. Chromium (total and hexavalent) will continue to be monitored.
- **Potassium**. Potassium concentrations increased from an average of 18,900 µg/L in CY 2017 to an average of 20,700 µg/L in CY 2018.
- **Specific conductance**. The average specific conductance increased from 2,124 µS/cm in 2017 to 2,646 µS/cm in 2018.
- **Anions**. Nitrate concentrations have slightly rebounded from the historic low seen in September 2012 samples but remain well below previous maximums, averaging approximately 270 mg/L. A line representing the delisting level has been included on the nitrate trend graph (Appendix D, Figure D-16). The other primary anions (chloride and sulfate) have similarly rebounded from the September 2012 lows. They are showing a general upward trend; chloride remains below historical maximums, while sulfate has exceeded the historical maximum for all CY 2018 samples.
- **Total dissolved solids**. Total dissolved solids concentratins have been increasing slightly through 2006 and have stabilized through CY 2018, averaging approximately 2,150 mg/L, which is a slight decrease from CY 2017.
- **Gross alpha**. Gross alpha activity historically increased through December 2008, reaching a maximum concentration of 3,380 pCi/L, declined through 2011, and was generally stable through 2018 with an average of 550 pCi/L, which is a slight increase from 442 pCi/L in CY 2017.
- **Gross beta**. Gross beta activity historically increased through December 2008, reaching a maximum concentration of 1,500 pCi/L, declined through 2011, and was generally steady through September 2018. In December 2018, gross beta activity increased to 590 pCi/L and 881 pCi/L in duplicate samples.
- **Uranium**. Uranium concentrations historically increased through December 2008 and reached a new maximum concentration of 3,060 µg/L in March 2010 but then declined rapidly. Concentrations have been less than 1,500 µg/L since October 2011.
- **Technetium-99**. Technetium-99 concentrations generally have decreased since March 2010, from 892 µg/L to an average of 208 pCi/L in CY 2018.
- **Tritium**. Tritium concentrations remained above 100,000 pCi/L from the beginning of analysis in December 2008 through CY 2010, and then declined to approximately half of the maximum values. Concentrations stabilized through CY 2015 ranging from 80,000 to 90,000 pCi/L. For CY 2018, sample results increased from below 90,000 to over 100,000 pCi/L over the course of the year. The CY 2018 average of 127,400 pCi/L is a substantial increase from the CY 2017 average of 51,850 pCi/L. In December 2018 a new record high concentration of 179,000 pCi/L was reported.

- **Carbon-14.** Carbon-14 values have increased in recent years through mid-CY 2015. A maximum value of 305 pCi/L was reported in March 2015. The average concentration increased from 39 pCi/L in CY 2017 to 102 pCi/L in CY 2018.
- **Total radioactive strontium**. Total radioactive strontium analysis began in fall 2015. No significant trends have been noted through CY 2018. The average concentration increased from 10 pCi/L in CY 2017 to 14 pCi/L in CY 2018.

## 3.7 Leachate Generation

Leachate liquids are primarily generated from natural precipitation and the application of dust control water that percolates downward through the disposed waste materials. Each ERDF cell was constructed with a double-liner system designed to deliver leachate to sump areas. Leachate is collected from the primary (upper) leachate collection layer sump and the secondary (lower) leak detection sump for each ERDF cell. The leachate collected in the primary and secondary sumps is routinely transferred from the sumps to onsite leachate storage tanks prior to transfer to the 200 West P&T Facility. A summary of recent annual leachate generation volumes (primary and secondary volumes are combined for each cell) is included in Appendix C, Table C-4.

# 4 Lysimeter Monitoring and Sampling

## 4.1 Purpose and Objectives

The purpose of this section is to evaluate the conditions and identify trends to develop Hanford Site-specific data on the performance of the lysimeter systems related to the vadose zone monitoring and potential future use of the lysimeter systems. The objectives of this section are as follows:

- Assess data from routine ERDF lysimeter sampling to determine if COC concentrations over time may be attributed to the ERDF operations.
- Describe and evaluate the sample data, identify changes or trends in the data, and incorporate a summary of the results.
- Evaluate the data to determine if the routine analyte list of indicator parameters is adequate.
- Document and describe the changes in the volume of liquid in the lysimeter.

## 4.2 Lysimeter Monitoring and Sampling

The lysimeter monitoring program is described in CP-60093, *Environmental Restoration Disposal Facility Lysimeter Monitoring and Sampling Plan, formerly WCH-291 Rev. 0*. This section provides an overview of the monitoring and sample results.

### 4.2.1 Camera Inspection and Dewatering

The lysimeters were structurally intact without any obstructions within the visual portion of the pipe. The lysimeters had some silt sediment within the water layer that clouded the camera view when disturbed in some cells. Prior to the visual disturbance associated with the silt, the liquid associated with the lysimeters appeared transparent with minimal suspended particles. The liquid surfaces had no apparent sheen and only had a very minor amount of unidentified floating particles. Significant amounts of sediment were noted in cell 5 in the CY 2018 inspections. The lysimeter dewatering activity with each cell is presented in Table 3.

**Table 3. Lysimeter Dewatering Activity**

| CY Year | Cell Number Lysimeter (gal) | | | | | |
|---|---|---|---|---|---|---|
| | 5 | 6 | 7 | 8 | 9 | 10 |
| 2005 | N/A | 2,302 | | | | |
| 2006 | 3,541 | 273 | | | | |
| 2007 | N/A | N/A | | | | |
| 2008 | 2,770 | N/A | | | | |
| 2009 | 1,851 | 3,000 | 800 | 650 | | |
| 2010 | 400 | 360 | 400 | Insufficient volume to pump* | | |
| 2011 | Insufficient volume to pump* | Insufficient volume to pump* | Insufficient volume to pump* | Insufficient volume to pump* | 1,600 | 6,000 |
| 2012 | 1,700 | 1,500 | 4,800 | 2,300 | 4,400 | 2,800 |
| 2013 | 750 | 550 | 1,200 | 1,250 | 2,400 | 1,850 |
| 2014 | 750 | 400 | 1,525 | 1,200 | 1,400 | 1,400 |
| 2015 | 350 | 300 | 850 | 450 | 1,975 | 1,050 |
| 2016 | 200 | 425 | 600 | 1,050 | 1,400 | 725 |
| 2017 | 100 | 170 | 650 | 705 | 800 | 400 |
| 2018 | 100 | 100 | 500 | 0 | 550 | 400 |
| **Total** | **14,322** | **9,377** | **16,725** | **7,605** | **13,525** | **14,625** |

*Malfunction of the dewatering pump system may have falsely indicated insufficient pumpable volumes in the lysimeter. An upgraded dewatering pump was utilized in CY 2012.

CY = calendar year

N/A = not available or not applicable

### 4.2.2 Lysimeter Sampling

Analytical results are evaluated to document vadose zone conditions, characterized to ensure proper management of liquids, and monitored for any trends in the data.

The vadose zone monitoring activities are expected to continue until after the final landfill cap is installed and the annual quantity of leachate collected in the secondary leachate collection and removal system is shown to be insignificant (i.e., less than the amount needed to activate the removal pumps).

Lysimeters in cells 5 and 6 were initially sampled in August 2005 in accordance with BHI-01777. Initial lysimeter samples for cells 5 and 6 were analyzed for chloride, gross alpha, technetium-99, and gross beta. In CY 2009, CP-60093 (formerly WCH-291) was developed. It was determined that the COCs for the initial sampling of the lysimeters should be consistent with the COCs for the routine leachate sampling at ERDF, as described in the ERDF SAP (CP-60070). The routine leachate list is identified in Appendix C. Cell 7 and 8 lysimeters were initially sampled in CY 2009. Cell 9 and 10 lysimeters were initially sampled in CY 2011.

The purpose of the initial characterization was to establish a baseline and determine if the routine analyte list of indicator parameters was adequate. No changes to the routine lysimeter analysis lists were identified from the initial characterization results.

All subsequent sampling of lysimeter liquids after the initial sampling were analyzed for the routine lysimeter list defined in CP-60093.

### 4.2.3 General Approach to Evaluating Results

Table 4 lists routine lysimeter analytes by analytical method. Lysimeter samples were analyzed in accordance with the requirements of SW-846, industry standard, or laboratory-specific test methods as presented in Table 4. The following data selection and evaluation criteria were applied when reviewing the data:

- Quality assurance/quality control data were evaluated for the purpose of identifying potential collection or analytical problems. However, unless a problem with the data was identified during this review, the results of or a discussion regarding the quality assurance/quality control data were not included in this report.
- All data qualifiers were recorded.
- If the relative percent difference between values reported for main and duplicate laboratory samples was greater than 20%, the samples were flagged in the data spreadsheet and the data evaluated to determine their applicability.

  Data acceptance based on a less than 20% relative percent difference criterion was relaxed for analytical results reported at or near the method detection limit (e.g., typically within five times the detection limit). This allows for an expected increased analytical error when values are close to the detection limit.

**Table 4. List of Routine Lysimeter Analytes by Analytical Method**

| Analyte | Method[a] | Practical Quantitation Limit | Accuracy[b] (%) | Precision[b] (%) |
|---|---|---|---|---|
| Calcium | 6010 | 1,050 µg/L | 80-120 | ≤ 20 |
| Magnesium | 6010 | 1,050 µg/L | 80-120 | ≤ 20 |
| Potassium | 6010 | 5,250 µg/L | 80-120 | ≤ 20 |
| Sodium | 6010 | 1,050 µg/L | 80-120 | ≤ 20 |
| Chloride | 300.0, 9056 | 400 µg/L | 80-120 | ≤ 20 |
| Nitrate | 300.0, 9056 | 250 µg/L | 80-120 | ≤ 20 |
| Sulfate | 300.0, 9056 | 1,050 µg/L | 80-120 | ≤ 20 |
| Total dissolved solids | Standard Methods 2540C | 21,000 µg/L | 80-120 | ≤ 20 |
| Total suspended solids | Standard Methods 2540D | 21,000 µg/L | 80-120 | ≤ 20 |
| Total organic carbon | 415.1, 9060 | 1,050 µg/L | 80-120 | ≤ 20 |
| Technetium-99 | Liquid scintillation counting[c] | 50 pCi/L | 80-120% or statistically derived limits[d] | ≤ 20 |
| Total uranium | 6020 | 1.05 µg/L | 80-120 | ≤ 20 |

**Table 4. List of Routine Lysimeter Analytes by Analytical Method**

| Analyte | Method[a] | Practical Quantitation Limit | Accuracy[b] (%) | Precision[b] (%) |
|---|---|---|---|---|
| Gross alpha | Gas proportional counting[c] | 3 pCi/L | 80-120% or statistically derived limits[d] | ≤ 20 |
| Gross beta | Gas proportional counting[c] | 4 pCi/L | 80-120% or statistically derived limits[d] | ≤ 20 |
| Tritium | Liquid scintillation counting[c] | 700 pCi/L | 80-120% or statistically derived limits[d] | ≤ 20 |
| pH | 9040, 150.1 | N/A | N/A | N/A |
| Specific conductance | 9050, 120.1 | N/A | N/A | N/A |

a. For EPA Method 300.0, see EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples*. For EPA Methods 120.1, 150.1, and 415.1, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*. For four-digit EPA methods, see SW-846, *Test Method for Evaluating Solid Wastes: Physical/Chemical Methods, Third Edition; Final Update VI*. For Standard Methods, see APHA/AWWA/WEF 2017, *Standard Methods for the Examination of Water and Wastewater.*

b. Accuracy is measured by the laboratory control sample and expressed as percent recovery; precision is measured by a duplicate or matrix spike and matrix spike duplicate pair and expressed as a relative percent difference.

c. Industry standard method, laboratory-specific.

d. Laboratory-determined, statistically derived control limits based on historical data are used here. Control limits are reported with the data.

CY = calendar year
EPA = U.S. Environmental Protection Agency
N/A = not available or not applicable
pH = hydrogen ion concentration

## 4.3 Summary of Lysimeter Analytical Results

Data associated with the cell lysimeter sampling conducted during CY 2018 are presented in Appendix E. A summary of the analytical results from the CY 2018 sampling events is discussed below.

## 4.4 Summary of Lysimeter Analysis

Lysimeter samples contained detectable concentrations of common metals, anions, and radionuclides. No analytical anomalies were noted for the analysis. The following is a brief description of recent analytical results.

- **Sulfate**. Soluble salts (i.e., sulfate) (primary salt constituent present) were the main constituents present within the lysimeter liquid and can be directly correlated to the levels of the constituents found within the admix material used to construct the cells. There was an increase of sulfate in CY 2018 samples for all cells except cell 8.
- **Total dissolved solids**. Total dissolved solids remained relatively the same in the CY 2018 samples with a slight increase in cells 6, 9, and 10.
- **Total suspended solids**. Total suspended solid values are typically low; however, cells 7 and 9 have shown occasional spikes relative to the other cells. Similar spikes were observed for cell 7 in the CY 2018 samples.
- **Uranium**. Uranium levels within cell 5, 7, and 8 lysimeters had low detectable levels. Cell 6, 9, and 10 lysimetrs had very low levels present. No significant changes were noted in the CY 2018 samples from previous years.

- **Gross alpha**. Gross alpha activity concentrations have been mostly constant except for spikes seen in cells 7 and 9 when total suspended solids are high. No significant changes were noted in the CY 2018 samples from previous years.
- **Gross beta**. Gross beta activity appears to be within a consistent range within the lysimeters except for spikes seen in cells 7 and 9 when total suspended solids are high. No significant changes were noted in the CY 2018 samples from previous years.
- **Technetium-99**. Technetium-99 continued to be nondetect in all lysimeters.
- **pH**. The cells appear to have stable pH levels.

## 4.5 Evaluation of Calendar Year 2018 Lysimeter Results

No indication of lysimeter contamination by leachate generated during ERDF operations has been observed. The absence of technetium-99 and tritium within the lysimeter liquid is a good indicator that the leachate collection system located above the lysimeters is not leaking liquid into the lysimeters. This is based on the presence of technetium-99 in the leachate and the high solubility and mobility of technetium-99 through soils. Additional supporting evidence is the high sulfate and low nitrate (primary soluble anions in the leachate) concentrations in the lysimeter liquid compared to the leachate, indicating there is no effective dilution of the lysimeter liquid.

Concentrations for most analytes in the lysimeter liquids appear to be stabilizing. The routine lysimeter analyte list appears to continue to be adequate at this time. Monitoring will continue with annual samples.

Based on the data, future inspections and dewatering of lysimeters is planned as an annual activity.

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# Appendix A

# Groundwater Sampling Results, 2018

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**Table A-1. Data Qualifier Definitions for Tables A-2 Through A-27**

| Qualifier | Definition |
|---|---|
| B | Estimated results |
| C | Detected in both the sample and quality control blank, and sample concentration was ≤5× the blank concentration |
| D | Reported from dilution |
| DUP | Laboratory sample duplicate; sample was collected for only one groundwater well during each sample event |
| N | Spike sample recovery is outside control limits |
| U | Result is nondetected |

## Table A-2. Arsenic Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 4 U | | | | 4.72 B | | | | 1.4 B | | 1.7 B | | | 4.2 |
| Sep-18 | 2.1 B | 2.2 B | | | 5.13 | | | | 1.8 B | 1.4 B | 4 UD | | | 4.2 |

Notes: Values reported in µg/L.

Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.

Laboratory qualifiers are defined in Table A-1.

## Table A-3. Barium Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 33.3 D | | | | 37 | | | | 78.5 | | 62.8 | | | 122.3 |
| Sep-18 | 36.5 | 35.5 | | | 40.7 | | | | 76.1 | 72 | 66 D | | | 122.3 |

Notes: Values reported in µg/L.

Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.

Laboratory qualifiers are defined in Table A-1.

## Table A-4. Chromium Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 18 D | | | | 3.54 B | | | | 2.7 | | 3.2 | | | 13.4 |
| Sep-18 | 17.3 | 17.4 | | | 3.57 B | | | | 2.4 | 4.1 B | 4 BD | | | 13.4 |

Notes: Values reported in µg/L.

Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.

Laboratory qualifiers are defined in Table A-1.

## Table A-5. Lead Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 1 UD | | | | 0.5 U | | | | 0.18 U | | 0.18 U | | | 5 |
| Sep-18 | 0.18 U | 0.18 U | | | 0.5 U | | | | 0.18 U | 0.079 U | 1 U | | | 5 |

Notes: Values reported in µg/L.

Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.

Laboratory qualifiers are defined in Table A-1.

## Table A-6. Selenium Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 5.1 D | | | | 2.36 B | | | | 4.8 B | | 3.3 B | | | 5.6 |
| Sep-18 | 4.1 B | 3.8 B | | | 2.09 B | | | | 4.6 B | 4.4 B | 4.2 BD | | | 5.6 |

Notes: Values reported in µg/L.

Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.

Laboratory qualifiers are defined in Table A-1.

## Table A-7. Tin Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 1.2 UD | | | | 1 U | | | | 0.77 U | | 0.77 U | | | 10 |
| Sep-18 | 0.77 U | 0.77 U | | | 1 U | | | | 0.77 U | 0.12 U | 1.2 UD | | | 10 |

Notes: Values reported in µg/L.

Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.

Laboratory qualifiers are defined in Table A-1.

## Table A-8. Uranium Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 2.4 D | | | | 2.65 | | | | 1.7 | | 2.4 | | | 3.4 |
| Sep-18 | 2 | 1.9 | | | 3.01 | | | | 1.7 | 1.9 | 2.9 D | | | 3.4 |

Notes: Values reported in µg/L.
Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.
Laboratory qualifiers are defined in Table A-1.

## Table A-9. Vanadium Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 22.4 B | | | | 30.6 | | | | 25.6 | | 27.2 | | | 40 |
| Sep-18 | 24.5 | 24.7 | | | 27.8 | | | | 23.7 | 22 | 25.4 B | | | 40 |

Notes: Values reported in µg/L.
Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.
Laboratory qualifiers are defined in Table A-1.

## Table A-10. Zinc Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 7.5 UD | | | | 3.3 UN | | | | 2 U | | 2 U | | | 26.5 |
| Sep-18 | 2 U | 2.1 B | | | 3.3 U | | | | 2 U | 1.4 U | 7.5 U | | | 26.5 |

Notes: Values reported in µg/L.
Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.
Laboratory qualifiers are defined in Table A-1.

## Table A-11. Alkalinity Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 131 | | | | 134 | | | | 130 | | 156 | | | 152.9 |
| Sep-18 | 138 | 138 | | | 128 | | | | 133 | 135 | 143 | | | 152.9 |

Notes: Values reported in mg/L.
Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.
Laboratory qualifiers are defined in Table A-1.

## Table A-12. Chloride Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 12 D | | | | 13 D | | | | 19 D | | 22 D | | | 26 |
| Sep-18 | 13 D | 13 D | | | 14 D | | | | 19 D | 21.0 D | 24 D | | | 26 |

Notes: Values reported in µg/L.
Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.
Laboratory qualifiers are defined in Table A-1.

## Table A-13. Fluoride Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 0.32 D | | | | 0.41 D | | | | 0.29 D | | 0.31 B | | | 0.45 |
| Sep-18 | 0.34 D | 0.34 D | | | 0.43 D | | | | 0.28 D | 0.29 D | 0.31 B | | | 0.45 |

Notes: Values reported in µg/L.
Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.
Laboratory qualifiers are defined in Table A-1.

## Table A-14. Sulfate Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 27 D | 26.2D | | | 26 D | | | | 29 D | | 30 D | | | 37.8 |
| Sep-18 | 27 DN | 27 DN | | | 27 D | | | | 29 D | 29 DN | 29.3 DN | | | 37.8 |

Notes: Values reported in µg/L.
Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.
Laboratory qualifiers are defined in Table A-1.

## Table A-15. Gross Alpha Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 5.33 | | | | 4.14 | | | | 1.36 U | | 3.35 | | | 2.98 |
| Sep-18 | 0.939 U | 1.06 U | | | 1.93 | | | | 1.72 U | 1.04 U | 1.02 | | | 2.98 |

Notes: Values reported in pCi/L.
Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.
Laboratory qualifiers are defined in Table A-1.

## Table A-16. Gross Beta Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-17 | 91.6 | | | | 17.7 | | | | 39.9 | | 39.3 | | | 31.5 |
| Sep-17 | 50 | 40.9 | | | 11.5 | | | | 42 | 17.8 | 20.2 | | | 31.5 |

Notes: Values reported in pCi/L.
Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.
Laboratory qualifiers are defined in Table A-1.

## Table A-17. Carbon-14 Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 18.2 U | | | | 10.4 U | | | | 10 U | | 0.0851 U | | | 58.1 |
| Sep-18 | 18 U | 17.2 U | | | 20 U | | | | 0.644 U | 10.9 U | 47.7 | | | 58.1 |

Notes: Values reported in pCi/L.

Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.

Laboratory qualifiers are defined in Table A-1.

## Table A-18. Iodine-129 Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 3.61 | | | | 10.6 | | | | 1.69 | | 6.55 | | | 21.1 |
| Sep-18 | 4.32 | 4.36 | | | 15.2 | | | | 1.49 | 1.69 | 6.43 | | | 21.1 |

Notes: Values reported in pCi/L.

Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.

Laboratory qualifiers are defined in Table A-1.

## Table A-19. Technetium-99 Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 45.9 | | | | 22.1 | | | | 65.4 | | 64.4 | | | 93.8 |
| Sep-18 | 145 | 137 | | | 17.2 | | | | 69.2 | 60.3 | 61.3 | | | 93.8 |

*Duplicate analysis not within control limits.

Notes: Values reported in pCi/L.

Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.

Laboratory qualifiers are defined in Table A-1.

## Table A-20. Radium Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 2.86 | | | | -0.15 U | | | | | | 0.05 U | | | 0.695 |
| Sep-18 | 0.51 U | 0.12 U | | | 0 U | | | | 0.59 | | 0.19 U | | | 0.695 |

Notes: Values reported in pCi/L.

Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.

Laboratory qualifiers are defined in Table A-1.

## Table A-21. Carbon Tetrachloride Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 0.79 J | | | | 2.9 | | | | 1.7 | | 2.4 | | | 11 |
| Sep-18 | 0.96 J | 0.99 J | | | 2.53 J | | | | 1.7 | 1.7 | 2.6 | | | 11 |

Notes: Values reported in µg/L.

Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.

Laboratory qualifiers are defined in Table A-1.

## Table A-22. Nitrogen in Nitrite/Nitrate Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | | | | | | | | | | | | | | 51.1 |
| Sep-18 | 5.2 D | 5.29 D | | | 3.12 D | | | | 31.2 D | | 11 D | | | 51.1 |

Notes: Values reported in mg/L.

Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.

Laboratory qualifiers are defined in Table A-1.

## Table A-23. Total Organic Halides Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 7. UN | | | | 3.6 B | | | | 7.7 UN | | 7.7 UN | | | 5 |
| Sep-18 | 3.58 B | 3.33 U | | | 5.38 B | | | | 3.33 U | 7.7 U | 3.33 U | | | 5 |

Notes: Values reported in µg/L.
Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.
Laboratory qualifiers are defined in Table A-1.

## Table A-24. Total Dissolved Solids Data

| Sample Date | 699-35-66A | | 699-36-67 | | 699-36-70A | | 699-37-68 | | 699-37-66 | | 699-36-66B | | Limit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Downgradient | DUP | Retired 2007 | DUP | Upgradient | DUP | Retired 2007 | DUP | Downgradient | DUP | Downgradient | DUP | Old (through 2006) | New (2007 onward) |
| Mar-18 | 227 | | | | 223 | | | | 414 | | 301 | | | 570 |
| Sep-18 | 260 | 251 | | | 260 | | | | 399 | 433 | 309 | | | 570 |

Notes: Values reported in mg/L.
Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.
Laboratory qualifiers are defined in Table A-1.

## Table A-25. Turbidity Data

| Sample Date | 699-35-66A (Downgradient) | 699-36-67 (Retired 2007) | 699-36-70A (Upgradient) | 699-37-68 (Retired 2007) | 699-37-66 (Downgradient) | 699-36-66B (Downgradient) | Old Limit (through 2006) | New Limit (2007 onward) |
|---|---|---|---|---|---|---|---|---|
| Mar-18 | 3.41 | | 1.18 | | 2.21 | 1.43 | | 49.8 |
| Sep-18 | 3.66 | | 1.79 | | 1.67 | 3.16 | | 49.8 |

Notes: Values reported in nephelometric turbidity units.
Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.
Laboratory qualifiers are defined in Table A-1.

## Table A-26. pH Data

| Sample Date | 699-35-66A (Downgradient) | 699-36-67 (Retired 2007) | 699-36-70A (Upgradient) | 699-37-68 (Retired 2007) | 699-37-66 (Downgradient) | 699-36-66B (Downgradient) | Old Limits (through 2006) | New Limits (2007 onward) |
|---|---|---|---|---|---|---|---|---|
| Mar-18 | 7.99 | | 7.74 | | 7.61 | 7.73 | | 7.48–8.01 |
| Sep-18 | 7.75 | | 7.75 | | 7.63 | 7.75 | | 7.48–8.01 |

Notes: Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.
Laboratory qualifiers are defined in Table A-1.

## Table A-27. Specific Conductance Data

| Sample Date | 699-35-66A (Downgradient) | 699-36-67 (Retired 2007) | 699-36-70A (Upgradient) | 699-37-68 (Retired 2007) | 699-37-66 (Downgradient) | 699-36-66B (Downgradient) | Old Limit (Through 2006) | New Limit (2007 Onward) |
|---|---|---|---|---|---|---|---|---|
| Mar-18 | 382 | | 356 | | 615 | 478 | | 774 |
| Sep-18 | 402 | | 376 | | 647 | 498 | | 774 |

Notes: Values reported in µS/cm.
Shaded cells represent that no sample data are available due to the removal of two groundwater wells and the new data from two new or replacement groundwater wells.
Laboratory qualifiers are defined in Table A-1.

