Clean Air Status and Trends Network (CASTNET)
Quarterly Data Summary for Second Quarter 2019 (April through June)

Prepared for: U.S. Environmental Protection Agency (EPA), Clean Air Markets Division
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Prepared by: Wood Environment & Infrastructure Solutions, Inc. (Wood), Gainesville, Florida
Wood Project No.: 6064193003
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Introduction

This quarterly report summarizes the Clean Air Status and Trends Network (CASTNET) data collected during second quarter 2019. Trends in pollutants measured at eastern and western reference sites are shown. Results from the quality assurance/quality control (QA/QC) program are presented for second quarter data and include completeness and precision of filter concentrations and hourly O_3 concentrations. This report also analyzes data for continuous, trace-level NO_y from eight sites and continuous SO_2 concentrations from three sites. Other QC statistics are given in the CASTNET Second Quarter 2019 Quality Assurance Report (Wood, 2019).

Figure 1. Fourth Highest Daily Maximum 8-hour Average O_3 Concentrations through Second Quarter 2019 (ppb)

Figure 1 shows fourth highest daily maximum 8-hour average (DM8A) O_3 concentrations measured through second quarter 2019. Two sites exceeded the 0.070 parts per million (ppm) National Ambient Air Quality Standard for O_3. The fourth highest DM8A O_3 concentration for Dinosaur National Monument, UT (DIN431) for the first quarter and YTD was 70 parts per billion (ppb). The second quarter declined to 60 ppb compared to the 70 ppb.

Trends

Trend analyses were performed based on filter pack pollutant concentrations measured in micrograms per cubic meter ($\mu g/m^3$) of air at the 34 eastern and 16 western reference sites during second quarter. Trends in quarterly mean filter pack and O_3 concentrations are shown using box plots in Figures 2 through 13.

Second Quarter Concentrations

Quarterly mean concentrations of all pollutants decreased at both eastern and western sites except for Cl^-, which increased at the eastern reference sites.

Quarterly O_3 concentrations were analyzed using box plots constructed by averaging all valid hourly O_3 concentrations within second quarter 2019 by site and then averaging those averages for all eastern and western reference sites (Figure 13). The figure shows an overall reduction in quarterly mean O_3 concentrations at both eastern and western sites. Quarterly mean concentrations were higher at the western reference sites than at the eastern sites.

Figure 2. Trends in Second Quarter Mean HNO_3 Concentrations

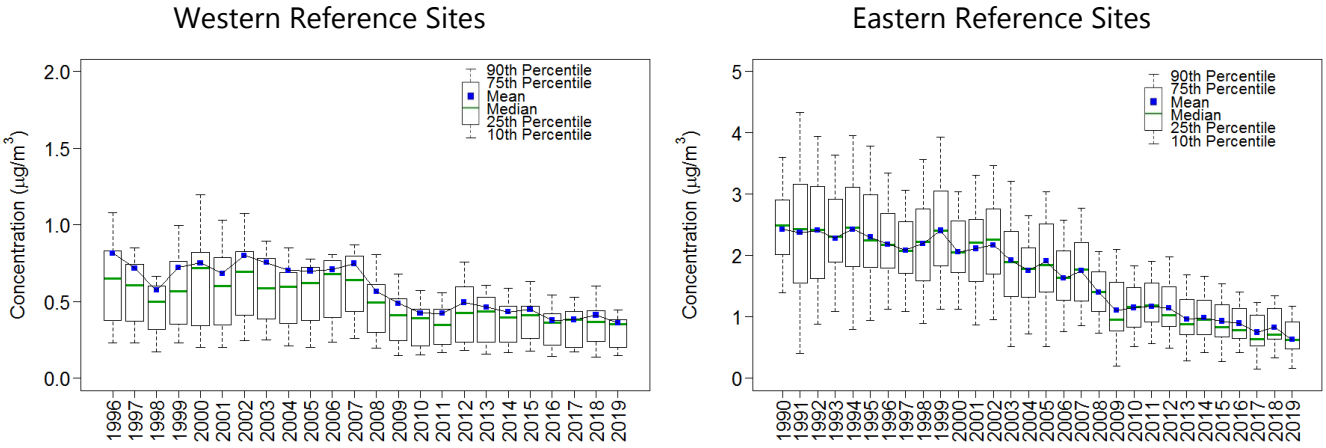


Figure 3. Trends in Second Quarter Mean NO_3^- Concentrations

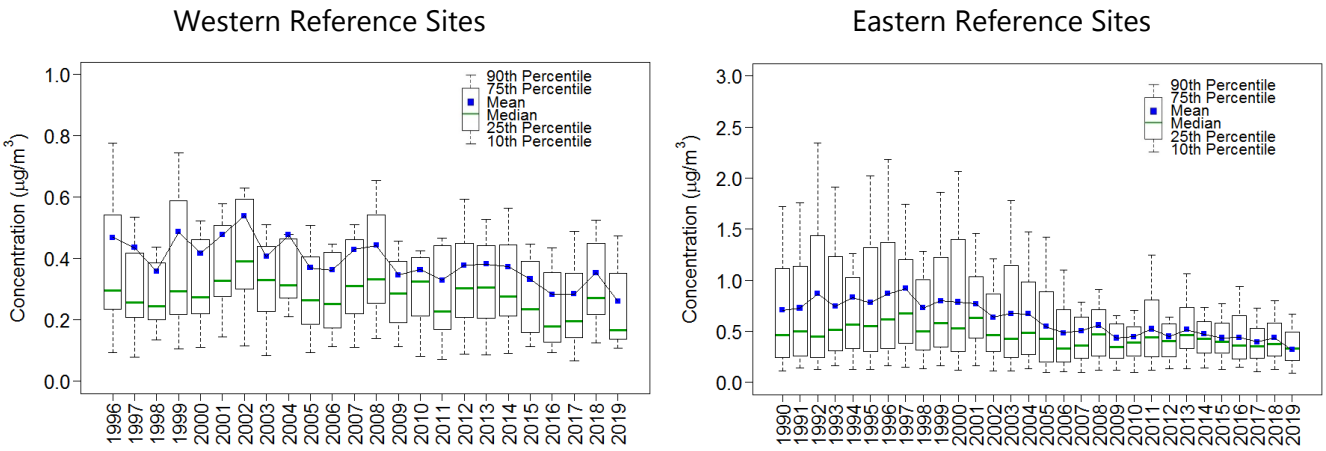


Figure 4. Trends in Second Quarter Mean NH_4^+ Concentrations

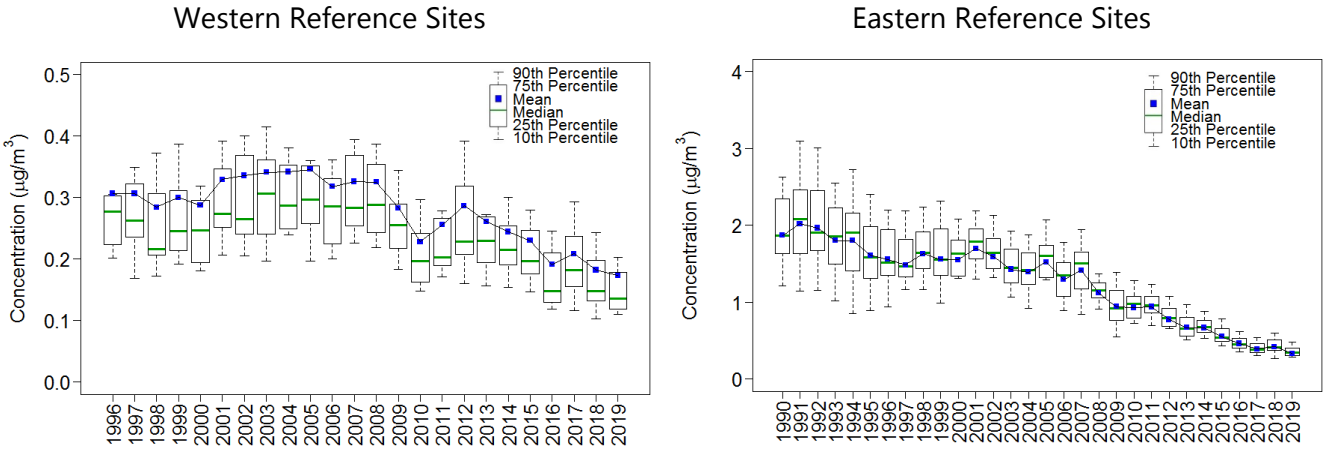


Figure 5. Trends in Second Quarter Mean Total NO_3^- Concentrations

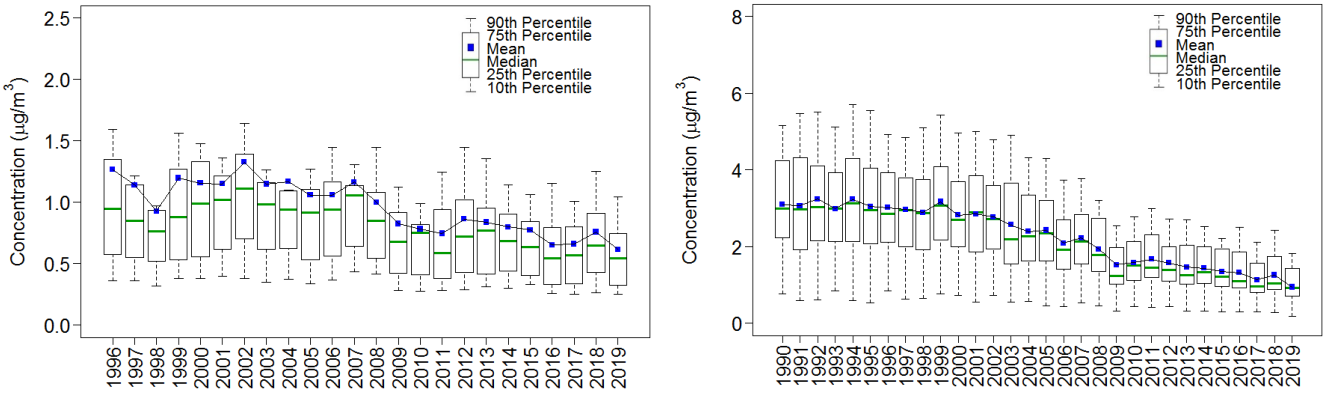
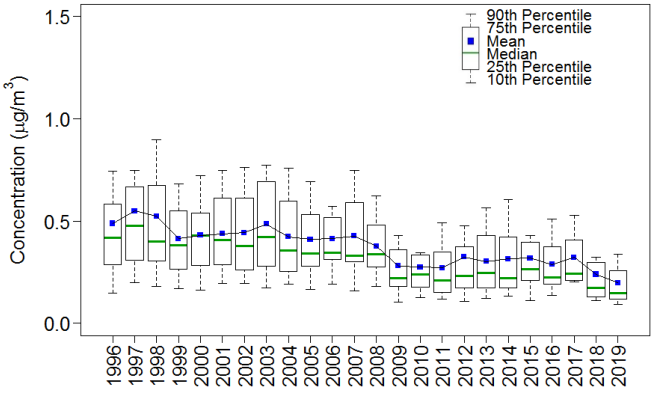


