Prepared for:
Dan Joseph, Environmental Health Director
Weld County Department of Public Health and Environment
Prepared by:
Ramboll
December 20, 2024

Project Number:
1690018039-001

WELD COUNTY AMBIENT AIR MONITORING PROGRAM
QUALITY MANAGEMENT PLAN/QUALITY ASSURANCE PROJECT PLAN

Bright ideas. Sustainable change.

TITLE AND APPROVAL SHEET

Document Title:	Weld County Air Quality Monitoring Program: Quality Management Plan/Quality Assurance Project Plan
Project Owner:	Dan Joseph, Environmental Health Director Weld County Department of Public Health and the Environment 1555 North 17th Street, Greeley, CO 80631
Plan Preparer:	Jake Zaragoza, Michael Ring, Kaitlyn Elkind 231 S. Howes Street Fort Collins, CO 80521
Preparation Date:	December 20, 2024
Ramboll Principal:	Courtney Taylor
	12/20/2024 ______________________________ __________ Signature/Date
Ramboll Quality Assurance Officer:	Michael Ring
	12/20/2024 ______________________________ __________ Signature/Date
Project Manager:	Kaitlyn Elkind
	12/20/2024 ______________________________ __________ Signature/Date
Signature Note:	Due to locations of signees, this approval sheet may be signed in counter parts for full approval.

VERSION CONTROL

Revision Number	Date	Description of Change
0	November 11, 2020	Initial QAPP for Network Installation
1	August 11, 2021	Addition of Data Handling Procedures and SOPs; updated staff and contact information
2	January 1. 2023	Conversion to a Quality Management Plan and updated information for comprehensive adherence to QMP requirements; updated staff and contact information
3	February 6, 2023	Revised training resources; updated staff and contact information
4	September 18, 2023	Revised site photos; updated staff and contact information; consolidated and reorganized tabular information
5	December 20, 2024	Inclusion of version control history record; updated staff and contact information; updated procedures to align with release of EPA Technical Assistance Document EPA-454/B-22-003 on ozone transfer standards

CONTENTS

APPENDICES

TABLES

FIGURES

ACRONYMS AND ABBREVIATIONS

$\mu g/m^3$	Micrograms per meter cubed
µS/cm	Micro-Siemens per centimeter
AGL	Above ground level
AMoN	Ammonia Monitoring Network
APCD	Colorado Air Pollution Control Division
APTI	Air Pollution Training Institute
AQS	Air Quality System
ARM	Approved regional methods
ASL	Above Sea Level
ASQC	American Society for Quality Control
AWMA	Air & Waste Management Association
BOCC	Weld County Board of County Commissioners
Br	Bromide
Ca	Calcium
CAL	Central Analytical Laboratory
CDPHE	Colorado Department of Public Health and Environment
Cl	Chloride
CO	Colorado
CSV	Comma separated values
CTS	Certified transfer standard
DAS	Data Acquisition System
deg	Degrees
DQIs	Data Quality Indicators
DQOs	Data Quality Objectives
EPA	United States Environmental Protection Agency
FEM	Federal equivalent method
FRM	Federal reference method
in/hour	Inches per hour
K	Potassium
LDL	Lower Detectable Limits
LDL	Lower Detectable Limits
m/s	Meters per second
Mg	Magnesium
mg/m^3	Milligrams per meter cubed
mm/hr	Millimeters per hour
mmHg	Millimeters of mercury
MQOs	Measurement Quality Objectives
Na	Sodium
NAA	Nonattainment Area
NAAQS	National Ambient Air Quality Standards
NADP	National Atmospheric Deposition Program
NH_3	Ammonia

NH_4	Ammonium
NIST	National Institute of Standards and Technology
NO	Nitric Oxide
NO_2	Nitrogen dioxide
NO_3	Nitrate
NOx/ NO_x	Nitrogen oxides/ Oxides of nitrogen
NPAP	National Performance Audit Program
NTN	National Trends Network
O_3	Ozone
OAQPS	Office of Air Quality Planning and Standards
ºC	Degrees Celsius
PFA	Perfluoroalkoxy
pH	Acidity
PO_4	Phosphate
Ppb	Parts per billion
Ppm	Parts per million
PSD	Prevention of Significant Deterioration
QA	Quality Assurance
QAD	EPA Quality Assurance Division
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMP	Quality Management Plan
RH	Relative humidity
SLAMS	State or Local Air Monitoring Stations
SO_4	Sulfate
SOPs	Standard Operating Procedures
SPMs	Special purpose monitors
SRP	EPA Standard Ozone Reference Photometer
TAPI	Teledyne Advanced Pollution Instrumentation
USFS	United States Forest Service’s
VOC	Volatile organic compounds
W/m^2	Watts per meter squared
WESTAR	Western States Air Resources Council
WSLH	University of Wisconsin State Laboratory of Hygiene

PREFACE

The content and layout of this document was written following the EPA's Requirements for Quality Management Plans (EPA/QA-R2, March 2001) and Guide to Writing Quality Assurance Project Plans for Ambient Air Monitoring Networks (EPA-454/B-18-006, August 2018).

As suggested for smaller agencies and monitoring programs of limited size and scope[1], the QMP and QAPP are combined into this single document. This document follows the QAPP guidance convention that divides the document in four sections:

1. Overall plan goals and project management (Section 1)
2. How the plan will be implemented to generate data (Section 2)
3. How the data will be assessed and its oversight (Section 3)
4. How the data will be evaluated and validated (Section 4)

Other content is based on applicable federal air quality and meteorological monitoring guidance, as indicated.

[1] 40 CFR 58, Appendix A, Section 2.1.1.

1 PROJECT MANAGEMENT

1.1 Distribution List

The distribution list in Table 1 identifies all individuals that should receive a copy of this Quality Management Plan/Quality Assurance Project Plan (QMP/QAPP), either in hard copy or electronic format, as well as any subsequent revisions.

Table 1: Distribution List

Name and Title	Organization	Phone Number
Bruce Barker – Weld County Attorney	Weld County Greeley, CO	970-400-4390
Dan Joseph – Environmental Health Director	Weld County Department of Public Health and Environment Greeley, CO	970-400-2206
Courtney Taylor – Principal	Ramboll Fort Collins, CO	[redacted]
Kaitlyn Elkind- Project Manager	Ramboll, Phoenix, AZ	[redacted]
Michael Ring– Quality Assurance Officer	Ramboll Seattle, WA	[redacted]
Jake Zaragoza – Senior Data and Field Analyst	Ramboll Fort Collins, CO	[redacted]
Abraham Dearden—Data Analyst	Ramboll Fort Collins, CO	[redacted]
Blake Himes—Data Analyst	Ramboll Novato, CA	[redacted]
Danielle Serna—Site Operator	Weld County Department of Public Health and Environment Greeley, CO	970-400-2239
Miguel Garcia—Site Operator	Weld County Department of Public Health and Environment Greeley, CO	970-400-2316
Alexander Clemments—Site Operator	Weld County Department of Public Health and Environment Greeley, CO	970-400-2241
Erick Mattson, Technical Services Program Manager	Colorado Department of Public Health & Environment (CDPHE)	303-692-3231

1.2 Project Organization

This section of the plan identifies the roles and responsibilities of the key individuals involved in the major aspects or phases of this project. This section also illustrates the lines of authority and reporting between these individuals and authorities. Figure 1 on the following page illustrates the communication pathway for the project outlined in this QMP/QAPP. Bruce Barker and Dan Joseph both report to the Weld County Board of County Commissioners (BOCC). The BOCC make final approval decisions, with Bruce and Dan providing recommendations. Under Dan Joseph are the Weld County Site Technicians, Danielle Serna, Miguel Garcia, Alex Clemments, and the Ramboll team. The Weld County Site Technicians make routine site visits to perform regular National Atmospheric Depositions Program activities and make filter changes. The Ramboll team oversees all data activities. Courtney Taylor oversees the Ramboll team, Kaitlyn Elkind performs project management activities, and Michael Ring oversees quality assurance tasks. Jake Zaragoza, Abraham Dearden, and Blake Himes perform site installation tasks, data review, and other routine operations. Table 2 illustrates key team personnel and their roles in this project.