# Appendix B

# Groundwater Sampling Trends, 1996-2018

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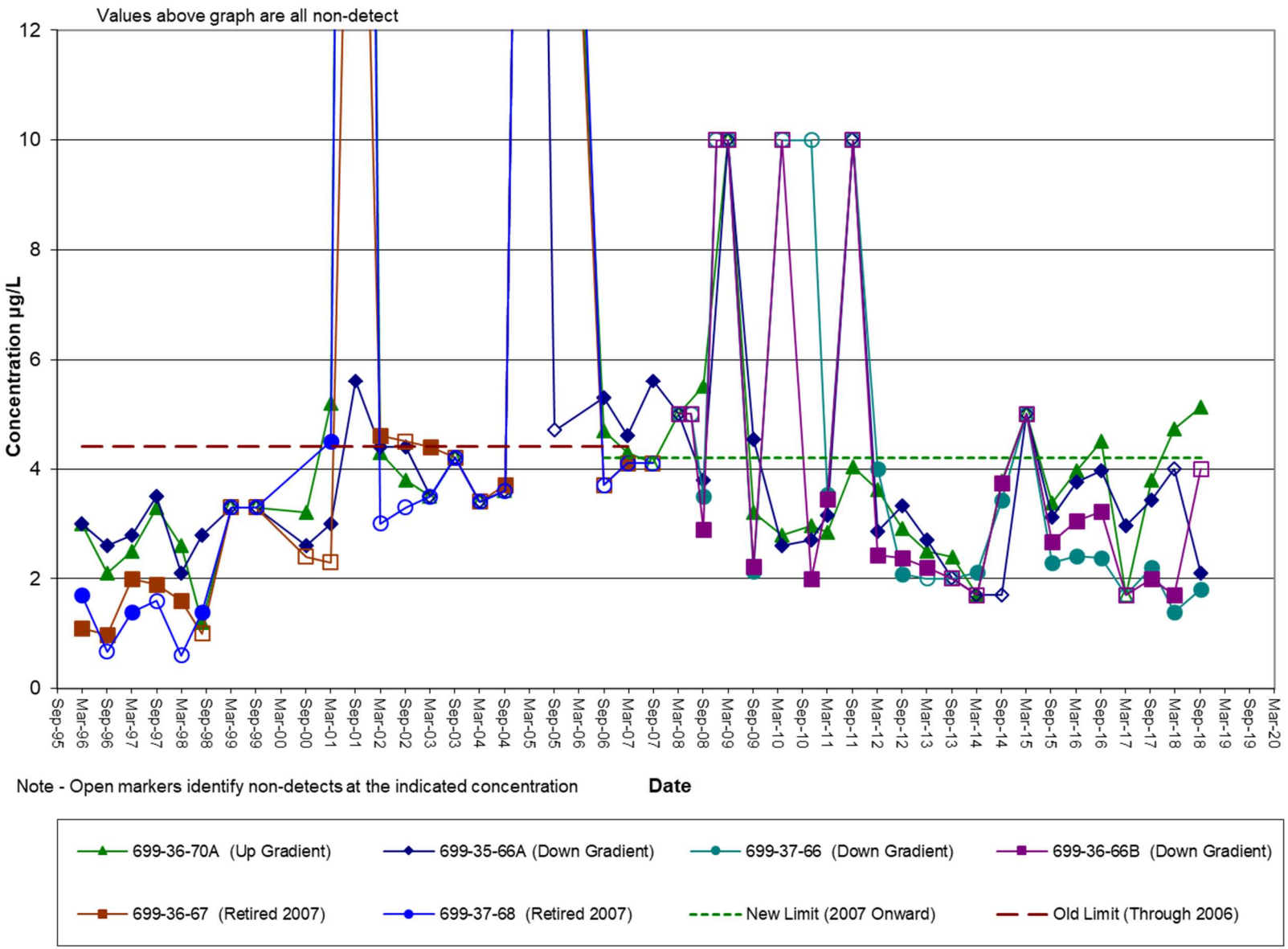



**Figure B-1. Arsenic (Filtered)**

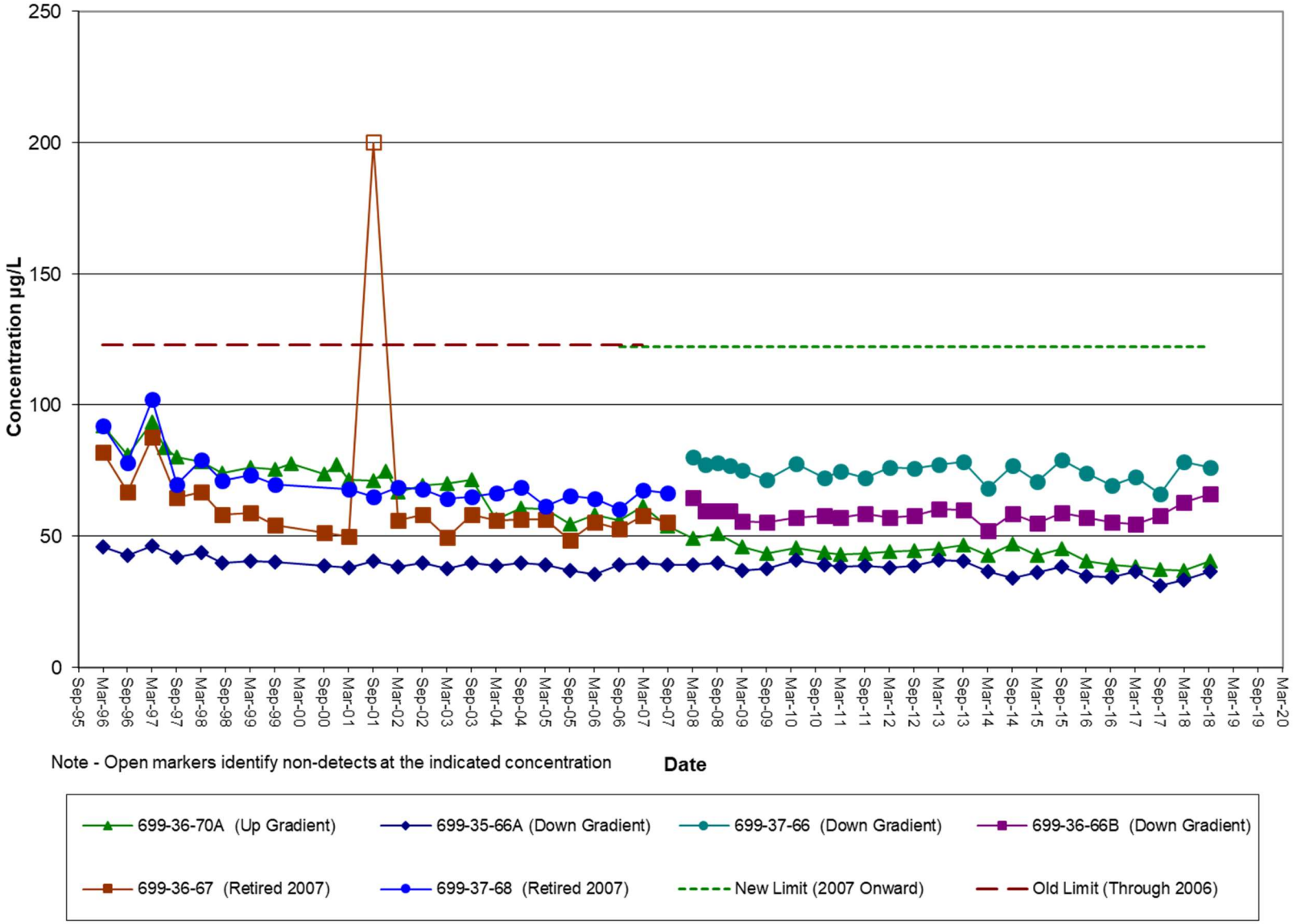



**Figure B-2. Barium (Filtered)**

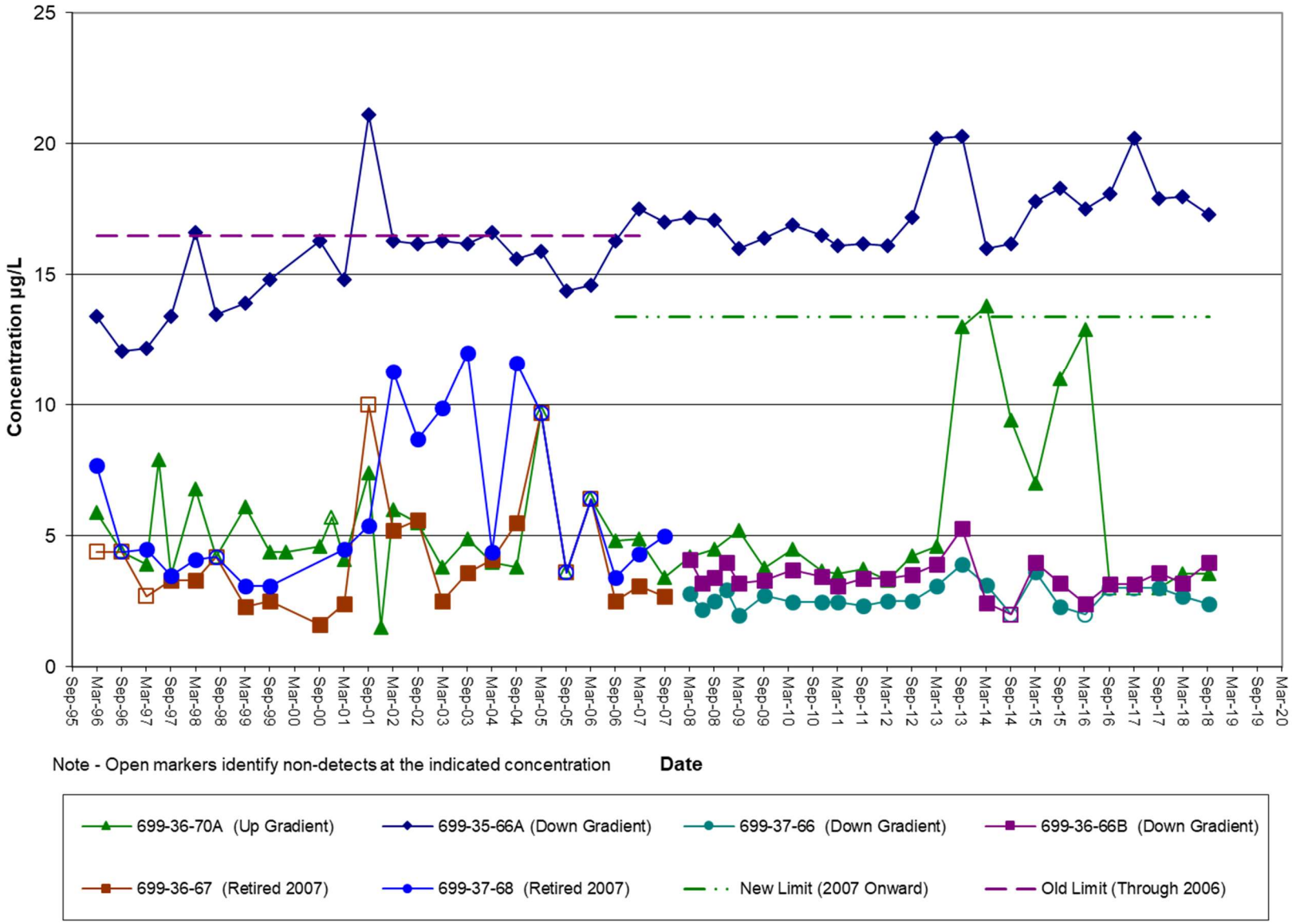



**Figure B-3. Chromium (Filtered)**

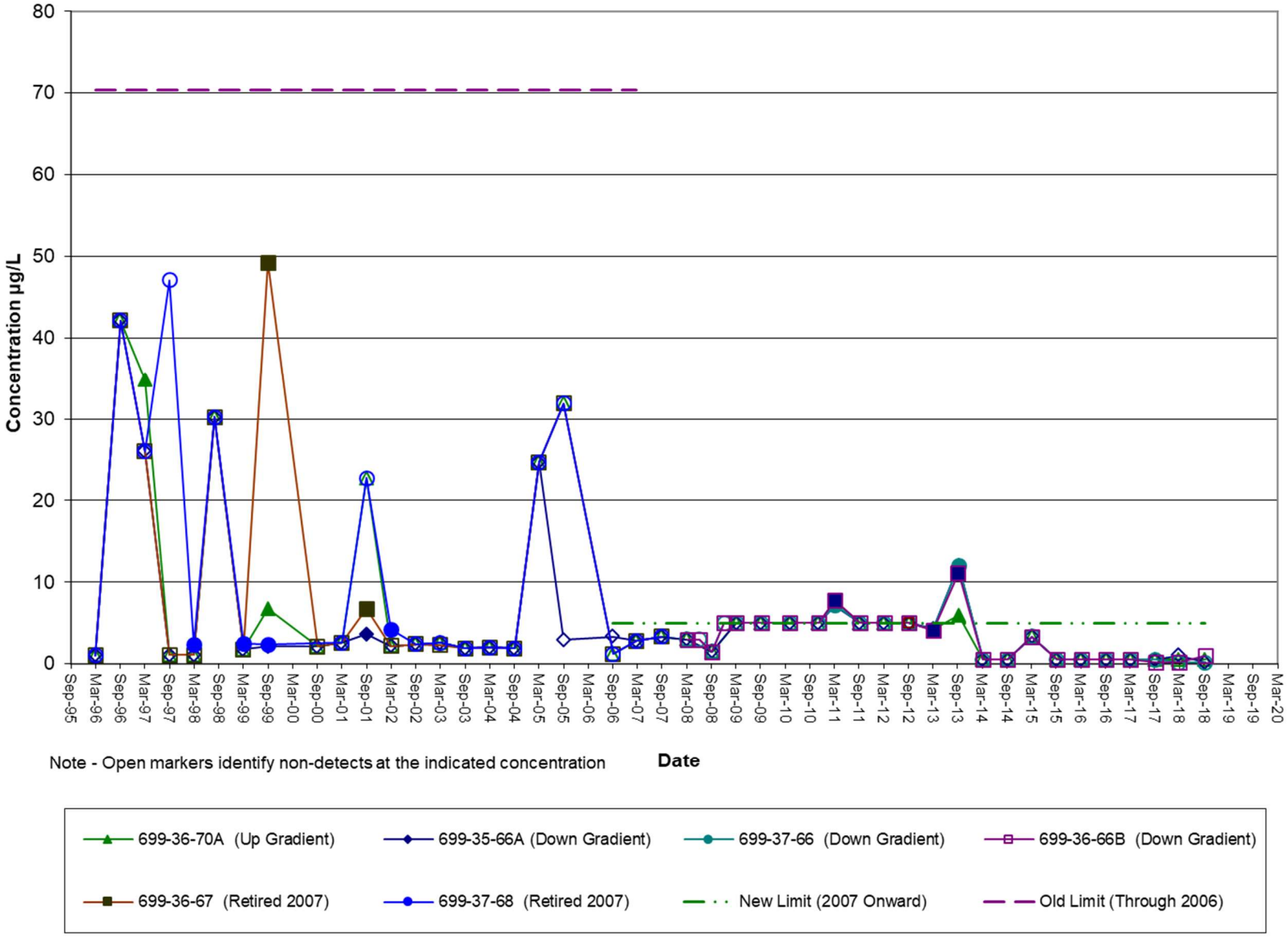



**Figure B-4. Lead (Filtered)**

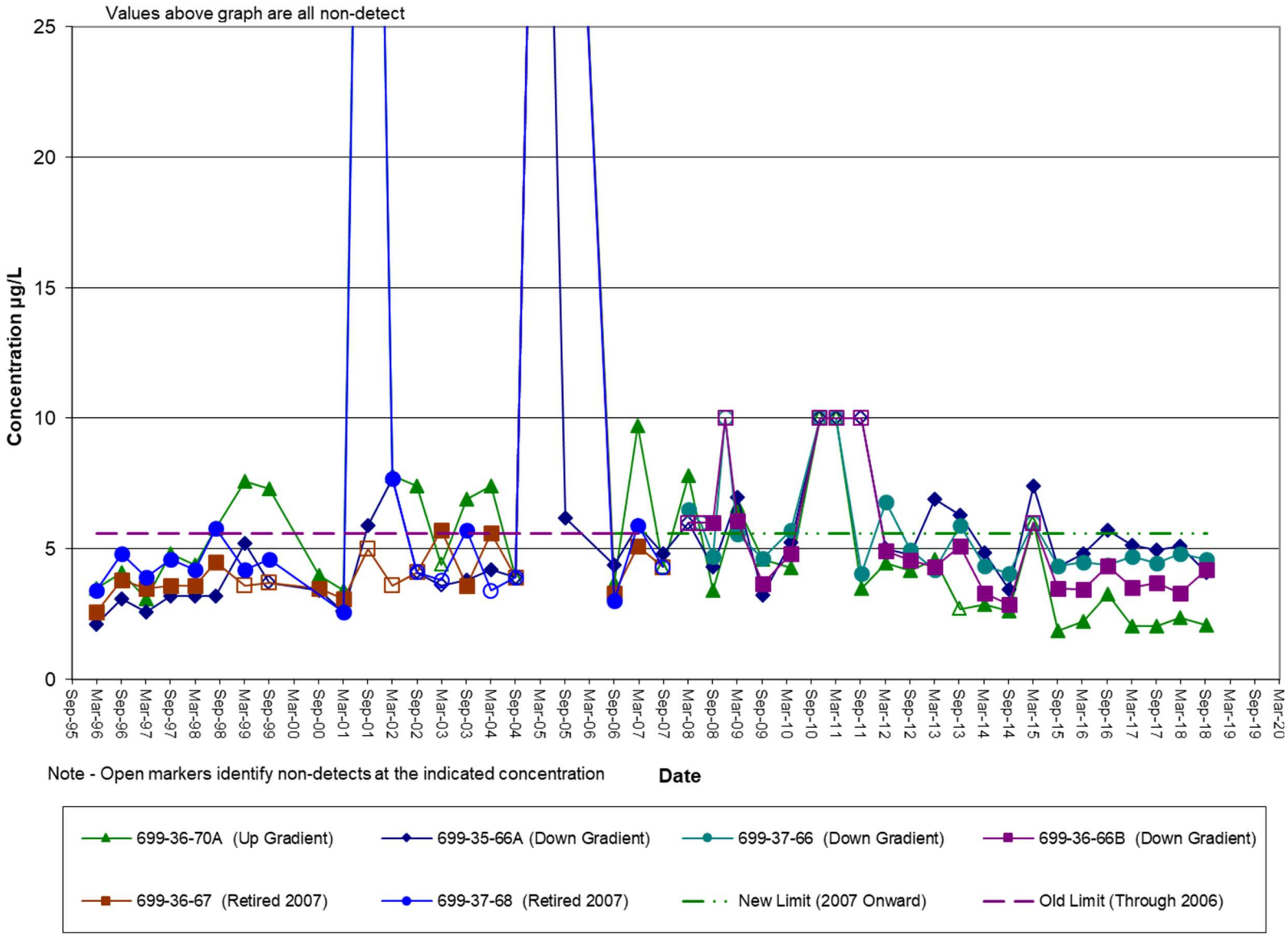



**Figure B-5. Selenium (Filtered)**

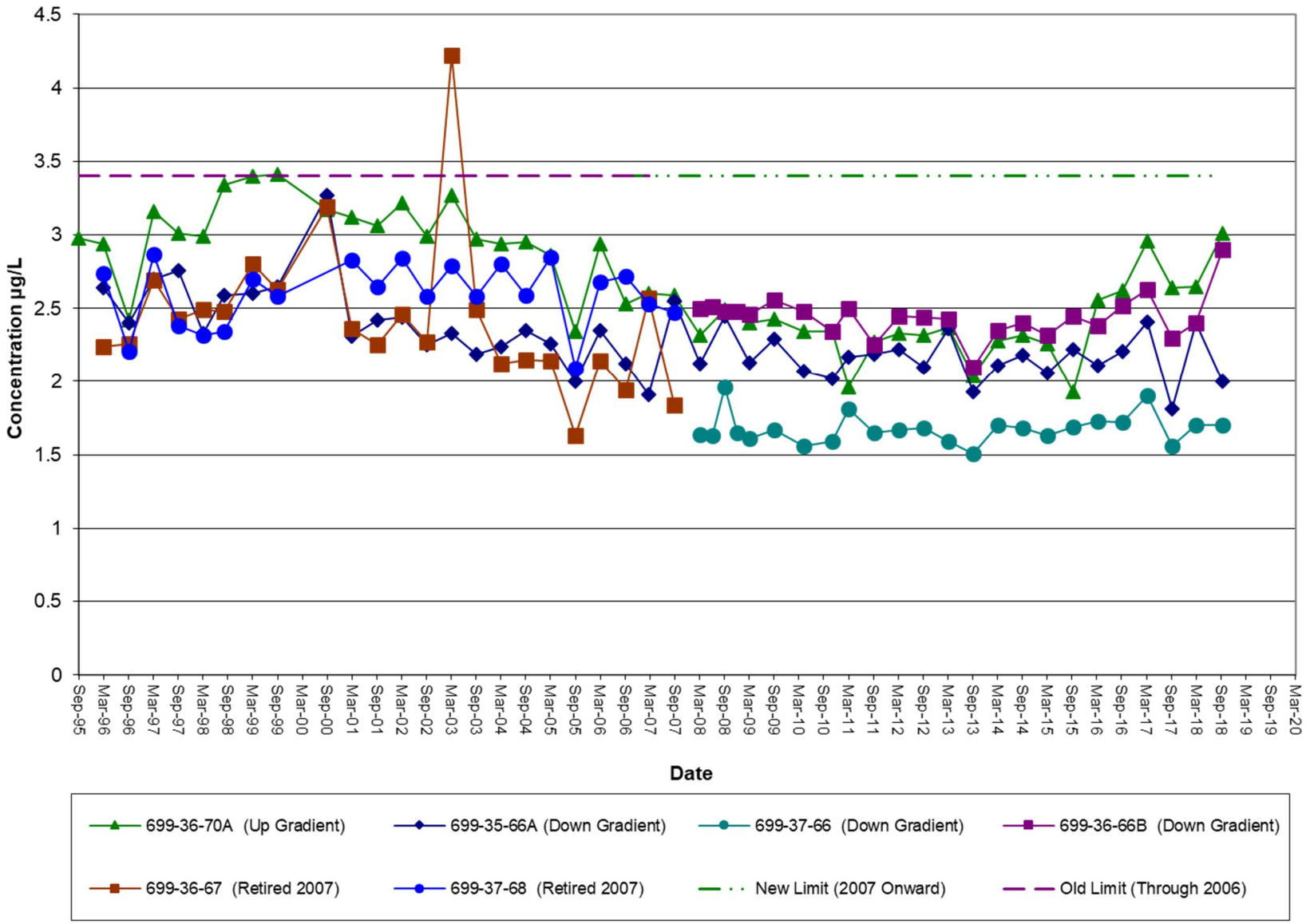



**Figure B-6. Uranium**

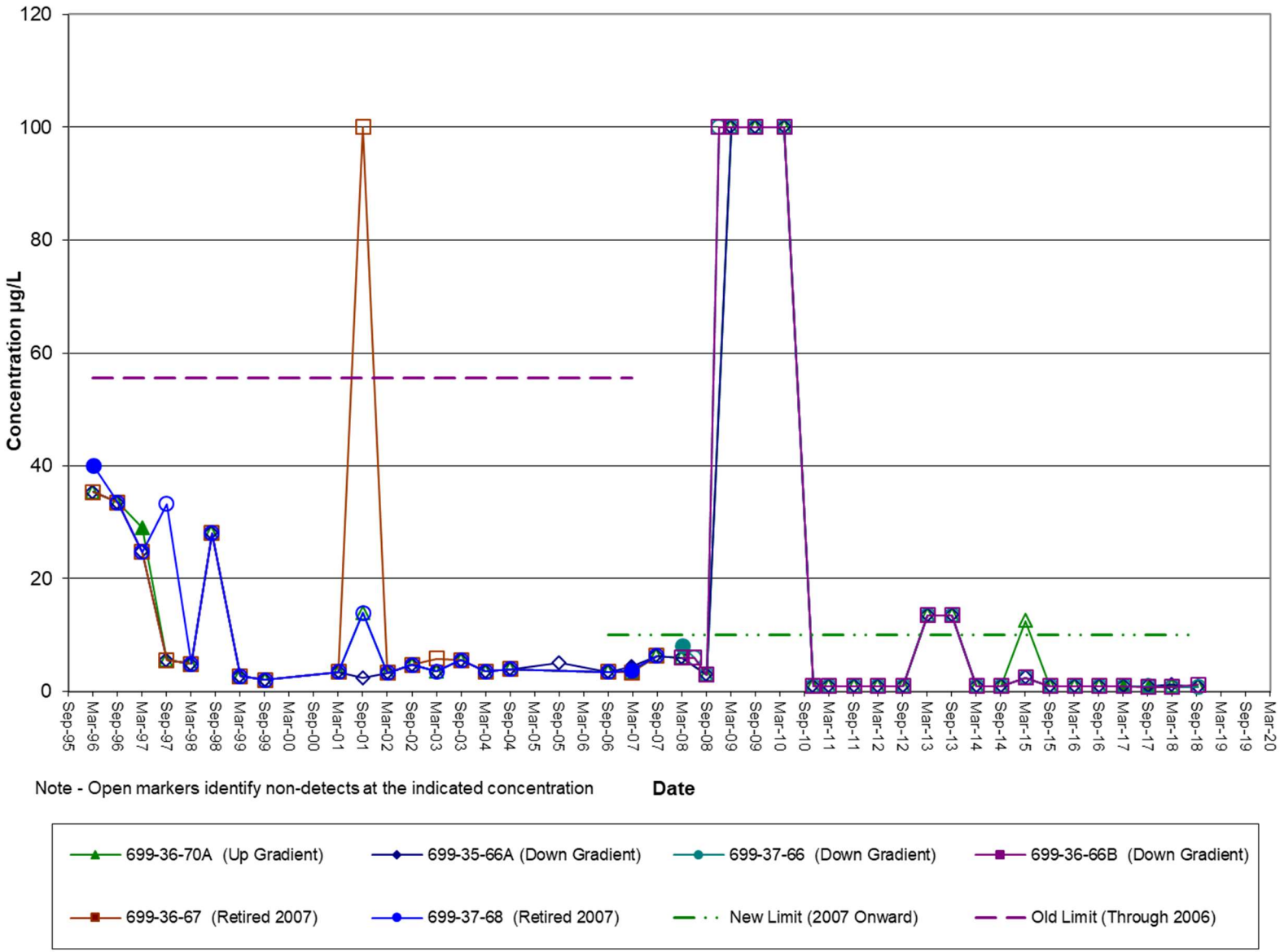
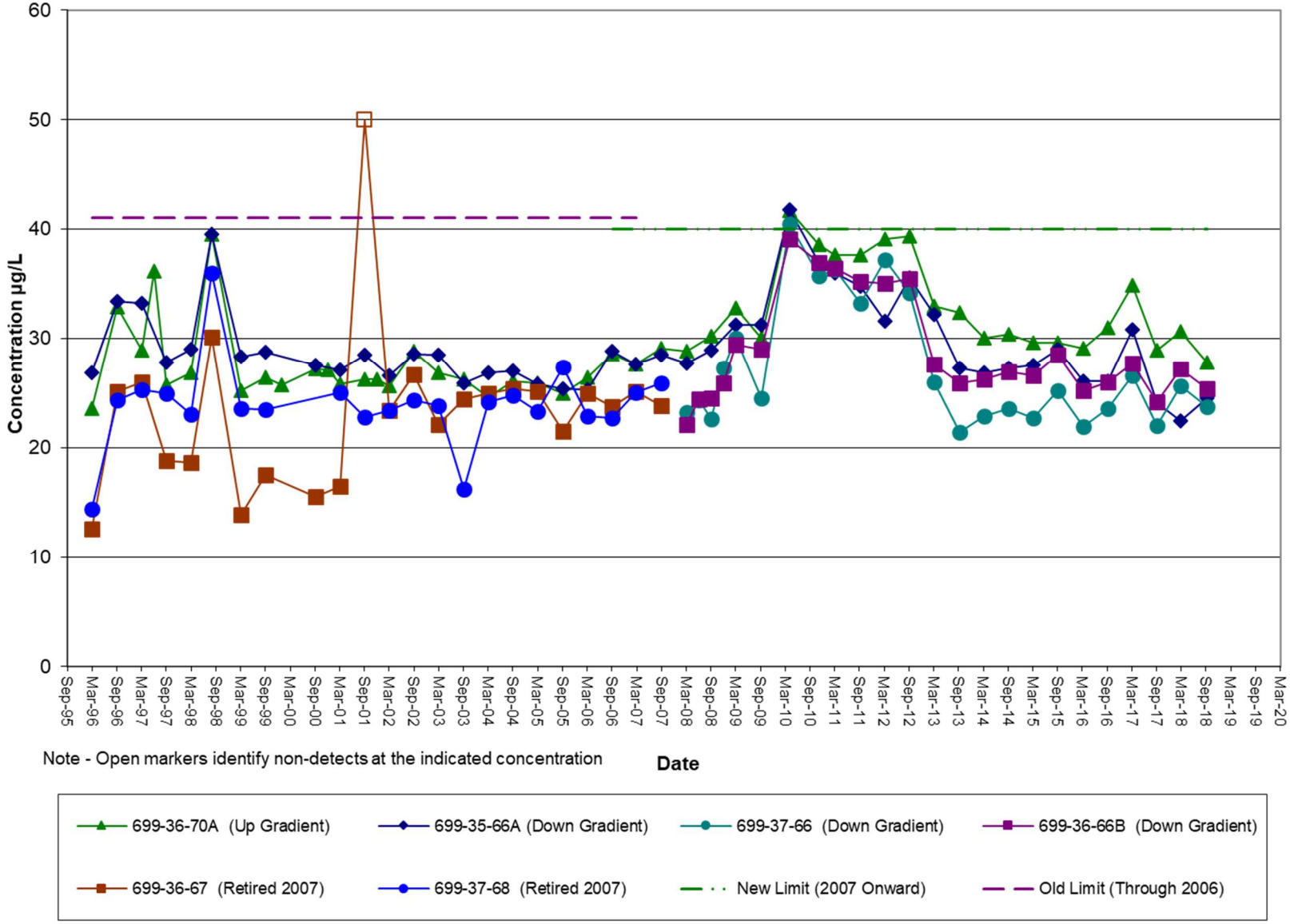



