ROCKY MOUNTAIN ARSENAL

2023 BASIN F COVER AND GROUNDWATER MONITORING REPORT

Revision 0

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U.S. Department of the Army

Shell Oil Company

Prepared by:

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ACRONYMS

AMA	Army Maintained Areas
CCR	Code of Colorado Regulations
CDPHE	Colorado Department of Public Health and Environment
CGMR	Cover and Groundwater Monitoring Report
CPMSO2	p-Chlorophenylmethyl sulfone
DCPD	Dicyclopentadiene
DIMP	Diisopropylmethyl phosphonate
EPA	United States Environmental Protection Agency
FY21	Fiscal Year 2021
FY23	Fiscal Year 2023
FY24	Fiscal Year 2024
IC	Indicator Compound
LTCP	Long-Term Care Plan
NNDMEA	n-Nitrosodimethylamine
NRAP	Non-Routine Action Plan
NWS	National Weather Service
O&M	Operations and Maintenance
OCN	O&M Change Notice
PCGMP	Post-Closure Groundwater Monitoring Plan
PCP	Post-Closure Plan
PT	Principal Threat
RCRA	Resource Conservation and Recovery Act
RMA	Rocky Mountain Arsenal
SOP	Standard Operating Procedure
SQAPP	Sampling Quality Assurance Project Plan
TCLEE	Tetrachloroethene
UFS	Unconfined Flow System
UPL	Upper Prediction Limit
WP	Wastepile

EXECUTIVE SUMMARY

This *2023 Basin F Cover and Groundwater Monitoring Report* (CGMR) for the Rocky Mountain Arsenal (RMA) was prepared in accordance with the *Basin F Post-Closure Plan* (PCP), Revision 2 (Navarro 2023d) and the *RCRA-Equivalent, 2-, and 3-Foot Covers Long-Term Care Plan* (LTCP), Revision 3 (Navarro 2021d). 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 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 2023 (FY23), that is, between October 1, 2022 and September 30, 2023. This report addresses the fourteenth 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, and in the long-term O&M Period defined in Section 1.0 of the LTCP.

The Basin F Cover was in excellent condition throughout FY23. Potential deficiencies observed during the reporting period include noxious or undesirable weeds and tumbleweed accumulation, which are typical for the site and were addressed through routine maintenance activities. Soil cover thickness loss met the compliance standard and was below the non-routine action trigger level for FY23.

The 2023 Vegetation Performance Assessment of the Basin F Resource Conservation and Recovery Act (RCRA)-Equivalent Cover was conducted in accordance with Standard Operating Procedure 002 of the Basin F PCP, Revision 2. In all, 15 vegetation transects were sampled. A total of 100 observations were made along each transect. The 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.

Percolation collected at each of the five lysimeters on Basin F was below the non-routine action trigger level (1.0 mm per nine-month period) and met the compliance standard (1.3 mm per 12-month period). The precipitation measured during FY23 at the rain gauge located west of the Lime Basins RCRA-Equivalent Cover in Section 36 was 20.92 inches.

Upgradient and downgradient groundwater data collected during post-closure monitoring of Wastepile (WP) and Principal Threat (PT) wells were evaluated to demonstrate post-closure O&M 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 was conducted in April and May of 2023.

Groundwater flow in the vicinity of Basin F is generally to the north. A groundwater divide has become evident as local and regional water levels have decreased, where localized and minor variations occur beneath the north end of Basin F where groundwater flows to the north-northwest and north-northeast. The overall decrease in unconfined flow system water levels in the vicinity of Basin F is consistent with a general decreasing trend noted across RMA over the past several years. Historical changes in water levels in wells near Basin F are consistent with

regional fluctuations in the water table and are not related to the performance of the Basin F cover.

Based on the distribution of the analyte concentrations and water quality trends, it appears that the PT groundwater flow path is having a greater impact on water quality downgradient of the former Basin F compared to the WP flow path. While concentrations of indicator compounds less frequently exceed upper prediction limits, with many indicator compounds demonstrating decreasing trends, concentrations downgradient of the PT indicate an impact due to contaminated groundwater migrating from upgradient sources and/or residual contamination within the unsaturated zone beneath the Basin F PT area.

In accordance with the *Basin F Post-Closure Groundwater Monitoring Plan*, Revision 2 (Navarro 2023d, Appendix B), there are no chemical-specific standards that apply to Basin F groundwater since the RMA remedy addresses contaminated groundwater downgradient at the North Boundary Containment System and Northwest Boundary Containment System, where it is extracted and treated.

Cost incurred performing post-closure care of the Basin F AMA during FY23, including inspections, repairs, maintenance, groundwater monitoring, and groundwater sampling described in the *Optimization Plan for the Basin F Post-Closure Groundwater Monitoring Network,* Revision 1 (Navarro 2023b) was $210,560. A complete budget for Fiscal Year 2024 (FY24) has not been approved as of the issuance of this report. However, the FY24 budget for work required under the Basin PCP and *Optimization Plan for the Basin F Post-Closure Groundwater Monitoring Network* is estimated to be approximately $230,000.

In summary and based on the information presented in this report, there are no corrective measures required. Routine inspections and maintenance of the Basin F AMA will continue throughout FY24 in accordance with the requirements of the Basin F PCP. In addition to routine maintenance activities, the Army recommends a prescribed burn of the Basin F AMA in the fall of 2023 or spring of 2024. A prescribed burn will be beneficial to the health of established native perennial grasses and will remove litter left behind after the robust growth of vegetation. This recommendation will be discussed in the 2024 Basin F CGMR.

No corrective measures are currently planned for FY24.

1.0 INTRODUCTION

This *2023 Basin F Cover and Groundwater Monitoring Report* (CGMR) for the Rocky Mountain Arsenal (RMA) was prepared in accordance with the *Basin F Post-Closure Plan* (PCP), Revision 2 (Navarro 2023d) and the *RCRA-Equivalent, 2-, and 3-Foot Covers Long-Term Care Plan* (LTCP), Revision 3 (Navarro 2021d). 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 plans to improve or sustain cover conditions. This Basin F CGMR documents the monitoring and maintenance-related activities performed on the Basin F Army Maintained Area (AMA) during Fiscal Year 2023 (FY23), that is, between October 1, 2022 and September 30, 2023. This report addresses the fourteenth 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, and in the long-term O&M Period defined in Section 1.0 of the LTCP.

2.0 METHODOLOGY

The Basin F Resource Conservation and Recovery Act (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 2, 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 Basin F PCP, Revision 2

In Fiscal Year 2021 (FY21) the Army evaluated the inspection requirements for the Integrated Cover System and the Basin F RCRA-Equivalent Cover to identify areas where the process could be improved. After ten years of cover inspection and maintenance experience, the Army and regulatory agencies had amassed a significant body of operational data and institutional knowledge that were not available when the Basin F inspection requirements were originally developed. The information and experience were used to refine the inspection requirements identified in the Basin F PCP, which were documented in O&M Change Notice (OCN)-BASINF-2021-001 dated July 14, 2021 (Navarro 2021b). The regulatory agencies reviewed the proposed changes and found them to be acceptable. The Colorado Department of Public Health and Environment (CDPHE) determined that the inspection frequency changes proposed in OCN-2021-001 qualified as a Class 2 modification per 6 Code of Colorado Regulations (CCR) 1007-3 Section 265.118(d) and 6 CCR 1007-3 Section 100.63. Thus, the RMA-specific OCN change process was not sufficient and an administrative process consistent with 6 CCR 1007-3 Section 265.118(d) was required prior to approval.

The Army submitted the Basin F PCP, Revision 1 to the regulatory agencies on October 5, 2022. Revision 1 of the Basin F PCP included all previously approved OCNs, agreed-upon changes to the inspection requirements, and other administrative changes. The Army only received comments on Revision 1 from the CDPHE on November 1, 2022, which initiated the development of another revision to the Basin F PCP. Revision 2 of the Basin F PCP, which incorporated CDPHE comments, went through a public review and comment period between April 27 and May 26, 2023, where ultimately no comments were received. The United States

Environmental Protection Agency (EPA) provided comments on the Basin F PCP, Revision 2 on June 29, 2023. The Army and regulatory agencies reviewed comments from EPA collectively and determined the comments did not warrant additional revision or public comment period. The parties agreed that EPA comments would be incorporated through the OCN process. Therefore, CDPHE submitted an acceptance letter to the Army dated July 26, 2023, for the Basin F PCP, Revision 2 which went into effect the same date.

2.2 Type I and Type II Cover Inspections

The procedure for inspecting cover soil 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. Copies of the cover inspection forms are provided in Appendix C of this report.

2.3 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 of this report. Refer to Appendix B of this report for photos and other information collected during the 2023 Vegetation Performance Assessment.

2.4 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 of this report. 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.

2.5 Groundwater Monitoring

Groundwater monitoring was performed in April and May of 2023 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 2 (PCGMP) (Navarro 2023d, 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 migration of hazardous contaminants to groundwater (6 CCR 1007-3, Section 265, Subpart G).

2.6 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. Routine repair activities performed in FY23 are discussed in Section 4.0 of this report and illustrated on Figure 4.0-1.

There were no Non-Routine Action Plans (NRAPs) prepared or non-routine actions performed during this reporting period.

3.0 PRECIPITATION AND WEATHER CONDITIONS

The rain gauge located west of the Lime Basins RCRA-Equivalent Cover, near the Lime Basins Metering Building collects precipitation data for the RMA. The precipitation measured at the Lime Basins gauge during FY23 was 20.92 inches. Precipitation data collected by the Lime Basins gauge are provided in Appendix A.

3.1 National Weather Service Summary

Figures 3.1-1 and 3.1-2 illustrate the Rocky Mountain Region's monthly temperature and precipitation values for FY23 as 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. FY23 had near average temperatures and above normal spring and summer precipitation in the Rocky Mountain Region.

3.2 Significant Storm Events at RMA

RMA experienced two significant storm events in FY23. A significant storm event is defined as a rainstorm event in which greater than 1.0 inch of precipitation falls within 24 hours. On May 12 and June, 5, 2023, the RMA received 2.92 inches of rain and 1.23 inches of rain, respectively in a 24-hour period.

4.0 SOIL COVER ASSESSMENT, MAINTENANCE AND REPAIR ACTIONS

During FY23, 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 January 17, March 1, May 3, June 21, and July 19, 2023. Type II inspections were performed on October 11, 2022 and April 12, 2023.

There were two significant storm events that occurred on FY23 on May 12 and June 5, 2023. Post-storm drive around inspections were performed on May 15 and June 5, 2023 and these inspections were documented in the project logbook. A post-storm inspection was performed concurrently with the June 21, 2023 Type I inspection and documented on Basin F PCP Form SOP 001-1 which is included in Appendix C.

The soil cover was inspected for the following:

- Surface Conditions
- Vegetative Cover
- Engineering and Access Controls

- Percolation Monitoring
- Surface Drainage Controls
- Erosion/Settlement Monuments
- Other deleterious conditions

The Basin F Cover was in excellent condition throughout FY23. Observations of cover conditions listed on Form SOP 001-1 and Form SOP 001-2 are described below with references to inspection form item numbers where appropriate. Cover inspection documentation is provided in Appendix C of this report. For all inspection categories not listed, no observations were noted, and maintenance was not required.

Other maintenance-related observations were made during normal field activities, independent from formal pre-scheduled inspections. The repair actions associated with these observations are also shown on Figure 4.0-1 and are also described below.

4.1 Noxious or Undesirable Weeds

The herbicide Plainview SC® was applied as a ground clear in November of 2022 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.

Inspection Form Item 2.3 – Deep rooted, noxious or undesirable weedy species: Canada and Musk thistles along with other noxious weeds were identified on areas of Basin F. Weed control efforts were performed in June of 2023 using the herbicides Escort XP® and Vision®.

4.2 Perimeter Fence

Inspection Form Item 3.2 – Debris has collected along the perimeter fence: Tumbleweeds accumulated along the perimeter fence in the winter months of FY23. The tumbleweed accumulation was monitored periodically, and buildup was removed using the fence cleaner in May of 2023.

In August of 2023, there was a bison breach on a portion of the southern Basin F perimeter fence. Some fence fabric was stretched and torn, and a wooden post was damaged. The wooden post was replaced, and the fence fabric was stretched back into place and mended where torn.

4.3 Debris Present in the Channel

Inspection Form Item 4.3 – Erosion rills or gullies in the grass-lined channel: Tumbleweeds were observed in Channels 24 and 25. Some tumbleweed accumulation was removed by high winds and the remaining tumbleweeds were removed using a deck mower mounted to a skidsteer in June of 2023.

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 the Type II inspection in October of 2022 and April of 2023 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 2023 Vegetation Performance Assessment of the Basin F RCRA-Equivalent Cover was conducted on September 14, 2023 in accordance with SOP 002 of the Basin F PCP. The vegetation community met all three vegetation-related compliance standards (i.e., total absolute live vegetation cover, two-year running average for total absolute ground cover, and three-year running average for total absolute ground cover). Results of the assessment are summarized on Table 6.0-1. Appendix B of this report includes additional tables that provide cover and frequency by species, expanded vegetation performance assessments providing two and three year running average comparisons, sample adequacy checks, and raw transect data. 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.

Five vegetation transects were sampled 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 of this report. 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 not observed using the point-intercept sampling method, were tallied and used to calculate species density (species per 100 square meters).

The Basin F RCRA-Equivalent Cover was seeded in 2009 and continues to maintain a successfully established plant community. Based on the sample data, total absolute mean vegetation cover was 87.2 percent, composed primarily of warm season grass species which is a continued trend observed over the past few years. Cover by warm season species was 44.0 percent which is an increase compared to previous years. In 2013, the lowest amount of cover by warm season species was recorded at only about three percent. Since then, warm season grasses have generally increased in the amount of cover provided. Weedy vegetation contributed a lesser amount to the total for live cover in contrast to previous years. The relative weed cover was 6.42 percent which is lower than the relative allowable weed cover of 10 percent.

Warm season species were prolific and robust at the time the vegetation assessment was conducted. Due to an abundance of precipitation in the spring and summer of 2023, the cool season grasses were larger in stature than they were in previous drought years. 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 in all areas.

6.1 Comparison to the Performance Standard

Total absolute mean vegetation was 87.2 percent. Since the allowable cover by weeds was less than 10 percent, the calculation of allowable total absolute live vegetation cover was not affected by weed fraction, and was therefore determined to be 87.2 percent, which is well above the performance standard of 25 percent. Total absolute ground cover was high at 96.4 percent, and

corresponding bare ground was relatively low at 3.60 percent. Average cover by litter was low at 9.2 percent and did not appear to be inhibiting vegetation production.

The lower percentages for bare soil and litter collected this year may be attributed to the above average precipitation year the RMA experienced. The perennial grasses were more robust than in previous years of vegetation data collection and thus were point-intercepted more frequently.

The two-year running average for total absolute ground cover remained high at 94.16 percent, well above the standard of 50 percent. The three-year running average for total absolute ground cover was 95.44 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 6.42 percent of the total live vegetation was comprised of undesirable annual or biennial species. Therefore, the total absolute live vegetation cover for this reporting year was not reduced to account for the weedy vegetation cover above the 10 percent limit. The total absolute live vegetation cover is 87.2 percent which 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 Basin F PCP SOP 002:

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

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 a N_{min} of 0.67, which is well below the number of samples collected, i.e., 5.

7.0 PERCOLATION MONITORING ASSESSMENT

The Basin F RCRA-Equivalent Cover uses a network of five lysimeters to monitor deep percolation. 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).

Percolation collected by the lysimeters was measured monthly between October of 2022 and July of 2023 when Revision 2 of the Basin F PCP was approved. After the revised PCP was approved the lysimeter measurement schedule was reduced to May, July, September, and

November, of each year. For this reporting period, August of 2023 was the only month in which percolation data were not collected.

The percolation measurements are 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 in nine months, and Table 7.0-3 presents twelve-month rolling totals for comparison to the compliance standard of 1.3 mm in 12 months. 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.

Quarterly submission of percolation monitoring results for all cover lysimeters were issued to the regulatory agencies and included six months of data. Each quarterly submittal included monthly measurements, 9-month cumulative totals, and 12-month cumulative totals. Percolation data for FY23 were transmitted in January (Navarro 2023a), March (Navarro 2023c), June (Navarro 2023e), and September (Navarro 2023f).

8.0 GROUNDWATER MONITORING

This section summarizes the water level monitoring, analytical results, and statistical evaluation of groundwater quality for the 2023 post-closure groundwater monitoring at Basin F. Refer to the *2023 Basin F Post-Closure Groundwater Monitoring Report*, provided in Appendix E of this report 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 network wells are used to monitor groundwater quality in the Unconfined Flow System (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 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 area. 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 evident at the initiation of post-closure groundwater monitoring. Refer to Figure 2-1 in Appendix E for well locations.

8.1 Groundwater Levels

Groundwater levels were measured in January of 2023 in 27 Basin F network wells to evaluate UFS conditions in the area of Basin F. Additional wells used to further delineate the water table in the vicinity were measured during the same time period. Additional information regarding groundwater levels is available in Appendix E of this report.

Similar to previous years, groundwater flow in the vicinity of Basin F is generally to the north. A groundwater divide has become evident as local and regional water levels have decreased, where localized and minor variations occur beneath the north end of Basin F where groundwater flow to the north-northwest and north-northeast beneath the north end of the former 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* (Navarro 2021a). A complete description of the subsurface lithology and groundwater flow in the vicinity of Basin F can be found in the PCGMP.

Water levels measured in the nine Basin F water quality network wells since 2006 are shown on hydrographs in Appendix E of this report. Beginning in 2018, groundwater elevations began to decrease in all wells except well 26128. Groundwater in well 26128 shows an increasing trend from 2014 through 2018, but has decreased since 2019. Water level data for well 26128 appears different from the other wells in the vicinity of Basin F because it is screened deeper within the unweathered Denver Formation. As such, this well does not provide an accurate depiction of the UFS upgradient of Basin F. The overall decrease in UFS water levels in the vicinity of Basin F is consistent with a general decreasing trend noted across RMA over the past several years (Navarro 2021c). Historical changes in water levels in wells near Basin F are consistent with regional fluctuations in the water table and are not related to the performance of the Basin F cover.

8.2 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, and the *Rocky Mountain Arsenal Sampling Quality Assurance Project Plan* (SQAPP) (Navarro 2019). Samples collected during post-closure monitoring were 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. Analytical data for the 11 ICs applicable to the Basin F water quality network wells are presented in Appendix E of this report.

8.3 Basin F WP Well Prediction Limit Exceedances

The 2023 Basin F WP upper prediction limits (UPLs) were applied to data for downgradient wells 26015 and 26017. The 2023 reported values for ICs detected in wells exceeding their respective UPLs are presented in Appendix E of this report. The following analytes were detected at concentrations exceeding their respective UPLs in 2023.

Well 26015	Well 26017
• Chloroform	• Chloroform
	• Dieldrin

The 2023 concentration of chloroform in exceedance of the UPL in well 26015 is within the historical range of detected concentrations, and its presence is likely attributable to higher water levels that have mobilized residual contamination and have remained as the water table has decreased over the past few years.

The 2023 concentrations of chloroform and dieldrin in exceedance of their respective UPLs in well 26017 are also within the historical range of detected concentrations.

The reported concentrations of analytes not listed above and detected in downgradient Basin F WP wells are below the respective UPLs. Based on the UPL comparison, it appears that groundwater quality downgradient of the Basin F WP area has been affected in the vicinity of wells 26015 and 26017.

8.4 Basin F PT Well Prediction Limit Exceedances

The 2023 Basin F PT UPLs were applied to data for downgradient wells 26015, 26133, 26157, 26163 and 26173. The 2023 reported values for ICs detected in wells exceeding their respective UPLs are presented in Appendix E of this report. The following analytes were detected at concentrations exceeding their respective UPLs in 2023.

Well 26133
- Chloroform
- CPMSO2
- DCPD
- Dieldrin
- NNDMEA
- TCLEE

Well 26157
- CPMSO2
- DCPD
- NNDMEA
- TCLEE

Well 26163
- Arsenic
- Chloride
- Copper
- CPMSO2
- DCPD
- DIMP
- NNDMEA
- TCLEE

Well 26173
- Chloroform
- CPMSO2
- DCPD
- NNDMEA
- TCLEE

CPMSO2 - p-Chlorophenylmethyl sulfone
DCPD - Dicyclopentadiene
DIMP - Diisopropylmethyl phosphonate
NNDMEA - n-Nitrosodimethylamine
TCLEE - Tetrachloroethene

The 2023 concentrations of all analytes in exceedance of UPLs in wells 26133, 26157, 26163 and 26173 are within the historical ranges of detected concentrations and many are likely attributable to higher water levels that have mobilized residual contamination. The remaining reported values for analytes not listed above in downgradient Basin F PT wells are below the respective UPLs. Based on the statistical evaluation, it appears that groundwater quality downgradient of the Basin F PT area has been affected in the vicinity of wells 26133, 26157, 26163, and 26173.

In 2023, no analyte concentrations exceeded PT UPLs in downgradient well 26015.

8.5 Groundwater Monitoring Conclusions

Groundwater along the PT flow path appears to have been impacted by residual soil contamination that remains within the PT area and may also be impacted by sources associated with the Sand Creek Lateral located east of the former basin, as demonstrated by observed increases of select ICs in wells northeast of the PT area. Several ICs exceed UPLs—including arsenic, chloride, chloroform, copper, CPMSO2, DCPD, dieldrin, DIMP, NNDMEA, and TCLEE—and appear to be increasing in one or more downgradient wells.

To a lesser extent as compared to the PT area, groundwater along the WP flow path appears to have been impacted by residual soil contamination that remains within western portion of the Basin F area. Chloroform in downgradient well 26015 exceeded the UPL and concentrations

appear to be increasing based on the Mann-Kendall trend analysis. Chloroform and dieldrin in downgradient well 26017 exceeded their respective UPLs, however Mann-Kendall analysis indicated no discernible trend for either analyte.

Based on the distribution of the analyte concentrations and water quality trends, it appears that the PT groundwater flow path is having a greater impact on water quality downgradient of the former Basin F compared to the WP flow path. While concentrations of ICs less frequently exceed UPLs, with many ICs demonstrating decreasing trends, concentrations downgradient of the PT indicate an impact due to contaminated groundwater migrating from upgradient sources and/or residual contamination within the unsaturated zone beneath the Basin F PT area.

8.6 Basin F Groundwater Monitoring Program Optimization

The Army began evaluating the Basin F post-closure groundwater monitoring approach in FY21 in response to the regulatory agencies' concerns regarding groundwater quality in the Basin F PT flow path. The evaluation led to changes in the statistical evaluation process that were captured in OCN-BASINF-2022-001 (Navarro 2022), which was approved by the regulatory agencies in June of 2022.

The Army and regulatory agencies also agreed that a complete evaluation of the Basin F groundwater monitoring program is warranted. The agreement led to the preparation of the *Optimization Plan for the Basin F Post-Closure Groundwater Monitoring Network,* Revision 1 (Navarro 2023b) in July of 2022. The plan provides the rationale to optimize the Basin F groundwater monitoring network, and tasks described in the plan form the basis for an optimization monitoring program that will support any revisions recommended for the groundwater monitoring network. Eight wells were installed in September of 2022 to support the network optimization, and sampling will be initiated shortly thereafter. If warranted, the Basin F groundwater monitoring program will be revised in Fiscal Year 2026.

9.0 ROUTINE AND NON-ROUTINE ACTIONS

9.1 Routine Actions

Routine maintenance and repairs were performed on the Basin F AMA and were intended to ensure that the cover continues to function as designed. Routine maintenance and repair actions discussed in Section 4.0 of this report were identified during inspections and during normal field activities. Figure 4.0-1 illustrates the locations of routine maintenance and repair activities performed on Basin F. Appendix D of this report 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 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 non-routine actions performed and no NRAPs prepared during this reporting period.

10.0 RECOMMENDATIONS AND CORRECTIVE MEASURES

Routine inspections and maintenance of the Basin F AMA will continue throughout FY24 in accordance with the requirements of the Basin F PCP. In addition to routine maintenance activities, the Army recommends a prescribed burn of the Basin F AMA in the fall of 2023 or spring of 2024. A prescribed burn will be beneficial to the health of established native perennial grasses and will remove litter left behind after the robust growth of vegetation. This recommendation will be discussed in the 2024 Basin F CGMR.

No corrective measures are currently planned for FY24.

11.0 FY23 COSTS AND FY24 BUDGETS

Cost incurred performing post-closure care of the Basin F AMA during FY23, including inspections, repairs, maintenance, groundwater monitoring, and groundwater sampling described in the *Optimization Plan for the Basin F Post-Closure Groundwater Monitoring Network*, Revision 1 (Navarro 2023b) was $210,560. A complete budget for FY24 has not been approved as of the issuance of this report. However, the FY24 budget for work required under the Basin PCP and *Optimization Plan for the Basin F Post-Closure Groundwater Monitoring Network* is estimated to be approximately $230,000.

12.0 REFERENCES

Navarro (Navarro Research and Engineering, Inc.)

2023a (Jan 3) *Rocky Mountain Arsenal Integrated Cover System and Basin F Cover Lysimeter Monitoring Data, July 2022 through December 2022.*

2023b (Mar 2) *Optimization Plan for the Basin F Post-Closure Groundwater Monitoring Network,* Revision 1.

2023c (Mar 22) *Rocky Mountain Arsenal Integrated Cover System and Basin F Cover Lysimeter Monitoring Data, October 2022 through March 2023.*

2023d (Apr 10) *Basin F Post-Closure Plan.* Revision 2.

2023e (Jun 28) *Rocky Mountain Arsenal Integrated Cover System and Basin F Cover Lysimeter Monitoring Data, January 2023 through June 2023*.

2023f (Sep 11) *Rocky Mountain Arsenal Integrated Cover System and Basin F Cover Lysimeter Monitoring Data, April 2023 through September 2023*.

2022 (May 18) *OCN-BASINF-2022-001*.

2021a (May 27) *Long-Term Monitoring Plan for Groundwater and Surface Water*. Revision 1.

2021b (Jul 14) *OCN-BASINF-2021-001*.

2021c (Jul 21) *Fiscal Year 2020 Annual Summary and Five-Year Summary Report for Groundwater and Surface Water.* Revision 0.

2021d (Aug 12) *RCRA-Equivalent, 2-, and 3-Foot Covers Long-Term Care Plan*. Revision 3.

2019 (Jan 30) *Rocky Mountain Arsenal Sampling Quality Assurance Project Plan Final.*

TABLES

Table 5.0-1: Soil Cover Thickness Loss

Basin F Monument No.	Measurement (in.) October 11, 2022	Measurement (in.) April 12, 2023	Change (in.)
ER92	0.00	0.00	0.00
ER93	0.00	0.00	0.00
ER94	0.00	0.00	0.00
ER95	0.00	0.00	0.00
ER96	0.00	0.00	0.00
ER97	0.25	0.00	-0.25
ER98	0.00	0.00	0.00
ER99	0.50	0.50	0.00
ER100	0.00	0.00	0.00
ER101	0.75	0.50	-0.25
ER102	0.25	0.00	-0.25
ER103	0.00	0.00	0.00
ER104	1.50	1.75	0.25
ER105	0.00	0.00	0.00
ER106	0.00	0.00	0.00
ER107	0.25	0.50	0.25
ER108	0.00	0.00	0.00
ER109	0.00	0.00	0.00

Table 6.0-1: 2023 Vegetation Performance Assessment Summary

Performance Criterion and Evaluation	Basin F Cover
Total Absolute Ground Cover	96.40%
Allowable Total Absolute Live Vegetation Cover	**87.20%**
Vegetation Performance Standard for Total Live Vegetation	≥ 25%
Is Vegetation Performance Standard met?	Yes
Two Year Running Average for Total Absolute Ground Cover	**94.16%**
Vegetation Performance Standard for Two Year Running Average	≥ 50%
Is Vegetation Performance Standard met?	Yes
Three Year Running Average for Total Absolute Ground Cover	**95.44%**
Vegetation Performance Standard for Three Year Running Average	≥ 67%
Is Vegetation Performance Standard met?	Yes
Relative Weed Cover	**6.42%**
Relative Allowable Weed Cover	≤ 10%
Calculate Total Live Vegetation without the weed fraction?	Yes (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 (Liters)											
	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23[1]	Sep-23
Lysimeter 016	0	0	0	0	0	0	0	0	0	0		0
Lysimeter 017	0	0	Trace	Trace	0	0	0	0	0	0		0
Lysimeter 018	0	0	Trace	Trace	0	0	0	0	0	0		0
Lysimeter 019	Trace	0	0	0	0	0	0	0	0	0		0
Lysimeter 020	0	0	0	0	0	Trace	0	0	0	0		0

Note 1: The Basin F Post-Closure Plan, Revision 2 was approved on July 26, 2023. This revised plan changed the inspection frequency of Lysimeters 016 through 020 to May, July, September, and November.