Figure 6. Trends in Second Quarter Mean SO_2 Concentrations

Western Reference Sites



Eastern Reference Sites

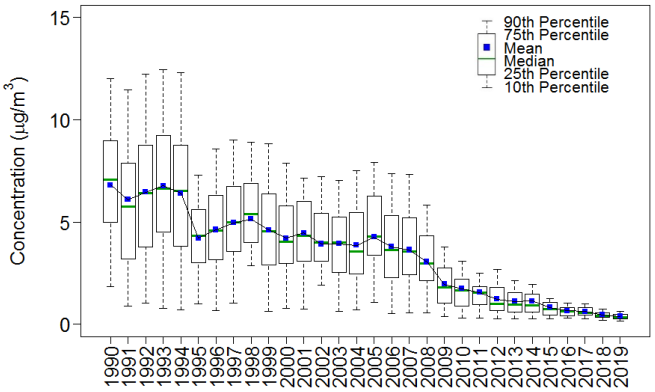
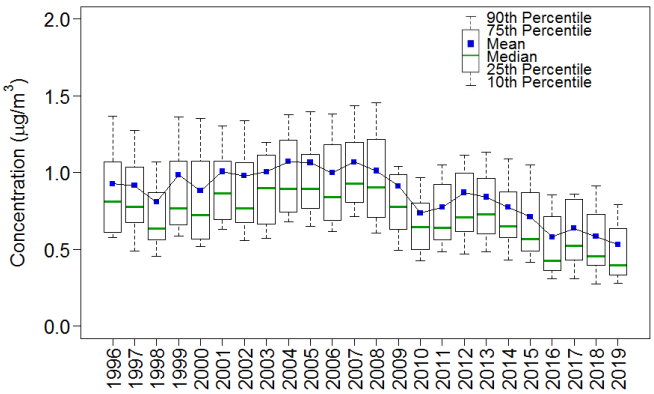


Figure 7. Trends in Second Quarter Mean SO_4^{2-} Concentrations

Western Reference Sites



Eastern Reference Sites

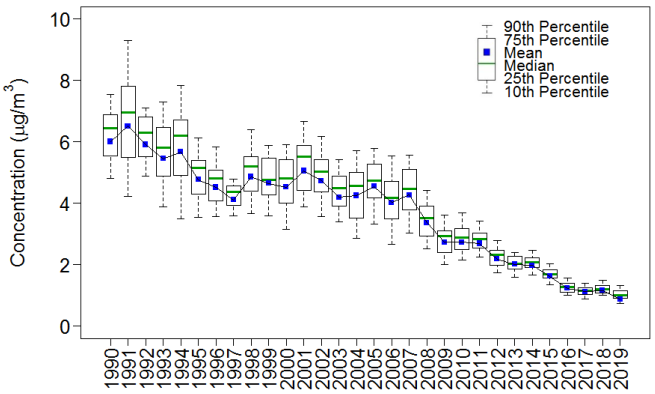
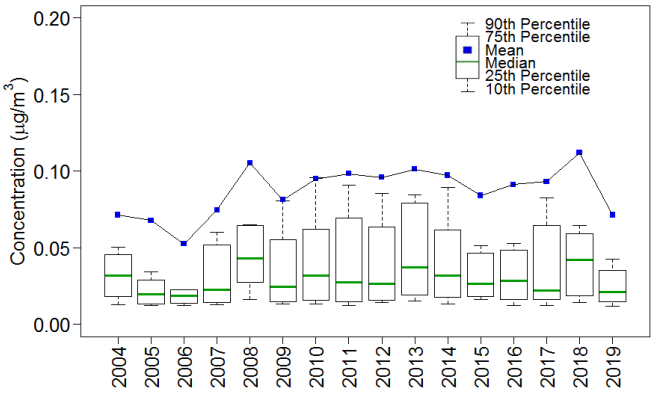


Figure 8. Trends in Second Quarter Mean Cl^- Concentrations

Western Reference Sites



Eastern Reference Sites

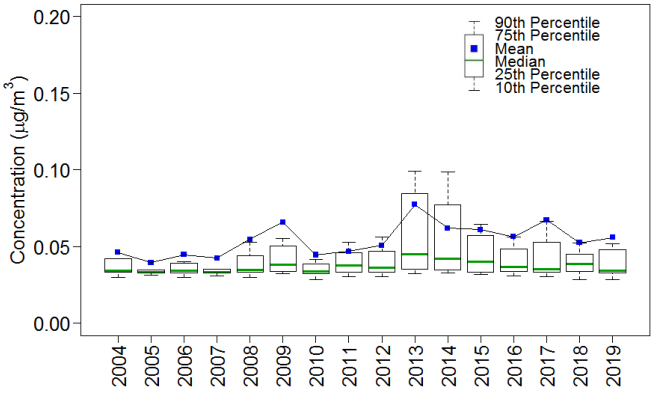
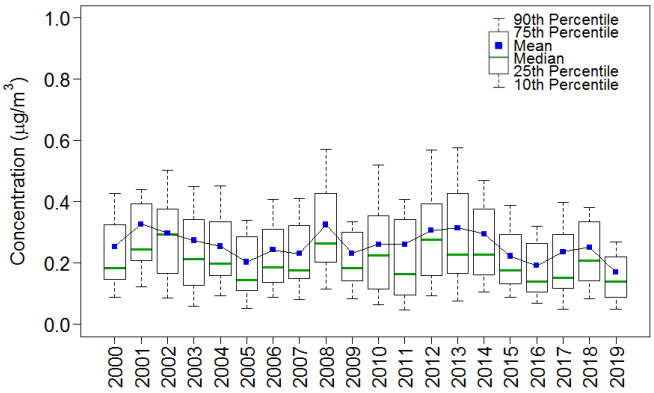


Figure 9. Trends in Second Quarter Mean Ca^{2+} Concentrations

Western Reference Sites



Eastern Reference Sites

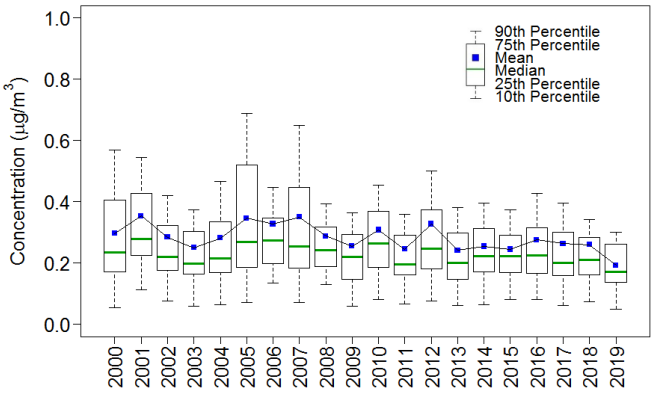
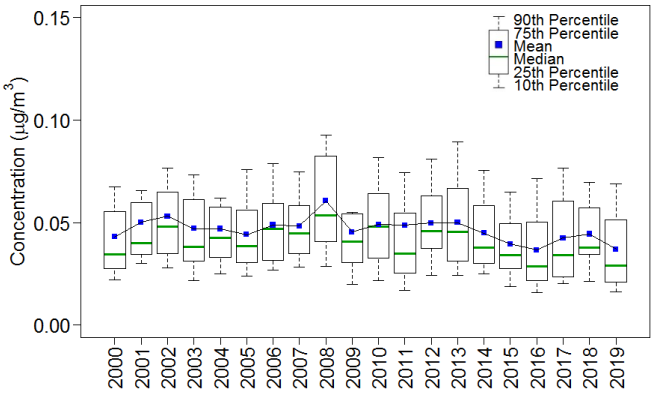


Figure 10. Trends in Second Quarter Mean K^{+} Concentrations

Western Reference Sites



Eastern Reference Sites

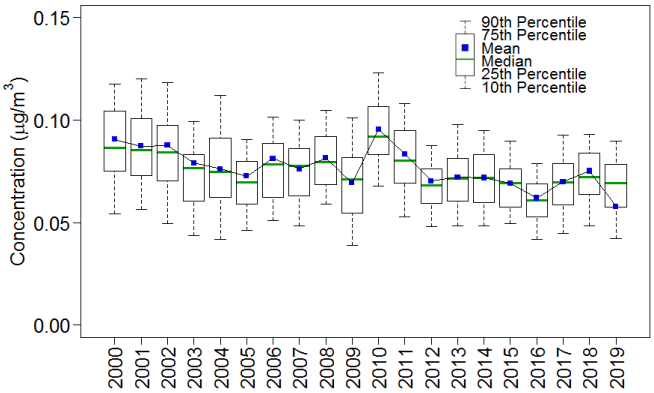
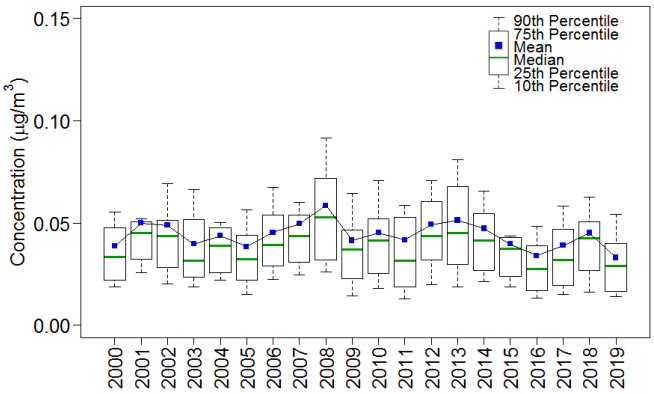


Figure 11. Trends in Second Quarter Mean Mg^{2+} Concentrations

Western Reference Sites



Eastern Reference Sites

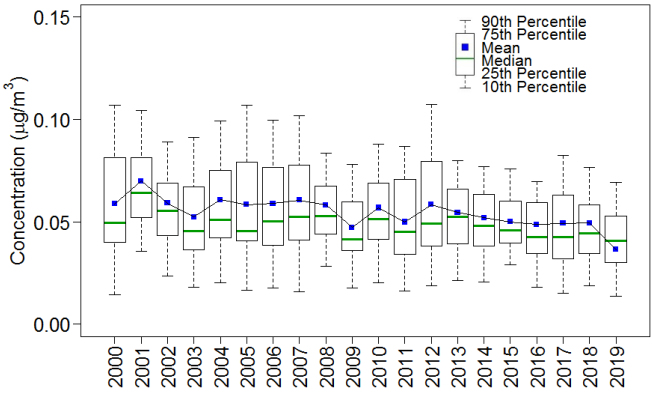
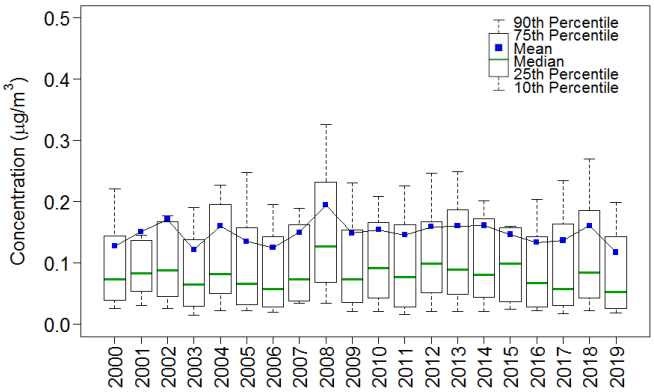


