ROCKY MOUNTAIN ARSENAL

2018 BASIN F COVER AND GROUNDWATER MONITORING REPORT

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Prepared by:

Navarro Research and Engineering, Inc.

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CONTENTS

Section **Page**

EXECUTIVE SUMMARY ES-1

1.0 INTRODUCTION 1

2.0 METHODOLOGY 1

2.1 Type I and Type II Cover Inspections 1
2.2 Vegetation Performance Assessment 1
2.3 Percolation Monitoring 2
2.4 Groundwater Monitoring 2
2.5 Maintenance and Repair Activities 2

3.0 PRECIPITATION AND WEATHER CONDITIONS 2

3.1 National Weather Service Summary 2
3.2 Significant Storm Events at RMA 4

4.0 SOIL COVER ASSESSMENT, MAINTENANCE AND REPAIR ACTIONS 4

4.1 Noxious or Undesirable Weeds 5
4.2 Burrowing Animal Holes 5
4.3 Lysimeters 5
4.4 Perimeter Fence 5

5.0 COVER SOIL THICKNESS LOSS 5

6.0 VEGETATION PERFORMANCE ASSESSMENT 6

6.1 Comparison to the Performance Standard 6
6.2 Comparison to the Non-Routine Action Trigger Level 7
6.3 Sample Adequacy 7

7.0 PERCOLATION MONITORING ASSESSMENT 7

8.0 GROUNDWATER MONITORING 8

8.1 Basin F Well Network Analytical Results 8
8.1.1 Indicator Compounds in Upgradient Wells 8
8.1.2 Indicator Compounds in Downgradient Wells 9
8.2 Prediction Limit Exceedances 9
8.2.1 Basin F WP Well Prediction Limit Exceedances 9
8.2.2 Basin F PT Well Prediction Limit Exceedances 10
8.3 Groundwater Levels 10
8.4 Groundwater Monitoring Conclusions 11

9.0 ROUTINE AND NON-ROUTINE ACTIONS 11

9.1 Routine Actions 11
9.2 Non-Routine Actions 11

10.0 RECOMMENDATIONS AND CORRECTIVE MEASURES 11

11.0 FY18 COSTS AND FY19 BUDGETS 12
12.0 REFERENCES 12

TABLES

5.0-1 Soil Cover Thickness Loss
6.0-1 2018 Vegetation Performance Assessment Summary
7.0-1 Monthly Percolation Measurements
7.0-2 Rolling Nine-Month Percolation Totals
7.0-3 Rolling Twelve-Month Percolation Totals
8.1-1 Basin F Groundwater Monitoring ICs
8.1.1-1 ICs Detected in Upgradient Wells
8.1.2-1 ICs Detected in Downgradient Wells

FIGURE

4.0-1 Basin F Routine Maintenance Activities Map

APPENDICES (All on CD)

A Precipitation Data (October 1, 2017 through September 30, 2018)
B 2018 Vegetation Performance Assessment Documentation
C Cover Inspection Documentation (October 1, 2017 through September 30, 2018)
D Maintenance and Repair Documentation (October 1, 2017 through September 30, 2018)
E Basin F Post-Closure Groundwater Monitoring Report 2018

ACRONYMS

ºF	degrees Fahrenheit
AMA	Army Maintained Areas
CGMR	Cover and Groundwater Monitoring Report
CPMSO2	p-Chlorophenylmethyl sulfone
DCPD	Dicyclopentadiene
DIMP	Diisopropylmethyl phosphonate
EPA	U.S. Environmental Protection Agency
FY18	Fiscal Year 2018
FY19	Fiscal Year 2019
IC	Indicator Compound
LT	Less Than
LTCP	Long-Term Care Plan
µg/L	micrograms per liter
NNDMEA	n-Nitrosodimethylamine
NRAP	Non-Routine Action Plan
NWS	National Weather Service
O&M	Operations and Maintenance
OMC	O&M Contractor
PCGMP	Post-Closure Groundwater Monitoring Plan
PCP	Post-Closure Plan
PT	Principal Threat
RCRA	Resource Conservation and Recovery Act
SDT	Shell Disposal Trenches
SOP	Standard Operating Procedure
SQAPP	Sampling Quality Assurance Project Plan
TCLEE	Tetrachloroethene
UFS	Unconfined Flow System
WP	Wastepile

EXECUTIVE SUMMARY

This *2018 Basin F Cover and Groundwater Monitoring Report* (CGMR) for the Rocky Mountain Arsenal Federal Facility Site was prepared in accordance with the *Basin F Post-Closure Plan* (PCP), Revision 0 (TtEC 2011a) and the *RCRA-Equivalent, 2-, and 3-Foot Covers Long-Term Care Plan* (LTCP), Revision 2 (TtEC 2011b). The purpose of this Basin F CGMR is to evaluate compliance with post-closure requirements, cover inspection and monitoring results, and maintenance activities performed during the reporting period, and to describe future plans to improve or sustain cover conditions. This Basin F CGMR documents monitoring and maintenance-related activities performed on the Basin F Army Maintained Area (AMA) during the Fiscal Year 2018 (FY18), that is, between October 1, 2017 and September 30, 2018. This report addresses the ninth year of Operations and Maintenance (O&M) for the Basin F cover since construction finished with the Final Inspection in March of 2010.

The Basin F AMA is currently in post-closure as defined in Section 1.0 of the Basin F PCP. The Basin F AMA was also in the Interim O&M Period defined in Section 1.0 of the LTCP for this reporting period. However, the Army issued the final *Basin F/Basin F Exterior Remediation Project Part 2 Construction Completion Report* (CCR) – *Part 2* (Navarro 2017) in August of 2017 to document the successful completion of the Interim O&M Period. The U.S. Environmental Protection Agency (EPA), with concurrence from the Colorado Department of Public Health and Environment, approved the CCR – Part 2 in September of 2017. The EPA has not made a determination regarding the Operational and Function status of the Basin F Resource Conservation and Recovery Act (RCRA)-Equivalent Cover.

Precipitation is recorded at the Shell Disposal Trenches RCRA-Equivalent Cover in Section 36 by a rain gauge located near Lysimeter 002. The combined total precipitation measured between October 1, 2017 and September 30, 2018 was 8.35 inches.

In general, the Basin F cover was in excellent condition throughout FY18. Potential deficiencies observed during the reporting period included noxious or undesirable weeds. Soil cover thickness loss was within the compliance standard and the non-routine action trigger level for FY18.

Percolation collected at each of the five lysimeters on Basin F was below the non-routine action trigger level (1.0 mm) and the compliance standard (1.3 mm).

The 2018 Vegetation Performance Assessment of the Basin F RCRA-Equivalent Cover was conducted in accordance with Standard Operating Procedure 002 of the Basin F PCP, Revision 0. In all, 15 vegetation transects were sampled in 2018 on the Basin F cover. A total of 100 observations were made along each transect. Based on data from the 15 vegetation transects sampled, total live vegetation values were well above the compliance standard of 25 percent. The two-year average of total ground cover was also comfortably above the compliance standard of 50 percent, and the three-year running average of total ground cover was also well above the compliance standard of 67 percent.

Upgradient and downgradient groundwater data collected during post-closure monitoring of Wastepile (WP) and Principal Threat (PT) wells were evaluated to demonstrate post-closure

operations and maintenance of the Basin F surface impoundment and that the Basin F WP meets the RCRA closure performance standards. Sampling of all nine Basin F network wells (26015, 26017, 26028, 26073, 26128, 26133, 26157, 26163, and 26173) was conducted in April and May of 2018. Water level measurements and analytical results for Basin F post-closure groundwater monitoring are provided in the *Basin F Post-Closure Groundwater Monitoring Report 2018*, included as Appendix E.

Groundwater flow in the vicinity of Basin F continues to be primarily to the north with flow components to the northwest and northeast at the northern end of Basin F. The confined flow system in the Basin F area is addressed as part of the *Long-Term Monitoring Plan for Groundwater and Surface Water* (TtEC/URS 2010). The water levels in downgradient wells 26017, 26133, 26157, 26163, and 26173; and upgradient wells 26028, 26073, and 26128 began to rise in 2014 due to abnormally high precipitation recharging groundwater upgradient of the site. In 2018, groundwater elevations decreased in the downgradient wells as well as upgradient wells 26028 and 26173. Groundwater in well 26128 continued to rise in 2018, and appears different from the other wells as it is screened deeper than other wells monitored for Basin F. The decrease in water levels in the vicinity of Basin F is consistent with a general decreasing trend noted within the unconfined flow system across RMA.

Impacts to groundwater along the WP flow path appear to have decreased with fewer exceedances of prediction limits in downgradient WP wells in 2018 as compared to previous years. Concentrations for some Indicator Compounds (ICs) have increased during post-closure monitoring compared to baseline data for the Basin F WP wells. However, the impact on groundwater along the PT flow path appears to have increased, with observed increases of select ICs in PT downgradient wells. Select ICs have also increased in some upgradient wells. Based on the distribution of the analyte concentrations and water quality trends, it appears that the groundwater flow path having a greater impact to water quality is to the north-northeast, in the vicinity of downgradient PT wells.

Cost incurred performing post-closure care of the Basin F AMA during FY18, including inspections, repairs, maintenance, and groundwater monitoring was $136,373. A complete budget for Fiscal Year 2019 (FY19) has not been approved as of the issuance of this report. However, the FY19 budget is estimated to be approximately $176,188.

In summary and based on the information presented in this report, there are no corrective measures required. Recommendations for FY19 include continued diligence in weed control efforts; continued examination and repair of erosion rills or gullies, ponding areas, excessive tire tracks and ruts, burrowing animal holes, excessive siltation, and localized settlement; and evaluation of the statistical approach to assessing potential impacts on groundwater quality. These recommendations will be performed in FY19 and will be discussed in the 2019 Basin F CGMR.

1.0 INTRODUCTION

This *2018 Basin F Cover and Groundwater Monitoring Report* (CGMR) for the Rocky Mountain Arsenal Federal Facility Site was prepared in accordance with the *Basin F Post-Closure Plan* (PCP), Revision 0 (TtEC 2011a) and the *RCRA-Equivalent, 2-, and 3-Foot Covers Long-Term Care Plan* (LTCP), Revision 2 (TtEC 2011b). The purpose of this Basin F CGMR is to evaluate compliance with post-closure requirements, cover inspection and monitoring results, and maintenance activities performed during the reporting period, and to describe future plans to improve or sustain cover conditions. This Basin F CGMR documents monitoring and maintenance-related activities performed on the Basin F Army Maintained Area (AMA) during Fiscal Year 2018 (FY18), that is, between October 1, 2017 and September 30, 2018. This report addresses the ninth year of Operations and Maintenance (O&M) for the Basin F cover since construction finished with the Final Inspection in March of 2010.

The Basin F AMA is currently in post-closure as defined in Section 1.0 of the Basin F PCP. The Basin F AMA was also in the Interim O&M Period defined in Section 1.0 of the LTCP for this reporting period. However, the Army issued the final *Basin F/Basin F Exterior Remediation Project Part 2 Construction Completion Report* (CCR) – *Part 2* (Navarro 2017) in August of 2017 to document the successful completion of the Interim O&M Period. The U.S. Environmental Protection Agency (EPA), with concurrence from the Colorado Department of Public Health and Environment, approved the CCR – Part 2 in September of 2017. The EPA has not made a determination regarding the Operational and Function status of the Basin F Resource Conservation and Recovery Act (RCRA)-Equivalent Cover.

2.0 METHODOLOGY

The Basin F RCRA-Equivalent Cover and associated non-cover area within the outside shoulder of the perimeter access road, collectively referred to as the Basin F AMA, was inspected, monitored, repaired, and maintained in accordance with the Basin F PCP, Revision 0, and related Standard Operating Procedures (SOPs). The results of inspections and environmental monitoring of vegetation, percolation, and cover soil thickness were used to verify cover performance and to trigger cover maintenance and repair activities.

2.1 Type I and Type II Cover Inspections

The procedure for inspecting soil cover conditions and infrastructure features is detailed in Basin F PCP SOP 001, *Cover Conditions Inspections*. This SOP includes procedures for Type I and Type II cover inspections, as well as a procedure for collecting cover soil thickness data, which were used to evaluate the actual cover thickness against the cover thickness compliance standard. Where feasible, multiple inspections were conducted concurrently for efficiency and to minimize traffic on the cover, i.e. Type I inspections were implemented concurrently with the Type II inspections. Copies of the cover inspection forms are provided in Appendix C.

2.2 Vegetation Performance Assessment

Basin F PCP SOP 002, *Cover Vegetation Performance Assessment*, provides the procedure to collect and document vegetation conditions for assessment and future management. This SOP includes a procedure for conducting the annual quantitative vegetation survey. Data collected using Basin F PCP SOP 002 were used to evaluate the vegetation against the vegetation performance standard. The results of the evaluation are presented in Section 6.0. Refer to

Appendix B for photos and other information collected during the 2018 Vegetation Performance Assessment.

2.3 Percolation Monitoring

The procedure for collecting percolation data and operating the lysimeters is provided in Basin F PCP SOP 003, *Percolation Monitoring System Data Collection and Operation*. Data collected under Basin F PCP SOP 003 were used to evaluate the measured percolation against the percolation compliance standard. The results of the evaluation are presented in Section 7.0. Monthly percolation measurements from all Basin F lysimeters are provided in Table 7.0-1. The nine-month and twelve-month rolling percolation totals are provided in Tables 7.0-2 and 7.0-3, respectively.

2.4 Groundwater Monitoring

Groundwater monitoring was performed in April and May of 2018 at wells surrounding the former Basin F Surface Impoundment and the former Basin F Wastepile (WP) in accordance with the *Basin F Post-Closure Groundwater Monitoring Plan*, Revision 0 (PCGMP) (TtEC 2011a, Appendix B). The groundwater monitoring program is designed to demonstrate that post-closure maintenance of the Basin F Surface Impoundment and the Basin F WP satisfies RCRA performance standards, which include the requirement to control, minimize or eliminate post-closure escape of hazardous contaminants to groundwater (6 Code of Colorado Regulations 1007-3, Section 265, Subpart G).

2.5 Maintenance and Repair Activities

Routine maintenance and repair activities are listed in Table 3.2-1 of the Basin F PCP, while conditions requiring non-routine actions are listed in Table 3.2-2 of the Basin F PCP. There were no non-routine actions performed on the Basin F AMA in FY18. Routine repair activities performed in FY18 are discussed in Section 4.0 of this report.

3.0 PRECIPITATION AND WEATHER CONDITIONS

Precipitation is recorded at the Shell Disposal Trenches (SDT) RCRA-Equivalent Cover by a rain gauge located near Lysimeter 002. The combined total precipitation measured between October 1, 2017 and September 30, 2018 was 8.35 inches. Precipitation data are provided in Appendix A.

3.1 National Weather Service Summary

The following evaluations of weather conditions for the Rocky Mountain Region between October of 2017 and September of 2018 are based on information published by the National Oceanic and Atmospheric Administration, National Weather Service (NWS) Forecast Office for Denver/Boulder, Colorado. Climate data reported by the NWS were collected at the Primary Local Climatological Data Site, located at the Denver International Airport. All temperatures are reported in degrees Fahrenheit (ºF).

The fall months of 2017 were variable in temperature and precipitation. The total precipitation for the month of October 2017 was 1.33 inches, which was 0.31 inches above the historical norm of 1.02 inches. November recorded 0.25 inches of precipitation, which was 0.36 inches below normal and December of 2017 recorded 0.15 inches of precipitation, which was 0.2 inches below

normal. October finished the month by being 0.8 degrees ºF below normal. November wrapped up 7 ºF above normal, which ranked November 2017 as the tenth warmest November on record since temperature records began in 1872. December also finished slightly warmer at 3.2 ºF above normal.

The 2018 winter months for the Rocky Mountain Region were fluctuating in temperature and precipitation. January 2018 recorded above normal temperatures and precipitation, February was cold and unsettled, and March experienced above normal temperatures and precipitation. The average temperature for January was 34.7 ºF, which was 4.0 ºF above normal. February's average temperature was 29.9 ºF, which was 2.6 ºF below normal and March's average temperature was 42.7 ºF, which was 2.3 ºF above normal. The total precipitation for the month of January 2018 was 0.54 inches, which was 0.13 inches above the historical norm of 0.41 inches. February of 2018 recorded 0.31 inches of precipitation, which was 0.06 inches below normal and March of 2018 recorded 1.02 inches of precipitation which was 0.10 inches above normal. January recorded 6.4 inches of snow during the month, which was 0.6 inches below normal. February recorded 6.2 inches of snow, which was 0.5 inches above normal. March recorded 4.8 inches of snow, which was 5.9 inches below the normal of 10.7 inches.

The 2018 spring months for the Rocky Mountain Region started off drier and with near normal temperatures in April, May proved to have near average precipitation and was the eighth warmest May on record, and June wrapped up with below average precipitation and was the seventh warmest June on record. The average temperature for April 2018 was 47.8 ºF, which was 0.4 ºF above normal. The average temperature for May 2018 was 61.4 ºF, which was 4.3 ºF above normal. Two record high temperatures were set or tied in May 2018. A record high of 90 ºF was reached on the 10th and a tie of 91 ºF on the 25th. In addition, there were four days during the month in which the high temperature reached or exceeded the 90 ºF mark. This breaks the record of 90 degrees days for the month of May. The average June temperature was 72.4 ºF, which was 5.0 ºF above normal. Three record high temperatures were set or tied in June 2018. A record high of 95 ºF was tied on the 5th, another tie of 95 ºF on the 6th, and a record smashing 105 ºF reached on the 28th. The record high temperature of 105 ºF also ties Denver's all-time record high temperature. The total precipitation for the month of April 2018 was 0.86 inches, which was 0.85 inches below the historical norm of 1.71 inches. May of 2018 recorded 1.86 inches of precipitation, which was 0.26 inches below normal. June of 2018 recorded 0.43 inches of precipitation, which was 1.55 inches below normal.

The 2018 summer months for the Rocky Mountain Region started off drier and warmer than average in July, August experienced near normal temperatures and below average precipitation, and September wrapped up to be warmer with below average precipitation. The average temperature for July was 75.3 ºF, which was 1.1 ºF above normal. August's average temperature was 72.4 ºF, which was 0.1 ºF below normal. September's average temperature was 67.8 ºF, which was 4.4 ºF above normal. This ranks September 2018 the sixth warmest since records began in 1872. The total precipitation for the month of July 2018 was 1.03 inches, which was 1.13 inches below the historical norm of 2.16 inches. August of 2018 recorded 0.93 inches of precipitation, which was 0.76 inches below normal and September of 2018 recorded 0.18 inches of precipitation, which was 0.78 inches below normal.

3.2 Significant Storm Events at RMA

Precipitation is monitored locally at RMA using two rain gauges, both of which are located in Section 36. These rain gauges are positioned near Lysimeter 002 on the SDT RCRA-Equivalent Cover, and near the Lime Basins Metering Building, located west of the Lime Basins RCRA-Equivalent Cover. The Lime Basins rain gauge is typically used to record precipitation values for RMA.

RMA experienced two significant storm events between October of 2017 and September of 2018. These events occurred on July 23 and July 25, 2018. A significant storm event is defined as a rain storm event in which greater than 1.0 inch of precipitation falls within 24 hours. On July 23 the Lime Basins rain gauge recorded 1.24 inches of precipitation. The storm that occurred on July 25 also produced 1.24 inches of precipitation, but was much more severe and included a large amount of hail that was not represented in the precipitation total. Some of the hail was quite large and caused damage to vehicles and structures on site. Neither of these significant storms is represented in the NWS climatological data provided in Section 3.1, illustrating the scattered nature that severe storms often exhibit on the front range of the Rocky Mountain Region.

4.0 SOIL COVER ASSESSMENT, MAINTENANCE AND REPAIR ACTIONS

During FY18, the condition of the Basin F AMA was inspected during the Type I, Type II, and Post-Storm inspections in accordance with the Basin F PCP. Type I inspections were conducted on December 13, 2017, and on March 7, May 2, June 6, and July 3, 2018. The spring Type II inspection was conducted on April 4, 2018 and the fall Type II inspection was conducted on September 20, 2018.

There were two significant storm events that occurred in FY18 where the RMA received more than one inch of precipitation in a 24-hour period. The significant storm events recorded by the Lime Basins rain gauge occurred on July 23, 2018 and July 25, 2018. The O&M Contractor (OMC) staff drove the perimeter road following each significant storm and documented all observations in the project logbook. Post-Storm inspections were performed when field conditions improved, minimizing the potential for damaging the cover. The Post-Storm inspection was performed on August 1, 2018.

The soil covers were inspected for the following:

- Surface Conditions
- Vegetative Cover
- Engineering and Access Controls
- Monthly Percolation Monitoring - Lysimeters
- Surface Drainage Controls
- Erosion/Settlement Monuments
- Other deleterious conditions

In general, the Basin F cover was in excellent condition throughout FY18. Observations made during the reporting period are described below and cover inspection documentation is located in

Appendix C. The repair actions associated with these observations are shown on Figure 4.0-1 and are described below.

4.1 Noxious or Undesirable Weeds

A combination of herbicides (Esplanade®, Method®, Arsenal®, Telar® and Roundup®) was applied as a ground clear in December of 2017 along the shoulders of the Basin F roadways, the cattle guards, in between the bollards for the groundwater wells located on the perimeter road, and the gate entrances.

Patches of cheatgrass were observed during the fall 2017 Type II Inspections. These areas were sprayed with a combination of Esplanade® and Roundup® in November of 2017.

Patches of cheatgrass were observed during the fall 2018 Type II inspection. These areas are scheduled to be sprayed in Fiscal Year 2019 (FY19) and will therefore be discussed in the 2019 Basin F CGMR.

4.2 Burrowing Animal Holes

During the fall 2018 Type II inspection, prairie dog holes were observed on the northwest corner of Basin F. These holes were not repaired during FY18 and will therefore be discussed in the 2019 Basin F CGMR.

Holes were identified along the south perimeter fence during the July 2018 Type I inspection. These holes were backfilled and repaired with cover soil from the Long Term Cover Soil Stockpile in September of 2018. While repairing the inspection related holes, another hole was identified and repaired as well. Figure 4.0-1 shows all of the areas that were repaired using cover soil. Cover maintenance documentation is located in Appendix D.

4.3 Lysimeters

During FY18, Lysimeters 017 and 019 had the standing water pumped from the bottom of the manholes. The amount of water that had collected in the bottom of the manhole made the monthly percolation collection procedure more difficult.

4.4 Perimeter Fence

In April of 2018, OMC personnel cleaned tumble weeds off the Basin F perimeter fence using a tractor and tumble weed fence equipment.

5.0 COVER SOIL THICKNESS LOSS

The Basin F RCRA-Equivalent Cover includes a network of 18 erosion/settlement monuments embedded within the cover soil on a 500-foot grid. Cover soil thickness loss was measured at each of the monuments during Type II inspections in April and September of 2018 in accordance with the Basin F PCP SOP 001, *Cover Conditions Inspections*. The measurements for each monument are provided on Table 5.0-1. All cover soil thickness loss measurements were well below the non-routine action trigger level of 0.25 foot and the compliance standard of 0.5 foot.

6.0 VEGETATION PERFORMANCE ASSESSMENT

The 2018 Vegetation Performance Assessment of the Basin F RCRA-Equivalent Cover was conducted on September 5, 2018 in accordance with SOP 002 of the Basin F PCP. Results of the assessment are summarized on Table 6.0-1.

In all, 15 vegetation transects were sampled in 2018 on the Basin F cover. Prior to performing the assessments, transect locations and compass bearings were randomly selected using Geographical Information System software. A map showing the pre-selected sample locations and bearings is included in Appendix B. Photos, provided in Appendix B, were taken along the compass bearing at the start of each 50-meter transect. A total of 100 observations were made along each transect. All plant species that were present within one meter on either side of the 50-meter transect, but had not been observed using the point-intercept sampling method, were tallied and used to calculate species density (species per 100 square meters). Appendix B includes cover and frequency summary tables, vegetation performance assessment tables for each of the sample areas, and the specific transect data for each sample. These tables meet the reporting requirements set forth by the *Revegetation of the Basin A Soil Cover*, developed during the Basin A dispute resolution process in 1999.

The Basin F RCRA-Equivalent Cover was seeded in 2009 and continues to maintain a successfully established plant community. Based on data from the 15 transects sampled, mean total live cover was estimated to be about 62 percent, composed primarily of cool season grass species. However, cover by warm season species increased significantly at this site compared to recent years and is the highest at 19 percent since the initial establishment in 2009 of about 18 percent cover by warm season species. In 2013, the lowest amount of cover by warm season species was recorded at only about three percent. Since then, warm season grasses have consistently increased in the amount of cover provided. Weedy vegetation contributed a negligible amount to the total for live cover.

Although the growing season generally had above average temperatures and below normal precipitation, warm season species were prolific at the time the vegetation assessment was conducted. However, cool season plants were somewhat diminished in stature. There did not appear to be excessive stress due to low soil moisture or biological stressors on the grassland community at the time of the assessment. Insects and other wildlife, such as small rodents, grassland birds and deer were observed on all of the areas.

6.1 Comparison to the Performance Standard

Total live vegetation was estimated to be 62 percent, well above the performance standard of 25 percent. Total ground cover was high at 99 percent, and corresponding bare ground was relatively low at 1 percent. These values, particularly the low value for bare ground, reflect the improved growth of the grassland due to the beneficial effects of the prescribed burn of the site in the fall of 2014 and four seasons of growth. Average cover by litter was relatively high at 37 percent, but did not appear to be inhibiting vegetation production. The two-year running average for absolute total ground cover remained high at 99 percent, well above the standard of 50 percent. The three-year running average for absolute total ground cover was also 99 percent; also well above the standard of 67 percent.

6.2 Comparison to the Non-Routine Action Trigger Level

The results of the quantitative vegetation assessment performed on the Basin F cover determined that less than 1 percent of the total live vegetation was comprised of undesirable annual or biennial species. Therefore, the results of comparison to the non-routine action trigger level evaluation are identical to that of the vegetative performance standard described in Section 6.1 because cover by undesirable annual and biennial species did not exceed 10 percent of the total live vegetation. The absolute live cover vegetation for this site is well above the non-routine trigger level established in the Basin F PCP.

6.3 Sample Adequacy

Sample adequacy calculations were performed for the cover area. The intent of the sample adequacy calculation is to determine whether sufficient samples have been gathered to be able to detect a 10 percent reduction in the mean with 90 percent confidence. Sample adequacy was calculated using the formula provided in SOP 002:

$$N_{\min} = t_{\alpha}^{2} s^{2} \big/ (d\bar{x})^{2}$$

To ensure that the sample size is adequate, N_{min} must be less than, or equal to the number of transects sampled in the respective area. If N_{min} is greater than the number of transects sampled, additional vegetation transects need to be sampled until N_{min} becomes less than, or equal to the number of transects sampled, or all transect blocks within the respective area have been sampled, whichever comes first. Sample adequacy was calculated for total absolute cover only. The sample adequacy calculation yielded an N_{min} of less than one, which is well below the number of samples collected, i.e. 15.

7.0 PERCOLATION MONITORING ASSESSMENT

The Basin F RCRA-Equivalent Cover uses a network of five lysimeters to monitor deep percolation. Percolation collected by the lysimeters was measured monthly in accordance with Basin F PCP SOP 003, *Percolation Monitoring System Data Collection and Operation*.

Percolation is reported in millimeters, which is calculated by dividing the measured percolation volume by the area of the lysimeter pan. Lysimeters 016, 017, 018 and 019 each have a surface area of 1,500 square feet (139.35 square meters), while Lysimeter 020 has a surface area of 7,500 square feet (696.75 square meters). The volume of percolation measured monthly from each lysimeter is presented in Table 7.0-1. Table 7.0-2 presents rolling nine-month percolation totals for comparison to the non-routine action trigger level of 1.0 mm, and Table 7.0-3 presents twelve-month rolling totals for comparison to the compliance standard of 1.3 mm. The compliance standard for percolation is the quantity of percolation that, if exceeded, would subject the Army to potential enforcement actions by the Regulatory Agencies. Enforcement of the compliance standard began on March 2, 2015.

The lysimeters within the Basin F cover collected no measurable percolation over the reporting period and are therefore well below the non-routine action trigger level and the compliance standard.

8.0 GROUNDWATER MONITORING

This section summarizes the water level monitoring, analytical results, and statistical evaluation of groundwater quality for the 2018 post-closure groundwater monitoring at Basin F. Refer to the *Basin F Post-Closure Groundwater Monitoring Report 2018*, provided in Appendix E for a complete set of water level monitoring data and analytical results, as well as a statistical evaluation of groundwater quality in both Basin F groundwater monitoring networks.

Nine wells screened in the Unconfined Flow System (UFS) are used to monitor groundwater conditions in the uppermost aquifer. Six downgradient wells 26015, 26017, 26133, 26157, 26163, and 26173; and three upgradient wells 26028, 26073, and 26128 are used for post-closure groundwater monitoring at Basin F. Three of the wells including upgradient well 26028, and downgradient wells 26015 and 26017 are specific to the Basin F WP. Seven wells including upgradient wells 26073 and 26128 and downgradient wells 26015, 26133, 26157, 26163, and 26173 are associated with the Principal Threat (PT) excavation. Downgradient well 26015 is included in both groups due to overlapping groundwater flow paths.

8.1 Basin F Well Network Analytical Results

Groundwater samples were collected from the wells identified in the Basin F WP and PT groundwater monitoring networks in accordance with procedures defined in the Basin F PCGMP (TtEC 2011a, Appendix B), and the *Rocky Mountain Arsenal Sampling Quality Assurance Project Plan* (SQAPP) (Navarro 2015). Samples collected during post-closure monitoring are submitted to Applied Research and Development Laboratory in Mount Vernon, Illinois. The analytical methods were developed as described in the SQAPP.

The groundwater samples were tested for the analytes and indicator compounds (ICs) listed in the Basin F PCGMP. The 11 ICs for the Basin F WP and PT groundwater monitoring networks are listed in Table 8.1-1.

