



Clean Air Status and Trends Network

Fourth Quarter 2023 Quality Assurance Report

Summary of Quarterly Operations (October through December) with 2023 Annual Summary

EPA Contract No. 68HERH21D0006

Introduction

This quarterly report summarizes results from the Clean Air Status and Trends Network (CASTNET) quality assurance/quality control (QA/QC) program for data collected during fourth quarter 2023. It also provides an annual summary that includes data from the three previous quarters. The various QA/QC criteria and policies are documented in the CASTNET Quality Assurance Project Plan [QAPP; WSP USA Environment & Infrastructure Inc. (WSP), 2022]. The QAPP is comprehensive and includes standards and policies for all components of project operation from site selection through final data reporting. It is reviewed annually and updated as warranted.

Significant Events for 2023

In early first quarter 2023, WSP's corporate management purchased a new, inductively coupled plasma-optical emission spectrometer (ICP-OES) for the CASTNET analytical laboratory. The new instrument takes up less bench space than the current version, is easier to use, has the capability to analyze a larger suite of analytes without changing the sample introduction system, and consumes less argon gas. The ICP-OES was installed in the analytical laboratory January 10–11, 2023. In-person training of laboratory personnel by PerkinElmer, the manufacturer, took place on January 18, 2023. Method detection limit results for the new ICP-OES showed some select spectrum peak shifting. The CASTNET Laboratory Operations Manager (LOM) contacted PerkinElmer to advise them of the problem. Replacement parts were shipped to the LOM, and a PerkinElmer technician installed the parts in February 2023. Test results after the parts were replaced did not show any peak shifting, and it never returned during subsequent sample analysis. The standard operating procedure was updated for the new ICP-OES as were related sections of the CASTNET QAPP.

Comparison of ammonium analyses completed on the older Braun+Luebbe AA3 with analyses completed on the SEAL AA500 showed a consistent 5 percent positive bias for analyses on the AA500. WSP contacted SEAL for assistance. SEAL reviewed information provided by WSP and then informed WSP that the method SEAL originally provided was not the correct method. SEAL provided WSP with a different method, which when used with a new set of calibration standards provided more reasonable results. Additional contamination was found in method detection limit (MDL) testing of ammonium analyses on the SEAL AA500 and was traced to the air conditioning system. The air vent in the laboratory is close to the instrument. The problem was resolved by replacing the current minimum efficiency reporting value (MERV) 8 filters in the air handlers serving the laboratory with MERV 13 filters. After additional troubleshooting and maintenance by a SEAL technician, additional MDL tests were completed. Ammonium data from the SEAL AA500 and the Braun+Luebbe AA3 were similar and compared well. Routine ammonium analyses were transitioned from the AA3 to the AA500 in mid-July 2023. Extracts from samples deployed during week 27 (on-date of July 4, 2023) and any samples received by the WSP analytical laboratory as of July 11, 2023, or later were analyzed using the AA500.

During first quarter 2023, WSP began preparations for the onsite assessment of the analytical and field laboratories by the American Association for Laboratory Accreditation (A2LA). WSP provided documentation to the assessor as requested. Additionally, the CASTNET QA Manager completed the annual review of site operator and site calibrator metrics to track the status of technical training and quality management system training. The QA Manager completed a similar review of analytical laboratory personnel. The QA Manager also performed a method evaluation with the primary analyst on the new PerkinElmer Avio 220 Max ICP-OES.

The biennial onsite assessment by the A2LA to continue WSP's International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) 17025:2017 accreditation took place on April 3–5, 2023. The assessor looked at WSP's quality management system as well as the technical capabilities of WSP's CASTNET personnel. The assessor was very complimentary and impressed with the staff's openness with explanations. There were two deficiencies. One relating to the supplier list not being inclusive (e.g., needed to include EPA Regions level 2 certifications and A2LA assessments) and the other relating to the need to document quality and schedule evaluations for suppliers, in addition to the documented technical evaluations. WSP supplied the needed information to A2LA within 30 days of the assessment on May 3, 2023. WSP was informed of the official A2LA reaccreditation approval on May 22, 2023. WSP's current ISO/IEC 17025:2017 accreditation for the analytical and field laboratories was renewed through May 2025.

During March 2023, WSP received technical direction from EPA to adjust the QC criteria for the CO monitor at the BVL130, IL site to improve data completeness and to meet the requirements in the precursor gas technical assistance guidance. This included adjusting the validation criteria for the zero check to 2.5 percent of full scale (± 50 ppb) and adjusting the challenge level of the 1-point precision check to 500 ppb. WSP incorporated these changes, which went into effect beginning March 9, 2023. WSP reviewed and revalidated CO data for 2022 and 2023 based on the changes. Data for 2022 were resubmitted to EPA and AQS with updated flagging where appropriate.

WSP's ongoing investigation of the unidentified peak that was co-eluting with bromide in the chromatograms associated with acceptance tested MTL nylon filters continued into early second quarter 2023. WSP identified that the co-eluting peak could be correlated to certain MTL filter washing dates. WSP provided data to MTL, and MTL told WSP they would investigate the cause of the unidentified peak. WSP requested a box of unwashed nylon filters from MTL to test if the co-eluting peak was native to the filter or introduced during washing. The unwashed filters did not show the co-eluting peak. It was found that the contamination occurred during the MTL drying process. MTL changed its filter drying process from air drying to oven drying. Newer boxes of filters were free of contamination, and older boxes were returned to MTL and credited back to WSP. WSP had a good supply of surplus filters that passed acceptance testing so there was no disruption in sampling.

In May 2023, the CASTNET QA Manager completed an audit of data quality for PFAS concentrations in cloud water covering the period June 2020 to August 2021. The report was submitted to EPA on June 6, 2023. In December 2023, the CASTNET QA Manager completed an audit of data quality for PFAS concentrations in precipitation samples that were collected between January 1, 2022 through January 1, 2023. The QA Manager found problems with some of these batches. The Wisconsin State

Laboratory of Hygiene will need to resubmit the problem batches to EPA. The report was submitted to EPA on December 27, 2023.

WSP proposed a change in key personnel for the CASTNET Data Management, Analysis, Interpretation and Reporting Manager. EPA approved Jayde Alderman on May 31, 2023.

During July 2023, WSP's CASTNET QA Manager was notified via EPA Chief Information Officer directives that EPA's QA/R-5, "EPA Requirements for QA Project Plans" had been superseded by "Quality Assurance Project Plan Standard" (CIO 2105-S-02.0). The QA Manager evaluated the changes and verified the effects of the updates on the CASTNET QAPP Revision 10.1. The only update required by the new standard was to identify the providers of the subcontracted field technicians: Inquest Environmental, Inc.; Trinity Consultants, Inc.; and S&P Air Quality Services Inc. The QAPP Revision 10.1 includes renaming from Wood Environment & Infrastructure Solutions, Inc. to WSP USA Environment & Infrastructure Inc. and updates to identify field subcontractors to align with the new directive.

The WSP Quality Management Plan is under the purview of the WSP Regional Quality Manager who is also the CASTNET Project QA Supervisor. The QA Manager notified the Project QA Supervisor that EPA's QA/R-2, "EPA Requirements for Quality Management Plans" had been superseded by "Quality Management Plan Standard" (CIO 2105-S-01.1).

The QA Manager conducted the annual management review in accordance with WSP's analytical laboratory's ISO/IEC 17025:2017 accreditation. The annual management review report in support of ISO/IEC 17025:2017 accreditation was completed and distributed to WSP QA and CASTNET management team reviewers. The QA Manager scheduled the presentation for July 26, 2023. Attendees included the CASTNET management team, WSP regional management, and WSP QA management. The presentation was well received by the CASTNET management team, CASTNET QA Supervisor, and WSP's regional corporate management and QA representatives. The management team was complimentary of the program.

During August 2023, the CASTNET Project Manager found a problem with the hourly flow data that was related to an issue with the National Park Service/Bureau of Land Management-Wyoming State Office continuous data exports received by WSP. Some flow data were flagged incorrectly. Concentration data for 2000 through 2023 were rerun to correct the flagging errors and recalculate weekly values.

The 9-meter temperature sensor at the PAR107, WV site failed a performance evaluation (PE) audit at the 49°C challenge point on August 8, 2023. Result was low by 0.6°C versus the 0.5°C accuracy criterion. The WSP audit of this probe in November 2023 was only low by 0.1°C. Data validity was not affected in either case. According to established project criteria data are considered valid if the calibration result is within two times the criterion.

EEMS performed annual PE audits of the ROM406/ROM206, CO co-located ozone systems on August 17, 2023. The ozone system used for regulatory purposes is the ROM406 system. EEMS notified WSP that the ROM206 site failed the audit. A WSP field technician tested the analyzer and

solenoids and found no problems. The QC checks of the ROM206 site analyzer were within criteria. However, the ROM206 analyzer was slower to respond than the ROM406 analyzer during the audit. Co-located responses compared well during routine ambient monitoring both before and after the audit. WSP replaced the ozone analyzer. The ozone analyzer was returned to WSP's Gainesville office and was found to be without issue.

Additionally, during the ROM206 PE audit, EEMS noted the temperature probe shield at the site as not being located properly in accordance with the CASTNET QAPP because it was not pointed north. WSP reviewed the QAPP temperature probe placement requirement. It states that probe inlets be "pointed north or otherwise positioned to avoid radiated heat sources such as buildings, walls, etc."

EPA Region 3 contacted EPA CAMD to offer a "mini" technical systems audit (TSA) of the ozone system at the PAR107 site consisting of a field site visit but no laboratory facility audit. WSP coordinated the field site TSA on August 21, 2023, with the site operator and EPA Region 3. The Region 3 auditor was very thorough with her assessment of the site operator's abilities and the CASTNET ozone monitoring system. The site audit went well. The auditor contacted the QA Manager and expressed satisfaction with the site operator's level of knowledge and cooperation.