Figure 12. Trends in Second Quarter Mean Na^+ Concentrations

Western Reference Sites



Eastern Reference Sites

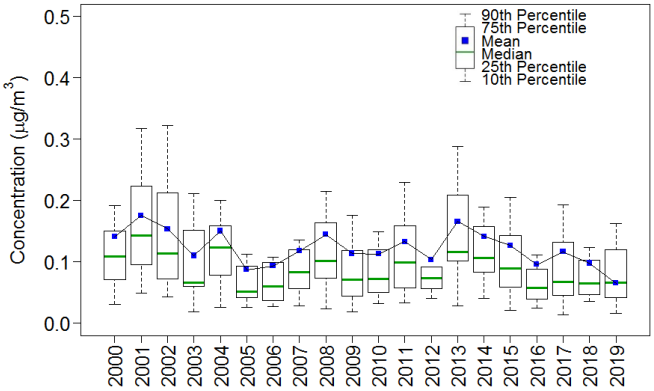
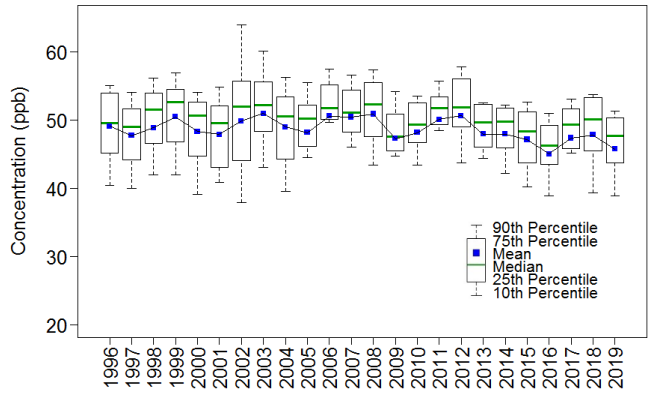
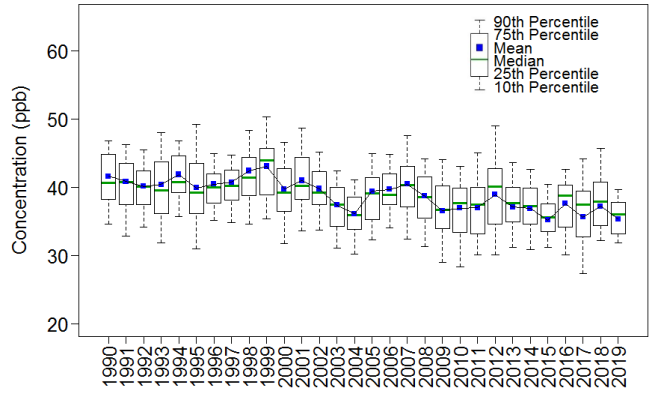


Figure 13. Trends in Second Quarter Mean O_3 Concentrations

Western Reference Sites



Eastern Reference Sites



Changes in 3-year Average Second Quarter Concentrations

Three-year averages of quarterly mean concentrations of total NO_3^-, NH_4^+, SO_2, SO_4^{2-}, and O_3 were reduced over the period 1990–1992 through 2017–2019 for eastern reference sites and 1996–1998 through 2017–2019 for western reference sites. Tables 1 and 2 summarize changes in 3-year average second quarter concentrations.

Table 1. Eastern Reference Sites: 3-Year Mean Nitrogen, Sulfur, and O_3 Pollutant Concentrations

	Total NO_3^- ($\mu g/m^3$)	NH_4^+ ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	SO_4^{2-} ($\mu g/m^3$)	O_3 (ppb)
1990–1992	3.1	2.0	6.5	6.1	41
2017–2019	1.1	0.4	0.5	1.1	36
Percent Change	-65	-81	-92	-83	-12

Table 2. Western Reference Sites: 3-Year Mean Nitrogen, Sulfur, and O_3 Pollutant Concentrations

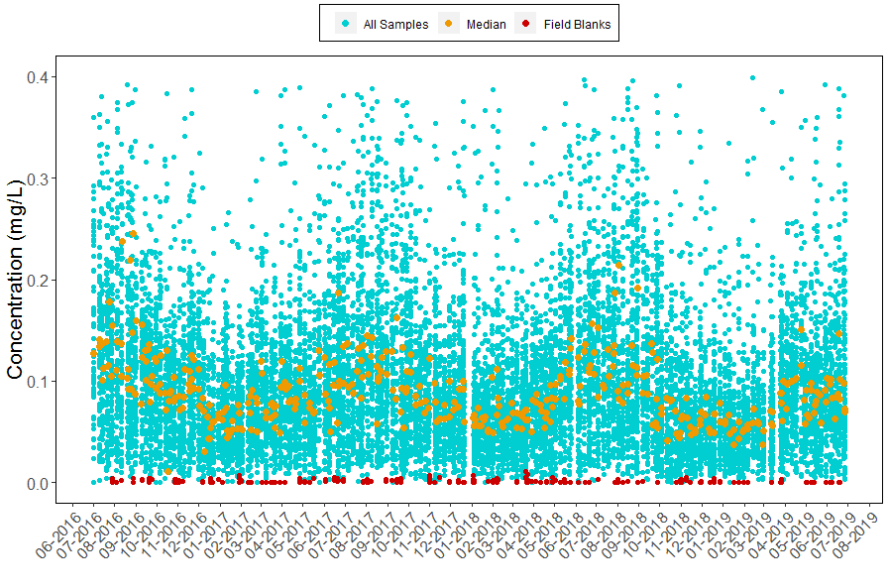
	Total NO_3^- ($\mu g/m^3$)	NH_4^+ ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	SO_4^{2-} ($\mu g/m^3$)	O_3 (ppb)
1996–1998	1.1	0.3	0.5	0.9	49
2017–2019	0.7	0.2	0.3	0.6	47
Percent Change	-39	-37	-51	-34	-3

Time Series of Laboratory Analysis Parameters for All Sites

Figures 14 through 24 give time series of laboratory-analyzed concentrations of field samples and field blanks (FB) in milligrams per liter (mg/L) of 11 parameters from third quarter 2016 through second quarter 2019. These figures provide indications of potential issues with concentration measurements relative to detection and reporting limits.

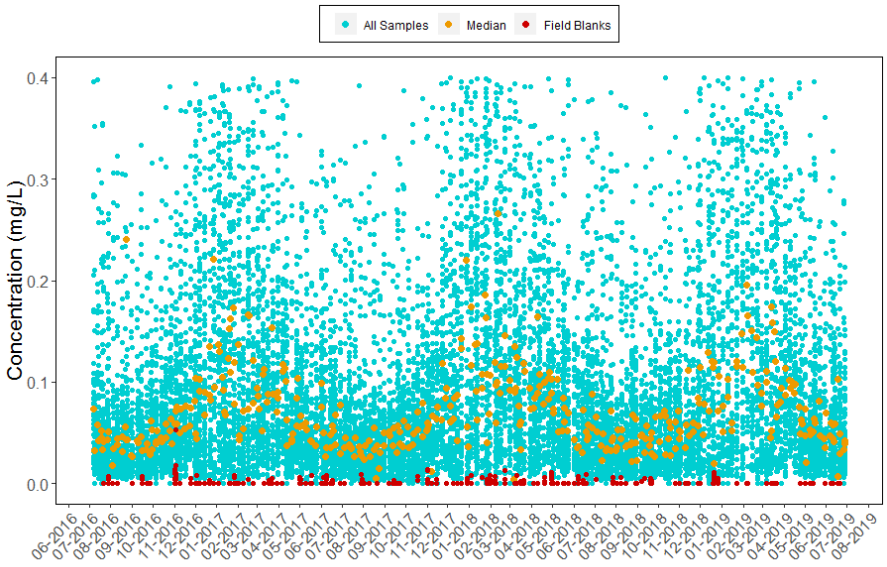
Previous review of filter pack analysis control charts indicated possible potassium contamination (Figure 22). Corrective actions were implemented and subsequent testing indicated these actions have been effective. Consider the recent 12-month data record in Figure 22.

Figure 14. Concentrations of NO_3^- (as N) from Nylon Filters



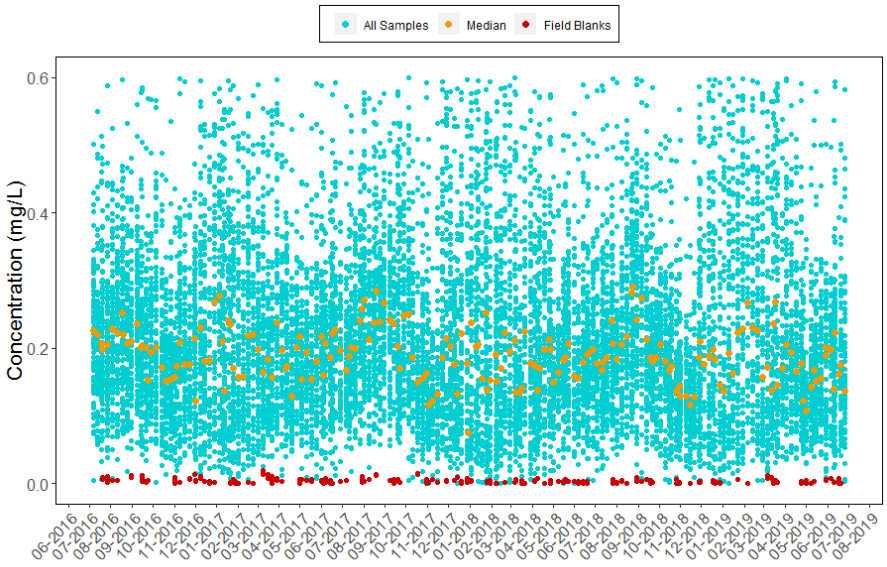
Note: Nominal reporting limit is 0.008 mg/L.