Table 8.1-1: Basin F Groundwater Monitoring ICs

ICs for the Basin F WP and PT Groundwater Monitoring Networks	
• Arsenic • Chloroform • Chloride • p-Chlorophenylmethyl sulfone (CPMSO2) • Copper • Dicyclopentadiene (DCPD)	• Diisopropylmethyl phosphonate (DIMP) • Dieldrin • n-Nitrosodimethylamine (NNDMEA) • Sulfate • Tetrachloroethylene (TCLEE)

Analytical data for the ICs detected in the Basin F water quality network wells are presented in Appendix E.

8.1.1 Indicator Compounds in Upgradient Wells

Annual sampling of the Basin F upgradient PT and WP wells as part of the post-closure monitoring was conducted in April and May of 2018. Table 8.1.1-1 lists the ICs detected in upgradient wells in 2018.

Table 8.1.1-1: ICs Detected in Upgradient Wells

ICs in Upgradient WP Wells	ICs in Upgradient PT Wells
• Arsenic • Chloride • DIMP • Dieldrin • Sulfate	• Arsenic • Chloroform • Chloride • CPMSO2 • DIMP • Dieldrin • NNDMEA • Sulfate • TCLEE

Additional compounds detected in the upgradient WP and PT wells are listed in the *Basin F Post-Closure Groundwater Monitoring Report 2018*, provided in Appendix E.

8.1.2 Indicator Compounds in Downgradient Wells

Table 8.1.2-1 lists the ICs detected in downgradient wells in 2018.

Table 8.1.2-1: ICs Detected in Downgradient Wells

ICs in Upgradient WP Wells	ICs in Upgradient PT Wells
• Arsenic • Chloroform • Chloride • DIMP • Dieldrin • NNDMEA • Sulfate • TCLEE	• Arsenic • Chloroform • Chloride • CPMSO2 • DCPD • DIMP • Dieldrin • NNDMEA • Sulfate • TCLEE

Additional compounds detected in the downgradient WP and PT wells are listed in the *Basin F Post-Closure Groundwater Monitoring Report 2018*, provided in Appendix E.

8.2 Prediction Limit Exceedances

The 2018 prediction limit values were exceeded in PT and WP downgradient wells.

8.2.1 Basin F WP Well Prediction Limit Exceedances

Analytical results from downgradient wells 26015 and 26017 collected in 2018 exceeded the prediction limit for chloroform. The remaining reported values from the downgradient Basin F WP wells were below the respective prediction limits. The 2018 chloroform concentrations in wells 26015 and 26017 are within the historical ranges of chloroform values for the wells. A conclusion can be made from the statistical evaluation that groundwater quality downgradient of

the Basin F WP area has potentially been affected in the vicinity of wells 26015 and 26017. Since the 2018 chloroform concentrations are only slightly above the prediction limit and likely were caused by higher water levels mobilizing residual chloroform, the potential effect on the groundwater quality is extremely small. Refer to Appendix E for the 2018 reported values that exceeded the prediction limit.

8.2.2 Basin F PT Well Prediction Limit Exceedances

Analytical results from downgradient wells 26133, 26157, 26163 and 26173 collected in 2018 exceeded the prediction limits for chloroform, DCPD, and TCLEE. The 2018 concentrations in wells 26133, 26163 and 26173 are within the historical ranges for chloroform and DCPD, and likely indicate residual contamination. The 2018 TCLEE concentration is higher than the historical values for well 26173. A conclusion can be made from the statistical evaluation that groundwater quality downgradient of the Basin F PT area has been potentially affected by residual subsurface contamination in the vicinity of wells 26133, 26157, 26163, and 26173. The remaining reported values from the downgradient Basin F PT wells are below the respective prediction limits. Refer to Appendix E for the 2018 reported values that exceeded the respective prediction limits.

8.3 Groundwater Levels

Water levels were measured in April and May of 2018 in 27 Basin F network wells to evaluate UFS conditions in the area of Basin F. Additional wells were used to further delineate the water table in the area. Additional information regarding groundwater levels is available in Appendix E.

Groundwater flow in the vicinity of Basin F continues to be primarily to the north with flow components to the northwest and northeast at the northern end of Basin F. Local variations occur beneath the north side of Basin F where groundwater flows to the north and northeast. The confined flow system in the Basin F area is addressed as part of the *Long-Term Monitoring Plan for Groundwater and Surface Water* (TtEC/URS 2010). A complete description of the subsurface lithology and groundwater flow in the vicinity of Basin F can be found in the Basin F PCGMP (TtEC 2011a, Appendix B).

The water levels in downgradient wells 26017, 26133, 26157, 26163, and 26173; and upgradient wells 26028, 26073, and 26128 began to rise in 2014 due to abnormally high precipitation recharging groundwater upgradient of the site. In 2018, groundwater elevations decreased in the downgradient wells as well as upgradient wells 26028 and 26173. Groundwater in well 26128 continued to rise in 2018, and appears different from the other wells as it is screened deeper than other wells monitored for Basin F. The decrease in water levels in the vicinity of Basin F is consistent with a general decreasing trend noted within the unconfined flow system across RMA.

The previous rise in water levels in wells near Basin F was likely caused by infiltration of precipitation outside of the Basin F cover in Sections 25, 26, 35, and 36 and is unrelated to the performance of the Basin F cover. Rising water levels in several wells may explain the increasing concentrations for some analytes in upgradient and downgradient wells. The effect of water levels on analyte concentrations is presented in *2018 Basin F Post-Closure Groundwater Monitoring Report*, provided in Appendix E.

8.4 Groundwater Monitoring Conclusions

Impacts to groundwater along the WP flow path appear to have decreased with fewer exceedances of prediction limits in downgradient WP wells in 2018 as compared to previous years. Concentrations for some ICs have increased during post-closure monitoring compared to baseline data for the Basin F WP wells. However, the impact on groundwater along the PT flow path appears to have increased, with observed increases of select ICs in PT downgradient wells. Select ICs have also increased in some upgradient wells. Based on the distribution of the analyte concentrations and water quality trends, it appears that the groundwater flow path having a greater impact to water quality is to the north-northeast, in the vicinity of downgradient PT wells.

The statistical evaluation using prediction limits for former Basin F appears not to be meaningful in a scenario where pre-existing contamination may be mobilized by fluctuating water levels. Furthermore, significant pre-existing contamination may be mobilized by relatively small fluctuations in water levels, as illustrated by downgradient chloroform concentrations in recent years. Consequently, Army and Shell believe that revising the statistical approach for post-closure groundwater monitoring should be considered because eight years of post-closure monitoring data are currently available and can support a more robust approach to evaluate Basin F water quality. In FY19 consultation with the Regulatory Agencies will be initiated to discuss modifying the evaluation approach in the Basin F PCGMP (TtEC 2011a, Appendix B).

9.0 ROUTINE AND NON-ROUTINE ACTIONS

9.1 Routine Actions

Routine maintenance and repairs were performed on Basin F and were intended to ensure that the cover continues to function as designed. Routine maintenance and repair actions were identified during inspections and are discussed in Section 4.0 of this report. Figure 4.0-1 illustrates the locations of routine maintenance and repair activities performed on Basin F. Appendix D includes Contractor Daily Quality Control Reports that describe the work performed.

9.2 Non-Routine Actions

The implementation of non-routine actions is described in the Basin F PCP. The Basin F PCP provides criteria for non-routine actions, and a mechanism for consultation between the parties and documentation of the consultative outcome. Each time a non-routine action is identified, a Non-Routine Action Plan (NRAP) will be prepared to document the substandard condition, the actions that will be carried out to remedy the condition, consultation between the parties, and concurrence on the proposed action. There were no NRAPs applicable to Basin F for this reporting period.

10.0 RECOMMENDATIONS AND CORRECTIVE MEASURES

Inspections and assessments performed during FY18 produced the following recommendations for FY19:

- The site should be examined for weeds throughout FY19. Occurrences of bindweed, cheatgrass, Canada thistle and other noxious weeds should be spot sprayed.

- The site should continue to be examined for erosion rills or gullies, ponding areas, excessive tire tracks and ruts, burrowing animal holes, excessive siltation, and localized settlement.
- The statistical approach for post-closure groundwater monitoring should be evaluated to determine if the current data set can be used to develop a more robust approach to evaluate Basin F water quality.

No corrective measures are currently planned for FY19.

11.0 FY18 COSTS AND FY19 BUDGETS

Cost incurred performing post-closure care of the Basin F AMA during FY18, including inspections, repairs, maintenance, and groundwater monitoring was $136,373. A complete budget for FY19 has not been approved as of the issuance of this report. However, the FY19 budget is estimated to be approximately $176,188.

12.0 REFERENCES

Navarro (Navarro Research and Engineering, Inc.)

2015 (Dec 10) *Rocky Mountain Arsenal Sampling Quality Assurance Project Plan Final.* Revision 1.

2017 (Aug 31) *Basin F/Basin F Exterior Remediation Project Part 2 Construction Completion Report - Part 2.* Revision 0.

TtEC (Tetra Tech EC Inc.)

2011a (Oct 6) *Basin F Post-Closure Plan.* Revision 0.

2011b (Sep 29) *RCRA-Equivalent, 2-, and 3-Foot Covers Long-Term Care Plan.* Revision 2.

TtEC/URS (Tetra Tech EC, Inc./URS Corporation)

2010 (Mar 3) *Long-Term Monitoring Plan for Groundwater and Surface Water.* Final.

TABLES

Table 5.0-1: Soil Cover Thickness Loss

Monument No.	Loss (in.) April 4, 2018	Loss (in.) September 20, 2018
ER92	0.00	0.00
ER93	0.00	0.00
ER94	0.00	0.50
ER95	0.00	0.00
ER96	0.00	0.00
ER97	0.00	0.25
ER98	0.00	0.00
ER99	1.00	1.00
ER100	0.00	0.00
ER101	1.00	0.50
ER102	0.50	1.00
ER103	0.00	0.00
ER104	1.50	1.50
ER105	0.00	0.00
ER106	0.00	0.00
ER107	0.50	0.50
ER108	0.00	0.00
ER109	0.25	0.75

Table 6.0-1: 2018 Vegetation Performance Assessment Summary

Performance Criterion and Evaluation	Basin F Cover
Total Absolute Ground Cover	98.90%
Allowable Total Absolute Live Vegetation Cover	**61.90%**
Vegetation Performance Standard for Total Live Vegetation	≥ 25%
Is Vegetation Performance Standard met?	Yes
Two Year Running Average for Total Absolute Ground Cover	**98.80%**
Vegetation Performance Standard for Two Year Running Average	≥ 50%
Is Vegetation Performance Standard met?	Yes
Three Year Running Average for Total Absolute Ground Cover	**99.00%**
Vegetation Performance Standard for Three Year Running Average	≥ 67%
Is Vegetation Performance Standard met?	Yes
Relative Weed Cover	**0.00%**
Relative Allowable Weed Cover	≤ 10%
Calculate Total Live Vegetation without the weed fraction?	No (Note 1)

Note 1: The relative weed cover is less than 10 percent, therefore, subtracting all but 10 percent of the total live vegetation cover fraction that is comprised of weeds does not affect the Total Live Vegetation calculation. The Total Live Vegetation values are within the Non-Routine Action Trigger Levels.

Table 7.0-1: Monthly Percolation Measurements

Lysimeter No.	Monthly Percolation Measurement (ml)											
	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18
Lysimeter 016	0	0	0	0	0	0	0	0	0	0	0	0
Lysimeter 017	0	0	Trace	0	Trace	0	0	0	0	0	0	0
Lysimeter 018	0	Trace	Trace	0	0	0	0	0	0	0	0	0
Lysimeter 019	0	0	Trace	0	0	Trace	0	0	0	0	0	0
Lysimeter 020	0	Trace	Trace	Trace	Trace	0	Trace	0	0	0	0	0

.

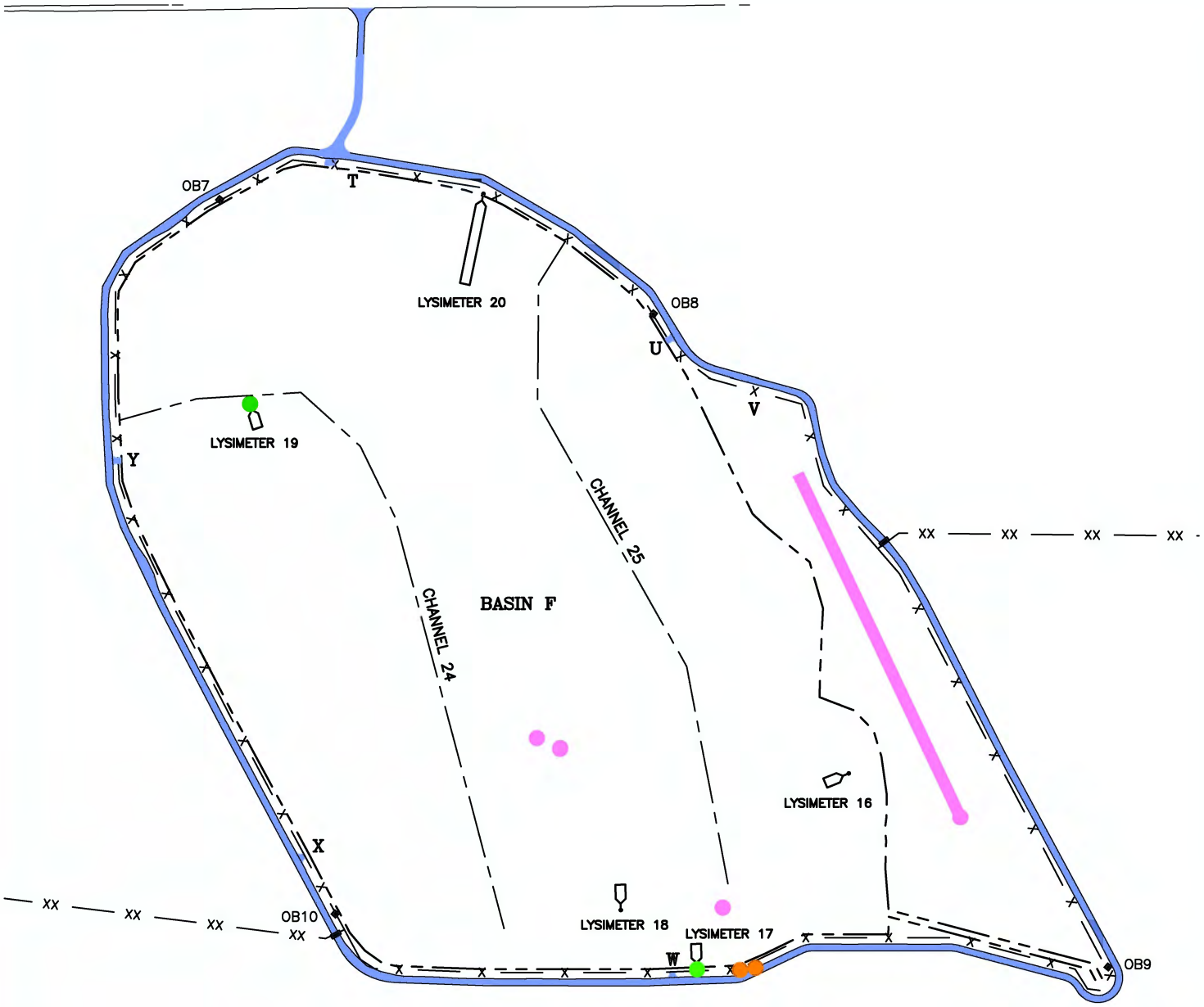
Table 7.0-2: Rolling Nine-Month Percolation Totals

Lysimeter No.	Rolling Nine-Month Percolation Total (mm)											
	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18
Lysimeter 016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 017	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 018	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 019	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 7.0-3: Rolling Twelve-Month Percolation Totals

Lysimeter No.	Rolling Twelve-Month Percolation Total (mm)											
	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18
Lysimeter 016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 017	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 018	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 019	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE



LEGEND

- COVER BOUNDARY
- PERIMETER FENCE
- USFWS BISON PASTURE FENCE
- PERIMETER ACCESS ROAD (SEE NOTE 1)
- LYSIMETER
- CHANNEL FLOW LINE
- OB9 — OBELISK
- W — LABELED GATES AND CATTLE GUARDS
- GROUND HERBICIDE
- CHEATGRASS
- LYSIMETER MAINTENANCE
- REPAIRED HOLES

NOTE 1: THE OUTSIDE SHOULDER OF THE PERIMETER ACCESS ROAD DEFINES THE ARMY MAINTAINED AREA BOUNDARY (AMA).
NOTE 2: TUMBLEWEEDS WERE REMOVED FROM THE BASIN F PERIMETER FENCE.

N
COLORADO STATE PLANE

0 250 500
Scale In Feet

Program Manager
Rocky Mountain Arsenal
U.S. Army • COMMITTED TO PROTECTION OF THE ENVIRONMENT •

ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, COLORADO

NAVARRO
Research and Engineering, Inc.

PROJECT NAME
2018 BASIN F COVER AND GROUNDWATER MONITORING REPORT

TITLE
BASIN F ROUTINE MAINTENANCE ACTIVITIES MAP

CAD FILE:	DATE	FIGURE NUMBER
BF FIGURE 4.0–1.DWG	10.29.18	4.0–1

S:\G PROJECTS\ANNUAL COVERS REPORT 2018 – OCTOBER\

APPENDICES

(All on CD)

A Precipitation Data (October 1, 2017 through September 30, 2018)

B 2018 Vegetation Performance Assessment Documentation

C Cover Inspection Documentation (October 1, 2017 through September 30, 2018)

D Maintenance and Repair Documentation (October 1, 2017 through September 30, 2018)

E Basin F Post-Closure Groundwater Monitoring Report 2018

ROCKY MOUNTAIN ARSENAL

BASIN F POST-CLOSURE GROUNDWATER MONITORING REPORT 2018

Revision 0

November 26, 2018

U.S. Department of the Army
Shell Oil Company

Prepared by:

Navarro Research and Engineering, Inc.

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CONTENTS

Section **Page**

1.0 INTRODUCTION 1

2.0 GROUNDWATER MONITORING RESULTS 1

2.1 Monitoring Well Activities 1
2.2 Water Level Monitoring 1
2.3 Water Quality Well Network 2
2.4 Basin F Network Wells – Analytical Results 3

3.0 WATER QUALITY EVALUATION 4

3.1 Historical Water Quality Evaluation 4
3.2 Post-Closure Water Quality Evaluation 4

4.0 DATA REVIEW 9

4.1 Precision 9
4.2 Accuracy/Bias 11
4.3 Representativeness 12
4.4 Completeness 13
4.5 Comparability 13

5.0 STATISTICAL EVALUATIONS 13

5.1 Basin F WP Statistical Evaluation 15
5.1.1 2018 Prediction Limits 15
5.1.2 2019 Prediction Limits 16
5.2 Basin F PT Statistical Evaluation 16
5.2.1 2018 Prediction Limits 16
5.2.2 2019 Prediction Limits 19

6.0 CONCLUSIONS 20

7.0 REFERENCES 25

ATTACHMENTS

Attachment A Hydrographs for Basin F Network Wells

Attachment B Time/Concentration Plots for Indicator Compounds

TABLES

Table 2.2-1 Water Level Measurements
Table 2.3-1 Water Quality Well Network
Table 2.4-1 Water Quality Monitoring Analyte List
Table 2.4-2 Quality Control Samples
Table 3.2-1 Post-Closure Water Quality Evaluation
Table 3.2-2 Summary of Post-Closure Monitoring 2006-2018 for Former Basin F WP Wells
Table 3.2-3 Summary of Post-Closure Monitoring 2007-2018 for Former Basin F PT Wells
Table 4.1-1 Summary of Qualified Data
Table 5.0-1 Wastepile Well Usage Table
Table 5.0-2 Principal Threat Well Usage Table
Table 5.1-1 2018 Prediction Limits for the Basin F WP Wells
Table 5.1-2 2018 Prediction Limit Exceedances for Basin F WP Wells
Table 5.1-3 2019 Prediction Limits for the Basin F WP Wells
Table 5.2-1 2018 Prediction Limits for the Basin F PT Wells
Table 5.2-2 2018 Prediction Limit Exceedances for Basin F PT Wells
Table 5.2-3 2019 Prediction Limits for the Basin F PT Wells
Table 6.0-1 Summary of 2018 Post-Closure Groundwater Monitoring

FIGURES

Figure 2.2-1 Former Basin F Well Location Map
Figure 2.2-2 Former Basin F 2018 Water Table Elevation Map of the Unconfined Flow System
Figure 2.4-1 Former Basin F Well Network Indicators Compound Detection Map 2018
Figure 5.2-1 Chloroform Concentrations and Water Elevations in Basin F Principle Threat Downgradient Wells 26133 and 26173
Figure 5.2-2 TCLEE Concentrations and Water Elevations in Basin F Principle Threat Downgradient Wells 26133 and 26173

SUPPORTING DOCUMENTATION

Compounds Detected in Basin F Groundwater (2006 – 2018)

Basin F 2018 Wastepile ChemStat Documentation

Basin F 2018 Principal Threat ChemStat Documentation

Basin F 2019 Wastepile ChemStat Documentation

Basin F 2019 Principal Threat ChemStat Documentation

Basin F Data Quality Review Results

ACRONYMS

AS	Arsenic
CHCL3	Chloroform
CL	Chloride
CPMSO2	p-Chlorophenylmethyl sulfone
DCPD	Dicyclopentadiene
DIMP	Diisopropylmethyl phosphonate
DLDRN	Dieldrin
EPA	U.S. Environmental Protection Agency
IC	Indicator Compound
IQR	Interquartile Range
LCS	Laboratory Control Spike
LT	Less Than
MRL	Method Reporting Limit
µg/L	micrograms per liter
NNDMEA	n-Nitrosodimethylamine
OMC	Operations and Maintenance Contractor
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PCGM	Post-Closure Groundwater Monitoring
PL	Prediction Limit
PPDDE	4,4-DDE/2,2-bis(p-chlorophenyl)-1,1-dichloroethene, also known as dichlorophenyldichloroethene
PPDDT	4-DDT/2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane, also known as dichlorophenyltrichloroethane
PQL	Practical Quantitation Limit
PT	Principal Threat
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RMA	Rocky Mountain Arsenal
RMAED	Rocky Mountain Arsenal Environmental Database
RPD	Relative Percent Difference

ACRONYMS

SAP	Sampling and Analysis Plan
SO4	Sulfate
SQAPP	Sampling Quality Assurance Project Plan
TCLEE	Tetrachloroethylene
UCL	Upper Confidence Limit
UFS	Unconfined Flow System
VOC	Volatile Organic Compounds
WP	Wastepile
ZN	Zinc

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1.0 INTRODUCTION

This Post-Closure Groundwater Monitoring Report documents the analytical results and data evaluation of the Basin F post-closure groundwater monitoring for the April through May 2018 annual groundwater sampling event on the Rocky Mountain Arsenal (RMA). The groundwater monitoring program is designed to evaluate that the post-closure maintenance of the Basin F Surface Impoundment and Basin F Wastepile (WP) satisfies the Resource Conservation and Recovery Act (RCRA) closure performance standards. Background information related to the Basin F monitoring approach, including site-specific characterization, applicable regulatory requirements, laboratory methods, statistical evaluation procedure, and monitoring program development are presented in the *Basin F Post-Closure Groundwater Monitoring Plan* (TtEC 2011a), *Basin F Post-Closure Groundwater Monitoring Sampling and Analysis Plan* (SAP) (TtEC 2011b), *Rocky Mountain Arsenal Sampling Quality Assurance Project Plan* (Navarro 2015), and previous annual groundwater reports.

2.0 GROUNDWATER MONITORING RESULTS

A summary of water level monitoring and analytical results for 2018 Basin F groundwater monitoring is presented in the following sections.

2.1 Monitoring Well Activities

As part of the annual water level measurements and groundwater sampling, field crews measured the well stickup heights and depths to water, and inspected the monitoring wells, well pads, and pumps. Total depths were measured in the wells without dedicated pumps. No discrepancies were noted, and repairs were not needed at this time.

2.2 Water Level Monitoring

Water levels were measured in April and May of 2018 in 27 Basin F network wells to evaluate Unconfined Flow System (UFS) conditions in the area of Basin F. Additional wells were used to further delineate the water table in the area. Water level monitoring network wells are shown on Figure 2.2-1. Water level measurements for April and May 2018 are presented in Table 2.2-1.

Figure 2.2-2 presents the water table elevation map for the UFS for April and May 2018. Groundwater flow in the vicinity of Basin F continues to be primarily to the north with flow components to the northwest and northeast at the northern end of Basin F. Local variations occur beneath the north side of Basin F where groundwater flows to the north and northeast. The confined flow system in the Basin F area is addressed as part of the *Long-Term Monitoring Plan for Groundwater and Surface Water* (TtEC/URS 2010). A complete description of the subsurface lithology and groundwater flow in the vicinity of Basin F can be found in the *Basin F Post-Closure Groundwater Monitoring Plan* (TtEC 2011a).

Water levels measured in the nine Basin F water quality network wells since 2006 are shown on hydrographs (Attachment A). The water levels in downgradient wells 26017, 26133, 26157, 26163, and 26173; and upgradient wells 26028, 26073, and 26128 began to rise in 2014 due to abnormally high precipitation recharging groundwater upgradient of the site. In 2018,

groundwater elevations decreased in the downgradient wells as well as upgradient wells 26028 and 26173. Groundwater in well 26128 continued to rise in 2018, and appears different from the other wells as it is screened deeper than other wells monitored for Basin F. The decrease in water levels in the vicinity of Basin F is consistent with a general decreasing trend noted within the unconfined flow system across RMA.

The previous rise in water levels in wells near Basin F was likely caused by infiltration of precipitation outside of the Basin F cover in Sections 25, 26, 35, and 36 and is unrelated to the performance of the Basin F cover. Rising water levels in several wells may explain the increasing concentrations for some analytes in upgradient and downgradient wells. The effect of water levels on analyte concentrations is presented in Section 3.2, Post-Closure Water Quality Evaluation.

2.3 Water Quality Well Network

Post-closure groundwater sampling was conducted in April and May 2018. The post-closure water quality well network for Basin F is presented in Table 2.3-1, and shown on Figure 2.2-1. The nine network wells are used to monitor groundwater conditions in the uppermost aquifer in the UFS. Six downgradient wells 26015, 26017, 26133, 26157, 26163, and 26173; and three upgradient wells 26028, 26073, and 26128 are used for post-closure groundwater monitoring (PCGM) at Basin F. Upgradient wells 26073 and 26128; and downgradient wells 26015, 26133, 26157, 26163, and 26173 are associated with the Principal Threat (PT) excavation. Upgradient well 26028; and downgradient wells 26015 and 26017 are associated with Basin F WP. Well 26015 is included in both groups due to overlapping groundwater flow paths (TtEC 2011a).

Table 2.3-1. Water Quality Well Network

Well Number	Well Network	Groundwater Flow System	Aquifer	Upgradient/ Downgradient
26015	WP/PT	UFS	Alluvial/Denver	Downgradient
26017	WP	UFS	Alluvial	Downgradient
26028	WP	UFS	Denver Formation	Upgradient
26073	PT	UFS	Denver Formation	Upgradient
26128	PT	UFS	Denver Formation	Upgradient
26133	PT	UFS	Denver Formation	Downgradient
26157	PT	UFS	Denver Formation	Downgradient
26163	PT	UFS	Alluvial/Denver	Downgradient
26173	PT	UFS	Alluvial	Downgradient

UFS – Unconfined Flow System
WP – Wastepile
PT – Principal Threat

Wells 26028, 26073, and 26128 on the south, and southeast sides of Basin F are used to evaluate contaminants upgradient of the Basin F surface impoundment. Based on historical data, the flow

paths associated with wells 26073 and 26128 appear under the eastern side of the Former Basin F and are upgradient of the PT excavation. The wells are useful for tracking chemical trends in the area since they have elevated concentrations of contaminants. Well 26028 is included to evaluate the long-term chemical trends in the area since the flow path of the well is directly upgradient of the Former Basin F WP.

2.4 Basin F Network Wells – Analytical Results

Groundwater samples were collected from the wells identified in Table 2.3-1 in accordance with procedures defined in the *Basin F Post-Closure Groundwater Monitoring Plan* (TtEC 2011a), and the Operations and Maintenance Contractor (OMC) *Sampling Quality Assurance Project Plan* (SQAPP) (Navarro 2015). Samples collected during post-closure monitoring are submitted to Applied Research and Development Laboratory in Mount Vernon, Illinois and analyzed for the parameters listed in Table 2.4-1. The analytical methods were developed as described in the SQAPP (Navarro 2015).

The groundwater samples were tested for the analytes and indicator compounds (ICs) listed in Table 2.4-1 (available in the Tables Section). The 11 ICs monitored include the following:

- Arsenic
- Chloroform
- Chloride
- p-Chlorophenylmethyl sulfone (CPMSO2)
- Copper
- Dicyclopentadiene (DCPD)
- Diisopropylmethyl phosphonate (DIMP)
- Dieldrin
- n-Nitrosodimethylamine (NNDMEA)
- Sulfate
- Tetrachloroethylene (TCLEE)

The analytical data for the ICs detected in the Basin F water quality network wells are presented on Figure 2.4-1. Analytical data for all detected analytes at Basin F are also included in the Supporting Documentation folder included with this report. Table 2.4-2 lists quality control (QC) samples collected and analyzed as part of the Basin F post-closure monitoring for 2018.

Table 2.4-2. Quality Control Samples

Sample Type/Site ID	Sample Date
Field Duplicate	
26015	5/7/2018
26017	5/2/2018
26128	4/30/2018
26133	5/7/2018
26157	4/30/2018
26173	5/8/2018
Lab Duplicates	
26015	5/7/2018

26017	5/2/2018
26128	4/30/2018
26133	5/7/2018
26157	4/30/2018
26173	5/8/2018
Trip Blanks	
26015	5/7/2018
26017	5/2/2018
26157	4/30/2018
26173	5/8/2018
Field Blanks	
26157	4/30/2018

The Basin F network wells 26015, 26017, 26028, 26073, 26128, 26133, 26157, 26163, and 26173 were sampled in April and May 2018. Detections of ICs are summarized in Table 3.2-1, with further discussion presented in Section 3.2.