During a PE audit by EEMS at the MCK131/231, KY site on September 22, 2023, the Nafion dryer at the MCK231 site was broken. As a result, WSP believes the MCK131/231 audit results were suspect. The MCK231 Nafion dryer stopped working as of September 22, 2023. WSP bypassed the dryer from September 28, 2023 until installation of the replacement dryer on October 20, 2023. Ambient data were valid during the period the dryer was bypassed.

WSP submitted the draft of the CASTNET QAPP Revision 10.1 to EPA on October 16, 2023.

In November 2023, EPA provided WSP with updated guidance for operation of regulatory ozone systems. The CASTNET Field Operations Manager began working with the CASTNET management team to develop an action plan to address the changes.

Providing a safe working environment is one of WSP's goals. Sites are routinely checked for safe working conditions at each calibration (i.e., twice per year). During 2023, WSP performed internal safety audits of selected sites. These safety audits provide a more in-depth review of site safety and include a safety-related evaluation of infrastructure condition and maintenance, use of equipment, site operator activities at the site, and verification that procedures are understood and followed by site personnel. There were no findings during 2023.

Quarterly/Annual Summary

Table 1 lists the quarters of data that were validated to Level 3 during 2023 by site calibration group. Table 2 lists the sites in each calibration group along with the calibration schedule. Table 3 presents the measurement criteria for continuous field measurements. These criteria apply to the instrument challenges performed during site calibrations. Table 4 presents the measurement criteria for laboratory filter pack measurements. These criteria apply to the QC samples listed in the following section of this report. Table 5 presents the critical criteria for ozone monitoring. Table 6 presents the critical criteria for trace-level gas monitoring.

Laboratory Intercomparison Results Summary

WSP's CASTNET laboratory continues to be a regular participant in the U.S. Geological Survey (USGS) laboratory intercomparison tests. Greg Wetherbee *et al.* (2023) of the USGS published a project report summarizing the results of the 2019 through 2020 USGS Interlaboratory Comparison Program. Out of 11 laboratories, only the WSP analytical laboratory and one other showed “no practically significant bias” for all analytes reported (<https://pubs.er.usgs.gov/publication/sir20235045>).

WSP's CASTNET laboratory regularly participates in the Environment and Climate Change Canada (ECCC) Proficiency Testing (PT) Program for Inorganic Environmental Substances. The results reported by the participating laboratories are evaluated for systematic bias and precision. Systematic bias is assessed using the Youden (1969) non-parametric analysis, while precision is calculated using algorithm A from the ISO standard 13528 (ISO, 2005). Laboratory results are considered systematically biased when individual parameters are ranked by the Youden analysis to be consistently and significantly higher or lower than the assigned value without regard to flagged results. The CASTNET laboratory's proficiency testing plan requires action for individual test results that are greater than three standard deviations from the assigned value, bias 5 percent or higher for a single parameter, three or more biased results of any magnitude in a single study, or a consecutive study result indicating bias of any magnitude for a given parameter.

During March 2023, WSP received results for sample analyses for PT study 121 for Rain and Soft Waters submitted to the Environmental Science and Technology Laboratories Division, a branch of the Water Science and Technology Directorate (WS&TD) with ECCC that provides QA services. Analyses of all parameters were rated as “Good” for PT study 121 (ECCC, 2023a). WSP's 5-year average was also rated as “Good” (ECCC, 2023a).

WSP had submitted results for the standard suite of CASTNET analyses and additionally included results for pH, specific conductance, and total nitrogen analyses. WSP's analyses for conductivity and total nitrogen for 1 of the 10 samples analyzed were flagged as receiving z-scores that indicated high and low bias, respectively. WSP received no flags for any parameter in the other nine samples analyzed. In PT study 121, WS&TD determined that the sample-parameter combinations for RN-06 for ammonia and RN-06 for dissolved organic carbon displayed signs of “insufficient homogeneity” and removed these sample-parameters from scoring. WSP's LOM contacted WS&TD for additional information, particularly as to why ammonia was removed from the study scoring but not total nitrogen since ammonia is a component of total nitrogen. WS&TD reviewed total nitrogen and found the percent RSD was in line with the others, so it was not excluded from scoring. The WS&TD sent a new bottle of the RN-06 to WSP, which WSP used for internal investigation.

During September 2023, WSP received results for sample analyses submitted for PT study 122 for Rain and Soft Waters. WSP's results were rated, “Good.” However, two low calcium values and three low sodium values were flagged, indicating potential bias (ECCC, 2023b). One calcium flag required corrective actions. WSP began troubleshooting what could have caused the low values and contacted PerkinElmer, the manufacturer of the ICP-OES used to analyze the PT samples. The PerkinElmer technician did not see any problems with WSP's data using current analysis techniques, but he suggested that WSP try testing other settings for different views and wavelengths. During October,

WSP began evaluating different settings. Testing ultimately showed that the change in settings seems to have minimal effect on sample concentration results. Final disposition of the corrective actions are pending first quarter 2024 results of PT study 123.

Quality Control Analysis Count

The QC sample statistics presented in this report are for reference standards (RF) and continuing calibration verification spikes (CCV) used to assess accuracy and for replicate sample analyses (RP) used to assess “in-run” precision. In addition, laboratory method blanks (MB) containing reagents without a filter; laboratory blanks (LB) containing reagents and a new, unexposed filter; and field blanks (FB) containing reagents and an unexposed filter that was loaded into a filter pack assembly and shipped to and from the monitoring site while remaining in sealed packaging are also included. Tables 7 through 10 present the number of analyses in each category that were performed during each quarter of 2023.

Sample Receipt Statistics

Ninety-five percent of field samples from EPA-sponsored sites must be received by the CASTNET laboratory in Gainesville, FL no later than 14 days after removal from the sampling tower. Table 11 presents the relevant sample receipt statistics for each of the four quarters of 2023 together with an annual summary for each category.

Data Quality indicator (DQI) Results

Figures 1 through 3 present the results of RF, CCV, and RP QC sample analyses for fourth quarter 2023. All results were within the criteria listed in Table 4. The nylon sulfate CCV value at 94.6 percent passes per the established rounding rules. Table 12 presents the percent recoveries and standard deviations for RF, CCV, and RP QC sample analyses for 2023. Quarterly averages are all within criteria.

Table 13 presents quarterly co-located filter pack precision results for data validated to Level 3 during the year. Results for MCK131/231, KY and ROM406/206, CO were within the criterion for all of the 11 parameters reported with the exception of third quarter 2022 results at ROM406/206. There were problems with the ROM406 flow system during third quarter 2022.

Figure 4 presents completeness statistics for continuous measurements validated to Level 3 during the year. All parameters met the 90 percent criterion.

Table 14 presents summary statistics of critical criteria measurements at ozone sites collected during fourth quarter 2023. The statistics presented contain data validated at Level 2 and Level 3. All data associated with QC checks that fail to meet the criteria listed in Table 5 were or will be invalidated unless the cause of failure has no effect on ambient data collection, and passing results still meet frequency criteria. Results in shaded cells either exceed documented criteria or are otherwise notable. Table 15 presents observations associated with the shaded cell results in Table 14.

Table 16 presents summary statistics of critical criteria measurements at trace-level gas monitoring sites collected during fourth quarter 2023. The statistics presented contain data validated at Level 2

and Level 3. All data associated with QC checks that fail to meet the criteria listed in Table 6 were or will be invalidated unless the cause of failure has no effect on ambient data collection, and passing results still meet frequency criteria. Results in shaded cells either exceed documented criteria or are otherwise notable. Table 17 presents observations associated with the shaded cell results in Table 16.

Laboratory Control Sample Analysis

The laboratory control sample (LCS) is a reagent blank spiked with the target analytes from the established analytical methods and carried through the same extraction process that field samples must undergo. LCS analyses are performed by the laboratory to monitor for potential sample handling artifacts and provide a means to identify possible analyte loss from extraction to extraction. Figure 5 presents LCS analysis results for fourth quarter 2023. All recovery values were between 83 percent and 109 percent.

Blank Results

Figures 6 through 8 present the results of MB, LB, and FB QC sample analyses for fourth quarter 2023. All fourth quarter results were within criteria (two times the reporting limit) listed in Table 4. Table 18 summarizes the record of filter blanks for 2023. All 2023 results were within criteria listed in Table 4 with the exception of a Teflon field blank for calcium and potassium at CAN407, UT that occurred during second quarter. Several field samples from sites near CAN407 during mid-April showed relatively high concentrations of calcium and were coded for visibly dirty filters. Utah and the Four Corners region (Utah, Colorado, New Mexico, and Arizona) suffered a heavy dust event in mid-April 2023. In addition, two Teflon filter acceptance test results for sodium and potassium respectively exceeded the criterion. The box this filter came from was set aside as per required procedure. All other blank QC checks in their respective batches were within criteria.

Suspect/Invalid Filter Pack Samples

Filter pack samples that were flagged as suspect or invalid during each of the four quarters of 2023 are listed in Table 19. This table also includes associated site identification and a brief description of the reason the sample was flagged. During fourth quarter, eight filter pack samples were invalidated.

Field Problem Count

Table 20 presents counts of field problems affecting continuous data collection for more than one day for each quarter during 2023. The problem counts are sorted by a 30-, 60-, or 90-day time period to resolution. A category for unresolved problems is also included. Time to resolution indicates the period taken to implement corrective action.

Field Calibration Results

A summary of field calibration failures by parameter for each quarter of 2023 is listed in Table 21. Calibrations were performed at 21 sites during fourth quarter 2023. During 2023, all sites and parameters were within the criteria listed in Table 3 with the exception of the parameters at the eight sites that are listed in Table 21.