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Table 7.0-2: Rolling Nine-Month Percolation Totals

Lysimeter No.	Rolling Nine-Month Percolation Total (mm)											
	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23
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-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23
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

FIGURES

Figure 3.1-1: Average Monthly Temperature for FY23

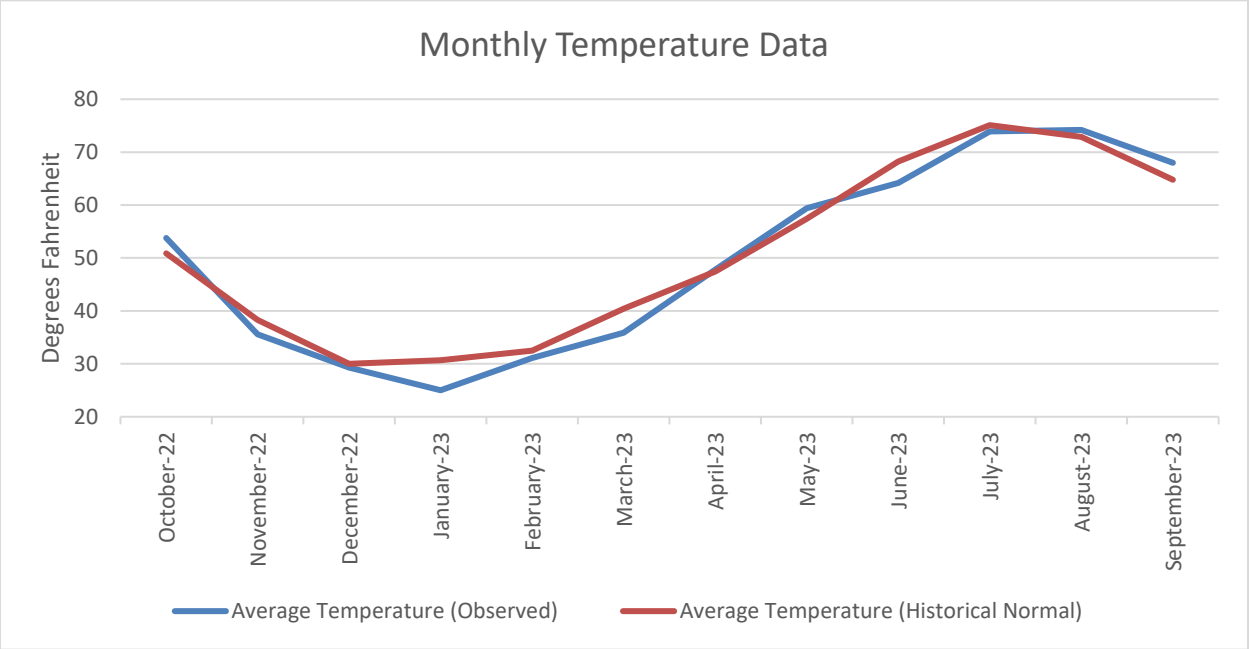
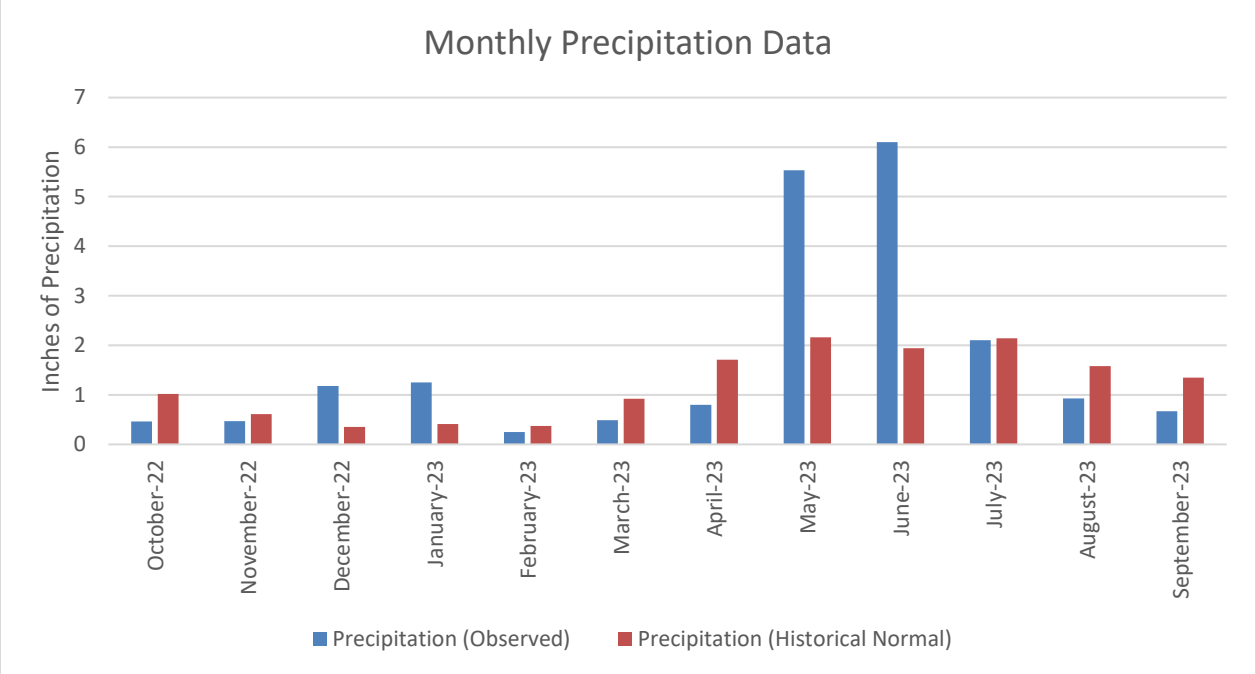
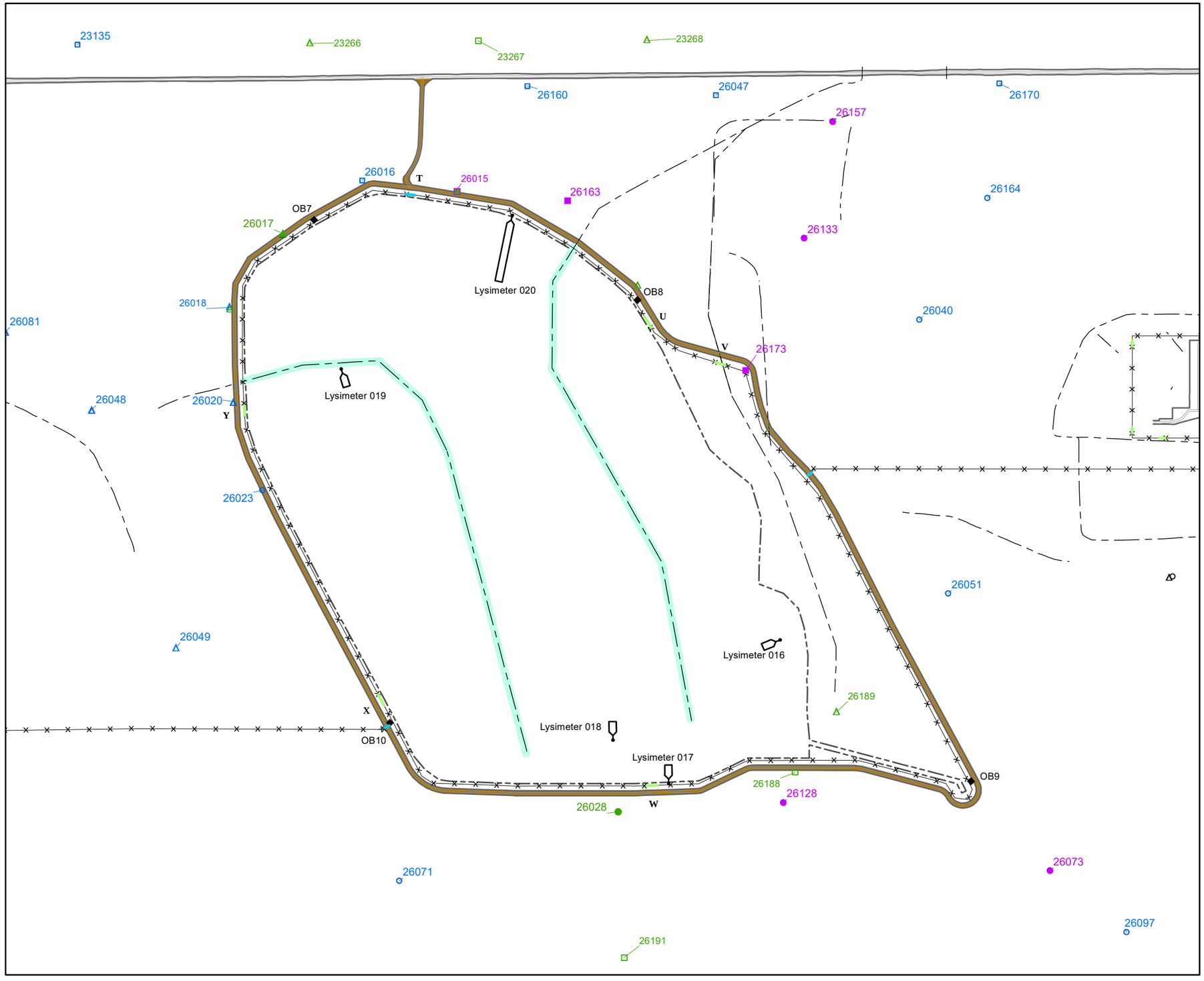


Figure 3.1-2: Average Monthly Precipitation for FY23





Legend

- Cover Boundary
- Perimeter Access Road
- Fence
- Cattle Guard
- Gate
- Lysimeter
- Channel Flow Line
- Obelisk
- Removed Debris Present In Channel
- Ground Clear Herbicide Application Area
- T — Labeled Gates and Cattle Guards

Note 1. The outside shoulder of the Perimeter Access Road defines the Army Maintained Area Boundary (AMA).
Note 2. Tumbleweeds were removed from the Perimeter Fence.
Note 3: Posts and fence fabric were repaired along the perimeter fence where necessary.

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

N

0 160 320 640 Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone
Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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Figure 4.0-1

2023 Basin F
Routine Maintenance Activities

BasinF_RoutineMaintenanceActivities_Nov2023.mxd
11/2/2023

APPENDICES

A Precipitation Data (October 1, 2022 through September 30, 2023)

B 2023 Vegetation Performance Assessment Documentation

C Cover Inspection Documentation (October 1, 2022 through September 30, 2023)

D Maintenance and Repair Documentation (October 1, 2022 through September 30, 2023)

E 2023 Basin F Post-Closure Groundwater Monitoring Report

APPENDIX A

Precipitation Data

(October 1, 2022 through September 30, 2023)

Appendix A: Precipitation Data (October 1, 2022 through September 30, 2023)

Note 1: This table provides precipitation data for all dates when precipitation was recorded. For dates not shown, there was no recorded precipitation.

Note 2: The yellow highlighted boxes indicate that there was more than one inch of precipitation in a 24-hour period.

Date	Lime Basins Daily Precipitation (in.)
October 1, 2022	0.03
October 3, 2022	0.55
October 27, 2022	0.25
November 3, 2022	0.02
November 4, 2022	0.05
November 15, 2022	0.09
November 17, 2022	0.01
November 18, 2022	0.05
November 19, 2022	0.01
November 29, 2022	0.04
December 21, 2022	0.03
December 22, 2022	0.01
December 24, 2022	0.25
December 28, 2022	0.19
December 29, 2022	0.22
December 30, 2022	0.06
December 31, 2022	0.14
January 2, 2023	0.09
January 3, 2023	0.04
January 18, 2023	0.18
January 19, 2023	0.03
January 20, 2023	0.02
January 21, 2023	0.01
January 22, 2023	0.04
January 23, 2023	0.04
January 24, 2023	0.04
January 26, 2023	0.01
February 15, 2023	0.01
February 16, 2023	0.06
February 17, 2023	0.07
February 22, 2023	0.02
March 15, 2023	0.12
March 16, 2023	0.07
April 15, 2023	0.12
April 16, 2023	0.01
April 20, 2023	0.02
April 22, 2023	0.06
April 23, 2023	0.09
April 26, 2023	0.19
April 27, 2023	0.05

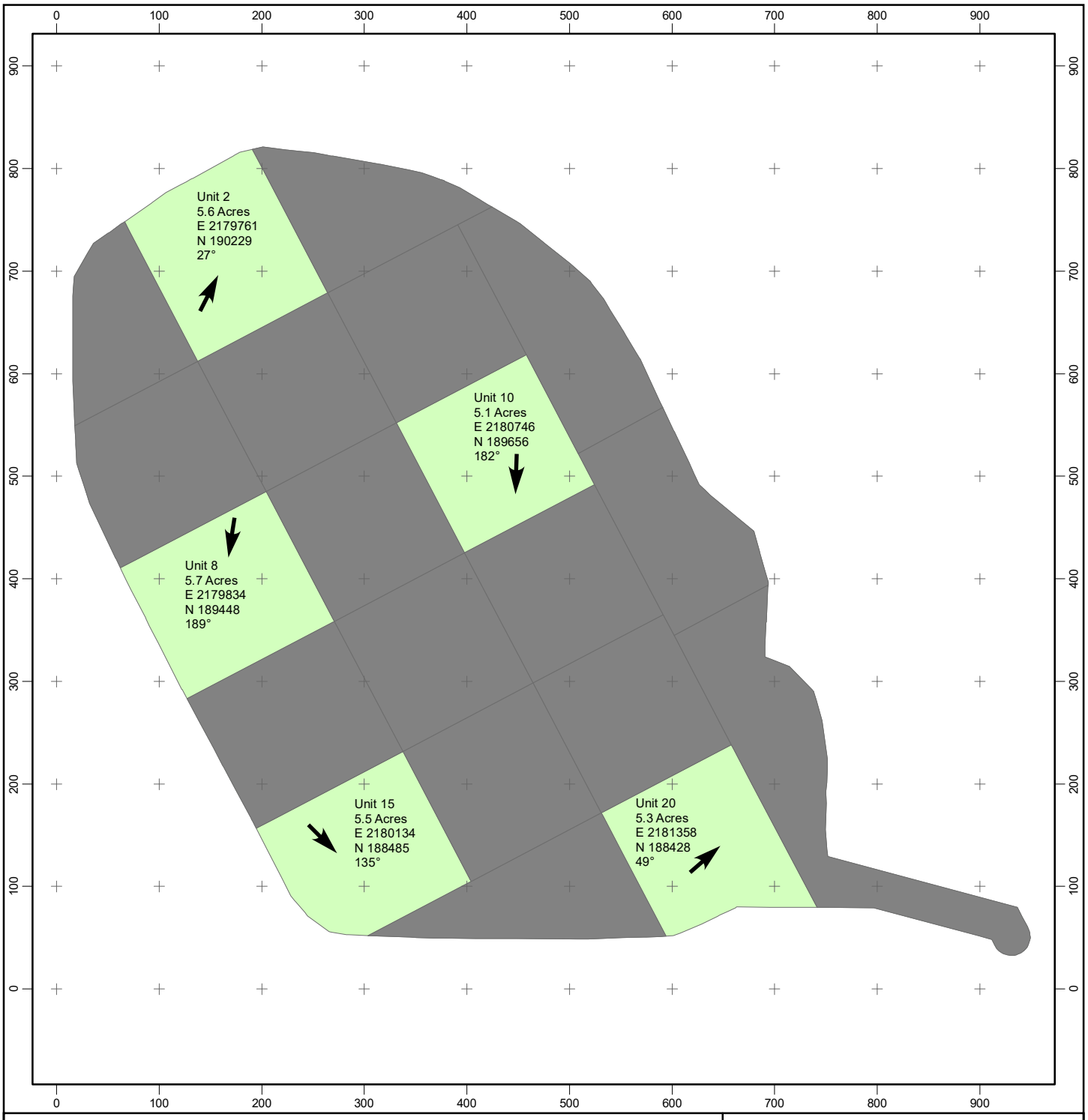
Date	Lime Basins Daily Precipitation (in.)
April 28, 2023	0.21
April 29, 2023	0.01
May 10, 2023	0.01
May 11, 2023	0.62
May 12, 2023	2.92
May 13, 2023	0.85
May 15, 2023	0.28
May 16, 2023	0.02
May 17, 2023	0.22
May 19, 2023	0.14
May 20, 2023	0.01
May 26, 2023	0.11
May 27, 2023	0.37
May 28, 2023	0.42
June 3, 2023	0.46
June 4, 2023	0.24
June 5, 2023	1.23
June 6, 2023	0.05
June 7, 2023	0.01
June 9, 2023	0.99
June 10, 2023	0.01
June 12, 2023	0.14
June 13, 2023	0.09
June 14, 2023	0.03
June 16, 2023	0.40
June 17, 2023	0.26
June 18, 2023	0.01
June 22, 2023	0.62
June 23, 2023	0.15
June 30, 2023	0.63
July 1, 2023	0.21
July 5, 2023	0.91
July 6, 2023	0.07
July 7, 2023	0.01
July 8, 2023	0.08
July 9, 2023	0.03
July 15, 2023	0.21
July 19, 2023	0.06
July 21, 2023	0.53
July 22, 2023	0.11

Appendix A: Precipitation Data (October 1, 2022 through September 30, 2023)

Date	Lime Basins Daily Precipitation (in.)
July 25, 2023	0.36
July 26, 2023	0.07
July 27, 2023	0.43
July 29, 2023	0.01
August 1, 2023	0.12
August 2, 2023	0.03
August 3, 2023	0.50
August 4, 2023	0.30
August 7, 2023	0.02
August 20, 2023	0.20
August 21, 2023	0.01
August 26, 2023	0.62
August 28, 2023	0.20
August 29, 2023	0.01
September 4, 2023	0.27
September 5, 2023	0.01
September 11, 2023	0.09
September 12, 2023	0.12
September 15, 2023	0.26
September 16, 2023	0.17
Total:	**20.92**

APPENDIX B

2023 Vegetation Performance Assessment Documentation



Legend

- Non-Sampled Unit
- Sampled Unit
- Transect Location and Bearing

N

100 meter grid shown for reference
Coordinates are listed in
Colorado State Plane
North Zone (NAD 1927)

0 25 50 100 150 200

Meters

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Appendix B, Figure 1

Basin F Cover
(103.25 Acres)
2023 Random Transect
Survey Locations

M:\projects\OMC\Vegetation\mxds\BasinF_2023.mxd
8/28/2023


Basin F
Unit 2


Basin F
Unit 8


Basin F
Unit 10


Basin F
Unit 15


Basin F
Unit 20

Table 6.1.1

Cover and Frequency summary for the Basin F at Rocky Mountain Arsenal. Based on data from 5 sampling locations. 2023 data. +/- values equal the standard deviation. Incidental Species present within 1 meter on either side of the data transect, but not quantitatively encountered.

2023

Species	Mean Cover (%)	Relative Cover (%)	Range of Cover Values (%)	Percent Frequency (%)	Relative Frequency(%)	[2]Rank
COOL SEASON PERENNIAL GRASSES						
Hesperostipa comata	1.0	1.15	0 - 4.00	40.0	5.0	9.0
Pascopyrum smithii	32.6	37.39	13.00 - 57.00	100.0	12.5	1.0
Sub-Total	33.6	38.54				
WARM SEASON PERENNIAL GRASSES						
Bouteloua curtipendula	9.6	11.01	0 - 18.00	80.0	10.0	4.0
Buchloe dactyloides	11.2	12.84	0 - 27.00	80.0	10.0	3.0
Chondrosum gracile	18.0	20.64	6.00 - 26.00	100.0	12.5	2.0
Sporobolus airoides	1.8	2.06	0 - 6.00	60.0	7.5	8.0
Sporobolus cryptandrus	3.4	3.9	1.00 - 9.00	100.0	12.5	5.0
Sub-Total	44.0	50.45				
INTRODUCED PERENNIAL GRASSES						

Psathyrostachys juncea	0.4	.46	0 - 2.00	20.0	2.5	10.0
Sub-Total	.4	.46				
ANNUAL GRASSES						
Panicum capillare	1.8	2.06	0 - 9.00	20.0	2.5	8.0
Sub-Total	1.8	2.06				
ANNUAL AND BIENNIAL FORBS						
[1] Bassia sieversiana	2.6	2.98	0 - 5.00	80.0	10.0	7.0
Descurainia incana	1.8	2.06	0 - 9.00	20.0	2.5	8.0
[1] Melilotus officinale	0.2	.23	0 - 1.00	20.0	2.5	11.0
[1] Salsola collina	2.8	3.21	0 - 9.00	80.0	10.0	6.0
Sub-Total	7.4	8.48				
SUM OF SPECIES COVER	87.2	99.99				

[3]Total Absolute Mean Vegetation Cover	87.20	+/-3.19
[3]Total Absolute Mean Litter Cover	9.20	+/-1.70
[3]Total Absolute Mean Bare Soil	3.60	+/-2.20
[3]Total Absolute Mean Weedy Cover	5.60	+/-3.44
Total Absolute Ground Cover	96.40	+/-2.20
Relative Weed Cover	6.42	
Relative Allowable Weed Cover	10.0	
Relative Non-Allowable Cover by Weeds	0.00	
Non-Allowable Absolute Weedy Cover	0.00	

Incidental Species
i.e < 0.01 Mean Cover

Bassia sieversiana
Bromus tectorum
Descurainia incana
Eragrostis cilianensis
Helianthus annuus
Hesperostipa comata
Lactuca serriola
Machaeranthera canescens

Allowable Total Absolute Live Vegetation Cover	87.20	
Mean Number of Species/Sample	8	
Mean Species Density/100sq. meters	12.00	+/-1.33

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[1] Weedy Species

[2] Based on total cover

[3] Based on 1st hit data

Machaeranthera tanacetifolia
Panicum capillare
Salsola collina
Solanum rostratum
Tragopogon dubius
Ximenesia encelioides

Table 6.1.2 **Vegetation Performance Assessment**
Basin F
Reporting Years 2021, 2022, 2023 **2023**

Reporting Year: 2021

Species	Mean Cover (%)	Relative Cover (%)	Range of Cover Values (%)	Percent Frequency (%)	Relative Frequency(%)	[2]Rank
COOL SEASON PERENNIAL GRASSES						
Hesperostipa comata	0.20	.32	0 - 1.00	20.00	2.16	11
Pascopyrum smithii	15.53	24.91	3.00 - 46.00	100.00	10.79	1
Sub-Total	15.73	25.23				
WARM SEASON PERENNIAL GRASSES						
Bouteloua curtipendula	5.33	8.55	0 - 12.00	80.00	8.63	6
Buchloe dactyloides	6.47	10.38	0 - 20.00	93.33	10.07	3
Chondrosum gracile	12.53	20.10	1.00 - 21.00	100.00	10.79	2
Sporobolus airoides	5.67	9.10	0 - 18.00	80.00	8.63	4
Sporobolus cryptandrus	3.13	5.02	0 - 13.00	80.00	8.63	8
Sub-Total	33.13	53.15				
INTRODUCED PERENNIAL GRASSES						

Agropyron cristatum	0.07	.11	0 - 1.00	6.67	.72	13
[1] Bromopsis inermis	0.13	.21	0 - 1.00	13.33	1.44	12
Psathyrostachys juncea	0.07	.11	0 - 1.00	6.67	.72	13
Sub-Total	0.27	0.43				
ANNUAL GRASSES						
Eragrostis cilianensis	0.20	.32	0 - 2.00	13.33	1.44	11
Panicum capillare	1.60	2.57	0 - 5.00	73.33	7.91	9
Sub-Total	1.80	2.89				
ANNUAL AND BIENNIAL FORBS						
[1] Bassia sieversiana	5.53	8.87	0 - 12.00	93.33	10.07	5
Chenopodium leptophyllum	0.07	.11	0 - 1.00	6.67	.72	13
Descurainia incana	0.13	.21	0 - 2.00	6.67	.72	12
[1] Lactuca serriola	0.07	.11	0 - 1.00	6.67	.72	13
[1] Salsola collina	4.93	7.91	2.00 - 11.00	100.00	10.79	7
[1] Sisymbrium altissimum	0.40	.64	0 - 4.00	20.00	2.16	10
Solanum triflorum	0.13	.21	0 - 1.00	13.33	1.44	12
Tragopogon dubius	0.07	.11	0 - 1.00	6.67	.72	13
Ximenesia encelioides	0.07	.11	0 - 1.00	6.67	.72	13
Sub-Total	11.40	18.28				
SUM OF SPECIES COVER	62.33	100.0				

CRITERIA ASSESSMENT

Total Absolute Cover	98.00
Allowable Total Absolute Live Vegetation Cover 2021	57.50

Reporting Year: 2022

Species	Mean Cover (%)	Relative Cover (%)	Range of Cover Values (%)	Percent Frequency (%)	Relative Frequency(%)	[2]Rank
COOL SEASON PERENNIAL GRASSES						
Hesperostipa comata	1.47	2.06	0 - 8.00	53.33	5.71	10
Pascopyrum smithii	15.60	21.87	0 - 32.00	93.33	10.00	2
Pascopyrum smithii	1.60	2.24	0 - 24.00	6.67	.71	9
Sub-Total	18.67	26.17				
WARM SEASON PERENNIAL GRASSES						
Bouteloua curtipendula	7.13	10.00	2.00 - 16.00	100.00	10.71	4
Buchloe dactyloides	10.27	14.40	3.00 - 24.00	100.00	10.71	3
Chondrosum gracile	15.87	22.25	6.00 - 32.00	100.00	10.71	1
Sporobolus airoides	3.47	4.86	0 - 9.00	86.67	9.29	8

Sporobolus cryptandrus	3.60	5.05	0 - 8.00	93.33	10.00	7
Sub-Total	40.34	56.56				
ANNUAL GRASSES						
[1] Bromus tectorum	0.07	.10	0 - 1.00	6.67	.71	13
Sub-Total	0.07	0.10				
ANNUAL AND BIENNIAL FORBS						
Amaranthus arenicola	0.73	1.02	0 - 2.00	60.00	6.43	12
[1] Bassia sieversiana	3.67	5.14	0 - 10.00	93.33	10.00	6
[1] Salsola collina	6.67	9.35	2.00 - 18.00	100.00	10.71	5
[1] Sisymbrium altissimum	1.20	1.68	0 - 10.00	40.00	4.29	11
Sub-Total	12.27	17.19				
SUM OF SPECIES COVER	71.35	100.0				

CRITERIA ASSESSMENT

Total Absolute Cover	91.93
Allowable Total Absolute Live Vegetation Cover 2022	66.87

Reporting Year: 2023

Species	Mean Cover (%)	Relative Cover (%)	Range of Cover Values (%)	Percent Frequency (%)	Relative Frequency(%)	[2]Rank
COOL SEASON PERENNIAL GRASSES						
Hesperostipa comata	1.00	1.15	0 - 4.00	40.00	5.00	9
Pascopyrum smithii	32.60	37.39	13.00 - 57.00	100.00	12.50	1
Sub-Total	33.60	38.54				
WARM SEASON PERENNIAL GRASSES						
Bouteloua curtipendula	9.60	11.01	0 - 18.00	80.00	10.00	4
Buchloe dactyloides	11.20	12.84	0 - 27.00	80.00	10.00	3
Chondrosum gracile	18.00	20.64	6.00 - 26.00	100.00	12.50	2
Sporobolus airoides	1.80	2.06	0 - 6.00	60.00	7.50	8
Sporobolus cryptandrus	3.40	3.90	1.00 - 9.00	100.00	12.50	5
Sub-Total	44.00	50.45				
INTRODUCED PERENNIAL GRASSES						
Psathyrostachys juncea	0.40	.46	0 - 2.00	20.00	2.50	10
Sub-Total	0.40	0.46				
ANNUAL GRASSES						
Panicum capillare	1.80	2.06	0 - 9.00	20.00	2.50	8
Sub-Total	1.80	2.06				

ANNUAL AND BIENNIAL FORBS						
[1] Bassia sieversiana	2.60	2.98	0 - 5.00	80.00	10.00	7
Descurainia incana	1.80	2.06	0 - 9.00	20.00	2.50	8
[1] Melilotus officinale	0.20	.23	0 - 1.00	20.00	2.50	11
[1] Salsola collina	2.80	3.21	0 - 9.00	80.00	10.00	6
Sub-Total	7.40	8.48				
SUM OF SPECIES COVER	87.20	100.0				

CRITERIA ASSESSMENT

Total Absolute Cover	96.40
Allowable Total Absolute Live Vegetation Cover 2023	87.20
Two year running average for Total Absolute Cover	94.16
Three year running average for Total Absolute Cover	95.44

[1] Weedy Species

[2] Based on total cover

[3] Based on 1st hit data

Table 6.1.3

Sample Adequacy Check

2023

Basin F

Year : 2023

Transect	Hits
02 :	88
08 :	82
10 :	90
15 :	93
20 :	83

Sample Adequacy = 0.67

(Mean value: 87.2, Sample Variance: 4.66, One Tailed Value: 1.533)

Table 6.1.4 - Basin F Cover
Raw Data Report

Sampled by: Kimberly Hoffman
Sample Date(s): 9/14/2023

1 - Only plant species that were hit or observed along the transect are recorded in this table.
Blank boxes indicate the species was not present on the transect.
2 - Species with cover values of 0.1 were species observed within the 100 meter zone associated with each transect, but not recorded in the quantitative data collection for each transect.
3 - # of species/100sq meter zone

SPECIES/Other	Transects				
	02	08	10	15	20
BARE SOIL	5.0	8.0	1.0		4.0
LITTER	7.0	10.0	9.0	7.0	13.0
BASSIA SIEVERSIANA	5.0	0.1	5.0	2.0	1.0
BOUTELOUA CURTIPENDULA		18.0	14.0	2.0	14.0
BROMUS TECTORUM	0.1				0.1
BUCHLOE DACTYLOIDES		27.0	9.0	4.0	16.0
CHONDROSUM GRACILE	6.0	19.0	19.0	26.0	20.0
DESCURAINIA INCANA		0.1	9.0		0.1
ERAGROSTIS CILIANENSIS				0.1	
HELIANTHUS ANNUUS		0.1		0.1	
HESPEROSTIPA COMATA		1.0	0.1	4.0	
LACTUCA SERRIOLA	0.1		0.1		
MACHAERANTHERA CANESCENS			0.1		
MACHAERANTHERA TANACETIFOLIA				0.1	
MELILOTUS OFFICINALE		1.0			
PANICUM CAPILLARE	9.0		0.1	0.1	0.1
PASCOPYRUM SMITHII	57.0	13.0	32.0	36.0	25.0
PSATHYROSTACHYS JUNCEA				2.0	
SALSOLA COLLINA	9.0	0.1	1.0	2.0	2.0
SOLANUM ROSTRATUM			0.1		
SPOROBOLUS AIROIDES		1.0		6.0	2.0
SPOROBOLUS CRYPTANDRUS	2.0	2.0	1.0	9.0	3.0
TRAGOPOGON DUBIUS		0.1			0.1

XIMENESIA ENCELIOIDES	0.1				
Total Hits plus Incidental Species:	**100.3**	**100.5**	**100.5**	**100.4**	**100.4**
Species Density:	**9**	**13**	**13**	**14**	**12**

[3] Sample Mean: 12.2, Variance: 1.92

APPENDIX C

Cover Inspection Documentation

(October 1, 2022 through September 30, 2023)

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspector Name(s): M. Jones, K. Hoffman, V. Stewart **Inspection Date(s):** 10-11-22

Conditions:
Previous 24-Hour Precipitation: Ø Weather Conditions: sunny, calm winds, 70s Acceptable/Unacceptable for Inspection ***(circle one)***

INSPECTION ITEM	CONDITION IS PRESENT Y	N	N/A	REPEAT OR CHRONIC CONDITION Y	N	N/A	OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
1.0 Percolation Collection Manhole (PCM) Condition								
1.1 Damage to the PCM or internal components		✓				✓	none	
1.2 Accumulation of a quantity of water greater than that caused by natural condensation in the manhole		✓				✓	none	
1.3 If the water level observed in the PCM impacts the ability to measure percolation, remove water accumulated in the PCM, and record the quantity here. Quantity removed from the PCM (liters): Ø								

2.0 Percolation Collection

Lysimeter Number	Measured Water Volume (liter)
016	Ø
017	Ø
018	Ø
019	trace
020	Ø

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspection Notes: For areas with deficiencies, provide identifying labels for deficient areas, descriptions of deficiencies, approximate dimensions of the areas, locations, and photographs. Provide attachments as appropriate.

lysimeters 016, 017, and 019 would benefit to have the standing water pumped from inside the manhole.

Inspector		
Name: Kim Hoffman	**Signature:** Kim Hoffman	**Date:** 10-11-22
Cover Manager Review of Inspection Documentation		
Name: Michael W. Jones	**Signature:** Michael W. Jones	**Date:** 11/4/22
Cover Manager Confirmation of Completed Actions		
Name: N/A	**Signature:** N/A	**Date:** N/A

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspector Name(s): M. Jones, K. Hoffman | **Inspection Date(s):** 11-2-22

Conditions:
Previous 24-Hour Precipitation: Ø | Weather Conditions: sunny, calm winds, 50's | Acceptable/Unacceptable for Inspection ***(circle one)***

INSPECTION ITEM	CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
	Y	N	N/A	Y	N	N/A		
1.0 Percolation Collection Manhole (PCM) Condition								
1.1 Damage to the PCM or internal components		✓				✓	none	
1.2 Accumulation of a quantity of water greater than that caused by natural condensation in the manhole		✓				✓	none	
1.3 If the water level observed in the PCM impacts the ability to measure percolation, remove water accumulated in the PCM, and record the quantity here. Quantity removed from the PCM (liters): Ø								

2.0 Percolation Collection

Lysimeter Number	Measured Water Volume (liter)
016	Ø
017	Ø
018	Ø
019	Ø
020	Ø

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspection Notes: For areas with deficiencies, provide identifying labels for deficient areas, descriptions of deficiencies, approximate dimensions of the areas, locations, and photographs. Provide attachments as appropriate.

lysimeters 016 and 019 would benefit to have the standing water pumped from inside the manhole.