3.0 WATER QUALITY EVALUATION

3.1 Historical Water Quality Evaluation

Analytical results of ICs detected in WP and PT monitoring wells during post-closure monitoring in 2018 are available through the Rocky Mountain Arsenal Environmental Database (RMAED) and provided in the Supporting Documentation Folder. Historically, downgradient PT wells have greater detection frequencies and concentrations of ICs than upgradient PT wells due to the residual contamination in the saturated zone beneath Basin F or ICs that may be continuing to migrate from the vadose zone to the saturated zone. The water quality data collected prior to post-closure monitoring in 2010 are included in previous Basin F reports, and are used in this report, as needed to illustrate contaminant trends. The historical data are available through the RMAED.

3.2 Post-Closure Water Quality Evaluation

The Basin F groundwater monitoring network is designed to demonstrate that the post-closure operations and maintenance of the Basin F Surface Impoundment and the Basin F WP satisfy RCRA closure performance standards. The post-closure monitoring results for the ICs were evaluated from samples collected from the start of post-closure monitoring in October 2010 through the annual sampling event in 2018. The 2018 data for ICs analyzed in samples collected from WP and PT monitoring wells are summarized in Table 3.2-1.

Tables 3.2-2 and 3.2-3 (available in the Tables Section) summarize the concentration trends during the post-closure period.

The time versus concentration graphs for the ICs detected in WP and PT monitoring wells are provided in Attachment B.

Table 3.2-1. Post-Closure Water Quality Evaluation

Analyte	Concentrations (µg/L)								
Designation	Downgradient		Upgradient			Downgradient			
Network	WP/PT	WP	WP	PT	PT	PT	PT	PT	PT
Well	26015	26017	26028	26073	26128	26133	26157	26163	26173
Arsenic	3.34	**2.42**	**3.43**	LT 1	**3.05**	**3.54**	1.55	2.49	1.56
Chloroform	0.88	**0.38**	LT 0.2	65	**0.34**	5,640	LT 5	LT 0.2	**34,400**
Chloride	1,030,000	**471,000**	10,000	**157,000**	**910,000**	**1,030,000**	707,000	2,400,000	**785,000**
CPMSO2	LT 1.2	LT 1.2	LT 1.2	**111**	LT 1.2	**24.94**	33.9	38.4	LT 1.2
Copper	LT 50	LT 50	LT 50	LT 50	LT 50	LT 50	LT 50	LT 50	LT 50
DCPD	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	**419**	**250**	**326**	**291**
DIMP	4.19	3.56	**1,120**	1.91	33.9	326	**138**	719	407
Dieldrin	0.29	**0.952**	0.0193	**0.122**	0.178	**1.44**	0.59	**1.16**	1.86
NNDMEA	0.01	0.00722	LT 0.003	LT 0.003	0.0483	0.305	0.157	0.406	0.572
Sulfate	498,000	**293,000**	**495,000**	728,000	**531,000**	606,000	**391,000**	1,100,000	**450,000**
TCLEE	LT 0.2	**0.262**	LT 0.2	1.11	**0.504**	**300**	48	**4.97**	**1,610**

Note: Values that increased in 2018 are in **bold**.
LT – Less than reported at the method reporting limit (MRL)

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As detailed in the *Basin F Post-Closure Groundwater Monitoring Plan* (TtEC 2011a), the high concentrations of contaminants in downgradient wells—including chloroform, CPMSO2, DIMP and TCLEE—may be the result of residual contamination present in the unsaturated and saturated zones that was mobilized with rising water levels or continuing migration from the vadose zone to the saturated zone. Basin F was constructed in 1956, and before Basin F was drained in 1988, significant contamination migrated from leaks in the Basin F liner through the 40- to 45-foot thick unsaturated zone to the saturated zone; thus, residual contamination present in the sediments above and below the water table will act as continuing sources to the groundwater. The leaks in the Basin F liner occurred on the east side of Basin F, especially in the PT excavation area, which explains the much higher groundwater concentrations in the downgradient PT wells. In addition, the ponding of water in below-grade excavations during key-cut excavating around the perimeter of Basin F may have mobilized additional contamination to the water table.

Compounds, in addition to ICs, detected in the upgradient WP and PT wells include the following:

- Alpha-chlordane
- Ammonia
- Benzene
- Bromide
- Calcium
- Carbon Tetrachloride
- Chlorobenzene
- p-Chlorophenylmethyl sulfide
- p-Chlorophenylmethyl sulfoxide
- Dithiane
- Dissolved organic carbon
- Endrin
- Fluoride
- Isodrin
- Isopropylmethyl Phosphonic acid
- Magnesium
- Manganese
- Nitrate
- Kjeldahl nitrogen
- 1,4-Oxathiane
- Dichlorophenyldichloroethene (PPDDE)
- Dichlorophenyltrichloroethane (PPDDT)
- Selenium
- Sodium
- Toluene
- Total organic carbon
- Total organic halogens
- Trichloroethylene
- Zinc

Compounds, in addition to ICs, detected in downgradient WP and PT wells include the following

- 1,1-Dichloroethene
- 1,1-Dichloroethane
- 1,2-Dichloroethane
- 1,3-Dichlorobenzene
- 1,1,1-Trichlroroethane
- Aldrin
- Alpha-chlordane
- Aluminum
- Ammonia
- Benzene
- Bicycloheptadiene
- Bromide
- cis-1,2-Dichloroethylene
- Calcium
- Carbon tetrachloride
- Chlorobenzene
- p-Chlorophenylmethyl sulfide
- Chlorobenzene
- p-Chlorophenylmethyl sulfoxide
- Dibromochloropropane
- Dissolved organic carbon
- Dithiane
- Endrin
- Fluoride
- Hexachlorocyclopentadiene
- Isodrin
- Isopropylmethyl Phosphonic acid
- Iron
- Magnesium
- Manganese
- Nickel
- Fluoride
- Nitrate
- Kjeldahl nitrogen
- 1,4-Oxathiane
- PPDDE
- PPDDT
- Selenium
- Sodium
- Supona
- Thiodiglycol
- Toluene
- Total organic carbon
- Total organic halogens
- trans-1,2-Dichloroethene
- Trichloroethylene
- Zinc

Contaminants in the Basin F pathway occur primarily in alluvium-filled paleochannels and weathered bedrock, which can affect the migration pathways and travel times from upgradient WP and PT wells to the downgradient wells. The groundwater concentrations in the Basin F wells can be affected by rising water levels, which may mobilize the residual contamination present above previous water table elevations. As a result, the increasing concentrations in the WP and PT wells should be compared to the trend in water levels to determine whether there is a correlation. Refer to Section 5.2.1 for additional discussion on the trends in groundwater quality in PT wells.

4.0 DATA REVIEW

The objective of the data review process is to determine whether the analytical results are acceptable for use in making decisions for the project. As a component of the data review process, the analytical data were evaluated against the data quality indicators Precision, Accuracy, Representativeness, Completeness, and Comparability (PARCC). The OMC reviewed the PARCC parameters with respect to the data QC goals stated in the Basin F PCGM SAP (TtEC 2011b). An evaluation of each analytical data quality indicator follows.

The sample results were evaluated against the data quality requirements and compared to the data quality objectives as presented in the Basin F PCGM SAP (TtEC 2011b). Data review and verification activities were conducted in accordance with the RMA SQAPP (Navarro 2014). The results of these evaluations are described below.

The OMC conducted data validation on approximately 13 percent of the Basin F groundwater analytical data. The SQAPP (Navarro 2015) data validation requirement of 10 percent was achieved. Validation checklists were completed and laboratory case narratives were reviewed by the analyst to determine potential problems with the data.

4.1 Precision

Precision is the measure of agreement among replicate measurements of the same property, under prescribed similar conditions. Results of laboratory duplicates and field duplicates will be used to calculate precision. Note that laboratory duplicates are designated by the laboratory and analyzed for inorganics only. The precision criteria for individual analytes will be determined using the Relative Percent Difference (RPD) values calculated from data where both the investigative sample and the duplicate sample are above the MRL. If one or both results are rejected or not analyzed, there will be no comparison of results. Duplicate samples determined to be not comparable will be subject to data qualification. The performance criteria is a RPD value of less than or equal to 35 percent. The RPD for a duplicate investigative sample pair is calculated using the following steps:

1. Identify the field duplicate investigative sample pair result;
2. Identify parameters detected in both results for the pair identified in Step 1;
3. Calculate the RPD value for the detected parameters identified in Step 2 using the following equation:

$$\boldsymbol{RPD = \frac{|x - y|}{\frac{(x + y)}{2}} \times 100}$$

Where:

x = investigative sample result
y = duplicate sample result

The investigative and duplicate results will be considered comparable if any of the following statements are true:

- If both sample results are less than the MRL.
- If both sample results are greater than the MRL, but less than or equal to twice the MRL.
- If both sample results are greater than twice the MRL and the RPD is less than or equal to the specified upper RPD limit.
- If both sample results are greater than the MRL, one result is less than or equal to twice the MRL, one result is greater than twice the MRL, and the RPD is less than or equal to the specified upper limit.
- If one sample result is less than the MRL, and one result is greater than the MRL and less than or equal to twice the MRL.

The investigative and duplicate results will be considered not comparable if any of the following statements are true:

- If both sample results are greater than twice the MRL and the RPD is greater than the specified upper RPD limit.
- If both sample results are greater than the MRL, one result is less than or equal to twice the MRL, one result is greater than twice the MRL, and the RPD is greater than the specified upper limit.
- If one sample result is less than the MRL, and one result is greater than twice the MRL.

The duplicate/investigative pairs are evaluated for comparability. The RPD upper limit is 35 percent for all analytes. A total of 105 field and 24 lab duplicate analyses were performed with an average RPD of 3.7 percent. The data are considered acceptable for their intended use and no additional action in addition to the data qualification described below is considered necessary. The frequency requirement of 10 percent for field duplicates was achieved.

The duplicate and investigative results are non-comparable for one duplicate analysis. The duplicate/ investigative pair considered non-comparable is presented in Table 4.1-1. The non-comparable investigative and duplicate data were assigned a "Z" data qualifier with the comment "Duplicate and investigative values are not comparable." No discernible trends or QC issues were observed in the non-comparable pair.

Table 4.1-1. Summary of Qualified Data

Site ID	Analyte	Sample Date	Method	Sample Result	Units	Flag	Data Qualifier
26128	DIMP	4/30/2018	UM87	55.1	UGL	D	Z
				33.9	UGL		Z

Note: Both values are great than or equal to two times the MRL. The RPD is greater than or equal to 35 percent.

4.2 Accuracy/Bias

Accuracy is the degree of agreement between an observed value (sample result) and an accepted reference value. Bias is the systematic or persistent distortion of a measurement process that causes errors in one direction (high or low). The terms accuracy and bias are used interchangeably. Accuracy/bias is indicated by percent recovery calculated from laboratory spike data using the following formula:

$$\boldsymbol{Recovery\ Rate}(\%) = \left(\frac{\boldsymbol{measured\ value}}{\boldsymbol{true\ value}}\right) \times \mathbf{100}$$

Where:

measured value = value after the spike –value before the spike
true value = value of the spike added

Accuracy/bias will be calculated based on results of laboratory control spikes (LCSs) and matrix spikes. Laboratory control spikes utilize laboratory grade water with some additions of inorganic constituents to mimic RMA water. Matrix spikes utilize RMA water to account for matrix-related interferences.

The calculated recovery rate is compared to the lower and upper recovery rate limits specific to each analyte. The median, 25th percentile, and 75th percentile for each analyte are calculated. The interquartile range (IQR) is calculated by subtracting the 25th percentile value from the 75th percentile value. The lower and upper recovery limits are determined respectively by subtracting and adding 1.5 times the IQR to the median value. Data will not be qualified solely on a recovery rate outside the calculated recovery limits. If an analysis is outside both the matrix spike and LCS recovery limits, the analysis will be assigned a “Z” data qualifier with the comment “Matrix spike recoveries and LCS recoveries were outside evaluation limits”. The recovery limits for matrix spikes and LCS are provided in the Supporting Documentation folder.

The data utilized for the historical recovery rate calculations was limited to the spike values for the analytical lots of the investigative data since May 2006. Spikes associated with highly contaminated sites are excluded from the calculation since the matrix spike could possibly be diluted out due to the high original concentration.

A total of 178 matrix spike analyses were evaluated. Matrix spike recoveries are not included in the evaluation if the investigative value is greater than four times the spike amount as the impact of the matrix spike would be minimized. Analyses with a “@” flag code (value is estimated) or “B” flag code (analyte found in the method blank or QC blank as well as the sample) are also excluded from recovery rate calculations. The average recovery rate for the 178 matrix spike analyses used in the evaluation was 99.7 percent. Spike recoveries outside the control limits were observed in eight analyses. The matrix spike recoveries outside the warning evaluation limits were not observed in the corresponding LCS recoveries. No discernible trends or QC issues that would require data qualification or additional action were observed in the lots below the specified limit. The data are considered acceptable for their intended use and no additional

action is considered necessary. A listing of the matrix spike sample results outside the evaluation limits is included in the Supporting Documentation folder.

The average recovery rate for the 178 LCS analyses corresponding to the matrix spike analyses was 95.4 percent. Spike recoveries outside the control limits were observed in 29 analyses. No discernible trends or QC issues were observed in the LCS samples exceeding the specified limits. The data are considered acceptable for their intended use and no additional action is considered necessary. A listing of the LCS sample results outside the evaluation limits is included in the Supporting Documentation folder.

4.3 Representativeness

Representativeness refers to the selection and implementation of analytical methods, sampling protocols, and sample locations to ensure the analytical data results are representative of the media being sampled and of the conditions being measured. Representativeness is evaluated by reviewing monitoring program design and implementation, as well as field and laboratory blank samples. Design of the monitoring program is reviewed qualitatively to assess whether the objectives were satisfied. Implementation of the monitoring program is reviewed qualitatively to evaluate whether the planned procedures were followed. A quantitative review of the QC blank results indicates whether influences outside the measurement systems have affected the analyses and interpretation of the media and conditions.

Sample locations, sampling frequency, and sample collection procedures applied during groundwater monitoring are described in the Basin F *Post-Closure G Groundwater Monitoring Plan* (TtEC 2011a). The program is designed and implemented to provide water quality data in the area of the Basin F WP as defined in the work plan.

QC blanks, including trip blanks and field blanks, are collected and analyzed to evaluate possible cross contamination of the investigative samples. Rinse blanks were not required as the wells were either bailed with a dedicated bailor or have dedicated pumps.

Trip blanks are included with each shipment of samples, and analyzed for volatile organic compounds. A total of 110 trip blank analyses were performed. No analytes were detected above the MRL in the trip blanks.

Field blanks were collected and analyzed to evaluate possible cross contamination related to ambient conditions. A total of 80 field blank analyses were performed with 1 value above the MRL. The data are considered acceptable for their intended use and no additional action in addition to the data qualification is considered necessary.

In addition, the laboratories prepared and analyzed method blanks as part of their analytical protocols. Method blanks measure potential contamination from laboratory sources such as glassware, reagents and laboratory water. Method blank detections that affect sample data result in the automatic qualification (“B” flag) of the sample data by the laboratory. No method blank detections were reported in 2018.

The analytical results of monitoring are representative of the groundwater quality with the exception of qualified data. Rejected data are not removed from the RMAED; however, they are not used to evaluate the Basin F groundwater data. Data qualified as "@" are not filtered out of the database. While not rejected, the data are considered estimated due to the concentration being above the linear range of the instrument.

4.4 Completeness

Completeness is the amount of valid data obtained from a measurement system compared to the amount that was expected and needed to meet the project goals. Expected results include all investigative samples, duplicates and field QC samples that were planned to be collected and as identified in the Basin F PCGM SAP (TtEC 2011b). Valid analytical data are those data that have been identified as usable, and included in the RMAED. The Basin F PCGM SAP sets the completeness goal for the sampling program at 90 percent. During the sampling period, all analyses were accepted. The completeness goal of 90 percent was achieved.

4.5 Comparability

Comparability is the confidence with which one data set can be evaluated relative to another. Standard sampling and analysis techniques, based on certified analytical methods approved by the OMC or promulgated U.S. Environmental Protection Agency (EPA) SW-846 methods, and standard procedures for sample collection were used throughout the groundwater monitoring programs at the Basin F. Consistent procedures for the reporting and management of the data generated were followed. All data are considered comparable.

5.0 STATISTICAL EVALUATIONS

Sections 5.1 and 5.2 present the results of the statistical evaluations for the WP and PT for 2018. The wells used for prediction limits and statistical evaluations are presented in Tables 5.0-1 and 5.0-2. A discussion of how the water quality data were used to calculate prediction limits is presented below.

Table 5.0-1. Wastepile Well Usage Table

Well	Data Used to Calculate Baseline (2006) Prediction Limits	Data Used to Calculate Current (2018) Prediction Limits	Prediction Limits Applied to these Wells (May 2018)	Well Network	Designation
	Baseline Monitoring Period May and September 2006	Upgradient Data from 2006-2017			
26015	X		X	WP/PT	Downgradient
26017	X		X	WP	Downgradient
26028	X	X		WP	Upgradient

[1] Downgradient Wells 26015 and 26017 were originally monitored as part of the Long-Term Monitoring Plan (LTMP), but have been transferred to the Basin F groundwater monitoring program.

Table 5.0-2. Principal Threat Well Usage Table

Well	Data Used to Calculate Baseline (2007) Prediction Limits	Data Used to Calculate Current (2018) Prediction Limits	Prediction Limits Applied to these Wells (May 2018)	Well Network	Designation
	Baseline Monitoring Period (May and November 2007)	Upgradient data from 2007-2017			
26015[1]	X		X	WP/PT	Downgradient
26073	X	X		PT	Upgradient
26128	X	X		PT	Upgradient
26133			X	PT	Downgradient
26157[1]			X	PT	Downgradient
26163[1]	X		X	PT	Downgradient
26173	X		X	PT	Downgradient

[1] Downgradient Wells 26015, 26157, and 26163 were originally monitored as part of the Long-Term Monitoring Plan (LTMP), but have been transferred to the Basin F groundwater monitoring program.

The general approach for determining prediction limits for Basin F is consistent with EPA guidance documents (EPA 1989, EPA 1992), except when necessary to account for pre-existing groundwater contamination present under Basin F, as noted below. Prediction limits for Basin F have been calculated using ChemStat, version 6.3, an industry-approved statistical software package. The prediction limits were used for statistical evaluation based on the following:

- The prediction limits were calculated for the 11 ICs identified for groundwater samples collected from the Basin F WP and Basin F PT. Prediction limits referenced for the Basin F groundwater monitoring evaluation represent the statistical 99 percent upper limit of the prediction interval.
- The prediction limit was calculated differently for each IC data set, depending on the percentage of values less than the MRL.
- A determination was made for the total number of samples for both detections and non-detections for all ICs.
- Since pre-existing groundwater contamination is present under Basin F, baseline sample results representing the first year of post-closure monitoring from upgradient and downgradient wells adjacent to Basin F were used to calculate prediction limits. This approach deviates from the approach in EPA guidance documents (EPA 1989, EPA 1992) that sets prediction limits for ICs detected in the upgradient groundwater for comparison to future downgradient groundwater sample analytical results. For example, baseline sample results from 2006 Basin F WP downgradient wells 26015 and 26017 and upgradient well 26028 were considered background when calculating the prediction

limits for the baseline WP events (Table 5.0-1). Baseline sample results from 2007 Basin F PT downgradient wells 26015, 26163, and 26173 and upgradient wells 26073 and 26128 were considered background when calculating prediction limits for the baseline PT events (Table 5.0-2).

- Wells 26133 and 26157 located downgradient of Basin F were not used to calculate baseline prediction limits for the Basin F PT as they have higher concentrations than wells adjacent to former Basin F due to the slower groundwater flowrates associated with the unconfined alluvial/Denver Formation and the greater distance from Basin F. New prediction limits were calculated annually for Basin F PT using the updated compilation of upgradient groundwater data.
- The use of prediction limits provides an indication of remedy effectiveness and potential impact to groundwater downgradient of Basin F WP and PT wells relative to upgradient water quality for future sampling events. Prediction limits were calculated in accordance with Appendix A of the *Basin F Post-Closure Groundwater Monitoring Plan* (TtEC 2011) for each IC, and are represented by a statistical 99 percent upper confidence limit calculated using ChemStat or defaulting to the baseline MRL. Baseline MRLs are appropriate for use as prediction limits when analytes have not been detected in the baseline and subsequent upgradient well datasets. Baseline prediction limits, representing the first year of post-closure monitoring for the WP and PT, were initially used for this comparison; and thereafter, prediction limits have been calculated annually. Baseline prediction limits provided a means for comparison for the first year of post-closure monitoring; and for subsequent years, the current year's upgradient well data were added to the baseline data set and prediction limits were determined. Each year the newly calculated prediction limits are compared to the historical maximum prediction limit, and the higher value is chosen to represent the new prediction limit.
- The reporting limits change as a result of method re-certification required by the SQAPP every three years (Navarro 2015a). The MRL for dieldrin (Method UH61, Organochlorine Pesticides) changed in November 2017. The updated MRL, based on a method recertification, is presented in Tables 5.1-3 and 5.2-3.

A detailed discussion on the calculation and evaluation of prediction limits for the selected ICs is presented in EPA guidance documents (EPA 1989, EPA 1992, EPA 2009).

5.1 Basin F WP Statistical Evaluation

5.1.1 2018 Prediction Limits

Table 5.1-1 (available in the Tables Section) presents the 2018 WP prediction limits for the 11 ICs. 2018 prediction limits were calculated for the Basin F WP using groundwater data from 2006 through 2017 for upgradient well 26028. Prediction limits for 2018 were determined by comparing the initial Baseline prediction limits and the calculated prediction limits based on downgradient data through 2017, with the maximum value selected to represent the new prediction limit. The 2018 Basin F WP prediction limits were applied to data for downgradient

wells 26015 and 26017. The prediction limits were recalculated based on the baseline certified MRL where applicable.

Analytical results from downgradient wells 26015 and 26017 collected in 2018 exceeded the prediction limit for chloroform. The remaining reported values from the downgradient Basin F WP wells were below the respective prediction limits. Impacts to groundwater along the WP flow path appear to have fewer exceedances of PLs in downgradient WP wells in 2018 as compared to previous years.

The 2018 chloroform concentrations in wells 26015 and 26017 are within the historical ranges of chloroform values for the wells (LT 0.2 to 24.5 µg/L and LT 0.2 to 1.4 µg/L, respectively). A conclusion can be made from the statistical evaluation that groundwater quality downgradient of the Basin F WP area has potentially been affected in the vicinity of wells 26015 and 26017. The 2018 reported values for the wells exceeding the respective prediction limit are presented in Table 5.1-2 and Figure 2.4-1. Since the 2018 chloroform concentrations are only slightly above the prediction limit and likely were caused by higher water levels mobilizing residual chloroform, the potential effect on the groundwater quality is extremely small.

Table 5.1-2. 2018 Prediction Limit Exceedances for Basin F WP Wells

Well	Analyte	2018 Concentration (µg/L)	Prediction Limit (µg/L)
26015	Chloroform	0.88	0.2
26017	Chloroform	0.38	0.2

5.1.2 2019 Prediction Limits

Table 5.1-3 (available in the Tables Section) presents the 2019 prediction limits for each of the Basin F WP ICs that will be applied to downgradient wells 26015 and 26017 for the 2019 sampling event. Unless future statistical evaluations show otherwise, the calculated 2006 Baseline prediction limits are being used in lieu of the maximum background concentration from upgradient wells for chloride, dieldrin, and sulfate.

5.2 Basin F PT Statistical Evaluation

5.2.1 2018 Prediction Limits

Table 5.2-1 (available in the Tables Section) presents the 2018 PT prediction limits for the 11 ICs. 2018 prediction limits were calculated for the Basin F PT using groundwater data from 2006 through 2017 for upgradient wells 26128 and 20673. Prediction limits for 2018 were determined by comparing the initial Baseline prediction limits and the calculated prediction limits based on downgradient data through 2017, with the maximum value selected to represent the new prediction limit. The 2018 Basin F PT prediction limits were applied to data for downgradient wells 26015, 26133, 26157, 26163 and 26173.

Analytical results from downgradient wells 26133, 26157, 26163 and 26173 collected in 2018 exceeded the prediction limits for chloroform, DCPD, and TCLEE. The 2018 concentrations in wells 26133, 26163 and 26173 are within the historical ranges for chloroform (0.52 to 86,000 µg/L for well 26133 and 2.73 to 55,000 µg/L for well 26173), and DCPD (38 to 2,500 µg/L for well 26133, 10.5 to 970 µg/L for well 26157, 0.55 to 2900 µg/L for well 26157 and 30.6 to 370 µg/L well 26173), and likely indicate residual contamination. The 2018 TCLEE concentration is higher than the historical values (LT 0.75 µg/L to 1,200 µg/L) for well 26173. A conclusion can be made from the statistical evaluation that groundwater quality downgradient of the Basin F PT area has been potentially affected by residual subsurface contamination in the vicinity of wells 26133, 26157, 26163, and 26173.

The 2018 reported values from the wells exceeding the respective prediction limits are presented in Table 5.2-2 and Figure 2.4-1. The remaining reported values from the downgradient Basin F PT wells are below the respective prediction limits.

Table 5.2-2. 2018 Prediction Limit Exceedances for Basin F PT Wells

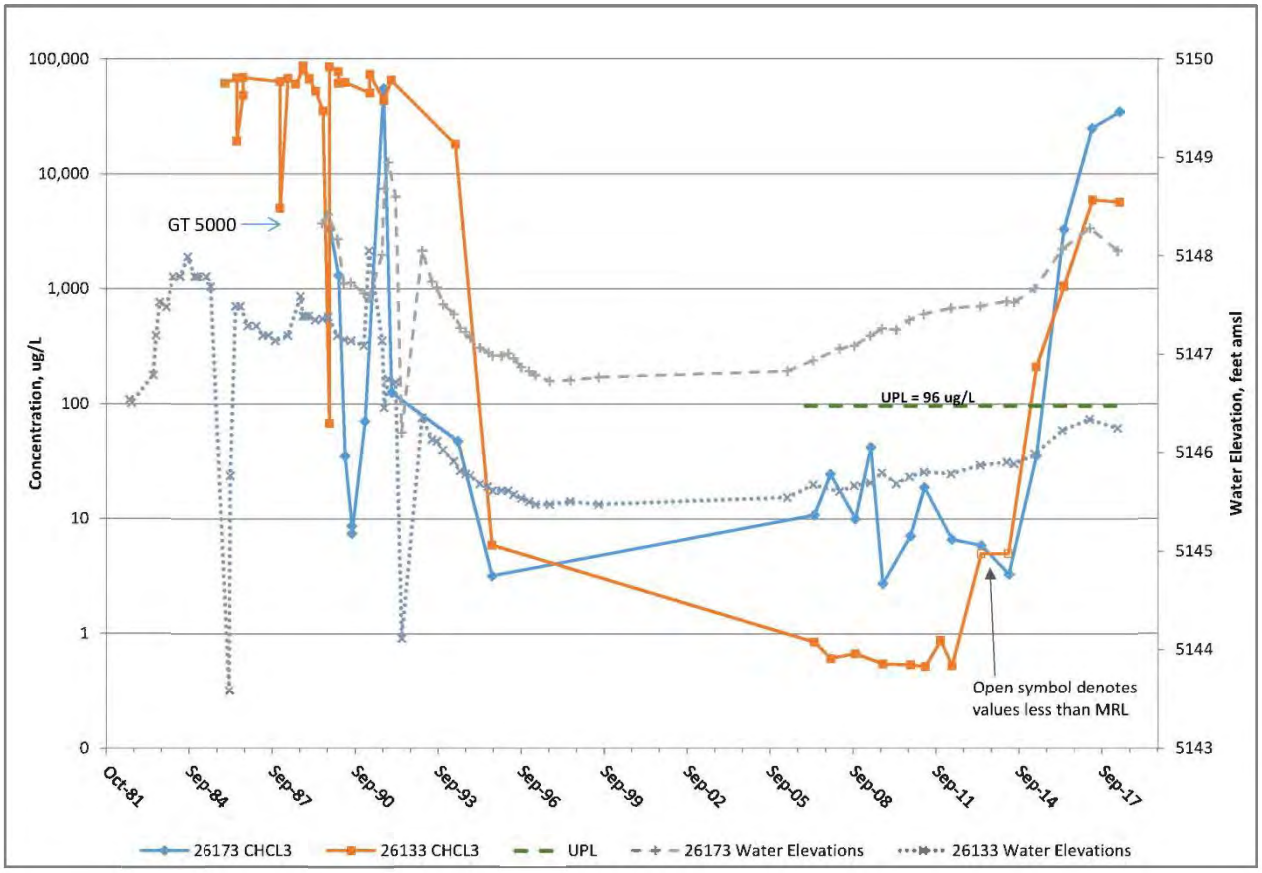
Well	Analyte	2018 Concentration (µg/L)	Prediction Limit (µg/L)
26133	Chloroform	5,640	96
26133	DCPD	419	51.2
26157	DCPD	250	51.2
26163	DCPD	326	51.2
26173	Chloroform	34,400	96
26173	DCPD	291	51.2
26173	TCLEE	1,610	321

Chloroform in Wells 26133 and 26173

The chloroform concentrations in well 26133 increased from LT 5 µg/L in 2014, to 210 µg/L in 2015, to 1,050 µg/L in 2016, and to 5,900 µg/L in 2017. In 2018, the chloroform concentration in well 26133 decreased slightly to 5,640 µg/L. The chloroform concentrations in well 26173 increased from 3.3 µg/L in 2014, to 35.5 µg/L in 2015, to 3,280 µg/L in 2016, to 24,800 µg/L in 2017, and to 34,400 µg/L in 2018. Figure 5.2-1 shows the historical chloroform concentrations and water elevations in wells 26133 and 26173. The water elevations are generally lower in 2018 than in 2017, and appear consistent with site-wide decreasing water levels attributable to high precipitation from late 2013 through mid-2016. Figure 5.2-1 shows that the 2018 chloroform concentrations of 5,640 µg/L in well 26133 and 34,400 µg/L in well 26173 are within the historical ranges for the wells.