Table 22 presents field accuracy results for 2023 based on instrument challenges performed using independent reference standards during site calibration visits. Each parameter was within its criterion with at least 90 percent frequency. Per CASTNET project protocols, data are flagged but still considered valid if the calibration criterion is not exceeded by more than its magnitude (i.e., if within two times the criterion). All calibration failures reported in 2023 for the indicated parameters were within two times the criterion with the exception of flow rate at GTH161, CO in June 2023. This failure was due to a deteriorating flow pump.

References

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- WSP USA Environment & Infrastructure Inc. (WSP) formerly known as Wood USA Environment & Infrastructure Inc. 2022. *Clean Air Status and Trends Network (CASTNET) Quality Assurance Project Plan (QAPP) Revision 9.5*. Prepared for U.S. Environmental Protection Agency (EPA), Office of Air and Radiation, Clean Air Markets Division, Washington, DC. Contract No. 68HERH21D0006. Gainesville, FL. <https://java.epa.gov/castnet/documents.do>.
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Table 1 Data Validated to Level 3 through Fourth Quarter 2023

Calibration Group*	Months Available	Number of Months	Complete Quarters	Number of Quarters
SE-4/MW-6 [†]	July 2022– June 2023	12	Quarter 3 2022– Quarter 2 2023	4
E-1/SE-5	August 2022– July 2023	12	Quarter 4 2022– Quarter 2 2023	3
MW-7/W-9	September 2022– August 2023	12	Quarter 4 2022– Quarter 2 2023	3
E-2/MW-8	October 2022– September 2023	12	Quarter 4 2022– Quarter 3 2023	4
E-3/W-10 [‡]	May 2022– April 2023	12	Quarter 3 2022– Quarter 1 2023	3

Notes: * The sites contained in each calibration group are listed in Table 2.

[†] Contains MCK131/231 co-located pair

[‡] Contains ROM206 of the ROM406/ROM206 co-located pair

Table 2 Field Calibration Schedule for 2023

Calibration Group	Months Calibrated	Sites Calibrated			
Eastern Sites (22 Total)					
E-1 (8 Sites)	February/August	BEL116, MD BWR139, MD	WSP144, NJ CTH110, NY	ARE128, PA PSU106, PA	PED108, VA VPI120, VA
E-2 (9 Sites)	April/October	ABT147, CT ASH135, ME WST109, NH	CAT175, NY HWF187, NY ¹ WFM105, NY	NIC001, NY EGB181, ON UND002, VT	
E-3 (5 Sites)	May/November	KEF112, PA MKG113, PA	LRL117, PA PAR107, WV	CDR119, WV	
Southeastern Sites (11 Total)					
SE-4 (7 Sites)	January/July	SND152, AL GAS153, GA	BFT142, NC CND125, NC	COW137, NC DUK008, NC ¹	SPD111, TN
SE-5 (4 Sites)	February/August	CAD150, AR IRL141, FL	SUM156, FL CVL151, MS		
Midwestern Sites (18 Total)					
MW-6 (6 Sites)	January/July	CDZ171, KY CKT136, KY	MCK131, KY MCK231, KY	PNF126, NC ¹ ESP127, TN	
MW-7 (8 Sites)	March/September	BVL130, IL ² STK138, IL	VIN140, IN RED004, MN	DCP114, OH OXF122, OH	QAK172, OH PRK134, WI
MW-8 (4 Sites)	April/October	SAL133, IN HOX148, MI	ANA115, MI UVL124, MI		
Western Sites (13 Total)					
W-9 (5 Sites)	March/September	KNZ184, KS KIC003, KS	CHE185, OK SAN189, NE	ALC188, TX	
W-10 (8 Sites)	May/November	LPO010, CA GTH161, CO	ROM206, CO ³ NPT006, ID	PAL190, TX UMA009, WA	CNT169, WY PND165, WY ³

Notes: ¹ Trace-level gas calibrations are performed quarterly in January, April, July, and October.

² Trace-level gas calibrations are performed quarterly in March, June, September, and December.

³ Trace-level gas calibrations are performed quarterly in February, May, August, and November.

Table 3 Data Quality Indicators for CASTNET Continuous Measurements

Measurements		Criteria ¹	
Parameter ²	Method	Precision	Accuracy
Filter pack flow	Mass flow controller	± 10%	± 5%
Ozone ³	UV absorbance	All points within ± 2% of fill scale of best fit straight line Linearity error < 5%	
Wind speed	Anemometer	± 0.5 m/s	The greater of ± 0.5 m/s for winds < 5 m/s or ± 5% winds ≥ m/s
Wind direction	Wind vane	± 5°	± 5°
Sigma theta	Wind vane	Undefined	Undefined
Ambient temperature	Platinum RTD	± 1.0°C (of full scale)	± 0.5°C
Delta temperature	Platinum RTD	± 0.5°C	± 0.5 °C
Relative humidity	Thin film capacitor	± 10% (of full scale)	± 10%
Precipitation	Tipping bucket rain gauge	± 10% (of reading)	± 0.05 inch ⁴
Solar radiation	Pyranometer	± 10% (of reading taken at local noon)	± 10%
Surface wetness	Conductivity bridge	Undefined	Undefined

Notes: °C = degrees Celsius
m/s = meters per second
RTD = resistance-temperature device
UV = ultraviolet

¹ Precision criteria apply to co-located instruments, and accuracy criteria apply to calibration of instruments. Co-located precision criteria do not apply to CASTNET sites that are configured and operated in accordance with Part 58 of Title 40 of the Code of Federal Regulations (EPA, 2022)

² Meteorological parameters are only measured at five of the EPA-sponsored CASTNET sites: IRL141, FL; BVL130, IL; BEL116, MD; CHE185, OK; and PND165, WY.

³ Ozone is not measured at eight EPA-sponsored CASTNET sites: KIC003, KS; KNZ184, KS; RED004, MN; EGB181, ON; CAT175, NY; NIC001, NY; WFM105, NY; and UND002, VT.

⁴ For target value of 0.50 inch

Table 4 Data Quality Indicators for CASTNET Laboratory Measurements

Analyte	Method	Precision ¹ (MARPD)	Accuracy ² (%)	Nominal Reporting Limits ³	
				mg/L	µg/Filter
Ammonium (NH ₄ ⁺)	AC	20	90–110	0.020*	0.5
Sodium (Na ⁺)	ICP-OES	20	95–105	0.005	0.125
Potassium (K ⁺)	ICP-OES	20	95–105	0.006	0.15
Magnesium (Mg ²⁺)	ICP-OES	20	95–105	0.003	0.075
Calcium (Ca ²⁺)	ICP-OES	20	95–105	0.006	0.15
Chloride (Cl ⁻)	IC	20	95–105	0.020	0.5
Nitrate (NO ₃ ⁻)	IC	20	95–105	0.008*	0.2
Sulfate (SO ₄ ²⁻)	IC	20	95–105	0.040	1.0

Notes: ¹ This column lists precision goals for both network precision calculated from co-located filter samples and laboratory precision based on replicate samples for samples > five times the reporting limit. The criterion is ± the reporting limit if the sample is ≤ five times the reporting limit.

² This column lists laboratory accuracy goals based on reference standards and continuing calibration verification spikes. The criterion is 90–110 percent for ICP-OES reference standards.

³ The reporting limit for sulfate on cellulose filters is 0.080 mg/L (2.0 µg/filter).

AC = automated colorimetry
 IC = ion chromatography
 ICP-OES = inductively coupled plasma-optical emission spectrometry
 MARPD = mean absolute relative percent difference
 mg/L = milligrams per liter
 µg/Filter = micrograms per filter
 * = as nitrogen

Values are rounded according to American Society for Testing and Materials (ASTM) E29-08, “Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications” (ASTM, 2008).

For more information on analytical methods and associated precision and accuracy criteria, see the CASTNET QAPP, (WSP, 2022).

Table 5 Ozone Critical Criteria*

Type Check	Analyzer Response
Zero	Less than ± 3.1 parts per billion (ppb)
Span	Less than ± 7.1 percent between supplied and observed concentrations
Single Point QC	Less than ± 7.1 percent between supplied and observed concentrations

Notes: * Applies to CASTNET sites that are configured and operated in accordance with Part 58 of Title 40 of the Code of Federal Regulations (EPA, 2020). The minimum frequency for these checks is once every two weeks.

Values are rounded according to ASTM E29-22, “Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications” (ASTM, 2022).

Table 6 Trace-level Gas Monitoring Critical Criteria*

Parameter	Analyzer Response	
	Zero Check	Span Check / Single Point QC Check
SO ₂	Less than ± 1.51 ppb	Less than ± 10.1 percent between supplied and observed concentrations
NO _y	Less than ± 1.51 ppb	
CO	Less than ± 50 ppb	

Notes: *Applies to CASTNET sites that are configured and operated in accordance with Part 58 of Title 40 of the Code of Federal Regulations (EPA, 2020). The minimum frequency for these checks is once every two weeks.

Values are rounded according to ASTM E29-22, "Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications" (ASTM, 2022).