Inspector		
Name: Kim Hoffman	**Signature:** Kim Hoffman	**Date:** 11-2-22
Cover Manager Review of Inspection Documentation		
Name: Michael W. Jones	**Signature:** Michael W. Jones	**Date:** 11/4/22
Cover Manager Confirmation of Completed Actions		
Name: N/A	**Signature:** N/A	**Date:** N/A

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspector Name(s): M. Jones, K. Hoffman **Inspection Date(s):** 12-7-22

Conditions:
Previous 24-Hour Precipitation: Ø Weather Conditions: sunny, calm winds, 30's Acceptable/Unacceptable for Inspection ***(circle one)***

INSPECTION ITEM	CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
	Y	N	N/A	Y	N	N/A		
1.0 Percolation Collection Manhole (PCM) Condition								
1.1 Damage to the PCM or internal components		✓				✓	none	
1.2 Accumulation of a quantity of water greater than that caused by natural condensation in the manhole		✓				✓	none	
1.3 If the water level observed in the PCM impacts the ability to measure percolation, remove water accumulated in the PCM, and record the quantity here. Quantity removed from the PCM (liters): Ø								

2.0 Percolation Collection

Lysimeter Number	Measured Water Volume (liter)
016	Ø
017	trace
018	trace
019	Ø
020	Ø

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspection Notes: For areas with deficiencies, provide identifying labels for deficient areas, descriptions of deficiencies, approximate dimensions of the areas, locations, and photographs. Provide attachments as appropriate.

lysimeters 016 and 019 would benefit to have the standing water removed from inside the manhole.

Inspector		
Name: Kim Hoffman	**Signature:** Kim Hoffman	**Date:** 12-7-22
Cover Manager Review of Inspection Documentation		
Name: Michael W. Jones	**Signature:** Michael W. Jones	**Date:** 12/14/22
Cover Manager Confirmation of Completed Actions		
Name: N/A	**Signature:** N/A	**Date:** N/A

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspector Name(s): M. Jones, K. Hoffman, V. Stewart

Inspection Date(s): 1-11-23

Conditions:
Previous 24-Hour Precipitation: Ø Weather Conditions: snowing, 30's, calm wind Acceptable/Unacceptable for Inspection ***(circle one)***

INSPECTION ITEM	CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
	Y	N	N/A	Y	N	N/A		
1.0 Percolation Collection Manhole (PCM) Condition								
1.1 Damage to the PCM or internal components		✓				✓	none	
1.2 Accumulation of a quantity of water greater than that caused by natural condensation in the manhole		✓				✓	none	
1.3 If the water level observed in the PCM impacts the ability to measure percolation, remove water accumulated in the PCM, and record the quantity here. Quantity removed from the PCM (liters): Ø								

2.0 Percolation Collection

Lysimeter Number	Measured Water Volume (liter)
016	Ø
017	trace
018	trace
019	Ø
020	Ø

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspection Notes: For areas with deficiencies, provide identifying labels for deficient areas, descriptions of deficiencies, approximate dimensions of the areas, locations, and photographs. Provide attachments as appropriate.

lysimeters 016 and 019 would benefit to have the standing water pumped from inside the manhole.

Inspector		
Name: Kim Hoffman	**Signature:** Kim Hoffman	**Date:** 1-12-23
Cover Manager Review of Inspection Documentation		
Name: Michael W. Jones	**Signature:**	**Date:** 1/23/23
Cover Manager Confirmation of Completed Actions		
Name: N/A	**Signature:** N/A	**Date:** N/A

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspector Name(s): M. Jones, K. Hoffman, V. Stewart **Inspection Date(s):** 2-1-23

Conditions:
Previous 24-Hour Precipitation: Ø Weather Conditions: sunny, calm winds, upper teens Acceptable/Unacceptable for Inspection ***(circle one)***

INSPECTION ITEM	CONDITION IS PRESENT Y	N	N/A	REPEAT OR CHRONIC CONDITION Y	N	N/A	OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
1.0 Percolation Collection Manhole (PCM) Condition								
1.1 Damage to the PCM or internal components		✓				✓	none	
1.2 Accumulation of a quantity of water greater than that caused by natural condensation in the manhole		✓				✓	none	
1.3 If the water level observed in the PCM impacts the ability to measure percolation, remove water accumulated in the PCM, and record the quantity here. Quantity removed from the PCM (liters): Ø								

2.0 Percolation Collection	
Lysimeter Number	**Measured Water Volume (liter)**
016	Ø
017	Ø
018	Ø
019	Ø
020	Ø

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspection Notes: For areas with deficiencies, provide identifying labels for deficient areas, descriptions of deficiencies, approximate dimensions of the areas, locations, and photographs. Provide attachments as appropriate.

lysimeters 016, 017, and 019 would benefit to have the standing water removed from inside the manhole.

Inspector		
Name: Kim Hoffman	**Signature:** Kim Hoffman	**Date:** 2-1-23
Cover Manager Review of Inspection Documentation		
Name: Michael W. Jones	**Signature:** Michael W. Jones	**Date:** 2/13/23
Cover Manager Confirmation of Completed Actions		
Name: N/A	**Signature:** N/A	**Date:** N/A

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspector Name(s): M. Jones, K. Hoffman, V. Stewart **Inspection Date(s):** 3-1-23

Conditions:
Previous 24-Hour Precipitation: Ø Weather Conditions: overcast, calm winds, 20's-30's Acceptable/Unacceptable for Inspection ***(circle one)***

INSPECTION ITEM	CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
	Y	N	N/A	Y	N	N/A		
1.0 Percolation Collection Manhole (PCM) Condition								
1.1 Damage to the PCM or internal components		✓				✓	none	
1.2 Accumulation of a quantity of water greater than that caused by natural condensation in the manhole		✓				✓	none	
1.3 If the water level observed in the PCM impacts the ability to measure percolation, remove water accumulated in the PCM, and record the quantity here. Quantity removed from the PCM (liters): Ø								

2.0 Percolation Collection	
Lysimeter Number	**Measured Water Volume (liter)**
016	Ø
017	Ø
018	Ø
019	Ø
020	trace

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspection Notes: For areas with deficiencies, provide identifying labels for deficient areas, descriptions of deficiencies, approximate dimensions of the areas, locations, and photographs. Provide attachments as appropriate.

Lysimeters 016, 017, and 019 would benefit to have the standing water removed from inside the manhole.

Inspector		
Name: Kim Hoffman	**Signature:** Kim Hoffman	**Date:** 3-2-23
Cover Manager Review of Inspection Documentation		
Name: Michael W. Jones	**Signature:** Michael W. Jones	**Date:** 4/24/23
Cover Manager Confirmation of Completed Actions		
Name: N/A	**Signature:** N/A	**Date:** N/A

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspector Name(s): M. Jones, K. Hoffman	**Inspection Date(s):** 4-13-23

Conditions:
Previous 24-Hour Precipitation: Ø Weather Conditions: sunny, calm, 70's Acceptable/Unacceptable for Inspection ***(circle one)***

INSPECTION ITEM	CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
	Y	N	N/A	Y	N	N/A		
1.0 Percolation Collection Manhole (PCM) Condition								
1.1 Damage to the PCM or internal components		✓				✓	none	
1.2 Accumulation of a quantity of water greater than that caused by natural condensation in the manhole		✓				✓	none	
1.3 If the water level observed in the PCM impacts the ability to measure percolation, remove water accumulated in the PCM, and record the quantity here. Quantity removed from the PCM (liters): Ø								

2.0 Percolation Collection	
Lysimeter Number	**Measured Water Volume (liter)**
016	Ø
017	Ø
018	Ø
019	Ø
020	Ø

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspection Notes: For areas with deficiencies, provide identifying labels for deficient areas, descriptions of deficiencies, approximate dimensions of the areas, locations, and photographs. Provide attachments as appropriate.

Lysimeters 016, 017, and 019 would benefit to have the standing water pumped from inside the manhole.

Inspector		
Name: Kim Hoffman	**Signature:** Kim Hoffman	**Date:** 4-13-23
Cover Manager Review of Inspection Documentation		
Name: Michael W. Jones	**Signature:**	**Date:** 4/24/23
Cover Manager Confirmation of Completed Actions		
Name: N/A	**Signature:** N/A	**Date:** N/A

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspector Name(s): M. Jones, K. Hoffman, V. Stewart

Inspection Date(s): 5-3-23

Conditions:
Previous 24-Hour Precipitation: 0 Weather Conditions: sunny, calm winds, 70's Acceptable/Unacceptable for Inspection ***(circle one)***

INSPECTION ITEM	CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
	Y	N	N/A	Y	N	N/A		
1.0 Percolation Collection Manhole (PCM) Condition								
1.1 Damage to the PCM or internal components		✓				✓	none	
1.2 Accumulation of a quantity of water greater than that caused by natural condensation in the manhole		✓				✓	none	
1.3 If the water level observed in the PCM impacts the ability to measure percolation, remove water accumulated in the PCM, and record the quantity here. Quantity removed from the PCM (liters): Ø								

2.0 Percolation Collection	
Lysimeter Number	**Measured Water Volume (liter)**
016	Ø
017	Ø
018	Ø
019	Ø
020	Ø

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspection Notes: For areas with deficiencies, provide identifying labels for deficient areas, descriptions of deficiencies, approximate dimensions of the areas, locations, and photographs. Provide attachments as appropriate.

Pump standing water from lysimeters 016, 017, and 019.

Inspector		
Name: Kim Hoffman	**Signature:** Kim Hoffman	**Date:** 5-3-23
Cover Manager Review of Inspection Documentation		
Name: Michael W. Jones	**Signature:** Michael W. Jones	**Date:** 6/30/23
Cover Manager Confirmation of Completed Actions		
Name: N/A	**Signature:** N/A	**Date:** N/A

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspector Name(s): M-Jones, K-Hoffman	Inspection Date(s): 6-21-23

Conditions:
Previous 24-Hour Precipitation: Ø Weather Conditions: calm winds, sunny, 70's-90's Acceptable/Unacceptable for Inspection ***(circle one)***

INSPECTION ITEM	CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
	Y	N	N/A	Y	N	N/A		
1.0 Percolation Collection Manhole (PCM) Condition								
1.1 Damage to the PCM or internal components		✓				✓	none	
1.2 Accumulation of a quantity of water greater than that caused by natural condensation in the manhole		✓				✓	none	
1.3 If the water level observed in the PCM impacts the ability to measure percolation, remove water accumulated in the PCM, and record the quantity here. Quantity removed from the PCM (liters): Ø								

2.0 Percolation Collection	
Lysimeter Number	**Measured Water Volume (liter)**
016	Ø
017	Ø
018	Ø
019	Ø
020	Ø

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspection Notes: For areas with deficiencies, provide identifying labels for deficient areas, descriptions of deficiencies, approximate dimensions of the areas, locations, and photographs. Provide attachments as appropriate.

Lysimeters 016, 017, and 019 would benefit to have the standing water pumped from inside the manhole.

Inspector		
Name: Kim Hoffman	**Signature:** Kim Hoffman	**Date:** 7-5-23
Cover Manager Review of Inspection Documentation		
Name: Michael W. Jones	**Signature:** Michael W. Jones	**Date:** 6/30/23
Cover Manager Confirmation of Completed Actions		
Name: N/A	**Signature:** N/A	**Date:** N/A

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspector Name(s): M. Sowles, V. Stewart **Inspection Date(s):** 7-19-23

Conditions:
Previous 24-Hour Precipitation: Ø Weather Conditions: sunny, calm winds, 80's Acceptable/Unacceptable for Inspection ***(circle one)***

INSPECTION ITEM	CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
	Y	N	N/A	Y	N	N/A		
1.0 Percolation Collection Manhole (PCM) Condition								
1.1 Damage to the PCM or internal components		✓				✓	none	
1.2 Accumulation of a quantity of water greater than that caused by natural condensation in the manhole		✓				✓	none	
1.3 If the water level observed in the PCM impacts the ability to measure percolation, remove water accumulated in the PCM, and record the quantity here. Quantity removed from the PCM (liters): Ø								

2.0 Percolation Collection	
Lysimeter Number	**Measured Water Volume (liter)**
016	Ø
017	Ø
018	Ø
019	Ø
020	Ø

FORM SOP 003-1
BASIN F PERCOLATION MONITORING SYSTEM DATA COLLECTION AND OPERATION FORM

Inspection Notes: For areas with deficiencies, provide identifying labels for deficient areas, descriptions of deficiencies, approximate dimensions of the areas, locations, and photographs. Provide attachments as appropriate.

lysimeters 016, 017, 019, and 020 would benefit to have the standing water pumped from inside the manhole.

Inspector		
Name: Kim Hoffman	**Signature:** Kim Hoffman	**Date:** 7-20-23
Cover Manager Review of Inspection Documentation		
Name: Michael W. Jones	**Signature:** Michael W. Jones	**Date:** 7/24/23
Cover Manager Confirmation of Completed Actions		
Name: N/A	**Signature:** N/A	**Date:** N/A

Form SOP 003-1: Basin F Percolation Monitoring System Data Collection and Operation Form

Inspector Name(s): M. Jones, K. Hoffman **Inspection Date(s):** 9-6-23

Conditions:
Previous 24-Hour Precipitation: Ø Weather Conditions: sunny, calm winds, 70's Acceptable/Unacceptable for Inspection ***(circle one)***

INSPECTION ITEM	CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
	Y	N	N/A	Y	N	N/A		
1.0 Percolation Collection Manhole (PCM) Condition								
1.1 Damage to the PCM or internal components		✓				✓	none	
1.2 Accumulation of a quantity of water greater than that caused by natural condensation in the manhole		✓				✓	none	
1.3 If the water level observed in the PCM impacts the ability to measure percolation, remove water accumulated in the PCM, and record the quantity here. Quantity removed from the PCM (liters): Ø								

2.0 Percolation Collection	
Lysimeter Number	**Measured Water Volume (liter)**
016	Ø
017	Ø
018	Ø
019	Ø
020	Ø

Form SOP 003-1: Basin F Percolation Monitoring System Data Collection and Operation Form

Inspection Notes: For areas with deficiencies, provide identifying labels for deficient areas, descriptions of deficiencies, approximate dimensions of the areas, locations, and photographs. Provide attachments as appropriate.

lysimeters 016, 017, 019, and 020 would benefit to have the standing water pumped from the lysimeter manhole.

Inspector	
Name: Kim Hoffman	**Signature and Date:** Kim Hoffman 9-6-23
Cover Manager Review of Inspection Documentation	
Name: Michael W. Jones	**Signature and Date:** 9/28/23
Cover Manager Confirmation of Completed Actions	
Name: N/A	**Signature and Date:** N/A

FORM SOP 001-2
BASIN F TYPE II INSPECTION FORM

Inspector Names: M. Jones | **Date(s):** 10-11-22 | **Time of Inspection:** 0830

Attachments: ☐ Form SOP 002-1 ☐ Form SOP 003-1 ☐ Photographs ☑ Figures ☐ Other

Conditions:

Previous 24-hour precipitation: 0 | Weather Conditions: sunny, calm winds, 70's | Acceptable/Unacceptable for Inspection ***(circle one)***

INSPECTION ITEM	CONDITION PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
	Y	N	N/A	Y	N	N/A		
1.0 Surface Conditions								
1.1 Erosion rills or gullies		✓				✓	none	
1.2 Sheet erosion or plant pedestalling		✓				✓	none	
1.3 Depressions, ponding areas, sedimentation, or other conditions that could interrupt cover drainage		✓				✓	none	
1.4 Surface salts, crusting, or evidence of compaction		✓				✓	none	
1.5 Excessive animal trails or tire tracks/ruts	✓				✓		Note 1.	No action required. MJ 6/30/23
1.6 Burrowing animal holes (localized burrows greater than 3 inches in diameter, or widespread burrows of any size)		✓				✓	none	
1.7 Seepage, differential settlement, cracking, subsidence, sliding, or creep		✓				✓	none	

FORM SOP 001-2
BASIN F TYPE II INSPECTION FORM

	INSPECTION ITEM	CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
		Y	N	N/A	Y	N	N/A		
1.0	**Surface Conditions (Continued)**								
1.8	Intrusive damage such as unplanned excavation, drilling, grading, damage to engineering or access controls, vandalism		✓				✓	none	
2.0	**Vegetative Cover**								
2.1	Bare area or areas of poor growth greater than 100 square feet		✓				✓	none	
2.2	Areas of poor vigor, disease, over grazing, stress, burned, or discoloration greater than 100 square feet		✓				✓	none	
2.3	Deep rooted, noxious or undesirable weeds	✓			✓			Note 2.	Weed control is on-going. MJ 11/8/22
2.4	Plants exhibiting decadence, including excessive litter accumulation		✓				✓	none	
3.0	**Engineering and Access Controls**								
3.1	The perimeter fence is damaged		✓				✓	none	
3.2	Debris has collected along the perimeter fence	✓				✓		Note 3.	Addressed in May 2023. MJ 6/30/23
3.3	Obelisks are damaged, not visible, or not legible		✓				✓	none	
3.4	Warning signs are not legible from 25 feet		✓				✓	none	

FORM SOP 001-2
BASIN F TYPE II INSPECTION FORM

Y N N/A Y N N/A

3.0	Engineering and Access Controls (Continued)							
3.5	Damage to the Perimeter Access Road such as potholes, washouts or burrowing		✓			✓	none	
3.6	Cover perimeter survey monuments appear to be disturbed (Inspect every five years, prior to the CERCLA Five Year Review for legibility and to confirm record locations)			✓		✓	not inspected this year	

4.0 Surface Water Drainage Controls: *Were the following conditions observed during the inspection of the stormwater drainage controls? (circle all that apply)*

	INSPECTION ITEM	CHANNEL NUMBER 24	CHANNEL NUMBER 25
4.1*	Impeded drainage or ponding in the channel	Y (N)	Y (N)
4.2*	Excessive siltation in the channel	Y (N)	Y (N)
4.3*	Debris or ice present in the channel	(Y) N	(Y) N
4.4*	Erosion rills or gullies in the channel	Y (N)	Y (N)
4.5*	Inadequate protective vegetation	Y (N)	Y (N)
4.6	Cracked or degraded concrete	Y (N)	Y (N)
4.7*	Inhibited drainage from the soil to the concrete-lined channel	Y (N)	Y (N)
4.8*	Subsidence or undercutting of the concrete-lined channel	Y (N)	Y (N)

→ 4.3: Tumbleweed accumulations in channels.
Addressed in June 2023. MJ 6/30/23

FORM SOP 001-2
BASIN F TYPE II INSPECTION FORM

6.0 Erosion/Settlement Monuments: *Inspect monuments for damage and legibility, and record the soil thickness loss, if any.*

INSPECTION ITEM	ER92	ER93	ER94	ER95	ER96	ER97	ER98	ER99	ER100	ER101	ER102	ER103	ER104	ER105	ER106	ER107	ER108	ER109
6.1 Was the monument free of damage and legible?	(Y) N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	(Y) N
6.2 Measured Soil Thickness Loss (inches)	Ø	Ø	Ø	Ø	Ø	0.25	Ø	0.5	Ø	0.75	0.25	Ø	1.5	Ø	Ø	0.25	Ø	Ø

Inspection Notes: For areas with deficiencies, provide identifying labels for deficient areas, descriptions of deficiencies, approximate dimensions of the areas, locations with GPS coordinates, and photographs. Provide attachments as appropriate.

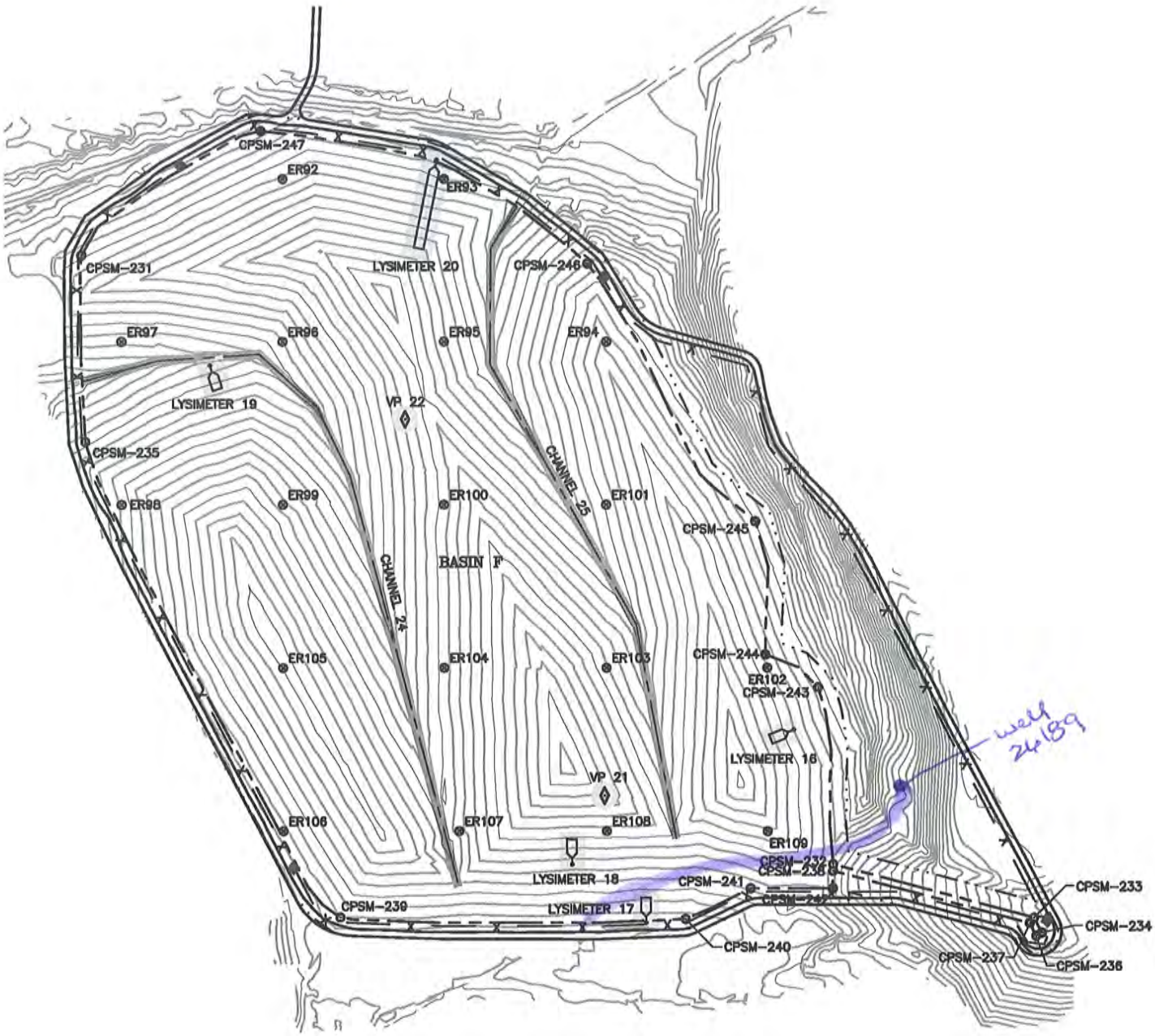
Performed 4 25 N/S Transects.

Note 1: Well 216189 was installed in September 2022. Some of the vegetation was driven over during the installation. No soil damage was observed. This area will continue to be monitored. See attached figure.

Note 2: Annual weeds (Kochia and Russian thistle) were observed over entire cover, sometimes in more dense patches.

Note 3: Tumble weed accumulation along fence line.

Inspector		
Name: Kim Hoffman	Signature: Kim Hoffman	Date: 10-13-22
Cover Manager Review of Inspection Documentation		
Name: Michael W. Jones	Signature: Michael W. Jones	Date: 11/8/22
Cover Manager Confirmation of Completed Actions		
Name: Michael W. Jones	Signature: Michael W. Jones	Date: 6/30/23



LEGEND

- COVER BOUNDARY
- BIOTA BARRIER MATERIAL BOUNDARY
- AS-BUILT CONTOURS (RECORD CONDITIONS)
- ARMY MAINTAINED AREA PERIMETER FENCE
- VANTAGE POINT
- LYSIMETER
- OBELISK (OUTSIDE FENCE)
- CONCRETE LINED DRAINAGE CHANNELS (SEE NOTE 2)
- PERIMETER ACCESS ROAD (SEE NOTE 1)
- ER107 — EROSION/SETTLEMENT MONUMENTS
- CPSM-239 — COVER PERIMETER SURVEY MONUMENTS

TRACKS FOR well install

NOTES:

1. THE OUTSIDE SHOULDER OF THE ACCESS ROAD DEFINES THE ARMY MAINTAINED AREA BOUNDARY.
2. CONCRETE LINED DRAINAGE CHANNELS ARE UNDERLAIN BY A SUBSURFACE LINER SYSTEM AT THE BASE OF THE COVER SOIL.

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

TETRA TECH EC

PROJECT NAME
BASIN F POST-CLOSURE PLAN

TITLE
BASIN F RCRA-EQUIVALENT COVER PLAN

CAD FILE:	DATE	FIGURE NUMBER
FIG SOP 001-1.DWG	04.08.11	SOP 001-1

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

Inspector Name(s): M. Jones, K. Hoffman, V. Stewart | **Inspection Date(s):** 1-17-23

Attachments: ☐ Form SOP 003-1 ☐ Photographs ☐ Figures ☐ Other

Conditions:
Previous 24-Hour Precipitation: Ø Weather Conditions: mostly sunny, calm winds, 30's (Acceptable/Unacceptable for Inspection *(circle one)*

Recent Significant Storm Event: ☑ No ☐ Yes (Date(s) of Event: N/A Precipitation: N/A)

*Note: Post-storm event inspection items are indicated with a * next to the Inspection Item number.*

INSPECTION ITEM	CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
	Y	N	N/A	Y	N	N/A		
1.0 Surface Conditions								
1.1* Erosion rills or gullies		✓				✓	none	
1.2* Sheet erosion or plant pedestalling		✓				✓	none	
1.3* Depressions, ponding areas, sedimentation, or other conditions that could interrupt cover drainage		✓				✓	none	
1.4 Surface salts, crusting, or evidence of compaction		✓				✓	none	
1.5 Excessive animal trails or tire tracks/ruts	✓				✓		Note 1.	No action required. MJ 4/24/23
1.6 Burrowing animal holes (localized burrows greater than 3 inches in diameter, or widespread burrows of any size)		✓				✓	none	
1.7* Seepage, differential settlement, cracking, subsidence, sliding, or creep		✓				✓	none	

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

	INSPECTION ITEM	CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
		Y	N	N/A	Y	N	N/A		
1.0	**Surface Conditions (Continued)**								
1.8	Intrusive damage such as unplanned excavation, drilling, grading, damage to engineering or access controls, vandalism		✓				✓	none	
2.0	**Vegetative Cover**								
2.1	Bare area or areas of poor growth greater than 100 square feet		✓				✓	none	
2.2	Areas of poor vigor, disease, over grazing, stress, burned, or discoloration greater than 100 square feet		✓				✓	none	
3.0	**Engineering and Access Controls**								
3.1	The perimeter fence is damaged		✓				✓	none	
3.2	Debris has collected along the perimeter fence	✓				✓		tumble weed accumulation along fence line	Addressed in May 2023. MJ 6/30/23
3.3	Obelisks are damaged, not visible, or not legible		✓				✓	none	
3.4	Warning signs are not legible from 25 feet		✓				✓	none	
3.5*	Damage to the Perimeter Access Road such as potholes, washouts or burrowing		✓				✓	none	

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

4.0 Surface Water Drainage Controls: *Were the following conditions observed during the inspection of the stormwater drainage controls? (circle all that apply)*		
INSPECTION ITEM	**CHANNEL NUMBER**	
	24	**25**
4.1* Impeded drainage or ponding in the channel	Y (N)	Y (N)
4.2* Excessive siltation in the channel	Y (N)	Y (N)
4.3* Debris or ice present in the channel	(Y) N	(Y) N
4.4* Erosion rills or gullies in the channel	Y (N)	Y (N)
4.5* Inadequate protective vegetation	Y (N)	Y (N)
4.6 Cracked or degraded concrete	Y (N)	Y (N)
4.7* Inhibited drainage from the soil to the concrete-lined channel	Y (N)	Y (N)
4.8* Subsidence or undercutting of the concrete-lined channel	Y (N)	Y (N)

→ 4.3: Tumble weed accumulation in channels. Not inhibiting drainage at this time.
Addressed in June 2023. MJ 6/30/23

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

Inspection Notes: For areas with deficiencies, provide identifying labels for deficient areas, descriptions of deficiencies, approximate dimensions of the areas, locations, and photographs. Provide attachments as appropriate.

Note 1: Wall 26189 was installed in September 2022. Some of the vegetation was driven over during the installation. NO soil damage has been observed. continue to monitor area for vegetation improvement.

Inspection postponed from 1-11-23 to 1-17-23 due to snow.

Inspector		
Name: Kim Hoffman	Signature: Kim Hoffman	Date: 1-18-23
Cover Manager Review of Inspection Documentation		
Name: Michael W. Jones	Signature: Michael W. Jones	Date: 1/23/23
Cover Manager Confirmation of Completed Actions		
Name: Michael W. Jones	Signature: Michael W. Jones	Date: 6/30/23

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

Inspector Name(s): M. Jones, K. Hoffman, V. Stewart **Inspection Date(s):** 3-1-23

Attachments: ☐ Form SOP 003-1 ☐ Photographs ☐ Figures ☐ Other

Conditions:
Previous 24-Hour Precipitation: 0 Weather Conditions: overcast, calm winds, 20-30's (Acceptable/Unacceptable for Inspection ***(circle one)***

Recent Significant Storm Event: ☒ No ☐ Yes (Date(s) of Event: N/A Precipitation: N/A)
*Note: Post-storm event inspection items are indicated with a * next to the Inspection Item number.*

INSPECTION ITEM	CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
	Y	N	N/A	Y	N	N/A		
1.0 Surface Conditions								
1.1* Erosion rills or gullies		✓				✓	none	
1.2* Sheet erosion or plant pedestalling		✓				✓	none	
1.3* Depressions, ponding areas, sedimentation, or other conditions that could interrupt cover drainage		✓				✓	none	
1.4 Surface salts, crusting, or evidence of compaction		✓				✓	none	
1.5 Excessive animal trails or tire tracks/ruts	✓				✓		Note 1.	Vegetation is recovering. MJ 4/24/23
1.6 Burrowing animal holes (localized burrows greater than 3 inches in diameter, or widespread burrows of any size)		✓				✓	none	
1.7* Seepage, differential settlement, cracking, subsidence, sliding, or creep		✓				✓	none	

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

	INSPECTION ITEM	CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
		Y	N	N/A	Y	N	N/A		
1.0	**Surface Conditions (Continued)**								
1.8	Intrusive damage such as unplanned excavation, drilling, grading, damage to engineering or access controls, vandalism		✓				✓	none	
2.0	**Vegetative Cover**								
2.1	Bare area or areas of poor growth greater than 100 square feet		✓				✓	none	
2.2	Areas of poor vigor, disease, over grazing, stress, burned, or discoloration greater than 100 square feet		✓				✓	none	
3.0	**Engineering and Access Controls**								
3.1	The perimeter fence is damaged		✓				✓	none	
3.2	Debris has collected along the perimeter fence	✓				✓		tumble weed accumulation along fence line	Addressed in May 2023. MJ 6/30/23
3.3	Obelisks are damaged, not visible, or not legible		✓				✓	none	
3.4	Warning signs are not legible from 25 feet		✓				✓	none	
3.5*	Damage to the Perimeter Access Road such as potholes, washouts or burrowing		✓				✓	none	

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

4.0 Surface Water Drainage Controls: *Were the following conditions observed during the inspection of the stormwater drainage controls? (circle all that apply)*		
INSPECTION ITEM	**CHANNEL NUMBER**	
	24	**25**
4.1* Impeded drainage or ponding in the channel	Y (N)	Y (N)
4.2* Excessive siltation in the channel	Y (N)	Y (N)
4.3* Debris or ice present in the channel	(Y) N	(Y) N
4.4* Erosion rills or gullies in the channel	Y (N)	Y (N)
4.5* Inadequate protective vegetation	Y (N)	Y (N)
4.6 Cracked or degraded concrete	Y (N)	Y (N)
4.7* Inhibited drainage from the soil to the concrete-lined channel	Y (N)	Y (N)
4.8* Subsidence or undercutting of the concrete-lined channel	Y (N)	Y (N)

→ 4.3: Tumble weed accumulation in channels - not inhibiting drainage at this time.
Addressed in June 2023. MJ 6/30/23

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

Inspection Notes: For areas with deficiencies, provide identifying labels for deficient areas, descriptions of deficiencies, approximate dimensions of the areas, locations, and photographs. Provide attachments as appropriate.