Figure 5.2-1

Chloroform Concentrations and Water Elevations in Basin F Principal Threat Downgradient Wells 26133 and 26173



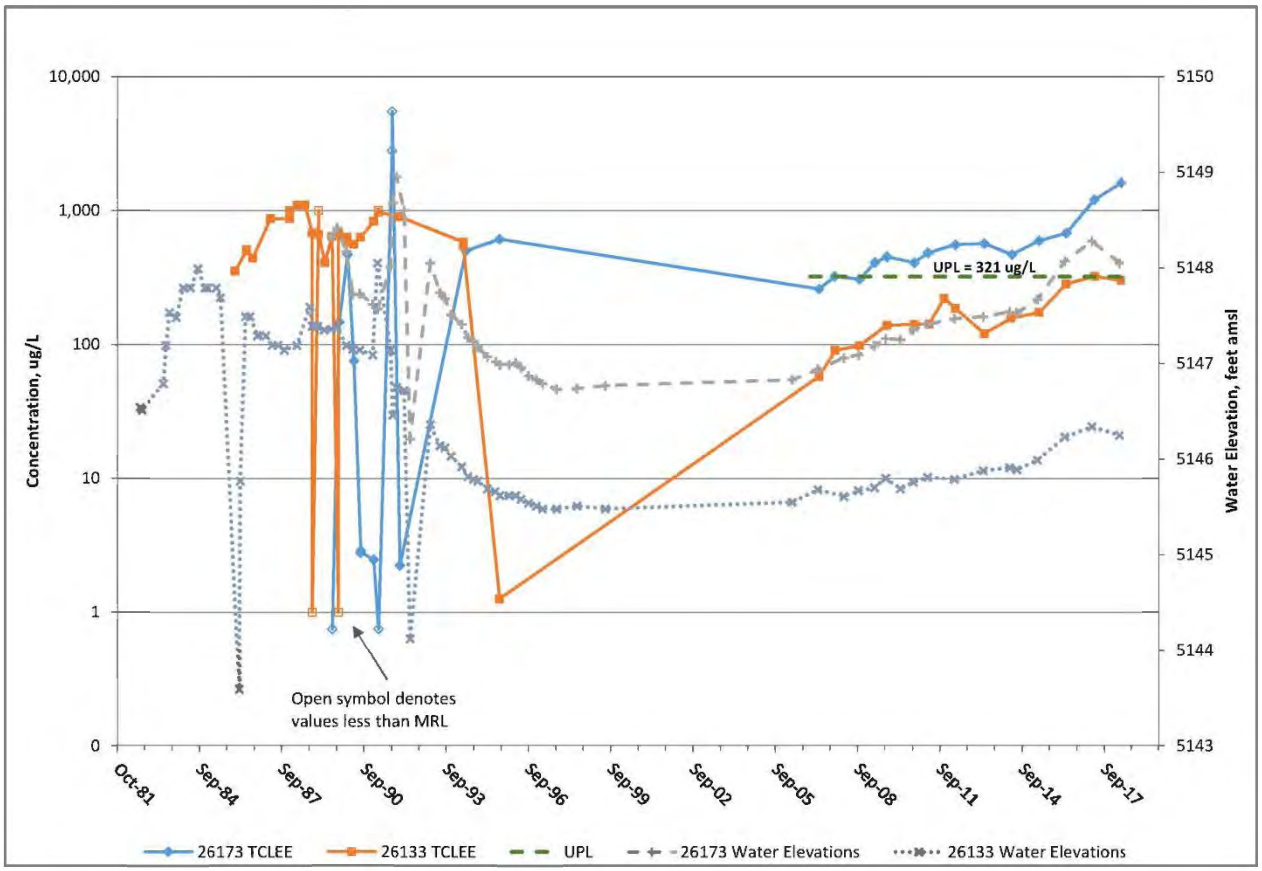
The water elevations in wells 26133 and 26173 were above 5,146 and 5,148 feet above mean sea level, respectively, in 2018, both are similar to corresponding water table elevations in the early 1990s when the chloroform concentrations also were higher. The maximum chloroform concentration of 55,000 µg/L in well 26173 occurred in 1991 when the water elevation was also above 5,148 feet. A similar relationship between the water elevations and chloroform concentrations is observed for well 26133. Although the water levels only rose less than 1 foot from 2015 through 2018, it appears that the 2016/2017 water elevations in wells 26133 and 26173 have exceeded critical elevations where the residual chloroform concentrations are significantly higher in the unsaturated zone near or upgradient of wells, and the higher chloroform concentrations likely were caused by mobilization of this residual contamination. The concentrations since 2016 have exceeded the prediction limit by up to two orders of magnitude; however, the prediction limit evaluation for Basin F does not appear to be meaningful in this scenario where significant pre-existing contamination may be mobilized by relatively small fluctuations in water levels.

Tetrachloroethylene in Well 26173

The 2018 concentrations for TCLEE exceeded the historical range in downgradient PT well 26173. Figure 5.2-2 shows the TCLEE concentrations and water elevations in wells 26133 and 26173. The 2018 TCLEE concentration in well 26173 was 1,610 µg/L and is higher than the historical range in this well (LT 0.75–1,200 µg/L).

Figure 5.2-2

TCLEE Concentrations and Water Elevations in Basin F Principle Threat Downgradient Wells 26133 and 26173



5.2.2 2019 Prediction Limits

Table 5.2-3 (available in the Tables Section) presents the 2019 prediction limits for each of the Basin F PT ICs that will be applied to downgradient wells 26015, 26133, 26157, 26163, and 26173 for the 2019 sampling event. Unless a future statistical evaluation shows otherwise, the calculated 2007 Baseline predication limits are being used in lieu of the maximum background concentration from upgradient wells for arsenic, chloride, dieldrin, and DIMP.

6.0 CONCLUSIONS

Upgradient and downgradient groundwater data collected during post-closure monitoring of WP and PT wells were evaluated to demonstrate post-closure operations and maintenance of the Basin F surface impoundment and that the Basin F WP meets the RCRA closure performance standards. The following conclusions are based on the groundwater monitoring results for the 2018 Basin F post-closure groundwater monitoring:

- In 2018, groundwater elevations decreased in the downgradient wells as well as upgradient wells 26028 and 26173. Groundwater in well 26128 continued to rise in 2018, and appears different from the other wells as it is screened deeper than other wells monitored for Basin F.
- Based on the findings of the PARCC evaluation, the analytical data collected are of acceptable quality for intended uses.
- Impacts to groundwater along the WP flow path appear to have fewer exceedances of PLs in downgradient WP wells in 2018 as compared to previous years. Concentrations for some ICs have increased during post-closure monitoring compared to baseline data for the Basin F WP wells (Table 6.0-1). Concentrations of arsenic, chloride, and DIMP appear to be increasing upgradient of Basin F. Arsenic and chloroform appear to be increasing in downgradient well 26015, while TCLEE appears to be increasing in downgradient well 26017. Sulfate concentrations are increasing in downgradient wells, but remain below the PL.
- Groundwater along the PT flow path appears to have been impacted, with observed increases of select ICs in PT downgradient wells. Select ICs have increased in some upgradient wells. Arsenic, chloroform, TCLEE appear to be increasing upgradient of Basin F during post-closure monitoring compared to baseline data for the Basin F PT wells (Table 6.0-1). Chloroform, DCPD, NNDMEA, and TCLEE appear to be increasing in downgradient wells.
- Based on the distribution of the analyte concentrations and water quality trends, it appears that the groundwater flow path having a greater impact to water quality is to the north-northeast, in the vicinity of downgradient PT wells.

Table 6.0-1 presents a summary of the results for the evaluation of water quality in WP and PT wells in 2018.

Table 6.0-1. Summary of 2018 Post-Closure Groundwater Monitoring

Wastepile Wells	Principle Threat Wells
Arsenic	
• Increasing trend observed in the upgradient well 26028. • Downgradient wells show increasing (26015) or stable (26017) trends. • Concentrations of arsenic were less than the PL in both downgradient wells.	• Not detected in upgradient well 26073 • Upgradient well 26128 shows an increasing trend. • Four wells of five downgradient wells showed a decrease in concentration in 2018, while well 26133 showed an increase in arsenic. • Concentrations of arsenic were less than the PL in all downgradient wells.
Chloroform	
• Not detected in the upgradient well. • Downgradient wells show increasing (26015) or stable (26017) trends. • Concentrations of chloroform exceeded the PL in both downgradient wells.	• Increasing trend observed in upgradient well 26073, while the trend in upgradient well 26128 remained stable. • Increasing (wells 26133 and 26173) and potentially increasing (26015) trends observed downgradient, while decreasing trend observed in well 26157 further downgradient. • Chloroform not detected in downgradient well 26163, and has only been detected once since 2007. • Concentrations of chloroform exceeded the PL in downgradient wells 26133 and 26173.
Chloride	
• Potential increasing trend observed in the upgradient well. • Downgradient wells show decreasing (26015) or stable (26017) trends. • Concentrations of chloride were less than the PL in both downgradient wells.	• Stable trends observed in upgradient wells 26073 and 26128. • Stable or decreasing trends observed in all downgradient wells, with chloride in well 26133 potentially increasing. • Concentrations of chloride were less than the PL in all downgradient wells.

Table 6.0-1. Summary of 2018 Post-Closure Groundwater Monitoring

Wastepile Wells	Principle Threat Wells
CPMSO2	
• Not detected in upgradient or downgradient wells.	• Apparent stable trend noted for CPMSO2 in upgradient well 26128. • Anomalous detection of CPMSO2 above the PL in upgradient well 26073 will be reevaluated in 2019 because it has never been detected in this well. • Not detected in downgradient well 26015. • Stable or decreasing trends observed in wells 26133, 26163, and 26157. • Anomalous nondetection in downgradient well 26173 will be reevaluated in 2019 because it has always been detected in this well, and was detected at a concentration above the PL in 2017.
Copper*	
• Not detected in upgradient well. • Not detected downgradient, and only detected once in well 26015 (2011).	• Copper results for all upgradient and downgradient wells were reported as LT 50 µg/L, with an elevated reporting limit due to dilution. • Downgradient well 26163 is the only well with a history of detections.
DCPD	
• Not detected in upgradient or downgradient wells.	• Not detected in upgradient wells. • Downgradient wells 26133 and 26157 show stable trends, while wells 26163 and 26173 show increasing trends. • DCPD was not detected in downgradient well 26015. • Concentrations of DCPD exceeded the PL in all downgradient wells.
DIMP	
• Increasing trend observed in upgradient well and is likely due to residual upgradient contamination migrating towards Basin F. • Downgradient wells show stable (26015) or decreasing (26017) trends. • Concentrations of DIMP were less than the PL in both downgradient wells.	• Upgradient well 26073 appears to have a stable trend, while well 26128 concentrations have been variable. • Concentrations in downgradient wells appear to be relatively stable over time, with only DIMP in well 26163 exceeding the PL.
Dieldrin	
• Decreasing trend observed in upgradient well. • Downgradient wells show stable trends. • Concentrations of dieldrin were less than the PL in both downgradient wells.	• Concentrations in upgradient wells appear to be relatively stable. • Concentrations in downgradient wells 26015, 26133, 26157, and 26173 follow similar trends; while well 26015 has lower concentrations. • Downgradient well 26163 shows no trend, but concentrations are highly variable, and have increased during the past three years.

Table 6.0-1. Summary of 2018 Post-Closure Groundwater Monitoring

Wastepile Wells	Principle Threat Wells
	• Dieldrin concentrations did not exceed the PL in downgradient wells in 2018.
NNDMEA	
• Variable concentrations in upgradient and downgradient wells since 2006. • Concentrations of NNDMEA were less than the PL in both downgradient wells.	• Concentrations in upgradient wells appear to be relatively stable. • Downgradient wells show stable (26015 and 26163) or decreasing (26157) trends. • Apparent increasing trends in wells 26133 and 26173. • Concentrations of NNDMEA decreased in all wells in 2018. • NNDMEA concentrations did not exceed the PL in downgradient wells in 2018.
Sulfate	
• Increasing trend observed in upgradient well and is likely due to residual upgradient contamination migrating towards Basin F. • Increasing trend observed in both downgradient wells since 2015. • Concentrations of sulfate were less than the PL in both downgradient wells.	• Upgradient and downgradient wells show relatively stable trends in upgradient and downgradient wells over the past five years. Only downgradient well 26015 shows an increase in concentration since 2015. • Sulfate concentrations did not exceed the PL in downgradient wells in 2018.
TCLEE	
• Not detected in upgradient well or downgradient well 26105. • Increasing trend observed in downgradient well 26017. • Concentrations of TCLEE were less than the PL in both downgradient wells.	• Upgradient wells 26073 and 26128 show a potential increasing trend since 2013. • Downgradient wells 26133, 26163, and 26173 show increasing trends, while well 26157 shows a decreasing trend. • TCLEE was not detected in downgradient well 26015. • Only TCLEE in downgradient well 26173 exceeded the PL.

* Copper will be reevaluated in in 2019. Data for 2018 indicate dilution accounts for the elevated reporting limit.

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TABLES

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Table: 2.2-1. Water Level Measurements

Well ID	Date	Depth to Water (feet)	Top of Casing Elevation (feet)	Water Level Elevation (feet)
23135	5/29/2018	42.72	5187.11	5144.39
26006	5/31/2018	27.14	5185.31	5158.17
26015	4/11/2018	45.14	5190.04	5144.9
26016	4/11/2018	41.8	5187.47	5145.67
26017	4/11/2018	41.71	5187.3	5145.59
26018	4/11/2018	46.09	5191.77	5145.68
26020	4/11/2018	38.8	5187.92	5149.12
26023	4/11/2018	44.78	5194.09	5149.31
26028	4/11/2018	39.66	5199.42	5159.76
26040	4/11/2018	49.85	5197.4	5147.55
26047	5/31/2018	43.19	5187.4	5144.21
26048	4/11/2018	21.7	5172.93	-999.99
26049	4/11/2018	25.59	5177.96	5152.37
26051	4/11/2018	53.99	5218.6	5164.61
26057	5/31/2018	28.33	5211.39	5183.06
26058	5/31/2018	23.34	5210.92	5187.58
26061	4/11/2018	30.04	5173.95	5143.91
26063	5/31/2018	26.67	5210.14	5183.47
26064	5/31/2018	36.42	5210.36	5173.94
26071	4/11/2018	42.91	5200.7	5157.79
26073	4/11/2018	47.46	5225.41	5177.95
26081	4/11/2018	27.13	5175.26	5148.13
26083	4/11/2018	24.71	5175.18	5150.47
26094	5/31/2018	31.73	5179.67	5147.94
26096	5/31/2018	18.16	5208.96	5190.8
26097	4/11/2018	54.08	5242.25	5188.17
26099	4/11/2018	47.88	5232.31	5184.43
26128	4/11/2018	39.34	5204.73	5165.39
26133	4/11/2018	43.22	5189.47	5146.25
26146	5/31/2018	32.91	5180.17	5147.26
26147	4/11/2018	43.23	5180.1	5136.87
26150	4/11/2018	47.12	5220.96	5173.84
26152	5/31/2018	43.7	5196.73	5153.03
26153	5/31/2018	51.45	5190.9	5139.45
26154	5/31/2018	26.39	5198.3	5171.91
26157	4/11/2018	43.52	5187.02	5143.5
26158	4/11/2018	33.39	5214.88	5181.49
26159	4/11/2018	28.36	5233.75	5205.39

Table: 2.2-1. Water Level Measurements

Well ID	Date	Depth to Water (feet)	Top of Casing Elevation (feet)	Water Level Elevation (feet)
26160	4/11/2018	46.34	5190.07	5143.73
26163	4/11/2018	43.78	5188.55	5144.77
26164	4/11/2018	44.54	5189.26	5144.72
26170	4/11/2018	43.41	5184.02	5140.61
26173	4/11/2018	52.69	5200.74	5148.05
26175	4/11/2018	47.83	5206.29	5158.46
26176	4/11/2018	47.31	5206.02	-999.99
26177	4/11/2018	54.44	5214.92	5160.48
26178	4/11/2018	34.25	5214.73	-999.99
26179	4/11/2018	53.95	5224.89	5170.94
26180	4/11/2018	46.08	5224.57	5178.49
26181	4/11/2018	48.05	5217.82	5169.77
26182	4/11/2018	40.3	5217.22	5176.92
26183	4/11/2018	46.64	5214.81	5168.17
26184	4/11/2018	42.5	5214.94	-999.99
26185	4/11/2018	55.59	5208.53	5152.94
26186	4/11/2018	41.46	5207.79	5166.33
26307	5/31/2018	29.85	5208.55	-999.99
26500	5/31/2018	19.19	5237.35	5218.16
26501	5/31/2018	19.44	5209.64	5190.2
26502	5/15/2018	17.69	5208.35	5190.66
26502	5/31/2018	17.84	5208.35	5190.51
26503	5/15/2018	18.05	5209.04	5190.99
26503	5/31/2018	18.13	5209.04	5190.91
26504	5/31/2018	18.36	5209.19	5190.83
26505	5/31/2018	18.22	5208.89	5190.67
26506	5/31/2018	17.03	5209.43	5192.4
26507	5/31/2018	16.24	5212.18	5195.94
26508	5/31/2018	29.56	5214.58	5185.02
26509	5/15/2018	17	5208.33	5191.33
26510	5/15/2018	17.7	5208.92	5191.22
26511	5/15/2018	18.59	5209.1	5190.51
26512	5/15/2018	18.53	5209.37	5190.84
27018	5/21/2018	20.98	5169.23	5148.25

Table 2.4-1. Water Quality Monitoring Analyte List

Method and Analyte Names	Test Name
Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry	
1,1,1-Trichloroethane	111TCE
1,1,2-Trichloroethane	112TCE
1,1-Dichloroethane	11DCLE
1,1-Dichloroethene	11DCE
1,2-Dichloroethane	12DCLE
1,3-Dichlorobenzene	13DCLB
Benzene	C6H6
Bicycloheptadiene	BCHPD
Carbon tetrachloride	CCL4
Chlorobenzene	CLC6H5
Chloroform	**CHCL3**
cis-1,2-Dichloroethene	C12DCE
Dibromochloropropane	DBCP
Dicyclopentadiene	**DCPD**
Ethylbenzene	ETC6H5
Methylene chloride	CH2CL2
Methyl isobutyl ketone	MIBK
Tetrachloroethylene	**TCLEE**
Toluene	MEC6H5
trans-1,2-Dichloroethene	T12DCE
Trichloroethylene	TRCLE
Vinyl chloride	C2H3CL
Xylenes	XYLEN
Total Phenols	
Phenols	PHENOL
Organochlorine Pesticides	
4,4'-DDE / 2,2-bis(p-Chlorophenyl)-1,1-dichloroethene	PPDDE
4,4'-DDT / 2,2-bis(p-Chlorophenyl)-1,1,1-trichloroethane	PPDDT
Aldrin	ALDRN
alpha-Chlordane	ACLDAN
Dieldrin	**DLDRN**
Endrin	ENDRN
gamma-Chlordane	GCLDAN
Hexachlorocyclopentadiene	CL6CP
Isodrin	ISODR

Table 2.4-1. Water Quality Monitoring Analyte List

Method and Analyte Names	Test Name
Organosulfur Compounds	
1,4-Oxathiane	OXAT
Benzothiazole	BTZ
Dimethyl disulfide	DMDS
Dithiane	DITH
p-Chlorophenylmethyl sulfide	CPMS
p-Chlorophenylmethyl sulfoxide	CPMSO
p-Chlorophenylmethyl sulfone	**CPMSO2**
Organophosphorus compounds by Gas Chromatography	
Dimethyl methyl phosphonate	DMMP
Diisopropyl methyl phosphonate	**DIMP**
Mercury by Cold Vapor Atomic Absorption	
Mercury	HG
Metals/Cations by Inductively Coupled Argon Plasma	
Aluminum	AL
Arsenic	**AS**
Antimony	SB
Cadmium	CD
Calcium	CA
Chromium	CR
Cobalt	CO
Copper	**CU**
Iron	FE
Lead	PB
Magnesium	MG
Manganese	MN
Nickel	NI
Potassium	K
Selenium	SE
Sodium	NA
Zinc	ZN
Cyanide by Colorimetric	
Cyanide	CYN
Ammonia	
Ammonia	NH3
Alkalinity	

Table 2.4-1. Water Quality Monitoring Analyte List

Method and Analyte Names	Test Name
Alkalinity	ALK
Anions	
Bromide	BR
Chloride	**CL**
Fluoride	F
Nitrate	NO3
Nitrite	NO2
Sulfate	**SO4**
Nitrosamines	
n-Nitrosodimethylamine	**NNDMEA**
Nitrogen-phosphorus Pesticides	
Atrazine	ATZ
Malathion	MLTHN
Parathion	PRTHN
Supona	SUPONA
Vapona	DDVP
Organic Carbon	
Total organic carbon	TOC
Total organic halogen	TOX
Dissolved organic carbon	DOC
Agent Degradation Products by High Performance Liquid Chromatography	
Thiodiglycol	TDGCL
Agent Products by Ion Chromatography	
Isopropylmethyl phosphonic acid	IMPA
Kjeldahl Nitrogen	
Nitrogen by Kjeldahl method	N2KJEL

Note: Indicator compounds are in **Bold**

Table 3.2-2. Summary of Post-Closure Monitoring 2006-2018 for Former Basin F WP Wells

Indicator Compound and Well Location	Well-Specific Monitoring Results
Arsenic	
Upgradient	26028 – Arsenic concentration increased in 2017 and 2018.
Downgradient	26015 – Detected at concentrations less than the PL (10 µg/L) with increases from 2015 to 2017. Concentration decreased slightly in 2018.
	26017 – Detected in 5 of 15 sampling events, and detected in 2018 at a concentration less than the PL and the concentration in upgradient well 26028.
Chloroform	
Upgradient	26028 – Chloroform not detected during post-closure monitoring.
Downgradient	26015 – Detected at varying concentrations through 2015 with an increase in 2016 and 2017 to levels greater than the PL (0.2 µg/L). There was a subsequent decrease in 2018, but the concentration still exceeds the PL.
	26017 – Detected at varying concentrations through 2015 with an increase in 2016 and a subsequent decrease in 2017. Concentrations increased again in 2018. The concentrations in 2016, 2017, and 2018 were greater than the PL.
Chloride	
Upgradient	26028 – Concentrations indicate an increasing trend since 2006.
Downgradient	26015 – Concentrations have generally decreased since 2006 and are less than the PL (5,215,697 µg/L).
	26017 – Concentrations appear to show a slight increasing trend, with an anomalous elevated detection in 2014. Concentrations are less than the PL.
CPMSO2	
Upgradient	26028 – CPMSO2 not detected during post-closure monitoring.
Downgradient	26015 – Not detected during post-closure monitoring.
	26017 – Not detected during post-closure monitoring.
Copper	
Upgradient	26028 – Copper not detected during post-closure monitoring. Data for 2018 indicate dilution accounts for the elevated reporting limit.
Downgradient	26015 – Copper detected once since 2006 and not detected since 2011. Data for 2018 indicate dilution accounts for the elevated reporting limit.
	26017 – Not detected during post-closure monitoring. Data for 2018 indicate dilution accounts for the elevated reporting limit.
DCPD	
Upgradient	26028 – DCPD not detected during post-closure monitoring.
Downgradient	26015 – Not detected during post-closure monitoring.
	26017 – Not detected during post-closure monitoring.
DIMP	
Upgradient	26028 – Historic high concentration in 2016 deceased significantly in 2017 and increased again in 2018. Upgradient concentrations are elevated compared to those in downgradient wells 26015 and 26017. 2018 concentration was greater than the PL (947 µg/L).
Downgradient	26015 – Concentrations have been relatively stable with a slight increase in 2016 and 2017. There was a slight decrease in 2018. Concentrations were not greater

Table 3.2-2. Summary of Post-Closure Monitoring 2006-2018 for Former Basin F WP Wells

Indicator Compound and Well Location	Well-Specific Monitoring Results
	than the PL.
	26017 – Concentrations have varied during post-closure monitoring, thus indicating a general decreasing trend that continued in 2018. Concentrations have not been greater than the PL.
Dieldrin	
Upgradient	26028 – Dieldrin concentrations indicate a general decreasing trend since 2006.
Downgradient	26015 – Concentrations have varied since 2006 and remain less than the PL (1.76 µg/L). Dieldrin was not detected in 2014, but was detected 2015-2018.
	26017 – Concentrations have varied since 2006 showing no apparent trend and remain less than the PL. The concentration of dieldrin slightly increased in 2018.
NNDMEA	
Upgradient	26028 – Concentrations have varied since 2006 and remain less than the PL (0.035 µg/L). While NNDMEA was not detected in 2015, concentrations increased in 2016 and 2017. NNDMEA was not detected in 2018.
Downgradient	26015 and 26017 – Concentrations have varied since 2006 and remain less than the PL. While NNDMEA was not detected in 2015, concentrations increased in 2016 and 2017 with decreases in 2018.
Sulfate	
Upgradient	26028 – Concentrations of sulfate have been consistent through 2016, but have increased since 2017.
Downgradient	26015 – Concentrations have been highly variable since 2006, and greater than the PL (651,521 µg/L) 2008-2010. From 2010 through 2015, the concentrations of sulfate decreased and show an increasing trend since 2015.
	26017 – Concentrations have varied since 2006 and remain less than the PL. The concentrations show an increasing trend since 2015.
TCLEE	
Upgradient	26028 – TCLEE not detected during post-closure monitoring.
Downgradient	26015 – Not detected during post-closure monitoring.
	26017 – TCLEE was only detected in 2010, 2017 and 2018. Concentrations have increased since 2016, but are less than the PL.

Table 3.2-3. Summary of Post-Closure Monitoring 2007-2018 for Former Basin F PT Wells

Indicator Compound and Well Location	Well-Specific Monitoring Results
Arsenic	
Upgradient	26073 – Arsenic not detected in 11 of 13 sampling events.
	26128 – Detected at varying concentrations below the PL (4.52 µg/L) with an increase in 2017 and 2018.
Downgradient	26015 – Detected at concentrations less than the PL with increases from 2015 to 2017. Concentration decreased slightly in 2018.
	26133 – Detected at varying concentrations below the PL and increasing since 2016.
	26157 – Detected at varying concentrations below the PL with a decrease in 2018.
	26163 – Detected at varying concentrations below the PL with an increase in 2017 to a concentration greater than the PL in 2017. 2018 concentration decreased to below the PL.
	26173 – Detected at varying concentrations below the PL with a decrease in 2018.
Chloroform	
Upgradient	26073 – Chloroform concentrations indicate an increasing trend since 2014 with concentrations greater than the PL (56 µg/L) in 2017. The PL was increased to 96 µg/L for 2018, and the 2018 chloroform concentration was below the new PL.
	26128 – Concentrations appear to be consistent since 2007 with little variability.
Downgradient	26015 – Detected at varying concentrations through 2015 with an increase in 2016 and 2017 to levels less than the PL (96 µg/L). There was a subsequent decrease in 2018.
	26133 – Concentrations indicate an increasing trend since 2012 with concentrations greater than the PL since 2015.
	26157 – Concentrations indicate a decreasing trend since 2009.
	26163 – Chloroform detected for the first time during post-closure monitoring in 2017; however, it was not detected in 2018.
	26173 – Concentrations indicate an increasing trend since 2014 with concentrations greater than the PL since 2016.
Chloride	
Upgradient	26073 – Chloride concentrations appear to have low variability during post-closure monitoring.
	26128 – Concentrations appear to have low variability during post-closure monitoring.
Downgradient	26015 – Concentrations have generally decreased since 2007 and are less than the PL (6,154,163 µg/L). Concentrations have been below the PL.
	26133 – Concentrations appear to have low variability during post-closure monitoring, and indicate a potential increasing trend since 2013. Concentrations have been below the PL.
	26157 – Concentrations appear to have low variability during post-closure monitoring and indicate a potential decreasing trend since 2014. Concentrations have been below the PL.
	26163 – Concentrations indicate a potential decreasing trend since 2014.

Table 3.2-3. Summary of Post-Closure Monitoring 2007-2018 for Former Basin F PT Wells

Indicator Compound and Well Location	Well-Specific Monitoring Results
	Concentrations have been below the PL.
	26173 – Concentrations appear to have low variability during post-closure monitoring.
CPMSO2	
Upgradient	26073 – CPMSO2 was detected during post-closure monitoring for the first time in 2018. There is a potential that sample results for wells 26073 and 26173 as reported by the lab were potentially switched based on review of post-closure data, considering that CPMSO2 has not been detected in this upgradient well.
	26128 – Concentrations have been variable since 2010 with a decrease to below the MRL in 2017 and 2018.
Downgradient	26015 – Not detected during post-closure monitoring.
	26133 – Concentrations have increased since 2013. The concentration of CPMSO2 decreased to a level below the PL (45.7 µg/L) in 2017 with a slight increase in 2018.
	26157 – Concentrations have decreased since 2013. The concentrations of CPMSO2 in 2017 and 2018 were less than the PL.
	26163 – Concentrations have generally increased since 2013. The concentration of CPMSO2 was greater than the PL in 2016, but decreased to levels below the PL in 2017 and 2018.
	26173 – Concentrations have increased since 2011. In 2017, the concentration of CPMSO2 increased to a level greater than the PL. In 2018, CPMSO2 was not detected. There is a potential that sample results for wells 26073 and 26173 as reported by the lab were potentially switched based on review of post-closure data, considering that CPMSO2 has been detected in this upgradient well since 2012 and exceeded the PL (45.7 µg/L) in 2017.
Copper	
Upgradient	26073 – Copper has not been detected during post-closure monitoring.
	26128 – Not detected during post-closure monitoring.
Downgradient	26015 – Copper detected once since 2006 and not detected since 2011. Data for 2018 indicate dilution accounts for the elevated reporting limit.
	26133 – Not detected during post-closure monitoring.
	26157 – Not detected during post-closure monitoring.
	26163 – Concentrations increased to a level greater than the PL (21 µg/L) in 2014 followed by a decrease in 2015. Since 2015, concentrations have increased with a level in 2017 greater than the PL (21 µg/L). In 2018, copper was reported as nondetect at LT 50 µg/L. Data for 2018 indicate dilution accounts for the elevated reporting limit.
	26173 – Not detected during post-closure monitoring.
DCPD	
Upgradient	26073 – DCPD not detected during post-closure monitoring.
	26128 – Not detected during post-closure monitoring.
Downgradient	26015 – Not detected during post-closure monitoring.