SO₂ = sulfur dioxide
 NO_y = total reactive oxides of nitrogen
 CO = carbon monoxide
 ppb = parts per billion

Table 7 QC Analysis Count for First Quarter 2023

Filter Type	Parameter	RF Sample Count	CCV Sample Count	RP Sample Count	MB Sample Count	LB Sample Count	FB Sample Count
Teflon	SO ₄ ²⁻	58	163	69	14	20	48
	NO ₃ ⁻	58	163	69	14	20	48
	NH ₄ ⁺	29	151	68	14	20	48
	Cl ⁻	58	163	69	14	20	48
	Ca ²⁺	28	146	69	14	20	48
	Mg ²⁺	28	146	69	14	20	48
	Na ⁺	28	146	69	14	20	48
	K ⁺	28	146	69	14	20	48
Nylon	SO ₄ ²⁻	31	142	68	11	22	57
	NO ₃ ⁻	31	142	68	11	22	57
Cellulose	SO ₄ ²⁻	43	144	64	14	22	82

Table 8 QC Analysis Count for Second Quarter 2023

Filter Type	Parameter	RF Sample Count	CCV Sample Count	RP Sample Count	MB Sample Count	LB Sample Count	FB Sample Count
Teflon	SO ₄ ²⁻	56	161	68	14	22	43
	NO ₃ ⁻	56	161	68	14	22	43
	NH ₄ ⁺	29	148	68	14	22	43
	Cl ⁻	56	161	68	14	22	43
	Ca ²⁺	28	146	68	14	22	43
	Mg ²⁺	28	146	68	14	22	43
	Na ⁺	28	146	68	14	22	43
	K ⁺	28	146	68	14	22	43
Nylon	SO ₄ ²⁻	31	144	71	10	24	43
	NO ₃ ⁻	31	144	71	10	24	43
Cellulose	SO ₄ ²⁻	48	172	76	15	28	84

Table 9 QC Analysis Count for Third Quarter 2023

Filter Type	Parameter	RF Sample Count	CCV Sample Count	RP Sample Count	MB Sample Count	LB Sample Count	FB Sample Count
Teflon	SO ₄ ²⁻	54	150	63	13	22	43
	NO ₃ ⁻	54	150	63	13	22	43
	NH ₄ ⁺	26	135	62	13	22	43
	Cl ⁻	54	150	63	13	22	43
	Ca ²⁺	26	135	62	13	22	43
	Mg ²⁺	26	135	62	13	22	43
	Na ⁺	26	135	62	13	22	43
	K ⁺	26	135	62	13	22	43
Nylon	SO ₄ ²⁻	27	125	56	8	22	43
	NO ₃ ⁻	27	125	56	8	22	43
Cellulose	SO ₄ ²⁻	38	133	60	12	24	85

Table 10 QC Analysis Count for Fourth Quarter 2023

Filter Type	Parameter	RF Sample Count	CCV Sample Count	RP Sample Count	MB Sample Count	LB Sample Count	FB Sample Count
Teflon	SO ₄ ²⁻	48	136	57	48	136	57
	NO ₃ ⁻	48	136	57	48	136	57
	NH ₄ ⁺	24	123	57	24	123	57
	Cl ⁻	48	136	57	48	136	57
	Ca ²⁺	24	123	57	24	123	57
	Mg ²⁺	24	123	57	24	123	57
	Na ⁺	24	123	57	24	123	57
	K ⁺	24	123	57	24	123	57
Nylon	SO ₄ ²⁻	30	132	66	30	132	66
	NO ₃ ⁻	30	132	66	30	132	66
Cellulose	SO ₄ ²⁻	27	105	45	27	105	45

Table 11 Filter Pack Receipt Summary for 2023

Description	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Annual Summary
Count of samples received more than 14 days after removal from tower:	9	11	15	15	50
Count of all samples received:	602	642	652	679	2575
Fraction of samples received within 14 days:	0.985	0.983	0.977	0.978	0.981
Average interval in days;	6.055	4.117	5.299	5.566	5.259*
First receipt date:	01/03/2023	04/01/2023	07/01/2023	10/02/2023	01/03/2023
Last receipt date:	03/21/2023	06/30/2023	09/27/2023	12/30/2023	12/30/2023

Note: Sample shipments for the Egbert, Ontario site (EGB181) are in groups of four. Samples associated with EGB181 are excluded from this statistic.

*Annual average

Table 12 Filter Pack QC Summary for 2023

Filter Type	Parameter	Reference Sample ¹ Recovery (%R)			Continuing Calibration Verification Samples (%R)			In-Run Replicate ² (RPD)		
		Mean	Std. Dev.	Count ³	Mean	Std. Dev.	Count ³	Mean	Std. Dev.	Count ³
Teflon	SO ₄ ²⁻	102.63	0.91	236	100.61	1.65	664	0.92	0.80	280
	NO ₃ ⁻	101.52	1.27	236	99.41	1.25	664	1.40	1.36	280
	NH ₄ ⁺	99.94	2.51	118	99.42	1.50	605	1.05	1.38	278
	Ca ²⁺	101.17	2.48	116	100.29	1.59	598	1.42	1.45	279
	Mg ²⁺	97.74	2.24	116	100.26	1.27	598	1.59	1.90	279
	Na ⁺	95.03	1.77	116	99.87	1.45	598	1.26	1.04	279
	K ⁺	98.35	1.91	116	100.01	1.41	598	1.67	1.93	279
	Cl ⁻	100.52	1.21	236	101.64	1.65	664	1.70	2.06	280
Nylon	SO ₄ ²⁻	102.61	1.18	126	100.61	1.97	575	6.23	4.51	275
	NO ₃ ⁻	100.39	1.42	126	100.11	1.85	575	2.74	2.59	275
Cellulose	SO ₄ ²⁻	101.67	1.53	156	100.53	2.11	554	2.99	2.55	245

Notes: % R = percent recovery
RPD = relative percent difference

¹Results of reference sample analyses provide accuracy estimates

²Results of replicate analyses provide precision estimates

³Number of QC Samples

Table 13 Precision Results for Third Quarter 2022 through Second Quarter 2023

Quarter	SO ₄ ²⁻	NO ₃ ⁻	NH ₄ ⁺	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	Cl ⁻	HNO ₃	SO ₂	Total NO ₃ ⁻
MCK131/231, KY											
2022 Q3	11.17	3.88	6.21	7.62	1.14	6.04	13.56	4.74	4.30	6.25	4.39
2022 Q4	1.30	3.16	2.96	8.17	8.92	4.61	9.28	2.07	4.38	3.78	2.55
2023 Q1	5.39	4.42	10.32	9.25	3.63	7.00	4.77	3.49	5.45	9.28	2.30
2023 Q2	1.66	5.79	2.75	6.47	6.30	1.68	4.08	3.62	4.43	8.87	3.76
Average	4.88	4.31	5.56	7.88	5.00	4.83	7.92	3.48	4.64	7.04	3.25
ROM406/206, CO											
2022 Q3	33.63	24.25	34.02	28.22	19.72	38.08	25.11	36.37	32.25	27.68	29.07
2022 Q4	9.87	16.71	9.30	17.93	14.36	17.00	16.82	4.33	13.94	10.83	14.27
2023 Q1	14.80	7.04	12.16	10.79	8.84	13.77	19.82	10.86	13.59	14.94	8.07
2023 Q2	5.16	13.48	7.21	6.92	7.04	7.71	12.77	11.05	14.05	14.59	10.10
Average	15.87	15.37	15.67	15.96	12.49	19.14	18.63	15.65	18.46	17.01	15.38

Notes: 10 of 88 site-quarter-parameters were outside criterion

Table 14 Ozone QC Summary for Fourth Quarter 2023 (1 of 2)

Site ID	% Span Pass ¹	Span [%D] ²	% Single Point QC Pass ¹	Single Point QC [%D] ²	% Zero Pass ¹	Zero Average (ppb) ²
ABT147, CT	100.00	1.61	100.00	1.37	100.00	0.24
ALC188, TX	100.00	0.48	100.00	0.76	100.00	0.49
ANA115, MI	100.00	1.83	100.00	2.49	100.00	0.18
ARE128, PA	100.00	1.86	100.00	1.31	100.00	0.41
ASH135, ME	N/A	N/A	N/A	N/A	N/A	N/A
BEL116, MD	100.00	0.70	100.00	0.70	100.00	0.54
BFT142, NC	100.00	1.84	100.00	1.65	100.00	0.30
BVL130, IL	100.00	1.77	100.00	1.42	100.00	0.09
BWR139, MD	100.00	0.84	100.00	1.22	100.00	0.53
CAD150, AR	100.00	3.72	100.00	3.44	100.00	0.28
CDR119, WV	N/A	N/A	N/A	N/A	N/A	N/A
CDZ171, KY	N/A	N/A	N/A	N/A	N/A	N/A
CKT136, KY	100.00	0.90	100.00	0.90	100.00	0.13
CND125, NC	100.00	1.79	100.00	1.71	100.00	0.31
CNT169, WY	77.78	20.61	77.50	18.83	87.50	2.91
COW137, NC	100.00	0.83	97.89	1.50	98.95	0.66
CTH110, NY	100.00	1.31	100.00	1.30	100.00	0.19
CVL151, MS	100.00	2.43	100.00	2.58	100.00	0.18
DCP114, OH	N/A	N/A	N/A	N/A	N/A	N/A
DUK008, NC	100.00	2.92	98.95	3.20	100.00	0.96
ESP127, TN	100.00	1.30	100.00	1.74	100.00	0.22
GAS153, GA	100.00	0.81	100.00	1.21	100.00	0.49
GTH161, CO	100.00	2.32	85.83	3.76	73.81	1.86
HOX148, MI	100.00	1.48	100.00	1.61	100.00	0.17
HWF187, NY	N/A	N/A	N/A	N/A	N/A	N/A
IRL141, FL	96.94	2.48	97.94	1.55	100.00	0.82
KEF112, PA	100.00	2.32	100.00	1.05	100.00	0.66
LPO010, CA	98.95	1.32	100.00	1.13	100.00	0.42
LRL117, PA	100.00	0.79	100.00	0.90	98.94	0.37
MCK131, KY	98.92	0.93	100.00	0.78	100.00	0.23
MCK231, KY	95.79	2.13	98.95	1.86	97.89	0.38
MKG113, PA	95.79	5.52	95.79	5.52	100.00	0.27
NPT006, ID	100.00	1.71	100.00	1.73	100.00	0.15
OXF122, OH	100.00	1.93	100.00	2.27	100.00	0.19
PAL190, TX	100.00	1.11	100.00	1.04	100.00	0.40
PAR107, WV	100.00	0.95	100.00	0.72	100.00	0.23
PED108, VA	100.00	1.84	100.00	2.38	100.00	0.25
PND165, WY	97.80	4.31	97.80	2.41	97.80	1.67
PNF126, NC	N/A	N/A	N/A	N/A	N/A	N/A
PRK134, WI	100.00	1.51	100.00	1.64	100.00	0.16
PSU106, PA	100.00	2.24	96.88	2.43	100.00	0.85
QAK172, OH	100.00	0.91	100.00	0.63	100.00	0.21