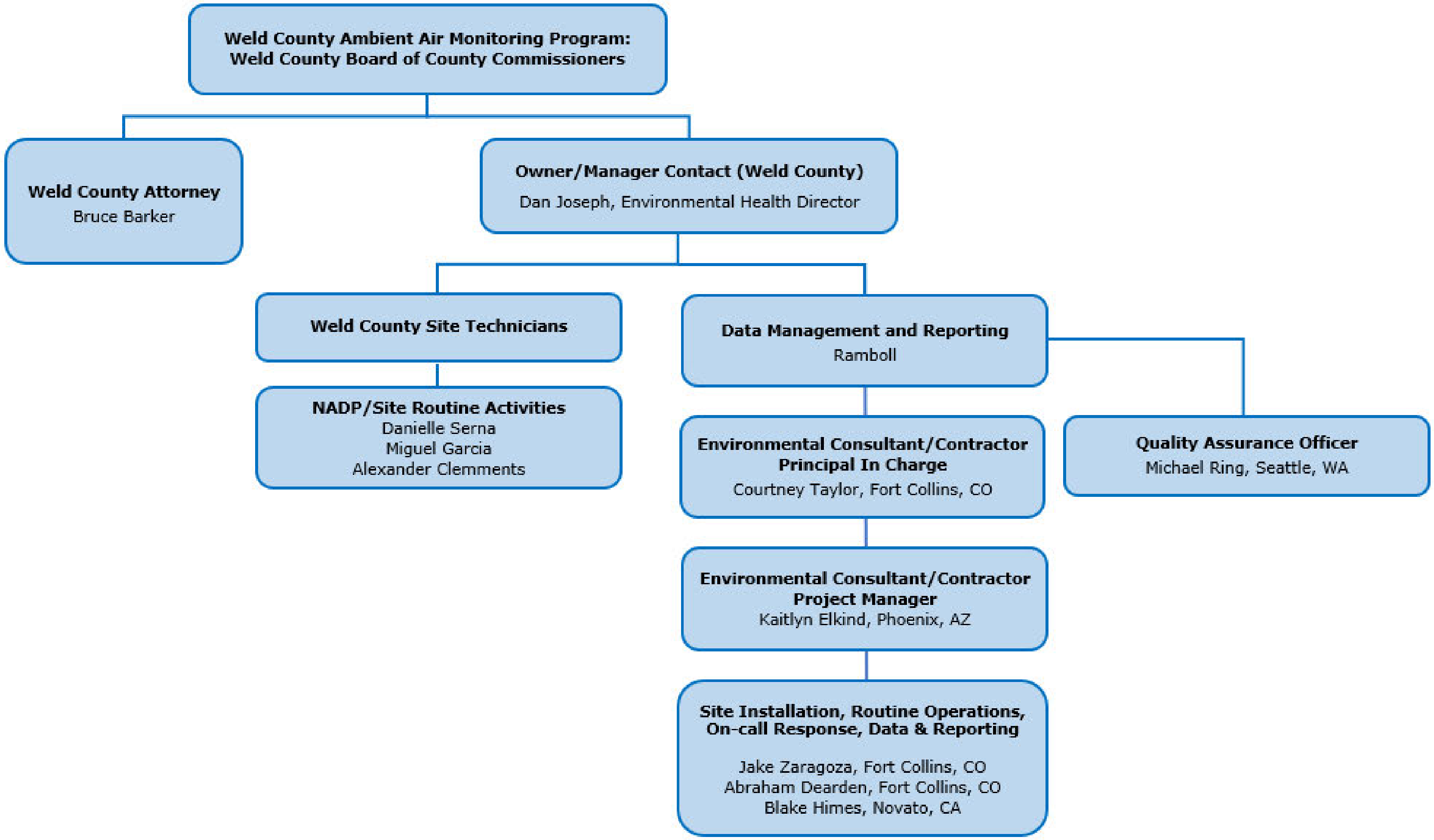

Figure 1: Project Organization Chart

Table 2: Key Individuals and Responsibilities

Name	Entity	Title	Responsibilities
Bruce Barker	Weld County	Attorney	Project Manager
Dan Joseph	Weld County	Environmental Health Director	Management Coordination with Weld County
Courtney Taylor	Ramboll	Principal	Project Risk Management
Michael Ring	Ramboll	Managing Consultant	Project Quality Management
Kaitlyn Elkind	Ramboll	Managing Consultant	Project Management of Scope, Cost, and Schedule & Management Coordination with Weld County
Jake Zaragoza	Ramboll	Senior Lead Consultant	Field Installations/Operations; Data management and analysis
Blake Himes	Ramboll	Consultant	Data management and analysis
Abraham Dearden	Ramboll	Consultant	Data management and analysis
Danielle Serna	Weld County	Environmental Health Specialist III	Routine Site Activities
Miguel Garcia	Weld County	Environmental Health Specialist II	Routine Site Activities
Alex Clemments	Weld County	Environmental Health Specialist II	Routine Site Activities
Erick Mattson	CDPHE	Technical Services Program Manager	Point of contact for CDPHE Technical Services Program
Jason Schroder	CDPHE	Interim Air Toxics & Ozone Precursor Program Manager	Point of contact for CDPHE VOC monitoring at Missile Site Park

1.3 Problem Definition and Background

The Weld County BOCC has commenced an ambient air quality monitoring program and collaborative monitoring studies in order to inform policies of the Weld County Health and Environment Department, the Weld County Oil and Gas Energy Department, and the Weld County Planning and Zoning Department. At the commencement of the program, a portion of Weld County was included in both the 2008 and 2015 ozone nonattainment areas. Since the monitoring program has begun, the 2015 ozone nonattainment area boundary was expanded to include all of Weld County (see Figure 4). Weld County's monitoring objectives are:

1. Ensure adequate spatial coverage of measurements throughout Weld County to fill spatial gaps in the existing air monitoring networks;
2. Inform the location of the northern ozone nonattainment area (NAA) boundary;
3. Track air pollution trends;
4. Quantify changes in air pollutant concentrations as a result of regulatory and economic changes;

5. Improve efforts to quantify sources and transport of air pollutants throughout the ozone NAA;
6. Quantify and better understand background air pollutant concentrations entering Weld County; and
7. Quantify and better understand the nitrogen deposition close to potential sources in Weld County.

An air quality monitoring network assessment was recently completed for Weld County to inform site selection. This network assessment examined existing monitoring for volatile organic compounds (VOCs), ozone (O_3), and nitrogen species. Based on identified spatial gaps in monitoring, three sites were chosen for the installation of additional air quality monitoring equipment. Information on each of the three proposed monitoring sites is provided below. A summary of site names, coordinates, and collected data is provided in Table 3. CDPHE is conducting VOC monitoring at Missile Site Park using Summa canisters. Figure 2 shows a map of the proposed site locations. The monitors will be classified as a special purpose monitors (SPMs) and select data (ozone, nitrogen dioxide, and meteorological parameters) will be uploaded to the Environmental Protection Agency's (EPA's) Air Quality System (AQS). The data collection program began at the end of 2020 and will continue until the monitoring objectives are achieved or Weld County determines the program should be discontinued.

Table 3: Weld County Monitoring Network Sites

Site Name	Coordinates	Air Quality Data	Deposition Data	Meteorological Data
Missile Site Park	40.428670 N, 104.860882 W	• Ozone • NOx • gas-phase ammonia	Yes	Yes
Orchard	40.334625 N, 104.159983 W	• Ozone • gas-phase ammonia	Yes	Yes
Hereford	40.978113 N, 104.304665 W	• Ozone	No	Yes