Table 3.2-3. Summary of Post-Closure Monitoring 2007-2018 for Former Basin F PT Wells

Indicator Compound and Well Location	Well-Specific Monitoring Results
	26133 – During post-closure monitoring, concentrations appear to have low variability at levels consistently greater than the PL (51.2 µg/L).
	26157 – During post-closure monitoring, concentrations appear to have low variability at levels consistently greater than the PL.
	26163 – Concentrations have been variable indicating a general increasing trend. In 2018 the concentration of DCPD was greater than the PL.
	26173 – Concentrations indicate a general increasing trend that continued in 2018.
DIMP	
Upgradient	26073 – General increasing trend observed through 2010, with low variability through 2018.
	26128 – Concentrations indicate a decreasing trend through 2015, with an increase in 2017 and a subsequent decrease in 2018.
Downgradient	26015 – Concentrations have been relatively stable with a slight increase in 2015 and remaining relatively stable. There was a slight decrease in 2018. Concentrations were not greater than the PL.
	26133 – General increasing trend observed through 2018.
	26157 – Concentrations indicate a general decreasing trend during post-closure monitoring, with a high concentration in 2011 and further decreasing 2012 through 2018.
	26163 – Concentrations exhibit low variability through 2018. An increase was observed in 2017 with the concentration greater than the PL (762.8 µg/L). In 2018, the concentration was less than the PL.
	26173 – General increasing trend observed through 2016, with an order-of-magnitude decrease in 2017. Concentration in 2018 continued the observed increasing trend.
Dieldrin	
Upgradient	26073 – Dieldrin detected at variable concentrations during post-closure monitoring with a notable decease in 2013 and a subsequent increase through 2016. The concentration decreased in 2017 and remained at a similar concentration in 2018.
	26128 – General decreasing trend since 2007, with consistent and stable levels since 2012.
Downgradient	26015 – Concentrations have varied since 2007 and remain less than the PL (2.82 µg/L). Dieldrin was not detected in 2014, but was detected 2015-2018.
	26133 – Concentrations appear to show no apparent trend and are less than the PL. The concentration increased in 2018.
	26157 – General decreasing through 2015. The levels of dieldrin increased in 2016, but decreased in 2017 and 2018.
	26163 – Intermittent detections of dieldrin since 2010 showing no apparent trend. The concentrations have increased since 2015.
	26173 – Concentrations have been variable during post-closure monitoring indicating no apparent trend with a decrease 2018 to a level less than the PL.

Table 3.2-3. Summary of Post-Closure Monitoring 2007-2018 for Former Basin F PT Wells

Indicator Compound and Well Location	Well-Specific Monitoring Results
NNDMEA	
Upgradient	26073 – NNDMEA detected in 2011, 2013 and 2017 sampling events. All concentrations were less than the PL (1.24 µg/L).
	26128 – Concentrations appear to show no apparent trend and are less than the PL. The concentration decreased in 2018.
Downgradient	26015 – Concentrations have varied since 2007 and remain less than the PL. While NNDMEA was not detected in 2015, concentrations increased in 2016 and 2017. There was a subsequent decrease in in 2018.
	26133 – Concentrations appear to show no apparent trend through 2014. Concentrations increased from 2015-2017, with a subsequent decrease in 2018.
	26157 – General decreasing trend since 2010, with consistent and stable levels 2013-2016. In 2017 and 2018 the concentration decreased.
	26163 – A decreasing trend was apparent through 2014, with a gradual increase through 2017. In 2018, the NNDMEA concentration was less than the PL.
	26173 – Concentrations indicate an increasing trend 2012-2017. There was a slight decrease in 2018. Concentrations were below the PL.
Sulfate	
Upgradient	26073 and 26128 – Concentrations indicate a relatively stable trend over the past five years.
Downgradient	26015 – Concentrations have been variable since 2010 and no greater than the PL (2,610,000 µg/L). From 2010 through 2015, the concentrations of sulfate have decreased with an increase evident since 2015.
	26133 and 26173 – Concentrations indicate a relatively stable trend over the past five years, with all concentrations less than the PL.
	26157 and 26163 – Concentrations indicate a relatively stable trend over the past five years, with all concentrations less than the PL.
TCLEE	
Upgradient	26073 and 26128 – Concentrations of TCLEE appear to show a general increase 2013-2018.
Downgradient	26015 – Not detected during post-closure monitoring.
	26133 – Concentrations indicate a general increasing trend 2013-2017. In 2017, the concentration approximated the PL, and declined to below the PL in 2018.
	26157 – Concentrations of TCLEE appear to show no apparent trend through 2015, with a decrease from 2016 - 2018. All concentrations are less than the PL.
	26163 – Concentrations indicate a general decreasing trend 2010-2012, with an increase in 2013. Since 2014 there has been a potential increasing trend, with all concentrations less than the PL.
	26173 – During post-closure monitoring, concentrations appear to indicate a general increasing trend at levels consistently greater than the PL.

Table 5.1-1. 2018 Prediction Limits for the Basin F WP Wells

Indicator Compound	Method Reporting Limit (µg/L)	Proportion of Upgradient Non-detected Sample Values (2006-2017)	Statistical Method Used	Selected Prediction Limit (µg/L)
Volatile Organic Compounds				
Chloroform	0.2	100	Non-parametric	0.2[2]
DCPD	0.2	100	Non-parametric	0.26[3]
TCLEE	0.283 (2006)	100	Non-parametric	0.283[2]
Organochlorine Pesticides				
Dieldrin	0.00361	21	Non-parametric	1.76[1]
Organophosphorus Compounds				
DIMP	0.5	0	Parametric	947
Organosulfur Compounds				
CPMSO2	1.6 (2006)	100	Non-parametric	2.08[3]
Nitrosamines				
NNDMEA	0.003	35	Non-parametric	0.035
Metals				
Arsenic	1	79	Non-parametric	10
Copper	10	100	Non-parametric	10
Anions				
Chloride	1000	0	Parametric	5,215,697[1]
Sulfate	2500	0	Parametric	651,521[1]

[1] The calculated PL for 2006 is being used in lieu of the highest background concentration from upgradient wells.

[2] Because this compound has not been detected in an upgradient well, the prediction limit value for this analyte is the baseline MRL.

[3] This compound has not been detected at all; therefore, the prediction limit value for this analyte is the 99 percent upper confidence limit (UCL) of the baseline MRL. The 99 percent of the UCL is defined as 1.3 times the baseline MRL.

Table 5.1-3. 2019 Prediction Limits for the Basin F WP Wells

Indicator Compound	Method Reporting Limit (µg/L)	Proportion of Upgradient Non-detected Sample Values (2006-2018)	Statistical Method Used	Selected Prediction Limit (µg/L)
Volatile Organic Compounds				
Chloroform	0.2	100	Non-parametric	0.2[2]
DCPD	0.2	100	Non-parametric	0.26[3]
TCLEE	0.283 (2006)	100	Non-parametric	0.283[2]
Organochlorine Pesticides				
Dieldrin	0.002630[4]	20	Non-parametric	1.76[1]
Organophosphorus Compounds				
DIMP	0.5	0	Parametric	1178
Organosulfur Compounds				
CPMSO2	1.6 (2006)	100	Non-parametric	2.08[3]
Nitrosamines				
NNDMEA	0.003	40	Non-parametric	0.035
Metals				
Arsenic	1	73	Non-parametric	10
Copper	10	100	Non-parametric	10
Anions				
Chloride	1000	0	Parametric	5,215,697[1]
Sulfate	2500	0	Parametric	651,521[1]

[1] The calculated PL for 2006 is being used in lieu of the highest background concentration from upgradient wells.

[2] Because this compound has not been detected in an upgradient well, the prediction limit value for this analyte is the baseline MRL.

[3] This compound has not been detected at all; therefore, the prediction limit value for this analyte is the 99 percent upper confidence limit (UCL) of the baseline MRL. The 99 percent of the UCL is defined as 1.3 times the baseline MRL.

[4] The reporting limits have changed as a result of an MRL study required by the SQAPP for method recertification every three years.

Table 5.2-1. 2018 Prediction Limits for the Basin F PT Wells

Indicator Compound	Current Method Reporting Limit (µg/L)	Proportion of Upgradient Non-detected Sample Values (2007-2017)	Statistical Method Used	Selected Prediction Limit (µg/L)
Volatile Organic Compounds				
Chloroform	0.2	0	Non-parametric	96
DCPD	0.2	100	Non-parametric	51.2[2]
TCLEE	0.283	0	Parametric[3]	321[2]
Organochlorine Pesticides				
Dieldrin	0.00361	4	Parametric[3]	2.82[1]
Organophosphorus Compounds				
DIMP	0.5	0	Non-parametric	762.8[1]
Organosulfur Compounds				
CPMSO2	1.2	72	Non-parametric	45.7[2]
Nitrosamines				
NNDMEA	0.00115	40	Non-parametric	1.24[2]
Metals				
Arsenic	1	48	Non-parametric	4.52[1]
Copper	10	100	Non-parametric	21[2]
Anions				
Chloride	1,000	0	Non-parametric	6,154,163[1]
Sulfate	2,500	0	Parametric	2,610,000

[1] The calculated PL from 2007 is being used in lieu of the highest background concentration from upgradient wells.

[2] Prediction limit is based on background detection from downgradient well.

[3] Data are parametric after transformation to a natural log.

Table 5.2-3. 2019 Prediction Limits for the Basin F PT Wells

Indicator Compound	Current Method Reporting Limit (µg/L)	Proportion of Upgradient Non-detected Sample Values (2007-2018)	Statistical Method Used	Selected Prediction Limit (µg/L)
Volatile Organic Compounds				
Chloroform	0.2	0	Non-parametric	96
DCPD	0.2	100	Non-parametric	51.2[2]
TCLEE	0.283	0	Non-parametric	321[2]
Organochlorine Pesticides				
Dieldrin	0.00263[4]	4	Parametric[3]	2.82[1]
Organophosphorus Compounds				
DIMP	0.5	0	Non-parametric	762.8[1]
Organosulfur Compounds				
CPMSO2	1.2	70	Non-parametric	111
Nitrosamines				
NNDMEA	0.00115	41	Non-parametric	1.24[2]
Metals				
Arsenic	1	48	Non-parametric	4.52[1]
Copper	10	100	Non-parametric	21[2]
Anions				
Chloride	1,000	0	Non-parametric	6,154,163[1]
Sulfate	2,500	0	Parametric	2,610,000

[1] The calculated PL from 2007 is being used in lieu of the highest background concentration from upgradient wells.

[2] Prediction limit is based on background detection from downgradient well.

[3] Data are parametric after transformation to a natural log.

[4]The reporting limits have changed as a result of an MRL study required by the SQAPP for method recertification every three years.

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FIGURES

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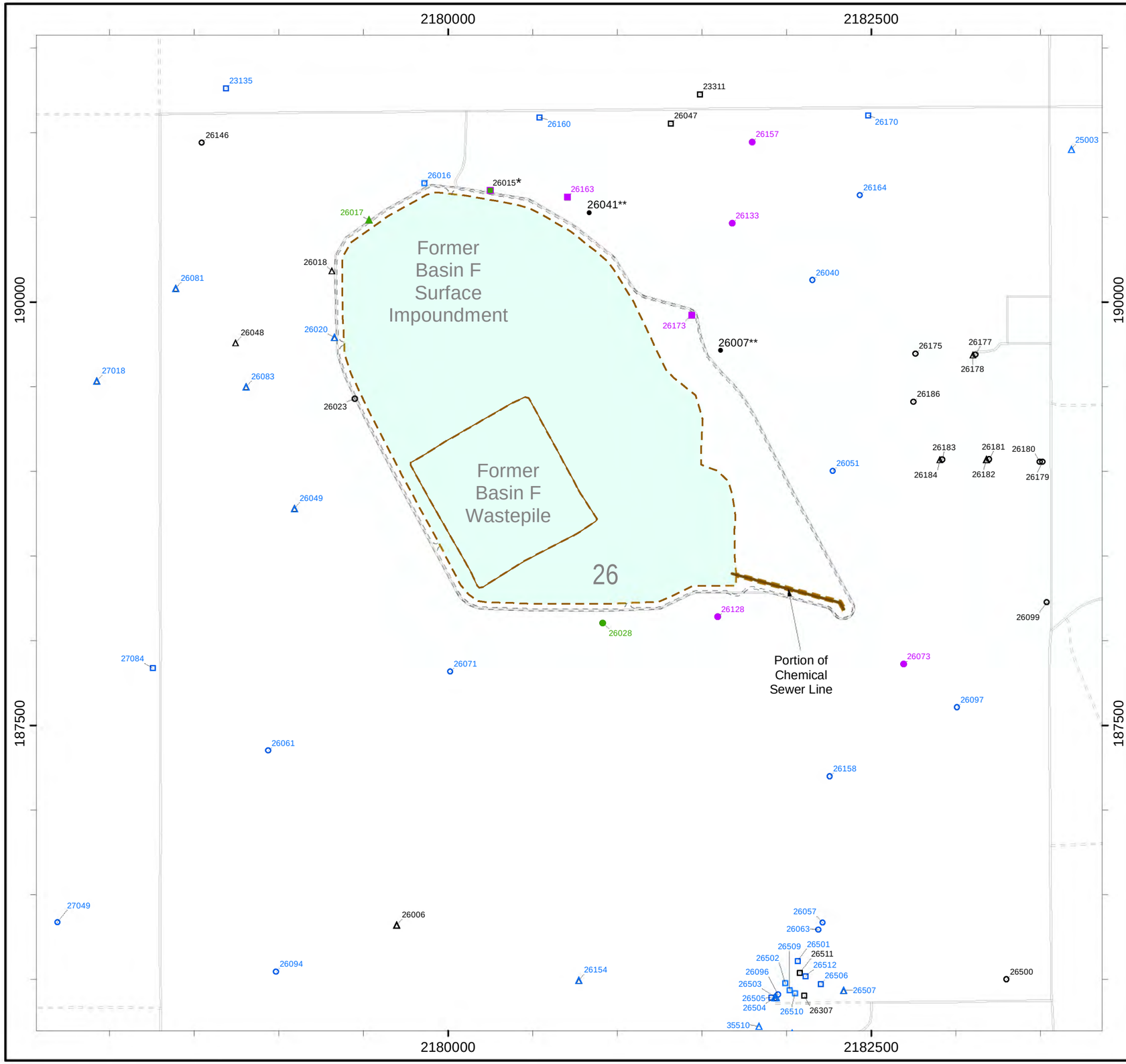

Former Basin F Well Location Map

Former Basin F Surface Impoundment

Paved Roads

Unpaved Roads

* Well 26015 is used in both Wastepile Water Quality and Principal Threat Water Quality Networks.

** Abandoned Wells 26007 and 26041 are shown for historical reference.

Monitoring Well/ Piezometer Network	Flow System / Aquifer				
	Unconfined Alluvial	Unconfined Alluvial/ Denver	Unconfined Denver	Confined Denver	Questionable
Water Level Network	△	□	○		
Other Network Wells	△	□	○	▽	◊
Basin F Wastepile Water Quality Network	▲	■	●		
Basin F Principal Threat Water Quality Network		■	●		

N

0 230 460 920 Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army, RVO GIS, PMC, OMC, Shell/URS Corp.

Figure 2.2-1

Army/Shell GIS

11/26/2018 RMITS

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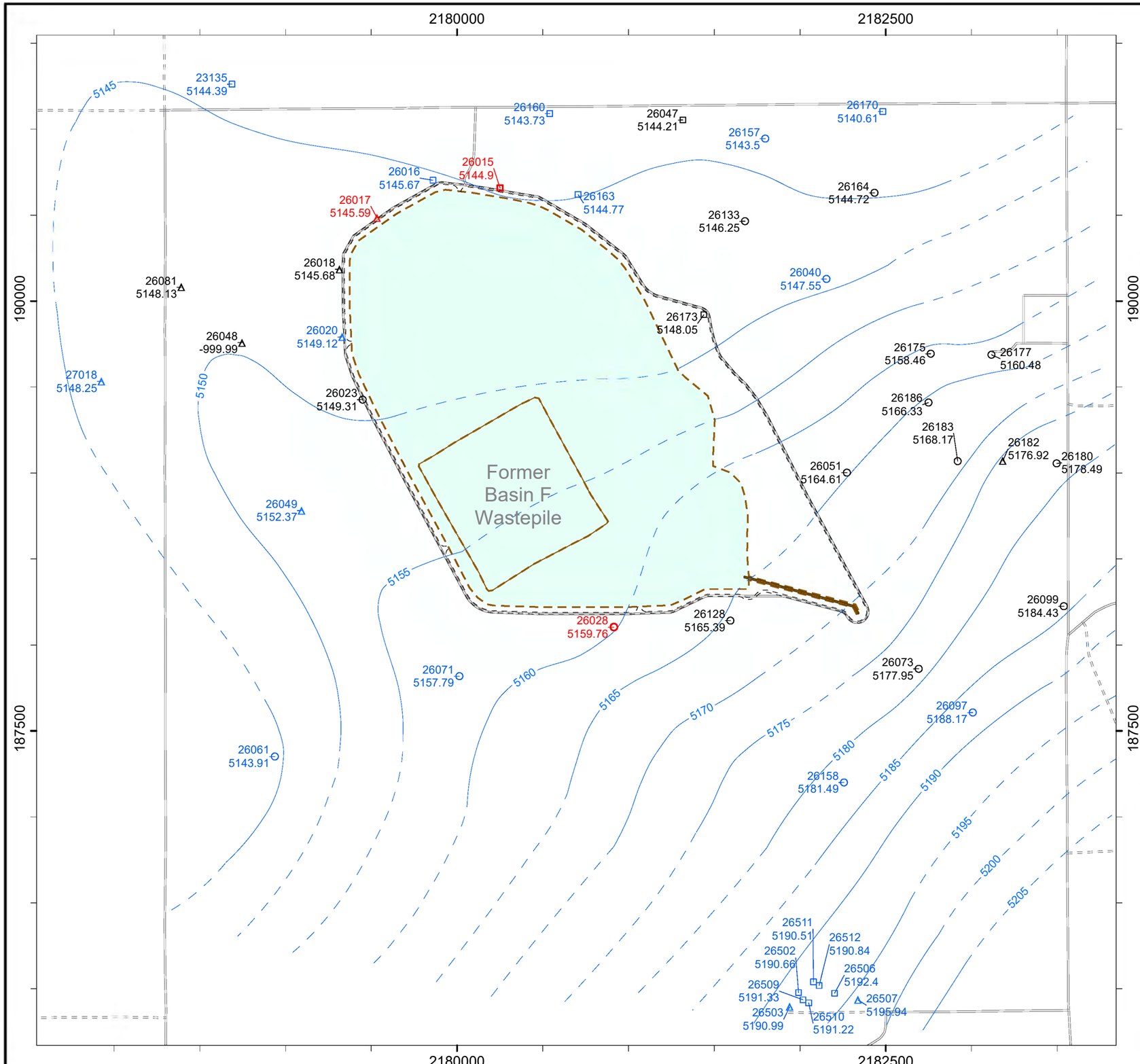

Former Basin F
2018 Water Table Elevation Map of the Unconfined Flow System

Water Elevation Contour - April 2018

Approximate Water Elevation Contour

Former Basin F Surface Impoundment

Paved Roads

Unpaved Roads

26051 5161.20 Well ID and Groundwater Elevation - April and May 2018

Monitoring Well/ Piezometer Network	FLOW SYSTEM/AQUIFER		
	Unconfined Alluvial	Unconfined Alluvial/ Denver	Unconfined Denver
Water Level Network	△	□	○
Basin F Wastepile Water Quality Network	△	□	○
Other Network Wells	△	□	○

N

0 125 250 500 750 1,000
Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army, RMA GIS, PMC, OMC, Shell/URS Corp.

Figure 2.2-2

Army/Shell GIS

11/26/2018 RMITS

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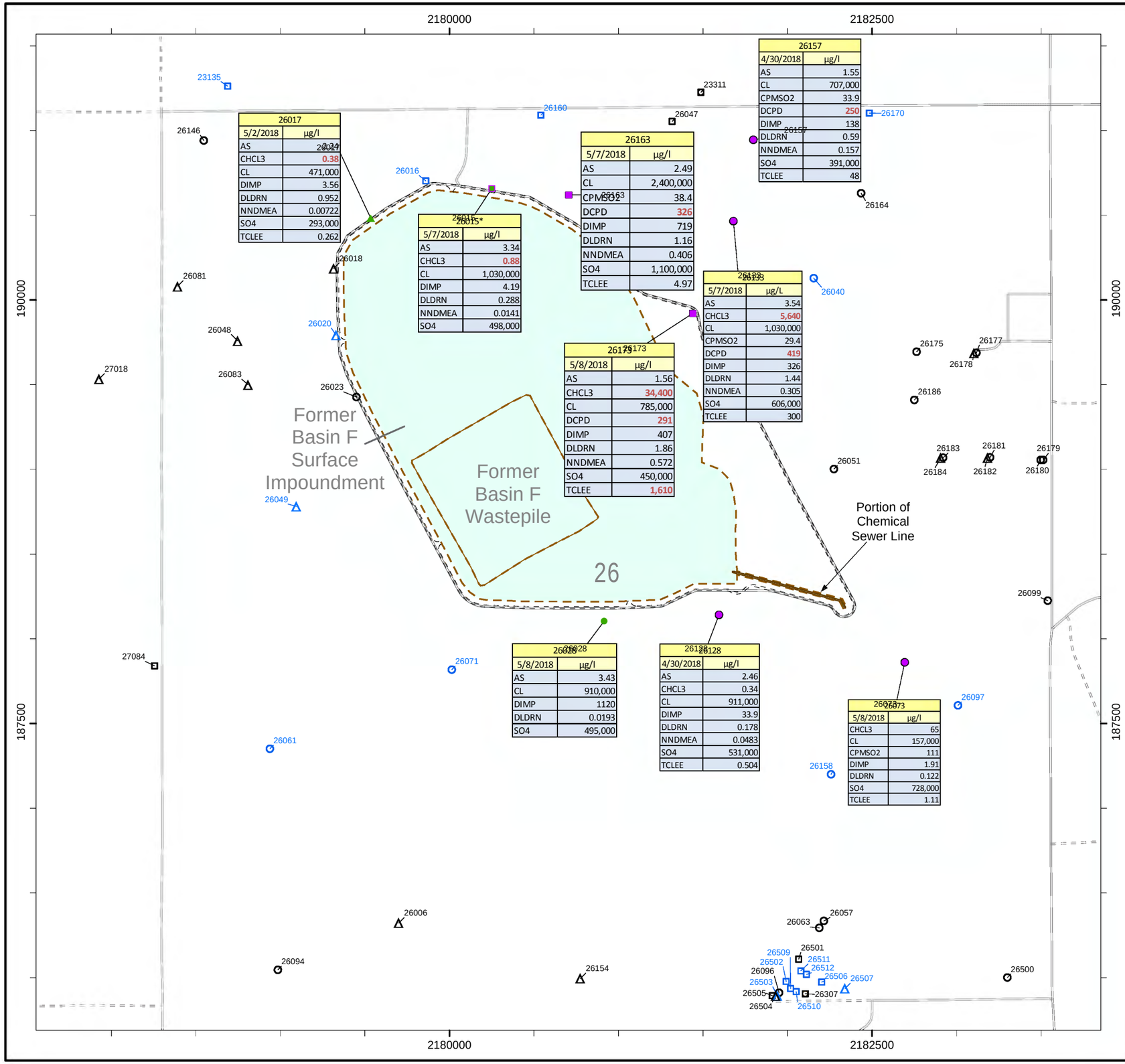

Former Basin F Well Network Indicator Compounds Detection Map 2018

Former Basin F Surface Impoundment

Paved Roads

Unpaved Roads

Extraction Well

* Well 26015 is used in both Wastepile Water Quality and Principal Threat Water Quality Networks.

Note - Bolded analytical results from downgradient wells exceeded the upper prediction limits.

Monitoring Well/ Piezometer Network	Flow System / Aquifer: Unconfined Alluvial	Unconfined Alluvial/ Denver	Unconfined Denver	Confined Denver	Questionable
Water Level Network	△	□	○		
Other Network Wells	△	□	○		
Basin F Wastepile Water Quality Network	▲	■	●		
Basin F Principal Threat Water Quality Network		■	●		

N

0 230 460 920 Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army, RVO GIS, PMC, OMC, Shell/URS Corp.