Table 14 Ozone QC Summary for Fourth Quarter 2023 (2 of 2)

Site ID	% Span Pass ¹	Span [%D] ²	% Single Point QC Pass ¹	Single Point QC [%D] ²	% Zero Pass ¹	Zero Average (ppb) ²
ROM206, CO	100.00	2.04	100.00	1.36	100.00	0.25
SAL133, IN	100.00	0.76	100.00	0.63	100.00	0.20
SAN189, NE	89.69	12.40	89.69	12.85	100.00	0.43
SND152, AL	100.00	1.91	100.00	1.87	98.94	0.41
SPD111, TN	98.80	2.14	100.00	0.73	100.00	0.28
STK138, IL	100.00	1.26	100.00	1.42	100.00	0.19
SUM156, FL	100.00	2.11	100.00	2.03	100.00	0.15
UMA009, WA	100.00	0.83	100.00	0.85	98.55	0.51
UVL124, MI	100.00	1.69	100.00	1.52	100.00	0.36
VIN140, IN	100.00	0.56	100.00	0.71	100.00	0.12
VPI120, VA	100.00	1.46	98.95	2.14	100.00	0.32
WSP144, NJ	97.59	1.60	100.00	0.89	100.00	0.26
WST109, NH	100.00	1.42	100.00	1.87	100.00	0.40

Notes: ¹Percentage of comparisons that pass the criteria listed in Table 5. Values falling below 90 percent are addressed in Table 15.

²Absolute value of the average percent differences between the on-site transfer standard and the site monitor. Values exceeding the criteria listed in Table 5 are addressed in Table 15.

%D = percent difference

ppb = parts per billion

Table 15 Ozone QC Observations for Fourth Quarter 2023

Site ID	QC Criterion	Comments
CNT169, WY	% Span Pass Span [%D] % Single Point QC Pass Single Point QC [%D] % Zero Pass Zero Average	The analyzer pump malfunctioned. The site operator installed a new pump on 12/06/2023 but did not connect the sample line to the analyzer until 12/12/2023. Associated data were flagged as invalid.
GTH161, CO	% Single Point QC Pass % Zero Pass	There was an intermittently noisy baseline seen in 1-minute data generally occurring overnight. On demand checks run outside of these noisy periods passed. Investigation into the system noise is ongoing.
SAN189, NE	Span [%D] Single Point QC [%D]	The analyzer pump malfunctioned in early December. The flow pump was replaced. Associated data were flagged as invalid.

Note: %D = percent difference

Table 16 Trace-level Gas QC Summary for Fourth Quarter 2023

Parameter	% Span Pass ¹	Span [%D] ²	% Single Point QC Pass ¹	Single Point QC [%D] ²	% Zero Pass ¹	Zero Average (ppb) ²
BVL130, IL						
SO ₂	100.00	2.96	100.00	3.28	100.00	0.14
NO _y	93.88	3.95	100.00	1.97	100.00	0.35
CO	100.00	1.04	100.00	4.48	93.33	14.37
DUK008, NC						
NO _y	100.00	2.02	100.00	2.06	100.00	0.38
HWF187, NY						
NO _y	N/A	N/A	N/A	N/A	N/A	N/A
PND126, NC						
NO _y	100.00	2.02	100.00	2.06	100.00	0.38
PNF126, NC						
NO _y	N/A	N/A	N/A	N/A	N/A	N/A
ROM206, CO						
NO _y	86.67	N/A	84.44	N/A	100.00	0.20

Notes: ¹Percentage of comparisons that pass the criteria listed in Table 6. Values falling below 90 percent are addressed in Table 17.

²Absolute value of the average percent differences between the supplied and observed concentrations. Values exceeding the criteria listed in Table 6 are addressed in Table 17.

%D = percent difference

ppb = parts per billion

Table 17 Trace-level Gas QC Observations for Fourth Quarter 2023

Site ID	Parameter	QC Criterion	Comments
ROM206, CO	NO _y	% Span Pass % Single Point QC Pass	QC failures in December required replacement of the prereactor and sample solenoid assemblies. Associated data were invalidated.

Table 18 Summary of Filter Blanks for 2023 (1 of 2)

Parameter Name	Detection Limit Total µg	Total Number	Number > Detection Limit	Average Total µg	Average Absolute Deviation	Maximum Total µg
FIELD BLANKS						
Teflon - NH ₄ ⁺ -N	0.500	301	0	0.500	0.000	0.500
Teflon - NO ₃ ⁻ -N	0.200	301	1	0.200	0.000	0.275
Teflon - SO ₄ ²⁻	1.000	301	0	1.000	0.000	1.000
Cl ⁻	0.500	301	0	0.500	0.000	0.500
Ca ²⁺	0.150	301	6	0.152	0.003	0.517
Mg ²⁺	0.075	301	0	0.075	0.000	0.075
Na ⁺	0.125	301	0	0.125	0.000	0.125
K ⁺	0.150	301	3	0.151	0.002	0.308
Nylon - NO ₃ ⁻ -N	0.200	310	0	0.200	0.000	0.200
Nylon - SO ₄ ²⁻	1.000	310	0	1.000	0.000	1.000
Cellulose - SO ₄ ²⁻	2.000	311	2	2.003	0.006	2.835
LABORATORY BLANKS						
Teflon - NH ₄ ⁺ -N	0.500	98	0	0.500	0.000	0.500
Teflon - NO ₃ ⁻ -N	0.200	98	0	0.200	0.000	0.200
Teflon - SO ₄ ²⁻	1.000	98	0	1.000	0.000	1.000
Cl ⁻	0.500	98	0	0.500	0.000	0.500
Ca ²⁺	0.150	98	1	0.150	0.001	0.188
Mg ²⁺	0.075	98	0	0.075	0.000	0.075
Na ⁺	0.125	98	0	0.125	0.000	0.125
K ⁺	0.150	98	0	0.150	0.000	0.150
Nylon - NO ₃ ⁻ -N	0.200	100	0	0.200	0.000	0.200
Nylon - SO ₄ ²⁻	1.000	100	0	1.000	0.000	1.000
Cellulose - SO ₄ ²⁻	2.000	100	2	2.008	0.015	2.550

Table 18 Summary of Filter Blanks for 2023 (2 of 2)

Parameter Name	Detection Limit Total µg	Total Number	Number > Detection Limit	Average Total µg	Average Absolute Deviation	Maximum Total µg
METHOD BLANKS						
Teflon - NH ₄ ⁺ -N	0.500	58	0	0.500	0.000	0.500
Teflon - NO ₃ ⁻ -N	0.200	58	0	0.200	0.000	0.200
Teflon - SO ₄ ²⁻	1.000	58	0	1.000	0.000	1.000
Cl ⁻	0.500	58	0	0.500	0.000	0.500
Ca ²⁺	0.150	58	0	0.150	0.000	0.150
Mg ²⁺	0.075	58	0	0.075	0.000	0.075
Na ⁺	0.125	58	0	0.125	0.000	0.125
K ⁺	0.150	58	0	0.150	0.000	0.150
Nylon - NO ₃ ⁻ -N	0.200	42	0	0.200	0.000	0.200
Nylon - SO ₄ ²⁻	1.000	42	0	1.000	0.000	1.000
Cellulose - SO ₄ ²⁻	2.000	50	0	2.000	0.000	2.000
ACCEPTANCE TEST VALUES ¹						
Teflon - NH ₄ ⁺ -N	0.500	216	0	0.500	0.000	0.500
Teflon - NO ₃ ⁻ -N	0.200	216	0	0.200	0.000	0.200
Teflon - SO ₄ ²⁻	1.000	216	0	1.000	0.000	1.000
Cl ⁻	0.500	216	1	0.501	0.002	0.708
Ca ²⁺	0.150	216	1	0.150	0.001	0.252
Mg ²⁺	0.075	216	0	0.075	0.000	0.075
Na ⁺	0.125	216	1	0.127	0.004	0.587
K ⁺	0.150	216	1	0.154	0.008	0.982
Nylon - NO ₃ ⁻ -N	0.200	130	1	0.201	0.002	0.353
Nylon - SO ₄ ²⁻	1.000	130	1	1.008	0.015	1.992
Cellulose - SO ₄ ²⁻	2.000	216	1	2.006	0.012	3.305

Note: ¹Only filter batches passing QC requirements are used for sampling and analysis.

Table 19 Filter Packs Flagged as Suspect or Invalid

Site ID	Sample No.	Reason
First Quarter 2023		
ACA416, ME	2303003-01	Power failure
CNT169, WY	2307001-15	The flow pump failed.
DEN417, AK	2301003-05 2302003-05	Sample was invalidated for suspect data.
EGB181, ON	2307001-21	Site data were missing.
FOR605, WY	2305005-03	Flow data were missing.
GLR468, MT	2307003-08 2309003-08	Power failure
GRS420, TN	2304003-11	Sample was invalidated for suspect data.
GTH161, CO	2301001-24 2303001-24	Sample was invalidated for suspect data.
JOT403, CA	2305003-12	Flow data were missing.
MCK231, KY	2304001-32	There was an obstruction in flow system.
MKG113, PA	2302001-33	The mass flow controller malfunctioned and was replaced.
SAN189, NE	2304004-07	The data logger flow channel was left down.
Second Quarter 2023		
ALC188, TX	2316004-01	Sample was invalidated for suspect data.
EGB181, ON	2314001-21	The site had a polling issue, and flow data were missing for five out of seven days.
SUM156, FL	2315001-49 2316001-49	The site had a polling issue, and flow data were missing for several days, which affected two samples.
Third Quarter 2023		
CND125, NC	2330001-14 2331001-14	The site had data logger issues due to low voltage from the battery pack.
CVL151, MS	2331001-18	Data logger issues
KNZ184, KS	2329001-29	Flow pump was left off until the broken knockout bottle was replaced.
SHE604, WY	2327005-05 2328005-05 2329005-05 2330005-05 2331005-05	The flow pump and the mass flow controller failed. Both were replaced.
Fourth Quarter 2023		
ALB801, AB	2344007-01	Site data were missing.
BUF603, WY	2344005-02	Flow data were missing.
FOR605, WY	2344005-03	Flow data were missing.
JOT403, CA	2344003-12	Data were missing for all parameters for most of the week.
SHE604, WY	2345005-05	Flow channel was left down resulting in no flow data for the week.
SHN418, VA	2344003-20 2345003-20	Power failure
UMA009, WA	2343004-08	The mass flow controller malfunctioned.