Figure 15. Concentrations of NO_3^- (as N) from Teflon Filters



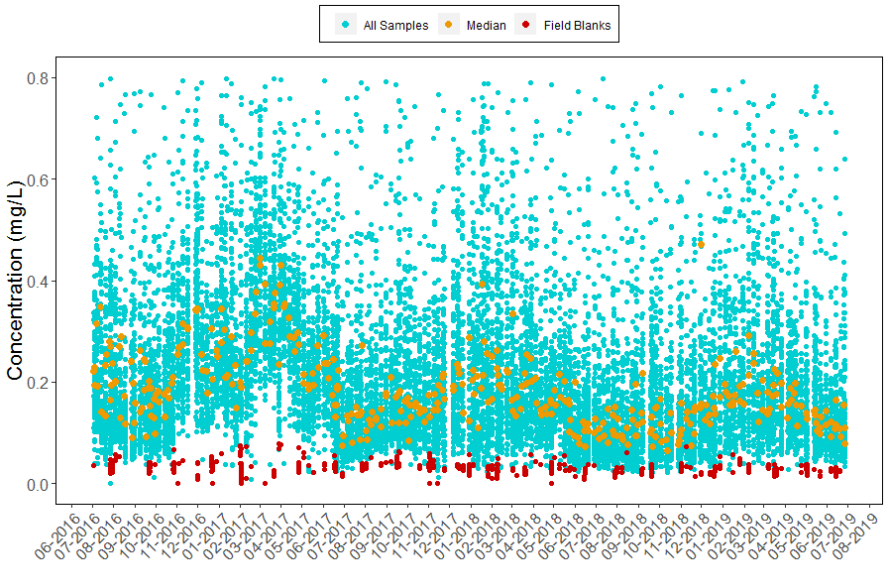
Note: Nominal reporting limit is 0.008 mg/L.

Figure 16. Concentrations of NH_4^+ (as N) from Teflon Filters



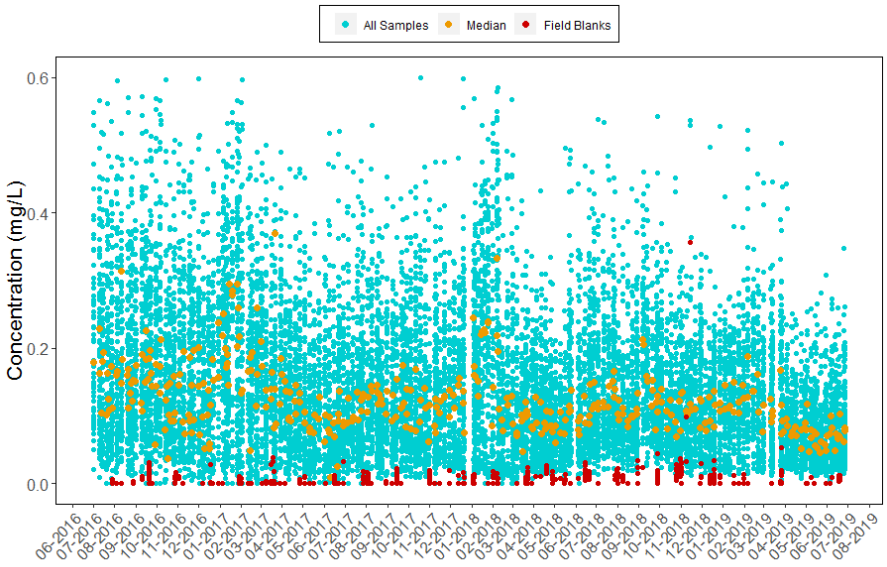
Note: Nominal reporting limit is 0.020 mg/L.

Figure 17. Concentrations of SO_2 from K_2CO_3 Impregnated Cellulose Filters



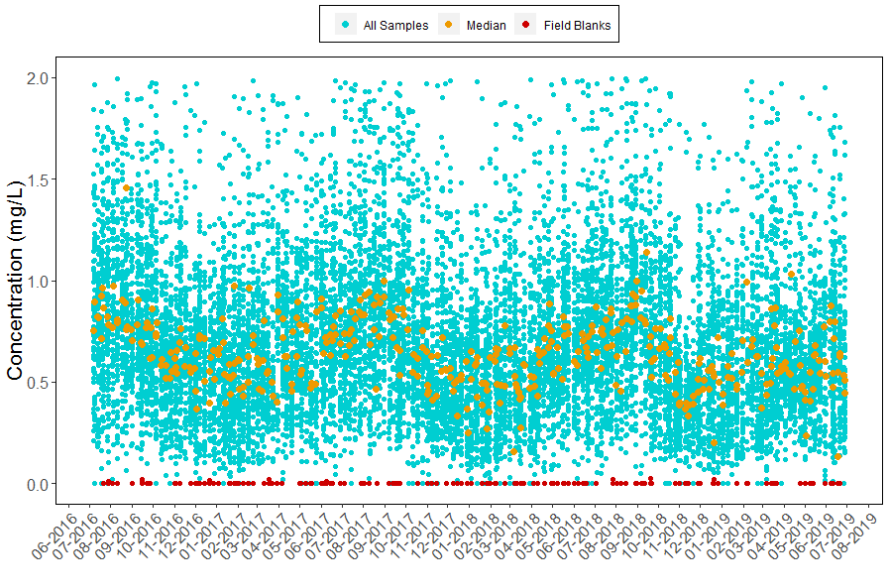
Note: Nominal reporting limit is 0.040 mg/L.

Figure 18. Concentrations of SO_4^{2-} from Nylon Filters



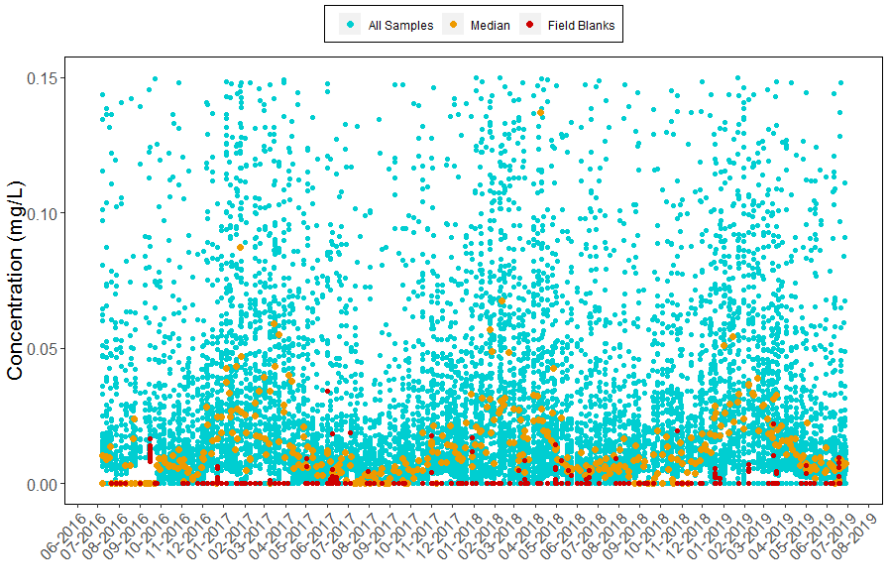
Note: Nominal reporting limit is 0.040 mg/L.

Figure 19. Concentrations of SO_4^{2-} from Teflon Filters



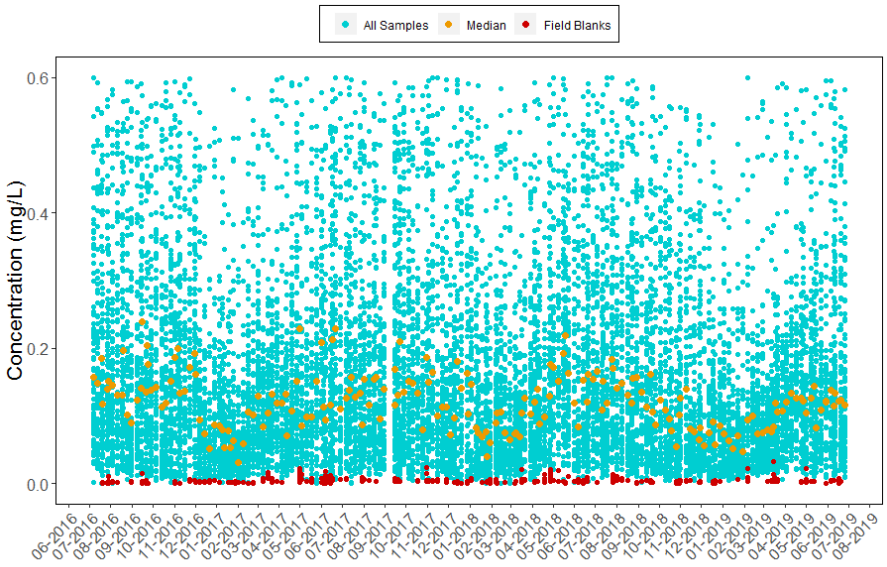
Note: Nominal reporting limit is 0.040 mg/L.

Figure 20. Concentrations of Cl^- from Teflon Filters



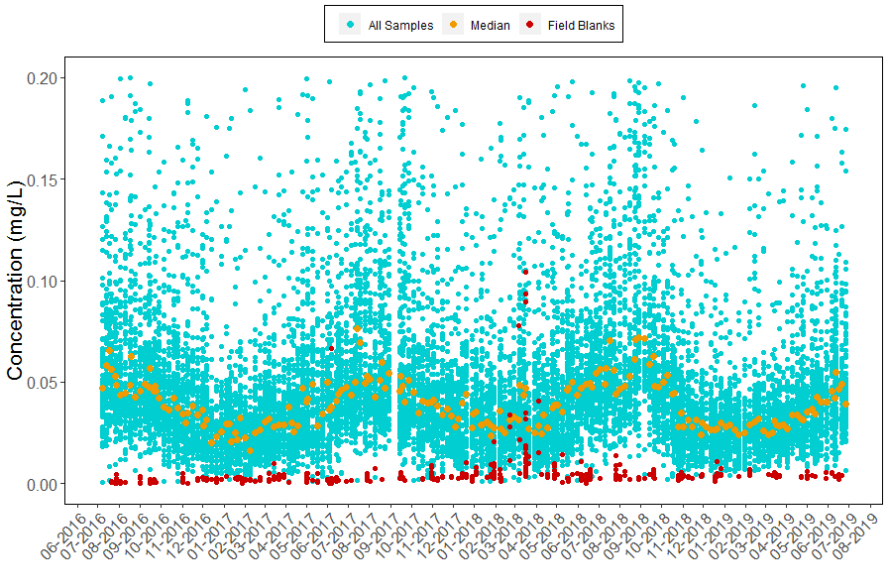
Note: Nominal reporting limit is 0.020 mg/L.