Figure 2.4-1

Army/Shell GIS

11/26/2018 RMITS

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ATTACHMENTS

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ATTACHMENT A

Hydrographs for Basin F Network Wells

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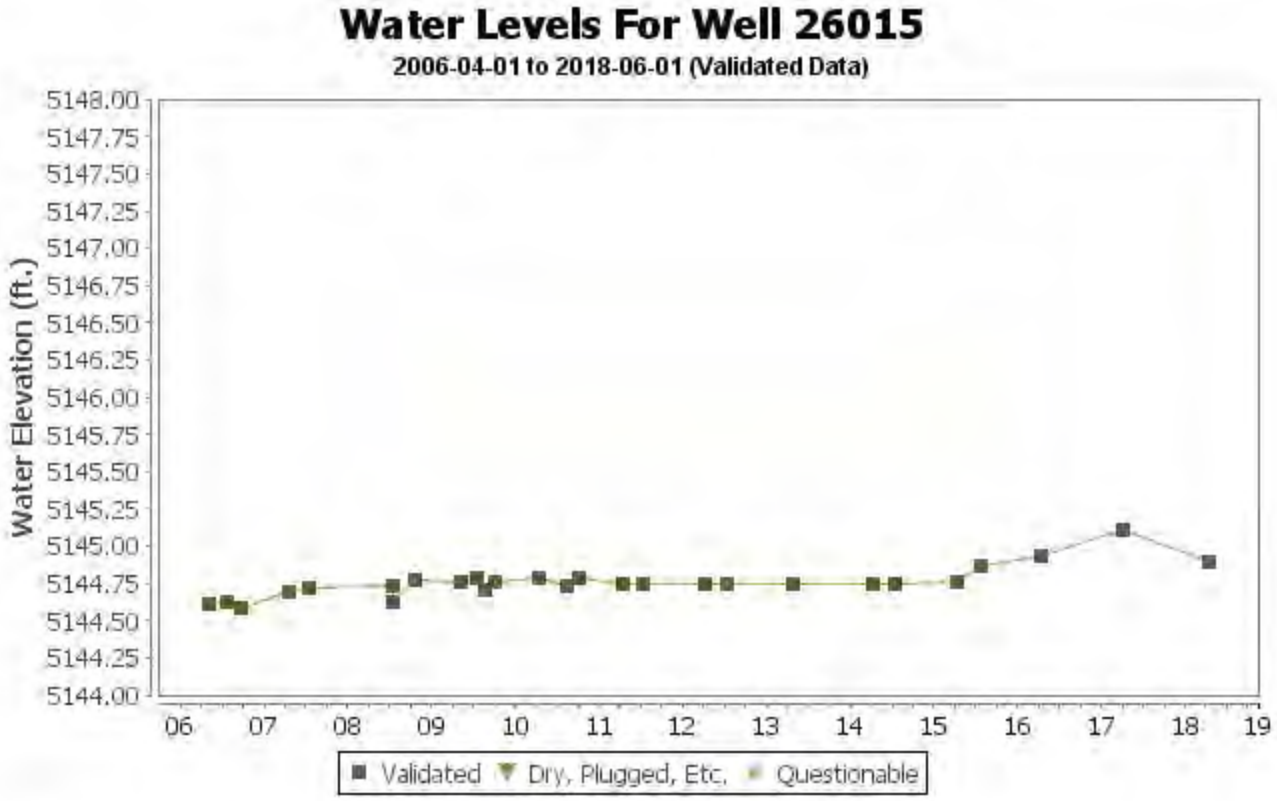
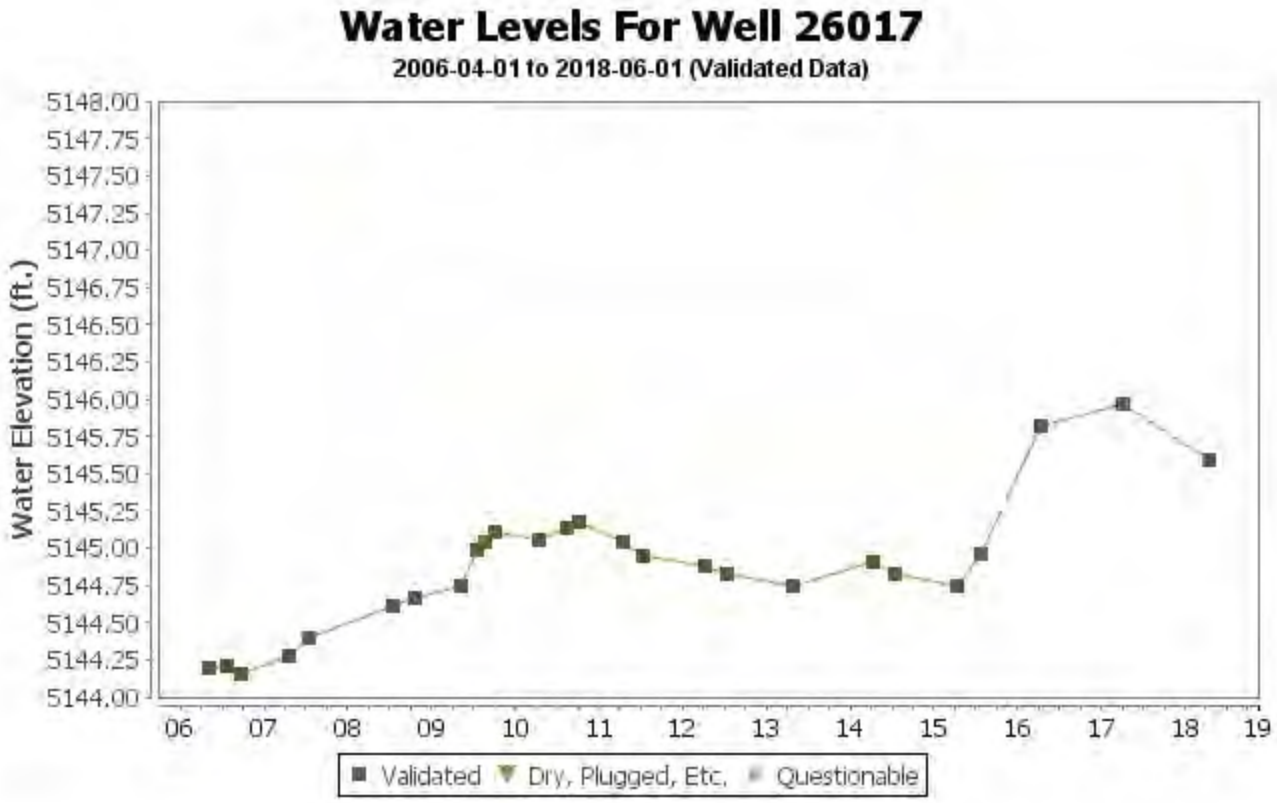
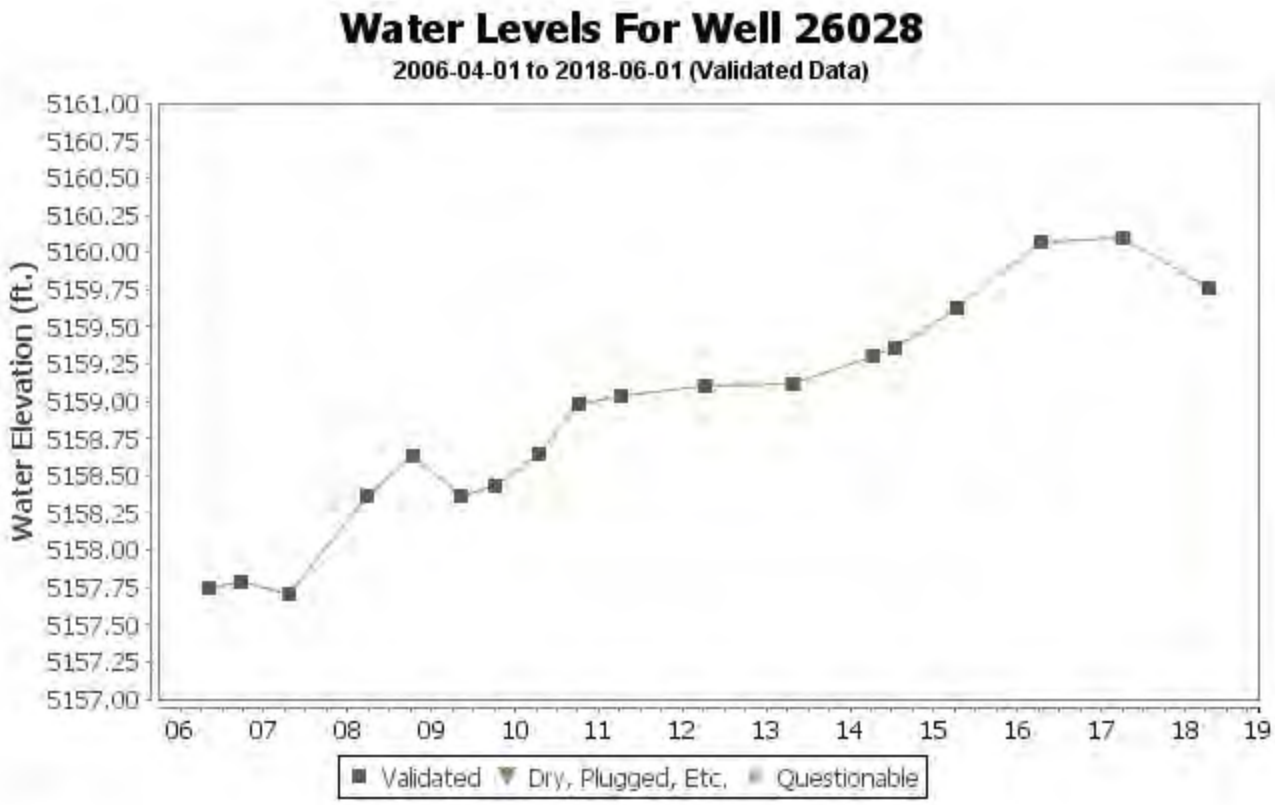
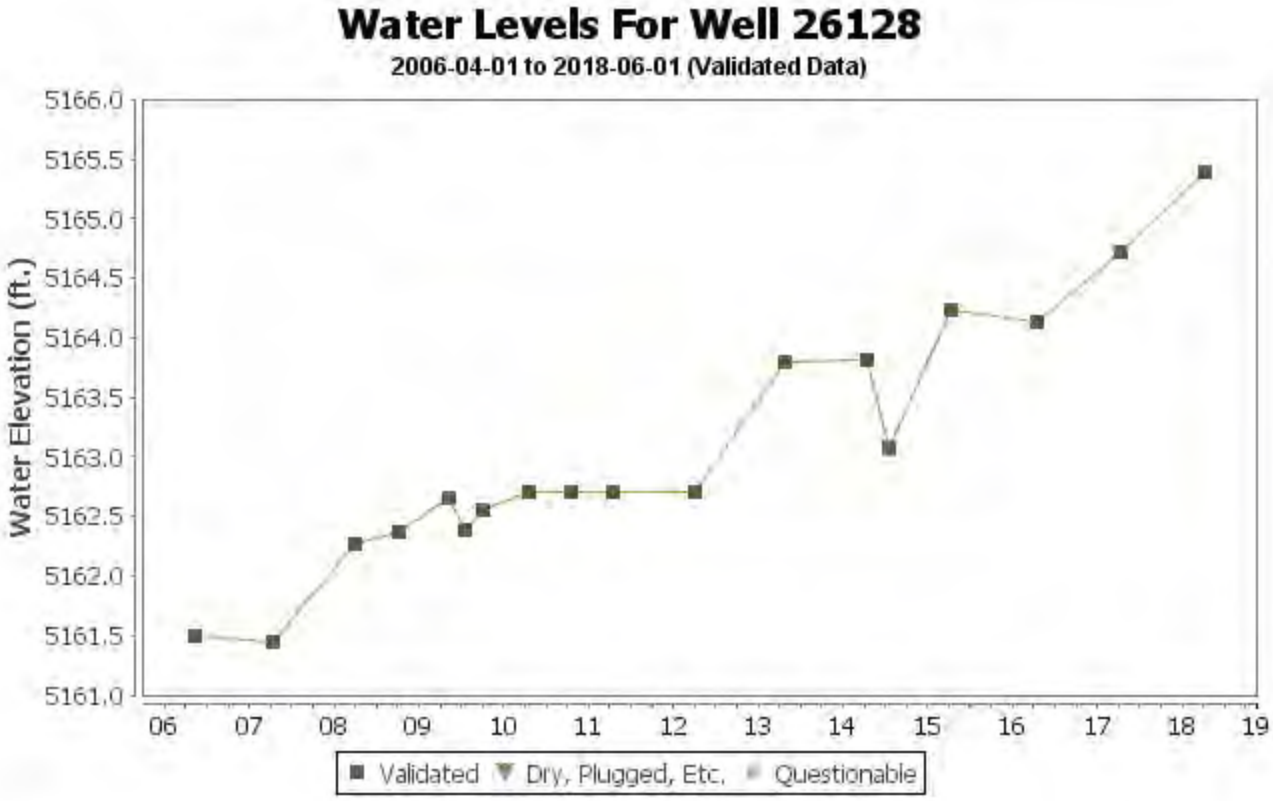
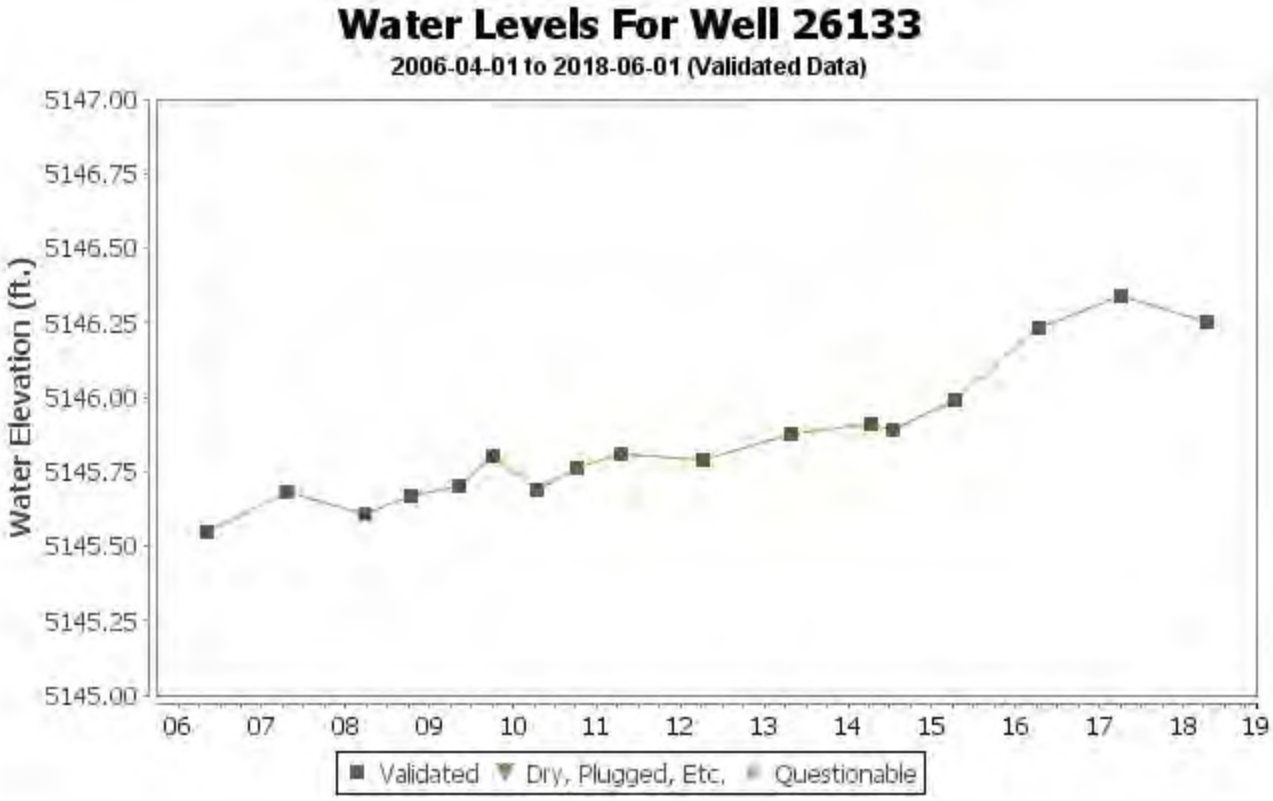

Water Levels For Well 26015
2006-04-01 to 2018-06-01 (Validated Data)
Water Elevation (ft.)
5148.00
5147.75
5147.50
5147.25
5147.00
5146.75
5146.50
5146.25
5146.00
5145.75
5145.50
5145.25
5145.00
5144.75
5144.50
5144.25
5144.00
06
07
08
09
10
11
12
13
14
15
16
17
18
19
Validated
Dry, Plugged, Etc.
Questionable

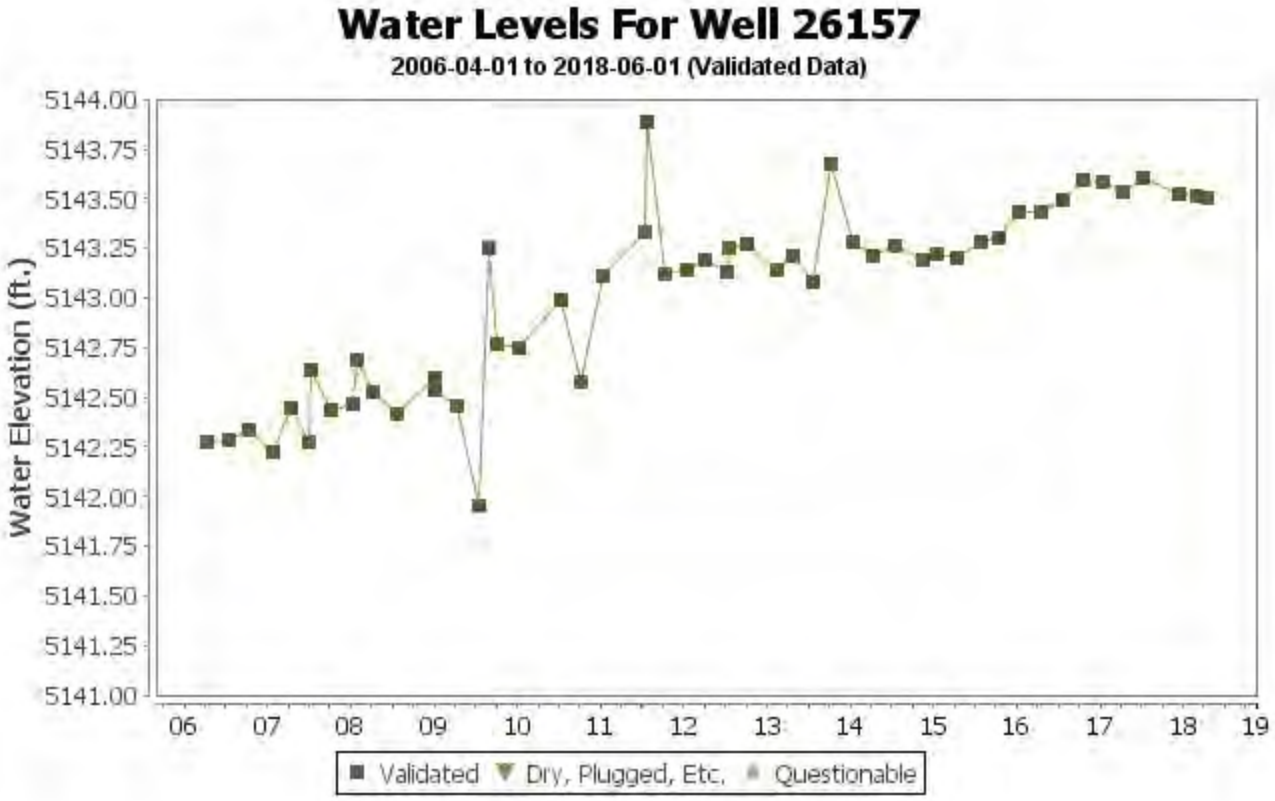

Water Levels For Well 26017
2006-04-01 to 2018-06-01 (Validated Data)
Water Elevation (ft.)
5148.00
5147.75
5147.50
5147.25
5147.00
5146.75
5146.50
5146.25
5146.00
5145.75
5145.50
5145.25
5145.00
5144.75
5144.50
5144.25
5144.00
06
07
08
09
10
11
12
13
14
15
16
17
18
19
Validated
Dry, Plugged, Etc.
Questionable

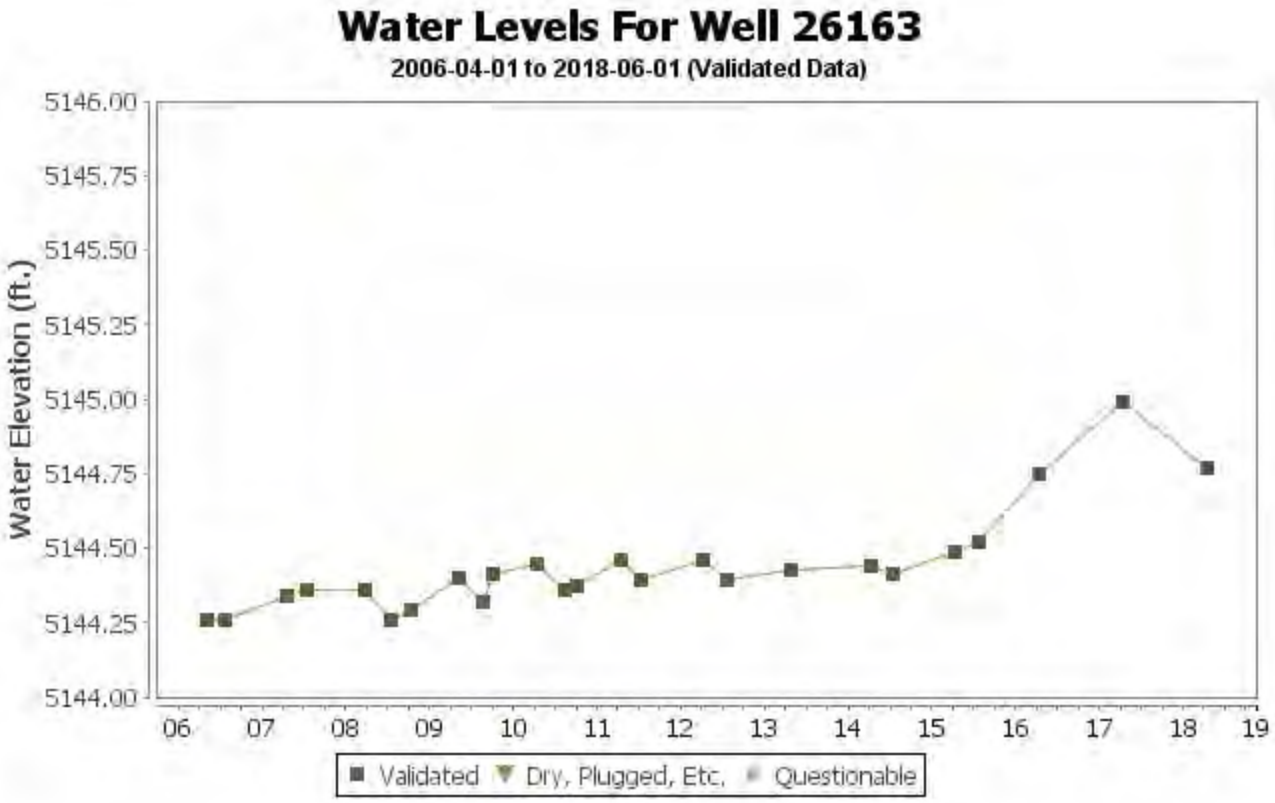


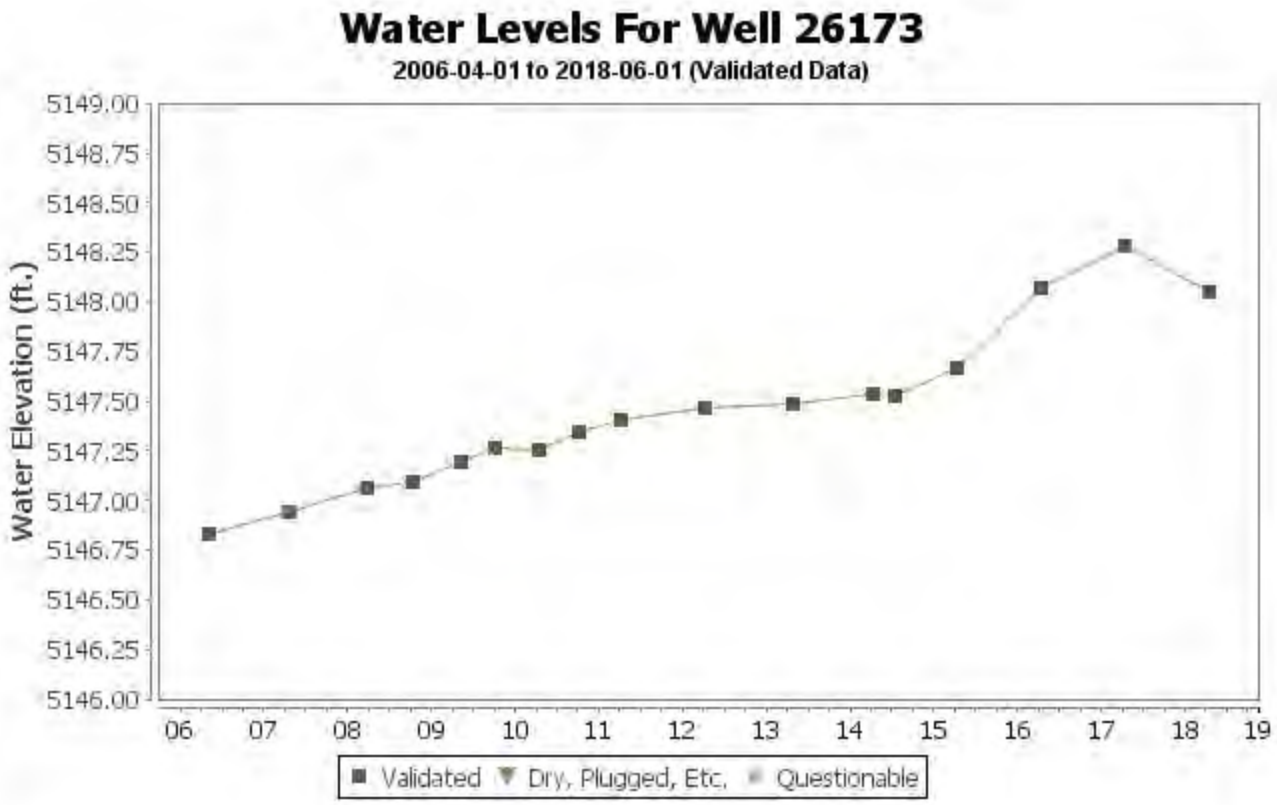
The water elevation increase of 0.94 feet on January 14, 2011 in well 26073 coincided with a top-of-casing elevatation change resulting from modifications to the well. The well was re-surveyed and updated in the Rocky Mountain Arsenal Environmental Database (RMAED).


Water Levels For Well 26128
2006-04-01 to 2018-06-01 (Validated Data)
Water Elevation (ft.)
5166.0
5165.5
5165.0
5164.5
5164.0
5163.5
5163.0
5162.5
5162.0
5161.5
5161.0
06
07
08
09
10
11
12
13
14
15
16
17
18
19
Validated
Dry, Plugged, Etc.
Questionable


Water Levels For Well 26133
2006-04-01 to 2018-06-01 (Validated Data)
Water Elevation (ft.)
5147.00
5146.75
5146.50
5146.25
5146.00
5145.75
5145.50
5145.25
5145.00
06
07
08
09
10
11
12
13
14
15
16
17
18
19
Validated
Dry, Plugged, Etc.
Questionable


Water Levels For Well 26157
2006-04-01 to 2018-06-01 (Validated Data)
Water Elevation (ft.)
5144.00
5143.75
5143.50
5143.25
5143.00
5142.75
5142.50
5142.25
5142.00
5141.75
5141.50
5141.25
5141.00
06
07
08
09
10
11
12
13
14
15
16
17
18
19
Validated
Dry, Plugged, Etc.
Questionable


Water Levels For Well 26163
2006-04-01 to 2018-06-01 (Validated Data)
Water Elevation (ft.)
5146.00
5145.75
5145.50
5145.25
5145.00
5144.75
5144.50
5144.25
5144.00
06
07
08
09
10
11
12
13
14
15
16
17
18
19
Validated
Dry, Plugged, Etc.
Questionable


Water Levels For Well 26173
2006-04-01 to 2018-06-01 (Validated Data)
Water Elevation (ft.)
5149.00
5148.75
5148.50
5148.25
5148.00
5147.75
5147.50
5147.25
5147.00
5146.75
5146.50
5146.25
5146.00
06
07
08
09
10
11
12
13
14
15
16
17
18
19
Validated
Dry, Plugged, Etc.
Questionable