Note 1: Well 26189 was installed September 2022. Some of the vegetation was driven over during the installation. No soil damage has been observed. Continue to monitor the area for vegetation improvement.

Inspector		
Name: Kim Hoffman	**Signature:** Kim Hoffman	**Date:** 3-2-23
Cover Manager Review of Inspection Documentation		
Name: Michael W. Jones	**Signature:**	**Date:** 4/24/23
Cover Manager Confirmation of Completed Actions		
Name: Michael W. Jones	**Signature:**	**Date:** 6/30/23

FORM SOP 001-2
BASIN F TYPE II INSPECTION FORM

Inspector Names: M. Jones, K. Hoffman | **Date(s):** 4-12-23 | **Time of Inspection:** 0800

Attachments: ☐ Form SOP 002-1 ☐ Form SOP 003-1 ☐ Photographs ☑ Figures ☐ Other

Conditions:

Previous 24-hour precipitation: 0 | Weather Conditions: sunny, calm winds, 30's | Acceptable/Unacceptable for Inspection ***(circle one)***

INSPECTION ITEM	CONDITION PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
	Y	N	N/A	Y	N	N/A		
1.0 Surface Conditions								
1.1 Erosion rills or gullies		✓				✓	none	
1.2 Sheet erosion or plant pedestalling		✓				✓	none	
1.3 Depressions, ponding areas, sedimentation, or other conditions that could interrupt cover drainage		✓				✓	none	
1.4 Surface salts, crusting, or evidence of compaction		✓				✓	none	
1.5 Excessive animal trails or tire tracks/ruts		✓				✓	none	
1.6 Burrowing animal holes (localized burrows greater than 3 inches in diameter, or widespread burrows of any size)		✓				✓	none	
1.7 Seepage, differential settlement, cracking, subsidence, sliding, or creep		✓				✓	none	

FORM SOP 001-2
BASIN F TYPE II INSPECTION FORM

INSPECTION ITEM		CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
		Y	N	N/A	Y	N	N/A		
1.0	**Surface Conditions (Continued)**								
1.8	Intrusive damage such as unplanned excavation, drilling, grading, damage to engineering or access controls, vandalism		✓				✓	none	
2.0	**Vegetative Cover**								
2.1	Bare area or areas of poor growth greater than 100 square feet		✓				✓	none	
2.2	Areas of poor vigor, disease, over grazing, stress, burned, or discoloration greater than 100 square feet		✓				✓	none	
2.3	Deep rooted, noxious or undesirable weeds		✓				✓	none	
2.4	Plants exhibiting decadence, including excessive litter accumulation		✓				✓	none	
3.0	**Engineering and Access Controls**								
3.1	The perimeter fence is damaged		✓				✓	none	
3.2	Debris has collected along the perimeter fence	✓				✓		tumbleweed accumulation along fence line	Addressed in May 2023. MJ 6/30/23
3.3	Obelisks are damaged, not visible, or not legible		✓				✓	none	
3.4	Warning signs are not legible from 25 feet		✓				✓	none	

FORM SOP 001-2
BASIN F TYPE II INSPECTION FORM

Y N N/A Y N N/A

3.0	Engineering and Access Controls (Continued)							
3.5	Damage to the Perimeter Access Road such as potholes, washouts or burrowing		✓			✓	none	
3.6	Cover perimeter survey monuments appear to be disturbed (Inspect every five years, prior to the CERCLA Five Year Review for legibility and to confirm record locations)			✓		✓	not inspected this year	

4.0 Surface Water Drainage Controls: *Were the following conditions observed during the inspection of the stormwater drainage controls? (circle all that apply)*

	INSPECTION ITEM	CHANNEL NUMBER 24	CHANNEL NUMBER 25
4.1*	Impeded drainage or ponding in the channel	Y (N)	Y (N)
4.2*	Excessive siltation in the channel	Y (N)	Y (N)
4.3*	Debris or ice present in the channel	(Y) ~~N~~ YSL 4-12-23	(Y) ~~N~~ YSL 4-12-23
4.4*	Erosion rills or gullies in the channel	Y (N)	Y (N)
4.5*	Inadequate protective vegetation	Y (N)	Y (N)
4.6	Cracked or degraded concrete	Y (N)	Y (N)
4.7*	Inhibited drainage from the soil to the concrete-lined channel	Y (N)	Y (N)
4.8*	Subsidence or undercutting of the concrete-lined channel	Y (N)	Y (N)

→ 4.3: Tumble weed accumulation in channels.
Addressed in June 2023. MJ 6/30/23

FORM SOP 001-2
BASIN F TYPE II INSPECTION FORM

6.0 Erosion/Settlement Monuments: *Inspect monuments for damage and legibility, and record the soil thickness loss, if any.*

INSPECTION ITEM	ER92	ER93	ER94	ER95	ER96	ER97	ER98	ER99	ER100	ER101	ER102	ER103	ER104	ER105	ER106	ER107	ER108	ER109
6.1 Was the monument free of damage and legible?	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N
6.2 Measured Soil Thickness Loss (inches)	Ø	Ø	Ø	Ø	Ø	Ø	Ø	0.5	Ø	0.5	Ø	Ø	1.75	Ø	Ø	0.5	Ø	Ø

Inspection Notes: For areas with deficiencies, provide identifying labels for deficient areas, descriptions of deficiencies, approximate dimensions of the areas, locations with GPS coordinates, and photographs. Provide attachments as appropriate.

+50 N/S transects performed

Kim Hoffman 4-19-23

Inspector		
Name: Kim Hoffman	Signature: Kim Hoffman	Date: 4-19-23
Cover Manager Review of Inspection Documentation		
Name: Michael W. Jones	Signature: Michael W. Jones	Date: 4/24/23
Cover Manager Confirmation of Completed Actions		
Name: Michael W. Jones	Signature: Michael W. Jones	Date: 6/30/23

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

Inspector Name(s): M. Jones, K. Hoffman, V. Stewart | **Inspection Date(s):** 5-3-23

Attachments: ☐ Form SOP 003-1 ☐ Photographs ☐ Figures ☐ Other

Conditions:
Previous 24-Hour Precipitation: 0 Weather Conditions: sunny, calm winds, 30's (Acceptable/Unacceptable for Inspection ***(circle one)***

Recent Significant Storm Event: ☑ No ☐ Yes (Date(s) of Event: N/A Precipitation: N/A)
*Note: Post-storm event inspection items are indicated with a * next to the Inspection Item number.*

INSPECTION ITEM	CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
	Y	N	N/A	Y	N	N/A		
1.0 Surface Conditions								
1.1* Erosion rills or gullies		✓				✓	none	
1.2* Sheet erosion or plant pedestalling		✓				✓	none	
1.3* Depressions, ponding areas, sedimentation, or other conditions that could interrupt cover drainage		✓				✓	none	
1.4 Surface salts, crusting, or evidence of compaction		✓				✓	none	
1.5 Excessive animal trails or tire tracks/ruts		✓				✓	none	
1.6 Burrowing animal holes (localized burrows greater than 3 inches in diameter, or widespread burrows of any size)		✓				✓	none	
1.7* Seepage, differential settlement, cracking, subsidence, sliding, or creep		✓				✓	none	

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

INSPECTION ITEM		CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
		Y	N	N/A	Y	N	N/A		
1.0	**Surface Conditions (Continued)**								
1.8	Intrusive damage such as unplanned excavation, drilling, grading, damage to engineering or access controls, vandalism		✓				✓	none	
2.0	**Vegetative Cover**								
2.1	Bare area or areas of poor growth greater than 100 square feet		✓				✓	none	
2.2	Areas of poor vigor, disease, over grazing, stress, burned, or discoloration greater than 100 square feet		✓				✓	none	
3.0	**Engineering and Access Controls**								
3.1	The perimeter fence is damaged		✓				✓	none	
3.2	Debris has collected along the perimeter fence	✓				✓		tumble weeds have accumulated along fence	Addressed in May 2023. MJ 6/30/23
3.3	Obelisks are damaged, not visible, or not legible		✓				✓	none	
3.4	Warning signs are not legible from 25 feet		✓				✓	none	
3.5*	Damage to the Perimeter Access Road such as potholes, washouts or burrowing		✓				✓	none	

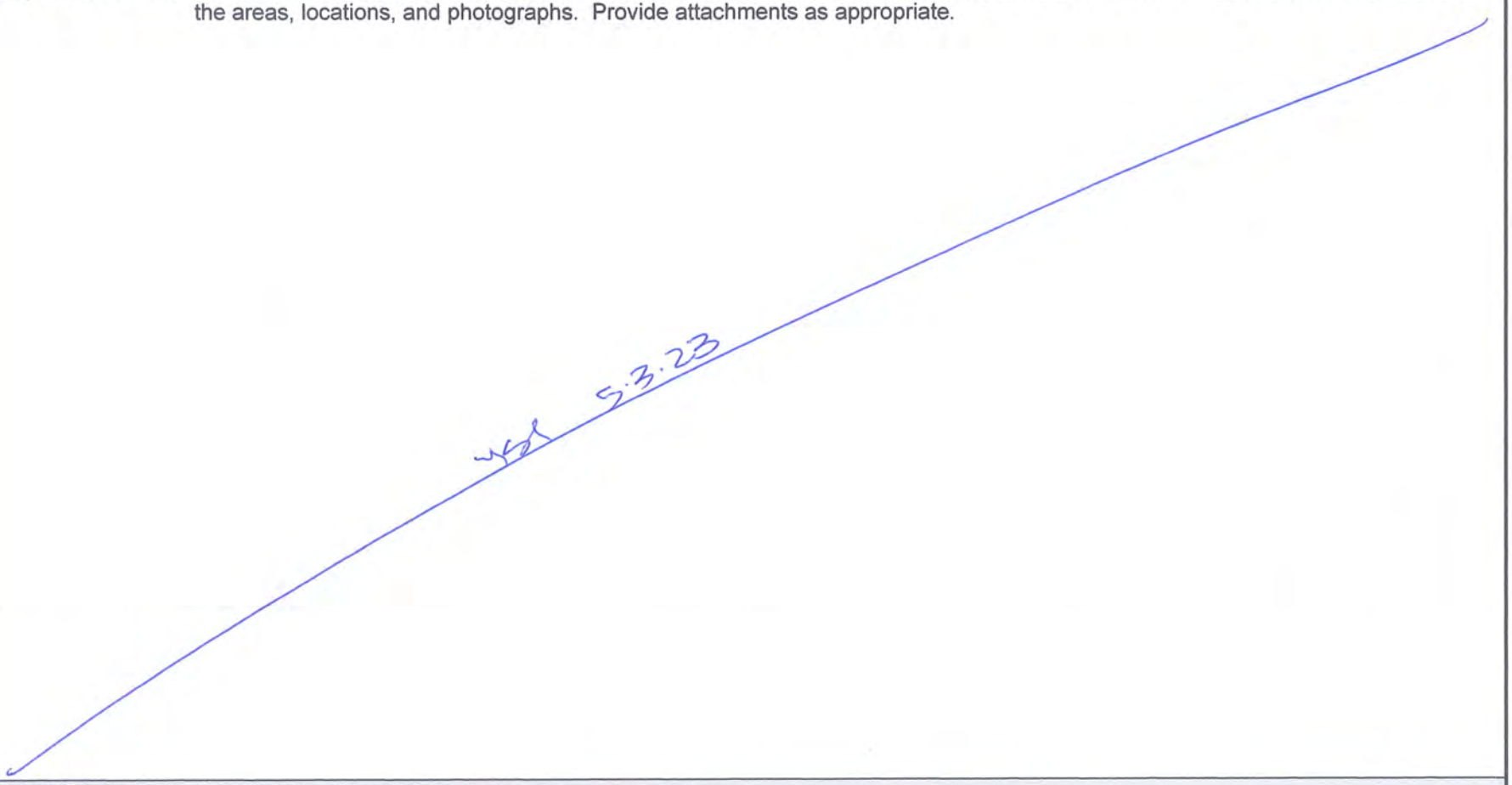
FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

4.0 Surface Water Drainage Controls: *Were the following conditions observed during the inspection of the stormwater drainage controls? (circle all that apply)*		
INSPECTION ITEM	**CHANNEL NUMBER**	
	24	**25**
4.1* Impeded drainage or ponding in the channel	Y (N)	Y (N)
4.2* Excessive siltation in the channel	Y (N)	Y (N)
4.3* Debris or ice present in the channel	(Y) N	(Y) N
4.4* Erosion rills or gullies in the channel	Y (N)	Y (N)
4.5* Inadequate protective vegetation	Y (N)	Y (N)
4.6 Cracked or degraded concrete	Y (N)	Y (N)
4.7* Inhibited drainage from the soil to the concrete-lined channel	Y (N)	Y (N)
4.8* Subsidence or undercutting of the concrete-lined channel	Y (N)	Y (N)

4.3: Tumble weeds have accumulated in channels.
Addressed in June 2023. MJ 6/30/23

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

Inspection Notes: For areas with deficiencies, provide identifying labels for deficient areas, descriptions of deficiencies, approximate dimensions of the areas, locations, and photographs. Provide attachments as appropriate.



Inspector		
Name: Kim Hoffman	**Signature:** Kim Hoffman	**Date:** 5-3-23
Cover Manager Review of Inspection Documentation		
Name: Michael W. Jones	**Signature:** Michael W. Jones	**Date:** 6/30/23
Cover Manager Confirmation of Completed Actions		
Name: Michael W. Jones	**Signature:** Michael W. Jones	**Date:** 6/30/23

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

Inspector Name(s): M. Jones, K. Hoffman | **Inspection Date(s):** 6-21-23

Attachments: ☐ Form SOP 003-1 ☐ Photographs ☐ Figures ☐ Other

Conditions:
Previous 24-Hour Precipitation: Ø Weather Conditions: sunny, calm winds, 70's-80's (Acceptable/Unacceptable for Inspection ***(circle one)***

Recent Significant Storm Event: ☐ No ☑ Yes (Date(s) of Event: 5-10-23, 5-11-23, 6-4-23 Precipitation: 1.03", 2.92", 1.23")

*Note: Post-storm event inspection items are indicated with a * next to the Inspection Item number.*

INSPECTION ITEM	CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
	Y	N	N/A	Y	N	N/A		
1.0 Surface Conditions								
1.1* Erosion rills or gullies		✓				✓	none	
1.2* Sheet erosion or plant pedestalling		✓				✓	none	
1.3* Depressions, ponding areas, sedimentation, or other conditions that could interrupt cover drainage		✓				✓	none	
1.4 Surface salts, crusting, or evidence of compaction		✓				✓	none	
1.5 Excessive animal trails or tire tracks/ruts		✓				✓	none	
1.6 Burrowing animal holes (localized burrows greater than 3 inches in diameter, or widespread burrows of any size)		✓				✓	none	
1.7* Seepage, differential settlement, cracking, subsidence, sliding, or creep		✓				✓	none	

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

INSPECTION ITEM		CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
		Y	N	N/A	Y	N	N/A		
1.0	**Surface Conditions (Continued)**								
1.8	Intrusive damage such as unplanned excavation, drilling, grading, damage to engineering or access controls, vandalism		✓				✓	none	
2.0	**Vegetative Cover**								
2.1	Bare area or areas of poor growth greater than 100 square feet		✓				✓	none	
2.2	Areas of poor vigor, disease, over grazing, stress, burned, or discoloration greater than 100 square feet		✓				✓	none	
3.0	**Engineering and Access Controls**								
3.1	The perimeter fence is damaged		✓				✓	none	
3.2	Debris has collected along the perimeter fence		✓				✓	none	
3.3	Obelisks are damaged, not visible, or not legible		✓				✓	none	
3.4	Warning signs are not legible from 25 feet		✓				✓	none	
3.5*	Damage to the Perimeter Access Road such as potholes, washouts or burrowing		✓				✓	none	

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

4.0 Surface Water Drainage Controls: *Were the following conditions observed during the inspection of the stormwater drainage controls? (circle all that apply)*		
	CHANNEL NUMBER	
INSPECTION ITEM	**24**	**25**
4.1* Impeded drainage or ponding in the channel	Y (N)	Y (N)
4.2* Excessive siltation in the channel	Y (N)	Y (N)
4.3* Debris or ice present in the channel	Y (N)	Y (N)
4.4* Erosion rills or gullies in the channel	Y (N)	Y (N)
4.5* Inadequate protective vegetation	Y (N)	Y (N)
4.6 Cracked or degraded concrete	Y (N)	Y (N)
4.7* Inhibited drainage from the soil to the concrete-lined channel	Y (N)	Y (N)
4.8* Subsidence or undercutting of the concrete-lined channel	Y (N)	Y (N)

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

Inspection Notes: For areas with deficiencies, provide identifying labels for deficient areas, descriptions of deficiencies, approximate dimensions of the areas, locations, and photographs. Provide attachments as appropriate.

General note: There is an abundance of vegetation after much spring precipitation and hindered inspection of ground surface.

Inspector		
Name: Kim Hoffman	**Signature:** Kim Hoffman	**Date:** 6-26-23
Cover Manager Review of Inspection Documentation		
Name: Michael W. Jones	**Signature:** Michael W. Jones	**Date:** 6/30/23
Cover Manager Confirmation of Completed Actions		
Name: N/A	**Signature:** N/A	**Date:** N/A

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

Inspector Name(s): M. Jones, V. Stewart | **Inspection Date(s):** 7-19-23

Attachments: ☐ Form SOP 003-1 ☐ Photographs ☐ Figures ☐ Other

Conditions:
Previous 24-Hour Precipitation: 0 Weather Conditions: sunny, calm winds, 80's (Acceptable/Unacceptable for Inspection ***(circle one)***

Recent Significant Storm Event: ☑ No ☐ Yes (Date(s) of Event: N/A Precipitation: N/A)

*Note: Post-storm event inspection items are indicated with a * next to the Inspection Item number.*

INSPECTION ITEM	CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
	Y	N	N/A	Y	N	N/A		
1.0 Surface Conditions								
1.1* Erosion rills or gullies		✓				✓	none	
1.2* Sheet erosion or plant pedestalling		✓				✓	none	
1.3* Depressions, ponding areas, sedimentation, or other conditions that could interrupt cover drainage		✓				✓	none	
1.4 Surface salts, crusting, or evidence of compaction		✓				✓	none	
1.5 Excessive animal trails or tire tracks/ruts		✓				✓	none	
1.6 Burrowing animal holes (localized burrows greater than 3 inches in diameter, or widespread burrows of any size)		✓				✓	none	
1.7* Seepage, differential settlement, cracking, subsidence, sliding, or creep		✓				✓	none	

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

INSPECTION ITEM		CONDITION IS PRESENT			REPEAT OR CHRONIC CONDITION			OBSERVATION Indicate recommended action, if required.	CONFIRMATION THAT ACTION IS COMPLETE (Initial and Date)
		Y	N	N/A	Y	N	N/A		
1.0	**Surface Conditions (Continued)**								
1.8	Intrusive damage such as unplanned excavation, drilling, grading, damage to engineering or access controls, vandalism		✓				✓	none	
2.0	**Vegetative Cover**								
2.1	Bare area or areas of poor growth greater than 100 square feet		✓				✓	none	
2.2	Areas of poor vigor, disease, over grazing, stress, burned, or discoloration greater than 100 square feet		✓				✓	none	
3.0	**Engineering and Access Controls**								
3.1	The perimeter fence is damaged		✓				✓	none	
3.2	Debris has collected along the perimeter fence		✓				✓	none	
3.3	Obelisks are damaged, not visible, or not legible		✓				✓	none	
3.4	Warning signs are not legible from 25 feet		✓				✓	none	
3.5*	Damage to the Perimeter Access Road such as potholes, washouts or burrowing		✓				✓	none	

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

4.0 Surface Water Drainage Controls: *Were the following conditions observed during the inspection of the stormwater drainage controls? (circle all that apply)*		
	CHANNEL NUMBER	
INSPECTION ITEM	**24**	**25**
4.1* Impeded drainage or ponding in the channel	Y (N)	Y (N)
4.2* Excessive siltation in the channel	Y (N)	Y (N)
4.3* Debris or ice present in the channel	Y (N)	Y (N)
4.4* Erosion rills or gullies in the channel	Y (N)	Y (N)
4.5* Inadequate protective vegetation	Y (N)	Y (N)
4.6 Cracked or degraded concrete	Y (N)	Y (N)
4.7* Inhibited drainage from the soil to the concrete-lined channel	Y (N)	Y (N)
4.8* Subsidence or undercutting of the concrete-lined channel	Y (N)	Y (N)

FORM SOP 001-1
BASIN F TYPE I INSPECTION FORM

Inspection Notes: For areas with deficiencies, provide identifying labels for deficient areas, descriptions of deficiencies, approximate dimensions of the areas, locations, and photographs. Provide attachments as appropriate.

KH 3-24-23

Inspector		
Name: Kim Hoffman	**Signature:** Kim Hoffman	**Date:** 7-24-23
Cover Manager Review of Inspection Documentation		
Name: Michael W. Jones	**Signature:** Michael W. Jones	**Date:** 7/24/23
Cover Manager Confirmation of Completed Actions		
Name: N/A	**Signature:** N/A	**Date:** N/A

APPENDIX D

Maintenance and Repair Documentation

(October 1, 2022 through September 30, 2023)

CONTRACTOR DAILY QUALITY CONTROL REPORT

Project Information	
Subcontractor/Partner: Weed Wranglers	Project: Basin F O&M
Task: maintenance	Date: 11/11/22
Weather AM: acceptable	Weather PM: acceptable
Activities Inspected and Observed:	
Weed Wranglers completed the spraying of ground clear herbicide around Basin F on the perimeter road, the gate entrances, the cattle guards, and other hard working surfaces. Weed Wranglers used the herbicide Plainview SC®.	
Summary Meetings and Discussions Held or Attended, including Job Safety:	
N/A	
Comments:	
N/A	
Additional Documentation Submitted:	
N/A	
Sign Off:	
Inspector Name: Kim Hoffman	Title/company: Caps and Covers Lead/Navarro
Signature:	Date: 11-30-22
Reviewer Name: Michael Jones	Title/company: Caps and Covers Manager/Navarro
Signature:	Date: 12/14/22

CONTRACTOR DAILY QUALITY CONTROL REPORT

Project Information	
Subcontractor/Partner: N/A	Project: Basin F O&M
Task: maintenance	Date: 5/4/23
Weather AM: acceptable	Weather PM: acceptable
Activities Inspected and Observed:	
OMC used the USFWS tractor and OMC fence cleaner to remove accumulated tumble weeds from the Basin F perimeter fence.	
Summary Meetings and Discussions Held or Attended, including Job Safety:	
N/A	
Comments:	
N/A	
Additional Documentation Submitted:	
N/A	
Sign Off:	
Inspector Name: Kim Hoffman	Title/company: Landfills and Covers Lead/Navarro
Signature:	Date:
Reviewer Name: Michael Jones	Title/company: Landfills and Covers Manager/Navarro
Signature:	Date: 6/30/23

CONTRACTOR DAILY QUALITY CONTROL REPORT

Project Information	
Subcontractor/Partner: N/A	Project: Basin F O&M
Task: maintenance	Date: 5/11/23
Weather AM: acceptable	Weather PM: acceptable
Activities Inspected and Observed:	
OMC performed a drive around post-storm inspection due to the RMA receiving 1.03" of precipitation in a 24-hour period. No observations were noted.	
Summary Meetings and Discussions Held or Attended, including Job Safety:	
N/A	
Comments:	
N/A	
Additional Documentation Submitted:	
N/A	
Sign Off:	
Inspector Name: Kim Hoffman	Title/company: Landfills and Covers Lead/Navarro
Signature:	Date: 6-27-23
Reviewer Name: Michael Jones	Title/company: Landfills and Covers Manager/Navarro
Signature:	Date: 6/30/23

CONTRACTOR DAILY QUALITY CONTROL REPORT

Project Information	
Subcontractor/Partner: N/A	Project: Basin F O&M
Task: maintenance	Date: 5/15/23
Weather AM: acceptable	Weather PM: acceptable
Activities Inspected and Observed:	
OMC personnel performed a drive-around post-storm inspection due to the RMA receiving the following precipitation: **5/10/23** 0.62" **5/11/23** 2.92" **5/12/23** 0.85" **5/14/23** 0.28" No observations were noted.	
Summary Meetings and Discussions Held or Attended, including Job Safety:	
N/A	
Comments:	
N/A	
Additional Documentation Submitted:	
N/A	
Sign Off:	
Inspector Name: Kim Hoffman	Title/company: Lanfills and Covers Lead/Navarro
Signature:	Date:
Reviewer Name: Michael Jones	Title/company: Landfills and Covers Manager/Navarro
Signature:	Date: 6/30/23

CONTRACTOR DAILY QUALITY CONTROL REPORT

Project Information	
Subcontractor/Partner: H2	Project: Basin F O&M
Task: maintenance	Date: 6/1/23
Weather AM: acceptable	Weather PM: acceptable
Activities Inspected and Observed:	
H2 used a deck mower mounted to a skidsteer to mow tumble weeds from the Basin F concrete lined channels.	
Summary Meetings and Discussions Held or Attended, including Job Safety:	
N/A	
Comments:	
N/A	
Additional Documentation Submitted:	
N/A	
Sign Off:	
Inspector Name: Kim Hoffman	Title/company: Landfills and Covers Lead/Navarro
Signature:	Date: 6/30/23
Reviewer Name: Michael Jones	Title/company: Landfills and Covers Manager/Navarro
Signature:	Date: 6/30/23

CONTRACTOR DAILY QUALITY CONTROL REPORT

Project Information	
Subcontractor/Partner: N/A	Project: Basin F O&M
Task: maintenance	Date: 6/5/23
Weather AM: acceptable	Weather PM: acceptable
Activities Inspected and Observed:	
OMC performed a drive around post-storm inspection due to the RMA receiving 1.23" of rain in a 24-hour period on June 4. No observations were noted.	
Summary Meetings and Discussions Held or Attended, including Job Safety:	
N/A	
Comments:	
N/A	
Additional Documentation Submitted:	
N/A	
Sign Off:	
Inspector Name: Kim Hoffman	Title/company: Landfills and Covers Lead/Navarro
Signature:	Date:
Reviewer Name: Michael Jones	Title/company: Landfills and Covers Manager/Navarro
Signature:	Date: 6/30/23

CONTRACTOR DAILY QUALITY CONTROL REPORT

Project Information	
Subcontractor/Partner: Weed Wranglers	Project: Basin F O&M
Task: maintenance	Date: 6/28/23
Weather AM: acceptable	Weather PM: acceptable
Activities Inspected and Observed:	
Weed Wranglers spot sprayed noxious weeds on Basin F. Thistles, bindweed, and deep-rooted weeds were sprayed with Escort XP®, Vision®, and surfactant.	
Summary Meetings and Discussions Held or Attended, including Job Safety:	
N/A	
Comments:	
N/A	
Additional Documentation Submitted:	
N/A	
Sign Off:	
Inspector Name: Kim Hoffman	Title/company: Landfills and Covers Lead/Navarro
Signature: [signature]	Date: 10-22-23
Reviewer Name: Michael Jones	Title/company: Landfills and Covers Manager/Navarro
Signature: [signature]	Date: 10/26/23

CONTRACTOR DAILY QUALITY CONTROL REPORT

Project Information	
Subcontractor/Partner: N/A	Project: Basin F O&M
Task: maintenance	Date: 8/8/23
Weather AM: acceptable	Weather PM: acceptable
Activities Inspected and Observed:	
OMC personnel repaired a south section of the Basin F perimeter fence due to bison activity. The fence had minor damage including stretched fabric, tore fabric, and a damaged wooden post. The wooden post was replaced and the fence fabric was straightened out and mended.	
Summary Meetings and Discussions Held or Attended, including Job Safety:	
N/A	
Comments:	
N/A	
Additional Documentation Submitted:	
N/A	
Sign Off:	
Inspector Name: Kim Hoffman	Title/company: Landfills and Covers Lead/Navarro
Signature:	Date: 10-23-23
Reviewer Name: Michael Jones	Title/company: Landfills and Covers Manager/Navarro
Signature:	Date: 10/26/23

APPENDIX E

2023 Basin F Post-Closure Groundwater Monitoring Report

ROCKY MOUNTAIN ARSENAL

2023 BASIN F POST-CLOSURE GROUNDWATER MONITORING REPORT

Revision 0

November 15, 2023

U.S. Department of the Army
Shell Oil Company

Prepared by:

Navarro Research and Engineering, Inc.

TABLE OF CONTENTS

Section **Page**

ATTACHMENTS

TABLES

FIGURES

SUPPORTIG DOCUMENTATION

Data Quality (folder)

Folder containing subfolders and files comprising the data review elements as described in Section 3.0 of the report. Folders include Excel files providing post-closure data, PARCC parameter evaluations, data usability, and quality control samples.

Statistical Eval (folder)

Folder containing subfolders and files comprising the statistical data evaluation elements as developed for Section 5.0 of the report. Files include data input, ChemStat project files, and associated ChemStat output in pdf format.

ACRONYMS

Basin F SAP	Basin F Closure and Post-Closure Groundwater Monitoring Sampling and Analysis Plan
EPA	U.S. Environmental Protection Agency
IC	Indicator Compound
IQR	Interquartile Range
LCS	Laboratory Control Spike
LT	Less Than
MRL	Method Reporting Limit
OMC	Operations and Maintenance Contractor
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PCGMP	Post-Closure Groundwater Monitoring Plan
PT	Principal Threat
QA	Quality Assurance
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RMA	Rocky Mountain Arsenal
RMAED	Rocky Mountain Arsenal Environmental Database
RPD	Relative Percent Difference
SQAPP	Sampling Quality Assurance Project Plan
UCL	Upper Confidence Limit
UFS	Unconfined Flow System
UPL	Upper Prediction Limit
WP	Wastepile
µg/L or UGL	micrograms per liter

Note: Analyte names and associated abbreviation test names are provided in Table 2-3.

1.0 INTRODUCTION

This 2023 Post-Closure Groundwater Monitoring Report documents the analytical results and data evaluation of the Basin F post-closure groundwater monitoring conducted during the annual groundwater sampling event on the Rocky Mountain Arsenal (RMA) April 26 through May 16, 2023. The groundwater monitoring program is designed to evaluate the post-closure maintenance of the Basin F Surface Impoundment and Basin F Wastepile (WP), thus satisfying 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* (PCGMP) (Navarro 2023), *Basin F Closure and Post-Closure Groundwater Monitoring Sampling and Analysis Plan* (Basin F SAP) (TtEC 2011), *Rocky Mountain Arsenal Sampling Quality Assurance Project Plan* (SQAPP) (Navarro 2019), and previous annual groundwater reports.