**Figure B-7. Tin (Filtered)**




Note - Open markers identify non-detects at the indicated concentration

**Figure B-8. Vanadium (Filtered)**

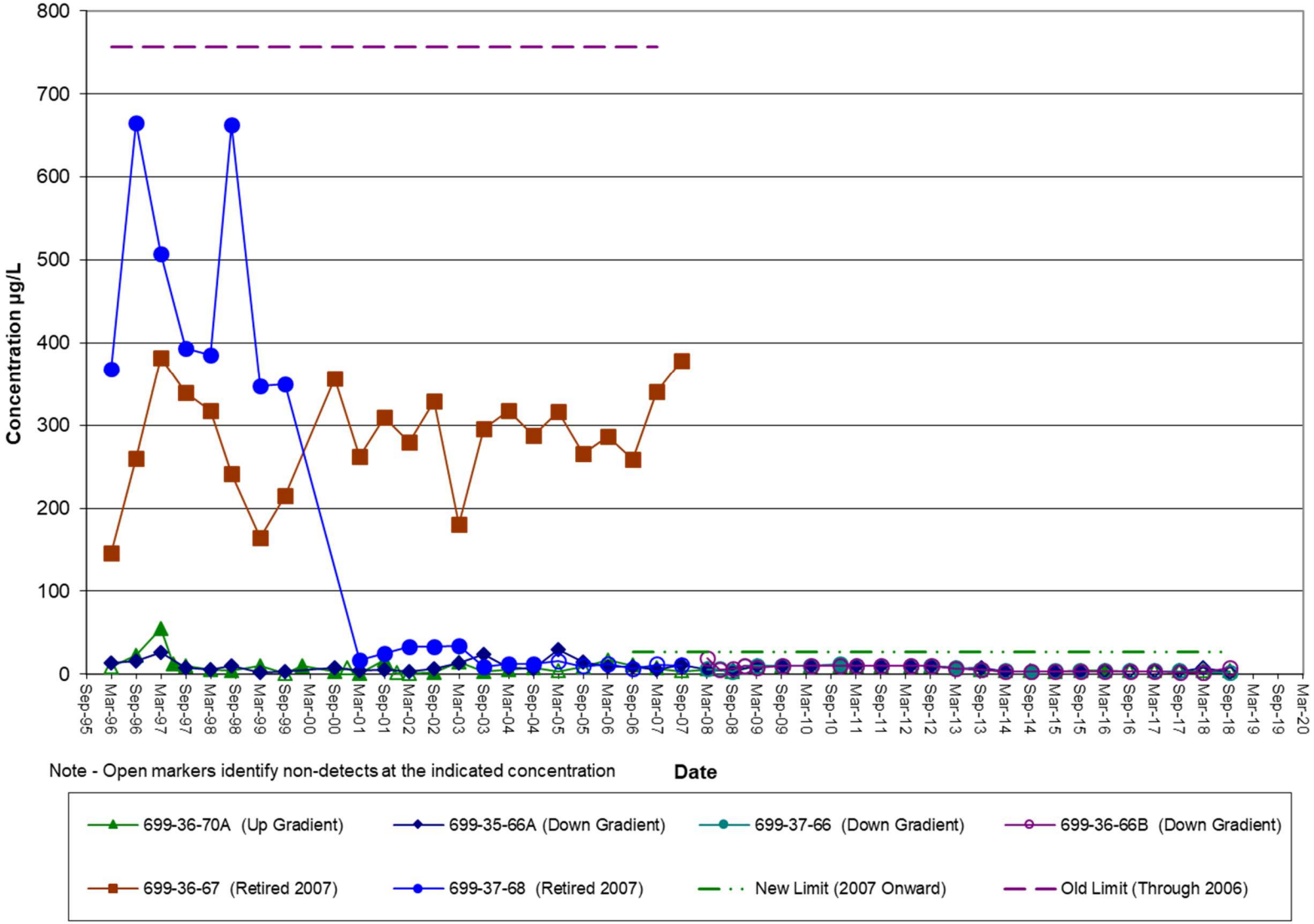



**Figure B-9. Zinc Filtered**

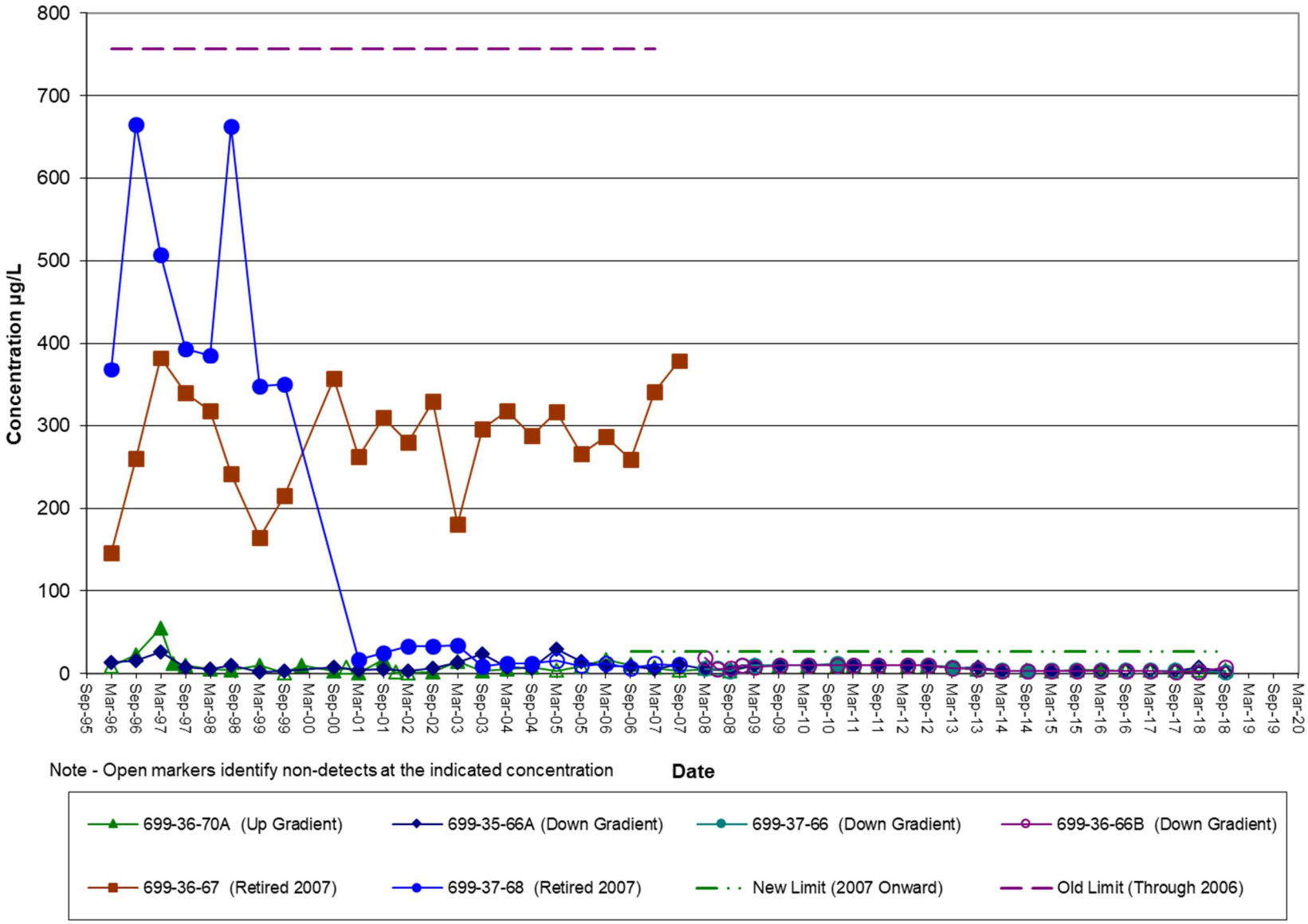



**Figure B-9. Zinc Filtered (page 2)**

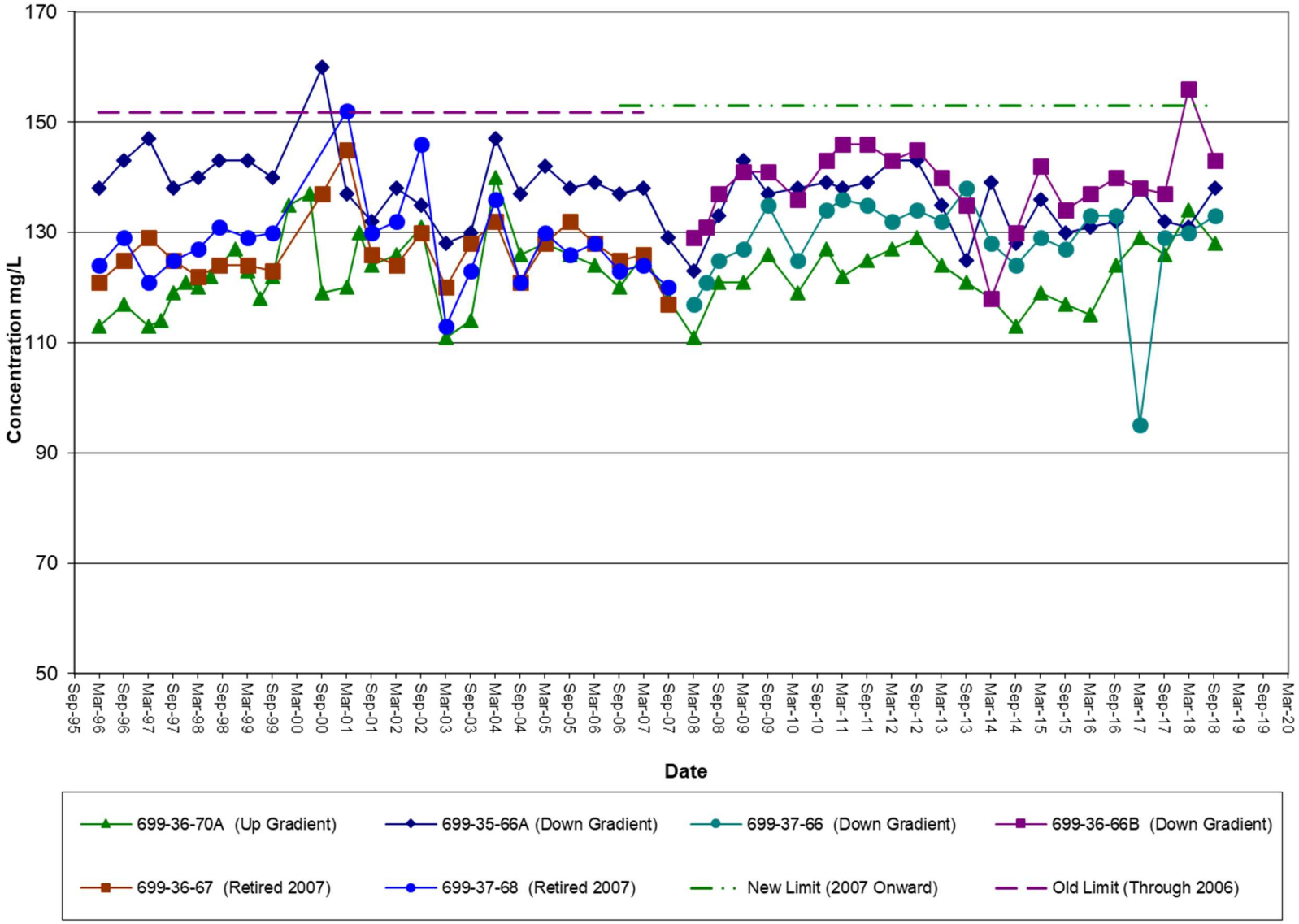
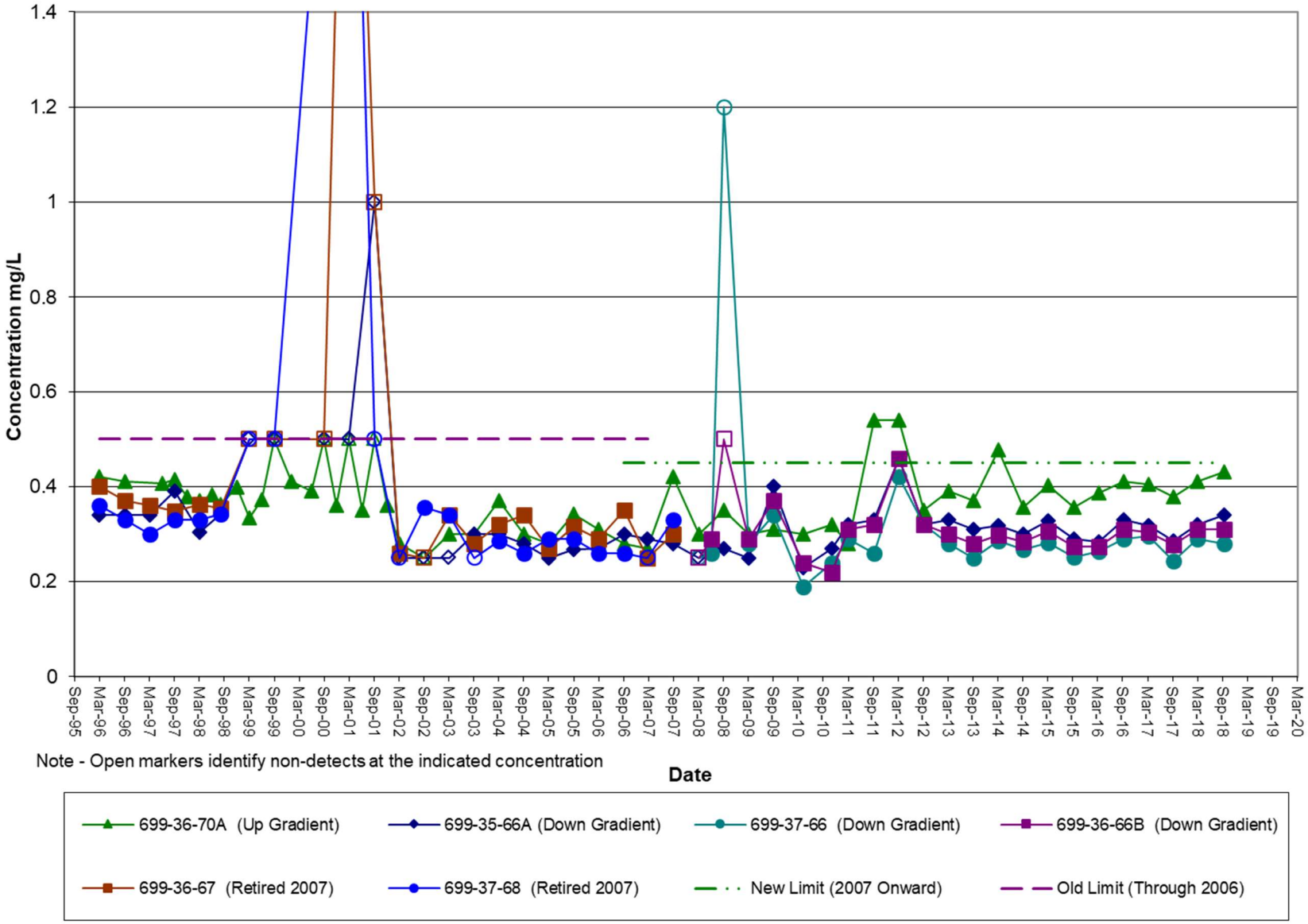