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ATTACHMENT B

Time/Concentration Plots for Indicator Compounds

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ATTACHMENT B

Time/Concentration Plots for Indicator Compounds

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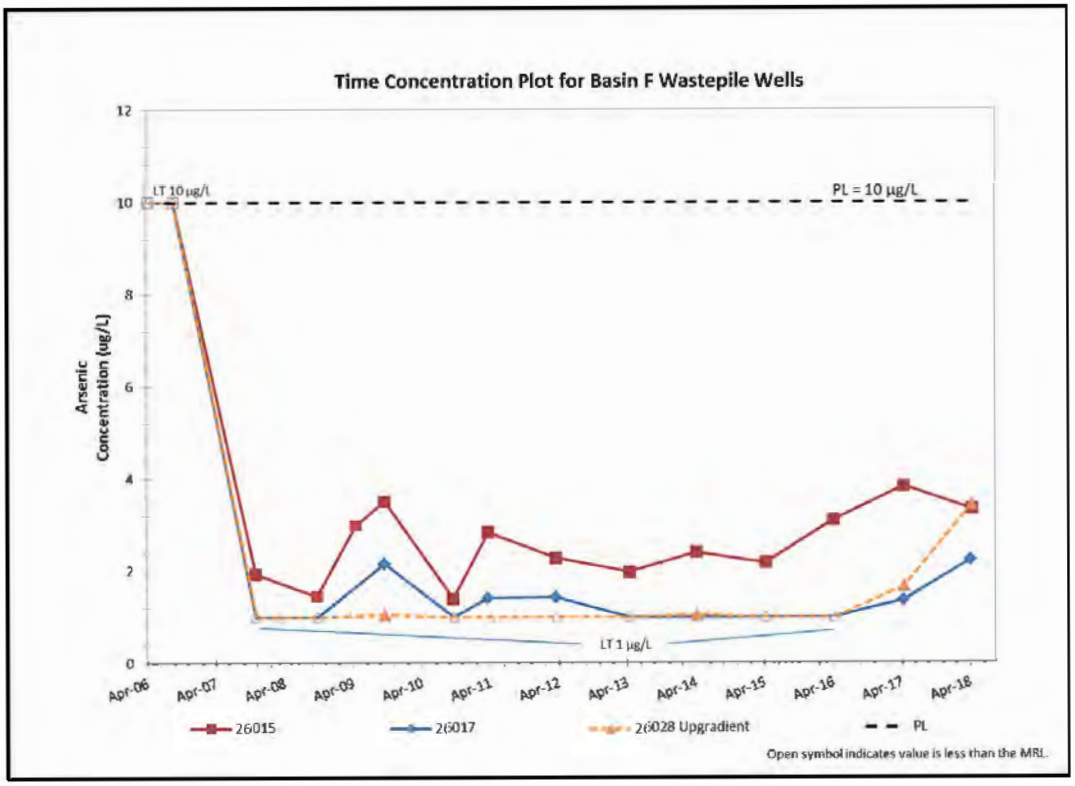
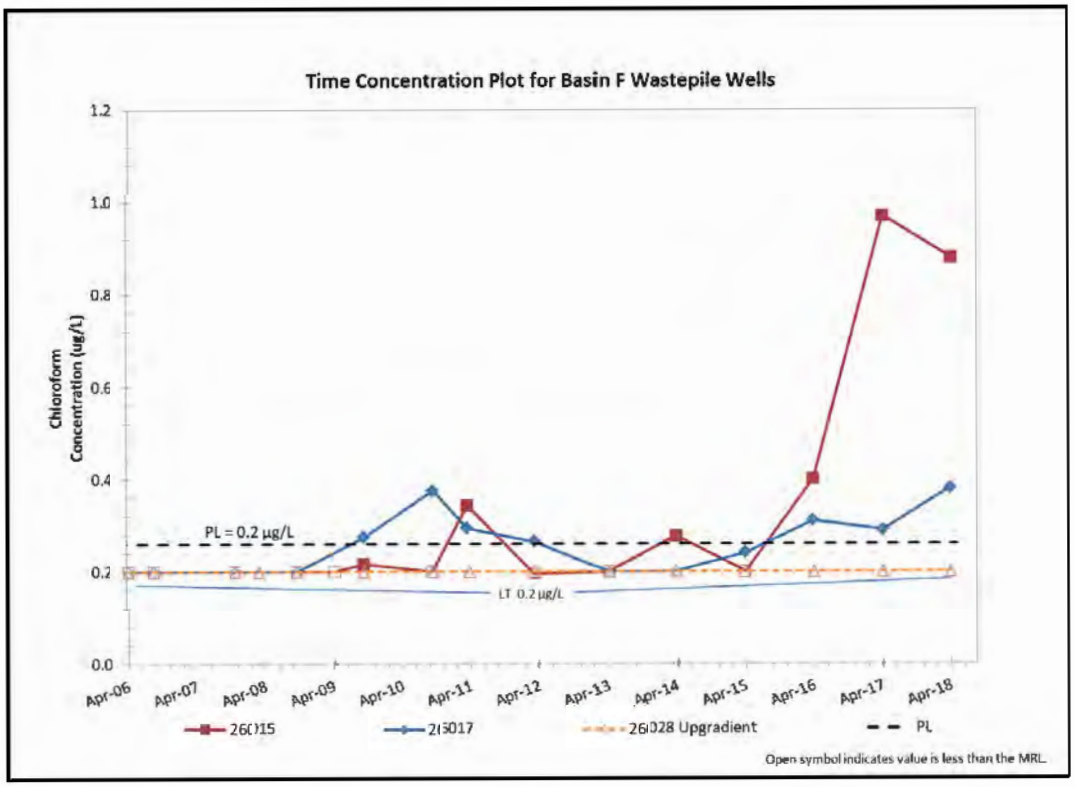
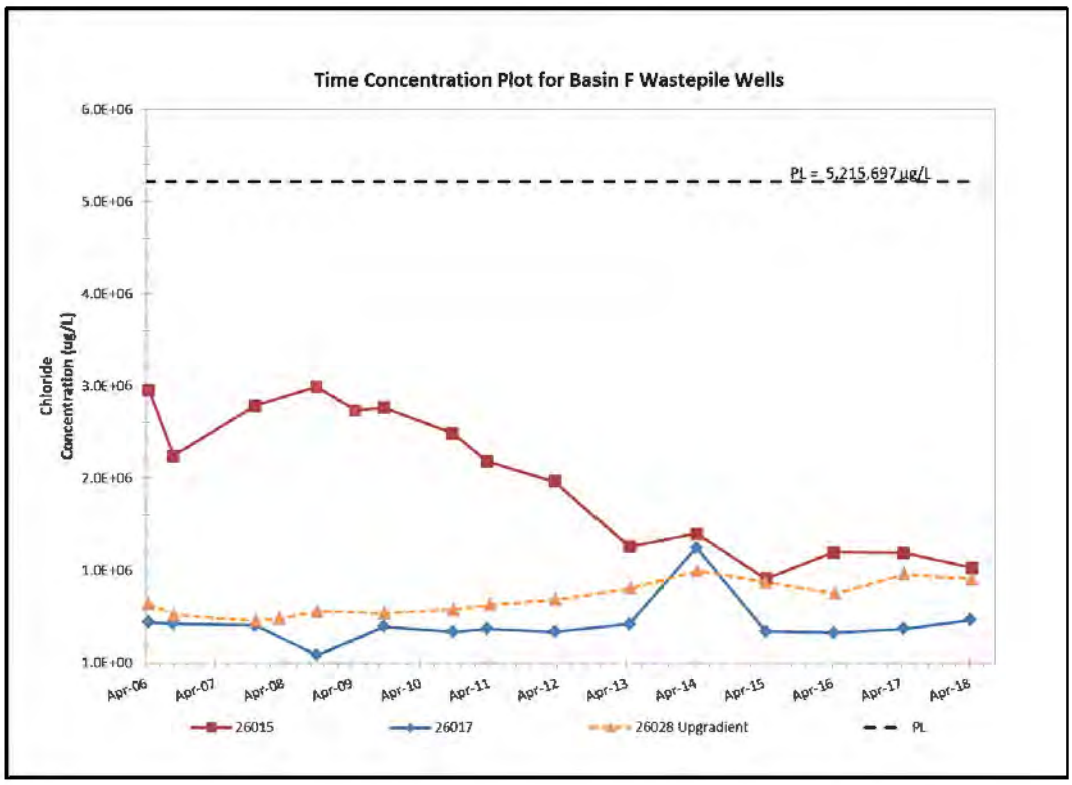
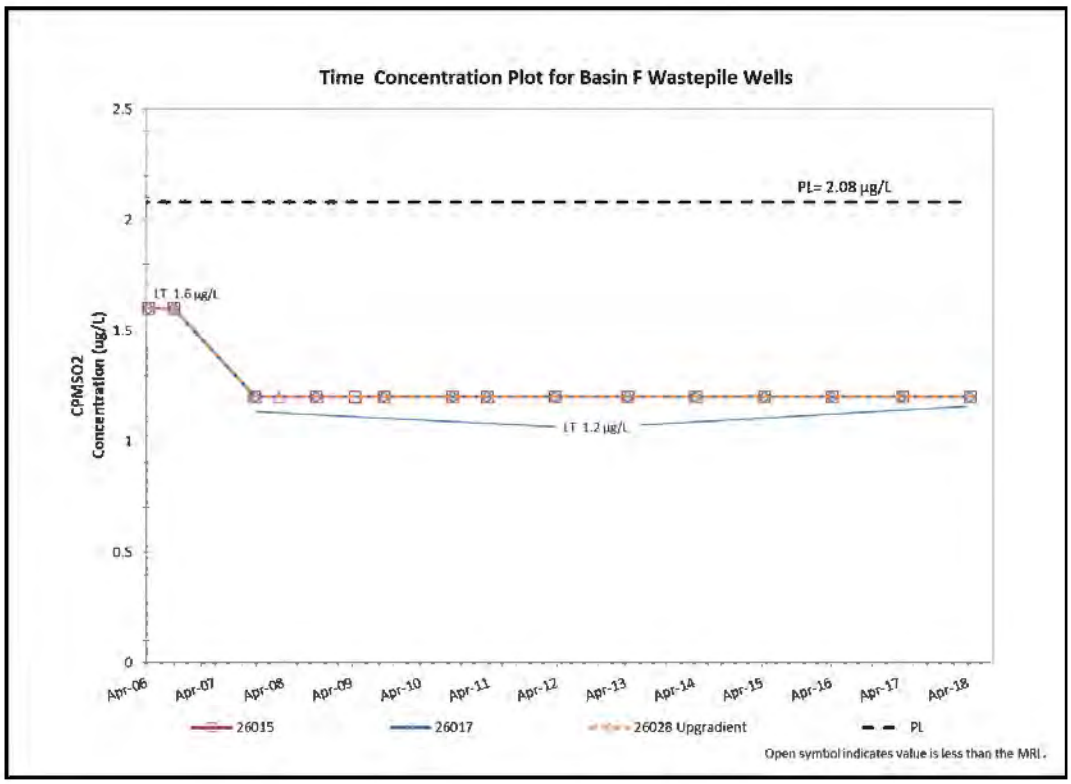
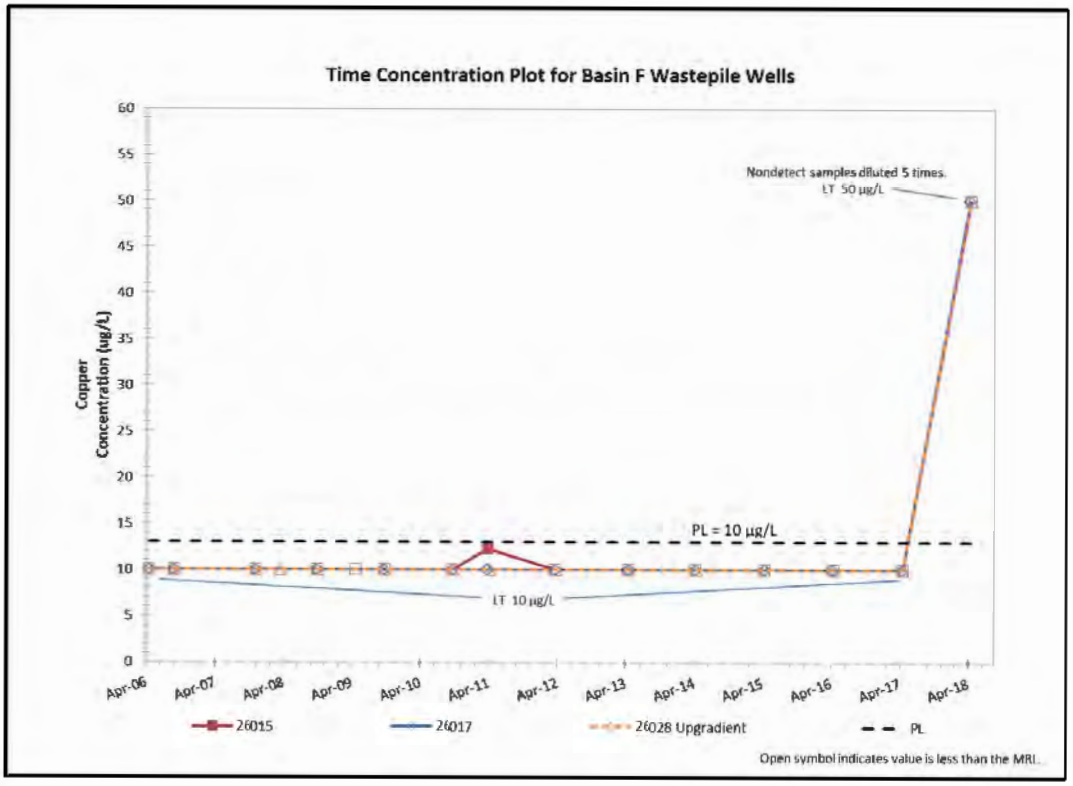
Basin F Wastepile



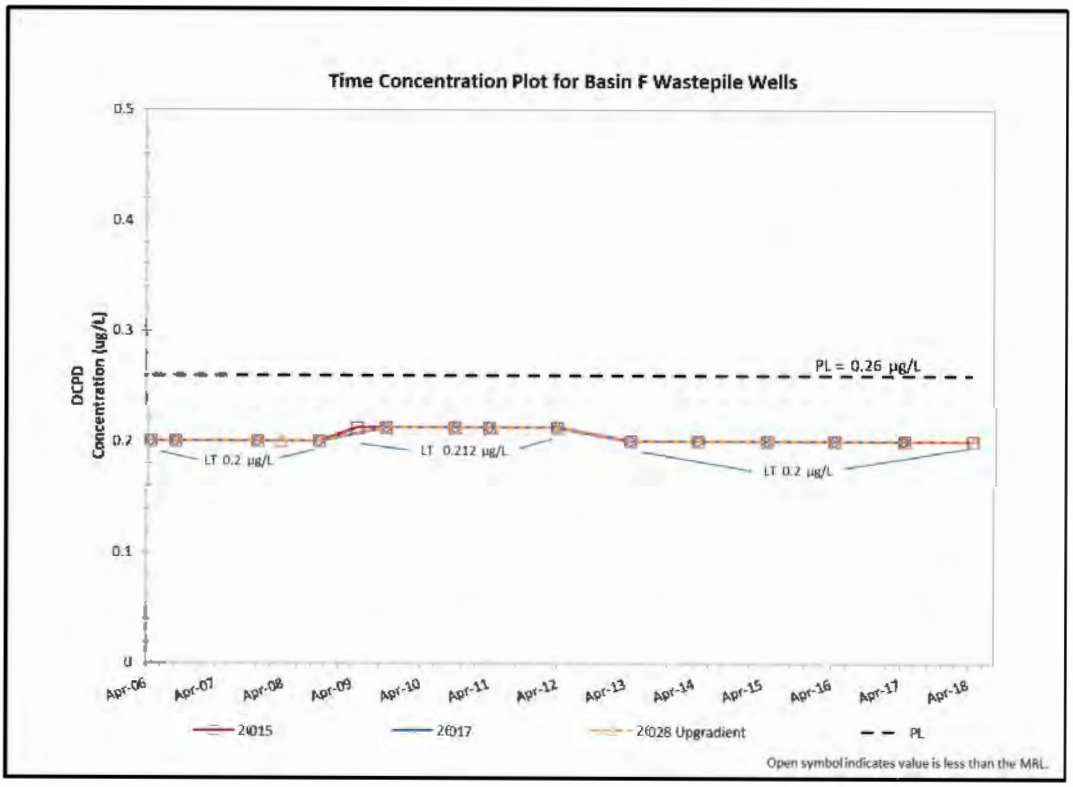


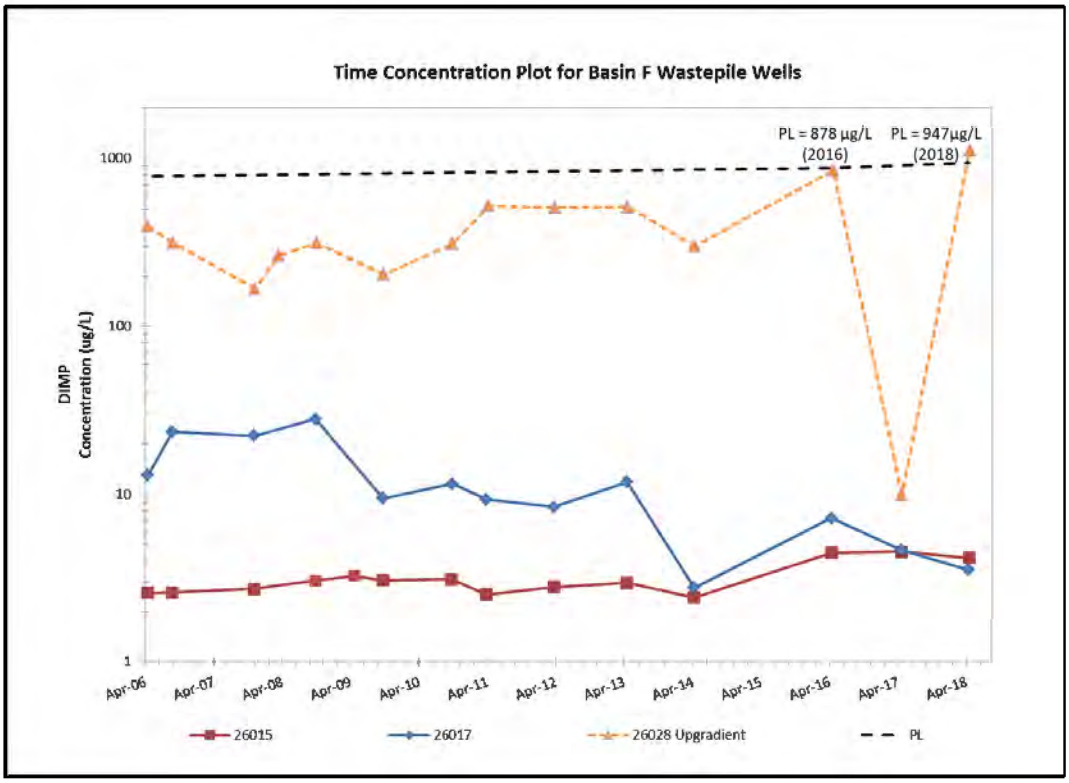

Time Concentration Plot for Basin F Wastepile Wells
Chloride Concentration (ug/L)
6.0E+06
5.0E+06
4.0E+06
3.0E+06
2.0E+06
1.0E+06
1.0E+00
PL = 5,215,697 µg/L
Apr-06
Apr-07
Apr-08
Apr-09
Apr-10
Apr-11
Apr-12
Apr-13
Apr-14
Apr-15
Apr-16
Apr-17
Apr-18
26015
26017
26028 Upgradient
PL

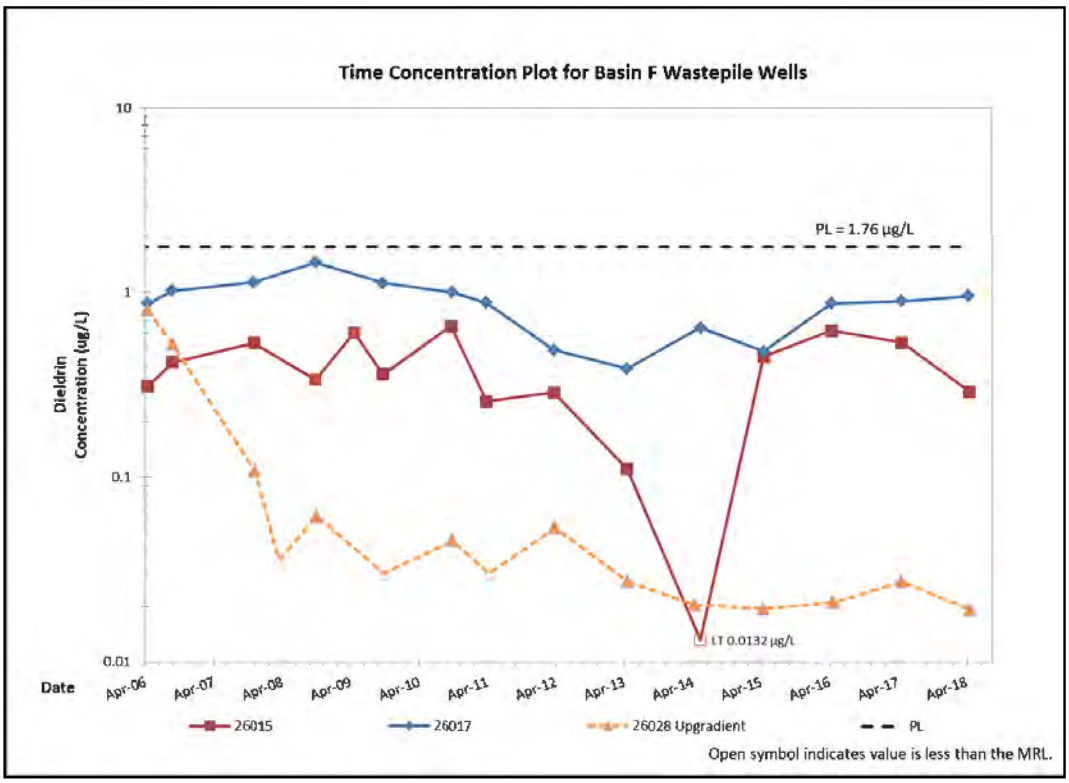

Time Concentration Plot for Basin F Wastepile Wells
CPMSO2 Concentration (ug/L)
2.5
2
1.5
1
0.5
0
PL= 2.08 µg/L
LT 1.6 µg/L
LT 1.2 µg/L
Apr-06
Apr-07
Apr-08
Apr-09
Apr-10
Apr-11
Apr-12
Apr-13
Apr-14
Apr-15
Apr-16
Apr-17
Apr-18
26015
26017
26028 Upgradient
PL
Open symbol indicates value is less than the MRL.

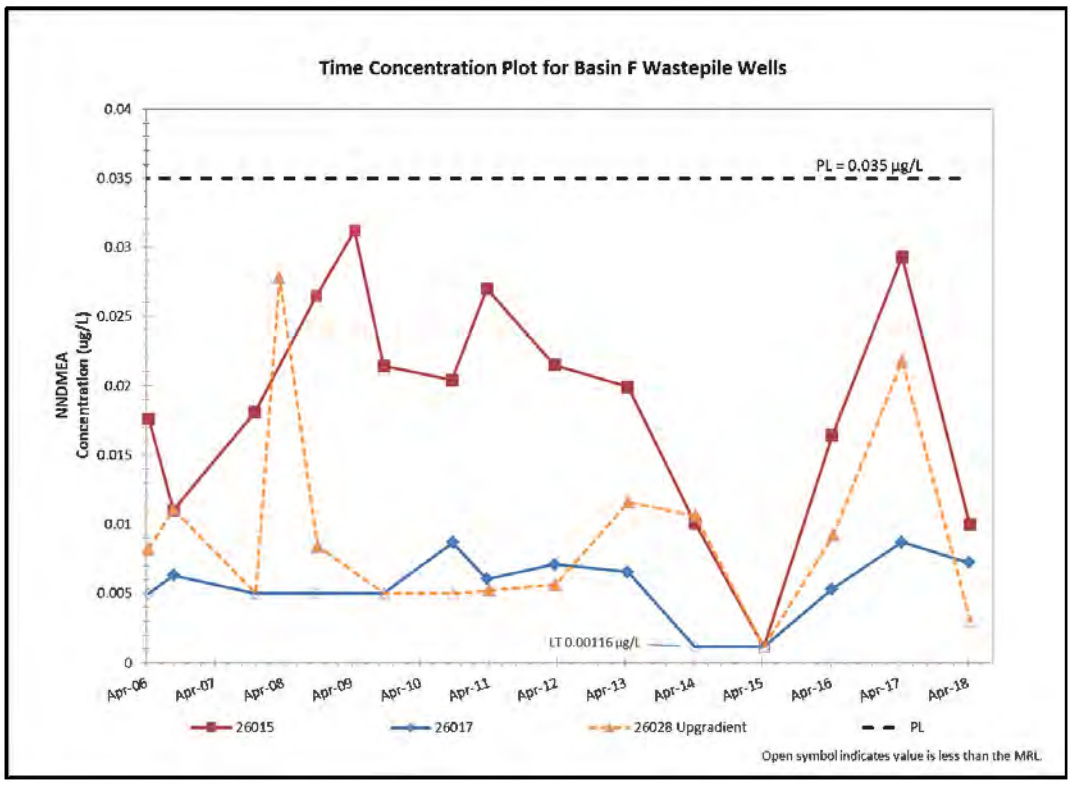


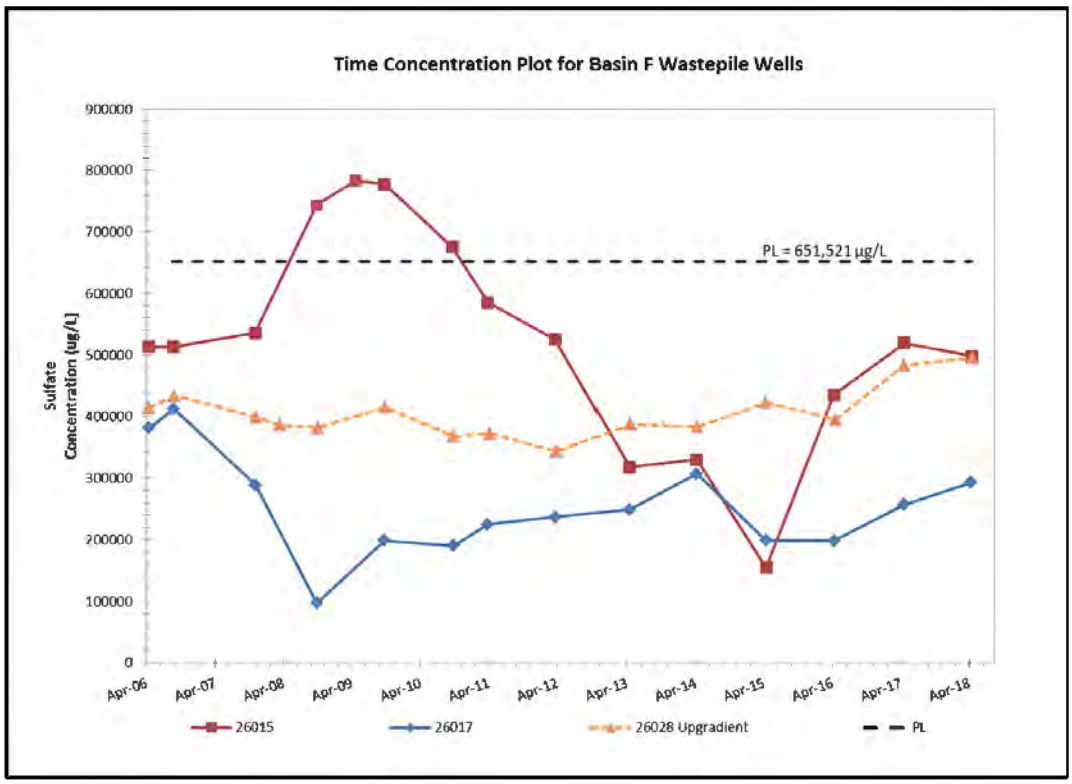
* Copper will be re-evaluated in 2019. Data for 2018 indicate dilution accounts for the elevated reporting limit.

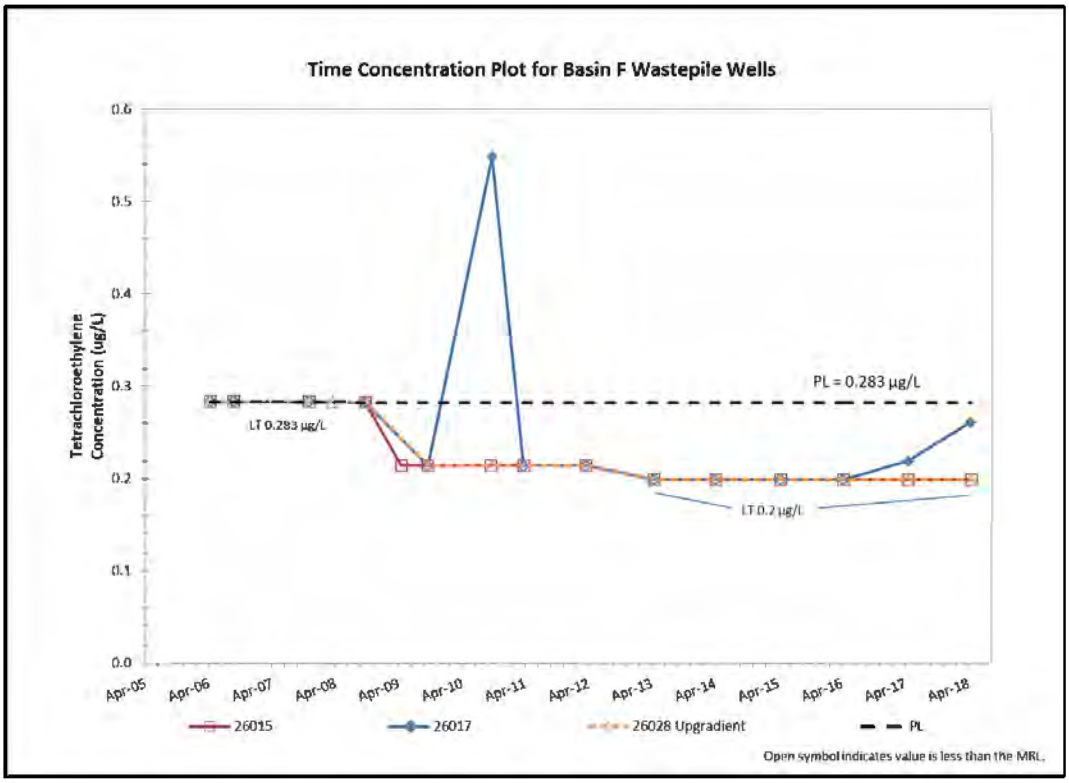



Time Concentration Plot for Basin F Wastepile Wells
PL = 878 µg/L (2016)
PL = 947µg/L (2018)
DIMP Concentration (ug/L)
1000
100
10
1
Apr-06
Apr-07
Apr-08
Apr-09
Apr-10
Apr-11
Apr-12
Apr-13
Apr-14
Apr-15
Apr-16
Apr-17
Apr-18
26015
26017
26028 Upgradient
PL

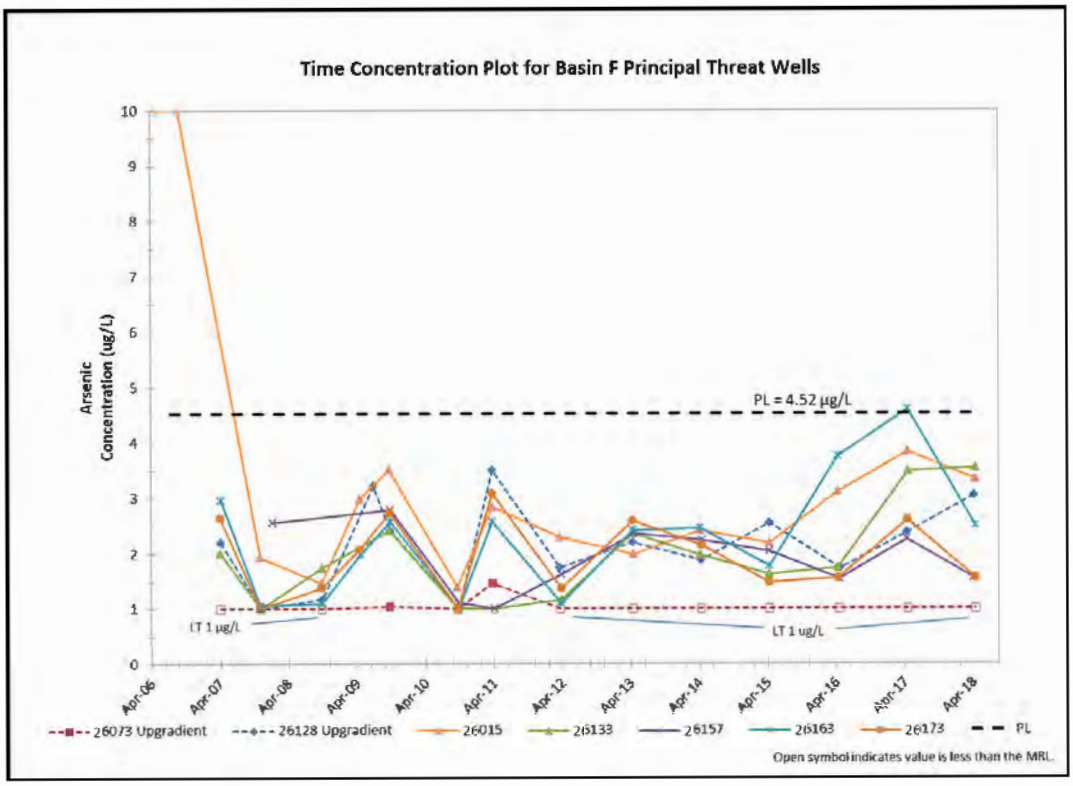

Time Concentration Plot for Basin F Wastepile Wells
PL = 1.76 µg/L
Dieldrin Concentration (ug/L)
10
1
0.1
0.01
LT 0.0132 µg/L
Date
Apr-06
Apr-07
Apr-08
Apr-09
Apr-10
Apr-11
Apr-12
Apr-13
Apr-14
Apr-15
Apr-16
Apr-17
Apr-18
26015
26017
26028 Upgradient
PL
Open symbol indicates value is less than the MRL.