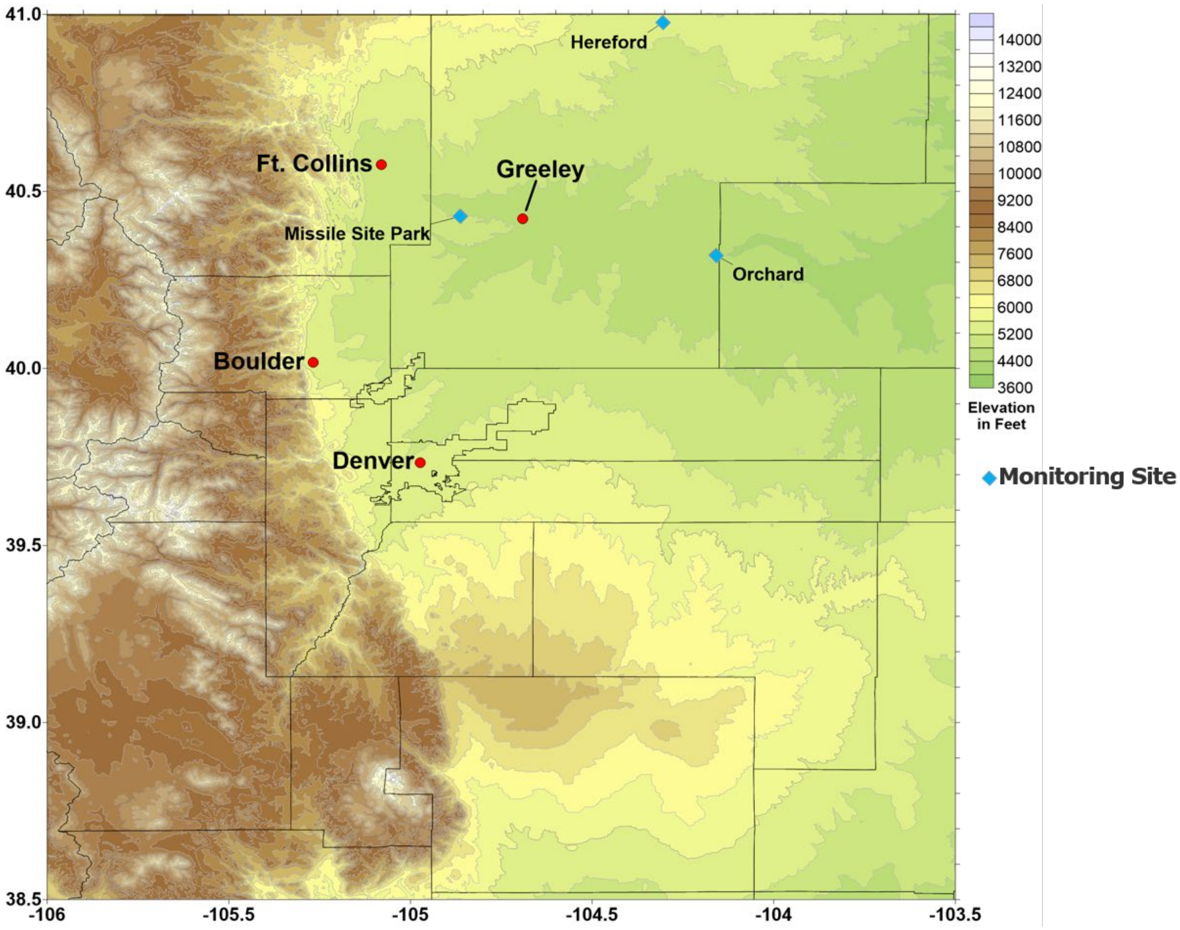

Figure 2: Weld County Monitoring Station Locations

1.3.1 Missile Site Park

Missile Site Park is located just northwest of Greeley, CO and will serve as the primary monitoring site. The site is anticipated to be representative of conditions in west-central Weld County. The air quality parameters that will be monitored include O_3 and NO_X. Meteorological data will be collected using a 10-meter (m) tower measuring ambient temperature at 2- and 10-m, temperature difference (referred to as Δ-temperature), horizontal wind speed and horizontal wind direction at 10-m, standard deviation of horizontal wind direction (sigma theta), solar radiation at 2-m, relative humidity at 2-m, and site barometric pressure and precipitation.

In addition, the site will also collect wet deposition in accord with National Atmospheric Deposition Program (NADP) program National Trends Network (NTN) protocols, and gas-phase ammonia in accord with Ammonia Monitoring Network (AMoN) protocols. Wet deposition of sulfate, nitrate, chloride, and ammonium (among other species) will be sampled with NTN collection buckets. The buckets are designed to sample wet deposition for one week (7 days). Collected samples are subsequently shipped to the Central Analytical Laboratory (CAL) at the University of Wisconsin's State Laboratory of Hygiene (WSLH) where they are analyzed, screened, and verified before entry to the long-term NTN database. Gaseous phase ammonia concentrations will be collected for two-week (14-day) periods with Radiello passive samplers, which utilize sorbent media that attracts and adsorbs gaseous ammonia. Detailed sample handling and associated quality assurance protocols are described in Section 2.2 of this QMP/QAPP.

This site is intended to support monitoring objectives related to improved spatial coverage; track trends and air pollutant transport; quantify impacts and changes in air pollutant concentrations as a result of regulatory and economic changes; and improve efforts to quantify sources and transport of air pollutants throughout the ozone NAA.

1.3.2 Orchard

The Orchard site located on the eastern border of Weld County, just west of Orchard, CO. The monitoring parameters for this site include: O_3, a 10-m meteorological tower with the same parameters as Missile Site Park, and collocated NADP samplers for the collection of wet deposition (NTN) and ammonia (AMoN).

This site is intended to support monitoring objectives related to improved spatial coverage; track trends and air pollutant transport; quantify impacts and changes in air pollutant concentrations as a result of regulatory and economic changes; improve efforts to quantify sources and transport of air pollutants throughout the ozone NAA; and quantify and better understand background air pollutant concentrations entering Weld County.

1.3.3 Hereford

The Hereford site, located in Hereford, CO will serve to capture data from northern Weld County. The monitoring parameters for this site include: O_3 and a 10-m meteorological tower with the same parameters as Missile Site Park.

This site is intended to support monitoring objectives related to improved spatial coverage; support the current northern nonattainment boundary; track trends and air pollutant transport; quantify impacts and changes in air pollutant concentrations as a result of regulatory and economic changes; improve efforts to quantify sources and transport of air pollutants throughout the ozone NAA; and quantify and better understand background air pollutant concentrations entering Weld County.

1.4 Project/Task Description

The proposed Weld County Monitoring Network is designed to address the Weld County monitoring goals listed in Section 1.3. Objectives for each goal are detailed below. Practical constraints for this project include availability of personnel and budgetary concerns, which will be dealt with as they occur by the project manager and assistant project manager.

1.4.1 Spatial Coverage

The first Weld County monitoring goal is to address the current spatial gaps in air quality measurements. The Weld County Network Assessment identified six zones within the county where new or altered monitoring would augment already existing monitoring. The locations of current monitoring sites in the Northern Front Range are presented in Figure 3 below. Of those six zones, three were selected for the installation of new monitoring sites. Two of the sites, the Orchard and Hereford sites, will directly address two spatial gaps in air quality monitoring, one in northern Weld County and the other in southeastern Weld County, where currently no monitoring occurs. The third site at Missile Site Park will address a specific gap for NO_x monitoring, of which there is currently none in Weld County.

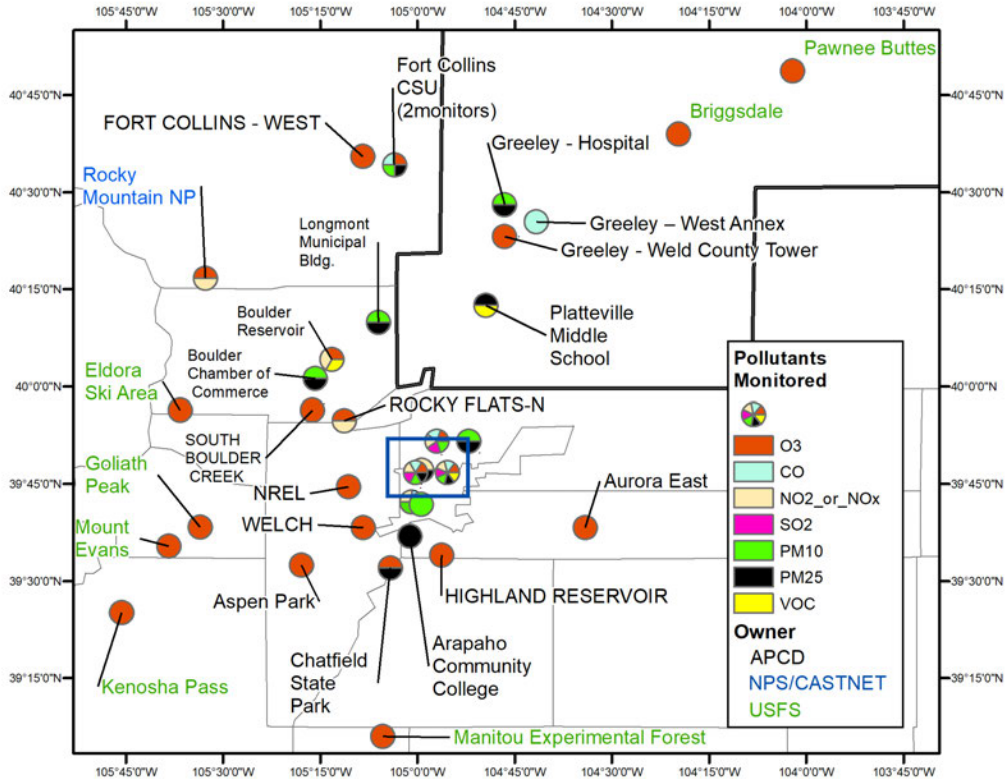

Figure 3: Map of existing air quality monitors excluding Weld County's monitoring network.