Table 20 Field Problems Affecting Data Collection

Days to Resolution	Problem Count
First Quarter 2023	
30	159
60	7
90	1
Unresolved by End of Quarter	3
Second Quarter 2023	
30	216
60	2
90	0
Unresolved by End of Quarter	3
Third Quarter 2023	
30	324
60	7
90	0
Unresolved by End of Quarter	0
Fourth Quarter 2023	
30	160
60	7
90	0
Unresolved by Date of Publication	14

Table 21 Field Calibration Failures by Parameter for 2023

Site ID	Reason
First Quarter 2023	
CVL151, MS	Flow
IRL141, FL	Temperature (ambient)
ALC188, TX	Temperature (ambient)
ARE128, PA	Temperature (ambient)
Second Quarter 2023	
GTH161, CO	Flow
Third Quarter 2023	
CTH110, NY	Flow
VPI120, VA	Flow
Fourth Quarter 2023	
CAT175, NY	Temperature (ambient)

Table 22 Accuracy Results for 2023 Field Measurements

Parameter	Percent Within Criterion
Flow rate	96.1*
Wind speed < 5 m/s	100.0
Wind speed ≥ 5 m/s	100.0
Wind direction north	100.0
Wind direction south	100.0
Temperature (0°C)	100.0
Temperature (ambient)	96.2
Delta temperature (0°C)	100.0
Delta temperature (ambient)	100.0
Relative humidity	100.0
Precipitation	100.0
Solar radiation	100.0
Wetness(w/in 0.5 volts)	100.0

Notes: °C = degrees Celsius

m/s = meters per second

* Per CASTNET project protocols, data are flagged as “suspect” (S) but still considered valid if the calibration criterion is not exceeded by more than its magnitude (i.e., if within two times the criterion). All calibration failures reported in 2023 for the indicated parameters were within two times the criterion with the exception of flow rate at GTH161, CO. Associated data were invalidated.

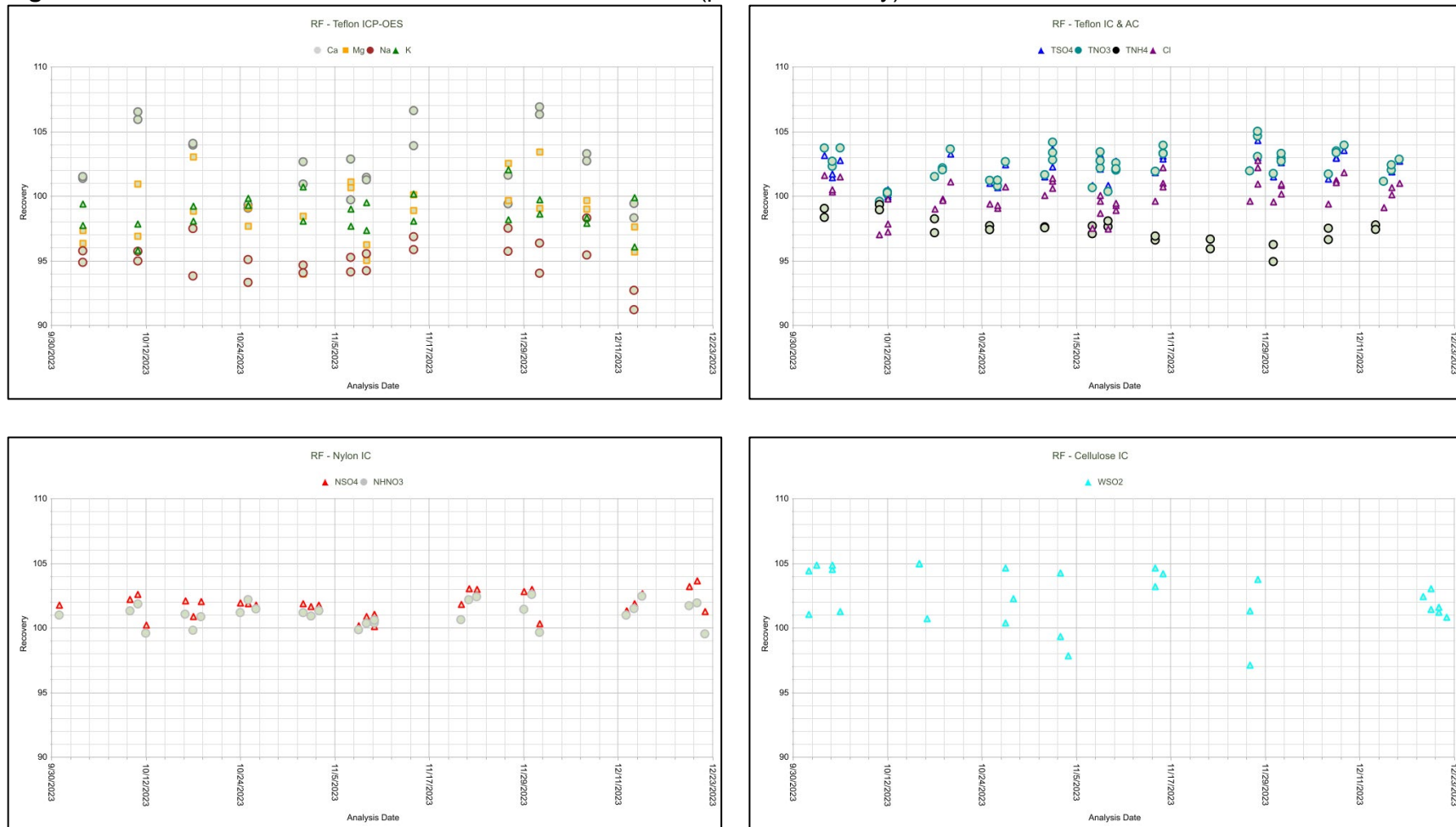
Figure 1 Reference Standard Results for Fourth Quarter 2023 (percent recovery)

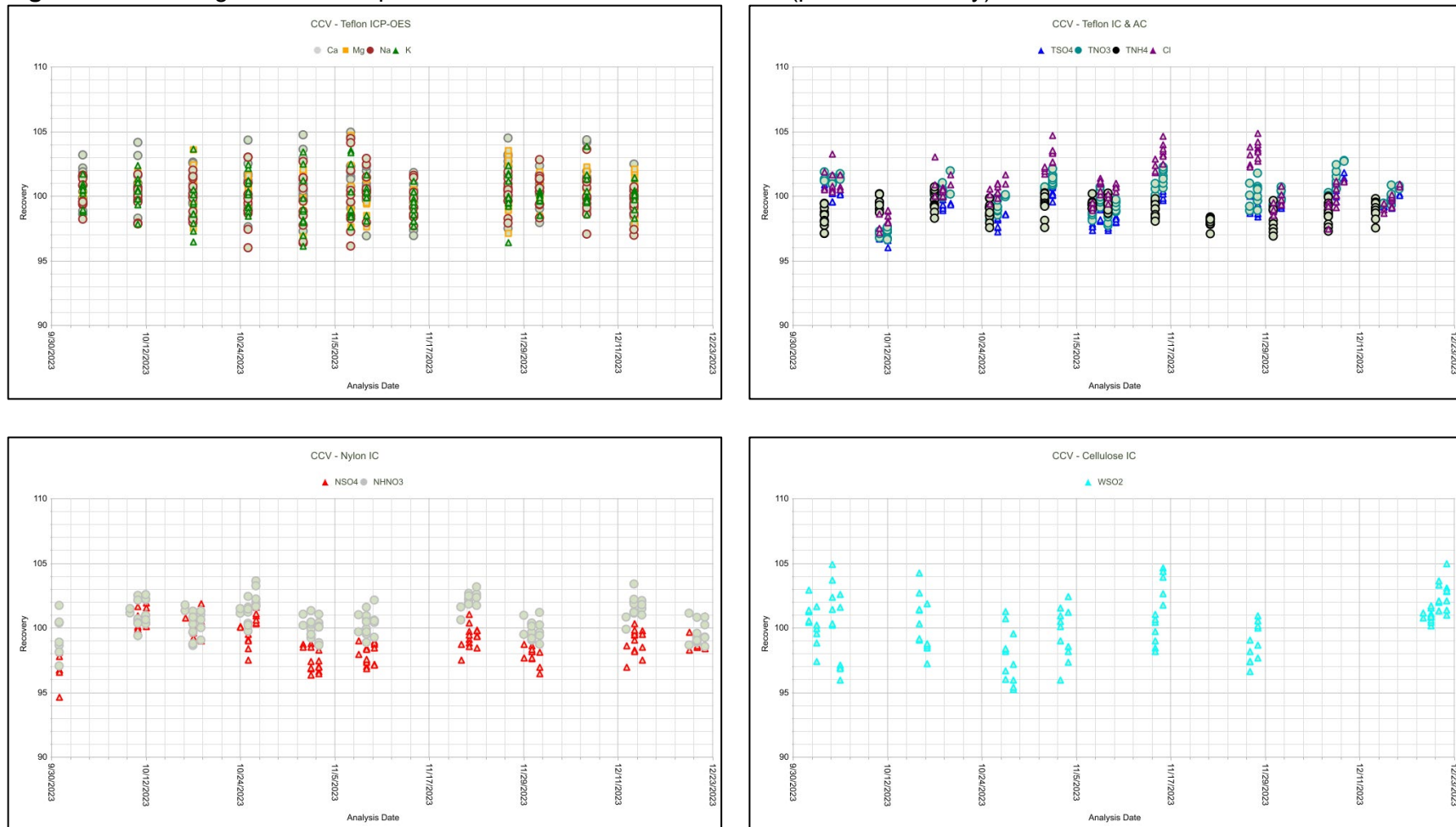
Figure 2 Continuing Calibration Spike Results for Fourth Quarter 2023 (percent recovery)