**Figure B-10. Alkalinity**




Note - Open markers identify non-detects at the indicated concentration

**Figure B-11. Fluoride**

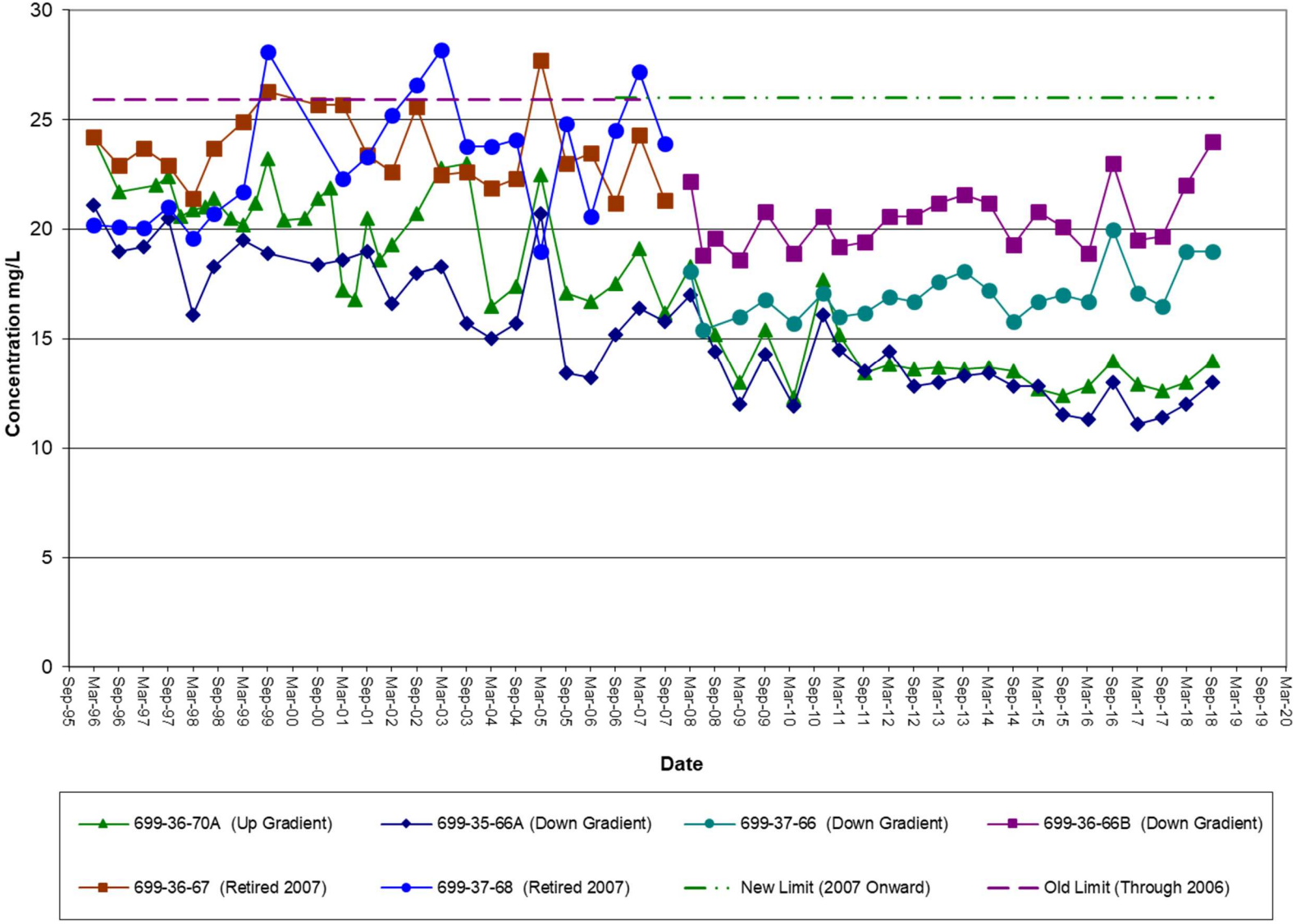



**Figure B-12. Chloride**

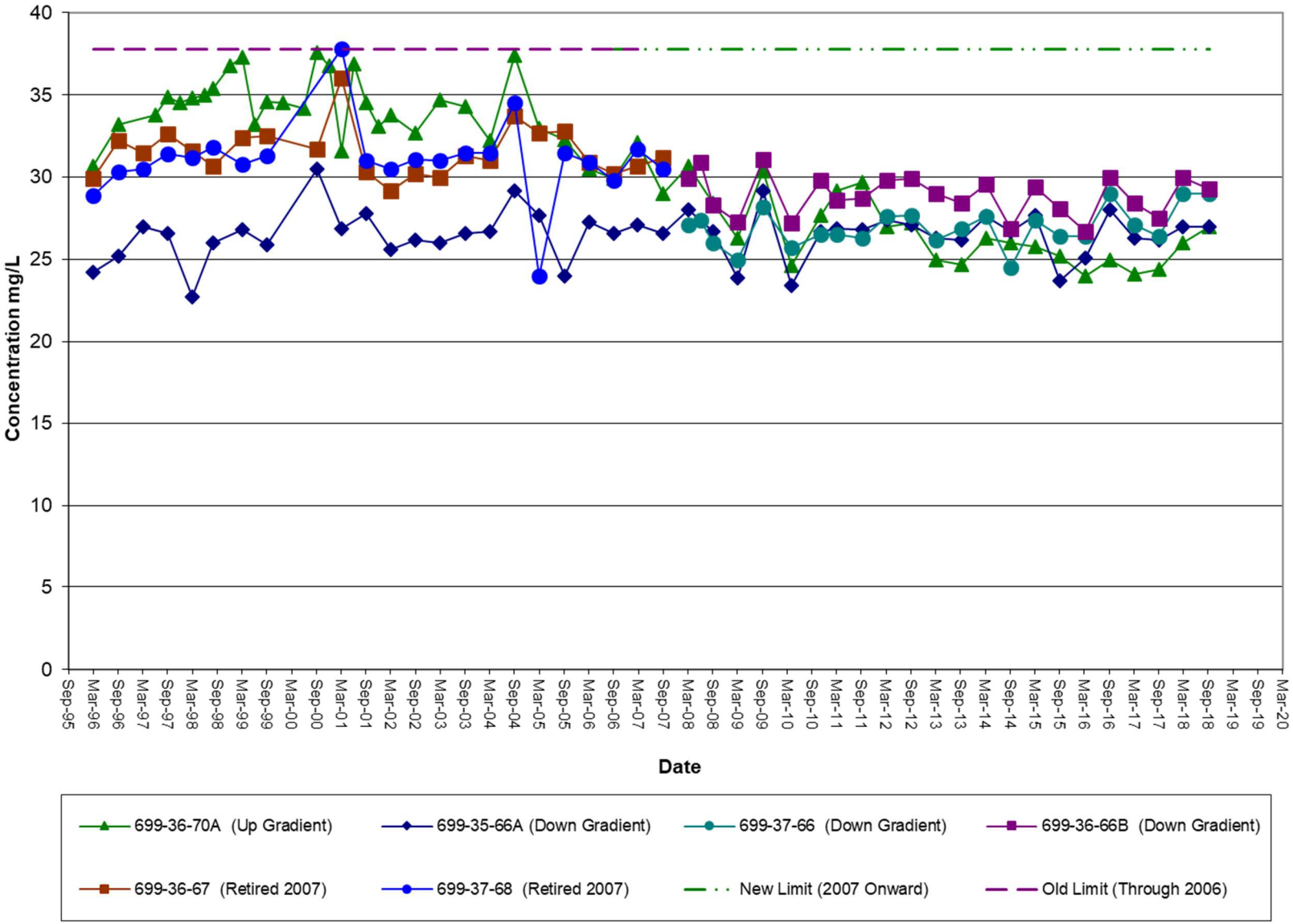



**Figure B-13. Sulfate**

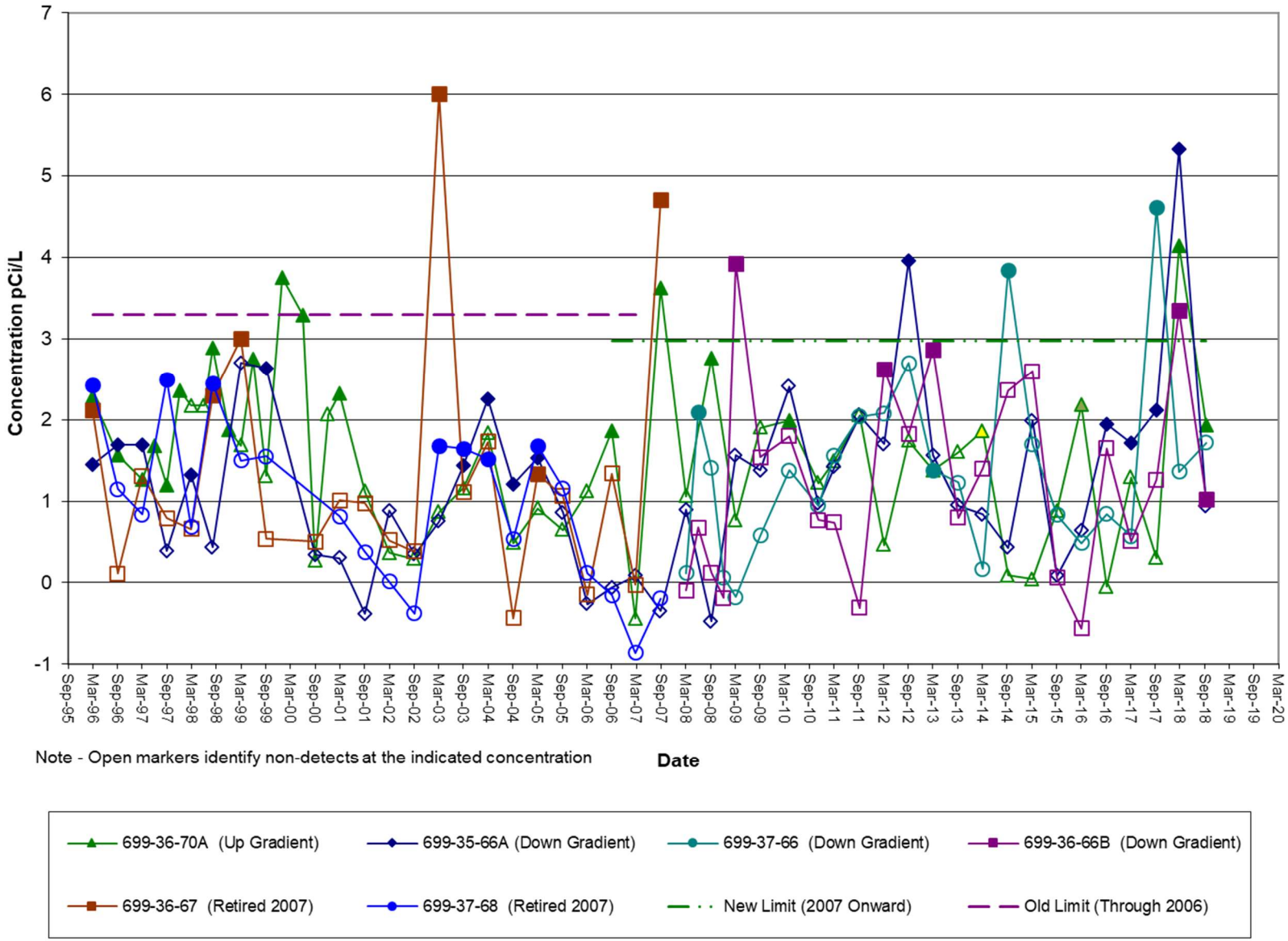



**Figure B-14. Gross Alpha**

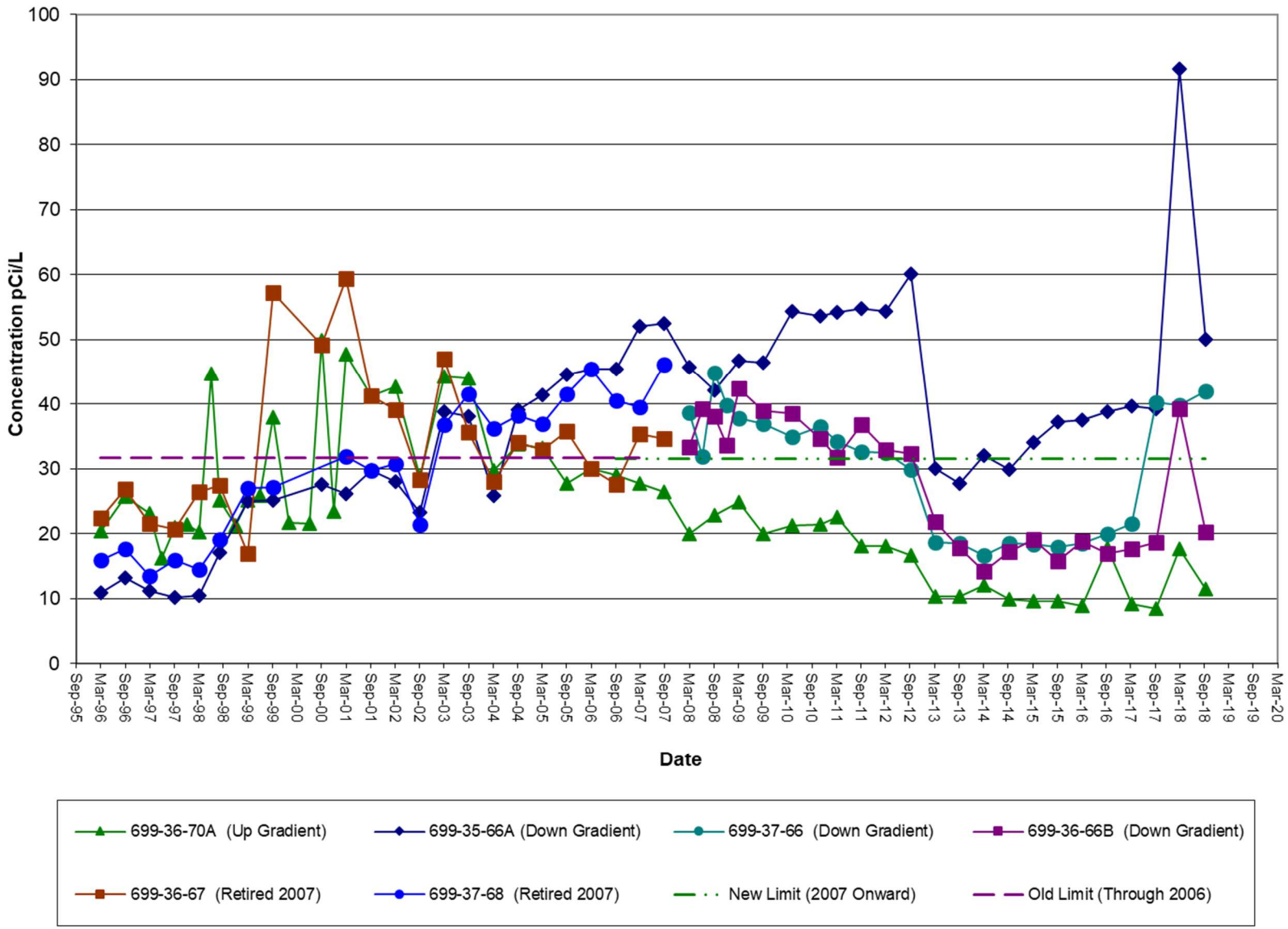
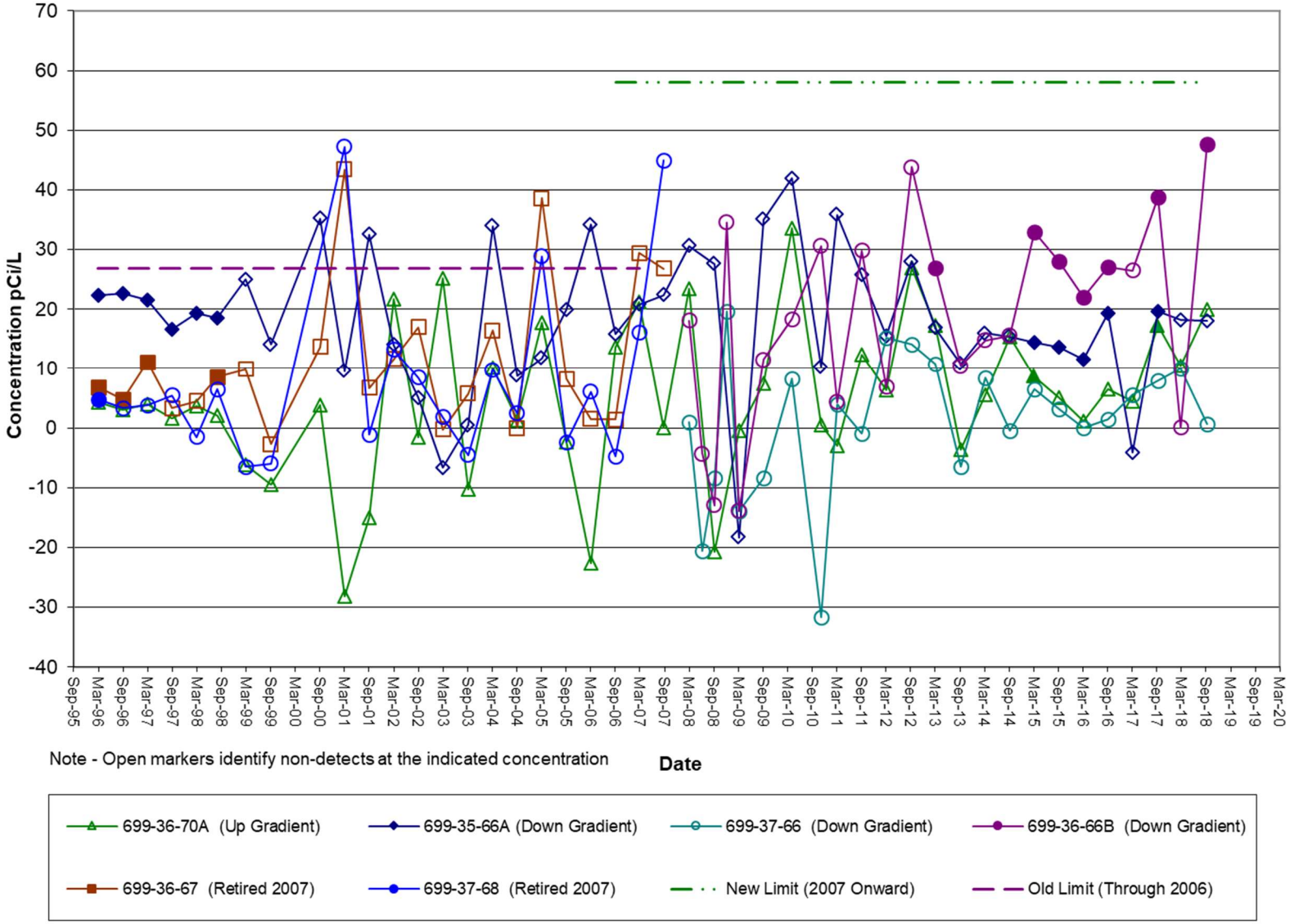



**Figure B-15. Gross Beta**




Note - Open markers identify non-detects at the indicated concentration

**Figure B-16. Carbon-14**

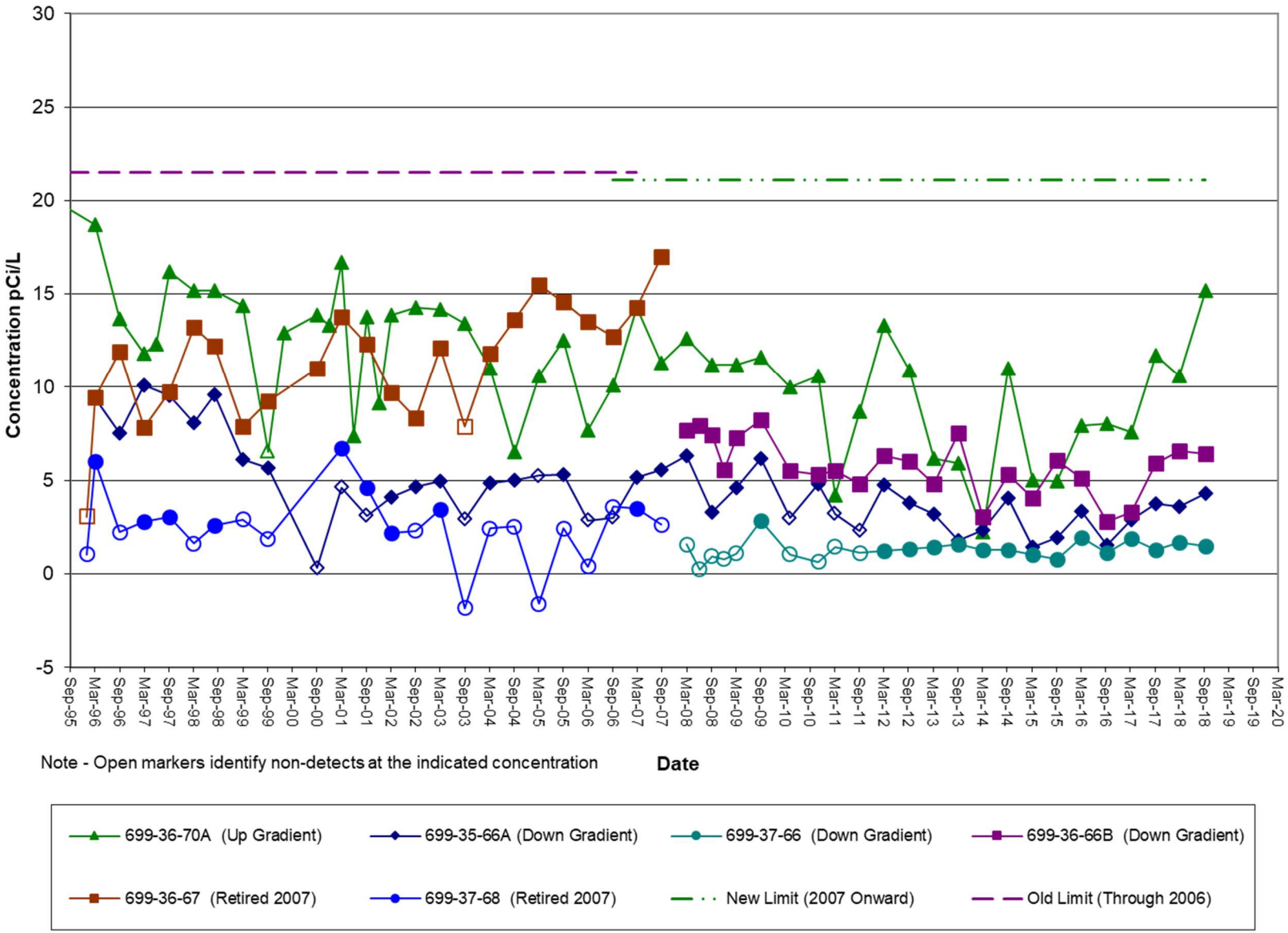



**Figure B-17. Iodine-129**

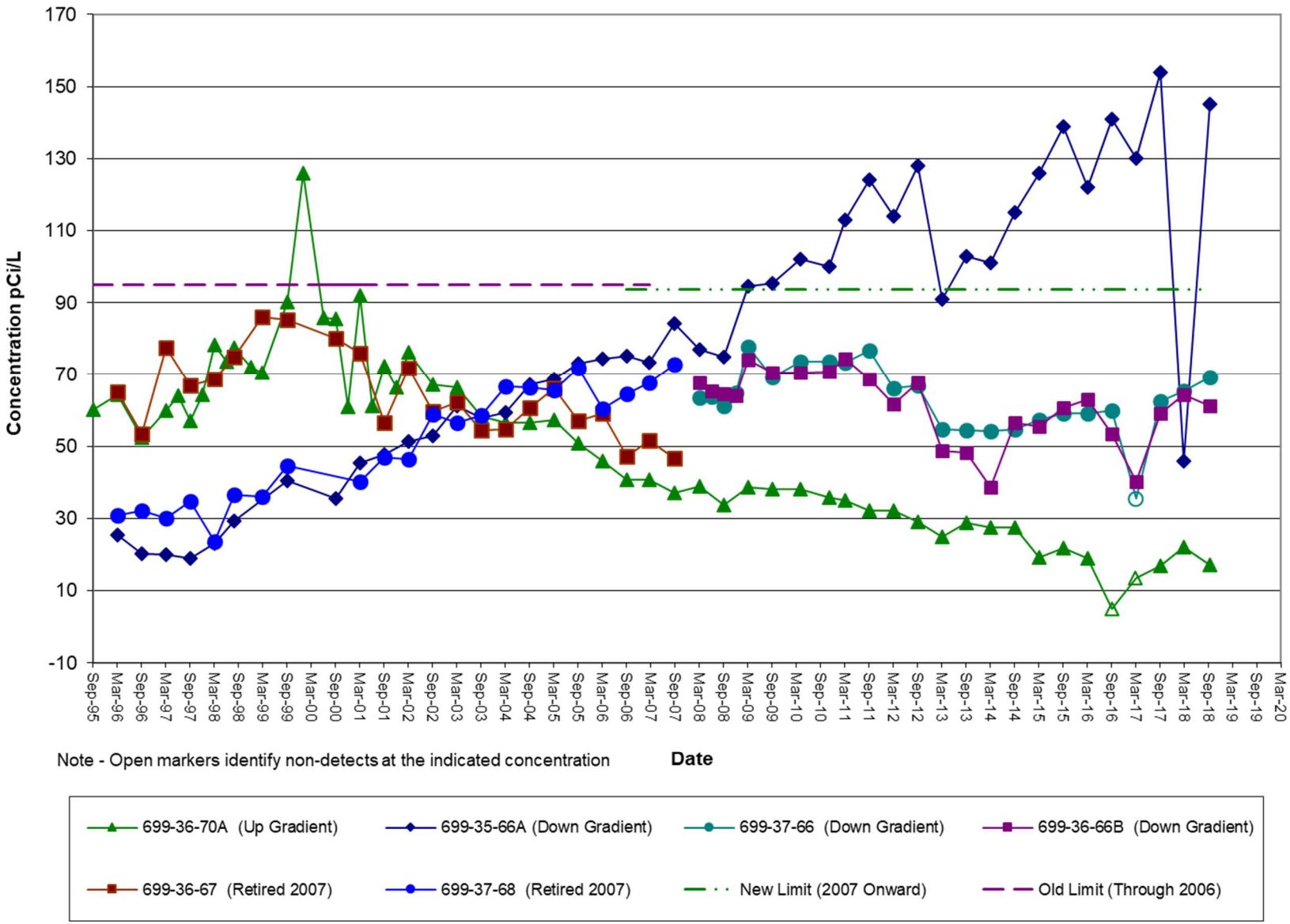
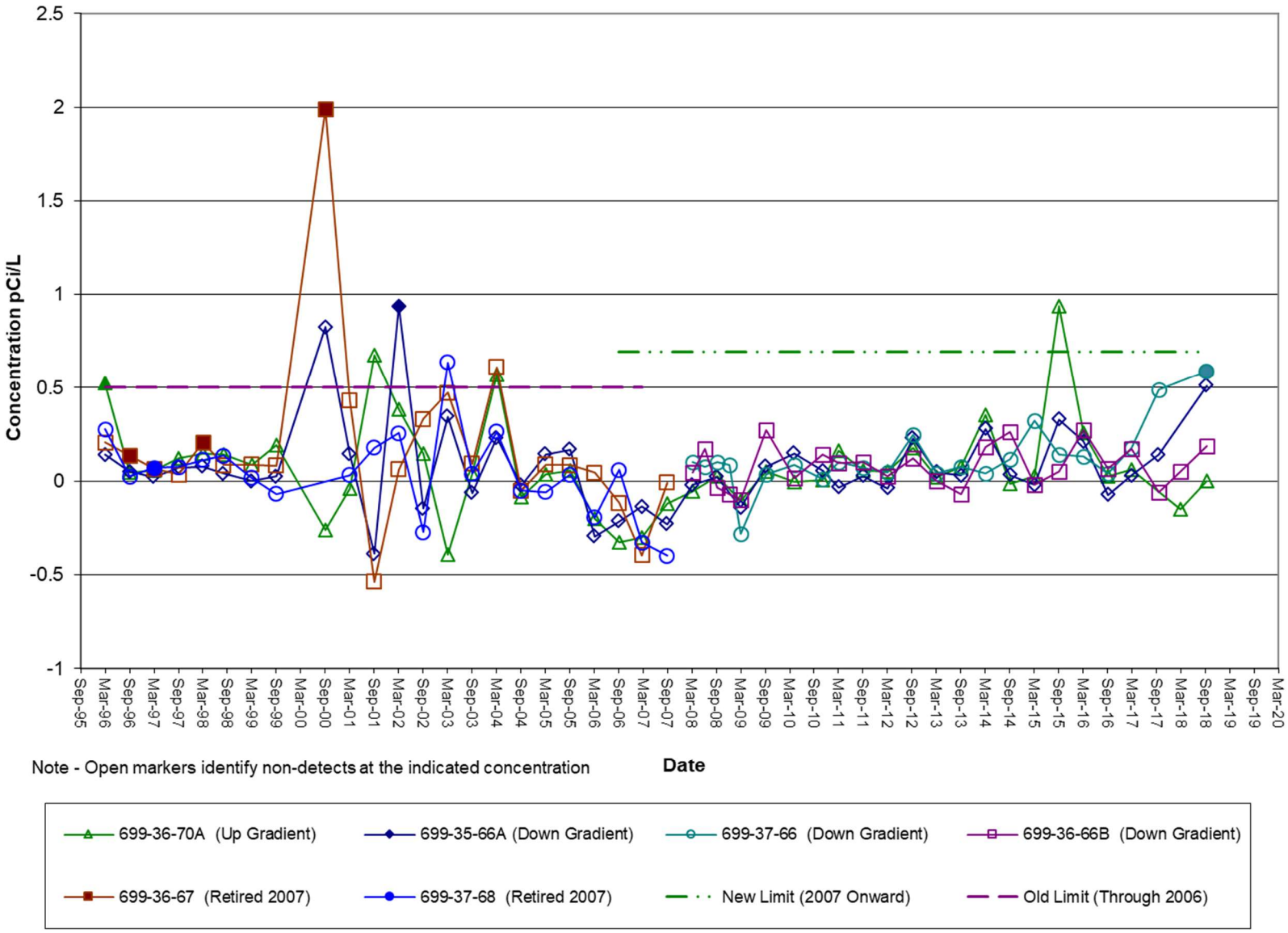