Figure 21. Concentrations of Ca^{2+} from Teflon Filters



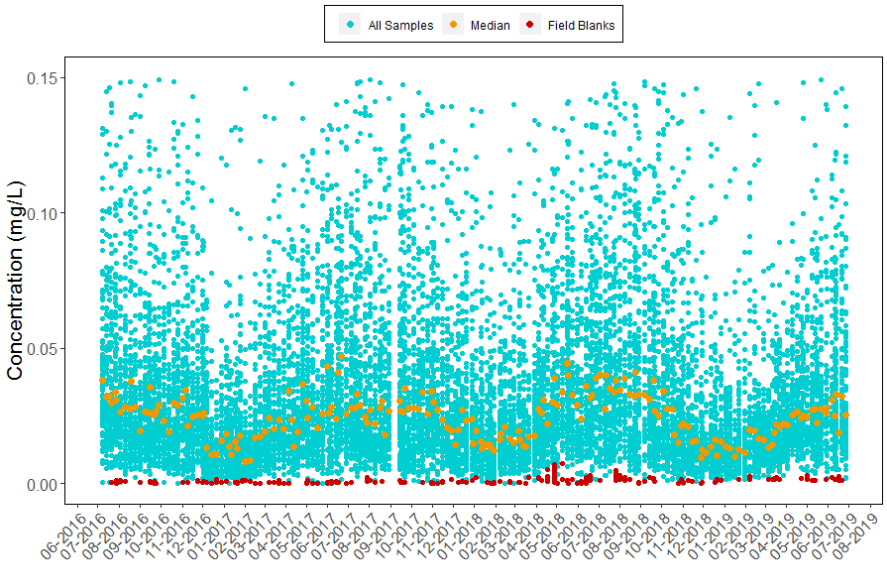
Note: Nominal reporting limit is 0.006 mg/L.

Figure 22. Concentrations of K^{+} from Teflon Filters



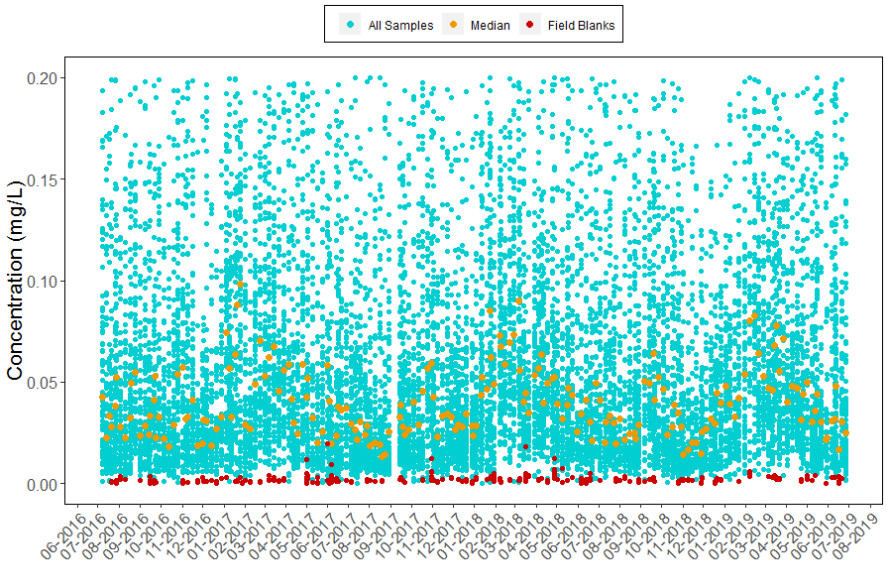
Note: Nominal reporting limit is 0.006 mg/L.

Figure 23. Concentrations of Mg^{2+} from Teflon Filters



Note: Nominal reporting limit is 0.003 mg/L.

Figure 24. Concentrations of Na^{+} from Teflon Filters



Note: Nominal reporting limit is 0.005 mg/L.

Time Series of Concentration Differences from Co-located Sites

Figures 25 and 26 show times series of concentration differences between the two sets of co-located sites. The filter pack differences for MCK131/231 observed near the end of the quarter will be evaluated during Level 3 validation. Initial analyses by field operations engineers indicate problems with filter pack flow.

Figure 25. Time Series of Filter Concentration Differences between MCK131 and MCK231, KY

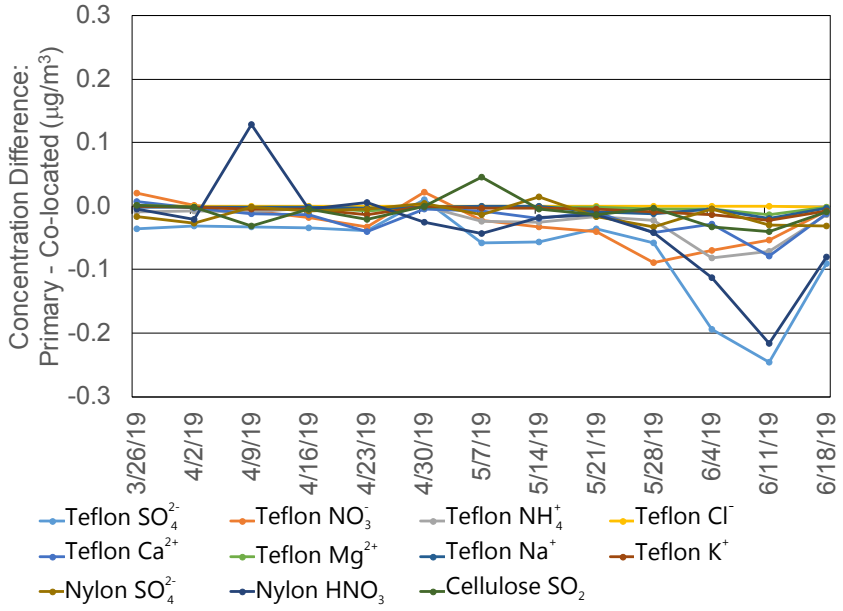
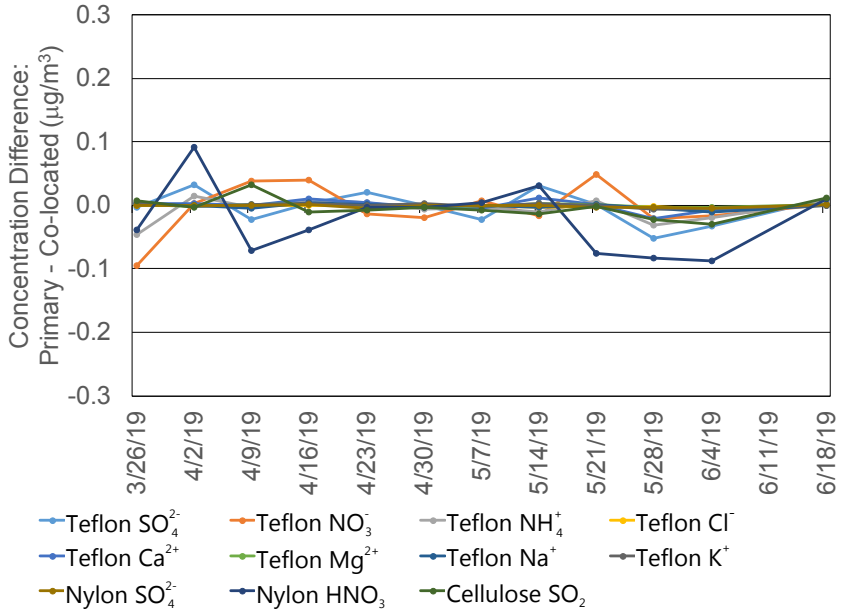


Figure 26. Time Series of Filter Concentration Differences between ROM406 and ROM206, CO



Precision of Filter Pack Concentrations

Table 3 shows mean absolute relative percent differences (MARPD) for concentrations measured at MCK131/231 and ROM406/206 during second quarter 2019. The MARPD values met the 20 percent criterion.

Table 3. Precision (MARPD) for Co-located Filter Pack Data during Second Quarter 2019

	SO_4^{2-}	NO_3^-	NH_4^+	Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-	HNO_3	SO_2	Total NO_3^-
MCK131/231, KY											
$\overline{X}$ (µg/m^3)	1.04	0.36	0.41	0.18	0.03	0.08	0.07	0.03	0.73	0.34	1.08
$\overline{Y}$ (µg/m^3)	1.11	0.38	0.43	0.20	0.04	0.08	0.08	0.03	0.77	0.36	1.15
MAD	0.07	0.03	0.02	0.02	0.00	0.00	0.01	0.00	0.06	0.02	0.09
MARPD	8.31	10.01	6.20	12.80	11.70	7.89	9.60	0.58	10.54	9.26	9.77
ROM406/206, CO											
$\overline{X}$ (µg/m^3)	0.45	0.22	0.17	0.12	0.02	0.03	0.03	0.02	0.50	0.14	0.71
$\overline{Y}$ (µg/m^3)	0.45	0.21	0.17	0.12	0.02	0.03	0.03	0.02	0.52	0.15	0.72
MAD	0.03	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.06	0.02	0.05
MARPD	5.90	13.72	8.65	6.63	10.90	11.74	10.98	10.82	10.76	12.11	6.65

Completeness for Filter Pack Concentrations

Table 4 shows CASTNET sites with less than 90 percent completeness for weekly filter pack concentrations. Comments are included to provide information on why these sites experienced low data completeness.

Table 4. Sites with less than 90 Percent Data Completeness for Filter Concentrations for Second Quarter 2019

Site ID	Teflon SO_4^{2-}	Teflon NO_3^-	Teflon NH_4^+	Teflon Minor Cations	Teflon Cl^-	Nylon HNO_3	Nylon SO_4^{2-}	Cellulose SO_2	Comment
ANA115, MI	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	Two 2-week samples were collected during the quarter.
CAD150, AR	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	The mass flow controller malfunctioned resulting in invalidation of two samples.
GRB411, NV	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	A loose ground wire caused insufficient valid flow volumes for two samples.
MEV405, CO	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	The flow pump failed, affecting one 2-week sample, and a data logger error occurred from 4/4 through 4/9/2019.
NPT006, ID	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	Power failures interfered with data collection, which affected two samples.
BWR139, MD	76.9	76.9	76.9	76.9	76.9	76.9	76.9	76.9	Two 2-week samples were collected during the quarter. A separate sample was invalidated due to improper installation.
UND002, VT	76.9	76.9	76.9	76.9	76.9	76.9	76.9	76.9	Power failures interfered with data collection, which affected three samples.
EGB181, ON	53.8	53.8	53.8	53.8	53.8	53.8	53.8	53.8	Six samples were invalidated due to a flow system leak.
NIC001, NY	46.2	46.2	46.2	46.2	46.2	46.2	46.2	46.2	Power at the park had been off for infrastructure work. The first sample for 2019 was installed on 5/21 after power was restored.

Precision of Ozone Concentrations

Time series of co-located hourly O_3 concentration differences for second quarter 2019 are provided in Figures 27 and 28 for MCK131/231 and ROM406/206, respectively. The figures indicate no consistent bias between the co-located analyzers at these site locations.