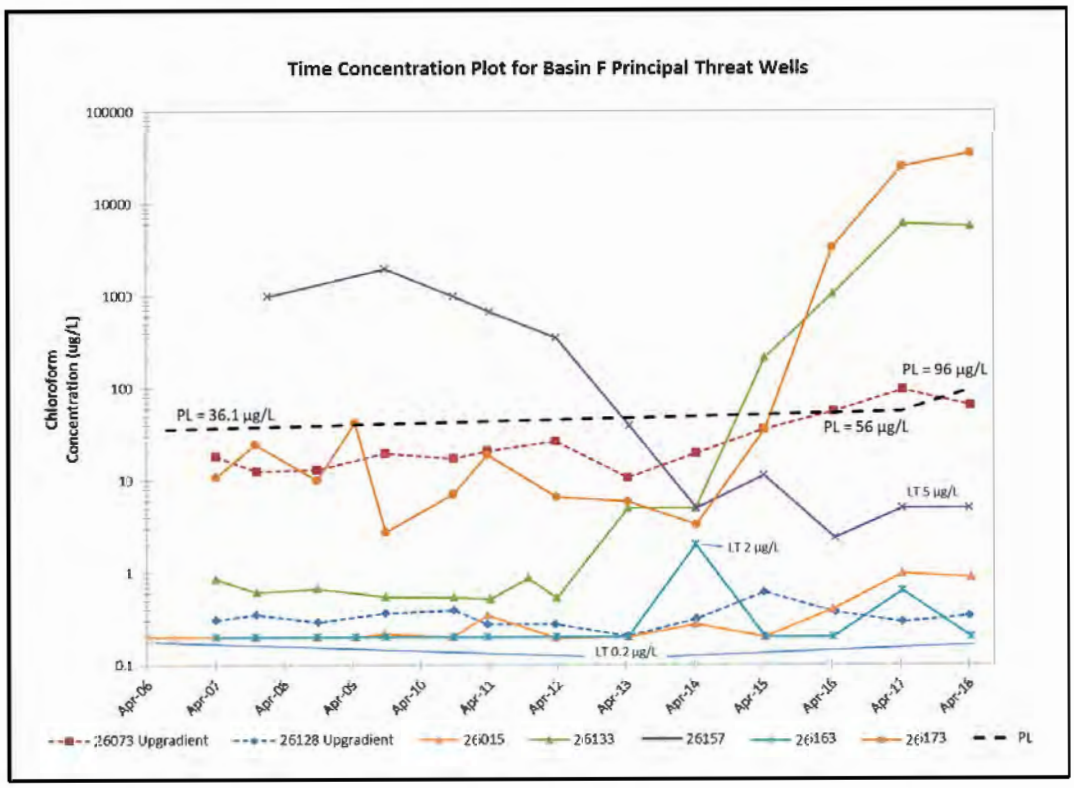

Time Concentration Plot for Basin F Wastepile Wells
NNDMEA Concentration (ug/L)
PL = 0.035 µg/L
LT 0.00116 µg/L
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Apr-06
Apr-07
Apr-08
Apr-09
Apr-10
Apr-11
Apr-12
Apr-13
Apr-14
Apr-15
Apr-16
Apr-17
Apr-18
26015
26017
26028 Upgradient
PL
Open symbol indicates value is less than the MRL

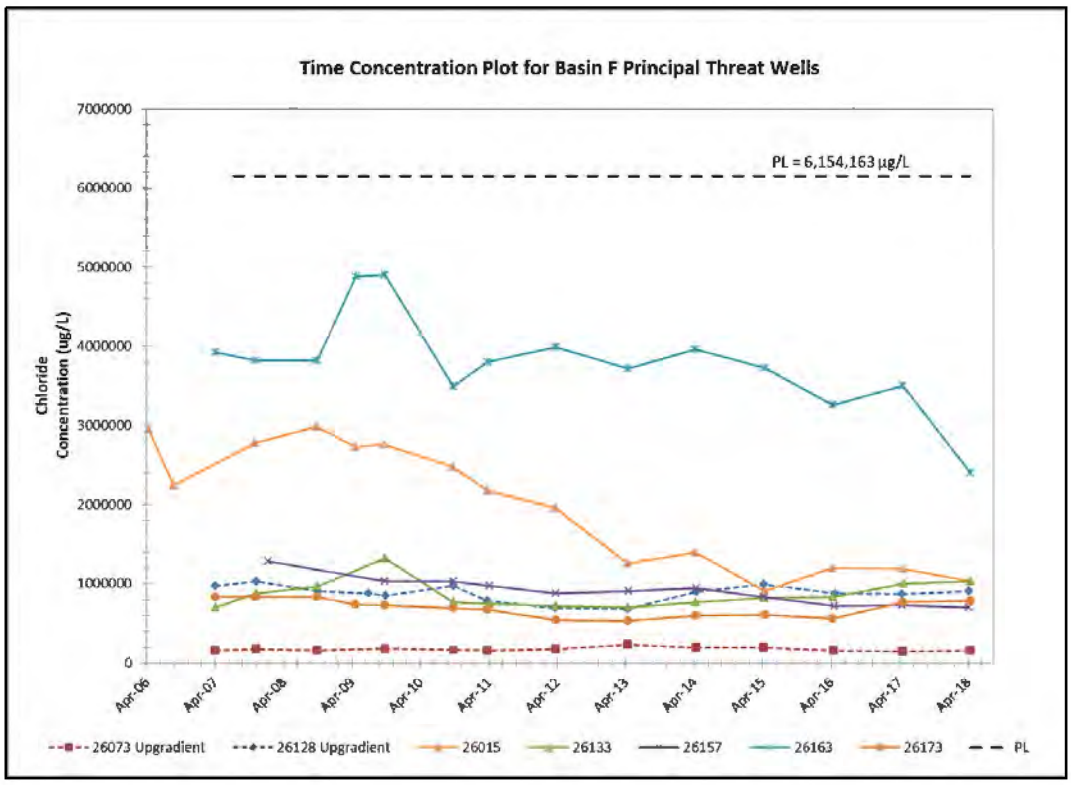

Time Concentration Plot for Basin F Wastepile Wells
Sulfate Concentration (ug/L)
PL = 651,521 µg/L
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
Apr-06
Apr-07
Apr-08
Apr-09
Apr-10
Apr-11
Apr-12
Apr-13
Apr-14
Apr-15
Apr-16
Apr-17
Apr-18
26015
26017
26028 Upgradient
PL

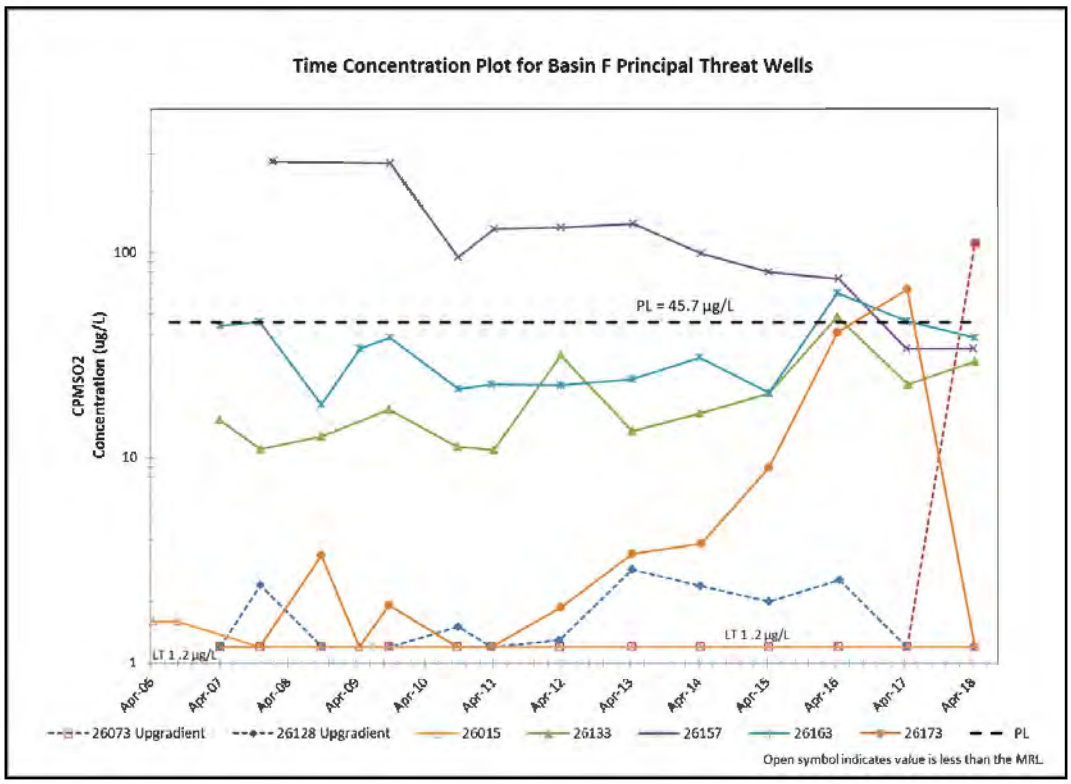

Time Concentration Plot for Basin F Wastepile Wells
Tetrachloroethylene Concentration (ug/L)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
PL = 0.283 µg/L
LT 0.283 µg/L
LT 0.2 µg/L
Apr-05
Apr-06
Apr-07
Apr-08
Apr-09
Apr-10
Apr-11
Apr-12
Apr-13
Apr-14
Apr-15
Apr-16
Apr-17
Apr-18
26015
26017
26028 Upgradient
PL
Open symbol indicates value is less than the MRL.

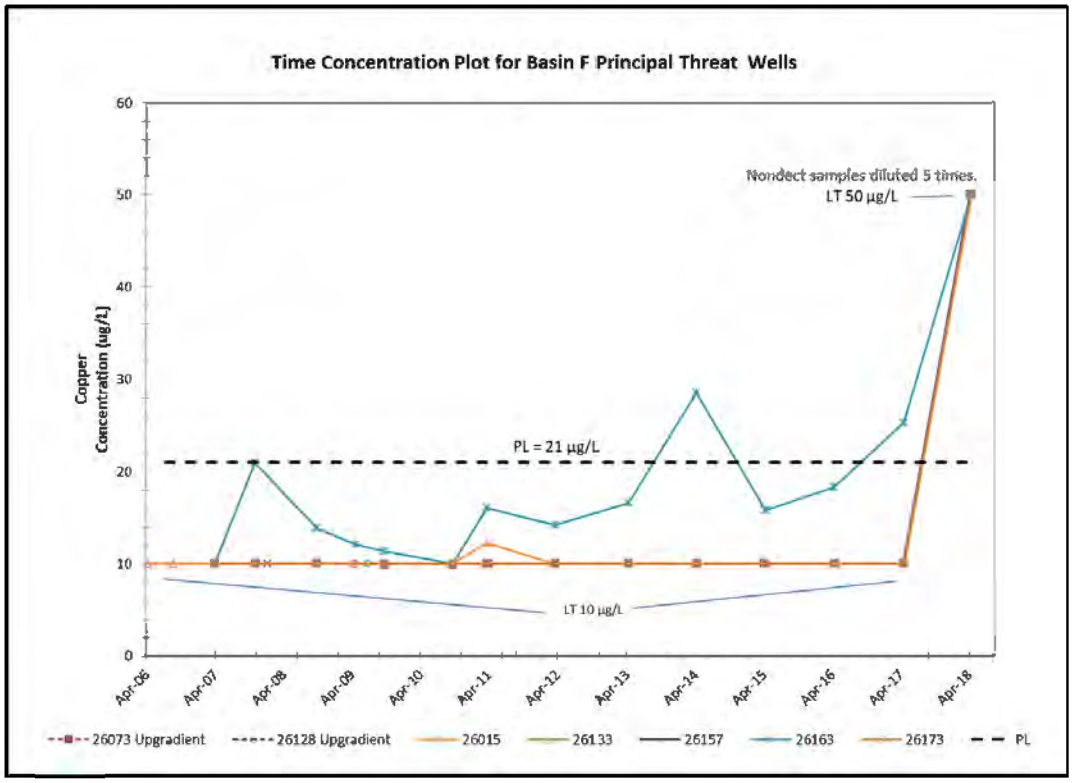
Basin F Principal Threat



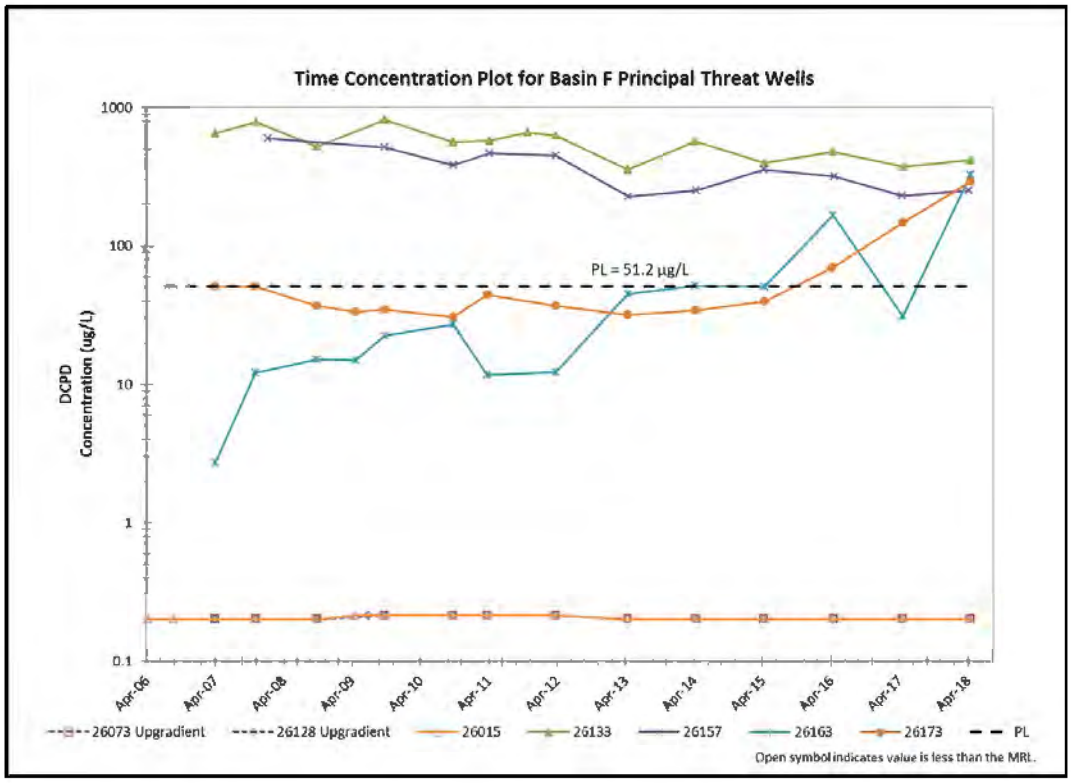


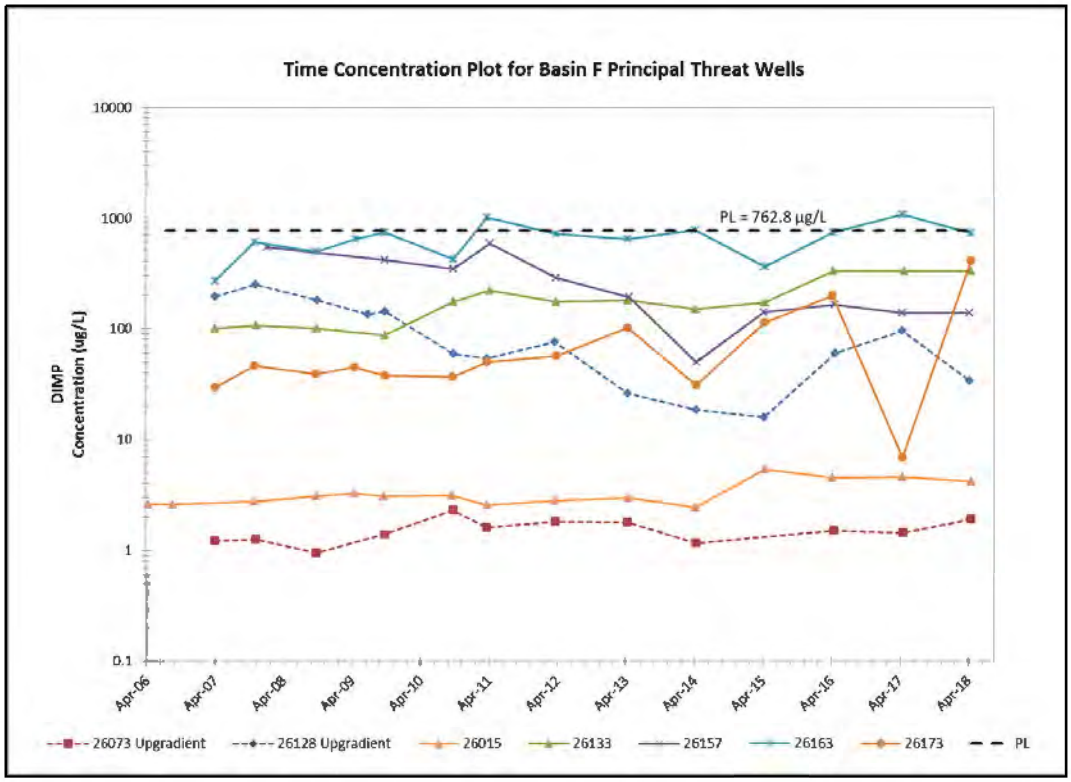

Time Concentration Plot for Basin F Principal Threat Wells
Chloride Concentration (ug/L)
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
PL = 6,154,163 µg/L
Apr-06
Apr-07
Apr-08
Apr-09
Apr-10
Apr-11
Apr-12
Apr-13
Apr-14
Apr-15
Apr-16
Apr-17
Apr-18
26073 Upgradient
26128 Upgradient
26015
26133
26157
26163
26173
PL

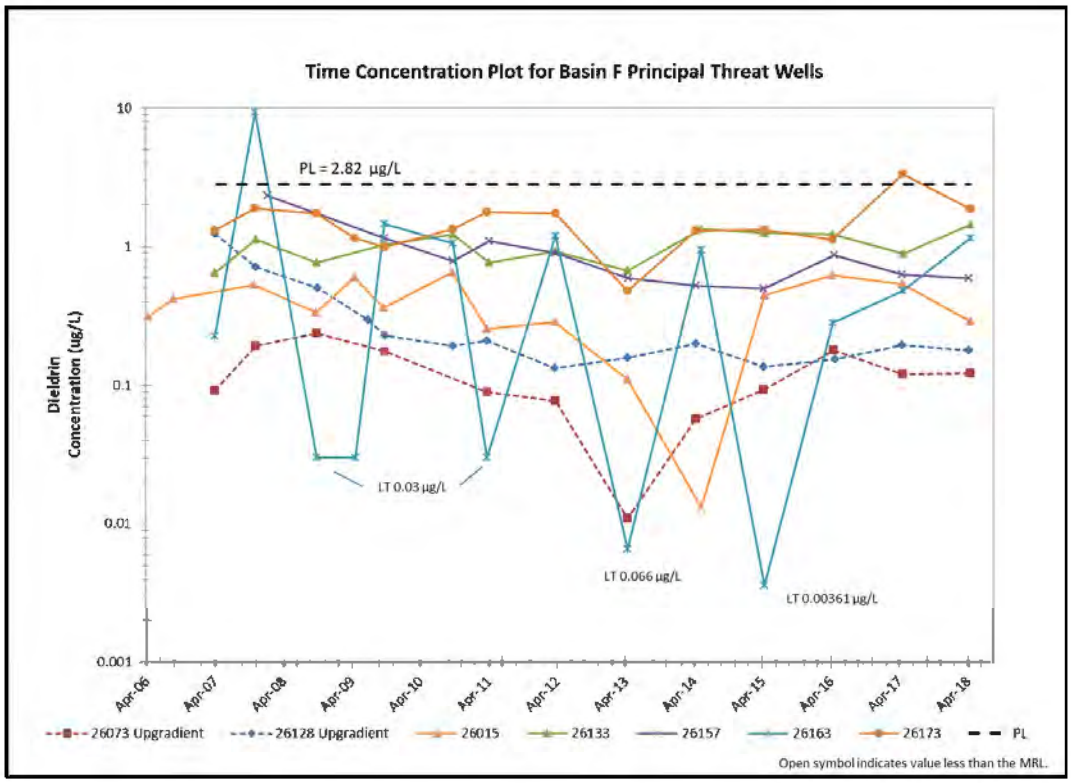

Time Concentration Plot for Basin F Principal Threat Wells
CPMSO2 Concentration (ug/L)
100
10
1
PL = 45.7 µg/L
LT 1.2 µg/L
LT 1.2 µg/L
Apr-06
Apr-07
Apr-08
Apr-09
Apr-10
Apr-11
Apr-12
Apr-13
Apr-14
Apr-15
Apr-16
Apr-17
Apr-18
26073 Upgradient
26128 Upgradient
26015
26133
26157
26163
26173
PL
Open symbol indicates value is less than the MRL

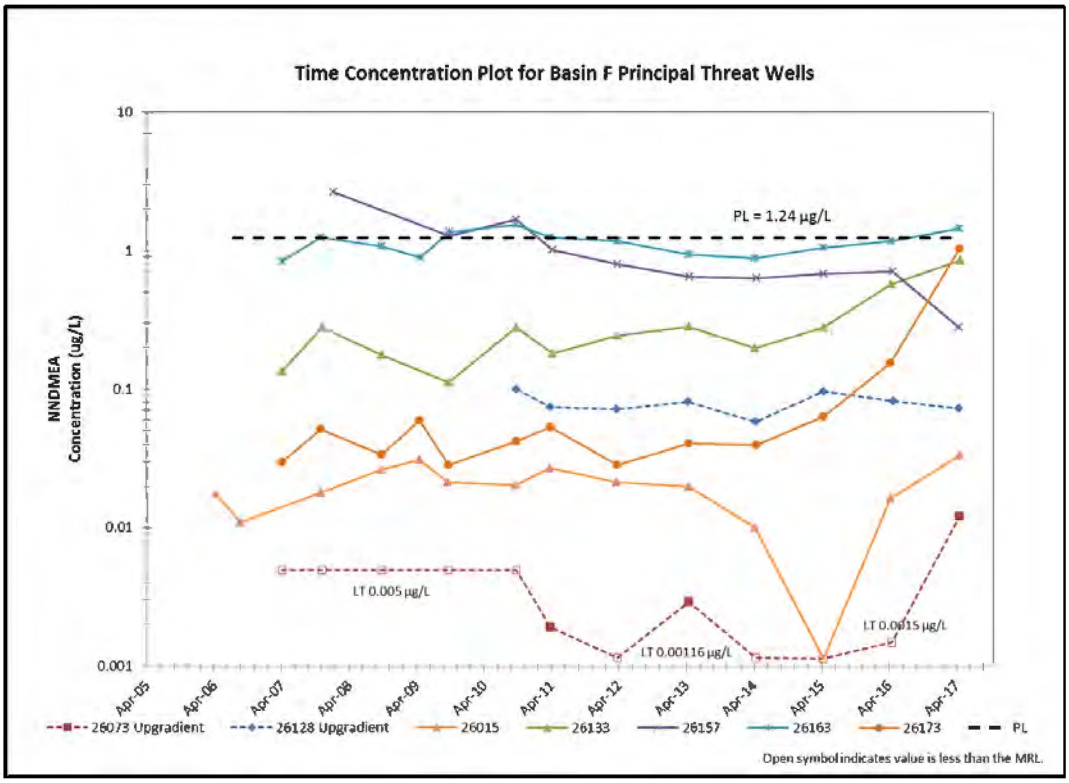


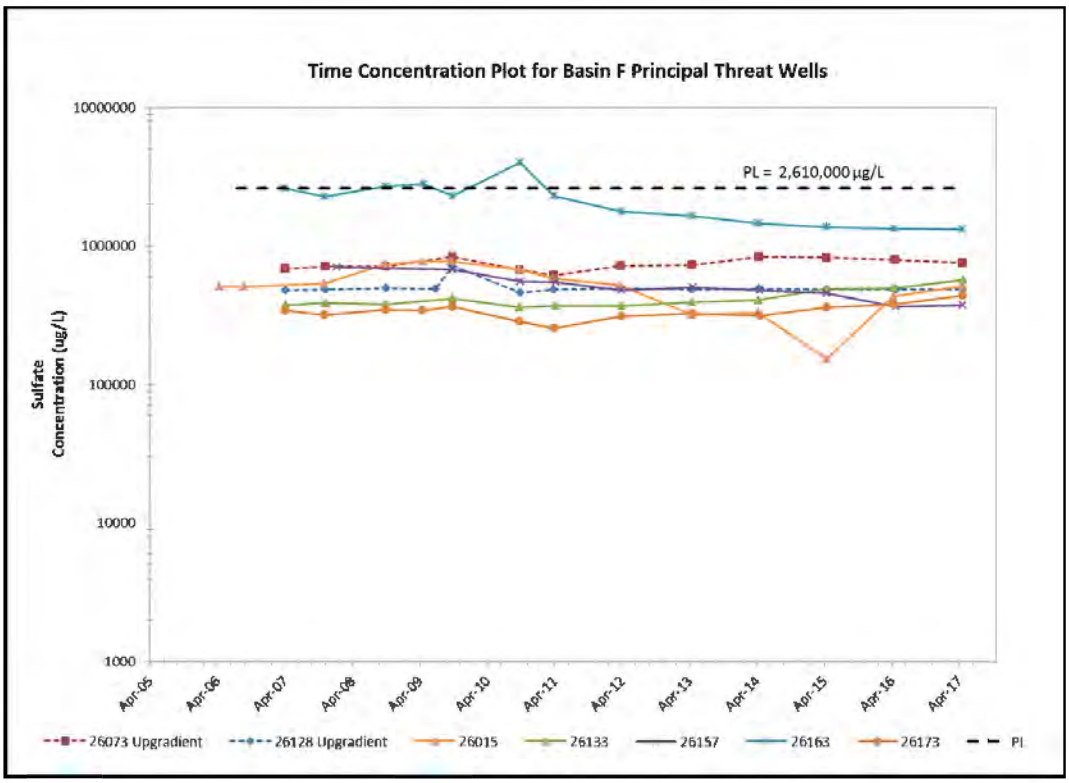
* Copper will be re-evaluated in 2019. Data for 2018 indicate dilution accounts for the elevated reporting limit.

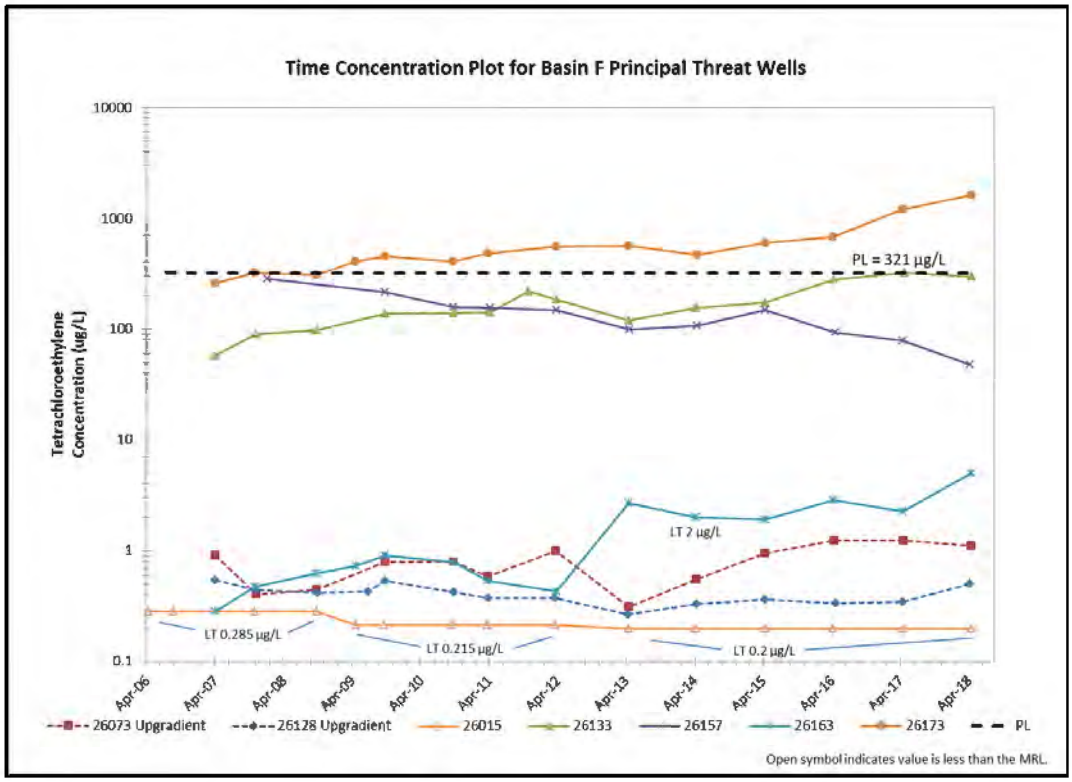



Time Concentration Plot for Basin F Principal Threat Wells
DIMP Concentration (ug/L)
10000
1000
100
10
1
0.1
PL = 762.8 µg/L
Apr-06
Apr-07
Apr-08
Apr-09
Apr-10
Apr-11
Apr-12
Apr-13
Apr-14
Apr-15
Apr-16
Apr-17
Apr-18
26073 Upgradient
26128 Upgradient
26015
26133
26157
26163
26173
PL


Time Concentration Plot for Basin F Principal Threat Wells
Dieldrin Concentration (ug/L)
10
1
0.1
0.01
0.001
PL = 2.82 µg/L
LT 0.03 µg/L
LT 0.066 µg/L
LT 0.00361 µg/L
Apr-06
Apr-07
Apr-08
Apr-09
Apr-10
Apr-11
Apr-12
Apr-13
Apr-14
Apr-15
Apr-16
Apr-17
Apr-18
26073 Upgradient
26128 Upgradient
26015
26133
26157
26163
26173
PL
Open symbol indicates value less than the MRL.


Time Concentration Plot for Basin F Principal Threat Wells
NNDMEA Concentration (ug/L)
10
1
0.1
0.01
0.001
PL = 1.24 µg/L
LT 0.005 µg/L
LT 0.00116 µg/L
LT 0.0015 µg/L
Apr-05
Apr-06
Apr-07
Apr-08
Apr-09
Apr-10
Apr-11
Apr-12
Apr-13
Apr-14
Apr-15
Apr-16
Apr-17
26073 Upgradient
26128 Upgradient
26015
26133
26157
26163
26173
PL
Open symbol indicates value is less than the MRL.


Time Concentration Plot for Basin F Principal Threat Wells
Sulfate Concentration (ug/L)
10000000
1000000
100000
10000
1000
PL = 2,610,000 µg/L
Apr-05
Apr-06
Apr-07
Apr-08
Apr-09
Apr-10
Apr-11
Apr-12
Apr-13
Apr-14
Apr-15
Apr-16
Apr-17
26073 Upgradient
26128 Upgradient
26015
26133
26157
26163
26173
PL


Time Concentration Plot for Basin F Principal Threat Wells
Tetrachloroethylene Concentration (ug/L)
10000
1000
100
10
1
0.1
PL = 321 µg/L
LT 7 µg/L
LT 0.285 µg/L
LT 0.215 µg/L
LT 0.2 µg/L
Apr-06
Apr-07
Apr-08
Apr-09
Apr-10
Apr-11
Apr-12
Apr-13
Apr-14
Apr-15
Apr-16
Apr-17
Apr-18
26073 Upgradient
26128 Upgradient
26015
26133
26157
26163
26173
PL
Open symbol indicates value is less than the MRL.