1.4.2 Support the Current Northern Boundary of the Ozone NAA

The northern boundary of the ozone NAA is in dispute for the 2015 O_3 standard. There are two monitors near the northern boundary, the United States Forest Service's (USFS) Pawnee Buttes and Briggsdale O_3 monitors; however, it is not clear if the sites continue to operate as no data past 2018 is publicly accessible. The USFS monitors typically only operate between March and September covering the unmodified typical 'ozone season', which has since been redefined to be January thru December for Colorado[2]. A permanent O_3 monitor (the Hereford site) near the northern boundary of the ozone NAA would be beneficial to better inform decisions that impact the northern boundary of the ozone NAA. Figure 4 shows a map of the O_3 monitors within the 2008 and 2015 O_3 standards NAA.

[2] APCD (2020). 2020 Ambient Air Monitoring Network Assessment. Downloaded from: https://www.colorado.gov/airquality/tech_doc_repository.aspx?action=open&file=2020_CO_5yr_Network_Assessment.pdf. Accessed January 2022.

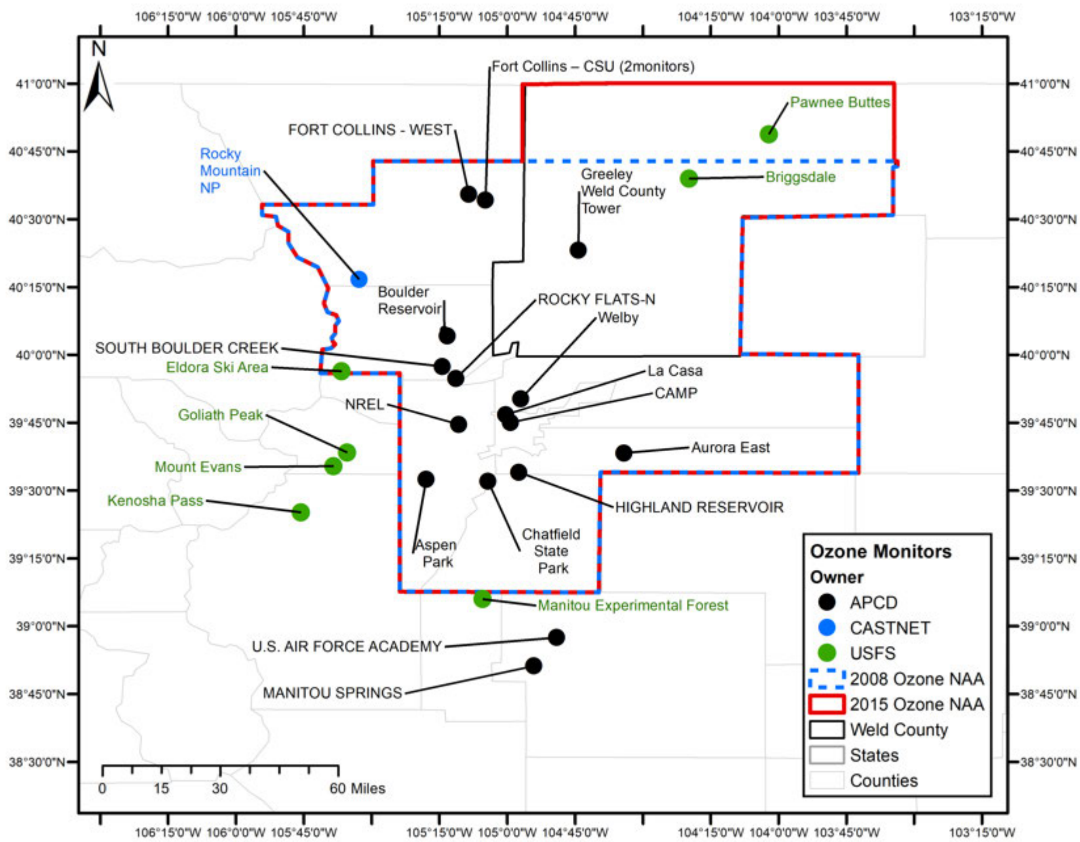

Figure 4: Map of O_3 monitors in the 2008 & 2015 O_3 Standards NAA.

1.4.3 Track Trends in Concentrations

In order to assess trends for any pollutant (or parameter of interest) a monitoring record is necessary. Usually, longer monitoring records are better suited for assessing trends because of their ability to average out short term variability in the data. With the installation of three permanent sites, Weld County will create a record of O_3, meteorological parameters, NO_x (site dependent), ammonia (site dependent), and wet deposition compounds of interest (site dependent). This record will then aid in assessing trends of these pollutants over spatial and temporal bounds.

1.4.4 Quantify changes in concentrations as a result of regulatory and economic changes

Quantifying changes in concentrations requires a record of concentration values from before and after a regulatory or economic change has occurred. The longer the record pre and post change, the better the ability to filter out variability. Similar to the above goal of tracking trends in concentrations, the installation of three permanent sites will allow Weld County to quantify changes in concentrations as a result of regulatory and economic drivers.

1.4.5 Improve efforts to quantify sources and transport pollutants through the ozone NAA

The Missile Site Park site will inform source and transport of pollutants, including NOx, throughout the ozone NAA. The Hereford site would be crucial in quantifying any transport of O_3 from the north, with its proposed meteorology and O_3 monitoring equipment. In east-central Weld County, the Orchard site would be crucial in quantifying any transport of O_3 (and NADP monitored pollutants) from the east with its proposed meteorology and O_3 monitoring equipment.

1.4.6 Quantify background concentrations entering Weld County

Two of the proposed sites would help achieve the goal of quantifying background concentrations entering Weld County, Hereford and Orchard. The location of each site, at the northern edge of Weld County outside of the O_3 NAA, and at east-central Weld County, will allow these two sites to both quantify elevated concentrations of pollutants as well as background concentrations of pollutants entering the county.

1.5 Quality Objectives and Criteria for Measurement Data

1.5.1 Data Quality Objectives

The Data Quality Objectives (DQOs) for the Weld County Monitoring Network have been established to enable end user(s) to make comparisons to the National Ambient Air Quality Standards (NAAQS) and support the objectives listed in Section 1.3. According to the EPA's "AQS Non-Regulatory Monitor Type Guidance Technical note"[3], for air concentration data to be compared to the NAAQS, ambient air monitors must meet three sets of requirements:

1. Use federal reference (FRM), federal equivalent (FEM) and approved regional (ARM) methods (40 CFR Part 58 Appendix C),
2. Meet siting criteria (40 CFR Part 58 Appendix E), and
3. Meet quality assurance (QA) requirements (40 CFR Part 58 Appendix A)

The technical note also states that "the Appendix C requirement for use of FRM/FEM/ARM monitors cannot be waived for any State or Local Air Monitoring Stations (SLAMS) monitor that state/local monitoring agencies use to meet the minimum requirements of 40 CFR 58 for the number of monitors to be operated; if a non FRM/FEM/ARM monitor is used, the monitor should be classified as a SPM and its data are not to be used for NAAQS compliance determinations." The Weld County monitors will be classified as a SPMs, however the Weld County program is committed to comply with all these requirements to ensure the monitors would be equivalent to SLAMS monitors. The meteorological data complies with the all the requirements established by the ambient monitoring guidelines for Prevention of Significant Deterioration (PSD) (EPA-450/4-87-007).

The Office of Air Quality Planning and Standards (OAQPS) has developed formal DQOs for several pollutants and networks. The applicable DQOs based on EPA-450/4-87-007 are summarized below:

- Monitoring data will be collected with instrumentation approved by EPA and that provide continuous measurements.
- Records of the quality control (QC) procedures that will be performed during the time period that the data is collected will be retained. This includes calibration, zero and span checks, and control checks.
- Calibration and span gas for NO_x, shall be a working standard certified by comparison to a National Bureau of Standards Gaseous Standard Reference Material.

[3] https://www.epa.gov/aqs/aqs-non-regulatory-monitor-type-guidance

- The data recovery shall be 75% of the data possible during the sampling period for nitrogen dioxide and 90% of the daily maximum 8-hour average O_3 during the O_3 season, which in Colorado is January to December.[4]
- The data recovery shall be 90% of the data possible during the sampling period for meteorological data.

The remaining sections of this QMP/QAPP provide guidance on how these objectives will be met.

The NTN and Amon sites will follow NADP standard operating procedures. NADP guidelines and data quality objectives are documented on their website[5] and described in further detail in section 2 of this document.

1.5.2 Criteria for Measurement Data

The data collected by each monitoring site will not be completely error free and is expected to contain some level of uncertainty. The reliability of decisions made from the data to be collected will be directly related to the certainty of that data. Consequently, the uncertainty of data increases the likelihood for incorrect decisions.