Figure 27. Time Series of the Differences in Co-located O_3 Concentrations for MCK131/231, KY

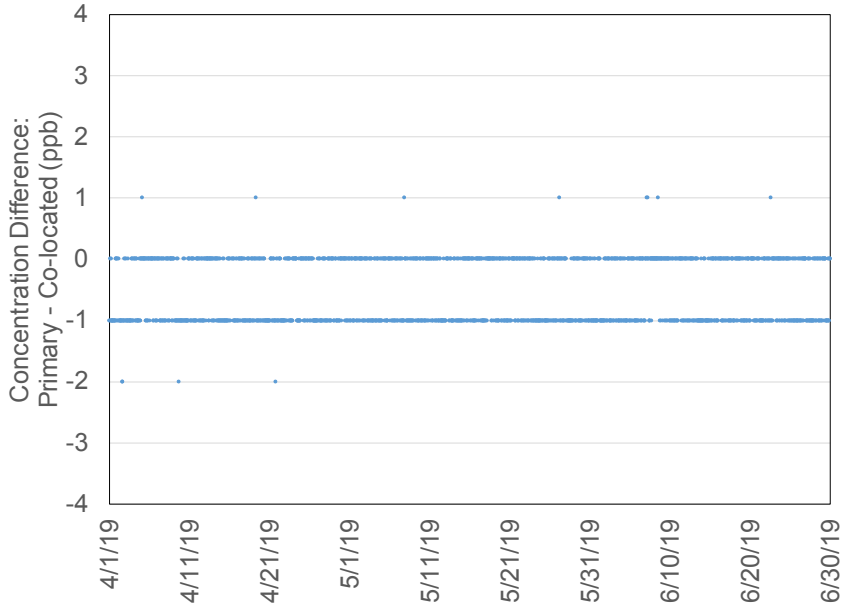


Figure 28. Time Series of the Differences in Co-located O_3 Concentrations for ROM406/206, CO

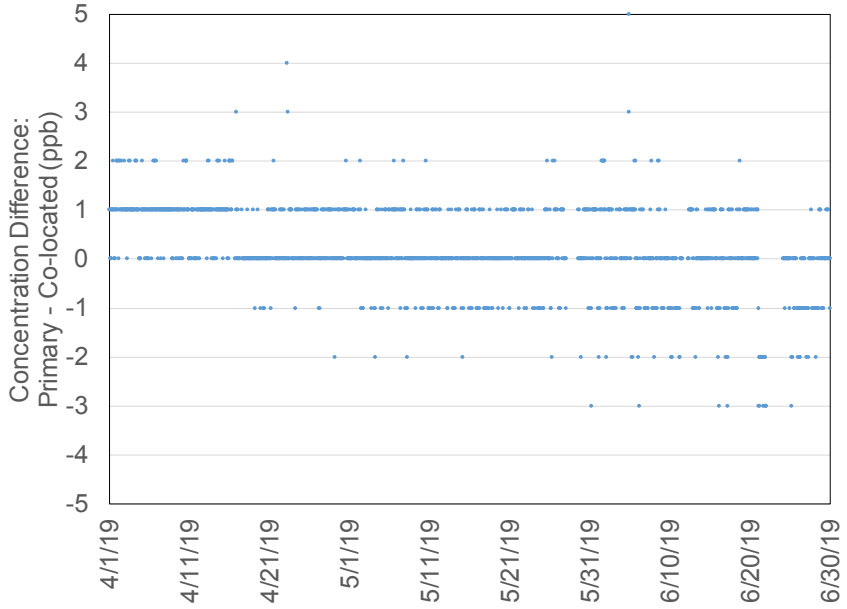


Table 5 gives MARPD data for O_3 data measured at the two co-located sites.

Table 5. Quarterly Precision (MARPD) for Co-located O_3 Concentrations

Site Pair	Quarter	Start Date	MARPD	Records
MCK131/231, KY				
	3	7/1/18	1.5	1921
	4	10/1/18	1.0	2025
	1	1/1/19	2.0	1873
	2	4/1/19	1.5	2064
ROM406/206, CO				
	3	7/1/18	1.1	2068
	4	10/1/18	1.9	1973
	1	1/1/19	1.5	1983
	2	4/1/19	1.3	1949

Completeness for O_3 Concentrations

Calculation of an annual O_3 value requires 75 percent completeness. However, calculation of the 3-year design value used for regulatory purposes requires 90 percent completeness. Table 6 shows CASTNET sites with less than 90 percent completeness for DM8A O_3 concentrations. Comments are provided for these sites.

Table 6. Sites with less than 90 Percent Data Completeness for DM8A Concentrations during Second Quarter 2019

Site ID	Percent Completeness	Comments
NPT006, ID	86.8	Intermittent power failures interfered with data collection.

Table 7 shows CASTNET sites with less than 90 percent completeness for hourly O_3 concentrations. Comments are provided for these sites. The annual average for each of these sites is included for reference.

Table 7. Sites with less than 90 Percent Data Completeness for O_3 Concentrations

Site ID	Q2 2019	Q3 2018–Q2 2019	Comments
CHC432, NM	86.7	95.0	Ozone data were invalid 5/13 through 5/21/2019 due to a pump failure.
MEV405, CO	89.9	90.0	A data logger error occurred from 4/4 through 4/9/2019, and several calibrations resulted in lower data capture throughout the quarter.
NPT006, ID	89.7	96.2	Intermittent power failures during the quarter caused data loss.
YEL408, WY	84.3	95.0	Ozone data were invalid 5/22 through 6/4/2019 due to a bad power supply.

Filter Pack Total Nitrate and Continuous Trace-level NO_y Concentrations at Eight CASTNET Sites

Figures 29 through 36 show a comparison of weekly average continuous NO_y measurements with weekly filter pack total NO_3^- concentrations collected at the eight sites with NO_y measurements. The NO_y concentrations were consistently higher than the total NO_3^- levels at all sites. The average weekly NO_y levels, the weekly total NO_3^- concentrations, and their ratios for the eight sites with available data are shown in Table 8. Ratios of NO_y to total NO_3^- varied from 3.46 at PNF126 to 9.81 at HWF187.

Table 8. Summary of Total NO_3^- and NO_y Measurements for Second Quarter 2019

Site ID	Elevation	Total NO_3^- (ppb)	NO_y (ppb)	Ratio
DUK008, NC	164	0.43	1.90	4.61
BVL130, IL	213	0.90	3.69	4.15
MAC426, KY	243	0.48	2.11	4.59
HWF187, NY	497	0.13	1.00	9.81
GRS420, TN	793	0.38	1.44	3.88
PNF126, NC	1216	0.31	1.04	3.46
PND165, WY	2386	0.13	0.51	4.19
ROM206, CO	2742	0.23	1.27	5.72