2.0 GROUNDWATER MONITORING RESULTS

A summary of water level monitoring and analytical results for 2023 Basin F groundwater monitoring is presented in the following sections.

2.1 Monitoring Well Evaluation

As part of the annual water level measurements and groundwater sampling, the physical condition of monitoring wells was evaluated by the field crew. This evaluation included measuring the well stickup heights and depths to water, and inspecting the monitoring wells, well pads, and pumps. Total depths were measured in the wells without dedicated pumps. No discrepancies were noted, and repairs are not needed at this time.

2.2 Water Level Monitoring

Groundwater levels were measured in January of 2023 in 27 Basin F network wells to evaluate unconfined flow system (UFS) conditions in the area of Basin F. Water levels measured in 2023 within the Basin F monitoring network are presented in Table 2-1. Additional wells used to further delineate the water table in the vicinity were measured during the same time period. Water level monitoring network wells are shown on Figure 2-1.

Figure 2-2 presents the potentiometric surface map for the UFS depicting water levels measured in January 2023. Similar to previous years, groundwater flow in the vicinity of Basin F is generally to the north. A groundwater divide has become evident as local and regional water levels have decreased, resulting in groundwater flow to the north-northwest and north-northeast beneath the north end of the former 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* (Navarro 2021a). A complete description of the subsurface lithology and groundwater flow in the vicinity of Basin F can be found in the PCGMP (Navarro 2023).

Table 2-1. 2023 Water Level Measurements

Well ID	Date	Depth to Water (feet TOC)	Top of Casing Elevation (feet amsl)	Groundwater Elevation (feet amsl)
23135	2/21/2023	43.22	5187.11	5143.89
26015	4/24/2023	45.39	5190.04	5144.65
26016	1/12/2023	41.89	5187.47	5145.58
26017	1/12/2023	42.78	5187.30	5144.52
26018	1/12/2023	47.18	5191.77	5144.59
26020	1/12/2023	39.12	5187.92	5148.80
26023	1/12/2023	45.40	5194.09	5148.69
26028	1/12/2023	41.34	5199.42	5158.08
26040	1/12/2023	49.96	5197.40	5147.44
26047	1/12/2023	43.54	5187.40	5143.86
26048	1/12/2023	21.68	5172.93	DRY
26049	1/12/2023	27.47	5177.96	5150.49
26051	1/12/2023	56.39	5218.60	5162.21
26061	1/12/2023	32.01	5173.95	5141.94
26071	1/12/2023	43.79	5200.70	5156.91
26073	1/12/2023	47.71	5225.41	5177.7
26081	1/12/2023	28.05	5175.26	5147.21
26097	1/12/2023	58.21	5242.25	5184.04
26128	1/12/2023	42.78	5204.73	5161.95
26133	1/12/2023	43.73	5189.47	5145.74
26158	1/12/2023	35.52	5214.88	5179.36
26160	1/12/2023	47.19	5190.07	5142.88
26163	1/12/2023	44.24	5188.55	5144.31
26164	1/12/2023	44.98	5189.26	5144.28
26170	1/12/2023	44.31	5184.02	5139.71
26173	1/12/2023	53.49	5200.74	5147.25
27018	2/1/2023	22.01	5169.23	5147.22

Note: Due to a January measurement error at well 26015, the April 24, 2023 water level measurement was utilized for mapping the potentiometric surface.

amsl – Above mean sea level

Water levels measured in the nine Basin F water quality network wells since 2006 are shown on hydrographs (Attachment A). Beginning in 2018, groundwater elevations began to decrease in all of the wells with the exception of well 26128. Groundwater in well 26128 shows an increasing trend from 2014 through 2018, but has decreased since 2019. Water level data for well 26128 appears different from the other wells in the vicinity of Basin F because it is screened deeper within the unweathered Denver Formation. As such, this well does not provide an accurate depiction of the UFS upgradient of Basin F. The overall decrease in UFS water levels in the vicinity of Basin F is consistent with a general decreasing trend noted across RMA over

the past several years (Navarro 2021b). Historical changes in water levels in wells near Basin F are consistent with regional fluctuations in the water table and are not related to the performance of the Basin F cover.

2.3 Water Quality Well Network

The post-closure water quality well network for Basin F is presented in Table 2-2 and is shown on Figure 2-1. The nine network wells are used to monitor groundwater conditions 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 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 area. 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 evident at the initiation of post-closure groundwater monitoring (Navarro 2023).

Table 2-2. 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

Wells 26028, 26073, and 26128 on the south and southeast sides of Basin F are used to evaluate contamination upgradient of the Basin F surface impoundment. The wells are useful for tracking chemical trends in the area since historically they have had elevated contaminant concentrations. Based on current and historical data, wells 26073 and 26128 are upgradient of the PT excavation. Well 26028 is in the flow path directly upgradient of the former Basin F WP.

2.4 Water Quality Monitoring

Groundwater samples were collected from the wells identified in Table 2-2 in accordance with procedures defined in the PCGMP (Navarro 2023), and the SQAPP (Navarro 2019). 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 2-3. The analytical methods were developed as described in the SQAPP.

The groundwater samples were tested for the analytes and indicator compounds (IC) listed in Table 2-3. The 11 ICs monitored at Basin F include the following:

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

The Basin F network wells 26015, 26017, 26028, 26073, 26128, 26133, 26157, 26163, and 26173 were sampled April through mid-May 2023. An evaluation of the analytical results is presented in Section 4.0. Analytical data for all detected analytes at Basin F are also included in the Supporting Documentation folder included with this report.

Table 2-3. 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**

Table 2-3. Water Quality Monitoring Analyte List

Method and Analyte Names	Test Name
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
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

Table 2-3. Water Quality Monitoring Analyte List

Method and Analyte Names	Test Name
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	
Alkalinity	ALK
Anions	
Bromide	BR
Chloride	**CL**
Nitrate	NO3
Nitrite	NO2
Sulfate	**SO4**
Ion Specific Electrode	
Fluoride	F
Nitrosamines	
n-Nitrosodimethylamine	**NNDMEA**

Table 2-3. Water Quality Monitoring Analyte List

Method and Analyte Names	Test Name
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**

The 2023 data for ICs analyzed in samples collected from WP and PT monitoring wells are discussed in Section 4.0 and summarized in Table 4-1.

3.0 DATA QUALITY ASSURANCE REVIEW

The objective of the data quality assurance (QA) 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 Operations and Maintenance Contractor (OMC) reviewed the PARCC parameters in accordance with the SQAPP (Navarro 2019) for comparison to the data quality control (QC) goals stated in the Basin F SAP (TtEC 2011). Table 3-1 lists QC samples collected and analyzed as part of the Basin F post-closure monitoring for 2023.

Table 3-1. 2023 Quality Control Samples

Sample Type/Site ID	Sample Date
Field Duplicate	
26157	5/1/2023
Lab Duplicates	
26028	1/4/2023
26015	4/26/2023
26163	5/2/2023
26173	5/4/2023
26133	5/4/2023
Field Blank	
26128	5/2/2023

The sample results were evaluated against the data quality requirements and compared to the data quality objectives as presented in the Basin F SAP (TtEC 2011), with data review and verification activities conducted in accordance with the SQAPP (Navarro 2019). An evaluation of each analytical data quality indicator is presented in Sections 3.1 through 3.5.

The OMC conducted data validation on the Basin F groundwater analytical data as specified in the SQAPP (Navarro 2019). Validation checklists were completed, and laboratory case narratives were reviewed by the analyst to determine potential problems with the data.

3.1 Precision

Precision is the measure of agreement among replicate or duplicate sample measurements of the same property under prescribed similar conditions. Results of laboratory duplicates and field duplicates were used to calculate precision. Note that laboratory duplicates are designated by the laboratory and analyzed for inorganics only. The precision 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 method reporting limit (MRL). If one or both results are rejected or not analyzed, there will be no evaluation of the RPD. Duplicate samples determined to be not comparable will be subject to data qualification. The performance criterion for precision is a RPD value less than or equal to 35 percent, the upper limit of the RPD range. 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 were evaluated for comparability. The RPD upper limit is 35 percent for all analytes. A total of 76 field and 26 lab duplicate analyses were performed with an average relative percent difference of 4.83 percent. The duplicate and investigative results are non-comparable for one duplicate analysis. The duplicate/investigative pairs considered non-comparable are presented in Table 3-2. 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. The data are considered acceptable for their intended use and no additional action to the data qualification is considered necessary. The frequency requirement of 10 percent for field duplicates was achieved. All data collected for the 2023 post-closure monitoring program can be found in the Supporting Documentation folder included with this report.

Table 3-2. 2023 Summary of Qualified Precision Data

Site ID	Analyte	Sample Date	Method	Relative Percent Difference	Reported Value (UGL)	Flag	Data Qualifier
26157	Zinc (ZN)	5/1/2023	35AR	125.65%	LT 10	DF	Z
					43.8	F	Z

Note:
For each sample pair, both sample results are greater than or equal to twice the MRL and the RPD is greater than or equal to 35%.

D – Field duplicate sample F – Filtered
LT – Analyte not detected and reported as less than the stated reporting limit.
UGL – micrograms per liter, as presented in the RMAED

3.2 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 the results of laboratory control spikes (LCS) and matrix spikes (MS). 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 included with this report.

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

A total of 472 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 472 matrix spike analyses used in the evaluation was 85.5 percent. There were 19 matrix spike recoveries outside the control limits and 41 matrix spikes outside the warning limits. 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 472 LCS analyses corresponding to the matrix spike analyses was 97.2 percent. Matrix spike recoveries outside the warning evaluation limits were observed in three corresponding LCS recoveries. All MS and LCS pairings were within control evaluation limits. 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.

3.3 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 PCGMP (Navarro 2023). The program is designed and implemented to provide water quality data in the area of Basin F as defined in the post-closure groundwater monitoring plan.

QC blanks are limited to field blanks. Rinse blanks were not required as the wells were sampled with dedicated equipment. Trip blanks are not required as of 2018.

A total of 76 field blanks were collected representing one well from the Basin F water quality well network and analyzed for the methods and analytes presented in Table 2-3. There were five

field blank detections above the MRL. Comparison to the associated investigative data indicated one iron result from well 26128 requiring data qualification based on review of field blank data. The value was assigned an "E" flag code indicating the analyte was found in the investigative sample as well as the field blank. 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 laboratory 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. A total of 369 method blank analyses were performed. No interference was observed in investigative analyses thus no additional action is required.

The analytical results of monitoring are deemed representative of the groundwater quality with the exception of qualified data. Rejected data are not removed from the Rocky Mountain Arsenal Environmental Database (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.

3.4 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 are required under the Basin F SAP (TtEC 2011). Valid analytical data are those data that have been identified as usable and included in the RMAED. The Basin F SAP sets the completeness goal for the sampling program at 90 percent. For the 2023 post-closure monitoring program all analyses were accepted. Therefore, the completeness goal of 90 percent was achieved.

3.5 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 Basin F. Consistent procedures for the reporting and management of the data generated were followed, thus all data are considered comparable.

3.6 Data Usability

A data usability evaluation was conducted on 729 records. The evaluation identified zero statistical outliers. The data are considered acceptable for their intended use and no additional action is considered necessary.

A summary of the identified outliers and trends evaluated as part of the data quality review process is included with the Supporting Documentation, in the Data Usability subfolder (Basin F_Data_Usability_Summary_2023.xlsx). Additionally, well-specific summaries are also provided for reference. In accordance with the SQAPP, statistical trend analyses were conducted to evaluate data usability utilizing ProUCL software (EPA 2022).

The evaluation did not positively identify data quality issues; thus, the data are considered to be of acceptable quality and meets or exceeds the established data quality objectives. The data are of the correct type, quality, and quantity to support the intended use.

4.0 2023 WATER QUALITY

The Basin F groundwater monitoring program—in conformance with post-closure care for RCRA interim status units regulated under 6 CCR 1007-3 Subpart F, Section 265.90-265.94—was designed to monitor general trends and provide information on water quality by means of statistical evaluations. Thus, comparisons to chemical-specific standards do not apply to Basin F groundwater, since the RMA remedy addresses downgradient contaminated groundwater at the North Boundary Containment System and Northwest Boundary Containment System, where it is extracted and treated.

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 2023.

As detailed in the PCGMP (Navarro 2023), the high concentrations of some contaminants in downgradient wells—including chloroform, CPMSO2, DCPD, 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. Before Basin F was drained in 1988, significant contamination migrated from leaks in the basin 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 can act as continuing sources to the groundwater as the water table fluctuates. The leaks in the Basin F liner primarily occurred on the east side of Basin F, specifically in the area where PT excavation took place, which accounts for the higher concentrations in the downgradient PT wells.

Upgradient Water Quality – In addition to ICs, the following compounds were detected in upgradient WP and PT wells:

- Aldrin
- Aluminum
- alpha-Chlordane
- Ammonia
- Benzene
- Bromide
- Calcium
- Carbon Tetrachloride
- Chlorobenzene
- Dithiane
- Fluoride
- Iron
- Hexachlorocyclopentadiene
- Iron
- Isodrin
- Kjeldahl nitrogen
- Lead
- Magnesium
- Manganese
- Nitrate
- 1,4-Oxathiane
- Potassium
- PPDDE
- PPDDT
- Selenium
- Sodium
- Thiodiglycol
- Trichloroethylene
- Total organic carbon
- Total organic halogen
- Zinc

Downgradient Water Quality – In addition to ICs, the following compounds were detected in downgradient WP and PT wells:

- 1,1-Dicholorethane
- 1,2-Dichloroethane
- cis-1,2-Dichloroethene
- trans-1,2-Dichlorethene
- 1,3-Dichorobenzene
- Aldrin
- Aluminum
- Ammonia
- Benzene
- Benzothiazole
- Bromide
- Calcium
- p-Chlorophenylmethyl sulfide
- p-Chlorophenylmethyl sulfoxide
- Cobalt
- Copper
- Cyanide
- Dibromochloropropane
- Dithiane
- Endrin
- Fluoride
- Hexachlorocyclopentadiene
- Isodrin
- Iron
- Lead
- Magnesium
- Manganese
- Nickel
- Nitrate
- Kjeldahl nitrogen
- 1,4-Oxathiane
- Potassium
- PPDDE
- PPDDT
- Selenium
- Sodium
- Supona
- Total organic carbon
- Total organic halogens
- Trichloroethylene
- Zinc

The 2023 data for ICs analyzed in samples collected from WP and PT monitoring wells are summarized in Table 4-1. The analytical data for the ICs detected in the Basin F water quality network wells are presented in Figure 4-1.

Contaminants in the Basin F pathway occur primarily in alluvium-filled paleochannels and weathered bedrock, which can affect the migration and travel times from upgradient WP and PT wells to the downgradient wells. The concentrations of contaminants in the Basin F wells can be affected by rising water levels, which may mobilize the residual soil contamination that was previously present above the water table. As a result, increasing concentrations in the WP and PT wells should be compared to the trends in water levels to determine whether these conditions can be correlated. Refer to Section 5.0 for additional discussion on the trends in groundwater quality in WP and PT wells, including a discussion of the statistical prediction limits to which downgradient water quality data are compared.

Table 4-1. 2023 Post-Closure Water Quality Results

Designation	Concentrations by Well (µg/L)								
	Downgradient		Upgradient			Downgradient			
Network	WP/PT	WP	WP	PT	PT	PT	PT	PT	PT
Analyte	26015	26017	26028	26073	26128	26133	26157	26163	26173
Arsenic	**2.2**	1.53	**1.7**	LT 1	**2.51**	**2.93**	**1.67**	**7.15**	1.97
Chloroform	**1.02**	**0.214**	LT 0.2	**36.6**	**0.265**	6,540	**0.624**	LT 0.2	3,330
Chloride	686,000	476,000	920,000	158,000	1,130,000	**771,000**	659,000	2,670,000	363,000
CPMSO2	LT 1.2	LT 1.2	LT 1.2	LT 1.2	LT 1.2	**23.2**	24	9.59	**9.71**
Copper	LT 10	LT 10	LT 10	LT 10	LT 10	LT 10	LT 10	18.7	LT 10
DCPD	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	665	281	**365**	108
DIMP	**7.24**	**4.84**	**1,730**	**2.84**	**43.3**	143	**79.7**	**690**	129
Dieldrin	**0.372**	**0.979**	**0.0268**	0.0215	0.209	**1.29**	**0.703**	**0.601**	1.23
NNDMEA	**0.021**	LT 0.0048	**0.0178**	LT 0.0048	0.0421	**0.635**	**0.385**	**0.814**	**0.183**
Sulfate	**270,000**	269,000	**534,000**	833,000	664,000	**436,000**	405,000	988,000	**361,000**
TCLEE	LT 0.2	LT 0.2	LT 0.2	**1.17**	**0.613**	608	65.8	**4.59**	976

5.0 STATISTICAL EVALUATION

For purposes of Basin F post-closure monitoring, downgradient groundwater analyte concentrations are compared to upper prediction limits (UPL) calculated using upgradient well data to determine whether water quality may have been impacted by Basin F during the post-closure reporting period.

If downgradient groundwater analyte concentrations exceed UPLs, additional statistical analyses, including the Mann-Kendall test for trends and Shewhart-CUSUM control charts, are conducted in order to evaluate downgradient water quality trends. The Mann-Kendall test for trends is a nonparametric tool used to determine the statistical trend of post-closure data over time, while Shewhart-CUSUM control charts provide an indication of statistically significant increases above background or baseline conditions (EPA 1989, 1992, 2009).

The following sections describe the results of the approach used for the statistical evaluation of Basin F groundwater data. The statistical evaluation of analytical data in accordance with the PCGMP was conducted utilizing ChemStat statistical software, version 6.4 (Starpoint 2016).

5.1 Upper Prediction Limit Evaluations

In accordance with the PCGMP (Navarro 2023), UPLs used for the current 2023 evaluation represent upgradient water quality as of 2022, while upgradient data collected through 2023 have been used to calculate UPLs for use in evaluating water quality in 2024.

The use of UPLs, in combination with evaluating statistical water quality trends, provides an indication of potential impact to groundwater downgradient of Basin F relative to upgradient water quality for future sampling events. UPLs based on current data were calculated in accordance with Appendix A of the PCGMP (Navarro 2023) for each IC and are represented by a statistical 99 percent upper confidence limit (UCL) or defaulting to the maximum MRL. Current UPLs were then compared to baseline UPLs, and the maximum UPLs were selected for comparison to downgradient well data.

The upgradient wells for which data were collected and used for UPLs and statistical evaluations include well 26028 for the WP evaluation and wells 26073 and 26128 for the PT evaluation. UPLs calculated for Basin F WP and PT networks applicable to the current 2023 evaluation are presented in Table 5-1.

5.1.1 Wastepile 2023 UPL Comparison

Table 5-1 presents the 2023 selected UPLs for Basin F WP ICs. UPLs for 2023 were calculated for the Basin F WP ICs using groundwater data from 2006 through 2022 for upgradient well 26028. The 2023 Basin F WP UPLs were applied to data for downgradient wells 26015 and 26017. The 2023 reported values for ICs detected in wells exceeding their respective UPLs are presented in Table 5-2 and shown in Figure 4-1. The following analytes were detected at concentrations exceeding their respective UPLs in 2023.

Well 26015
- Chloroform

Well 26017
- Chloroform
- Dieldrin

The 2023 concentration of chloroform in exceedance of the UPL in well 26015 is within the historical range of detected concentrations and its presence is likely attributable to higher water levels that have mobilized residual contamination and have remained as the water table has decreased over the past few years.

The 2023 concentrations of chloroform and dieldrin in exceedance of their respective UPLs in well 26017 are also within the historical range of detected concentrations.

The reported concentrations of analytes not listed above and detected in downgradient Basin F WP wells are below the respective UPLs. Based on the UPL comparison, it appears that groundwater quality downgradient of the Basin F WP area has been affected in the vicinity of wells 26015 and 26017.

5.1.2 Principal Threat 2023 UPL Comparison

Table 5-1 presents the 2023 selected UPLs for Basin F PT ICs. UPLs for 2023 were calculated for the Basin F PT using upgradient groundwater data from 2007 through 2022 for upgradient wells 26128 and 26073. The 2023 Basin F PT UPLs were applied to data for downgradient wells 26015, 26133, 26157, 26163 and 26173. The 2023 reported values for ICs detected in wells exceeding their respective UPLs are presented in Table 5-2 and shown in Figure 4-1. The following analytes were detected at concentrations exceeding their respective UPLs in 2023.

Well 26133
- Chloroform
- CPMSO2
- DCPD
- Dieldrin
- NNDMEA
- TCLEE

Well 26157
- CPMSO2
- DCPD
- NNDMEA
- TCLEE

Well 26163
- Arsenic
- Chloride
- Copper
- CPMSO2
- DCPD
- DIMP
- NNDMEA
- TCLEE

Well 26173
- Chloroform
- CPMSO2
- DCPD
- NNDMEA
- TCLEE

The 2023 concentrations of all analytes in exceedance of UPLs in wells 26133, 26157, 26163 and 26173 are within the historical ranges of detected concentrations and many are likely attributable to higher water levels that have mobilized residual contamination. The remaining reported values for analytes not listed above in downgradient Basin F PT wells are below the respective UPLs. Based on the statistical evaluation, it appears that groundwater quality downgradient of the Basin F PT area has been affected in the vicinity of wells 26133, 26157, 26163, and 26173.

In 2023, no analyte concentrations exceeded PT UPLs in downgradient well 26015.

Table 5-1. Upper Prediction Limits for 2023 Water Quality Evaluations

Indicator Compound	Method Reporting Limit (µg/L)	Percentage of Upgradient Nondetections	Statistical Method Used	2023 Upgradient UPL (µg/L)
Wastepile				
Arsenic	1	63	Nonparametric	3.43
Chloride	1,000	0	Parametric	1,372,270
Chloroform	0.2	100	Nonparametric	0.2[1]
Copper	10	100	Nonparametric	10[1]
CPMSO2	1.6	100	Nonparametric	2.08[3]
DCPD	0.212	100	Nonparametric	0.28[3]
Dieldrin	0.00252	16	Parametric	0.623
DIMP	0.5	0	Parametric	1,620
NNDMEA	0.003	48	Nonparametric	0.0278
Sulfate	2,500	0	Parametric	565,393
TCLEE	0.2	100	Nonparametric	0.2[1]
Principal Threat				
Arsenic	1	48	Nonparametric	3.17
Chloride	1,000	0	Nonparametric	1,330,000
Chloroform	0.2	0	Nonparametric	96
Copper	10	100	Nonparametric	10[1]
CPMSO2	1.2	71	Nonparametric	2.54[2]
DCPD	0.212	100	Nonparametric	0.28[3]
Dieldrin	0.00252	3	Nonparametric	1.24
DIMP	0.5	0	Nonparametric	249
NNDMEA	0.003	40	Nonparametric	0.1
Sulfate	2,500	0	Parametric	1,180,900
TCLEE	0.2	0	Parametric	0.77

[1] Because this compound has not been detected in an upgradient well, the UPL value for this analyte is the current MRL.

[2] Data validated as Questionable; therefore, CPMSO2 result for sample collected from 26073 in 2018 excluded from consideration as a nonparametric UPL.

[3] This compound was not detected during baseline sampling; therefore, the prediction limit value for this analyte is the 99 percent UCL of the baseline MRL. The 99 percent UCL is defined as 1.3 times the maximum historical MRL (Navarro 2023).

Table 5-2. Statistical Summary for UPL Exceedances in Basin F Downgradient Wells

Well	Indicator Compound	2023 Concentration (µg/L)	2023 Selected UPL (µg/L)	Statistical Method Used	Mann-Kendall Trend Analysis	Shewhart-CUSUM Control Chart [1] *Statistical significance indicated?*
Wastepile						
26015	Chloroform	1.02	0.2	Nonparametric	Increasing	—
26017	Chloroform	0.214	0.2	Nonparametric	No Discernible Trend	—
	Dieldrin	0.979	0.623	Parametric	No Discernible Trend	—
Principal Threat						
26133	Chloroform	6,540	96	Nonparametric	Increasing	—
	CPMSO2	23.2	2.54	Nonparametric	Increasing	Yes
	DCPD	665	0.28	Nonparametric	No Discernible Trend	—
	Dieldrin	1.29	1.24	Nonparametric	Increasing	No
	NNDMEA	0.635	0.1	Nonparametric	Increasing	Yes
	TCLEE	608	0.77	Parametric	Increasing	Yes
26157	CPMSO2	24	2.54	Nonparametric	Decreasing	—
	DCPD	281	0.28	Nonparametric	Decreasing	—
	NNDMEA	0.385	0.1	Nonparametric	Decreasing	—
	TCLEE	65.8	0.77	Parametric	Decreasing	—
26163	Arsenic	7.15	3.17	Nonparametric	Increasing	Yes
	Chloride	2,670,000	1,330,000	Nonparametric	Decreasing	—
	Copper	18.7	10	Nonparametric	Increasing	Yes
	CPMSO2	9.59	2.54	Nonparametric	No Discernible Trend	—
	DCPD	365	0.28	Nonparametric	Increasing	Yes
	DIMP	690	249	Nonparametric	Increasing	No
	NNDMEA	0.814	0.1	Nonparametric	No Discernible Trend	—

Table 5-2. Statistical Summary for UPL Exceedances in Basin F Downgradient Wells

Well	Indicator Compound	2023 Concentration (µg/L)	2023 Selected UPL (µg/L)	Statistical Method Used	Mann-Kendall Trend Analysis	Shewhart-CUSUM Control Chart [1] *Statistical significance indicated?*
	TCLEE	4.59	0.77	Parametric	Increasing	Yes
26173	Chloroform	3,330	96	Nonparametric	Increasing	—
	CPMSO2	9.71	2.54	Nonparametric	Increasing	—
	DCPD	108	0.28	Nonparametric	Increasing	—
	NNDMEA	0.183	0.1	Nonparametric	Increasing	Yes
	TCLEE	976	0.77	Parametric	Increasing	Yes

Notes:

[1] Shewhart-CUSUM control charts were developed for indicator compounds that demonstrate increasing concentration trends, and are only applicable to normal or lognormal distributions (EPA 1989, 1992, 2009). Control charts were not evaluated for data that do not have a normal or lognormal statistical distribution.

5.1.3 2024 Upper Prediction Limits

Table 5-3 presents the UPLs calculated for each of the Basin F WP and PT ICs utilizing water quality data collected through 2023. These UPLs will be applied to water quality results for downgradient wells sampled during the 2024 monitoring program.

Table 5-3. Upper Prediction Limits for 2024 Water Quality Evaluations

Indicator Compound	Method Reporting Limit (µg/L)	Percentage of Upgradient Nondetections	Statistical Method Used	2024 Upgradient UPL (µg/L)
Wastepile				
Arsenic	1	60	Nonparametric	3.43
Chloride	1,000	0	Parametric	1,368,760
Chloroform	0.2	100	Nonparametric	0.2[1]
Copper	10	100	Nonparametric	10[1]
CPMSO2	1.6	100	Nonparametric	2.08[2]
DCPD	0.212	100	Nonparametric	2.8[2]
Dieldrin	0.00252	15	Parametric	0.471
DIMP	0.602	0	Parametric	1,899
NNDMEA	0.0048	45	Nonparametric	0.278
Sulfate	2,500	0	Parametric	584,720
TCLEE	0.2	100	Nonparametric	0.2[1]
Principal Threat				
Arsenic	1	49	Nonparametric	3.17
Chloride	1,000	0	Nonparametric	1,330,000
Chloroform	0.2	0	Nonparametric	96
Copper	10	100	Nonparametric	10[1]
CPMSO2	1.2	75	Nonparametric	2.54[3]
DCPD	0.212	100	Nonparametric	0.28[2]
Dieldrin	0.00252	3	Nonparametric	1.24
DIMP	0.602	0	Nonparametric	249
NNDMEA	0.0048	41	Nonparametric	0.1
Sulfate	2,500	0	Parametric	1,178,090
TCLEE	0.2	0	Parametric	0.81

Notes:

[1] Because this compound has not been detected in an upgradient well, the UPL value for this analyte is the current MRL.

[2] This compound was not detected during baseline sampling; therefore, the prediction limit value for this analyte is the 99 percent UCL of the baseline MRL. The 99 percent UCL is defined as 1.3 times the maximum historical MRL (Navarro 2023).

[3] Data validated as Questionable; therefore, CPMSO2 result for sample collected from 26073 in 2018 was excluded from consideration as a nonparametric UPL.

5.2 Statistical Trend Analysis

Statistical trends using the Mann-Kendall test were evaluated for downgradient wells where the concentration of ICs exceeded their respective UPL in order to determine whether a statistical trend exists that indicates increasing concentrations downgradient of Basin F. The Mann-Kendall test for trend is a non-parametric test commonly used to evaluate whether a linear trend exists within time-dependent data. According to EPA guidance, the Mann-Kendall test assumes that the lack of trend correlates with concentrations over time (e.g., time series plot) that fluctuate about a constant mean level, without a visually apparent upward or downward pattern (EPA 1989, 1992, 2009). As a nonparametric test, the actual concentrations (or ranks) are not used to calculate the test statistic, only the relative magnitudes of the concentrations.

As presented in Sections 5.1.1 and 5.1.2, the concentrations of ICs in WP and PT downgradient wells exceeded UPLs and further evaluation for statistical trends was conducted. Table 5-2 includes a summary of the Mann-Kendall trend analyses conducted for ICs detected at concentrations exceeding their respective 2023 UPLs. Detailed information related to the Mann-Kendall analyses is included as supporting documentation.

For WP UPL exceedances, chloroform exceeded the UPL in downgradient well 26015 and concentrations indicate an increasing trend. This trend is a continuation of previously-evaluated trends that show chloroform increasing in well 26015 during post-closure monitoring. Chloroform detected in well 26015 at concentrations greater than the WP and PT prediction limits is likely attributable to higher water levels previously present beneath the former Basin F footprint that mobilized residual contamination.

Chloroform and dieldrin exceeded the WP UPL in downgradient well 26017, however Mann-Kendall analysis indicated no discernible trend for either analyte in 2023.

Increasing trends of ICs are evident in downgradient PT wells 26133, 26163, and 26173 (Table 5-2). The following ICs indicate increasing trends in groundwater downgradient of the former Basin F:

Well 26133
- Chloroform
- CPMOS2
- DIMP
- DLDRN
- NNDMEA
- TCLEE

Well 26163
- Arsenic
- Copper
- DCPD
- DIMP
- NNDMEA
- TCLEE

Well 26173
- Chloroform
- CPMSO2
- DCPD
- DIMP
- NNDMEA
- TCLEE

The presence of elevated concentrations of analytes in wells 26133 and 26173—as compared to well 26163, which is adjacent and immediately downgradient of the former basin—indicate that contamination historically may have mobilized from Basin F prior to the remedy. Alternatively, water level maps developed annually during the closure and post-closure periods indicate wells northeast of the former Basin F are located along a groundwater flow path east of the former basin which was historically impacted by contamination from the Sand Creek Lateral. Therefore, it is likely that groundwater in wells 26133, 26157, and 26173 may be affected by contamination associated with the Sand Creek Lateral, and not exclusively by former Basin F.

5.3 Shewhart-CUSUM Control Charts

In situations where the concentration of an IC exceeds the UPL and a statistical increasing trend is determined by Mann-Kendall analysis, control charts were assessed to determine whether the trends are statistically significant. Control charts are a parametric analytical tool; thus data must follow normal or lognormal distributions.