There are two types of uncertainty related to air quality analysis programs which are addressed in this QMP/QAPP. These are population uncertainty and measurement uncertainty.

Population uncertainty includes errors associated with the spatial and temporal components. Measurement uncertainty is associated with the errors that can be made during the various phases (field, preparation, and laboratory measurement).

Population uncertainty will be controlled for by ensuring the monitoring site locations are in physical positions that would provide accurate representative data. Representativeness is a qualitative term that expresses the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.

The monitoring sites were selected considering Weld County monitoring objectives and EPA requirements. The monitoring sites are expected to provide data representative of urban and remote locations, and of inflow conditions into Weld County.

Measurement uncertainty will be controlled by placing Measurement Quality Objectives (MQOs) on parameters being monitored and ensuring the data that will be used meets the MQOs. The MQOs are listed in Table 4 and Table 9. Following is a list of Data Quality Indicators (DQIs) to be used to determine measurement uncertainty.

Precision

Precision is a measure of agreement among repeated measurements of the same property under identical or substantially similar conditions; calculated as either the range or as a standard deviation. Precision will be ensured as discussed below.

[4] EPA Ozone Seasons. Available here: https://aqs.epa.gov/aqsweb/documents/codetables/ozone_seasons.html

[5] NADP SOP for data collection are available at: http://nadp.slh.wisc.edu/lib/qaPlans.aspx

Accuracy

Accuracy is a measure of overall agreement of a measure to a known value; includes a combination of random error (precision) and systematic error (bias) components of both sampling and analytical operations. Accuracy will be ensured as discussed below.

Comparability

Comparability is a qualitative term that expresses the measure of confidence that one data set has when compared to another.

Comparability of the data is dependent on good engineering designs/plans and proper implementation of the designs/plans. Comparability will be ensured by executing QA/QC procedures and implementing this QMP/QAPP.

Sensitivity

Sensitivity is the capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest.

To ensure good sensitivity, Ramboll designed the monitoring sites using sampling equipment that has been designated by the EPA as acceptable.

Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system. The completeness objective for the continuous monitoring system will be 90% for O_3 and 90% for meteorological data, and 75% for NO_2. This allows for unforeseen problems (power outages, equipment failure, etc.) throughout the monitoring program.

In determining the MQOs for this project, Ramboll referenced EPA documents EPA-454/B-17-001 and EPA-454/B-08-002. Table 4 and Table 9 of this report reflect the MQOs Ramboll will adopt into this air quality analysis program from the EPA guidance documents. MQOs have been established to ensure the data is accurate, precise, and meets the requirements defined in 40 CFR Part 58 Appendices A, C and E, and EPA guidance documents for meteorological and ambient air QA. The MQOs for each of the Meteorological parameters being monitored are summarized in Table 4. A complete list of Ambient Air Quality Monitoring MQOs can be found in Table 9 and calculations of measurement uncertainty are described in more details in Section 2.4.1.

Table 4: Meteorological Measurement Quality Objectives

Measurement	Method	Reporting Units	Operating Range	Resolution	Minimum Sample Frequency	Raw Data Collection Frequency
Ambient Temperature	Thermistor	^oC	-30-50	0.1	Hourly	15 minute
Vertical Temperature Difference	Thermistor	^oC	-3-7	0.1	Hourly	15 minute
Relative Humidity	Psychrometer/ Hygrometer	%	0-100	0.5	Hourly	15 minute
Barometric Pressure	Aneroid Barometer	mb	600-1100	0.5	Hourly	15 minute

Measurement	Method	Reporting Units	Operating Range	Resolution	Minimum Sample Frequency	Raw Data Collection Frequency
Wind Speed	Cup or sonic anemometer	m/s	0.5-50.0	0.25	Hourly	15 minute
Wind Direction	Vane or sonic anemometer	degrees	0-360 (540)	1.0	Hourly	15 minute
Solar Radiation	Pyranometer	W/m^2	0-1300	10	Hourly	15 minute
Vector Data Wind Speed Wind Direction Sigma Theta	DAS Calculations	m/s degrees degrees	0-50.0 0-360 0-105	0.1 1.0 1.0	Hourly	15 minute 15 minute 15 minute
Precipitation	Tipping Bucket	Mm/hr	0-50 mm/hr	0.2 mm/hr	Hourly	15 minute

*Table information obtained from EPA-454/B-08-002, Table 0-7

1.6 Training

Adequate education and training are key components to any monitoring program that strives for good quality data. Primary responsibility for training will rest with the individual's supervisor. Records on personnel qualifications and training will be maintained in personnel files. Training may consist of courses, workshops, classroom lectures, teleconferences, and on-the-job-training. Installation and routine operations work conducted under this monitoring plan will be by individuals with proper training and experience. All Ramboll personnel assigned to installation, operation, maintenance, QA, and data handling on this project will be college or university-degreed graduates with a scientific or engineering background. Training will be documented, and the corresponding records of training will be maintained at the Missile Site Park monitoring site.

Technical staff have access to SOPs, EPA Quality Assurance Guidance Documents as well as other guidance such as the manufacturer’s operating manuals. In addition, training includes self-instructional courses available through U.S. EPA’s AirKnowledge.

1.7 Documentation and Records

Documents and records required to support concentration data reported to EPA, which includes all data required to be collected as well as data deemed important by the CDPHE and Weld County, are listed in Table 5. All the documents and records listed in the table will be retained for ten years from the date of collection. Only final validated hourly data and final reports (Quality Management Plan/Quality Assurance Project Plan and Quarterly Reports) will be retained past the ten years retention time.

Table 5: Reporting Package Information

Category	Document	Record Type	File Locations/Access
Management and Organization	Quality Management Plan/Quality Assurance Project Plan	Reporting agency information Organizational structure Quality management plan Document control plan	Ramboll cloud-based project file
	Training Qualifications Report	Personnel qualifications and training Training Certification	Ramboll cloud-based project file
Site Information	Quarterly Report	Network description Site characterization file Site maps Site pictures Site visit logs	Ramboll cloud-based project file
Environmental Data Operations	Quality Management Plan/Quality Assurance Project Plan	QA Project Plans Standard Operating Procedures (SOPs)	Ramboll cloud-based project file
	Field Notebooks and other in site documents	Field notebooks Inspection/Maintenance records Laboratory notebooks Sample handling/custody records	Missile Site Park Orchard Site Hereford Site
Raw Data	Raw data files	Any original data (routine and QC data) including data entry forms	Ramboll cloud-based project file
Data Management	Quality Management Plan/Quality Assurance Project Plan	Data algorithms Data management plans/flowcharts Data Management Systems	Ramboll cloud-based project file
Quality Assurance	5-Year Network Assessment	Network reviews	Ramboll cloud-based project file
	Quality Management Plan/Quality Assurance Project Plan	Network reviews Control charts Data quality assessments QA reports System audits Site Audits Calibration reports Data validation logs	Ramboll cloud-based project file

Category	Document	Record Type	File Locations/Access
	Corrective Action Report	Data quality assessments Response/Corrective action reports	Ramboll cloud-based project file

Updated versions of this QMP/QAPP will be distributed to all personnel identified in the distribution list of this plan. Any updates to Ramboll's SOPs will be distributed to all personnel that will be directly affected by any changes in the procedures. Updated versions of this QMP/QAPP and/or Ramboll SOPs will either be sent via email in PDF format, or by hard copy to the appropriate recipients. Updated versions of all appropriate documentation will also be stored at the monitoring sites in hard copy format in a binder or folder. Upon transfer of operational oversight to another contractor, Ramboll will request that they develop their own SOPs but Ramboll will support development of equipment-specific SOPs.

2 DATA GENERATION AND ACQUISTION

2.1 Network Description

The topography of Weld County consists of mostly flat high-altitude plains to the east, the higher elevation foothills of the Rocky Mountains to the west, and the Pawnee Buttes in Pawnee National Grasslands to the North. Elevations within the project area range from 4,400 ft (1,341 m) along the Pawnee Creek to 6,200 ft (1,889 m) at the Pawnee Buttes. The drainages and streams in the area include the Big Thompson, Cache la Poudre, and St Vrain, many of which are tributaries to the South Platte River[6]. The project area is largely agricultural, with some suburban and urban centers including the city of Greeley. The current land uses in the area include agriculture, concentrated animal feeding operations, and oil and natural gas production.