Figure 29. Comparison of DUK008 Weekly Mean NO_y and Total NO_3^- Concentrations

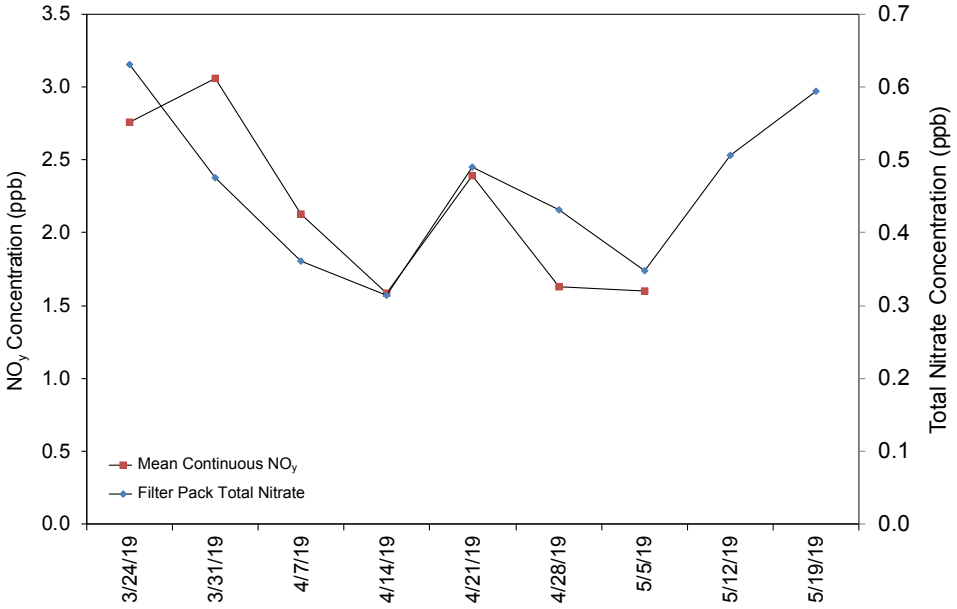


Figure 30. Comparison of BVL130 Weekly Mean NO_y and Total NO_3^- Concentrations

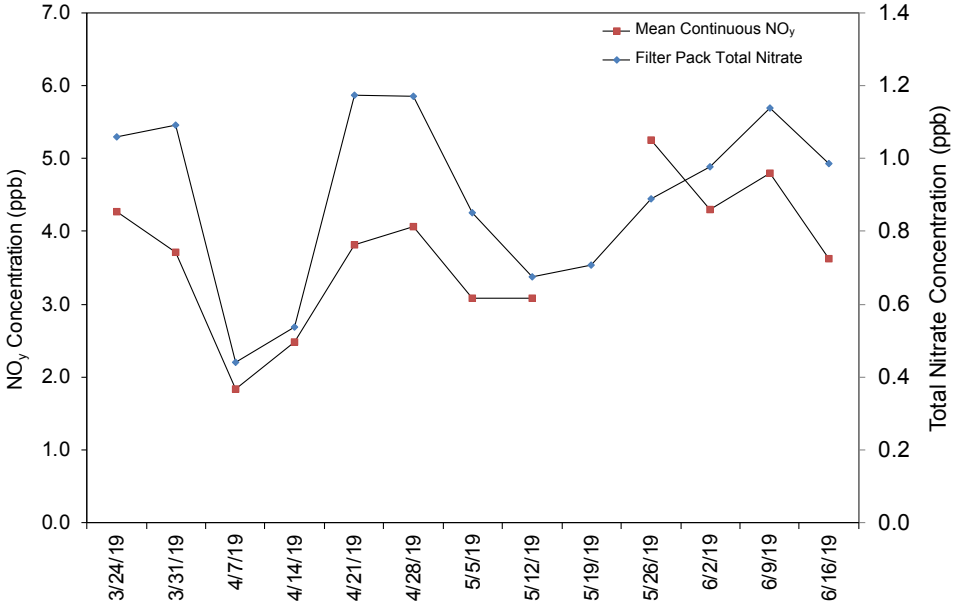


Figure 31. Comparison of MAC426 Weekly Mean NO_y and Total NO_3^- Concentrations

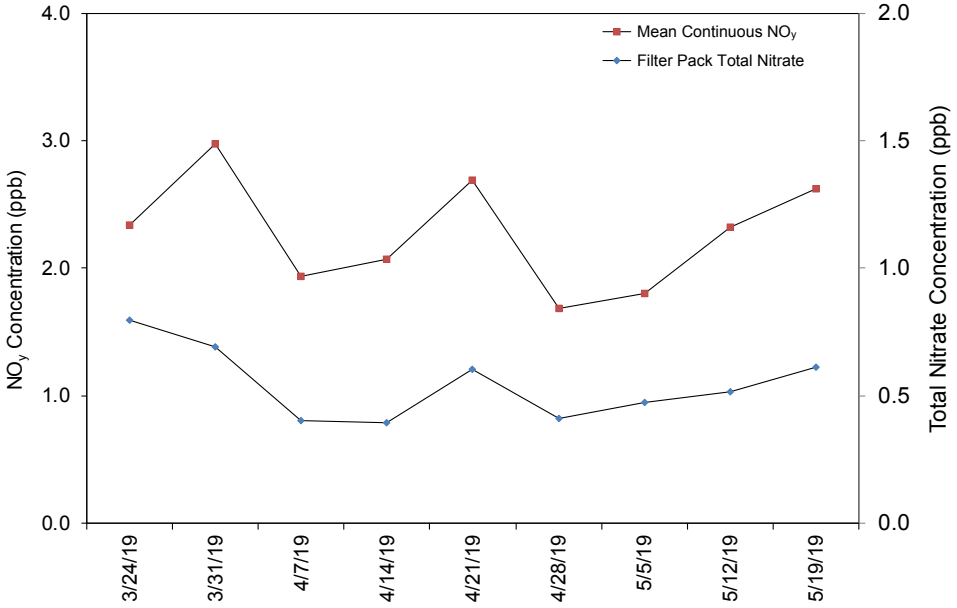


Figure 32. Comparison of HWF187 Weekly Mean NO_y and Total NO_3^- Concentrations

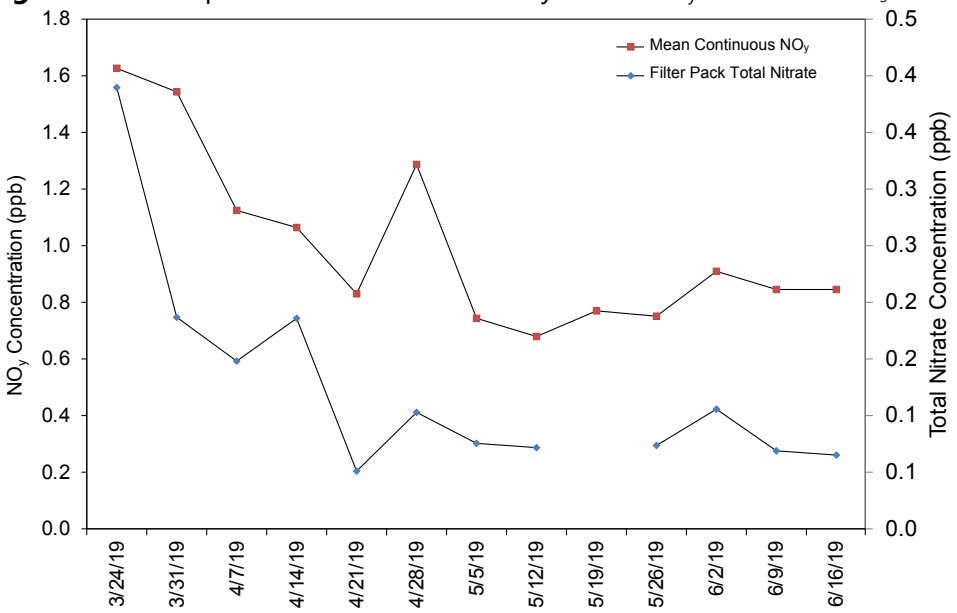


Figure 33. Comparison of GRS420 Weekly Mean NO_y and Total NO_3^- Concentrations

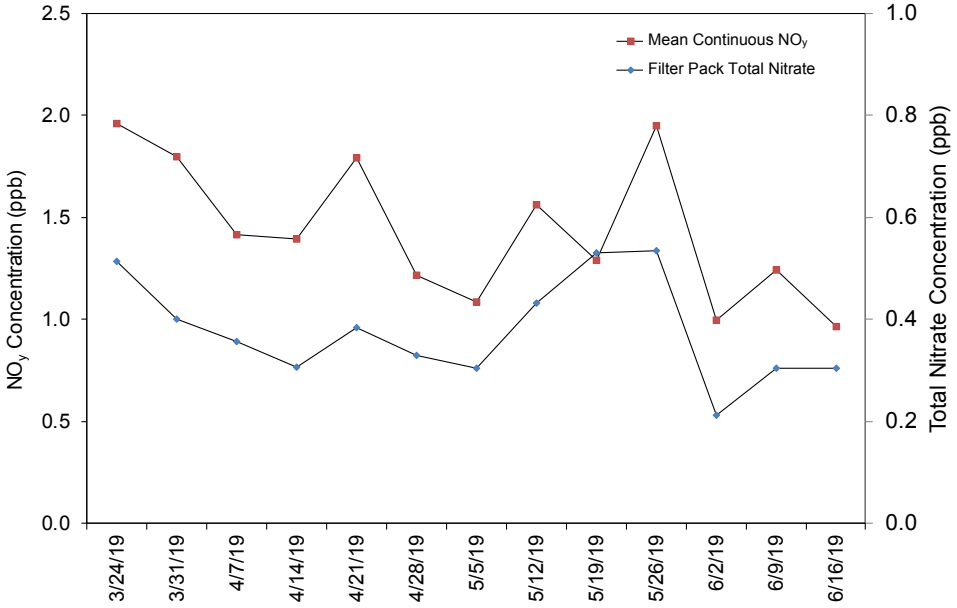


Figure 34. Comparison of PNF126 Weekly Mean NO_y and Total NO_3^- Concentrations

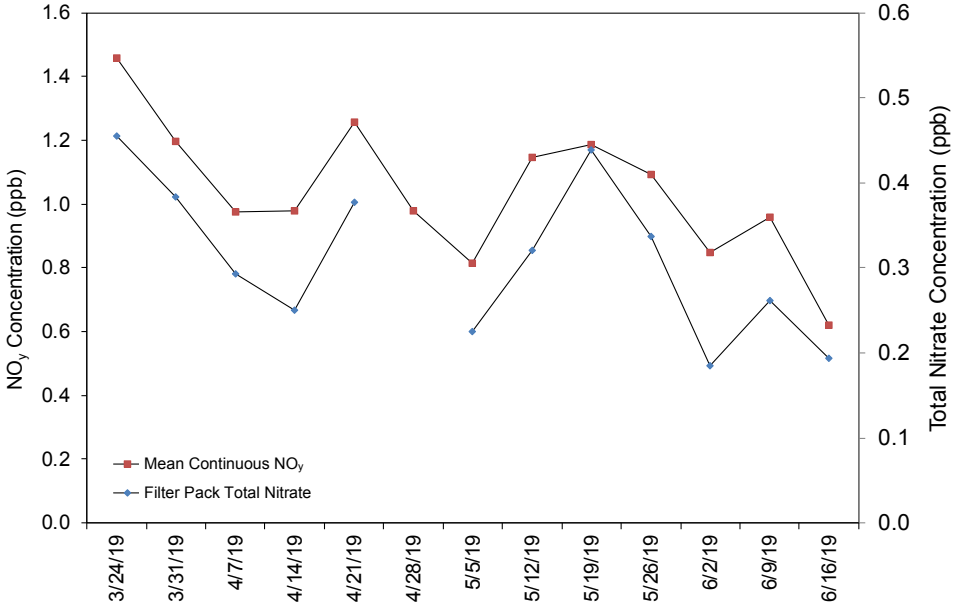


Figure 35. Comparison of PND165 Weekly Mean NO_y and Total NO_3^- Concentrations

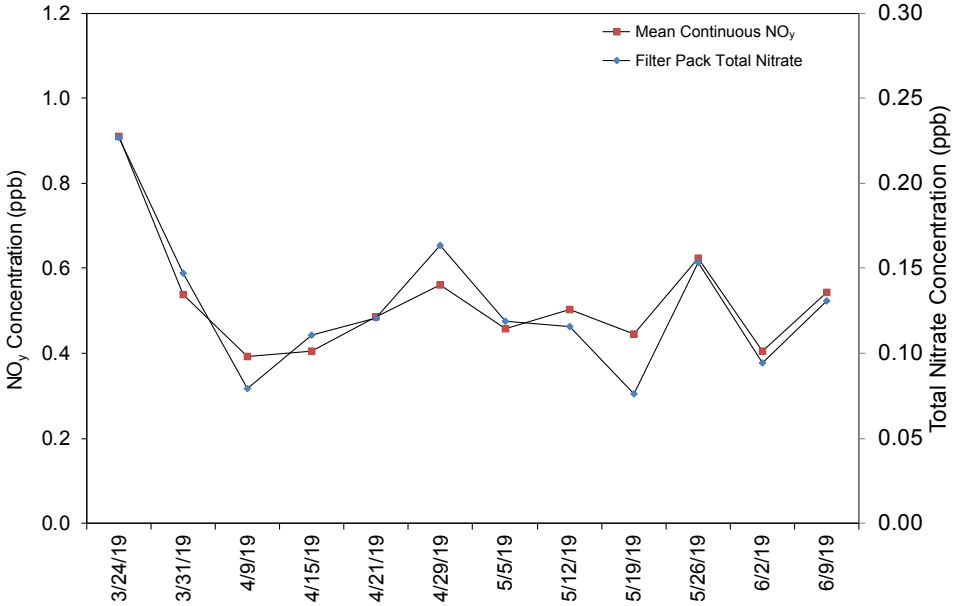
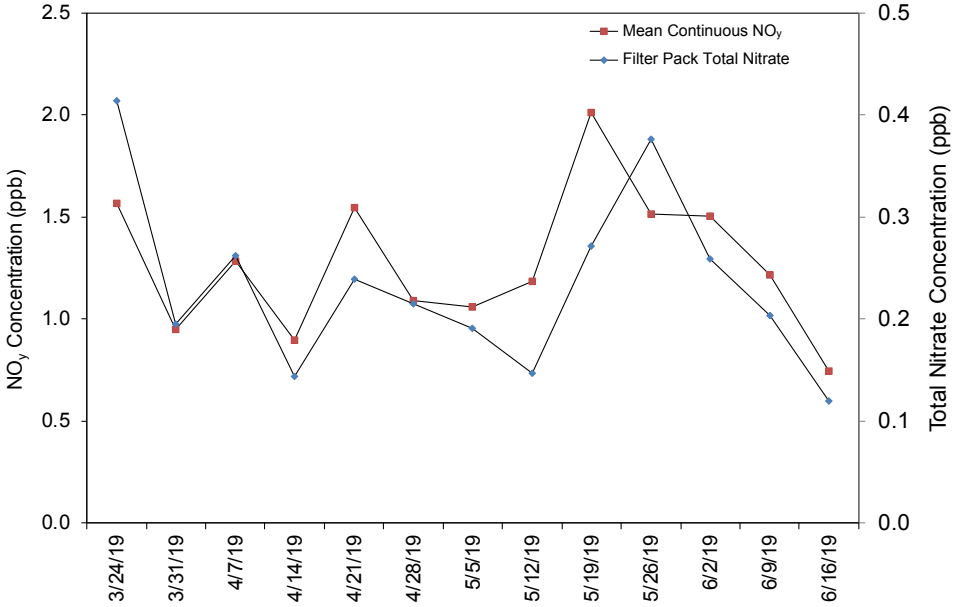


Figure 36. Comparison of ROM206 Weekly Mean NO_y and Total NO_3^- Concentrations



Filter Pack and Continuous Trace-level Gas Sulfur Dioxide Concentrations

Figures 37 through 39 provide diagrams that compare weekly filter pack SO_2 concentrations with continuous trace-level gas data measured at BVL130, MAC426, and GRS420. The continuously measured trace-level concentrations were higher than filter pack concentrations at BVL130 and were comparable at MAC426 and GRS420.