**Figure B-18. Technetium-99**




Note - Open markers identify non-detects at the indicated concentration

**Figure B-19. Radium**

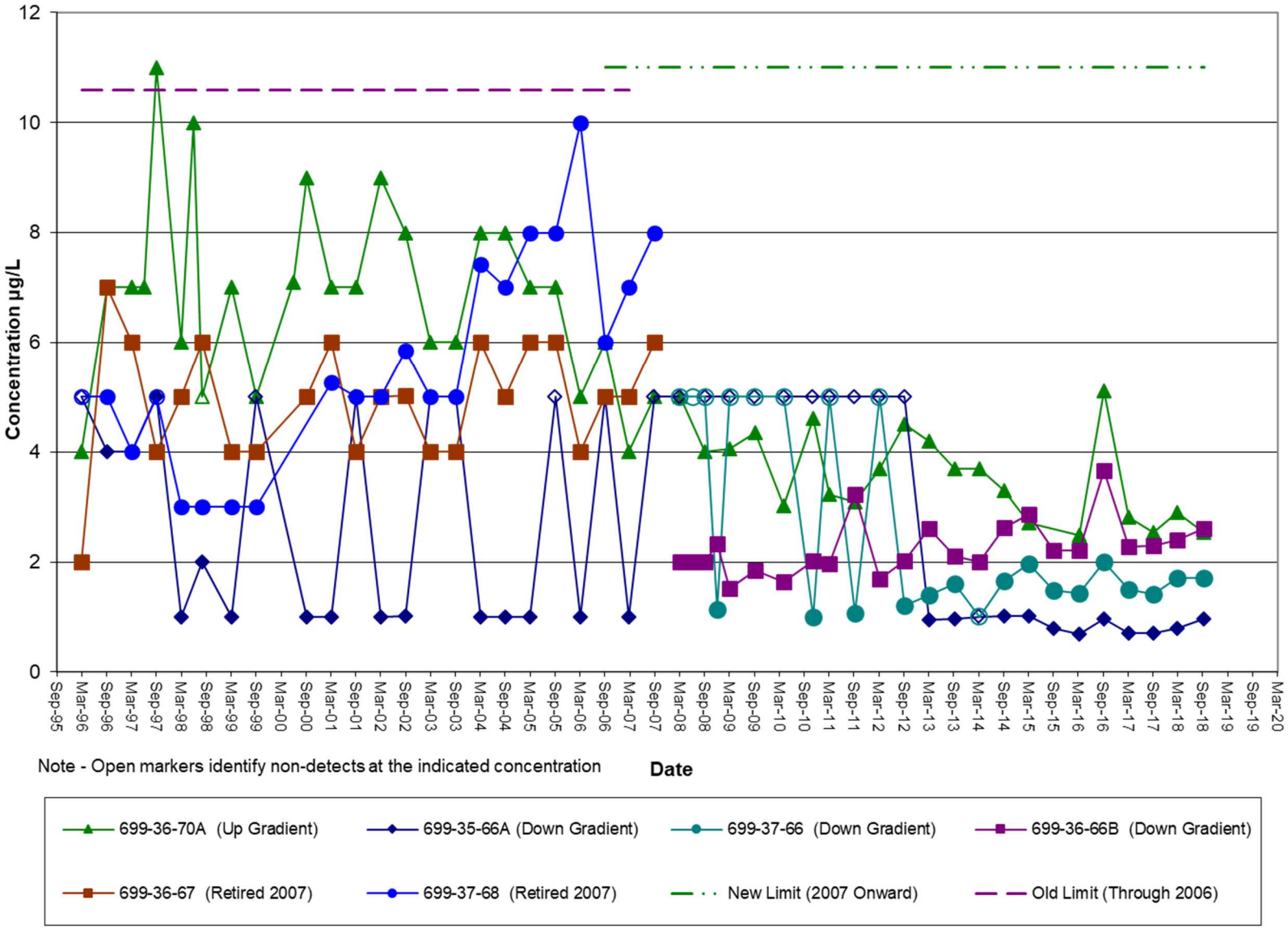



**Figure B-20. Carbon Tetrachloride**

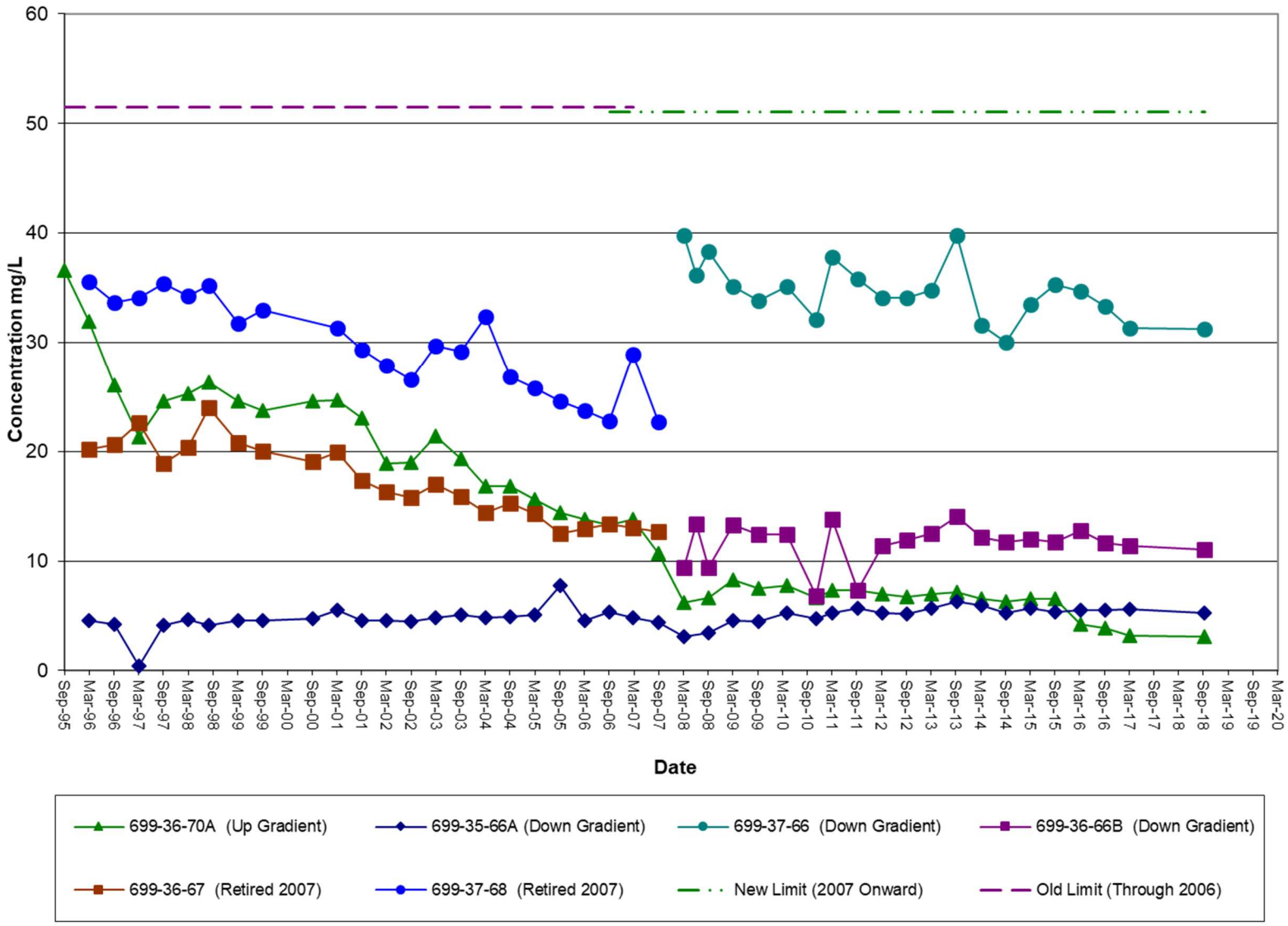



**Figure B-21. Nitrogen in Nitrite and Nitrate**

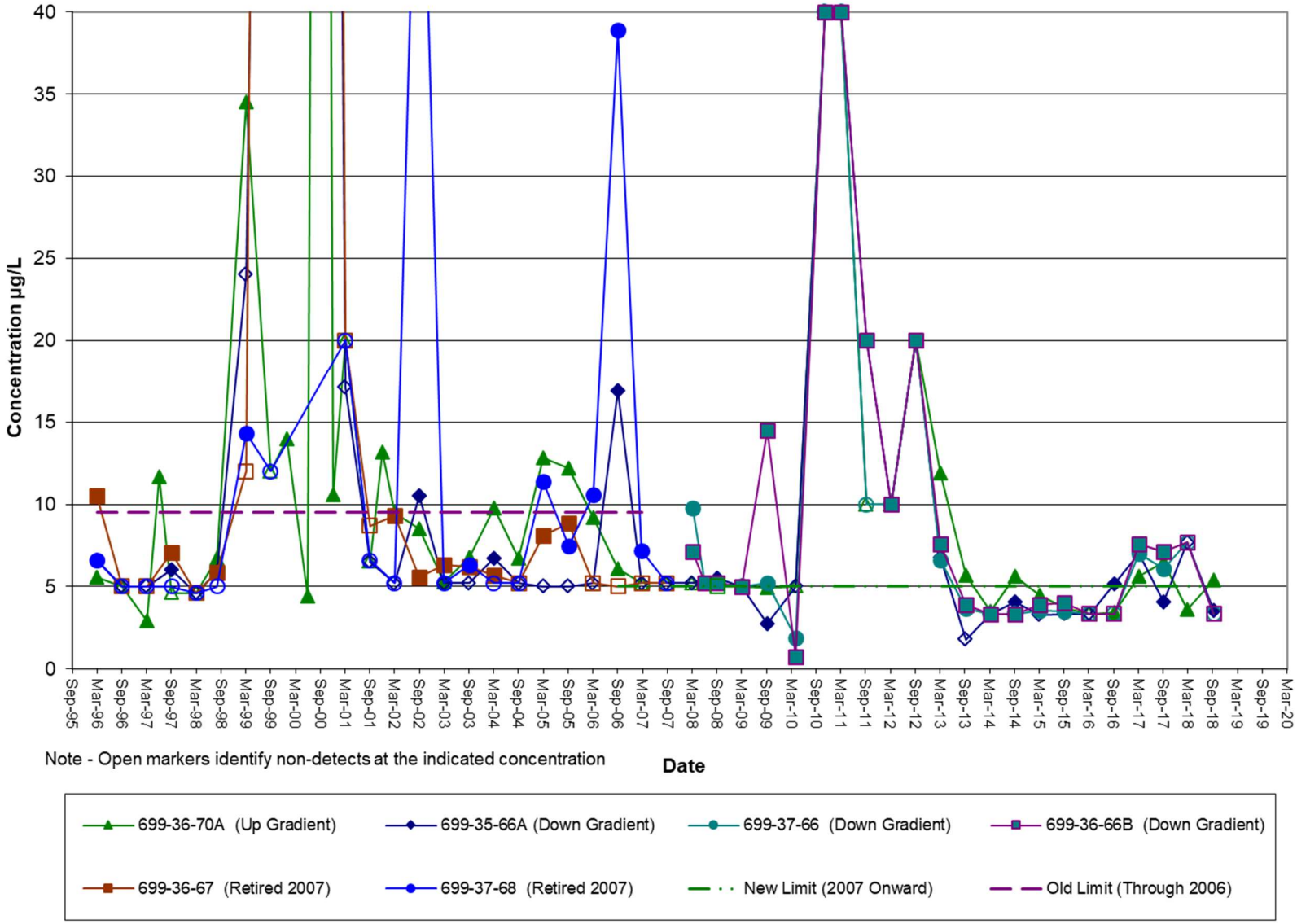
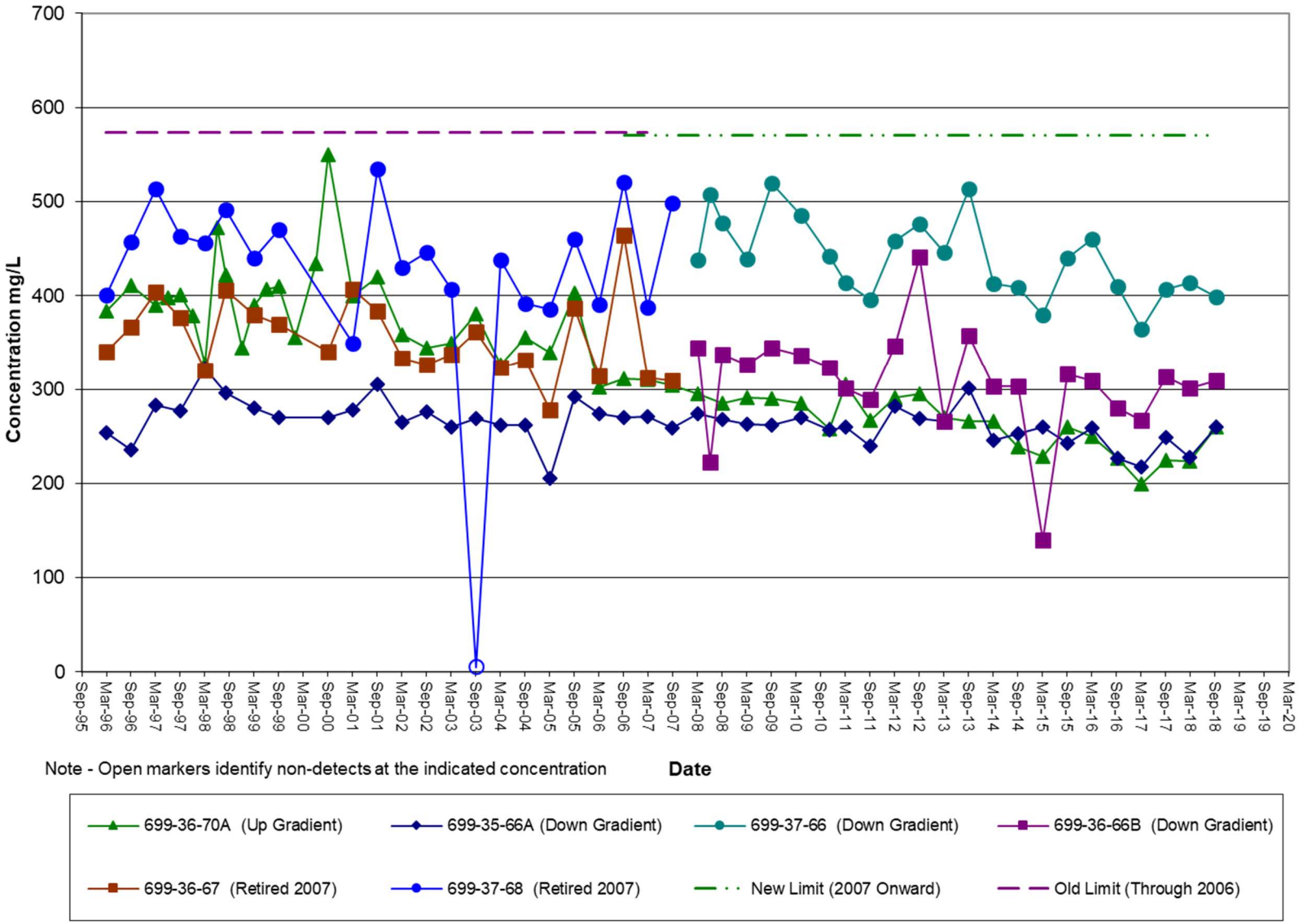



**Figure B-22. Total Organic Halides**




Note - Open markers identify non-detects at the indicated concentration

**Figure B-23. Total Dissolved Solids**

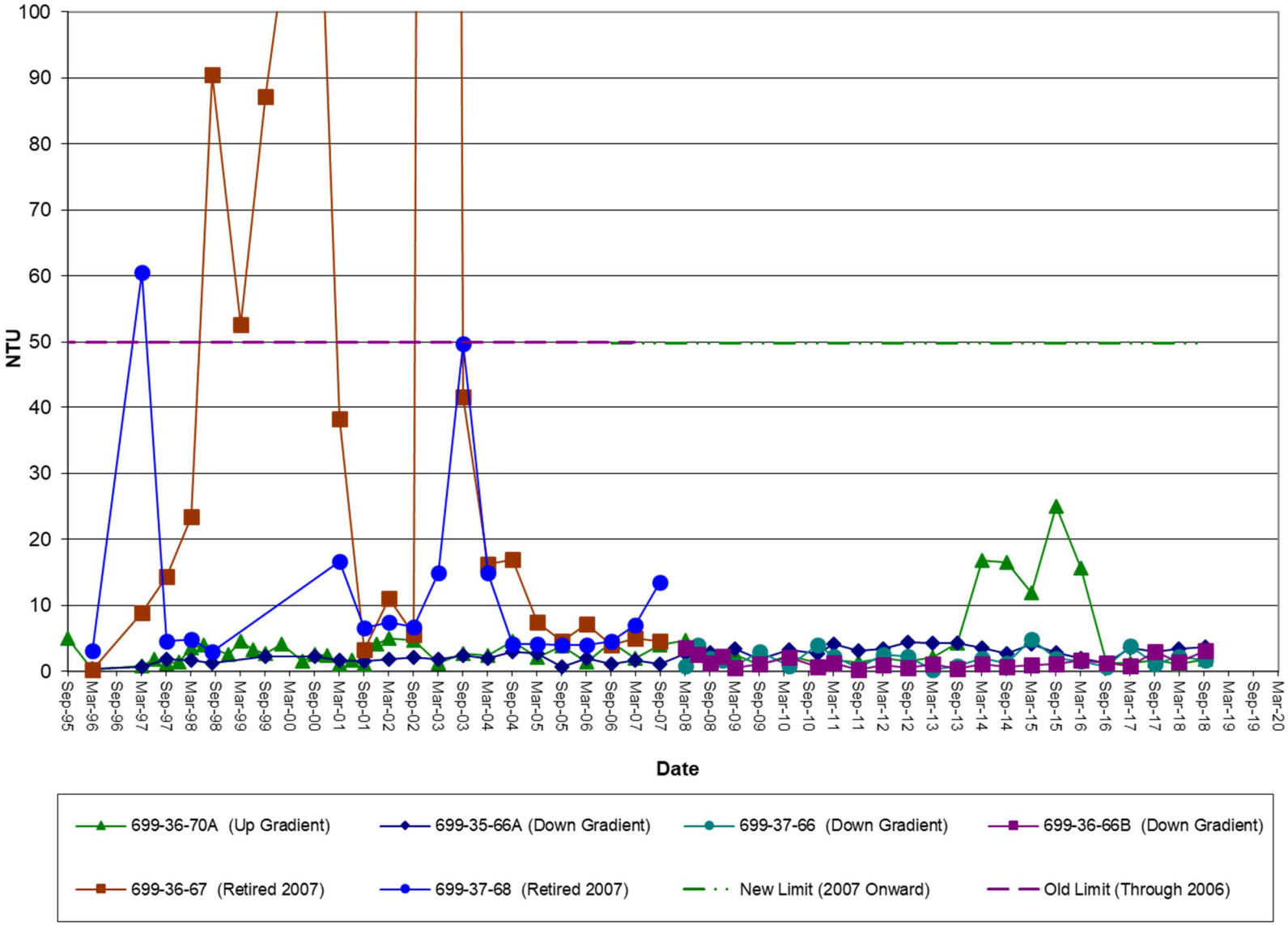



**Figure B-24. Turbidity**

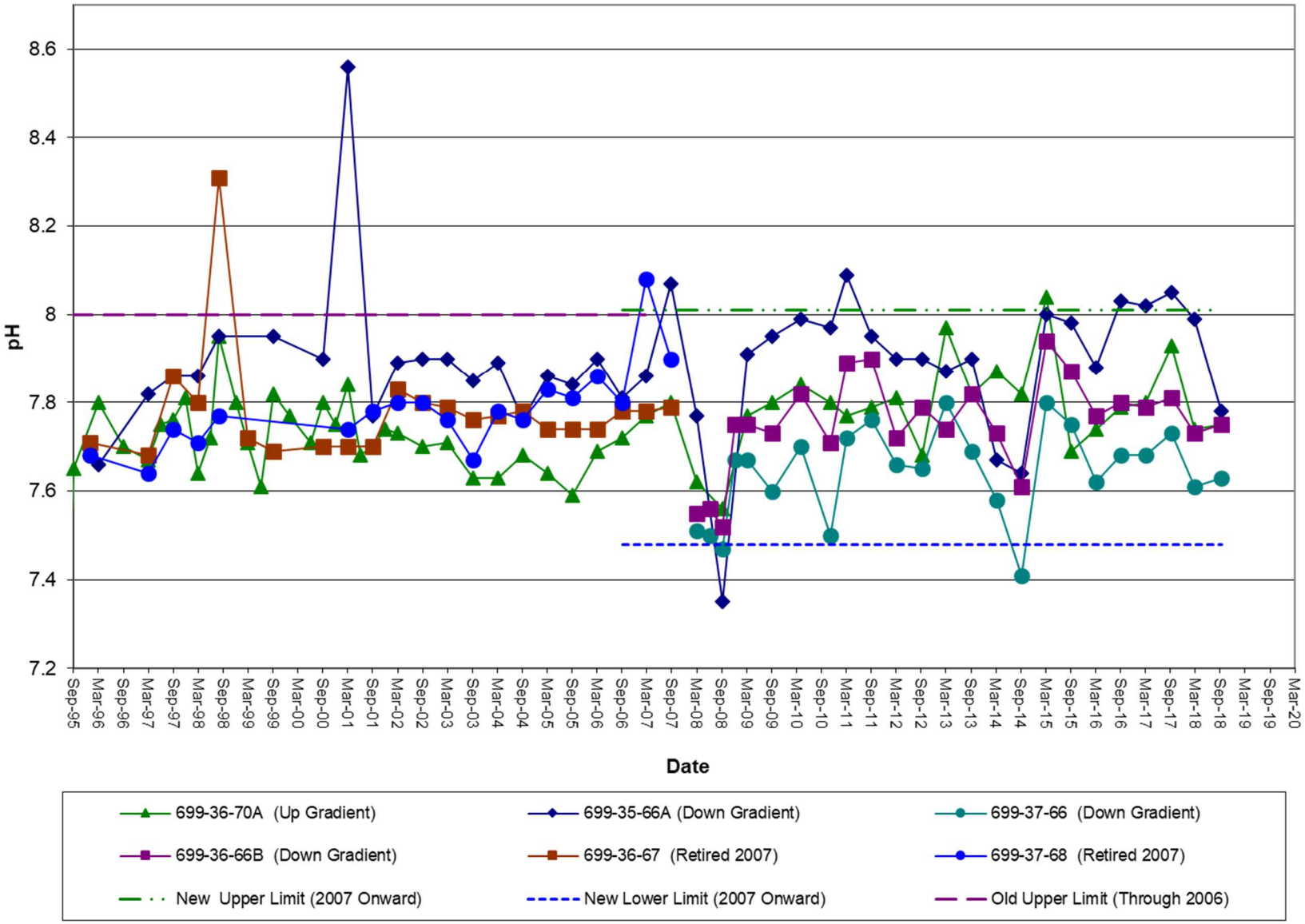



**Figure B-25. pH**

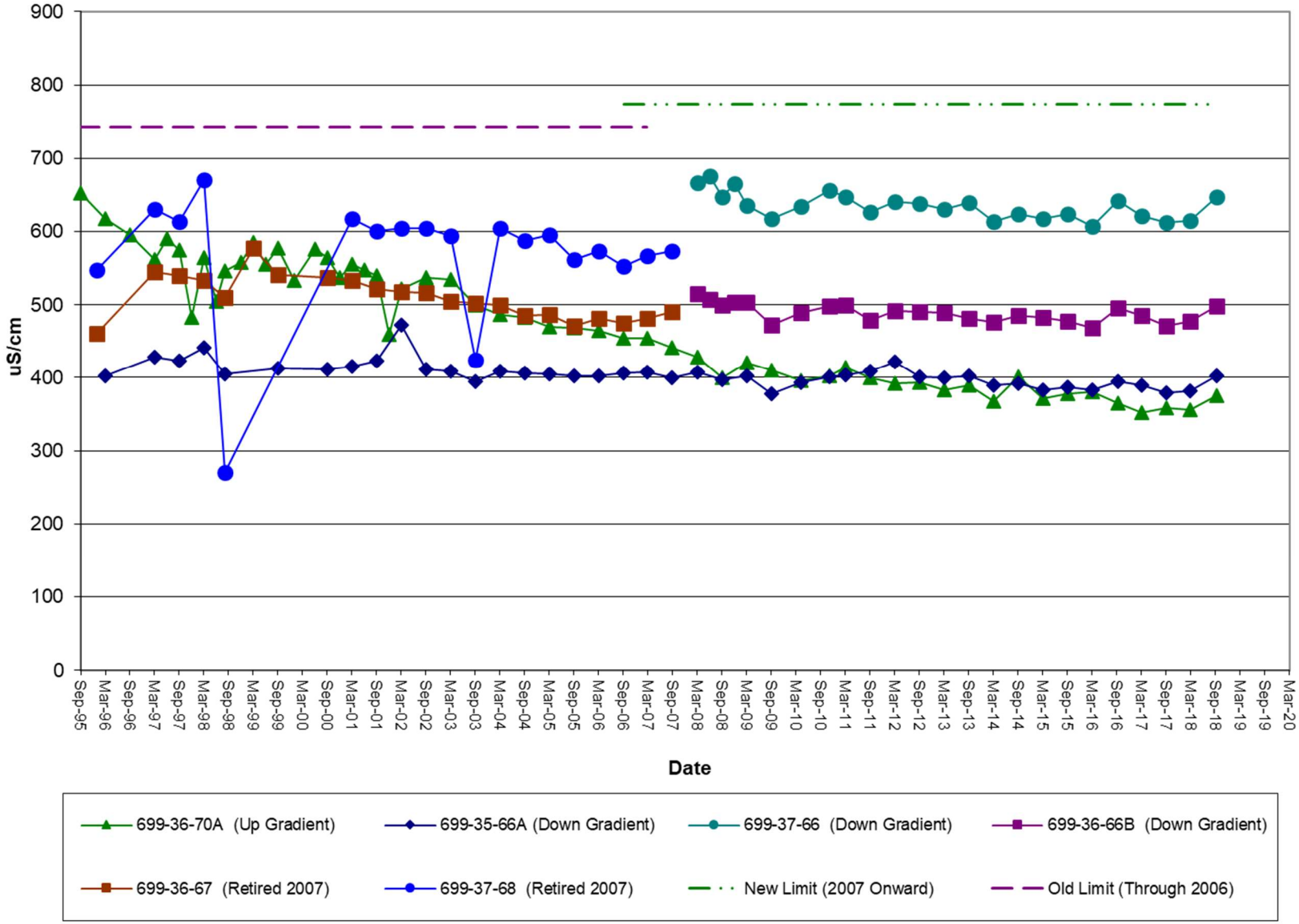



**Figure B-26. Specific Conductance**

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# Appendix C

# Leachate Sampling Results Summary, 2018

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# Tables

Table C-1. Leachate Sample Data ..... C-1
Table C-2. ERDF Historical Leachate Generation ..... C-4

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**Table C-1. Leachate Sample Data**

| Constituent | Units | 2018 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mar | Mar[a] | May | May[a] | Sep | Sep[a] | Dec | Dec [a] |
| Aluminum | µg/L | NR | NR | NR | NR | 9.2U | 9.2U | NR | NR |
| Antimony | µg/L | NR | NR | NR | NR | 0.4U | 0.4U | NR | NR |
| Arsenic[b] | µg/L | 5 | 5.1 | 4.6B | 4.9B | 4.2B | 3.9B | 4.7B | 4.2B |
| Barium[b] | µg/L | 87.5 | 85 | 77.7 | 80.2 | 76.4 | 71 | 88.2 | 80.2 |
| Beryllium[b] | µg/L | 0.08U | 0.17B | 0.08U | 0.1B | 0.08U | 0.08U | 0.28B | 0.08U |
| Calcium | µg/L | 327000 | 314000 | 243000 | 248000 | 304000 | 295000 | 366000 | 357000 |
| Chromium[b] | µg/L | 162 | 161 | 174 | 178 | 200 | 185 | 142 | 120 |
| Hexavalent chromium[b] | µg/L | 170 | 170 | 180 | 180 | 190 | 190 | 150 | 120 |
| Copper | µg/L | NR | NR | NR | NR | 2.3 | 2.1 | NR | NR |
| Iron | µg/L | NR | NR | NR | NR | 22UO | 22UO | NR | NR |
| Lead[b] | µg/L | 0.18U | 0.18U | 0.18U | 0.18B | 0.18U | 0.18U | 0.18BC | 0.18U |
| Magnesium | µg/L | NR | NR | NR | NR | 89000 | 88400 | NR | NR |
| Manganese | µg/L | NR | NR | NR | NR | 0.31U | 0.31U | NR | NR |
| Nickel | µg/L | NR | NR | NR | NR | 7.6 | 7.2 | NR | NR |
| Potassium[b] | µg/L | 20200 | 22200 | 17700 | 18200 | 21100 | 20900 | 22900 | 22400 |
| Selenium[b] | µg/L | 1.5B | 1.8B | 0.91B | 0.92B | 1.3B | 1.3B | 2B | 2B |
| Silicon[b] | µg/L | 20600 | 19700 | 16400 | 16700 | 21500 | 21300 | 22900N | 22400N |
| Sodium [b] | µg/L | 219000 | 214000 | 187000N | 191000N | 204000 | 198000 | 233000 | 229000 |
| Tin[b] | µg/L | 0.77U | 0.77U | 0.77U | 0.77U | 0.77U | 0.77U | 0.77U | 0.77U |
| Thallium[b] | µg/L | 0.05U | 0.05U | 0.05U | 0.05U | 0.05U | 0.05U | 0.16B | 0.066B |
| Tungsten[b] | µg/L | 1.1BC | 0.83BC | 0.2U | 0.2U | 0.2U | 0.22B | 0.61BC | 0.64BC |
| Vanadium[b] | µg/L | 15 | 14.4 | 15.4 | 16.1 | 16.4 | 16.2 | 14 | 13.1 |

**Table C-1. Leachate Sample Data**

| Constituent | Units | 2018 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mar | Mar[a] | May | May[a] | Sep | Sep[a] | Dec | Dec [a] |
| Zinc[b] | µg/L | 2U | 2U | 2U | 2U | 2U | 2U | 2U | 2U |
| Carbon tetrachloride[b] | µg/L | 0.19U | 0.19U | 0.19U | 0.19U | 0.18U | 0.18U | 0.3TU | 0.3TU |
| Trichloroethene | µg/L | 0.16U | 0.16U | 0.16U | 0.16U | 0.25U | 0.25U | 0.3U | 0.3U |
| Methyl alcohol | µg/L | NR | NR | NR | NR | 200U | 200U | NR | NR |
| Trichlorofluoromethane | µg/L | NR | NR | NR | NR | 0.16U | 0.16U | NR | NR |
| 1,2-Diphenylhydrazine | µg/L | 0.23U | 0.24U | 0.23U | 0.23U | 0.24U | 0.24U | 0.24U | 0.23U |
| pH[b] | pH | 7.91 | 7.9 | 7.92 | 8.02 | 8.07 | 8 | 8.02 | 8.01 |
| Specific conductance[b] | µS/cm | 2860 | 2790 | 2640 | 2510 | 2530 | 2450 | 2560 | 2830 |
| Bromide[b] | µg/L | 3100D | 3100D | 1670 | 1630 | 1570D | 1690D | 2960D | 2110D |
| Chloride[b] | µg/L | 340000D | 490000D | 285000D | 280000D | 281000D | 282000D | 324000D | 325000D |
| Fluoride[b] | µg/L | 200D | 200D | 255B | 261B | 190BD | 248BD | 257BD | 234BD |
| Nitrate[b] | µg/L | 274000DZ | 390000DZ | 245000D | 242000D | 234000D | 239000DX | 273000D | 273000D |
| Nitrite[b] | µg/L | 125UDN | 125UDN | 108U | 108U | 542DUX | 108U | 108U | 108U |
| Phosphate[b] | µg/L | 251UDN | 251UDN | 205U | 205U | 1030DUX | 205U | 411DUX | 411DUX |
| Sulfate[b] | µg/L | 250UD | 250UD | 689000D | 677000D | 686000D | 685000D | 705000D | 706000D |
| Nitrogen in ammonia[b] | µg/L | 26.7U | 26.7U | 297 | 188 | 26.7U | 26.7U | 26.7U | 26.7U |
| Total organic carbon | µg/L | NR | NR | NR | NR | 11800 | 12000 | NR | NR |
| Total organic halides[b] | µg/L | 60.2 | 62.1 | 58.3BND | 66.6ND | 95.2BND | 74BND | 76.6 | 47.2 |
| Oil and grease | µg/L | NR | NR | NR | NR | 2200BN | 1600UO | NR | NR |
| Total dissolved solids[b] | µg/L | 2180000 | 2150000 | 2120000 | 2070000 | 2040000 | 2100000 | 2290000 | 2230000 |
| Total suspended solids[b] | µg/L | 1100U | 1200B | 1600B | 1200B | 1100U | 2400B | 1600B | 4800 |
| Alkalinity[b] | µg/L | 304000 | 286000 | 255000 | 256000 | 209000 | 210000 | 261000 | 257000 |

**Table C-1. Leachate Sample Data**

| Constituent | Units | 2018 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mar | Mar[a] | May | May[a] | Sep | Sep[a] | Dec | Dec [a] |
| Chemical oxygen demand[b] | µg/L | 35600 | 33900 | 32500BD | 27000BD | 105000BD | 38800BD | 35800BD | 32500BD |
| Gross alpha[b] | pCi/L | 549 | 455 | 531 | 574 | 419 | 549 | 594 | 727 |
| Gross beta[b] | pCi/L | 477 | 480 | 483 | 474 | 393B | 392B | 590 | 881 |
| Carbon-14 [b] | pCi/L | 233 | 215 | 19.7U | 15.5U | 142 | 135 | 40.3 | 17.9U |
| Technetium-99[b] | pCi/L | 225 | 225 | 208 | 208 | 181 | 168 | 205 | 240 |
| Uranium (total) [b] | µg/L | 1390 | 1400 | 1250 | 1280 | 1040 | 954 | 1450 | 1410 |
| Iodine-129[b] | pCi/L | 0.36U | 0.292U | -0.024U | 0.16U | 0.291U | 0.378U | -0.269U | 0.0695U |
| Total radium alpha emissions | pCi/L | 0.0738U | -0.143U | -0.0712U | -0.0185U | 0.239U | 0.372U | NR | NR |
| Tritium[b] | pCi/L | 87700 | 92200 | 94600 | 99700 | 146000 | 146000 | 174000 | 179000 |
| Total radioactive strontium[b] | pCi/L | 18.2 | 17.4 | 12.6 | 13.4 | 9.65B | 10.6B | 16.1 | 16.8 |

a. Laboratory duplicate analysis sample results.

b. Routine "short list" analyses performed on these constituents on a 6-month cycle.