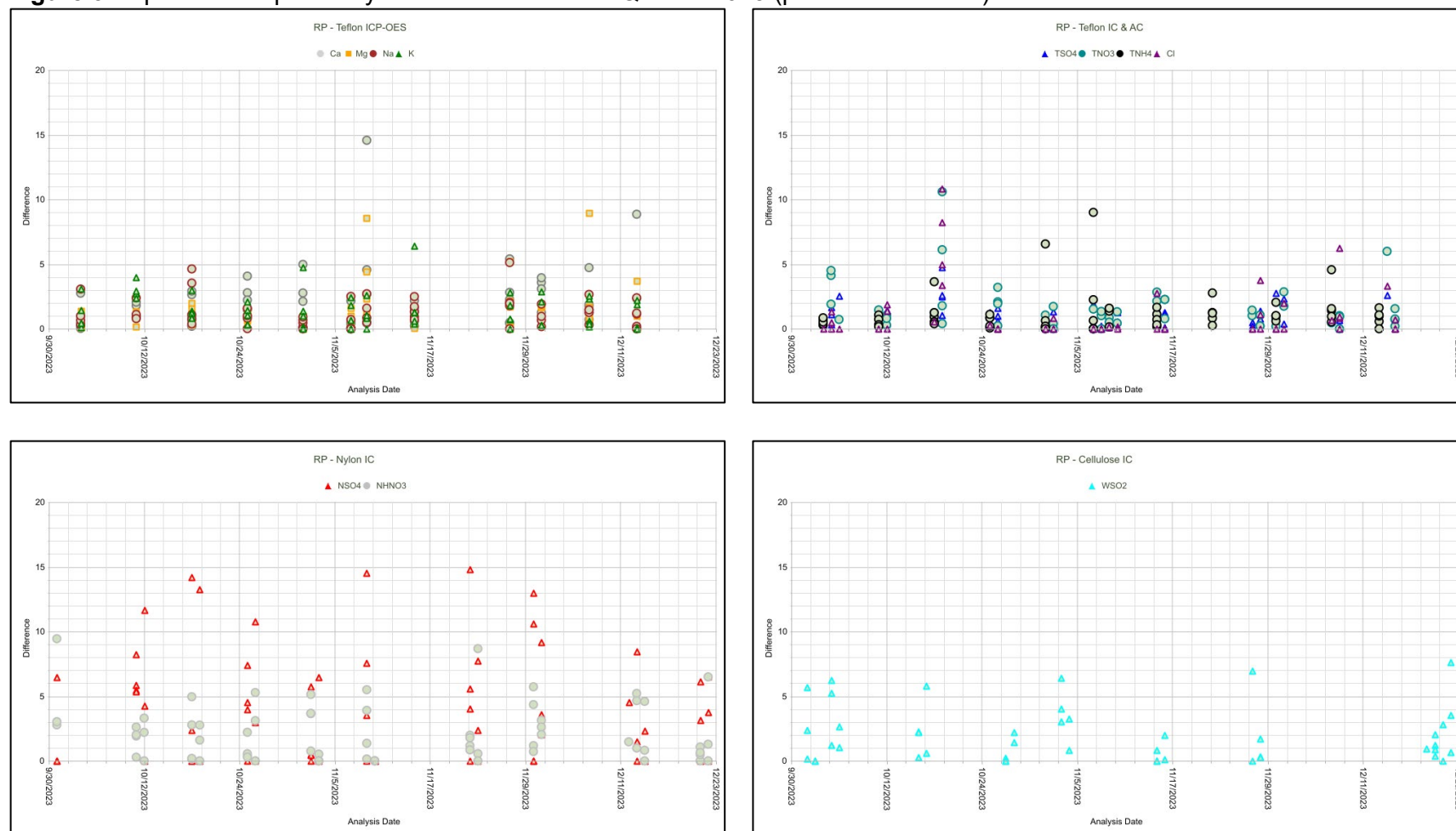
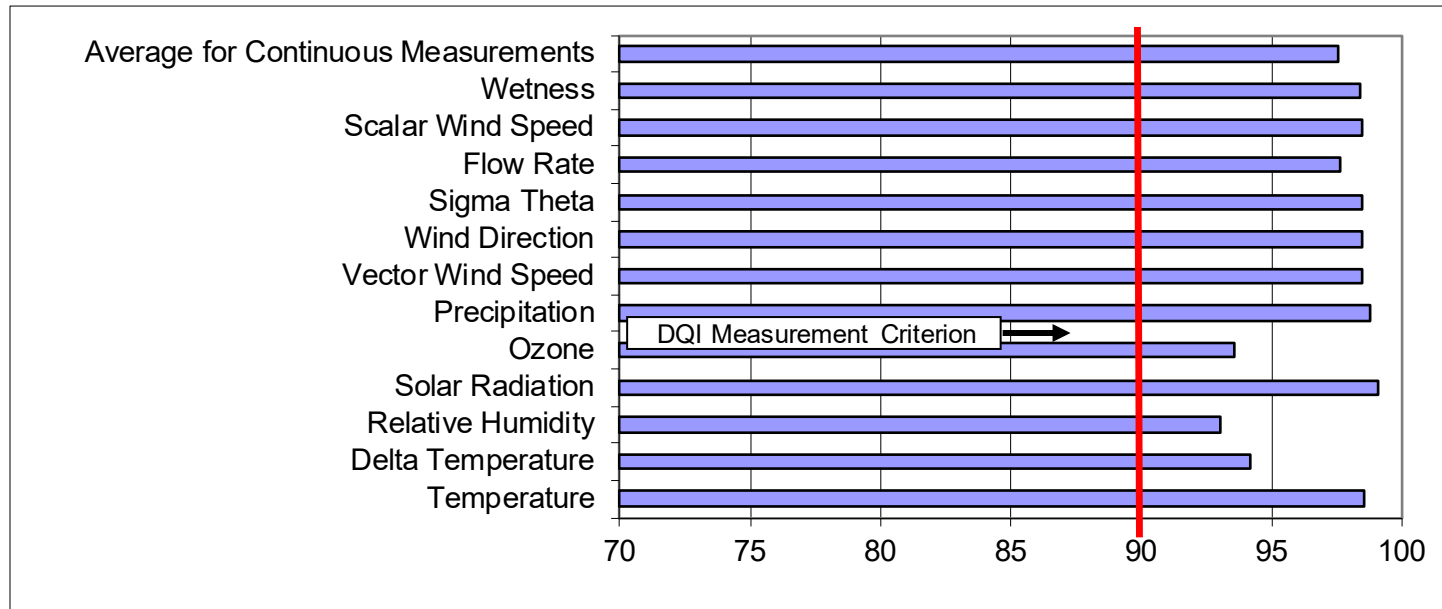
Figure 3 Replicate Sample Analysis Results for Fourth Quarter 2023 (percent difference)

Figure 4 Percent Completeness of Measurements for Second Quarter 2022 through Third Quarter 2023

Note: *Presents Level 3 data available during the fourth quarter of 2023

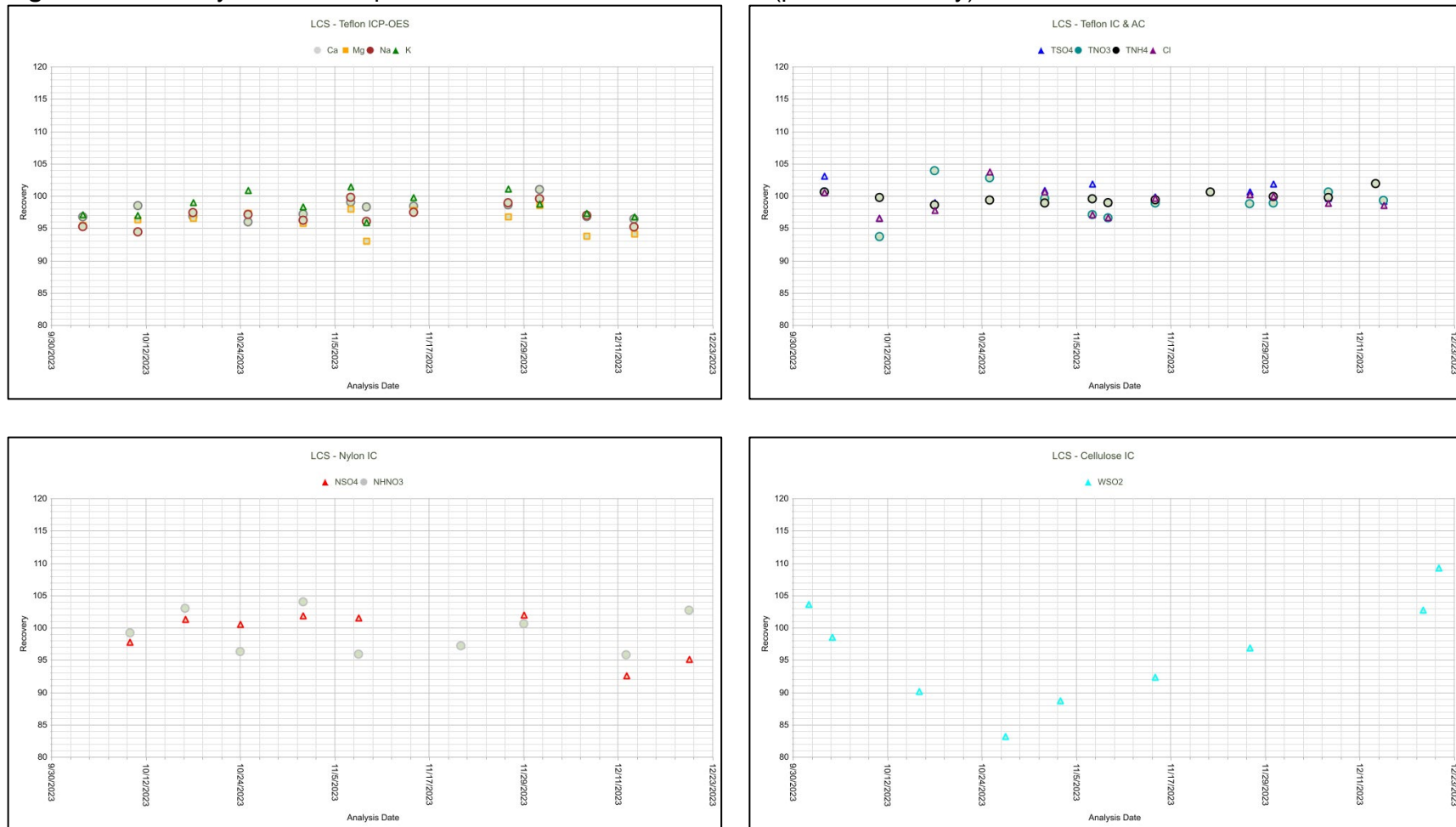
Figure 5 Laboratory Control Sample Results for Fourth Quarter 2023 (percent recovery)