Figure 37. Comparison of BVL130 Weekly Mean SO_2 Concentrations

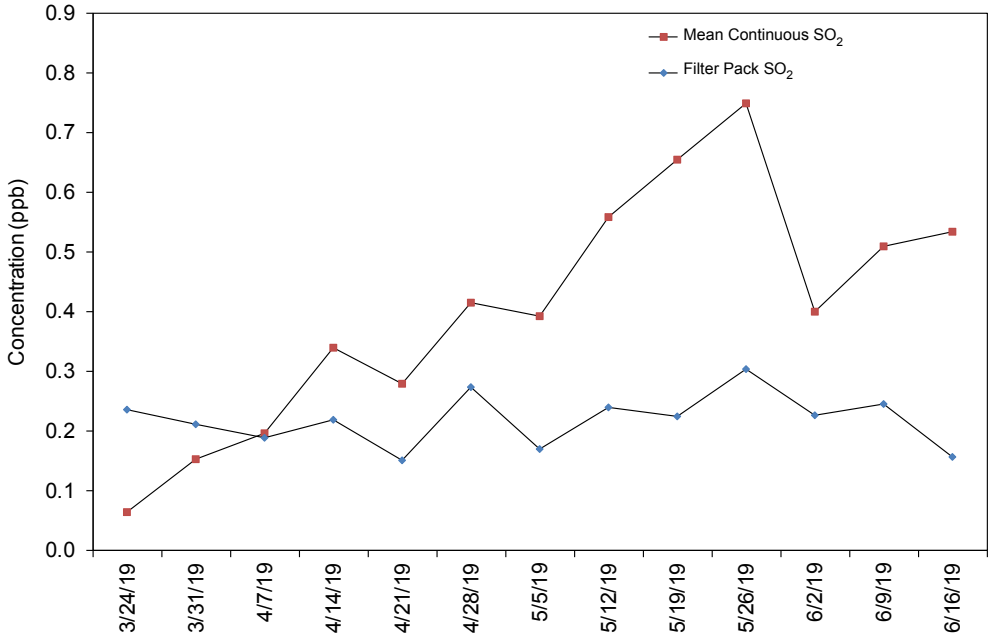


Figure 38. Comparison of MAC426 Weekly Mean SO_2 Concentrations

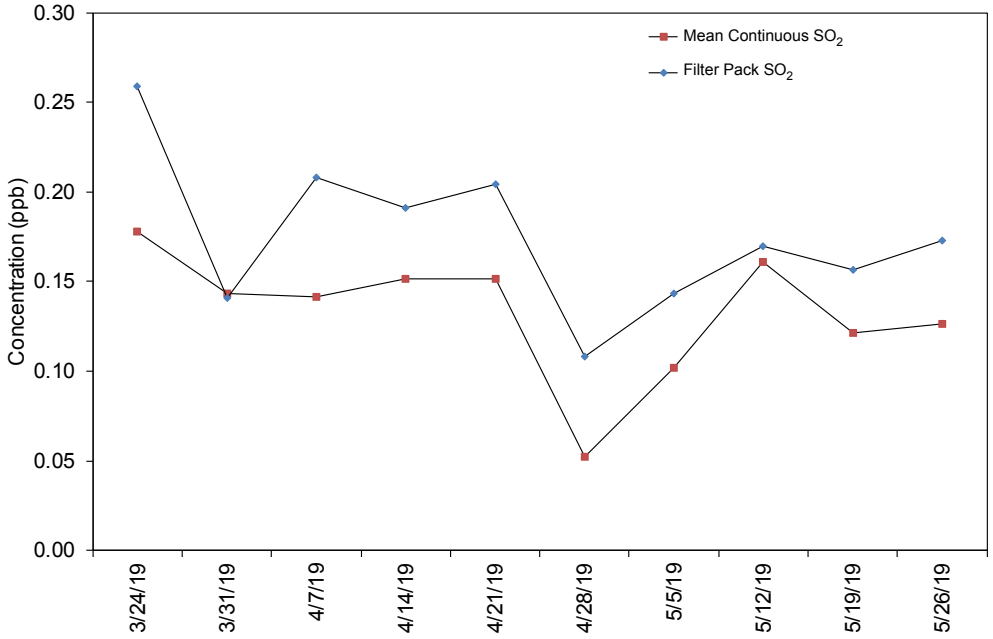
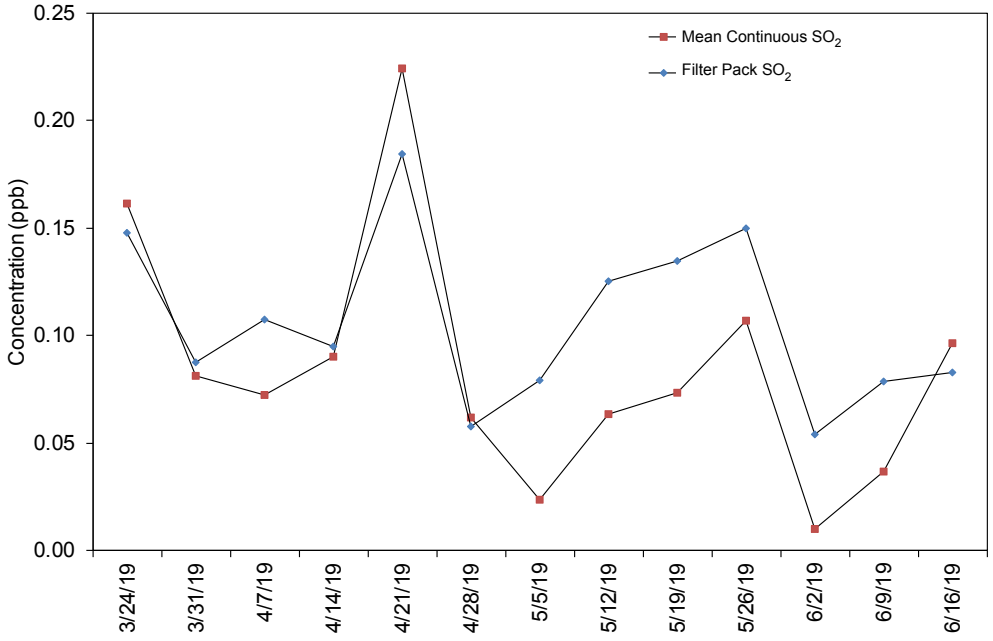


Figure 39. Comparison of GRS420 Weekly Mean SO_2 Concentrations



Completeness for Continuous Trace-level Gas Measurements

Table 9 shows the percent completeness for CASTNET trace-level gas measurements. Comments are provided for sites with less than 90 percent completeness for hourly trace-level gas concentrations during second quarter 2019. The annual hourly average for each of the sites is included for reference.

Table 9. Percent Data Completeness for Continuous Trace-level Gas Measurements

Site ID	Parameter*	Q2 2019	Q3 2018 – Q2 2019	Comments
BVL130, IL	CO	0	28	The CO analyzer malfunctioned and was removed for troubleshooting in February.
	NO	73	83	Intermittent zero/span/precision failures occurred, which were caused by problems with the umbilical connector that was replaced in June.
	NOY	80	87	
	NOYDIF	73	83	
	SO2_GA	92	91	
CHC432, NM	NO	95	97	
	NOX	95	97	
	NOXDIF	95	97	
DUK008, NC	HNO3	63	65	Invalid data were produced by a combination of shelter temperatures outside of criteria and data invalidated during long QC checks for NH3. There was an additional solenoid issue affecting NOY, NOYDIF, NH3, and HNO3
	NH3	67	66	
	NO	80	72	
	NO2_TRUE	80	75	
	NOX_TRUE	80	72	
	NOY	67	66	
	NOY_MINUS	76	69	
	NOYDIF	67	66	
	TNX	80	71	
GRS420, TN	CO	81	82	A pump failure occurred in May. Additional data loss resulted from calibrations and maintenance throughout the quarter.
	NO	86	85	Data loss resulted from calibrations and maintenance throughout the quarter.
	NOY	86	85	
	NOYDIF	88	87	
	SO2_GA	91	89	
HWF187, NY	NO	94	93	
	NOY	94	93	
	NOYDIF	94	93	
MAC426, KY	CO	88	87	Data loss resulted from calibrations and maintenance throughout the quarter.
	NO	89	87	
	NOY	89	87	
	NOYDIF	89	87	
	SO2_GA	89	89	
PND165, WY	NO	95	81	
	NOY	95	83	
	NOYDIF	95	80	
PNF126, NC	NO	94	90	
	NOY	94	93	
	NOYDIF	94	90	
ROM206, CO	NO	92	91	
	NOY	92	91	
	NOYDIF	92	91	

The parameters listed in Table 9 are both calculated and measured. Table 10 provides information on how the parameters listed in Table 9 are obtained.

Table 10. CASTNET Trace-level Gas Measurements

Parameter Name	How Obtained	Description of Process
CO	Measured	Gas filter correlation
HNO3	Calculated	NOY minus NOY_MINUS
NH3	Calculated	TNX minus NOY
NO	Measured	Chemiluminescence reaction/no converter used
NO2_TRUE	Calculated	NOX_TRUE minus NO
NOX_TRUE	Measured	Photolytic converter
NOY	Measured	Molybdenum converter at 315° Celsius
NOYDIF	Calculated	NOY minus NO
NOY_MINUS	Measured	Sodium carbonate denuder followed by molybdenum converter at 315° Celsius
NOX	Measured	Molybdenum converter at 325° Celsius
NOXDIF	Calculated	NOX minus NO
SO2_GA	Measured	Ultraviolet fluorescence
TNX	Measured	Platinum/stainless steel converter at 825° Celsius followed by molybdenum converter at 315° Celsius

References

Wood Environment & Infrastructure Solutions, Inc. 2019. *Clean Air Status and Trends Network (CASTNET) Second Quarter 2019 Quality Assurance Report.* https://java.epa.gov/castnet/documents.do