NR = not reported

Laboratory sample result qualifiers:

B = analyte was detected in the associated method blank above the MDC

C = detected in both the sample and QC blank, and sample concentration was ≤5× the blank concentration

D = reported from dilution

J = approximated value

M = duplicate precision not within control limits

N = spike sample recovery is outside control limits

U = results are nondetected

Y = duplicate analysis is not within control limits

**Table C-2. ERDF Historical Leachate Generation**

| | Cell | | | | | | | | | | Total | HMS Annual Precipitation (in.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | |
| Cell Size (ac) | 12 | 12 | 8.4 | 8.4 | 8.4 | 8.4 | 8.4 | 8.4 | 16.8 | 16.8 | 108.0 | |
| Year | (gallons) | | | | | | | | | | | |
| 2006 | 111,790 | 187,057 | 168,416 | 155,463 | 42,944 | 41,048 | | | | | 706,718 | 8.46 |
| 2007 | 277,473 | 353,085 | 231,098 | 208,067 | 216,690 | 95,119 | | | | | 1,381,532 | 5.48 |
| 2008 | 205,079 | 244,604 | 161,707 | 171,601 | 253,409 | 116,304 | | | | | 1,152,704 | 5.49 |
| 2009 | 170,657 | 192,501 | 145,888 | 158,203 | 172,211 | 132,377 | 42,947 | 66,547 | | | 1,081,331 | 5.47 |
| 2010 | 143,119 | 159,834 | 135,264 | 132,968 | 208,290 | 125,670 | 130,322 | 190,448 | | | 1,225,915 | 10.19 |
| 2011 | 129,726 | 139,909 | 161,586 | 161,010 | 233,322 | 129,870 | 261,649 | 245,242 | 531,218 | 283,656 | 2,277,188 | 4.45 |
| 2012 | 120,660 | 128,660 | 160,110 | 169,601 | 262,700 | 134,510 | 228,820 | 202,970 | 203,590 | 207,758 | 1,819,379 | 8.18 |
| 2013 | 109,540 | 112,130 | 146,000 | 160,170 | 245,810 | 161,600 | 190,790 | 182,570 | 256,760 | 350,110 | 1,915,480 | 5.38 |
| 2014 | 102,060 | 102,970 | 130,170 | 138,150 | 192,970 | 159,320 | 162,780 | 153,880 | 249,800 | 308,320 | 1,700,420 | 6.53 |
| 2015 | 93,870 | 96,490 | 122,230 | 132,010 | 170,300 | 154,270 | 149,780 | 134,880 | 354,460 | 325,380 | 1,733,670 | 6.48 |
| 2016 | 86,900 | 89,940 | 110,640 | 115,950 | 167,030 | 142,240 | 147,000 | 159,690 | 580,699 | 525,753 | 2,125,842 | 7.65 |
| 2017 | 81,510 | 86,410 | 96,570 | 107,400 | 196,700 | 152,200 | 190,220 | 271,160 | 737,733 | 1,353,562 | 3,273,465 | 8.60 |
| 2018 | 75,100 | 79,620 | 95,512 | 95,350 | 161,980 | 153,490 | 202,120 | 207,460 | 620,655 | 681,409 | 2,372,696 | 6.43 |

ERDF = Environmental Restoration Disposal Facility

HMS = Hanford Site Meteorological Station

# Appendix D

# Leachate Sampling Trends, 1998-2018

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# Figures

Figure D-1. Arsenic ..... D-1
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Figure D-4. Chromium ..... D-2
Figure D-5. Lead ..... D-3
Figure D-6. Potassium ..... D-3
Figure D-7. Selenium ..... D-4
Figure D-8. Silicon ..... D-4
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Figure D-24. Tritium ..... D-12
Figure D-25. Total Radioactive Strontium ..... D-13
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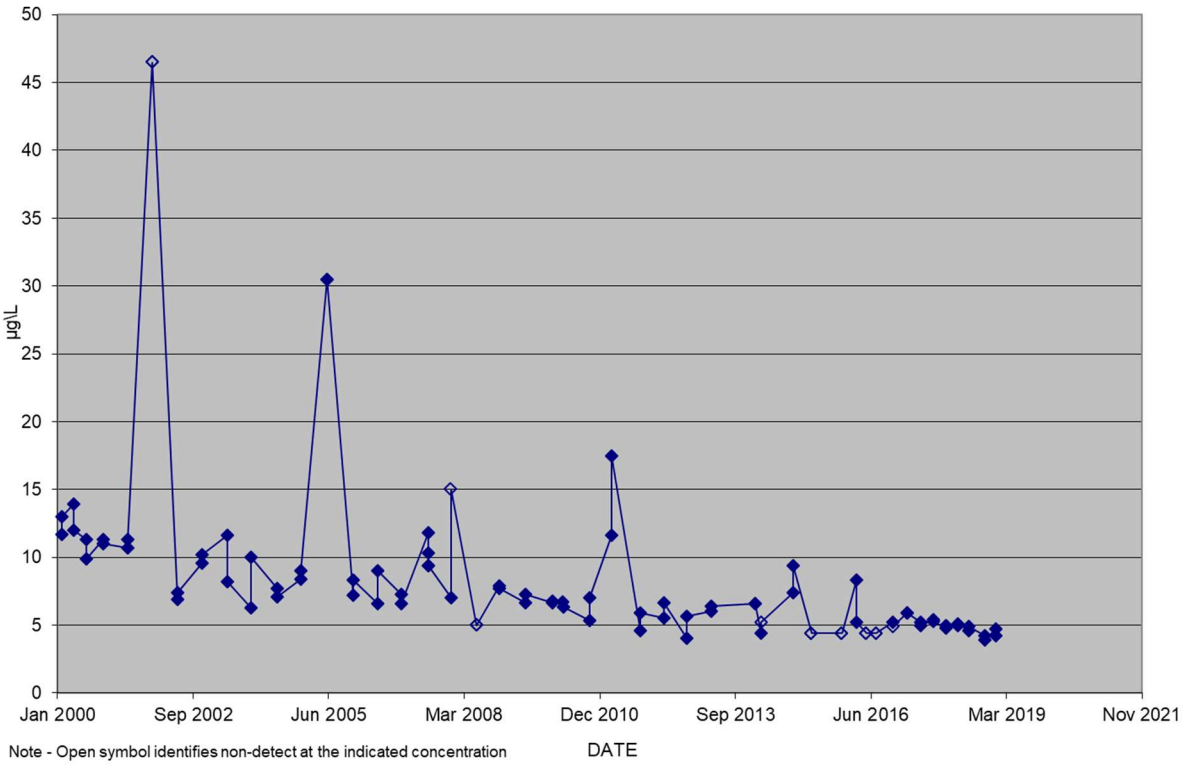