On-site reconnaissance was conducted in July and August 2020 for each site to identify a suitable location for the instrument shelter, meteorological tower, and NADP equipment. Ramboll referenced the EPA documents EPA-454/B-17-001 (Section 7. The Sampling System)[7], EPA-454/R-99-005 (Section 3. Siting and Exposure)[8], EPA-454/B-08-002 (Sections 1. Tower Guidance and Siting)[9], 40CFR Part 58 Appendix E[10], EPA-450/4-87-007 (Section 3. Network Design and Probe Siting Criteria)[11] and the NADP's Site Selection and Installation Manual[12] when evaluating these locations. Overall siting criteria are summarized below:

- O_3 and NO_2
    - Distance to obstructions should be at least twice the height of the obstruction
    - Distance to trees should be at least 10 m
    - Distance to roadways with 1,000 vehicles per day (or more) should be at least 10 m
- NTN & AMoN
    - No impact from irrigation sources
    - Distance to tall vegetation should be at least 2 m for AMoN and at least 5 m for NTN
    - Distance to objects greater than 1 m in height should be at least 5 m
    - Distance to access roadways with 10 vehicles per day (or more) should be at least 10 m
    - Distance to cultivated fields, fertilizer and herbicide use, and pastures should be at least 20 m
    - Distance to unpaved roadways with 10 vehicles per day (or more) should be at least 30 m

6 Weld County (2018). The Weld County Population & Development Report. Available at https://www.weldgov.com/UserFiles/Servers/Server_6/File/Departments/Planning%20&%20Zoning/Long%20Range%20Planning/2018%20Weld%20County%20Population%20and%20Development%20Report.pdf. Accessed September 2020.

7 Quality Assurance Handbook for Air Pollution Measurement Systems Volume II Ambient Air Quality. Accessed at https://www3.epa.gov/ttnamti1/files/ambient/pm25/qa/Final%20Handbook%20Document%201_17.pdf

8 Meteorological Monitoring Guidance for Regulatory Modeling Applications. Accessed at https://www.epa.gov/sites/default/files/2020-10/documents/mmgrma_0.pdf

9 Quality Assurance Handbook for Air Pollution Measurement Systems - Volume IV: Meteorological Measurements. Accessed at https://www.epa.gov/sites/default/files/2020-10/documents/volume_iv_meteorological_measurements.pdf

10 Probe and Monitoring Path Siting Criteria for Ambient Air Quality Monitoring. Accessed at https://www.ecfr.gov/cgi-bin/text-idx?node=pt40.6.58&rgn=div5

11 Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD). Accessed at https://www.epa.gov/nscep.

12 http://nadp.slh.wisc.edu/lib/manuals/NADP_Site_Selection_and_Installation_Manual_2014_11.pdf

- Distance to airports, chemical manufacturing, electric utilities, small feedlot operations, incinerators, landfills, mining operations, and paved roads with more than 100 vehicles per day should be at least 100 m
- Distance to highways with 100 vehicles per hour (or more), stationary combustion sources, and large animal operations should be at least 500 m
- Distance to interstates should be at least 1 kilometer

- Meteorological Parameters
    - Wind Speed and Direction
  - Distance to obstructions should be at least ten times the height of the obstruction
  - Slope should be level in immediate vicinity (e.g. within 15 m of tower slope should be 2% or less, 15 – 30 m of tower slope should be 3% or less, 30 – 100 m of tower slope should be 7% or less, and 100 – 300 m of tower slope should be 11% or less)
    - Ambient temperature and humidity
  - Distance to paved surfaces should be at least 30 m
    - Precipitation
  - Distance to obstructions should be at least two times the height of the obstruction
    - Solar radiation
  - No impact from obstruction shadows

Note, most of the above siting criteria will be met, except for the following:

- Missile Site Park obstruction setback criteria for the meteorology tower. There are trees on the eastern and western edge of the fence that may not meet the setback rule of an object being 10 times its height away from the tower. The trees on both edges appear to be only 3 times their height away from the tower.
- Missile Site Park 300 m grade setback criteria for the meteorology tower. There is land with grade greater than 11% within 300 m of the tower. Figure 7 below highlights grade greater than 11% approximately 120 m northeast of the tower location. This steep grade northeast of the tower encompasses between 10 and 20% of the total 300 m grade setback area.
- Missile Site Park 30 m setback criteria to paved surfaces for temperature and RH measurements. Figure 6 below highlights a paved section of road approximately 24 m southeast of the tower. The road directly south of the tower that runs east-west is only partially paved. The paved section ends just west of the north-south access road within the fenced area. The north-south access road is just outside the 30 m setback criteria, but the short portion that runs east-west is within this setback.
- Hereford 300 m grade setback criteria for the meteorology tower. There is slope greater than 11% within 300 m of the tower. Figure 21 greater than 11% southwest of the tower approximately 135 m south of the tower, 190 m west-southwest of the tower, and 250 m west-northwest of the tower. This steep grade encompasses a small portion of the 300 m setback area.

2.1.1 Missile Site Park

As shown in Figure 5 through Figure 7, Missile Site Park consists of a fenced compound surrounded by a gravel/semi-paved road. To the immediate west outside of the fenced compound is a public campground. To the north and west outside of the fenced compound are a few oil and gas pads and undeveloped open land, and to the east are agricultural fields. South of the fenced area are empty fields. The fence is 8 ft (') tall with steel posts spaced approximately 10' on center and has sporadic small to medium sized trees along the outer fence perimeter.

The Missile Site Park monitoring shelter will be located within the fenced boundary on the southwestern corner of the parking lot, at approximately 1,513 m above sea level (asl). The tower will be located approximately 25 m southwest of the shelter. A service box is already available on site. Power to the 100-amp, 120/240 VAC single phase shelter service panel will be drawn from the on-site service box. As such, a new electrical drop will not be required. Figure 5 through Figure 7 show the site layouts. Figure 5 and Figure 6 show the current setback at the site for the shelter and NTN equipment, and the meteorology tower, respectively. Figure 7 shows the grading of the terrain in proximity to the meteorology tower.

In Figure 5:

- For the monitoring shelter, a distance between itself and any obstructions needs to be at least twice the height of the obstruction away. The building just northwest of the monitoring shelter is about 3 m tall, so it needs to be at least 6 m away from the monitoring shelter. The blue ring highlights that there are no obstructions within about 6 m of the shelter, e.g. the distance between the monitoring shelter is larger than the 6 m setback required in this instance.
- For the monitoring shelter, the tree setback needs to be at least 10 m. The green ring shows that the closest trees to the Ozone and NOx shelter are about 18 m away.
- For NTN, a distance of at least 5 m is needed between the collector and nearby vegetation. The purple ring shows that the nearest shrubs (vegetation) are just under 5 m away. The shrubs shown in the aerial figure were removed during the site installation.
- For NTN, a distance of at least 5 m is needed between the collector and nearby large objects. In this case the large object is the monitoring shelter, which is about 3 m tall. The gold ring shows that there is no large object within about 6 m of the collector, e.g. the distance between the NTN collector and the monitoring shelter is larger than the 5 m setback required.
- For NTN, a tree can also be considered a large object, therefore a setback of 5 m is needed between any tree and the NTN collector. The yellow ring shows that there are no trees within about 9 m of the collector.
- For NTN, a roadway separation of 100 m is required for roads that see more than 100 cars per day. The white ring shows that there is a roadway within that 100 m setback. On heavy traffic days in the summer when the park is open, it is possible that this setback criteria is not met.

In Figure 6:

- For temperature and relative humidity, the requirement is that no irrigated ground be present within 9 m of their location. The yellow ring represents the radius around which no irrigation should occur. The County does not plan on irrigating within this setback.
- For wind speed and direction, the distance to any obstructions should be at least 10 times the height of the obstruction away. That will not be entirely possible for the monitoring shelter. The blue ring shows that it will only be about 24 m away, however, at 3 m tall, this setback is acceptable.
- For temperature and relative humidity, the requirement is that no paved surfaces be present within 30 m of their location. The black ring shows this 30 m setback and indicates there is a small portion of paved roadway just southeast of the tower that is within this setback.

- Finally, for wind speed and direction, trees can also be considered obstructions. This setback to trees also needs to be 10 times the height of the obstruction away. The tallest trees are only about 45 m away from the tower, and they are between 6 and 9 m tall, which does not meet the setback criteria.

In Figure 7:

- The dark blue ring represents the setback (15 m) where the ground slope should be less than 2%.
- The teal ring represents the setback (30 m) where the ground slope should be less than 3%.
- The white ring represents the setback (100 m) where the ground slope should be less than 7%.
- The black ring represents the setback (300 m) where the ground slope should be less than 11%. Note, this setback is very clearly not met with the slopes greater than 11% northeast of the tower.