An intrawell Shewhart-CUSUM control chart is a viable alternative to the use of UPLs to evaluate whether there is evidence that concentrations in a downgradient well exceeds upgradient, or background, water quality (EPA 2009). Control charts are advantageous such that they provide a graph and analysis of concentrations over time rather than a single point comparison. Control charts depicting Basin F water quality compare baseline data to post-closure data for a single downgradient well in order to identify whether the increase is statistically significant. Control charts were constructed using downgradient well baseline data collected prior to closure and data collected after closure. Attachment B provides supporting documentation of statistical analyses, including the control charts, evaluated in 2023.

Further evidence of statistical significance was identified in the intrawell control charts for the analytes detected in the downgradient PT wells below.

Well 26133	Well 26163	Well 26173
• CPMSO2	• Arsenic	• NNDMEA
• NNMEA	• Copper	• TCLEE
• TCLEE	• DCPD	
	• TCLEE	

While wells 26133 and 26173 have likely been impacted by releases not related to Basin F, elevated concentrations of arsenic, copper, DCPD, and TCLEE in well 26163 likely represent groundwater impacted by the remobilization of residual soil contamination caused by fluctuating water levels within the unsaturated zone beneath the former basin.

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. Table 6-1 presents a summary of the results for the evaluation of water quality in WP and PT wells in 2023.

The following conclusions are based on the groundwater monitoring results for the 2023 Basin F post-closure groundwater monitoring program:

- In 2023, groundwater elevations decreased in all downgradient and upgradient monitoring wells. Demonstrating a variable trend in water levels compared to other wells in the monitoring network, data for well 26128 appears different from the other wells in the vicinity of Basin F. It seems likely that well 26128 does not respond similar to other wells in the Basin F area because it is screened deeper within the weathered and

unweathered Denver Formation. As such, well 26128 does not provide an accurate depiction of the UFS upgradient of Basin F. The overall decrease in UFS water levels in the vicinity of Basin F is consistent with a general decreasing trend noted across RMA over the past several years.

- Based on the results of the data QA review, the analytical data collected in 2023 are of acceptable quality for their intended uses.
- To a lesser extent as compared to the PT area, groundwater along the WP flow path appears to have been impacted by residual soil contamination that remains within the western portion of the Basin F area. Chloroform in downgradient well 26015 exceeded the UPL and concentrations appear to be increasing based on the Mann-Kendall trend analysis. Chloroform and dieldrin in downgradient well 26017 exceeded their respective UPLs, however Mann-Kendall analysis indicated no discernible trend for either analyte (Table 5-2).
- Groundwater along the PT flow path appears to have been impacted by residual soil contamination that remains within the PT area and may also be impacted by sources associated with the Sand Creek Lateral located east of the former basin, as demonstrated by observed increases of select ICs in wells northeast of the PT area. Several ICs exceed UPLs—including arsenic, chloride, chloroform, copper, CPMSO2, DCPD, dieldrin, DIMP, NNDMEA, and TCLEE—and appear to be increasing in one or more downgradient wells.

Based on the distribution of the analyte concentrations and water quality trends, it appears that the PT groundwater flow path is having a greater impact on water quality downgradient of the former Basin F compared to the WP flow path. While concentrations of ICs less frequently exceed UPLs, with many ICs demonstrating decreasing trends, concentrations downgradient of the PT indicate an impact due to contaminated groundwater migrating from upgradient sources and/or residual contamination within the unsaturated zone beneath the Basin F PT area.

Table 6-1. Summary of 2023 Post-Closure Groundwater Quality

Wastepile Wells	Principal Threat Wells
Arsenic	
• Concentrations of arsenic increased in upgradient and downgradient well 26015 in 2023. • Concentrations of arsenic were less than the UPL in both downgradient wells.	• Concentrations of arsenic increased in downgradient wells 26015, 26157, and 26163, but only exceeded the UPL in 26163. • An increasing statistical trend was observed, and the presence of arsenic in well 26163 is statistically significant as demonstrated by a Shewhart-CUSUM control chart indicated an exceedance of the control limit.
Chloroform	
• Chloroform was not detected in upgradient well 26028. • Concentrations of chloroform in downgradient wells 26015 and 26017 increased in 2023 and exceeded the UPL. • Statistical analysis indicates an increasing trend of chloroform in well 26015 and no discernible trend in well 26017.	• Concentrations of chloroform were detected in all four downgradient wells and in both upgradient wells. • Chloroform exceeded the UPL in downgradient wells 26133 and 26173, with increasing trends also indicated by Mann-Kendall analysis.
Chloride	
• Concentrations of chloride decreased in downgradient wells 26015 and 26017 and in upgradient well 26028 in 2023. • Concentrations of chloride were less than the UPL in both downgradient wells.	• Concentration of chloride increased in downgradient well 26133 but was less than the UPL. • Chloride exceeded the UPL in downgradient well 26163, but a decreasing trend is indicated by Mann-Kendall analysis. • Chloride was detected in both upgradient wells.
CPMSO2	
• CPMSO2 was not detected in upgradient or downgradient WP wells.	• CPMSO2 was detected in downgradient wells 26133, 26157, 26163, and 26173 in 2023, but was not detected in well 26015 or either upgradient well. • Concentrations of CPMSO2 exceeded the UPL downgradient well 26133. • An increasing statistical trend was observed, and the presence of CPMSO2 in well 26133 is statistically significant as demonstrated by the Shewhart-CUSUM control chart.

Table 6-1. Summary of 2023 Post-Closure Groundwater Quality

Wastepile Wells	Principal Threat Wells
Copper	
• Copper was not detected in upgradient or downgradient wells in 2023.	• Copper was only detected in downgradient well 26163 in 2023 and exceeded the UPL, showing a statistically increasing trend in this well. • Copper was not detected in either upgradient well. • The presence of copper in well 26163 is statistically significant as demonstrated by a Shewhart-CUSUM control chart.
DCPD	
• DCPD was not detected in upgradient or downgradient wells in 2023.	• DCPD was detected in downgradient wells 26133, 26157, 26163, and 26173 with concentrations exceeding the UPL in the four wells. • DCPD was not detected in upgradient wells. • Concentrations of DCPD indicate statistically increasing trends during post-closure in well 26163, and the presence of DCPD in well 26163 is statistically significant as demonstrated by a Shewhart-CUSUM control chart.
DIMP	
• Concentrations of DIMP were less than the UPL in both downgradient wells.	• DIMP was detected in all five downgradient wells. Concentrations only exceed the UPL in well 26163. • Concentrations of DIMP indicate statistically increasing trends during post-closure in well 26163, but the presence of DIMP in well 26163 is *not* statistically significant as demonstrated by the Shewhart-CUSUM control chart.
Dieldrin	
• Concentrations of dieldrin increased in downgradient wells 26015 and 26017 and upgradient well 26028 in 2023. • Concentrations of dieldrin were less than the UPL downgradient well 26015 and above the UPL in downgradient well 27017.	• Dieldrin was detected in all five downgradient wells and in both upgradient wells in 2023. • Concentrations of dieldrin exceeded the UPL in downgradient well 26133. • Concentrations of dieldrin indicate a statistically increasing trend during post-closure in well 26133, but the presence of dieldrin in well 26163 is not statistically significant as demonstrated by the Shewhart-CUSUM control chart.

Table 6-1. Summary of 2023 Post-Closure Groundwater Quality

Wastepile Wells	Principal Threat Wells
NNDMEA	
• NNDMEA was detected in upgradient well 26028. • NNDMEA was detected in well 26015, at a concentration less than the UPL, but it was not detected in downgradient well 26017.	• NNDMEA was detected in all five downgradient wells in 2023, and concentrations exceeded the UPL in four of the five wells. • Increasing statistical trend observed in downgradient wells 26133 and 26173. • Increasing statistical trends were observed, and the presence of NNDMEA in wells 26133 and 26173 is statistically significant as demonstrated by a Shewhart-CUSUM control chart indicated an exceedance of the control limit. • NNDMEA was detected in upgradient well 26128.
Sulfate	
• Sulfate was detected in all downgradient and upgradient wells. • Concentrations of sulfate increased in well 26015 and decreased in well 26017 in 2023. Sulfate concentrations were less than the UPL in both downgradient wells. • Statistical analysis indicates a decreasing trend in well 26015 and no trend in well 26017.	• Sulfate was detected in all downgradient wells, but concentrations did not exceed the UPL. • Sulfate was detected in both upgradient wells.
TCLEE	
• TCLEE was not detected in upgradient or downgradient WP wells in 2023.	• Concentrations of TCLEE were detected in four of five downgradient wells and in both upgradient wells. • In 2023, concentrations increased in downgradient well 26163, and concentrations exceeded the UPL in downgradient wells 26133, 26163, and 26173. • Increasing statistical trends were observed in downgradient wells 26133, 26163, and 26173, with the presence of TCLEE in all three wells shown as statistically significant as demonstrated by Shewhart-CUSUM control charts.

7.0 REFERENCES

EPA (U.S. Environmental Protection Agency)

2022 ProUCL: Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations. Version 5.2.

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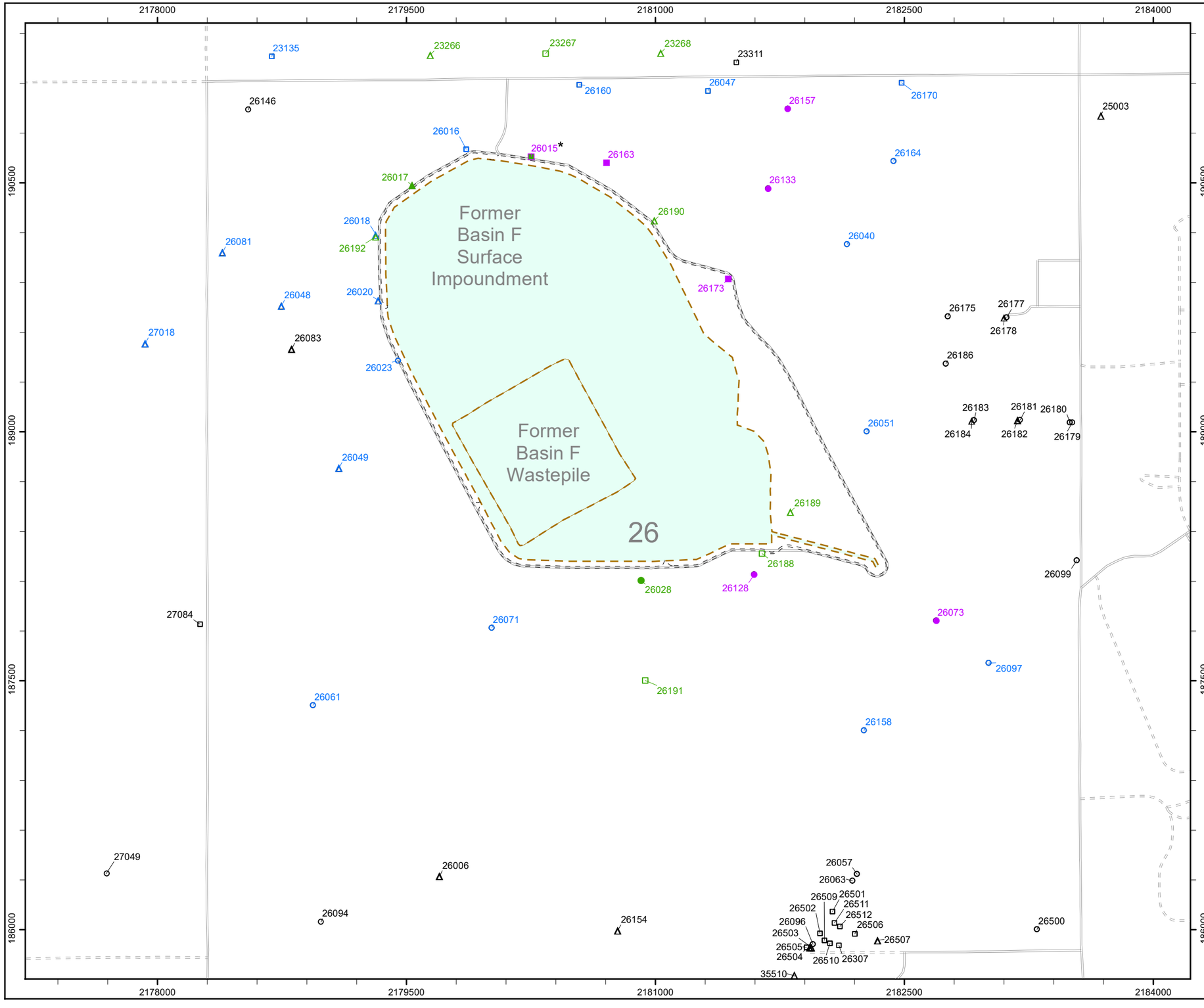
TtEC (Tetra Tech EC, Inc.)

2011 *Basin F Closure and Post-Closure Groundwater Monitoring Sampling and Analysis Plan*. Revision 2, March 2011.

FIGURES



Legend

- Former Basin F Surface Impoundment
- Paved Roads
- Unpaved Roads

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

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

N

0 230 460 920 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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Rocky Mountain Arsenal

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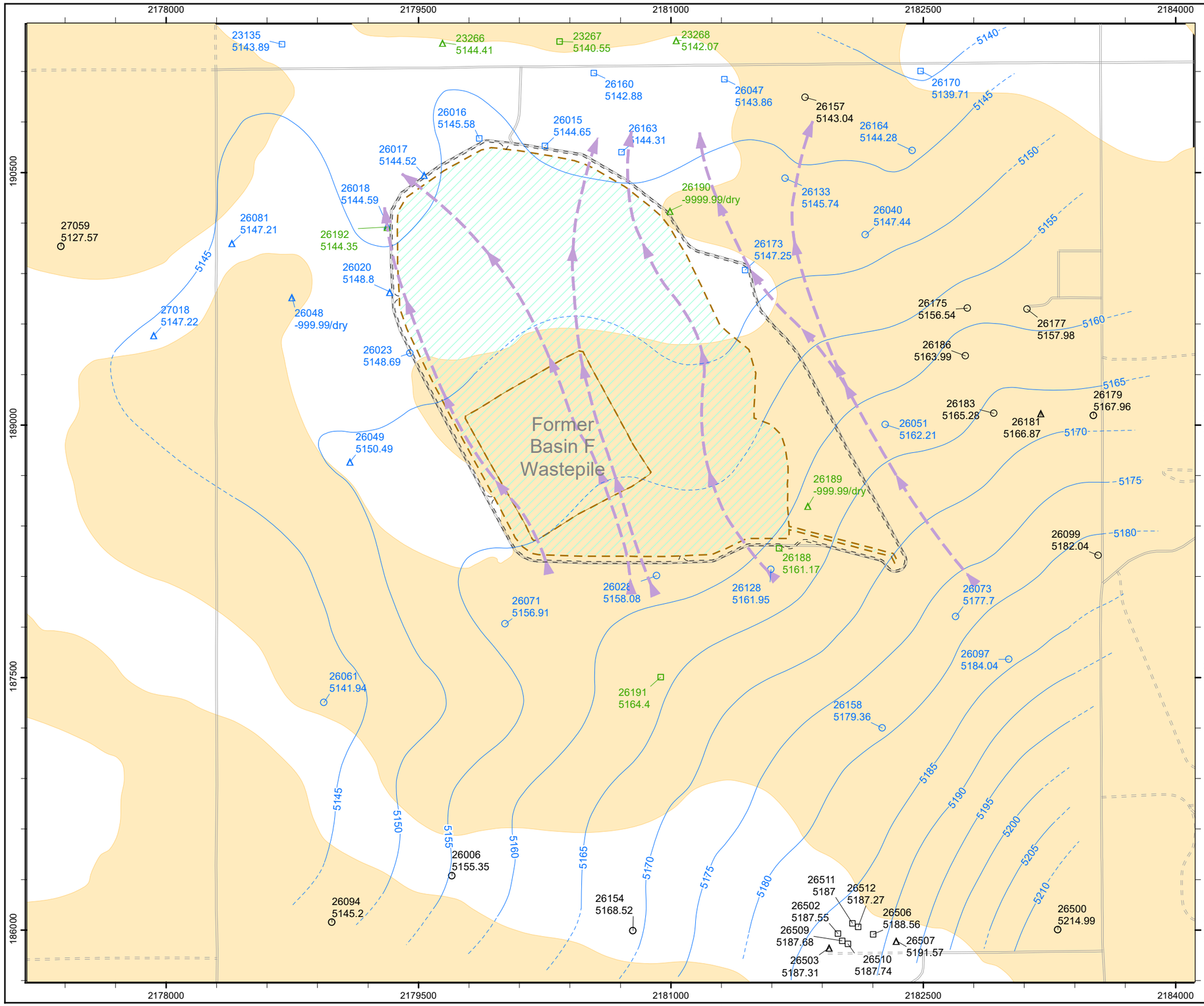
Figure 2-1

Former Basin F
Well and Piezometer
Location Map

M:\projects\basin-F_post-closure\2023\mxds\BF_CurrentMonWellNetwork_101823.mxd
10/23/2023



Legend

- Unsaturated Alluvium
- Former Basin F Surface Impoundment
- Paved Roads
- Unpaved Roads
- Groundwater Flowpath
- 26051 5161.20 — Well ID and Groundwater Elevation

Note: Water levels were measured in FY23 Quarters 2 and 3. Unsaturated alluvium interpreted using data from 2021 and 2022.

Monitoring Well/ Piezometer Network	Flow System / Aquifer		
	Unconfined Alluvial	Unconfined Alluvial/ Denver	Unconfined Denver
Water Level Network	△	□	○
Other Network Wells	△	□	○
Optimization Network Wells	△	□	○

N

0 230 460 920 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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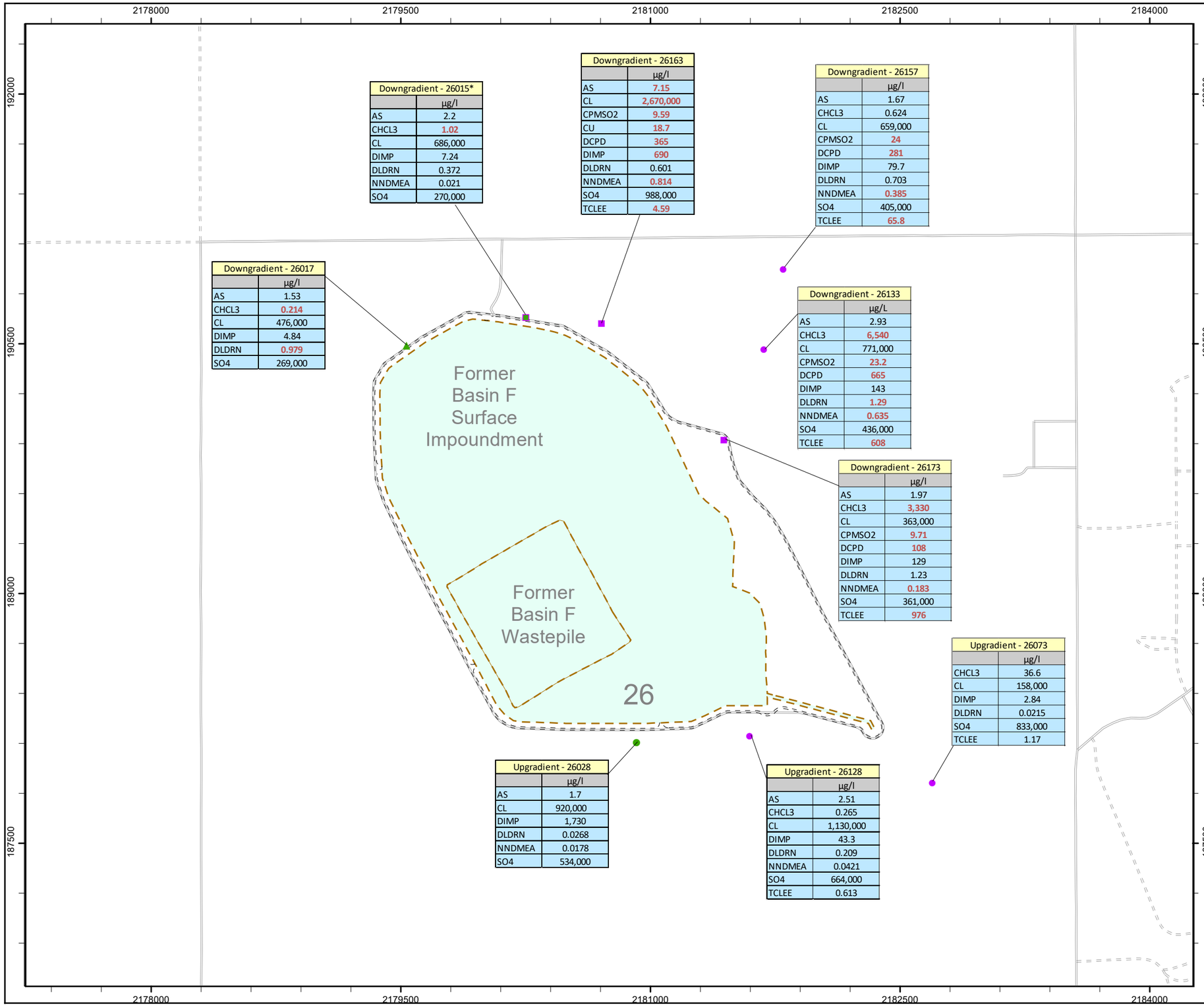
Figure 2-2

Former Basin F 2023 Potentiometric Surface of the Unconfined Flow System

M:\projects\basin-F_post-closure\2023\mxds\basinf_waterelev_uncon_FY23.mxd
10/23/2023



Downgradient - 26015*	
	µg/l
AS	2.2
CHCL3	1.02
CL	686,000
DIMP	7.24
DLDRN	0.372
NNDMEA	0.021
SO4	270,000

Downgradient - 26163	
	µg/l
AS	7.15
CL	2,670,000
CPMSO2	9.59
CU	18.7
DCPD	365
DIMP	690
DLDRN	0.601
NNDMEA	0.814
SO4	988,000
TCLEE	4.59

Downgradient - 26157	
	µg/l
AS	1.67
CHCL3	0.624
CL	659,000
CPMSO2	24
DCPD	281
DIMP	79.7
DLDRN	0.703
NNDMEA	0.385
SO4	405,000
TCLEE	65.8

Downgradient - 26017	
	µg/l
AS	1.53
CHCL3	0.214
CL	476,000
DIMP	4.84
DLDRN	0.979
SO4	269,000

Downgradient - 26133	
	µg/L
AS	2.93
CHCL3	6,540
CL	771,000
CPMSO2	23.2
DCPD	665
DIMP	143
DLDRN	1.29
NNDMEA	0.635
SO4	436,000
TCLEE	608

Downgradient - 26173	
	µg/l
AS	1.97
CHCL3	3,330
CL	363,000
CPMSO2	9.71
DCPD	108
DIMP	129
DLDRN	1.23
NNDMEA	0.183
SO4	361,000
TCLEE	976

Upgradient - 26073	
	µg/l
CHCL3	36.6
CL	158,000
DIMP	2.84
DLDRN	0.0215
SO4	833,000
TCLEE	1.17

Upgradient - 26028	
	µg/l
AS	1.7
CL	920,000
DIMP	1,730
DLDRN	0.0268
NNDMEA	0.0178
SO4	534,000

Upgradient - 26128	
	µg/l
AS	2.51
CHCL3	0.265
CL	1,130,000
DIMP	43.3
DLDRN	0.209
NNDMEA	0.0421
SO4	664,000
TCLEE	0.613

Legend

- Former Basin F Surface Impoundment
- Paved Roads
- Unpaved Roads
- * Well 26015 is used in both Wastepile Water Quality and Principal Threat Water Quality Networks.

Monitoring Well/ Piezometer Network	Flow System / Aquifer: Unconfined Alluvial	Unconfined Alluvial/ Denver	Unconfined Denver
Basin F Wastepile Water Quality Network	▲	■	●
Basin F Principal Threat Water Quality Network		■	●

Note: Values in red indicate analytical results that exceeded 2022 upper prediction limits.

N

0 230 460 920 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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Figure 4-1