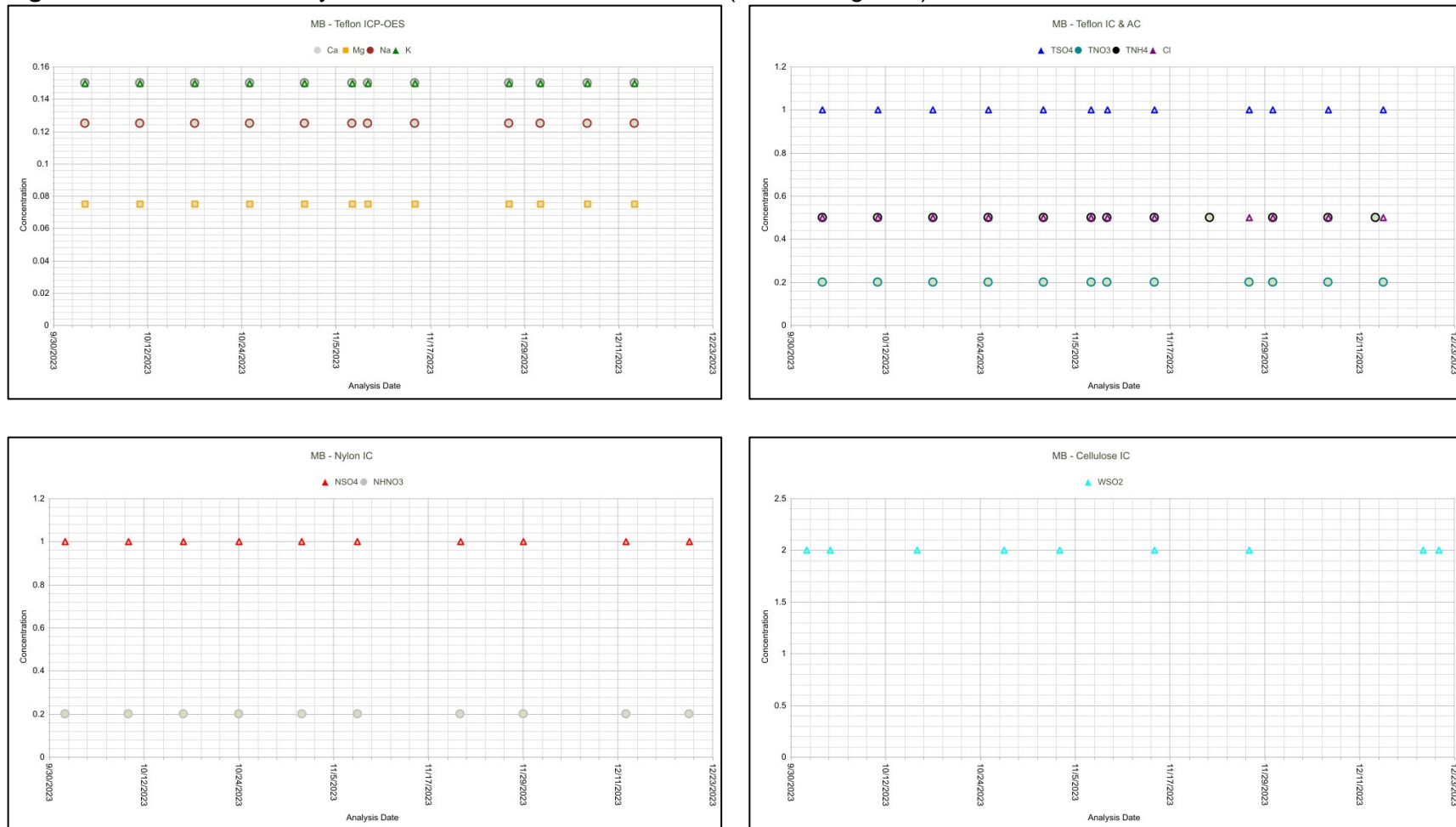
Figure 6 Method Blank Analysis Results for Fourth Quarter 2023 (total micrograms)

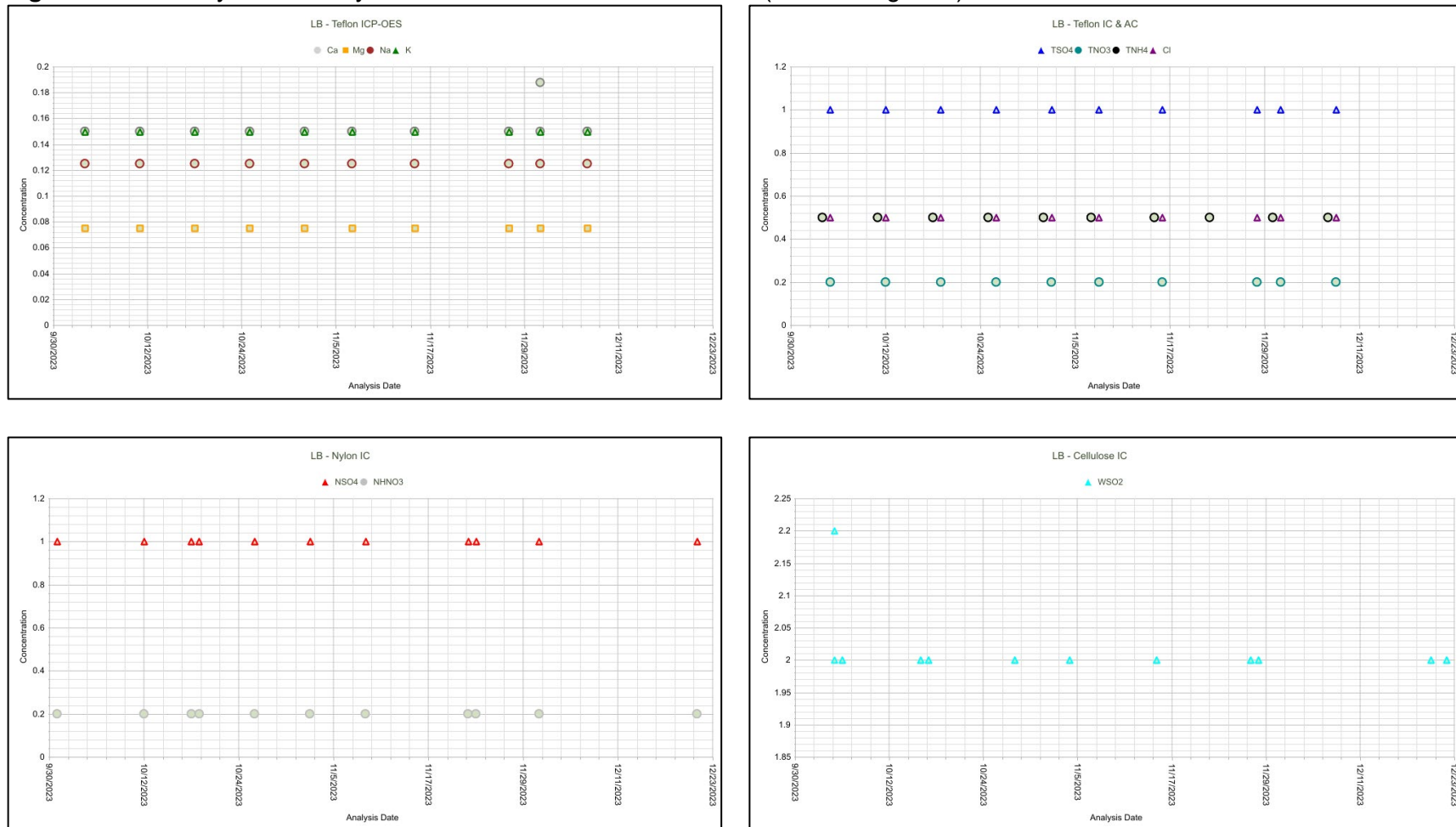
Figure 7 Laboratory Blank Analysis Results for Fourth Quarter 2023 (total micrograms)

Figure 8 Field Blank Analysis Results for Fourth Quarter 2023 (total micrograms)