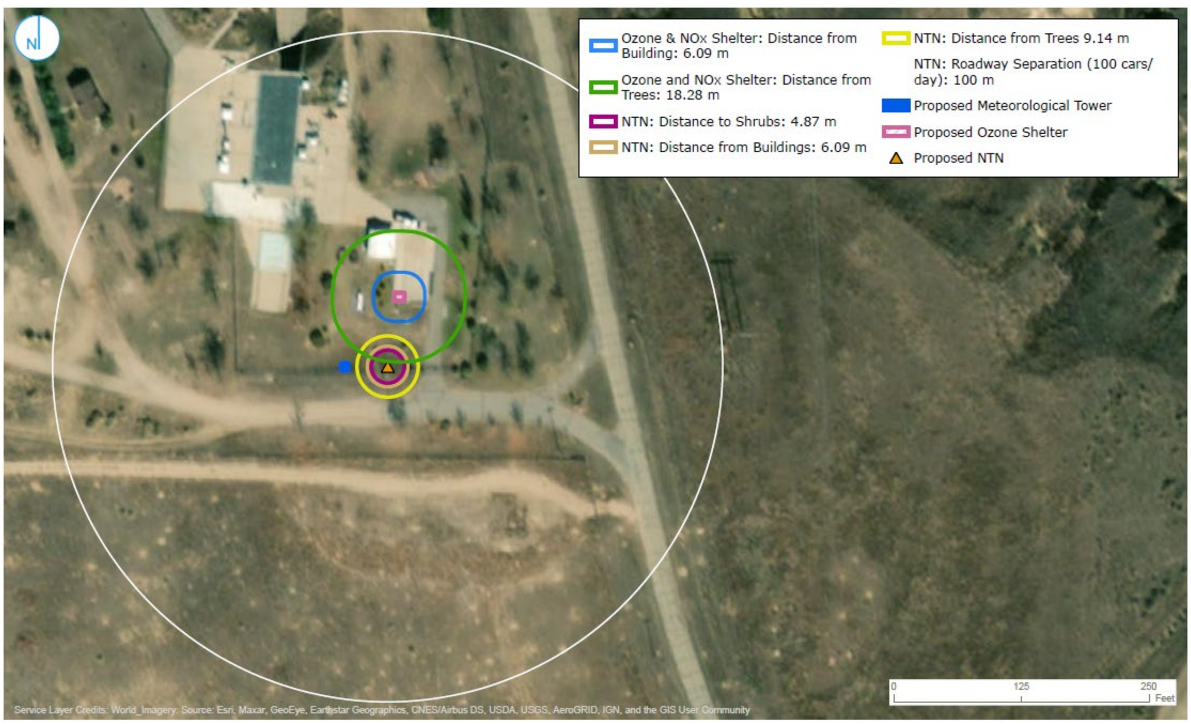

Figure 5: Missile Site Park Monitoring Site Layout with Shelter and NTN Setback Highlights-see text for detailed ring explanations

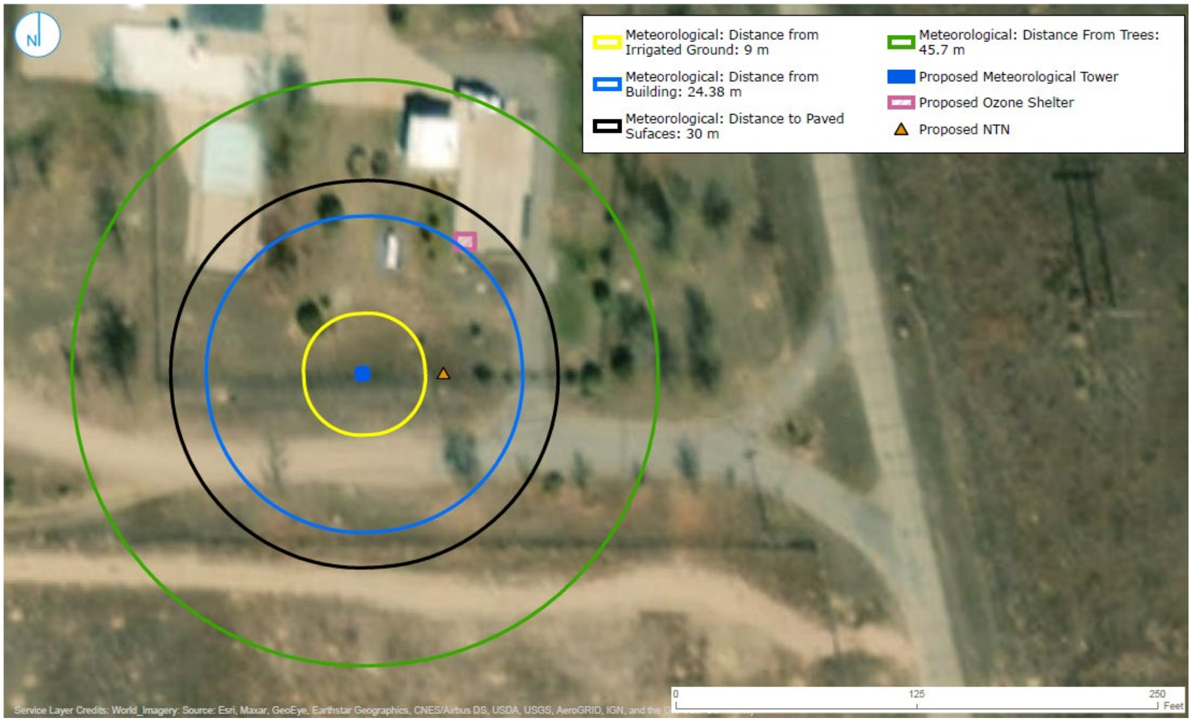

Figure 6: Missile Site Park Monitoring Site Layout with Meteorology Tower Setback Highlights- see text for detailed ring explanations

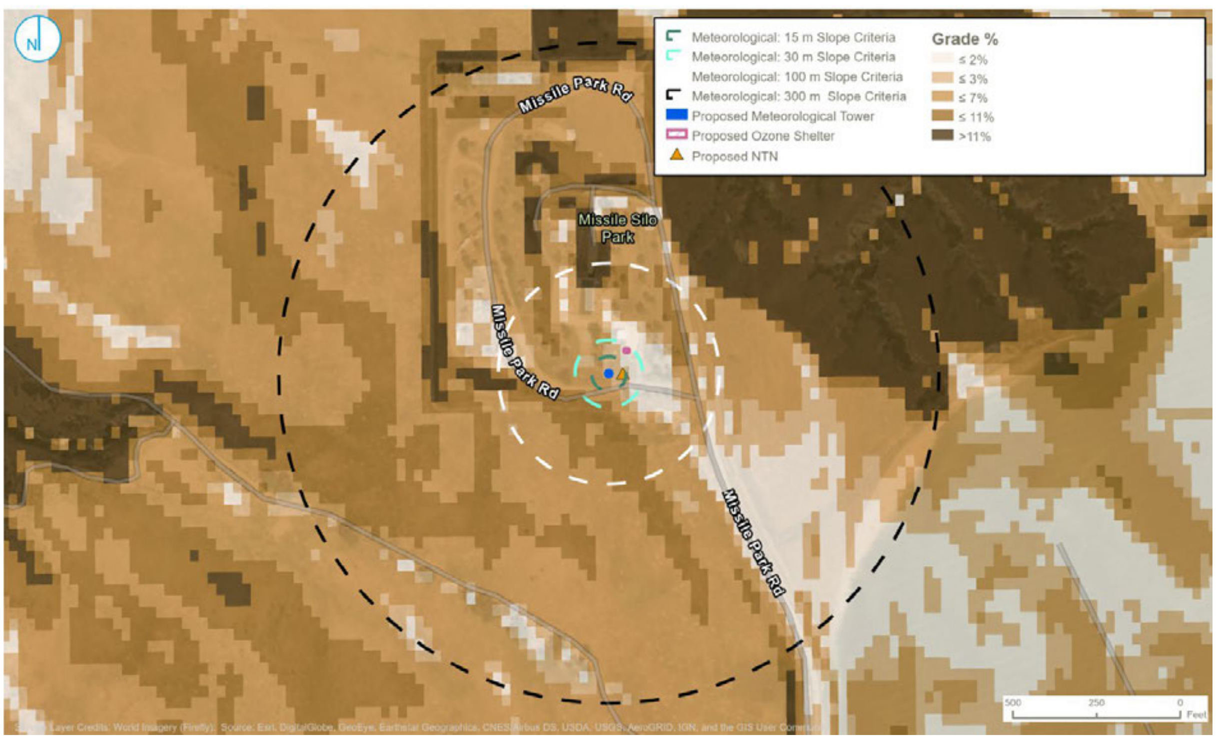

Figure 7: Missile Site Park Monitoring Site Layout with Meteorology Tower Slope Setback Highlights- see text for detailed ring explanations

Photos of the selected monitoring site and surrounding area are shown below.