**Figure D-1. Arsenic**

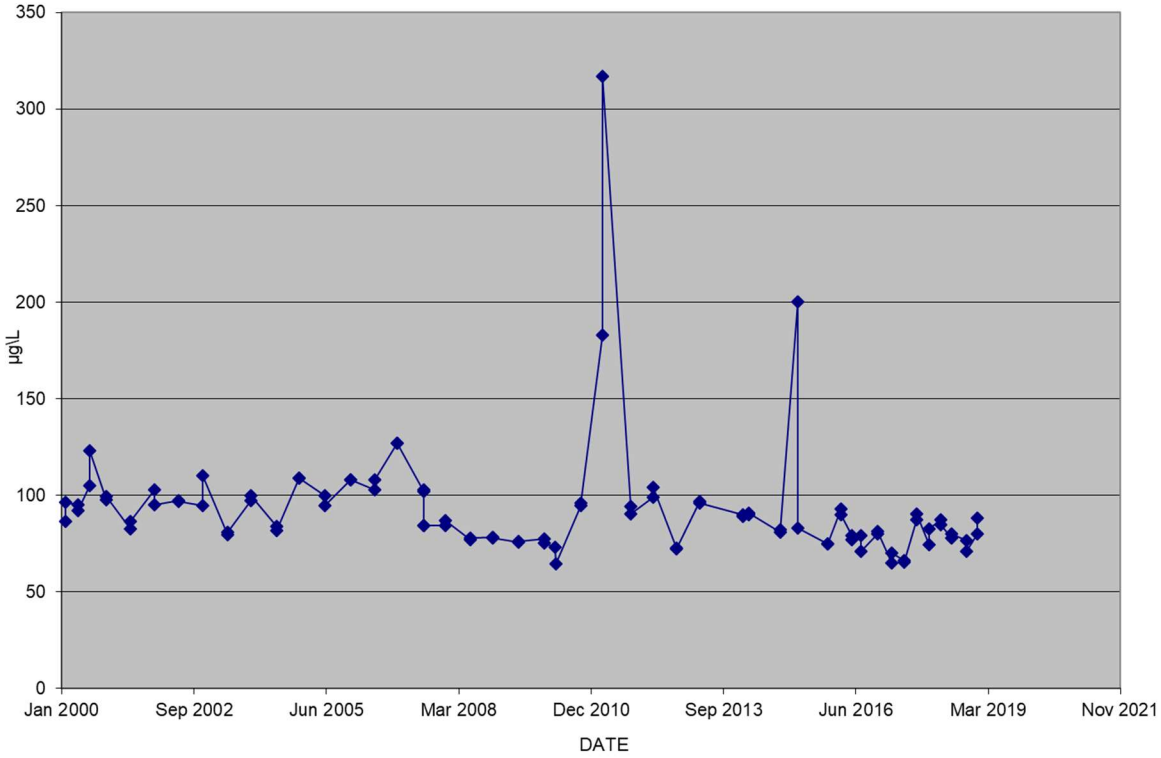


**Figure D-2. Barium**

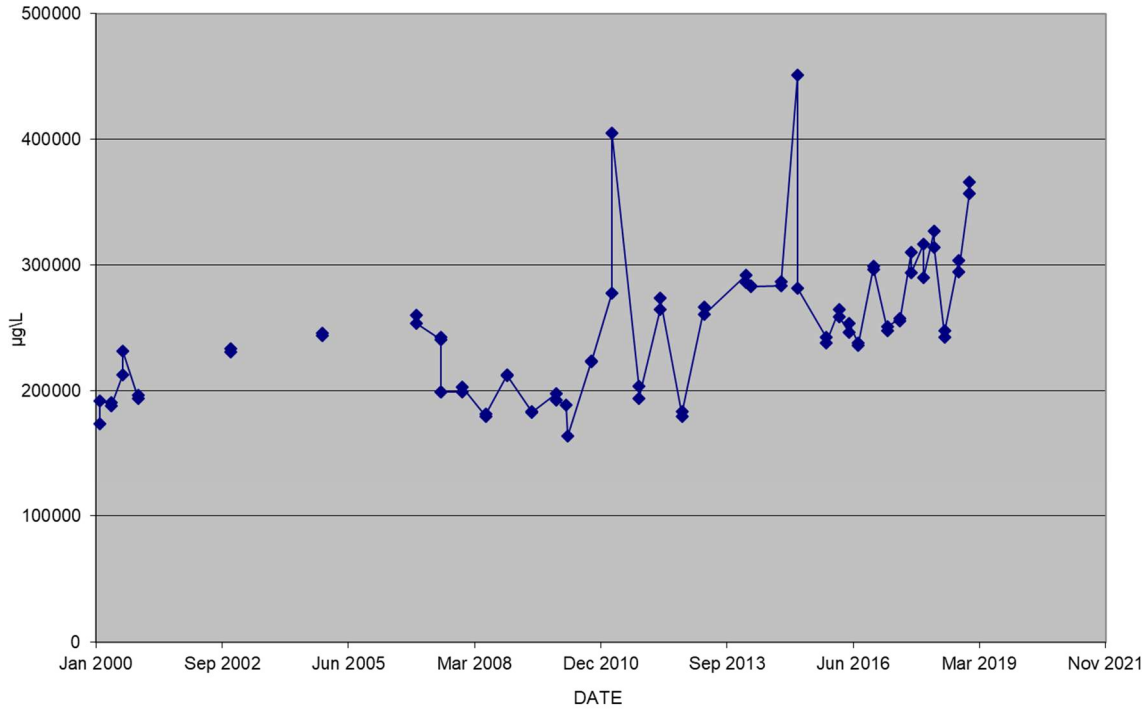


**Figure D-3. Calcium**

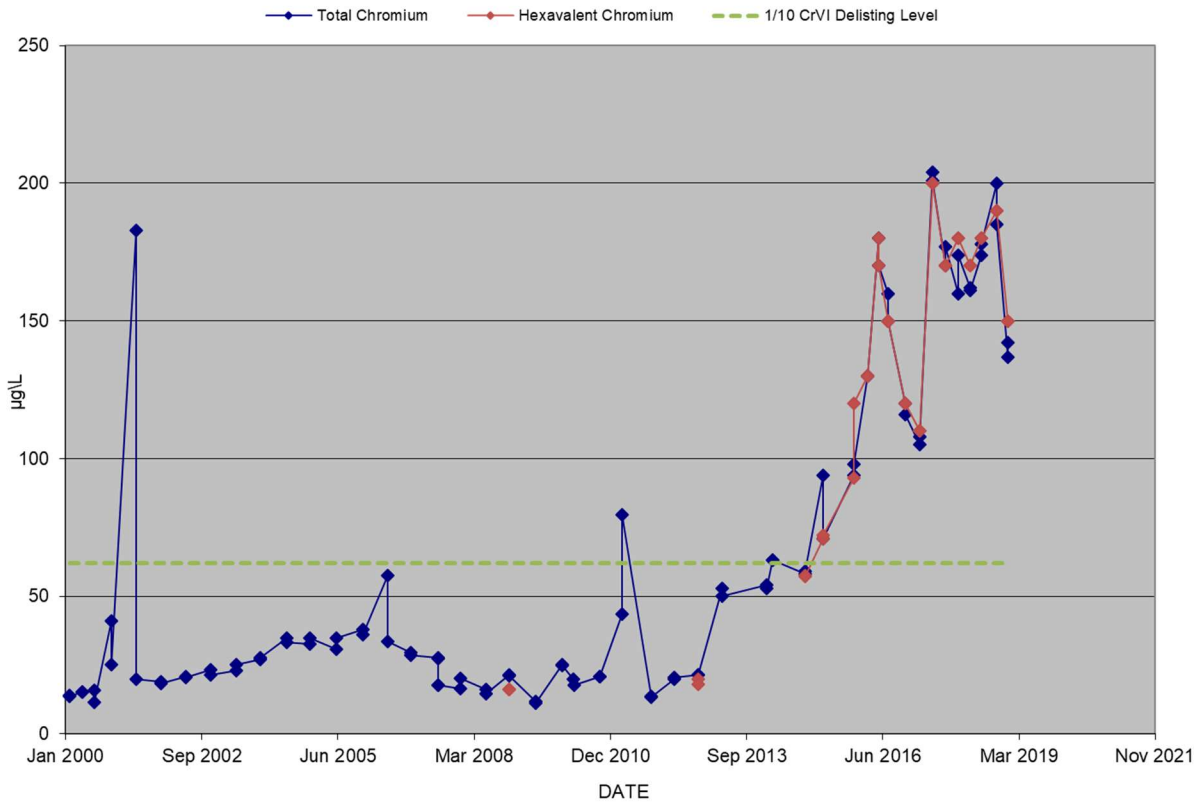


**Figure D-4. Chromium**

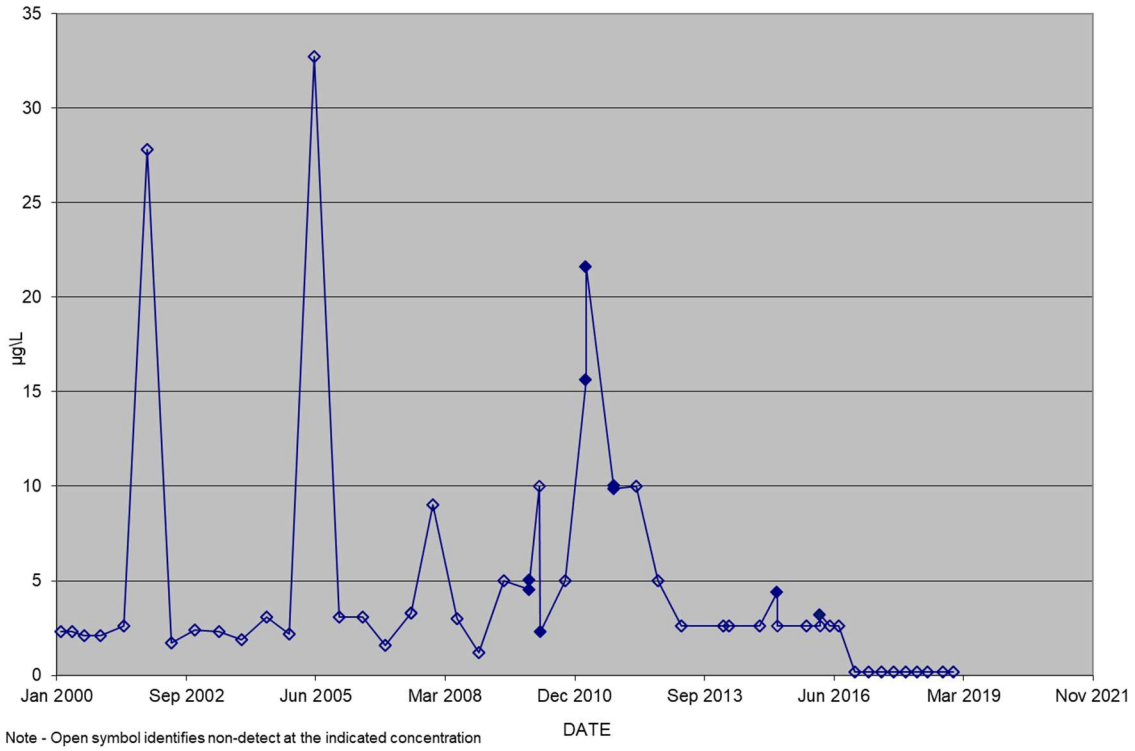


**Figure D-5. Lead**

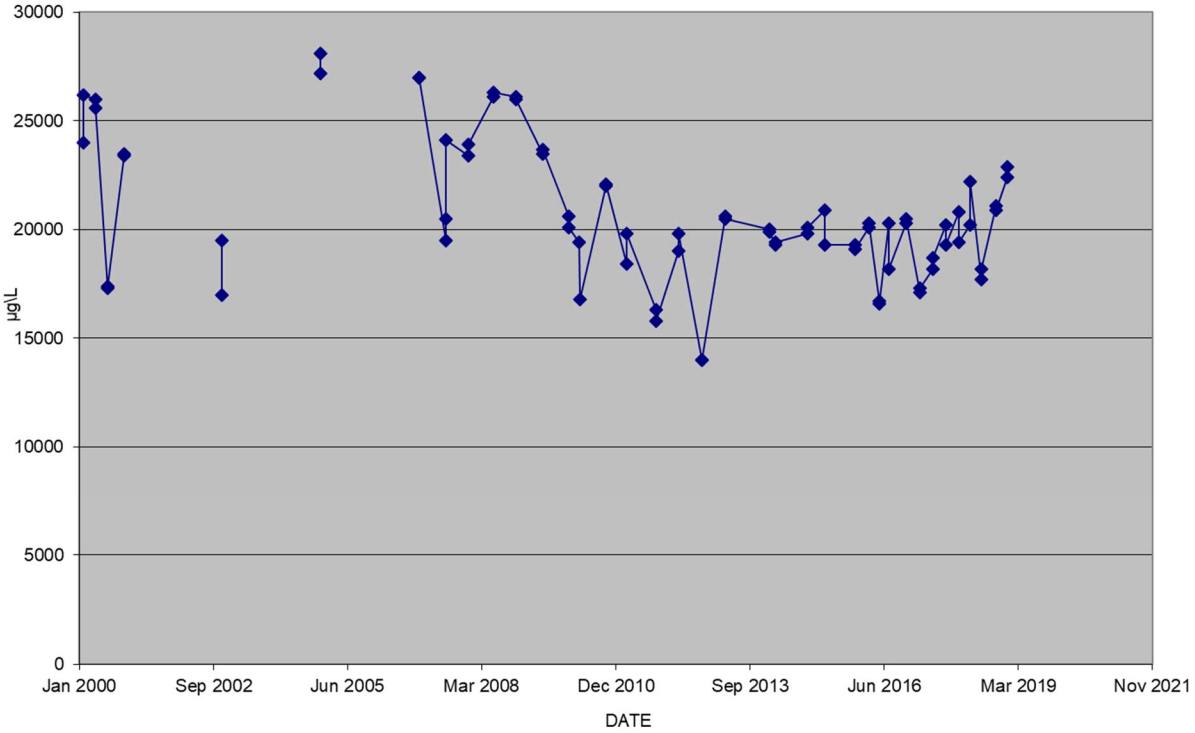


**Figure D-6. Potassium**

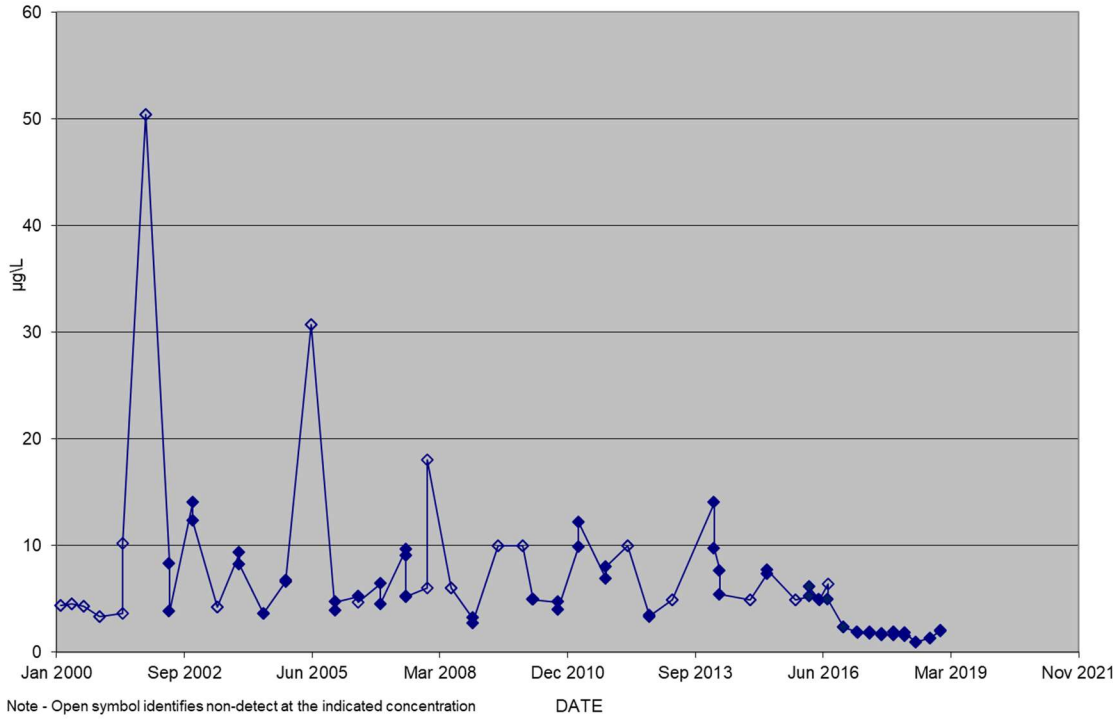


**Figure D-7. Selenium**

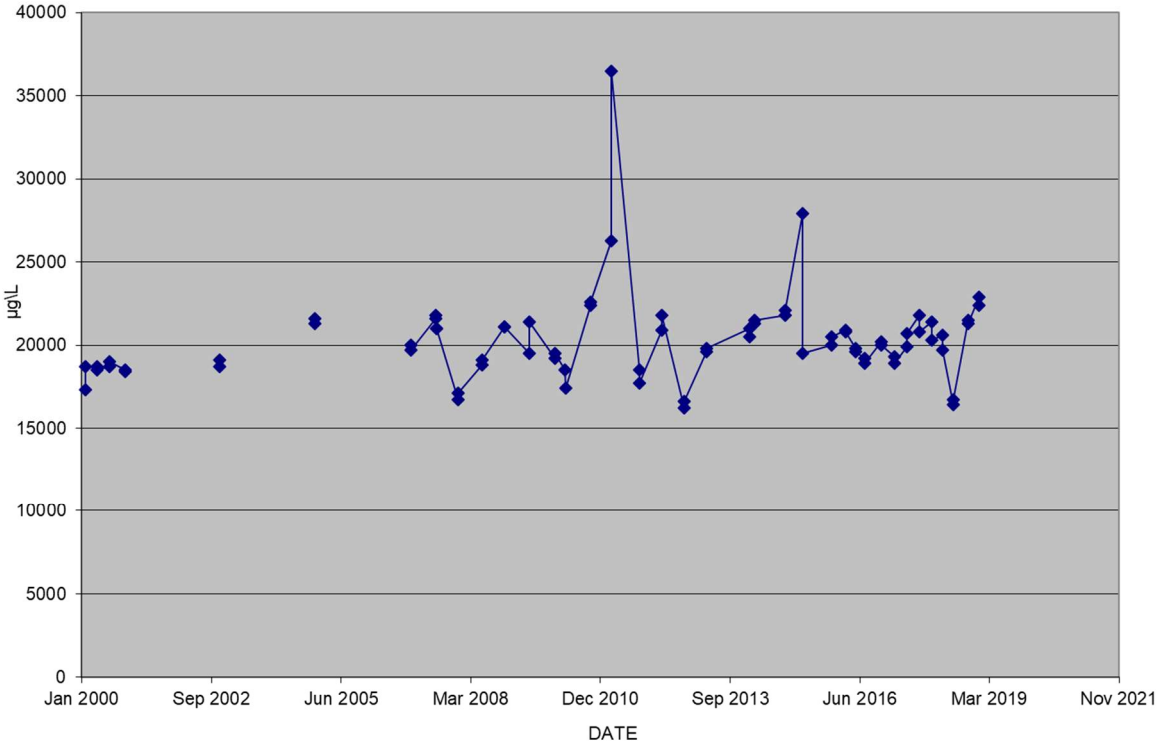


**Figure D-8. Silicon**

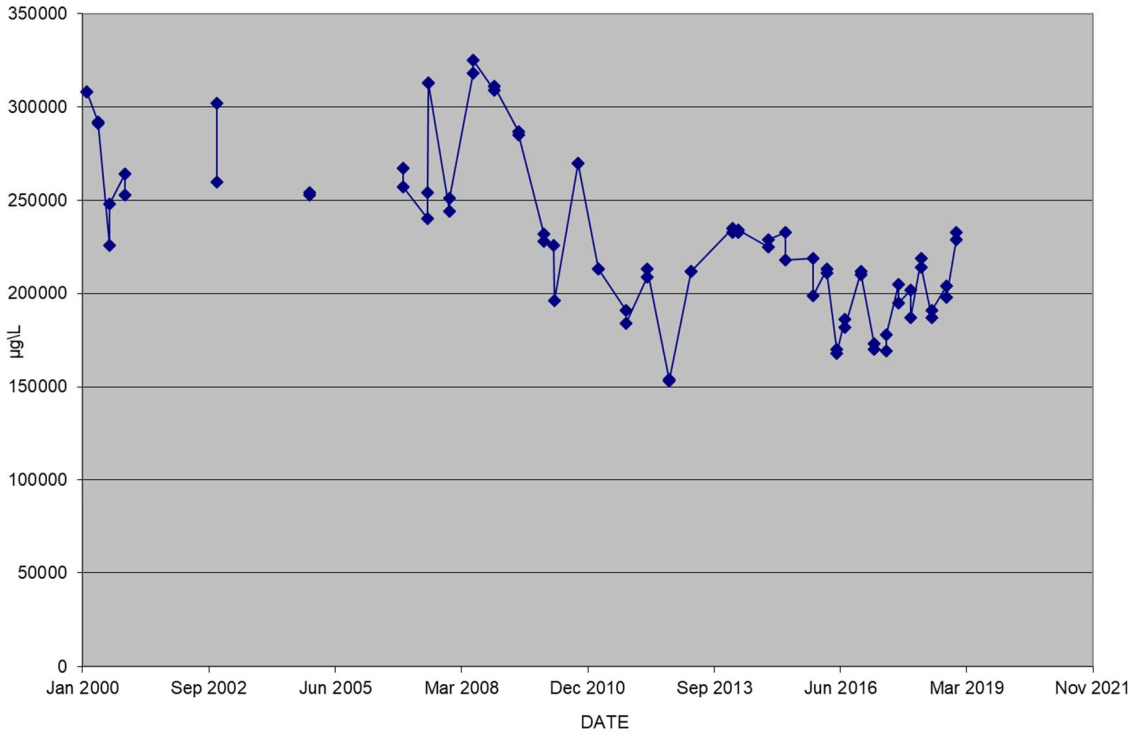


**Figure D-9. Sodium**

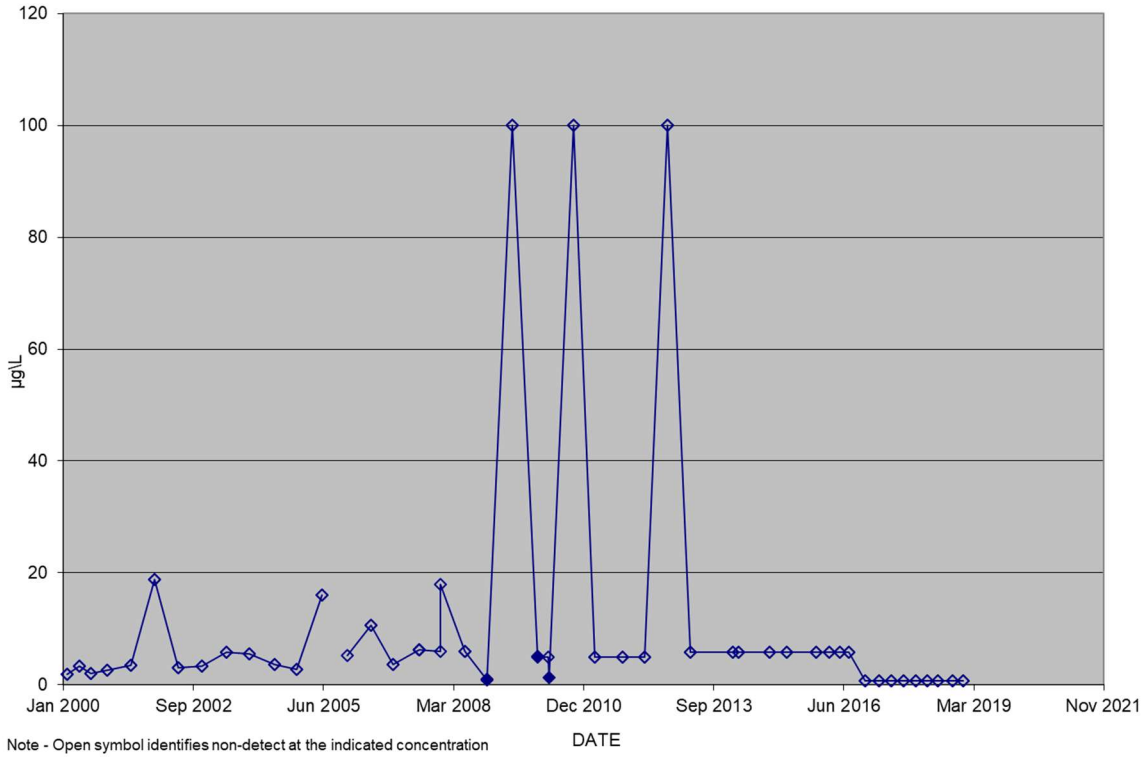


**Figure D-10. Tin**

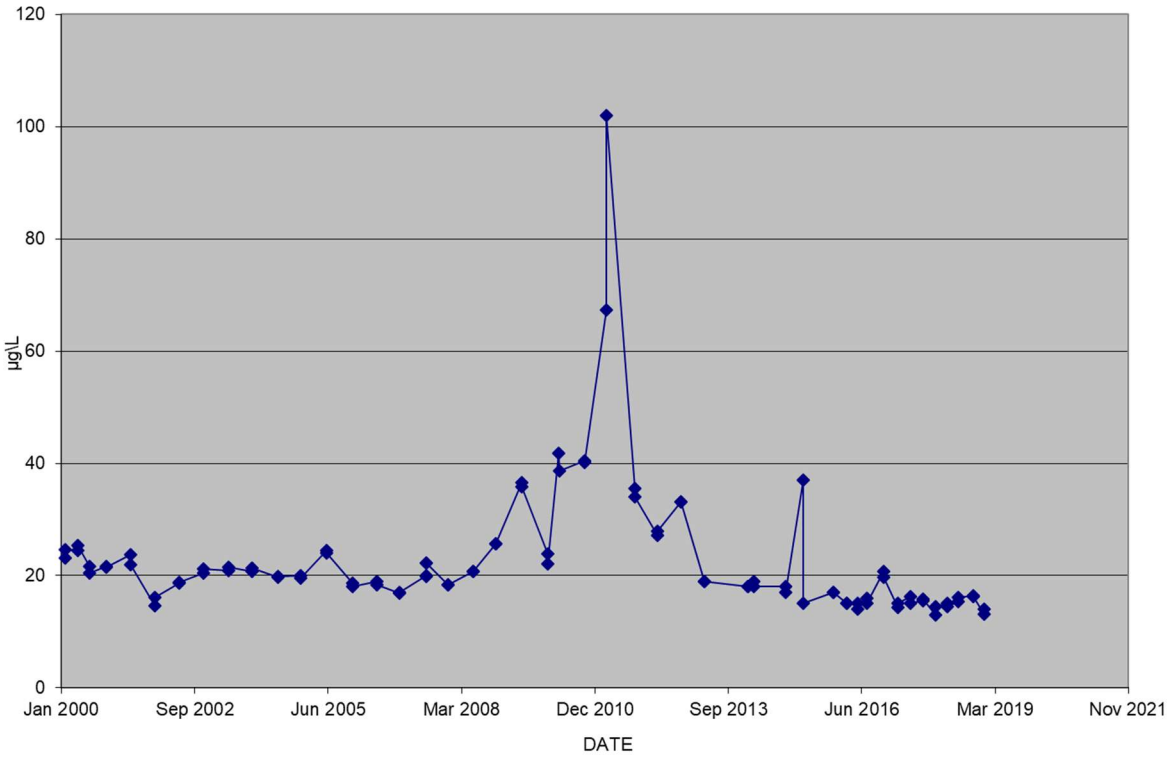


**Figure D-11. Vanadium**

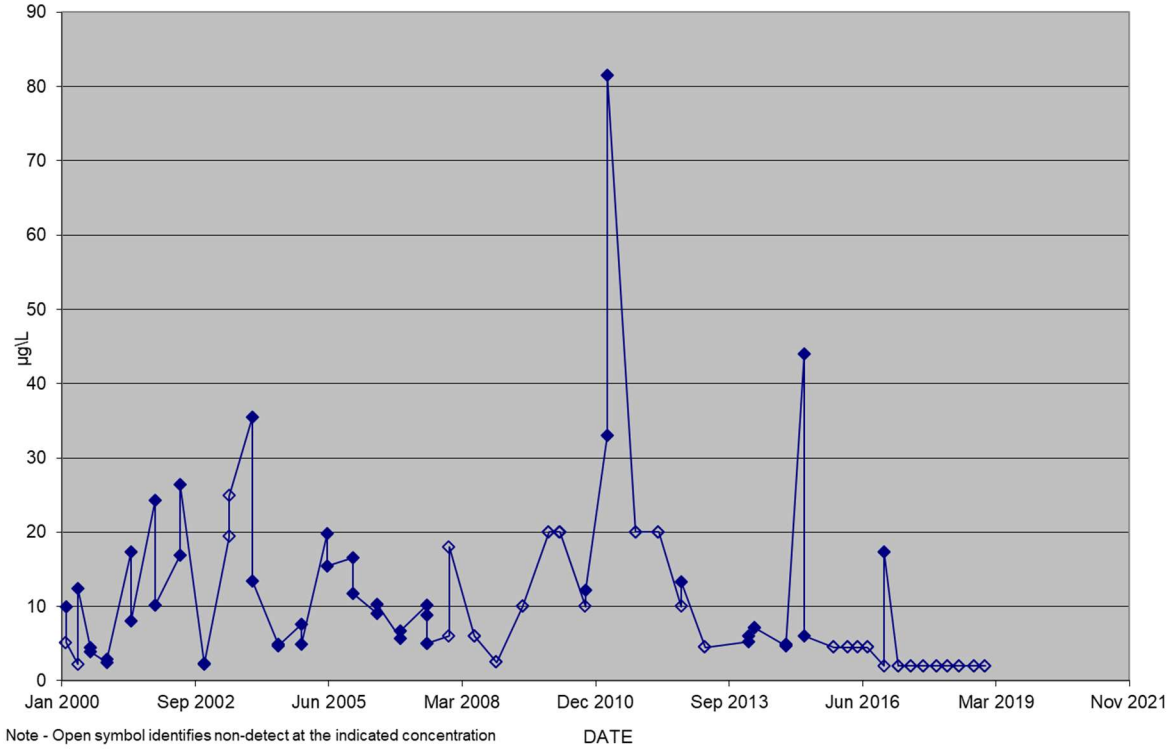


**Figure D-12. Zinc**

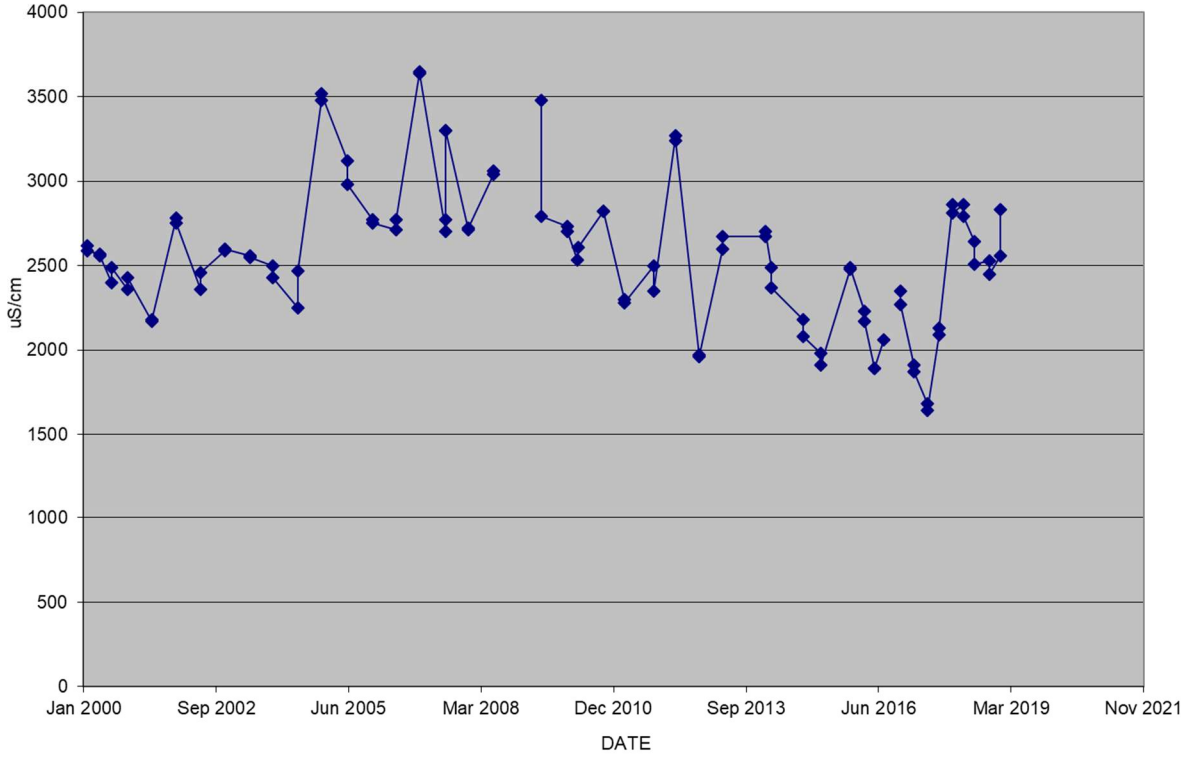


**Figure D-13. Conductivity**

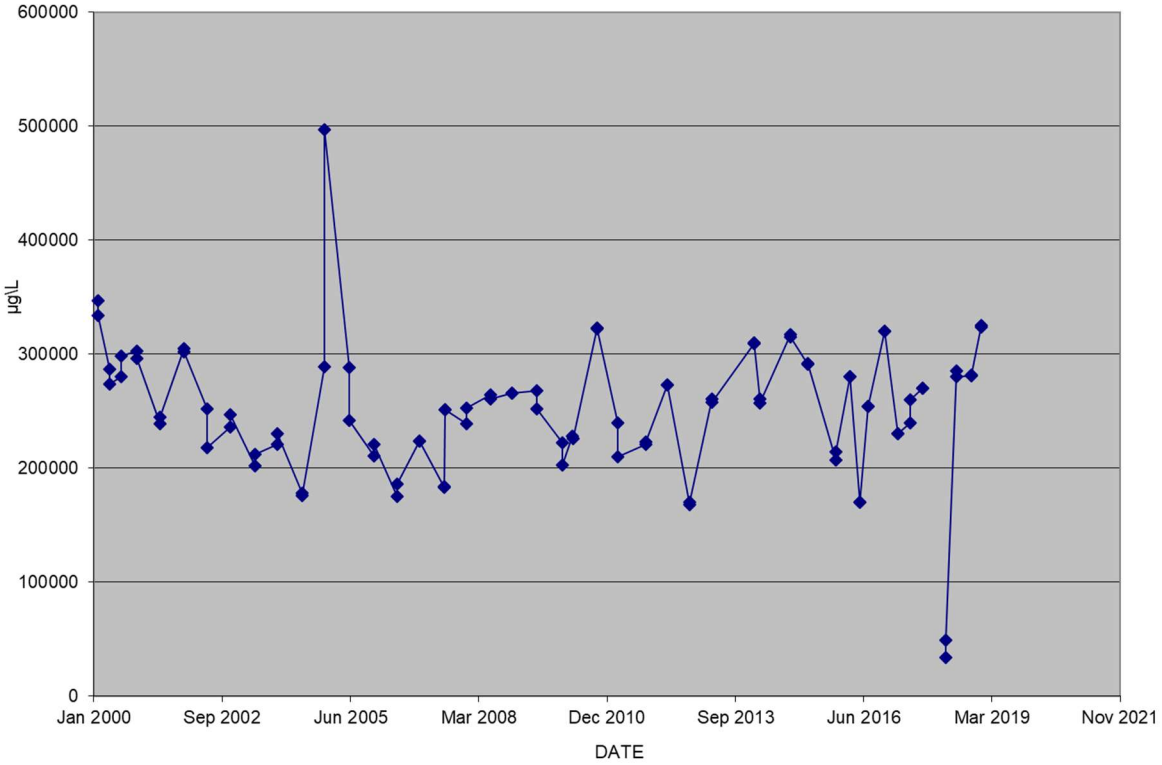


**Figure D-14. Chloride**

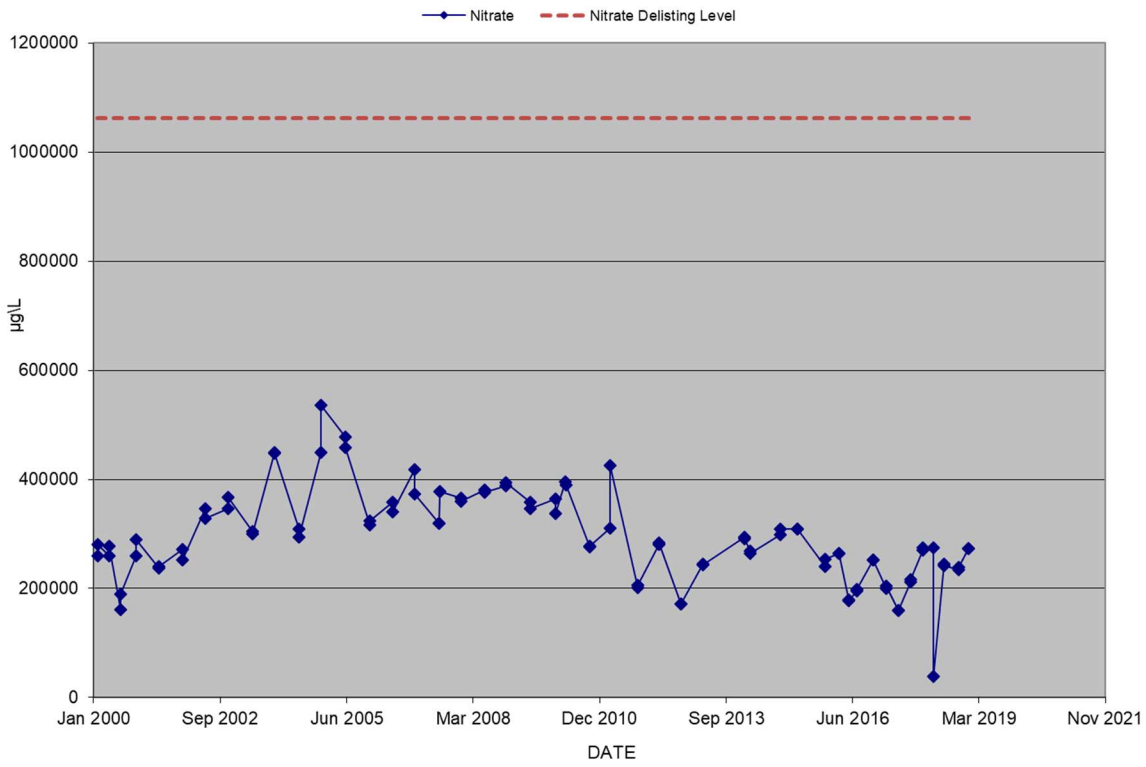


**Figure D-15. Nitrate**

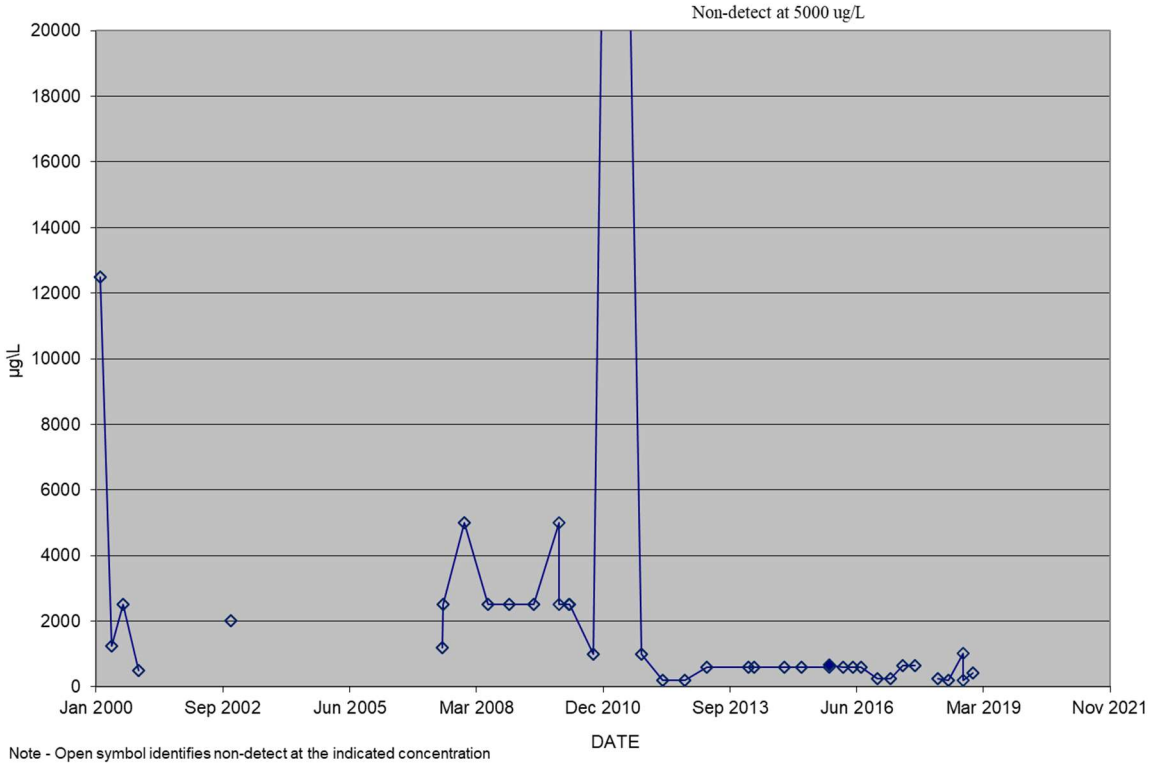


**Figure D-16. Phosphate**

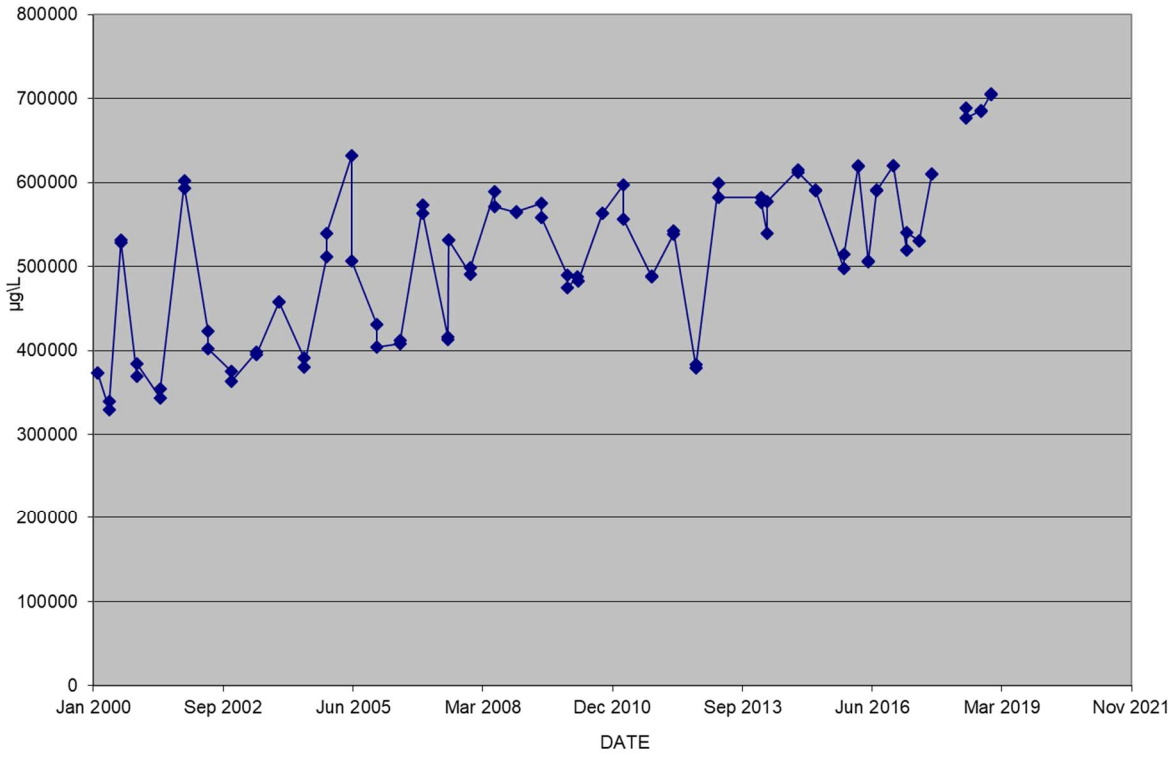


**Figure D-17. Sulfate**

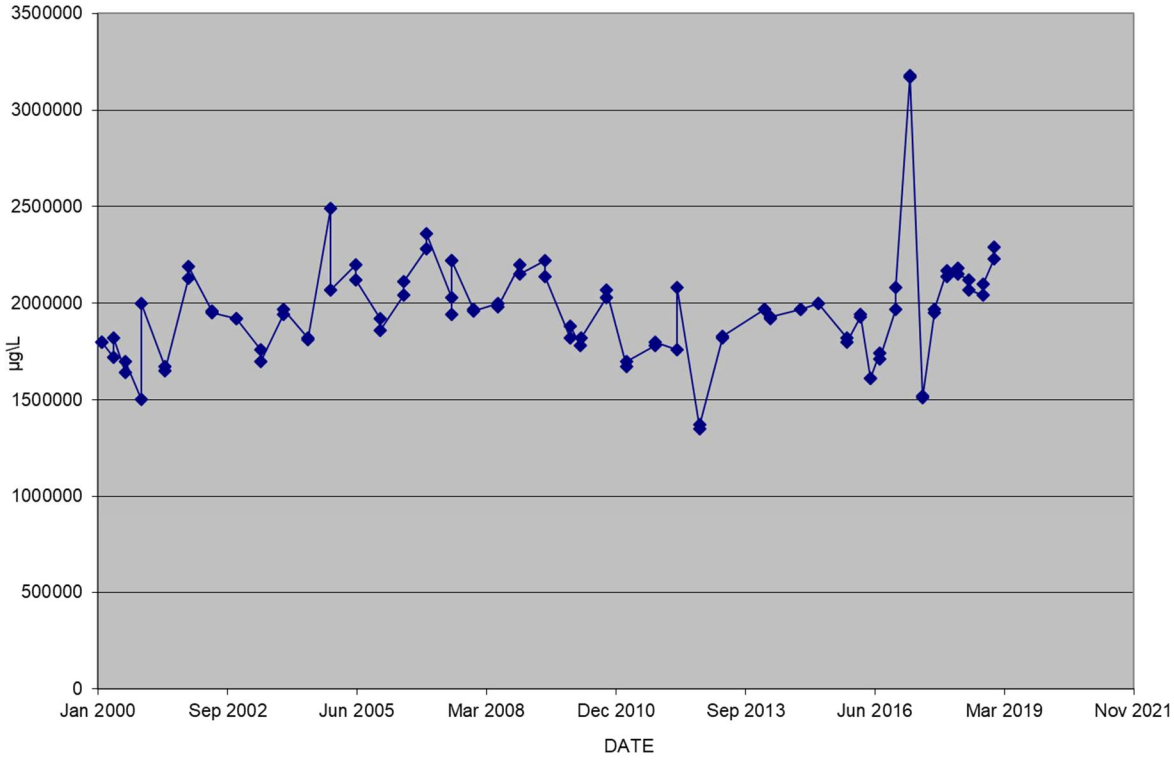


**Figure D-18. Total Dissolved Solids**

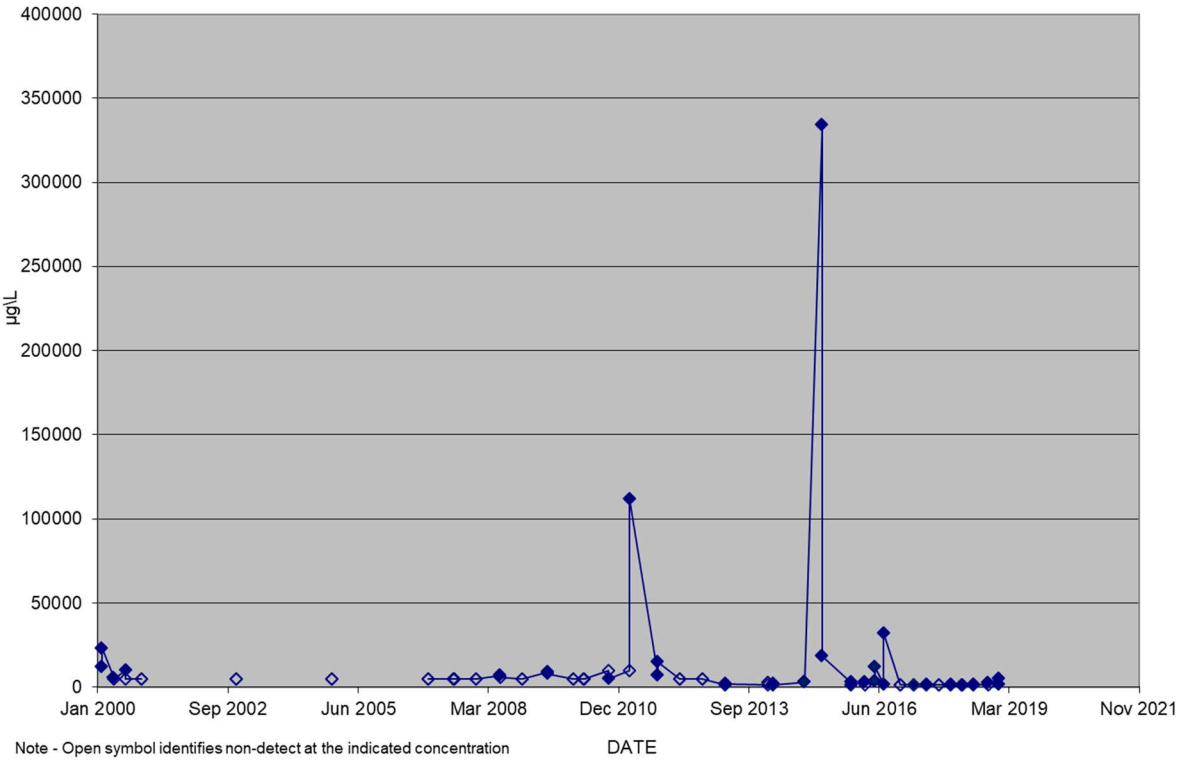


**Figure D-19. Total Suspended Solids**

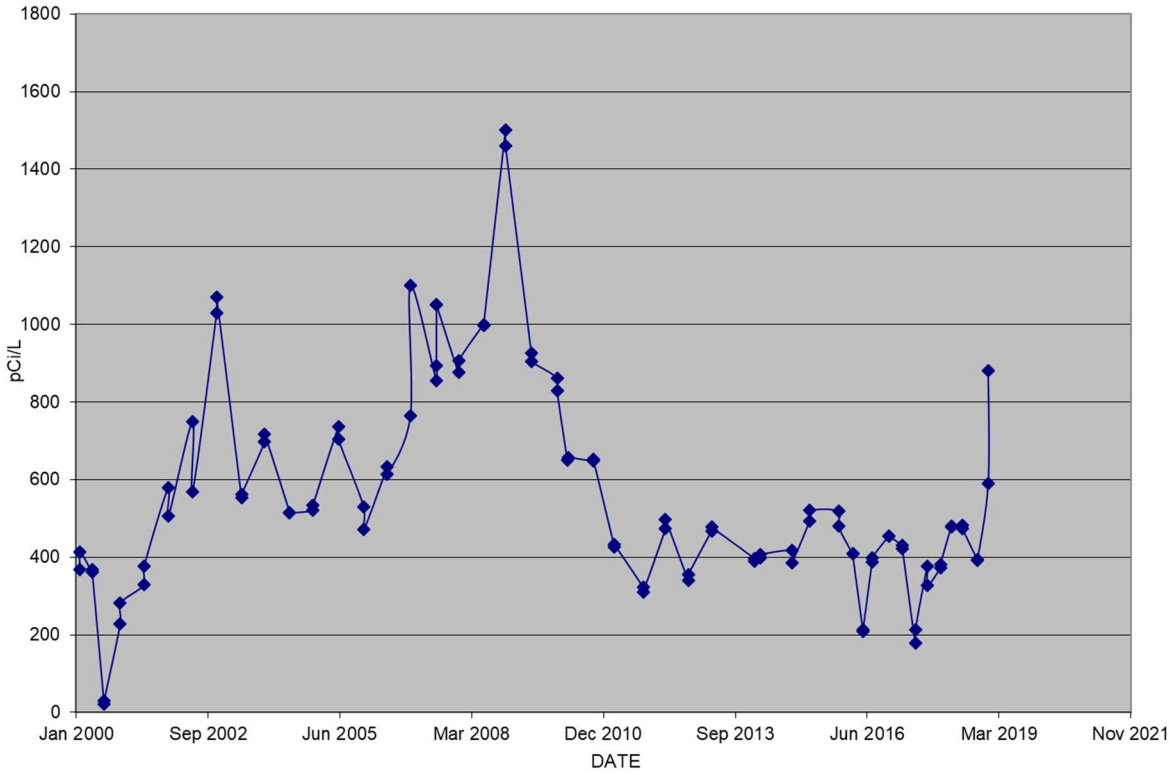


**Figure D-20. Gross Beta**

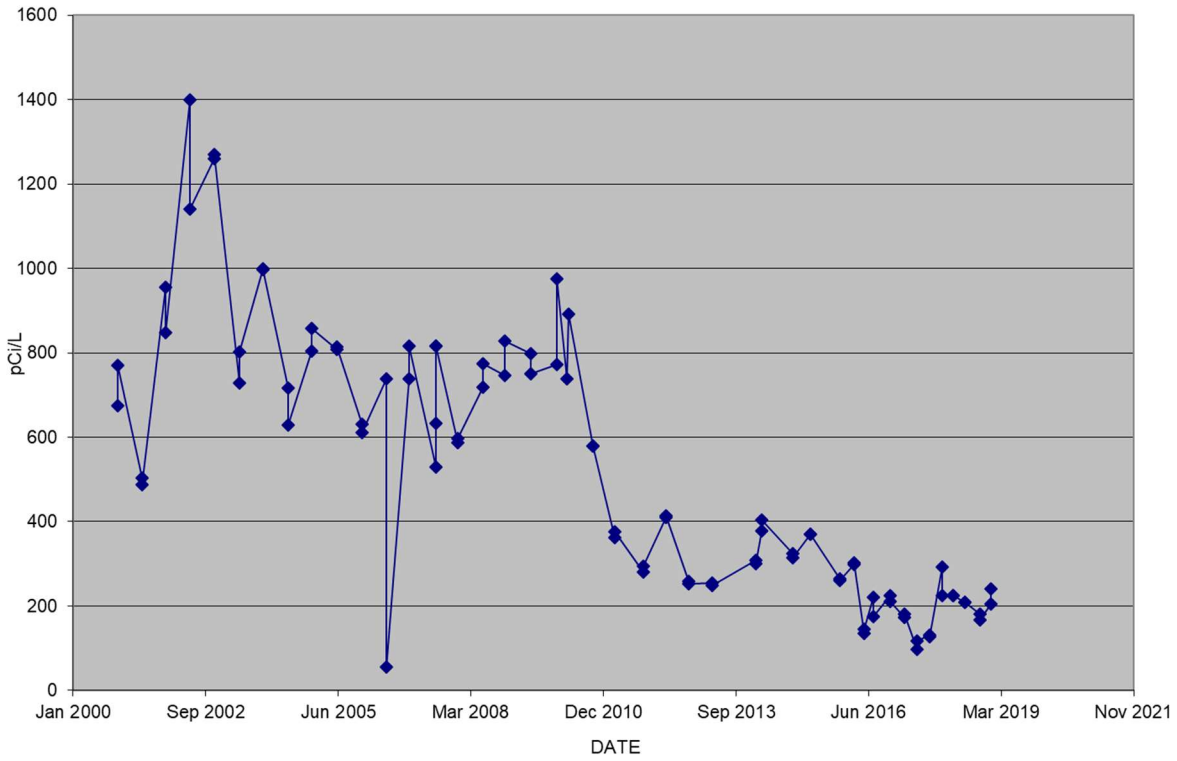


**Figure D-21. Technetium-99**

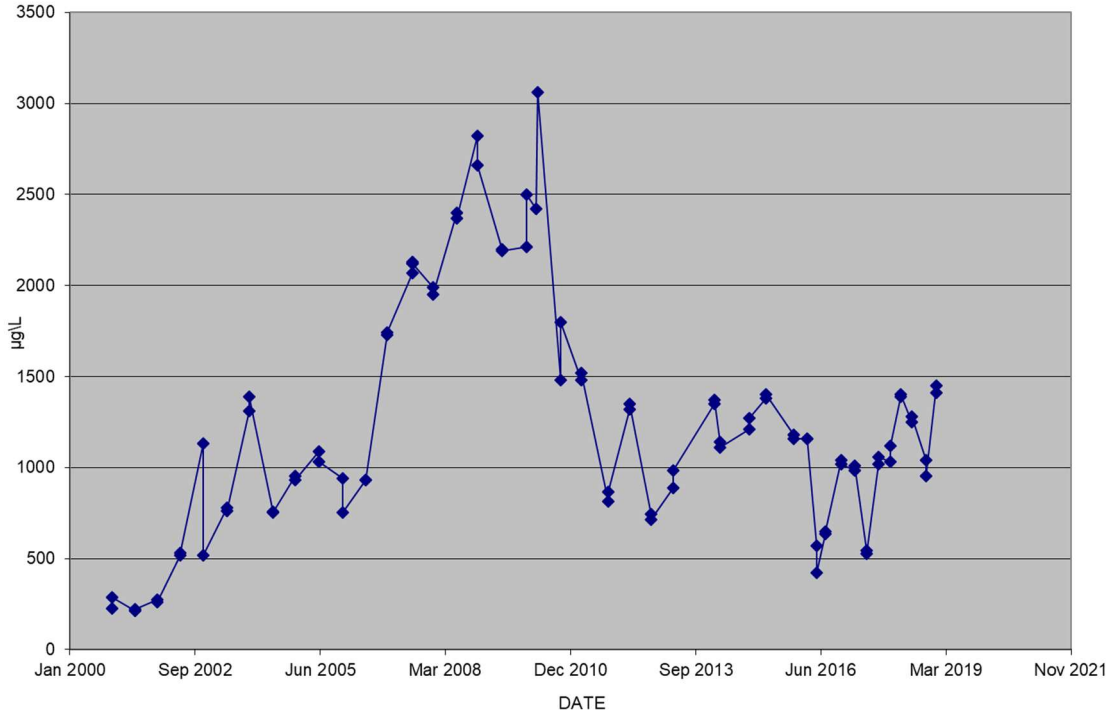


**Figure D-22. Total Uranium**

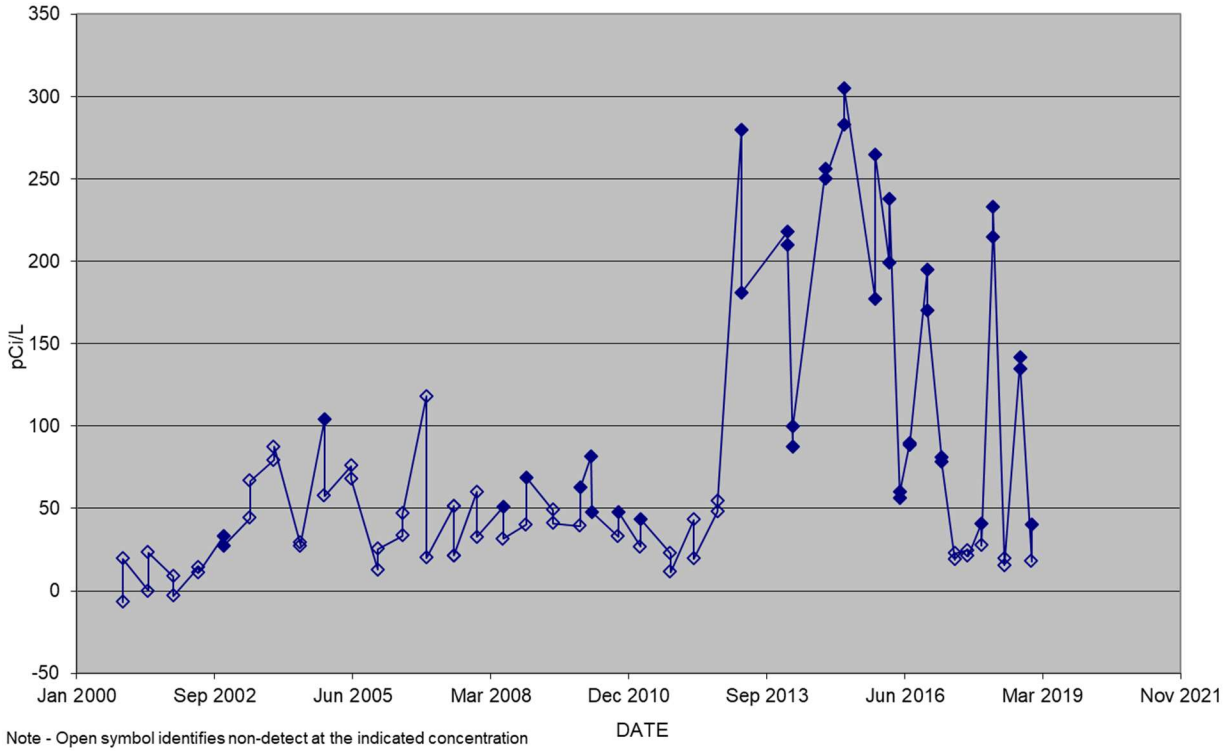


**Figure D-23. Carbon-14**

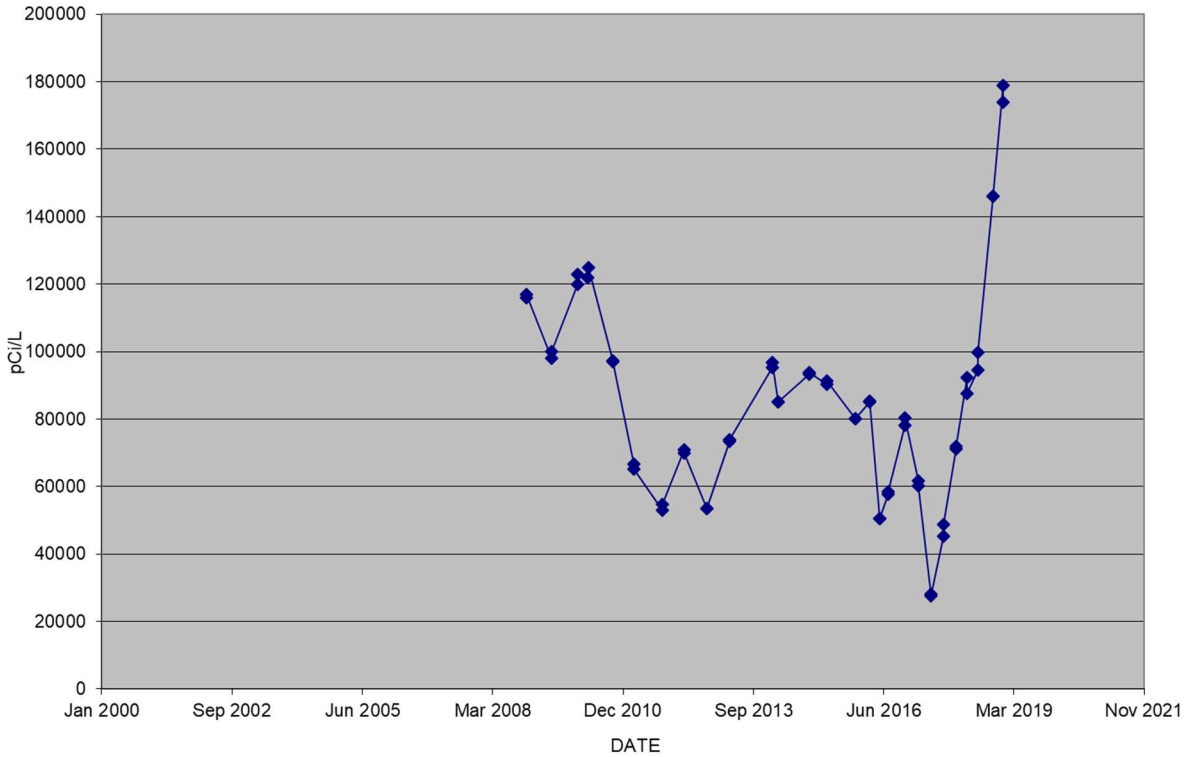


**Figure D-24. Tritium**

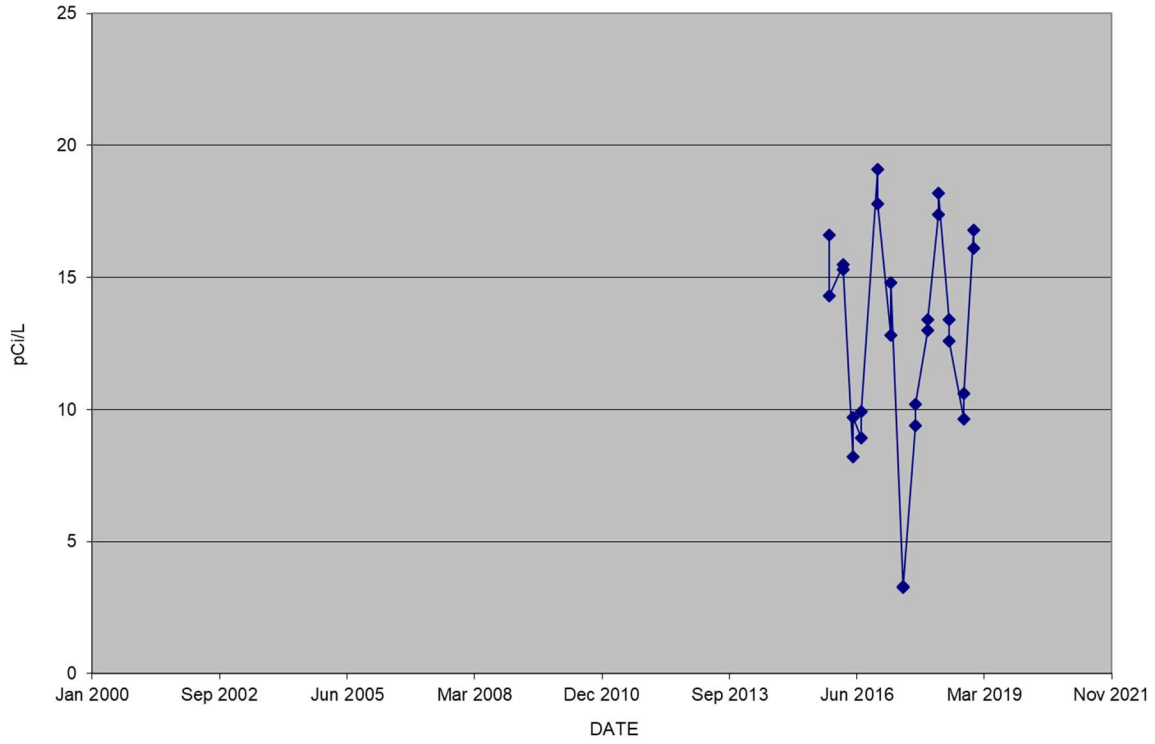


**Figure D-25. Total Radioactive Strontium**

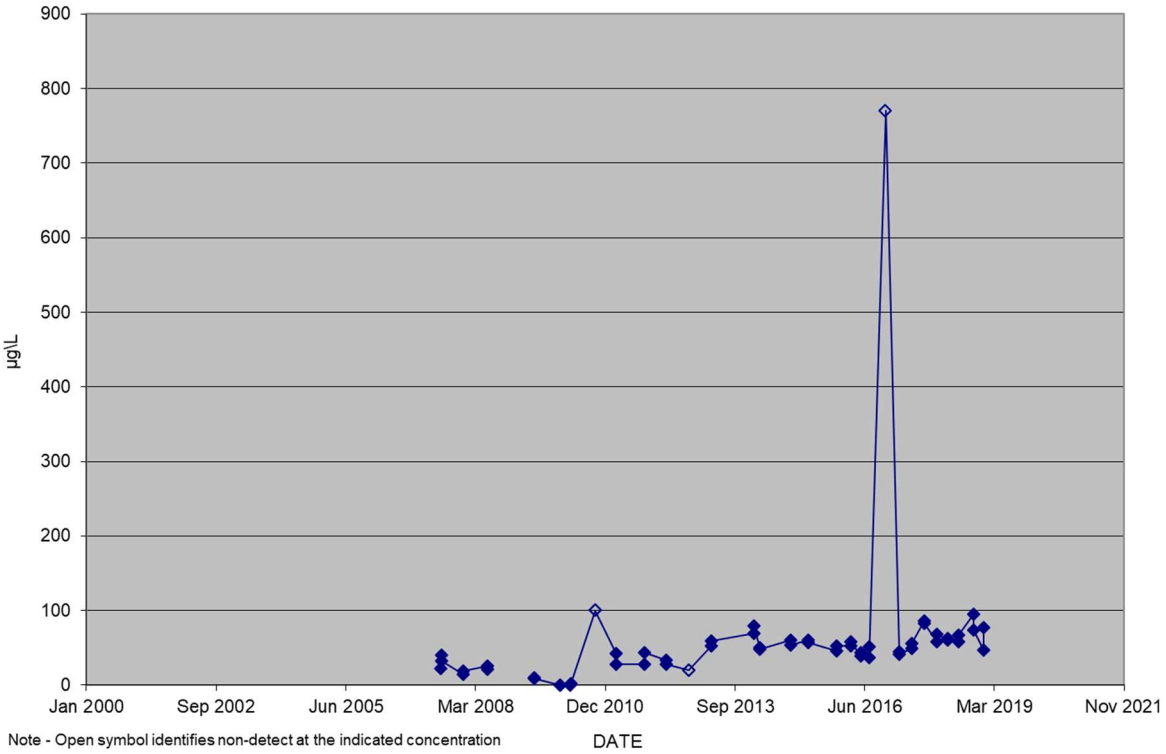


**Figure D-26. Total Organic Halide (TOX)**

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# Appendix E

# Environmental Restoration Disposal Facility Lysimeter Sampling Results, Calendar Year 2018

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**Table E-1. Lysimeter Analytical Results (May 2018)**