Former Basin F 2023 Well Network Indicator Compound Detection Map

M:\projects\basin-F_post-closure\2023\mxds\BasinF_ind_comp_2023.mxd
10/11/2023

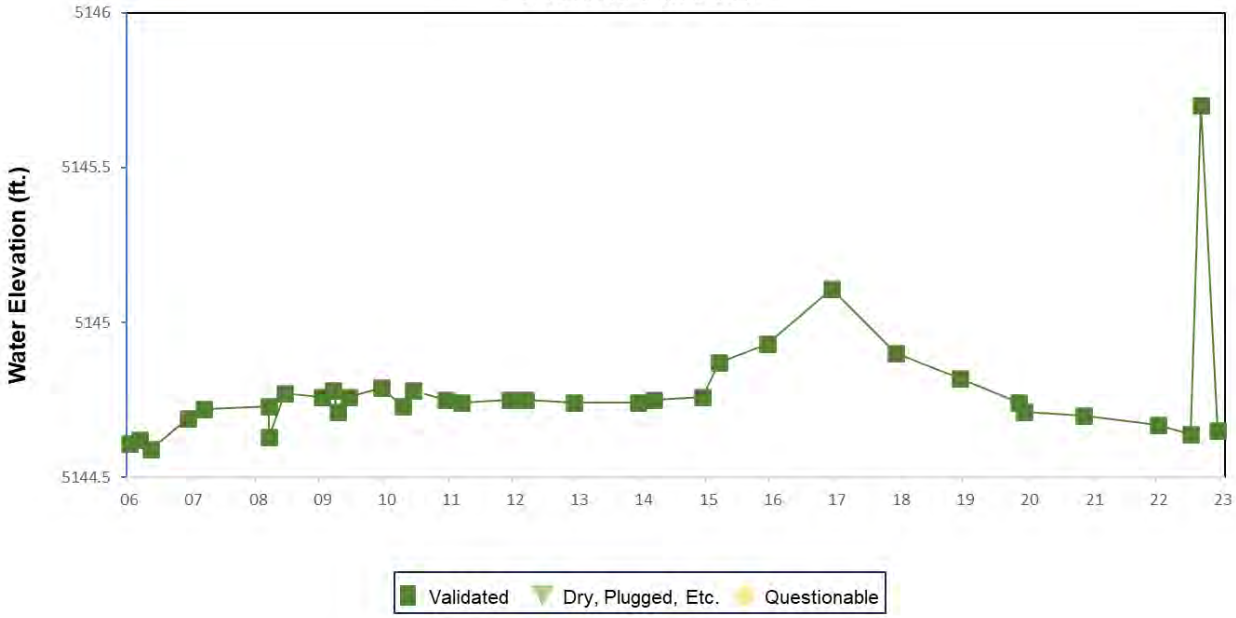
ATTACHMENTS

ATTACHMENT A

Hydrographs for Basin F Network Wells

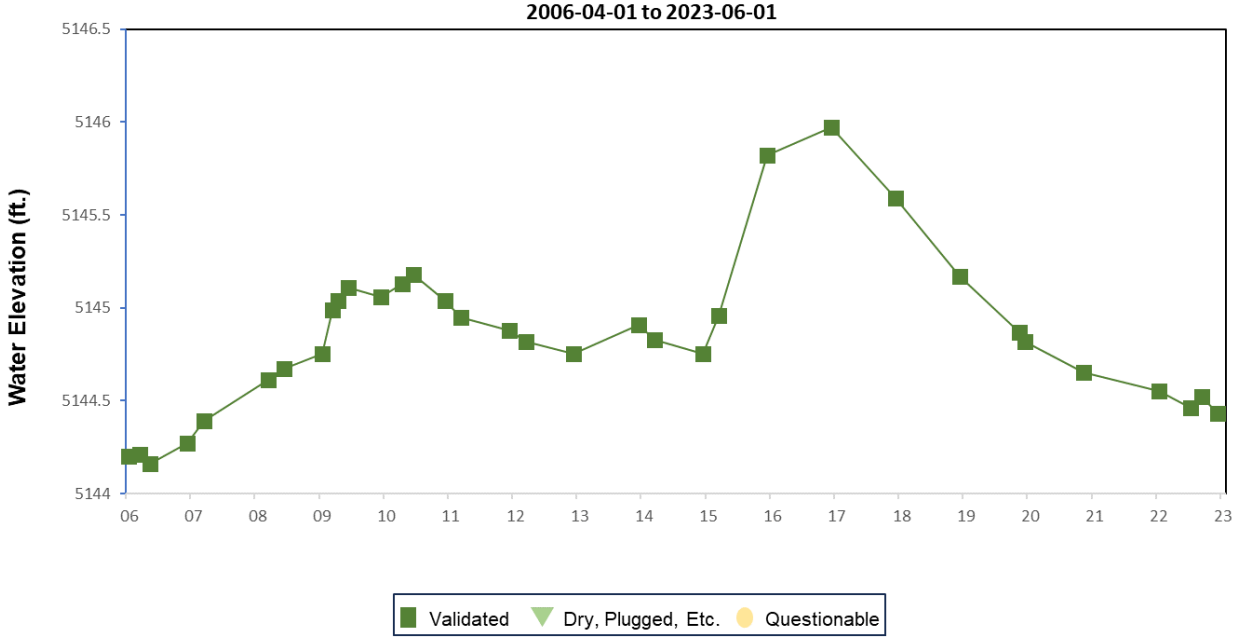
Water Levels for Well 26015

2006-04-01 to 2023-06-01



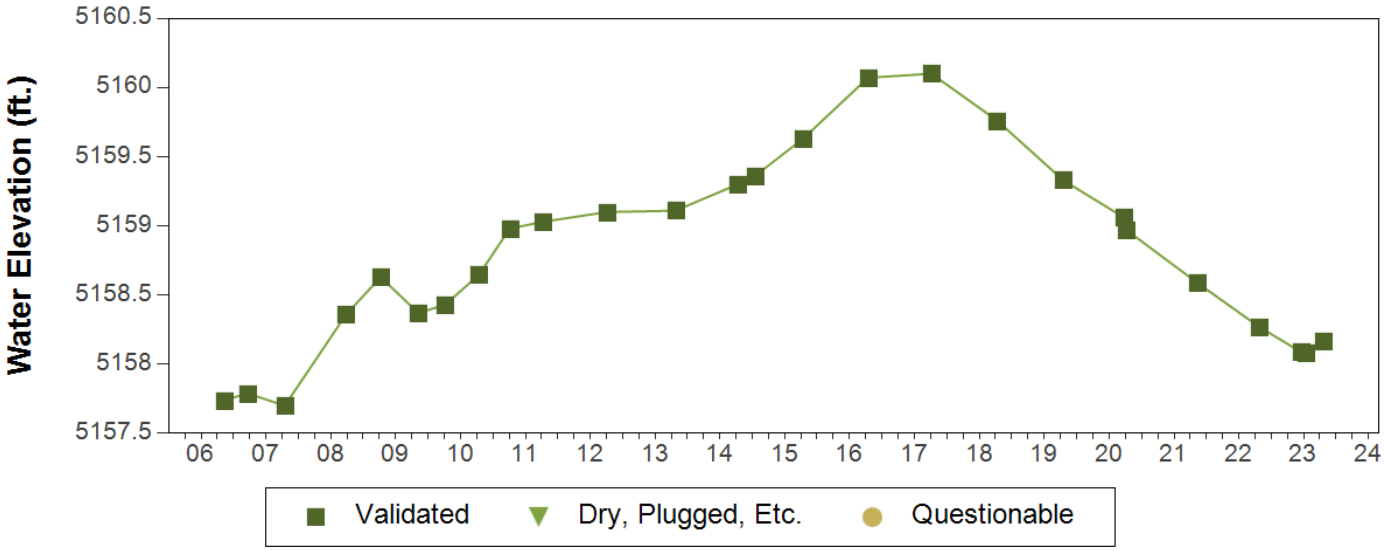
Water Levels for Well 26017

2006-04-01 to 2023-06-01



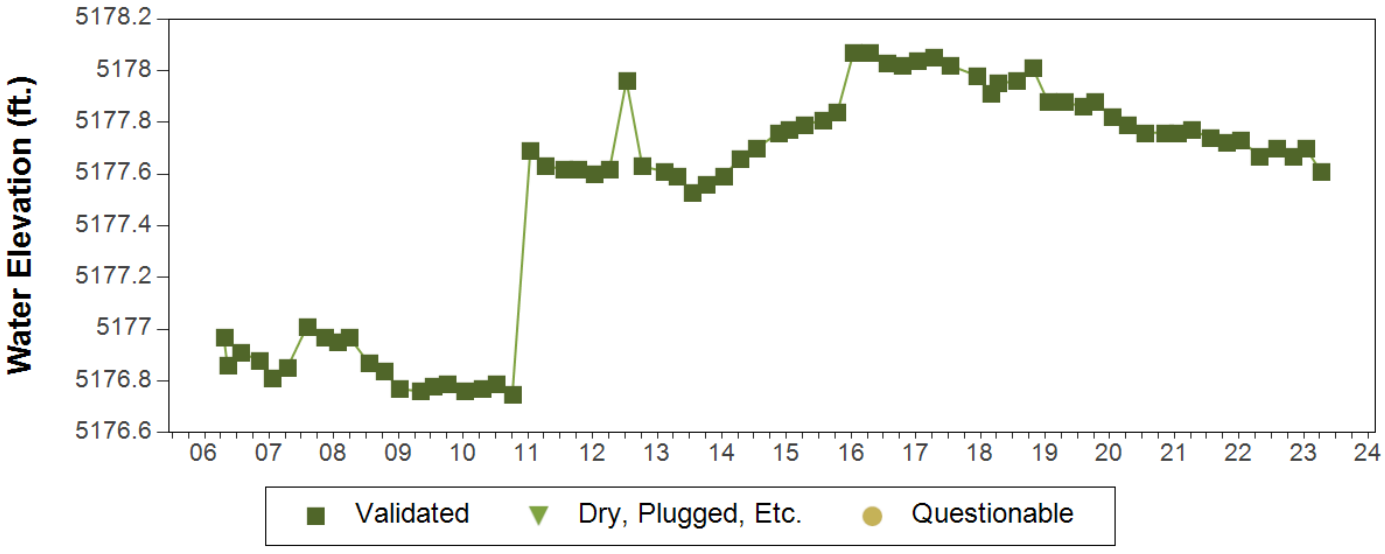
Water Levels for Well 26028

2006-04-01 to 2023-06-01



Water Levels for Well 26073

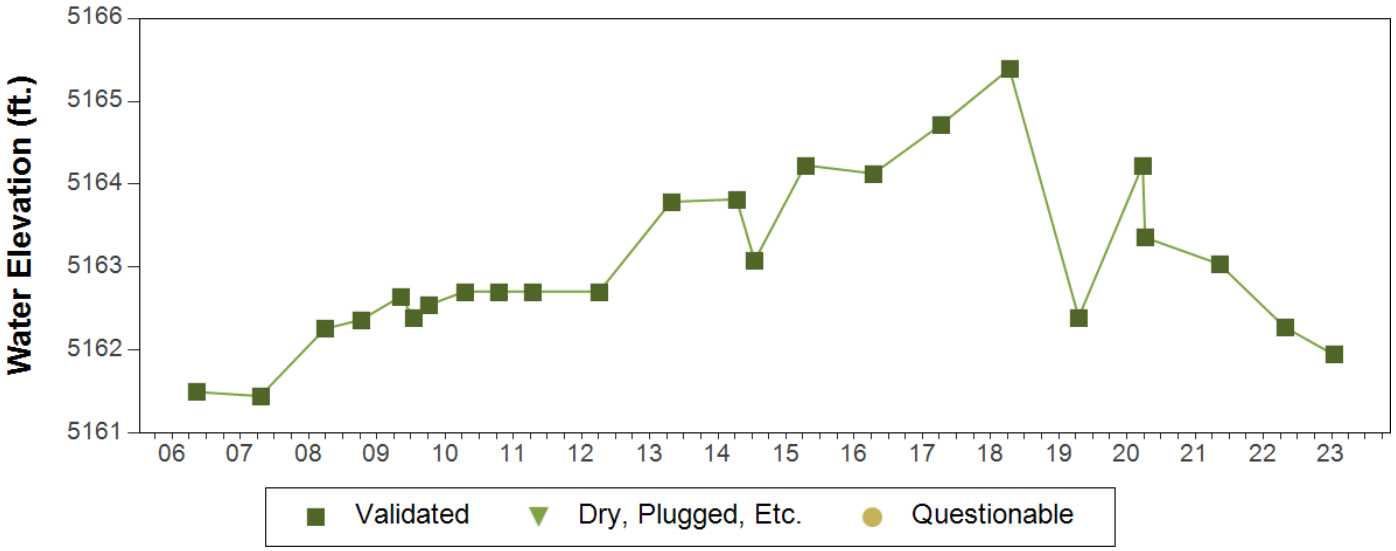
2006-04-01 to 2023-06-01



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

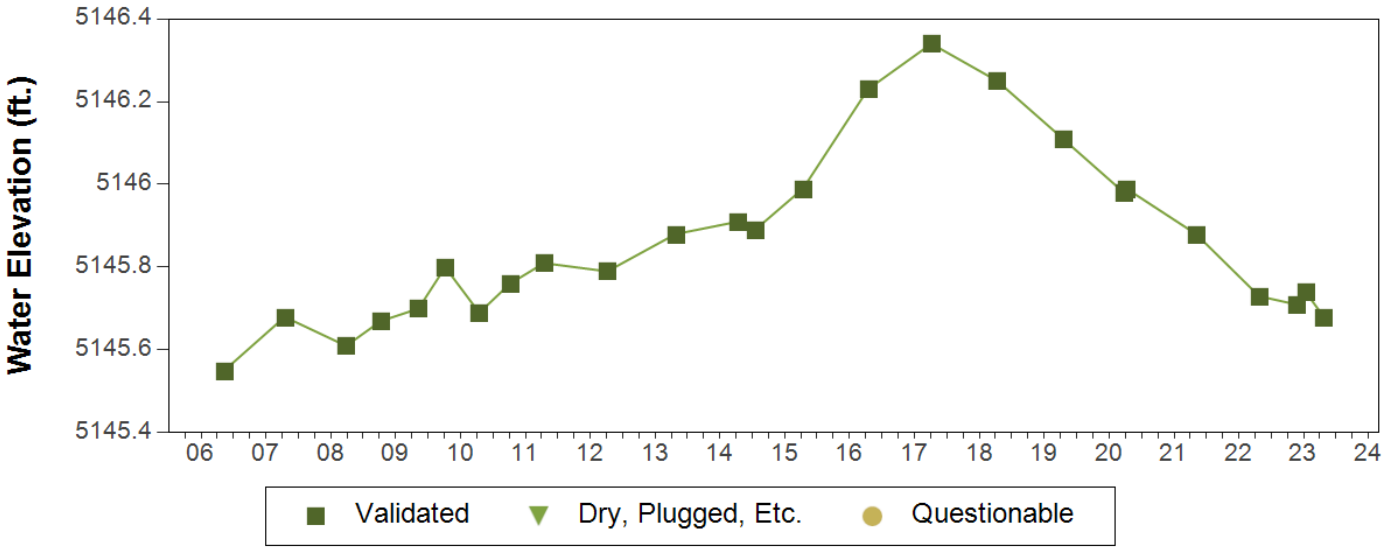
Water Levels for Well 26128

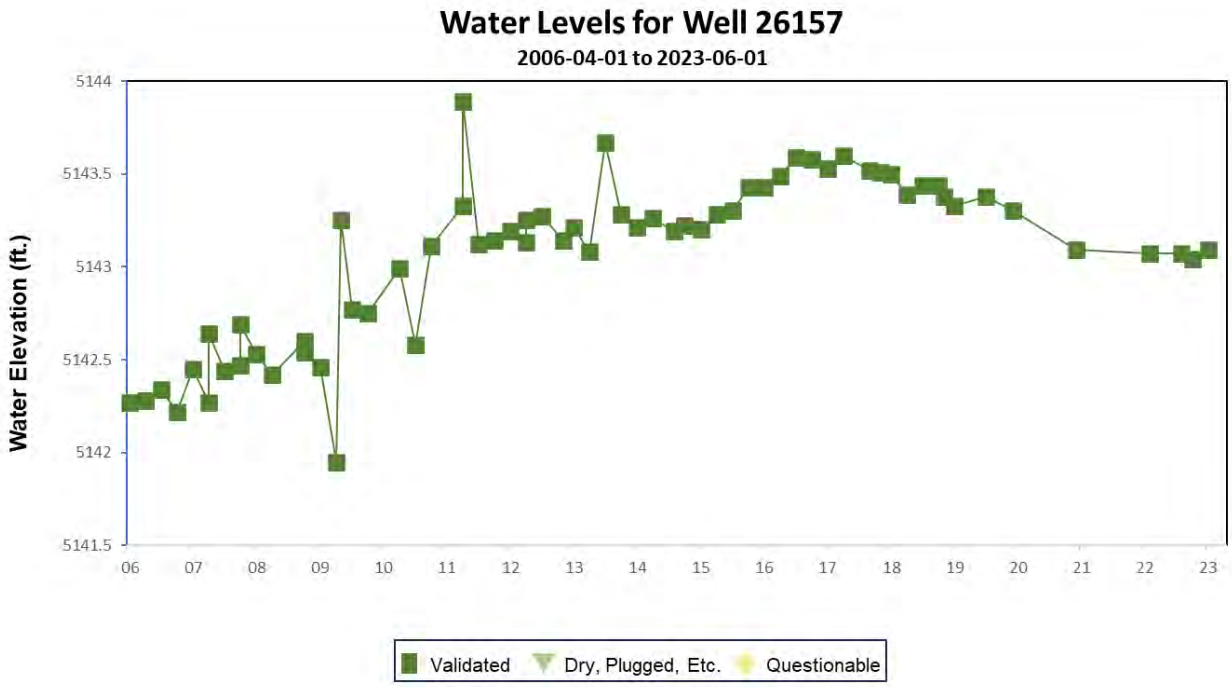
2006-04-01 to 2023-06-01



Water Levels for Well 26133

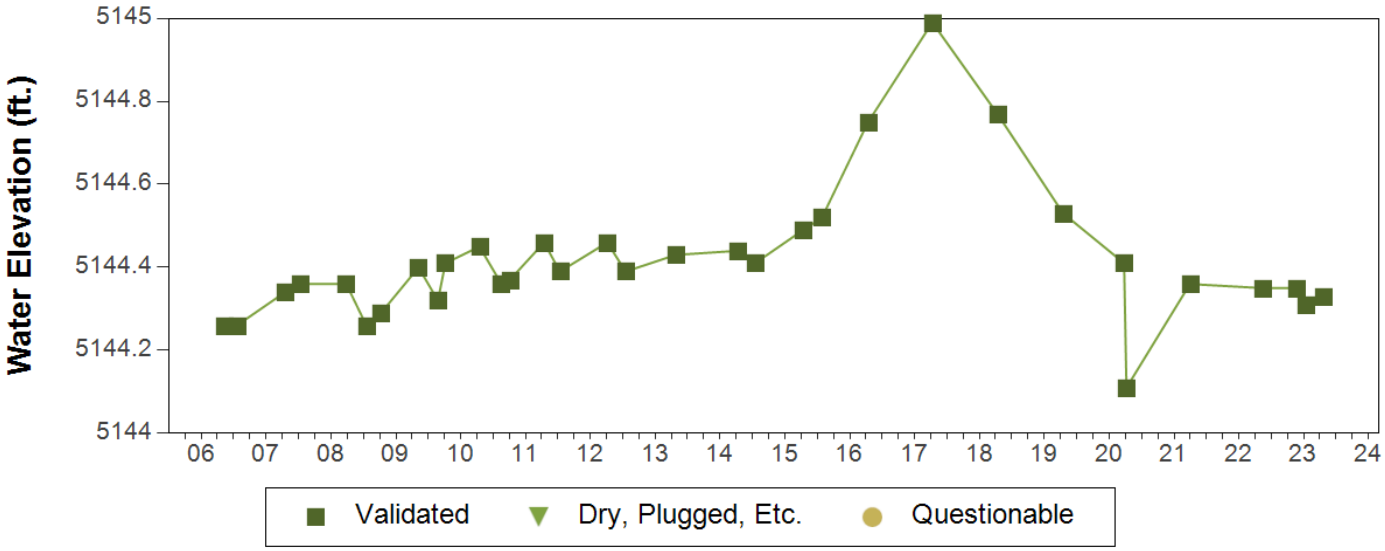
2006-04-01 to 2023-06-01




Water Levels for Well 26157
2006-04-01 to 2023-06-01
Water Elevation (ft.)
5144
5143.5
5143
5142.5
5142
5141.5
06
07
08
09
10
11
12
13
14
15
16
17
18
19
20
21
22
23
Validated
Dry, Plugged, Etc.
Questionable

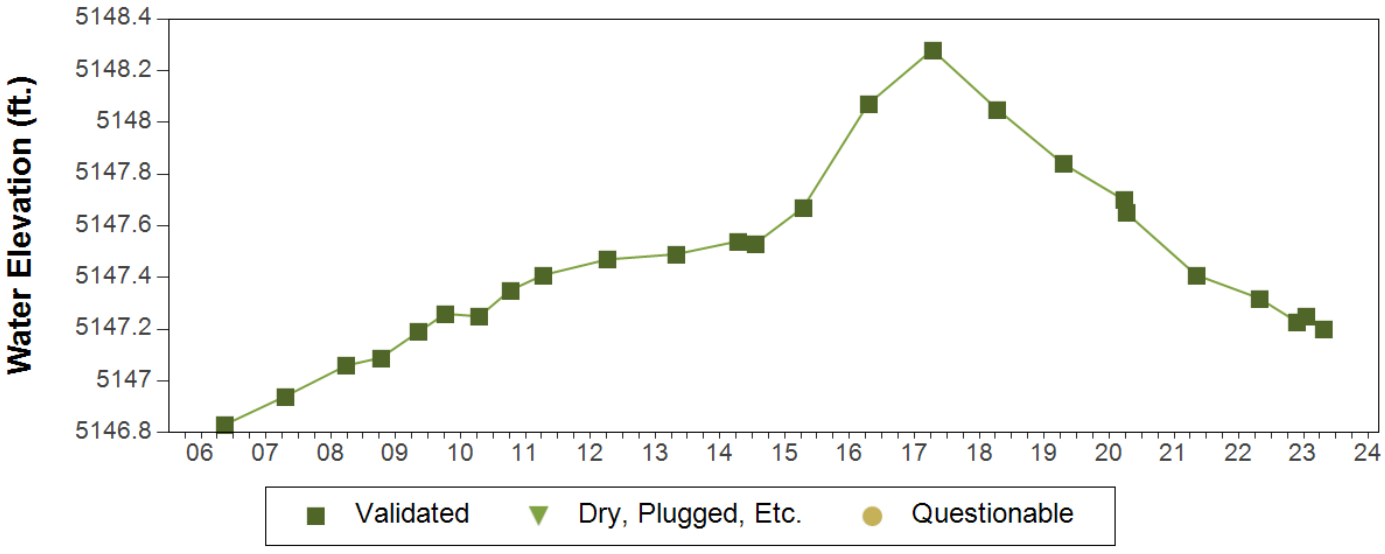
Water Levels for Well 26163

2006-04-01 to 2023-06-01



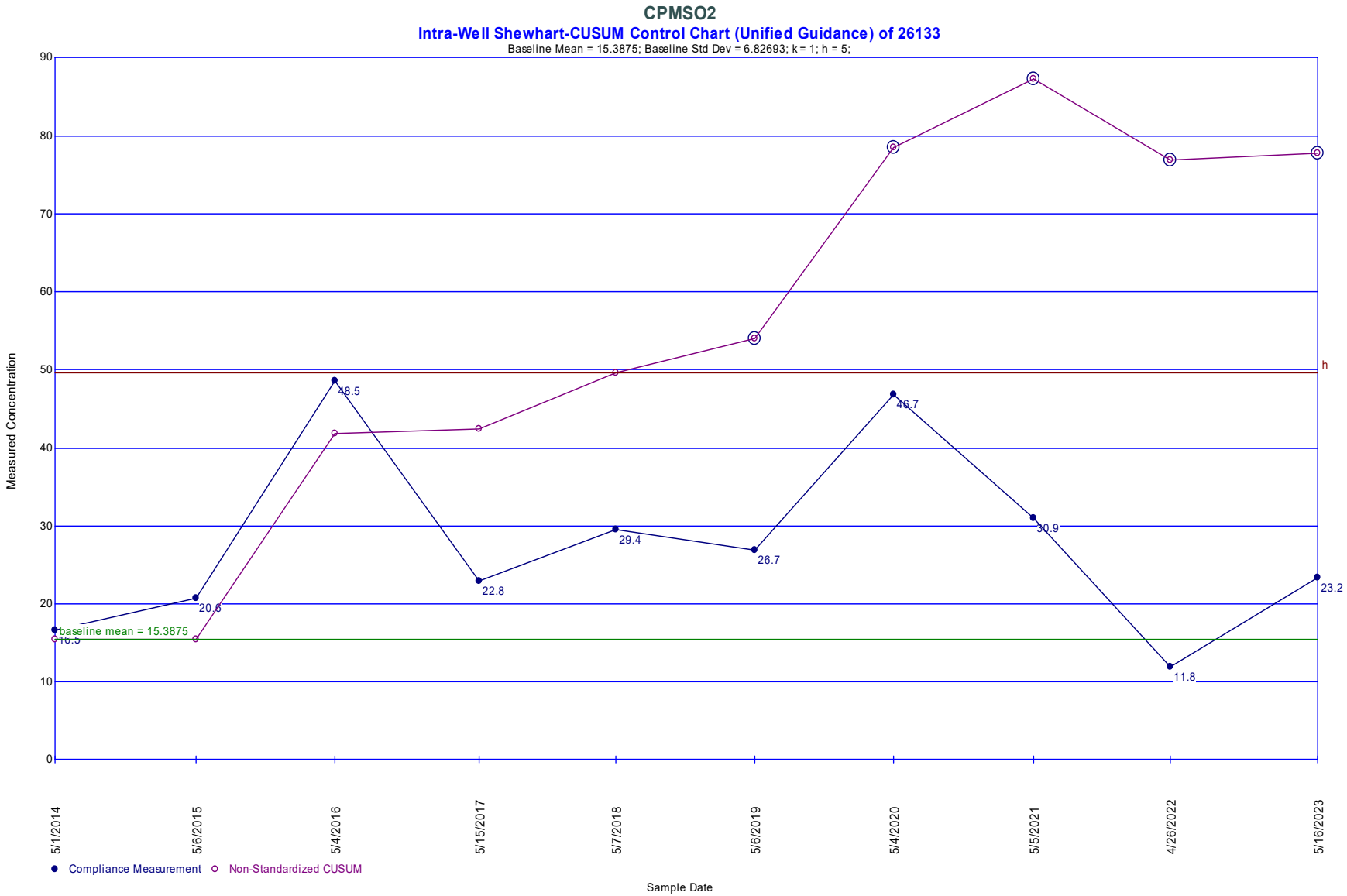
Water Levels for Well 26173

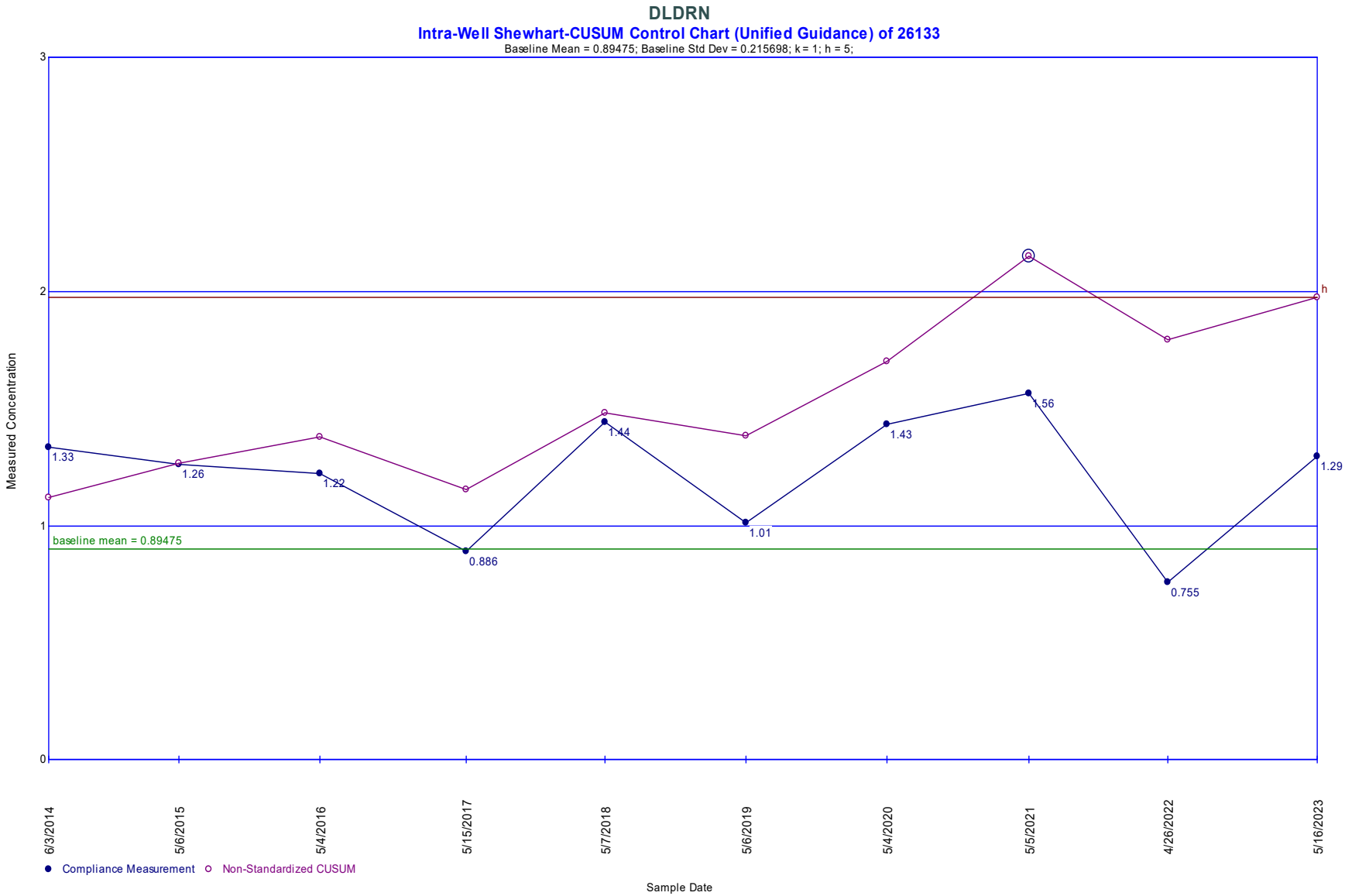
2006-04-01 to 2023-06-01

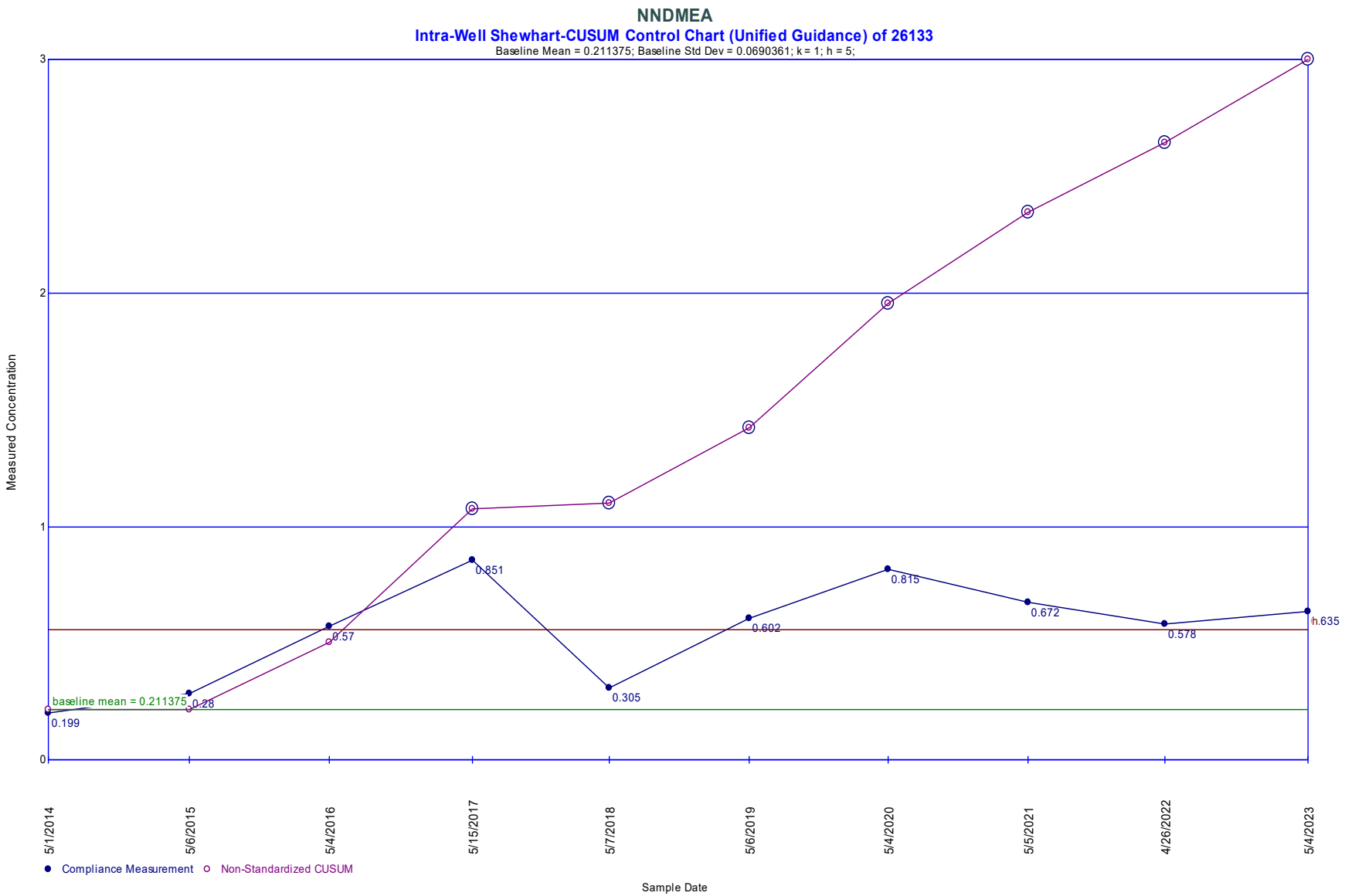


ATTACHMENT B

Shewhart-CUSUM Control Charts


CPMSO2
Intra-Well Shewhart-CUSUM Control Chart (Unified Guidance) of 26133
Baseline Mean = 15.3875; Baseline Std Dev = 6.82693; k = 1; h = 5;
Measured Concentration
Sample Date
h
baseline mean = 15.3875
16.5
20.6
48.5
22.8
29.4
26.7
46.7
30.9
11.8
23.2
5/1/2014
5/6/2015
5/4/2016
5/15/2017
5/7/2018
5/6/2019
5/4/2020
5/5/2021
4/26/2022
5/16/2023
Compliance Measurement
Non-Standardized CUSUM

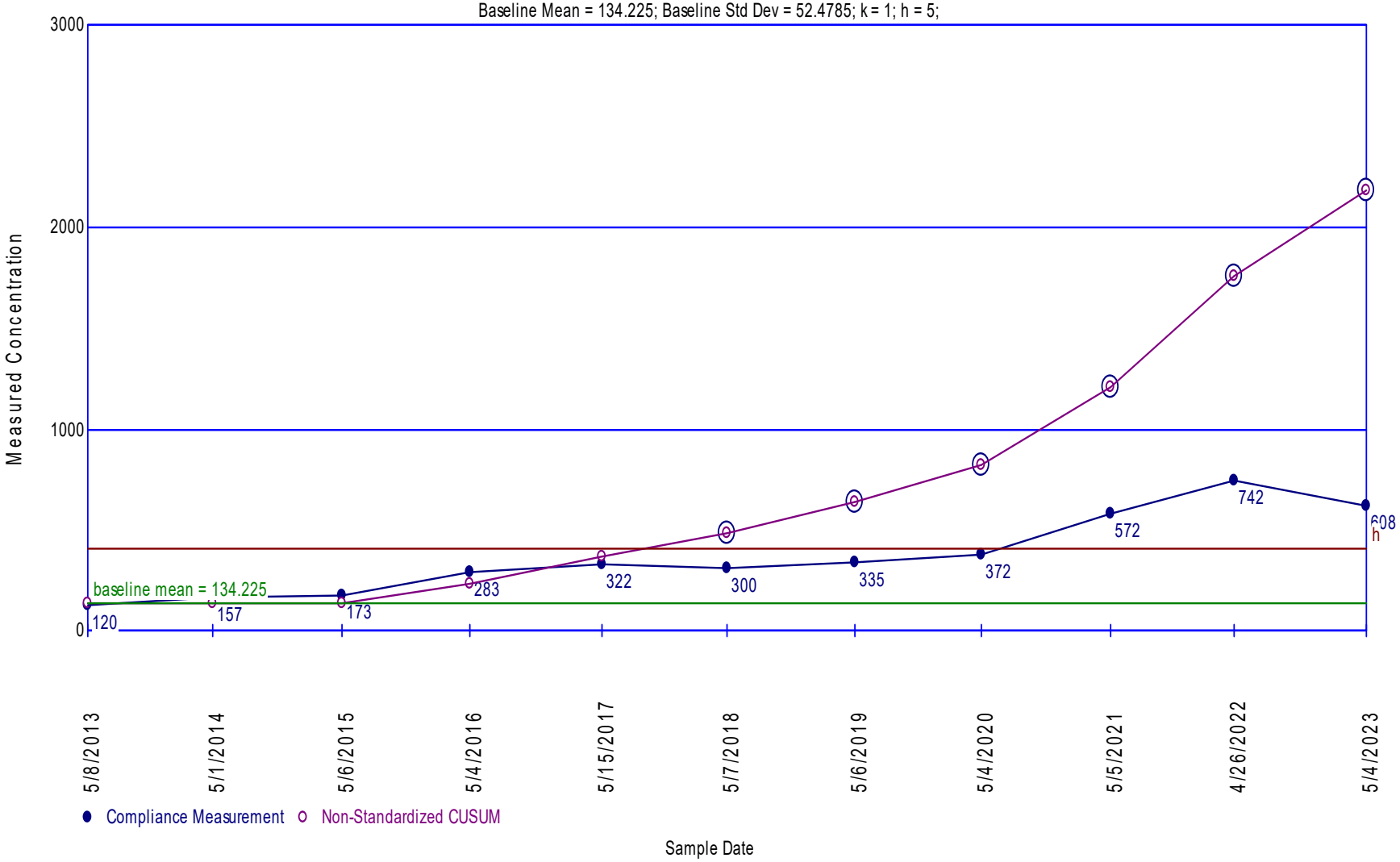

DLDRN
Intra-Well Shewhart-CUSUM Control Chart (Unified Guidance) of 26133
Baseline Mean = 0.89475; Baseline Std Dev = 0.215698; k = 1; h = 5;
Measured Concentration
3
2
1
0
h
baseline mean = 0.89475
1.33
1.26
1.22
0.886
1.44
1.01
1.43
1.56
0.755
1.29
6/3/2014
5/6/2015
5/4/2016
5/15/2017
5/7/2018
5/6/2019
5/4/2020
5/5/2021
4/26/2022
5/16/2023
Compliance Measurement
Non-Standardized CUSUM
Sample Date