| Constituent | Units | Cell 5 | Cell 5* | Cell 6 | Cell 7 | Cell 8 | Cell 9 | Cell 10 |
|---|---|---|---|---|---|---|---|---|
| Calcium | mg/L | 661000 | 652000 | 469000 | 587000 | 663000 | 665000 | 459000 D |
| Magnesium | mg/L | 116000 | 116000 | 24300 | 124000 | 122000 | 54500 | 6240 |
| Potassium | mg/L | 30000 | 30200 | 26700 | 32300 | 29600 | 24200 | 25000 |
| Sodium | mg/L | 178000 | 176000 | 173000 | 251000 | 183000 | 136000 | 185000 |
| Chloride | mg/L | 96000 DC | 99000 DC | 110000 DC | 130000 DC | 170000 DC | 180000 DC | 104000 D |
| Nitrate | mg/L | 221000 D | 226000 D | 243000 D | 102000 D | 239000 D | 226000 D | 175000 D |
| Nitrogen in nitrate | mg/L | 51400 | 52600 | 56500 | 23700 | 55600 | 52600 | 40700 |
| Sulfate | mg/L | 2100000 D | 2100000 D | 1400000 D | 2100000 D | 2100000 D | 1800000 D | 1060000 D |
| Total dissolved solids | mg/L | 3420000 | 3460000 | 2400000 | 3340000 | 3600000 | 3170000 | 2310000 |
| Total suspended solids | mg/L | 193000 | 165000 | 48400 | 1500000 | 227000 | 385000 | 61000 |
| Total organic carbon | mg/L | 8420 | 8390 | 12000 | 9560 | 13000 | 13500 | 12900 |
| Gross alpha | pCi/L | 19.6 | 19.5 | 5.12 U | 54.1 | 22.1 | 9.76 U | -1.32 U |
| Gross beta | pCi/L | 43.8 | 37.7 | 30.2 | 73.4 | 43.9 | 38.2 | 15.5 |
| Technetium-99 | pCi/L | -2.63 | 3.29 | 0.781 U | 0.49 U | -2.51 U | 4.04 U | -7.73U |
| Uranium (total) | ug/L | 41.9 | 42.9 | 8.9 | 61.8 | 49.6 | 7.4 | 1.1 |
| pH measurement | pH | 7.83 | 7.83 | 7.83 | 7.84 | 7.67 | 7.13 | 6.31 |
| Specific conductance | uS/cm | 3490 | 3100 | 2420 | 3060 | 3190 | 2930 | 2530 |

*Laboratory duplicate analysis sample results for the May 2018 sample event.

D = Result reported from secondary dilution

U = Result is nondetected

X = Serial dilution in the analytical batch indicates that physical and chemical interfaces are present

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