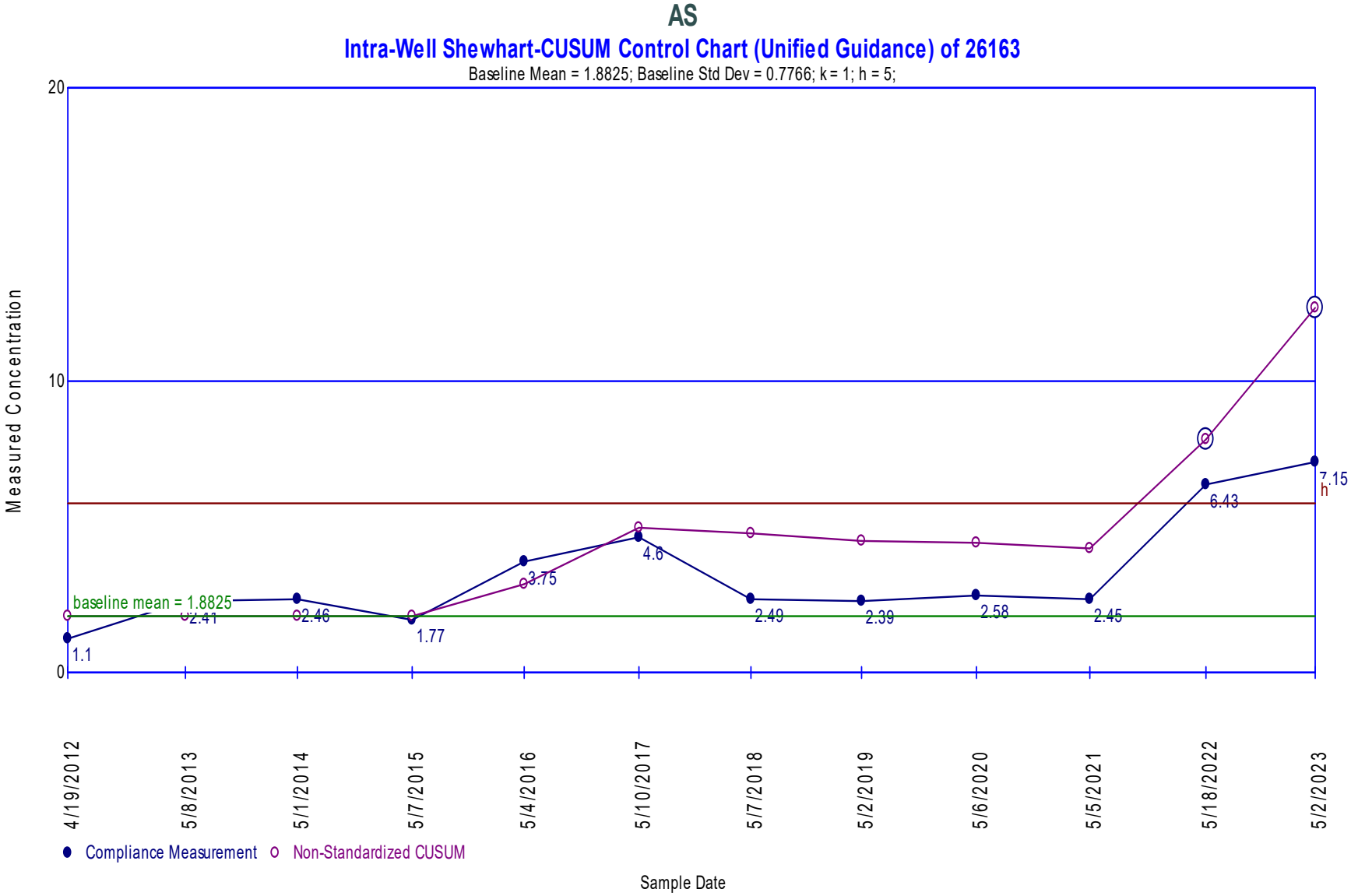

NNDMEA
Intra-Well Shewhart-CUSUM Control Chart (Unified Guidance) of 26133
Baseline Mean = 0.211375; Baseline Std Dev = 0.0690361; k = 1; h = 5;
Measured Concentration
3
2
1
0
baseline mean = 0.211375
0.199
0.28
0.57
0.851
0.305
0.602
0.815
0.672
0.578
h.635
5/1/2014
5/6/2015
5/4/2016
5/15/2017
5/7/2018
5/6/2019
5/4/2020
5/5/2021
4/26/2022
5/4/2023
Compliance Measurement
Non-Standardized CUSUM
Sample Date

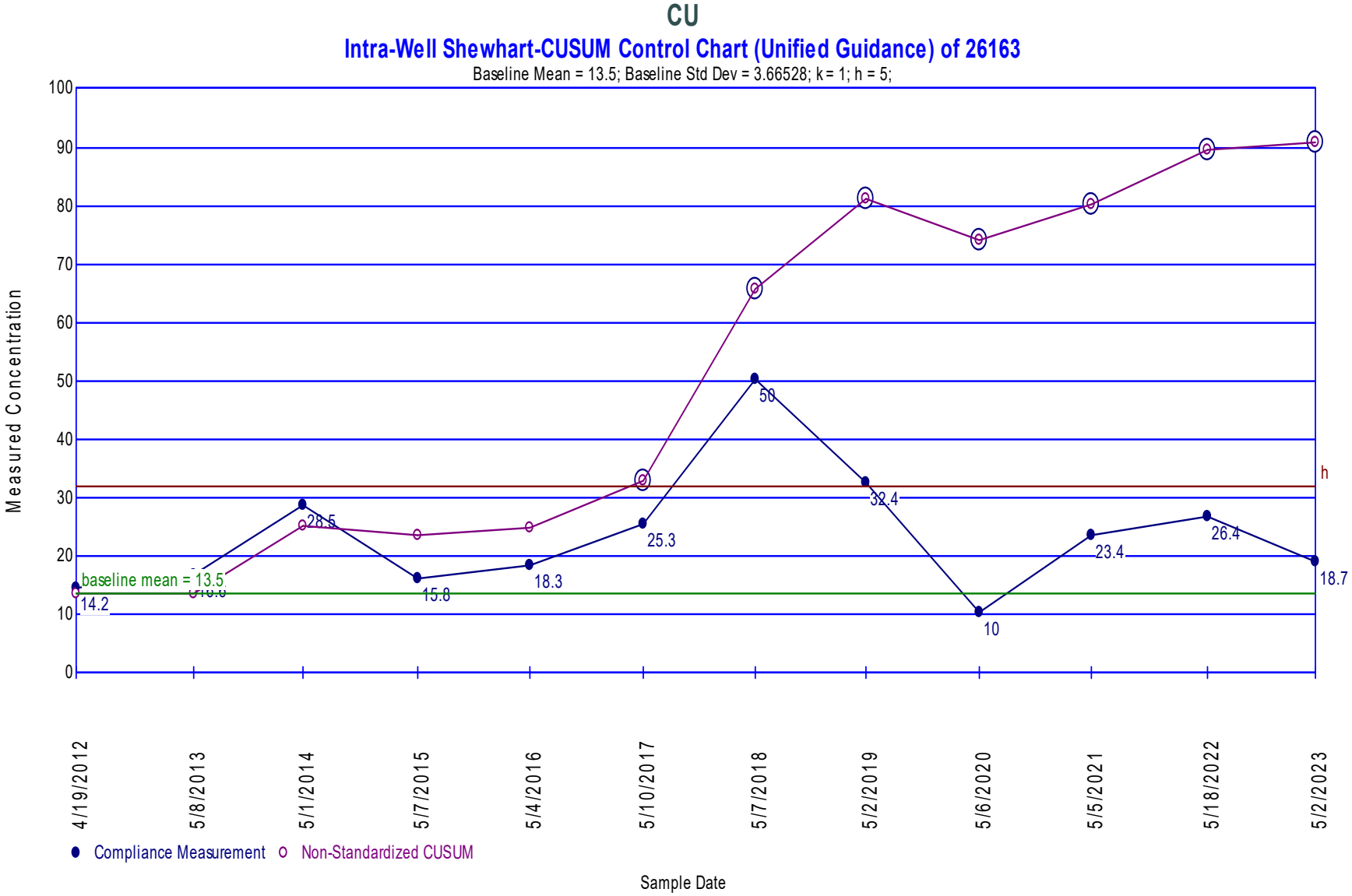
TCLEE

Intra-Well Shewhart-CUSUM Control Chart (Unified Guidance) of 26133

Baseline Mean = 134.225; Baseline Std Dev = 52.4785; k = 1; h = 5;



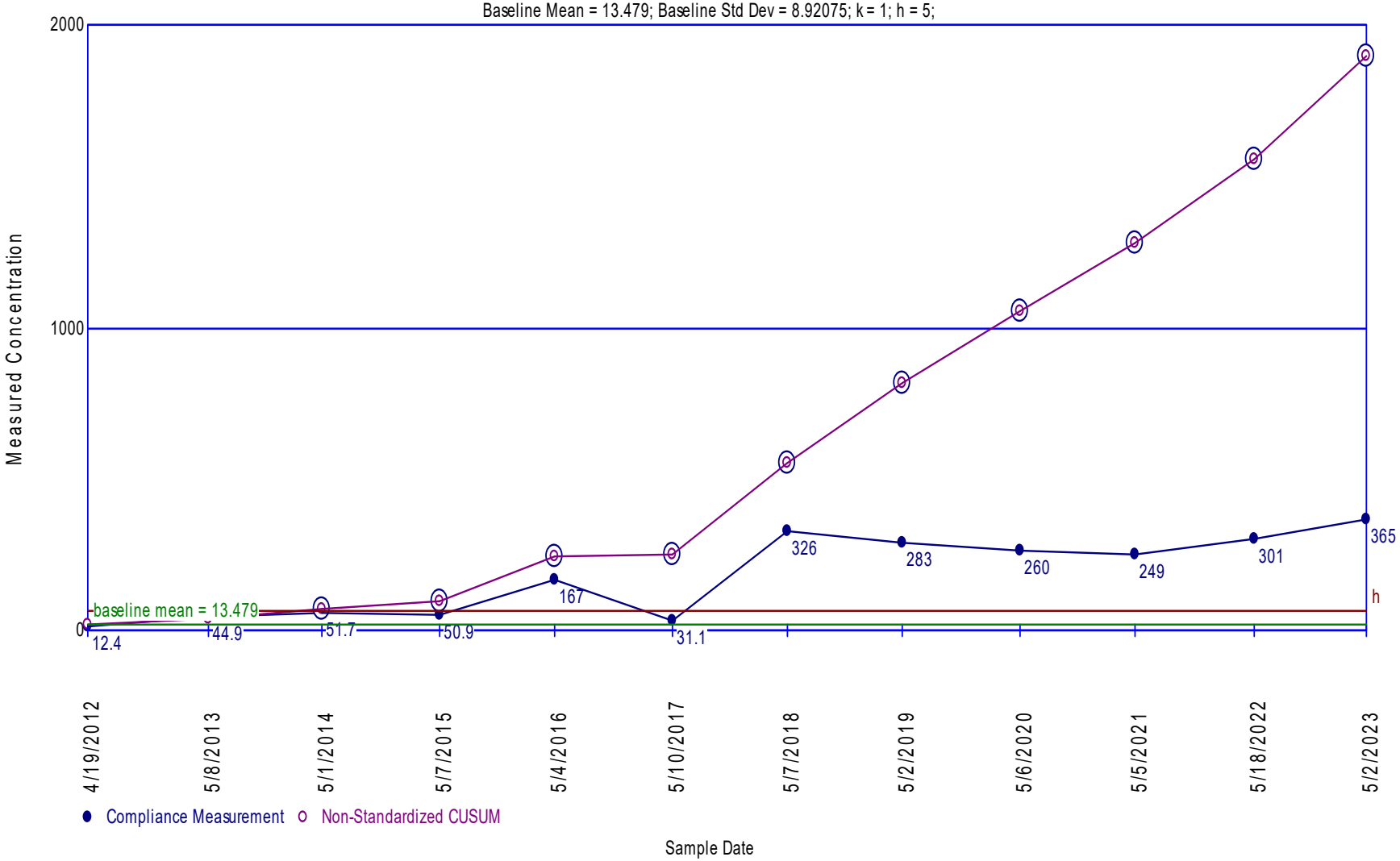

AS
Intra-Well Shewhart-CUSUM Control Chart (Unified Guidance) of 26163
Baseline Mean = 1.8825; Baseline Std Dev = 0.7766; k = 1; h = 5;
Measured Concentration
20
10
0
baseline mean = 1.8825
h
1.1
2.41
2.46
1.77
3.75
4.6
2.49
2.39
2.58
2.45
6.43
7.15
4/19/2012
5/8/2013
5/1/2014
5/7/2015
5/4/2016
5/10/2017
5/7/2018
5/2/2019
5/6/2020
5/5/2021
5/18/2022
5/2/2023
Compliance Measurement
Non-Standardized CUSUM
Sample Date


CU
Intra-Well Shewhart-CUSUM Control Chart (Unified Guidance) of 26163
Baseline Mean = 13.5; Baseline Std Dev = 3.66528; k = 1; h = 5;
Measured Concentration
100
90
80
70
60
50
40
30
20
10
0
h
baseline mean = 13.5
14.2
28.5
15.8
18.3
25.3
50
32.4
10
23.4
26.4
18.7
4/19/2012
5/8/2013
5/1/2014
5/7/2015
5/4/2016
5/10/2017
5/7/2018
5/2/2019
5/6/2020
5/5/2021
5/18/2022
5/2/2023
Compliance Measurement
Non-Standardized CUSUM
Sample Date

DCPD

Intra-Well Shewhart-CUSUM Control Chart (Unified Guidance) of 26163

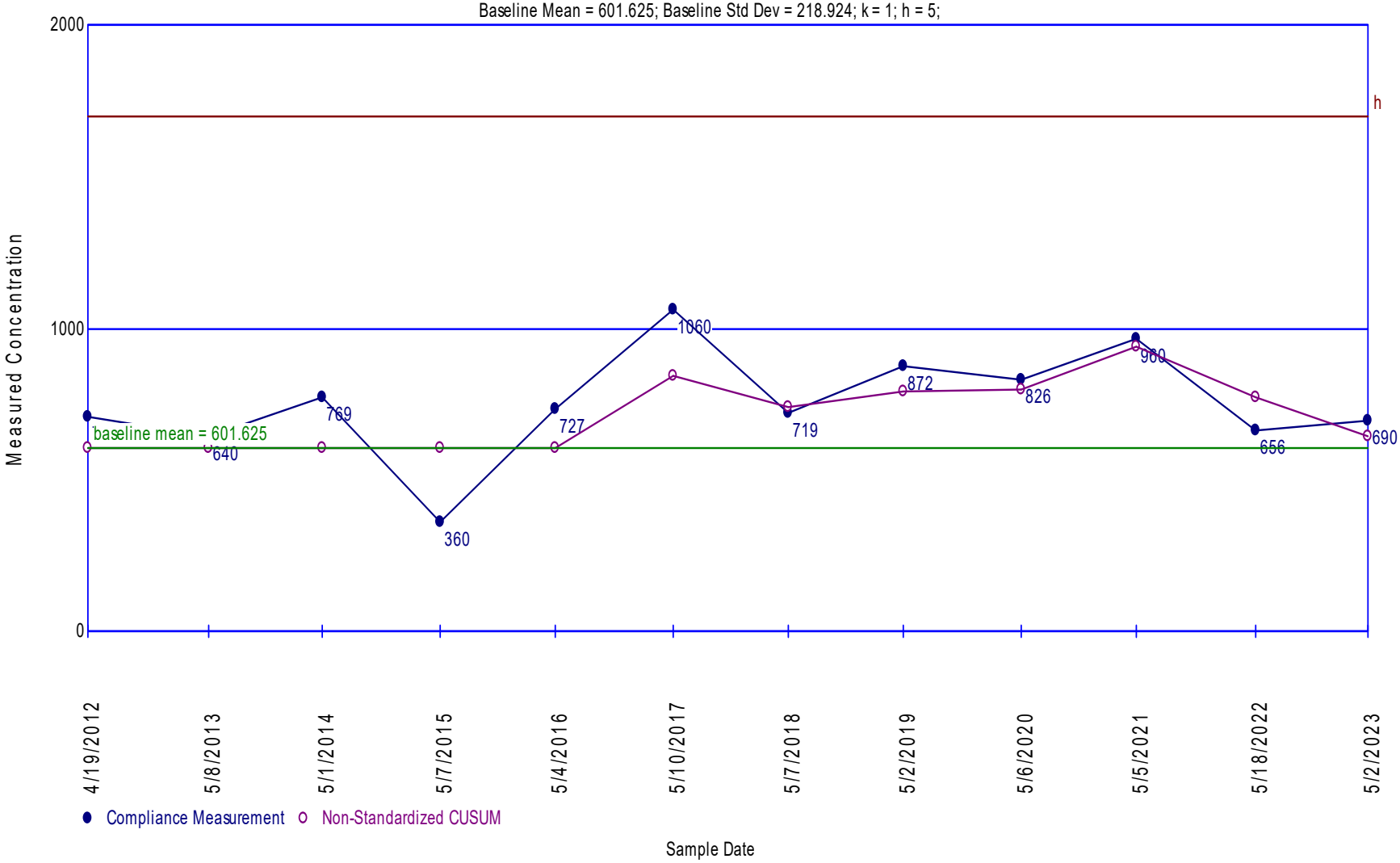
Baseline Mean = 13.479; Baseline Std Dev = 8.92075; k = 1; h = 5;



DIMP

Intra-Well Shewhart-CUSUM Control Chart (Unified Guidance) of 26163

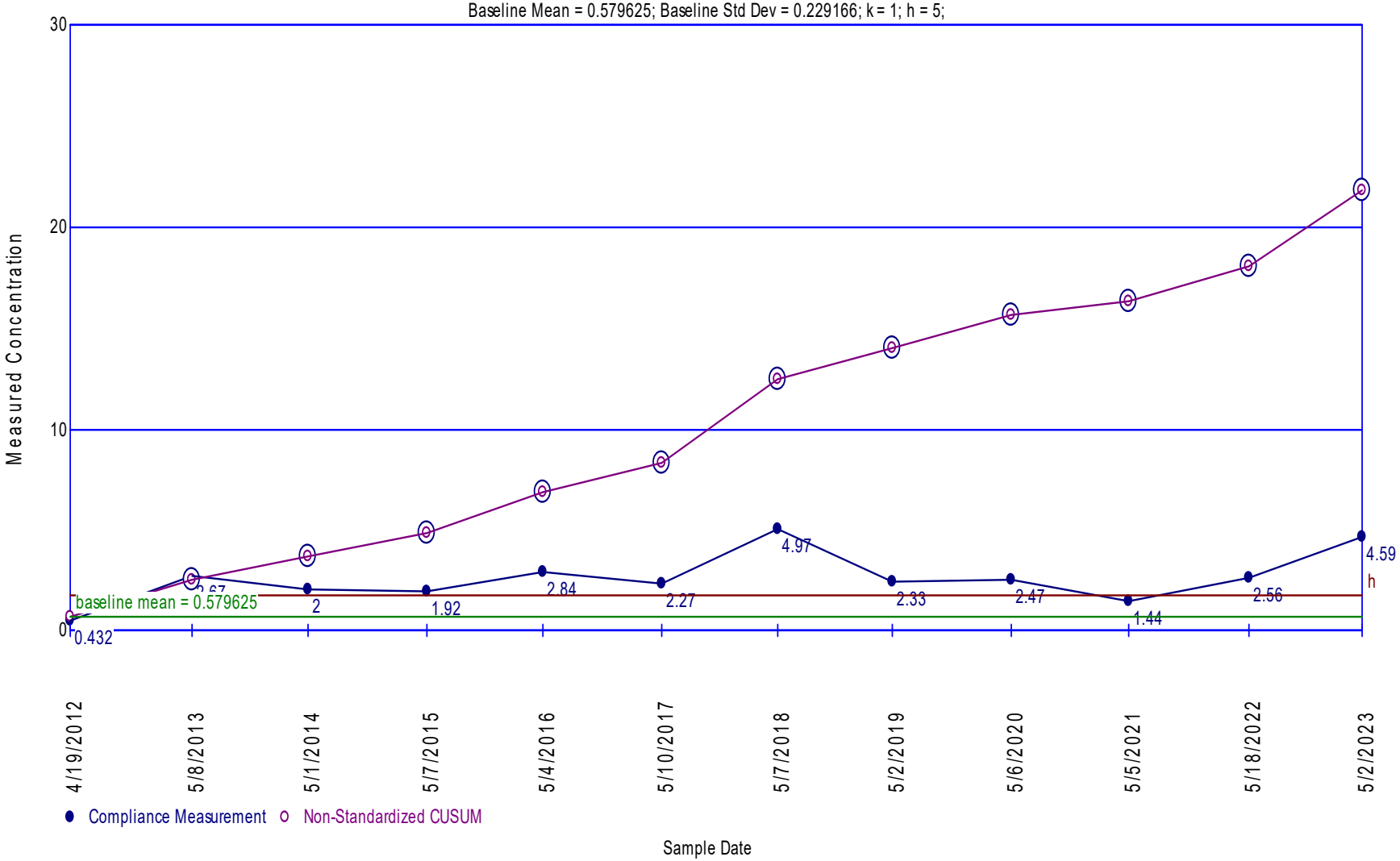
Baseline Mean = 601.625; Baseline Std Dev = 218.924; k = 1; h = 5;

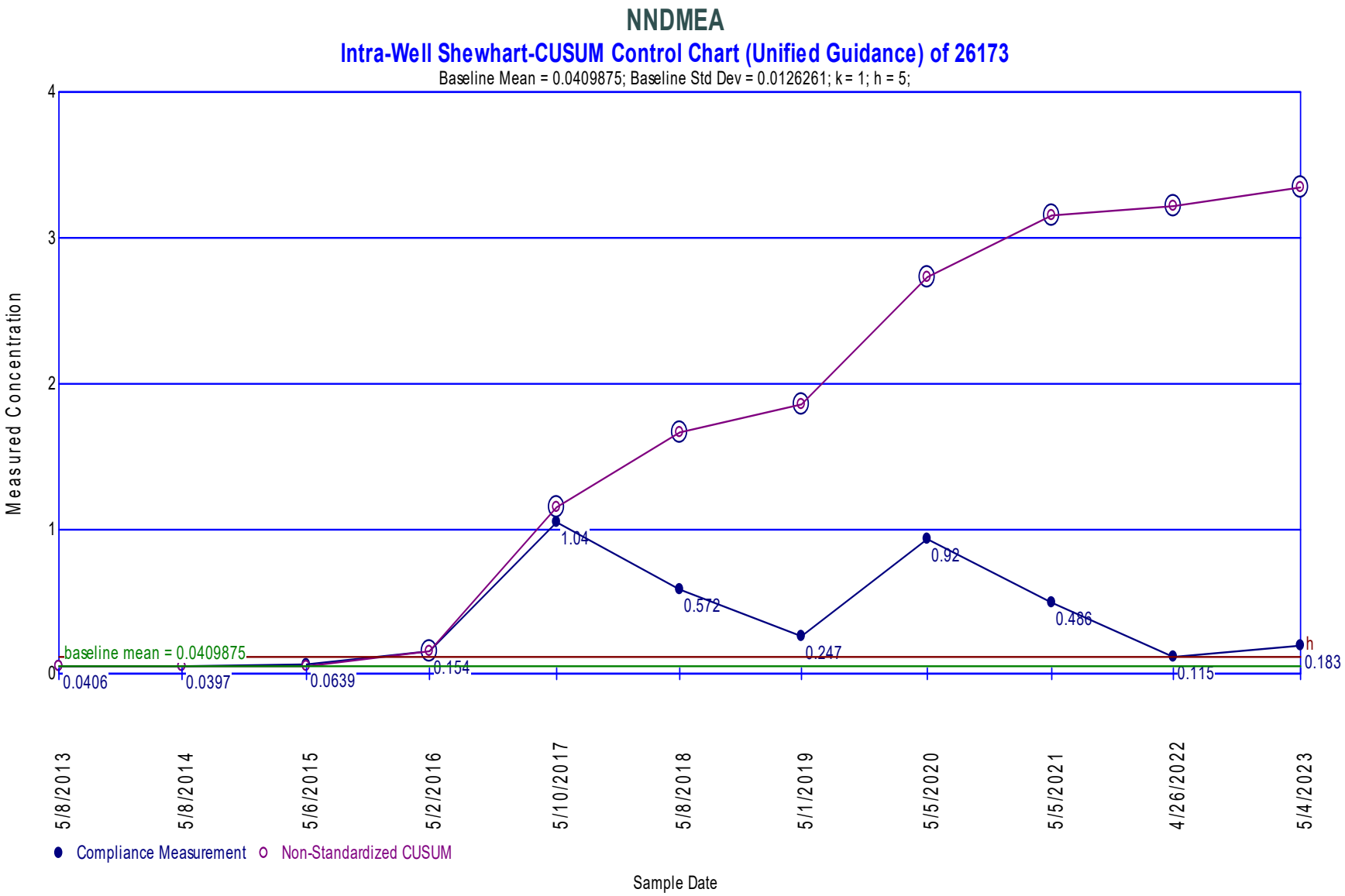


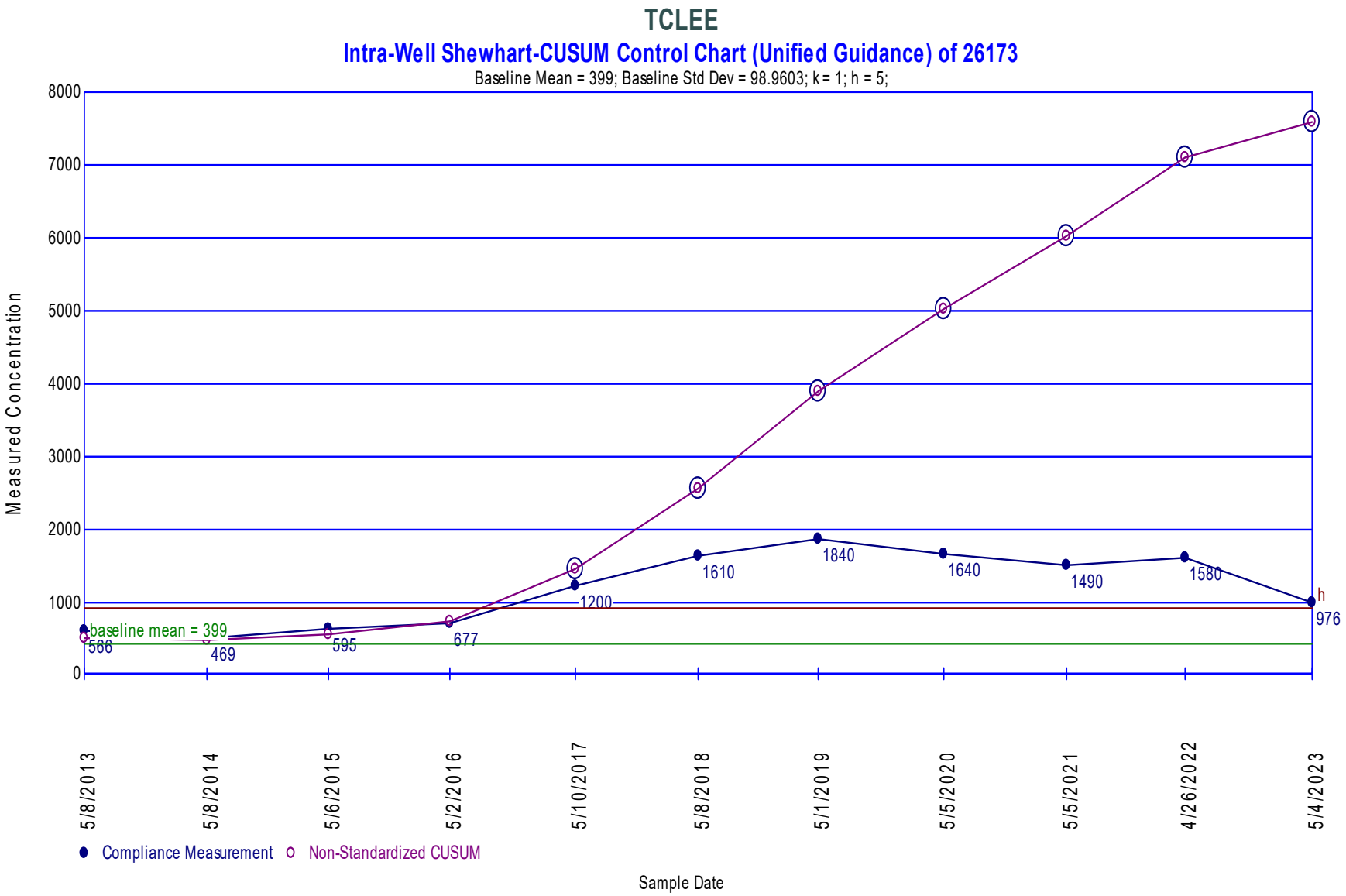
TCLEE

Intra-Well Shewhart-CUSUM Control Chart (Unified Guidance) of 26163

Baseline Mean = 0.579625; Baseline Std Dev = 0.229166; k = 1; h = 5;




NNDMEA
Intra-Well Shewhart-CUSUM Control Chart (Unified Guidance) of 26173
Baseline Mean = 0.0409875; Baseline Std Dev = 0.0126261; k = 1; h = 5;
Measured Concentration
4
3
2
1
0
baseline mean = 0.0409875
h
0.183
0.0406
0.0397
0.0639
0.154
1.04
0.572
0.247
0.92
0.486
0.115
5/8/2013
5/8/2014
5/6/2015
5/2/2016
5/10/2017
5/8/2018
5/1/2019
5/5/2020
5/5/2021
4/26/2022
5/4/2023
Compliance Measurement
Non-Standardized CUSUM
Sample Date


TCLEE
Intra-Well Shewhart-CUSUM Control Chart (Unified Guidance) of 26173
Baseline Mean = 399; Baseline Std Dev = 98.9603; k = 1; h = 5;
Measured Concentration
8000
7000
6000
5000
4000
3000
2000
1000
0
baseline mean = 399
566
469
595
677
1200
1610
1840
1640
1490
1580
976
h
5/8/2013
5/8/2014
5/6/2015
5/2/2016
5/10/2017
5/8/2018
5/1/2019
5/5/2020
5/5/2021
4/26/2022
5/4/2023
Compliance Measurement
Non-Standardized CUSUM
Sample Date