Figure 8: Photo#1: Looking North

Figure 9: Photo#2: Looking South

Figure 10: Photo#3: Looking East

Figure 11: Photo#4: Looking West

2.1.2 Orchard Site

The Orchard monitoring site is in an agricultural area. It is immediately surrounded by native grasses, with a two-track road on the northern edge. The site is accessed by a 0.5-mile dirt road.

The Orchard monitoring shelter will be located approximately 15 m northeast of the absolute corner of the plot, at 1360 m asl. The tower will be located approximately 10 m north of the shelter. A new electrical drop will be needed to power the 100-amp, 120/240 VAC single phase service panel in the shelter. See Figure 12 though Figure 14 for the site layout. Figure 12 and Figure 13 show the current setback at the site for the shelter and NTN equipment, and the meteorology tower, respectively. Figure 14 shows the grading of the terrain in proximity to the meteorology tower.

In Figure 12:

- For the monitoring shelter, the distance to any obstructions should be twice the height of the obstruction away. The distance to any trees should also be at least 10 m. There are no obstructions or trees at this site. The green ring shows that there are no buildings or trees within 15 m of the monitoring shelter.

- For the monitoring shelter, the distance to any roadways should be 10 m. The gray ring shows that there are no roadways within 20 m of the shelter.
- For NTN, a distance of at least 5 m is needed between the collector and nearby large objects, in this case the large object is the monitoring shelter, which is about 3 m tall. The gold ring shows that there are two large objects within 15 m of the collector, the shelter and the 10 m meteorology tower. The gold ring shows that the 5 m setback is met.
- For NTN, a roadway separation of 100 m is required for roads that see more than 100 cars per day. The white ring shows that there are no roadways within that 100 m setback.

Figure 13:

- For temperature and relative humidity, the requirement is that no irrigated ground be present within 9 m of their location. The yellow ring represents the radius around which no irrigation should occur. This plot of land is not irrigated at all.
- For temperature and relative humidity, the requirement is that no paved surfaces be present within 30 m of their location. The black ring shows this 30 m setback and how there are no paved surfaces within this setback.
- For wind speed and direction, the distance to any obstructions should be at least 10 times the height of the obstruction away. That will not be entirely possible for the monitoring shelter, which is within 9 m of the tower. However, the blue ring shows that there are no other obstructions within 80 m of the tower.

Figure 14:

- The dark blue ring represents the setback (15 m) where the ground slope should be less than 2%.
- The teal ring represents the setback (30 m) where the ground slope should be less than 3%.
- The white ring represents the setback (100 m) where the ground slope should be less than 7%.
- The black ring represents the setback (300 m) where the ground slope should be less than 11%.

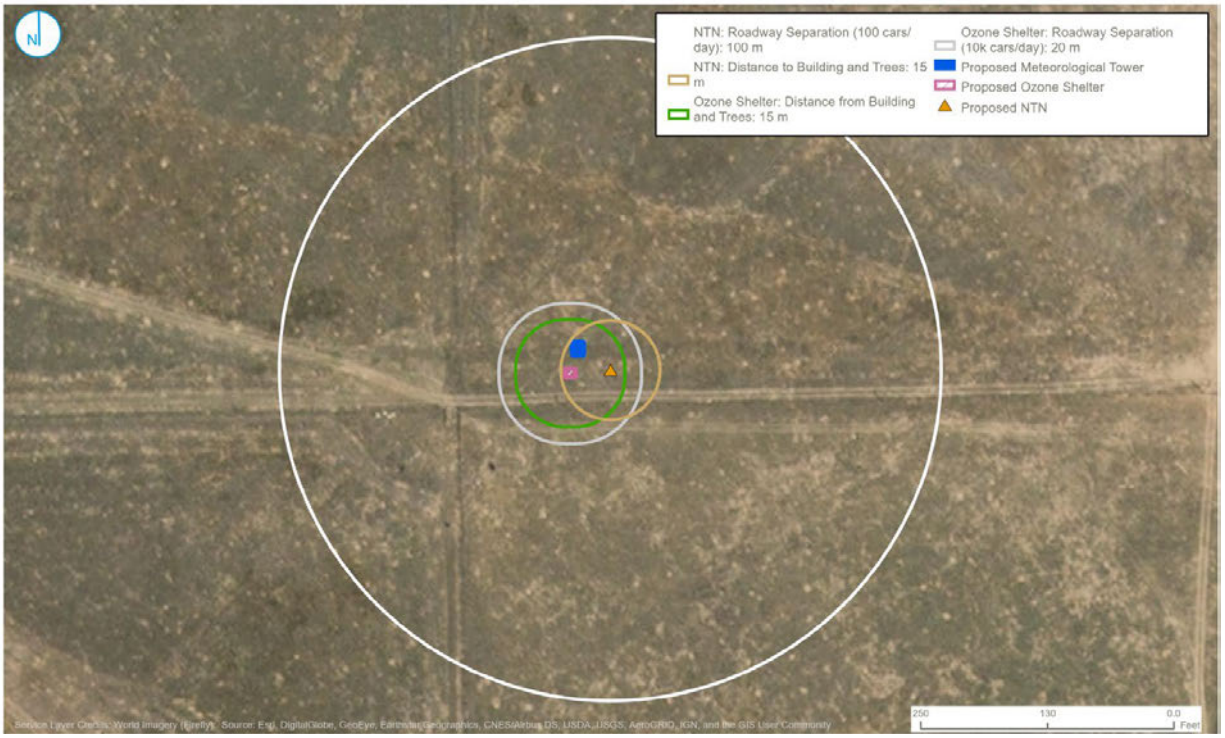

Figure 12: Orchard Monitoring Site Layout with Shelter and NTN Setback Highlights- see text for detailed ring explanations

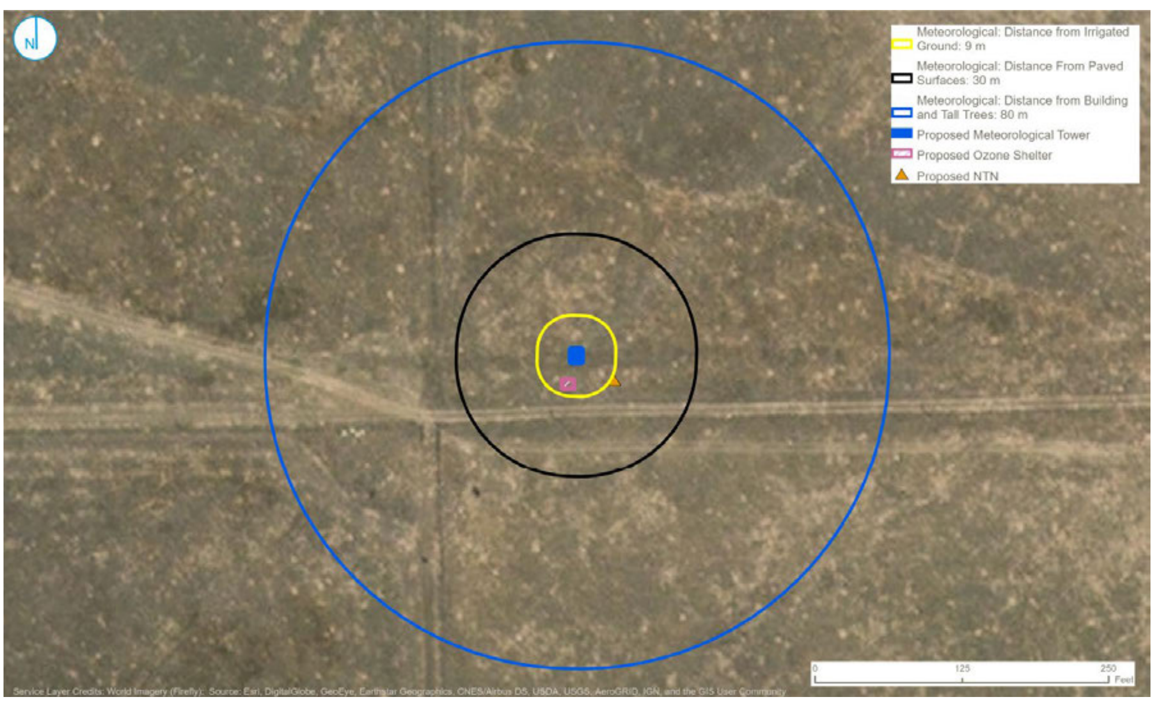

Figure 13: Orchard Monitoring Site Layout with Meteorology Tower Setback Highlights- see text for detailed ring explanations

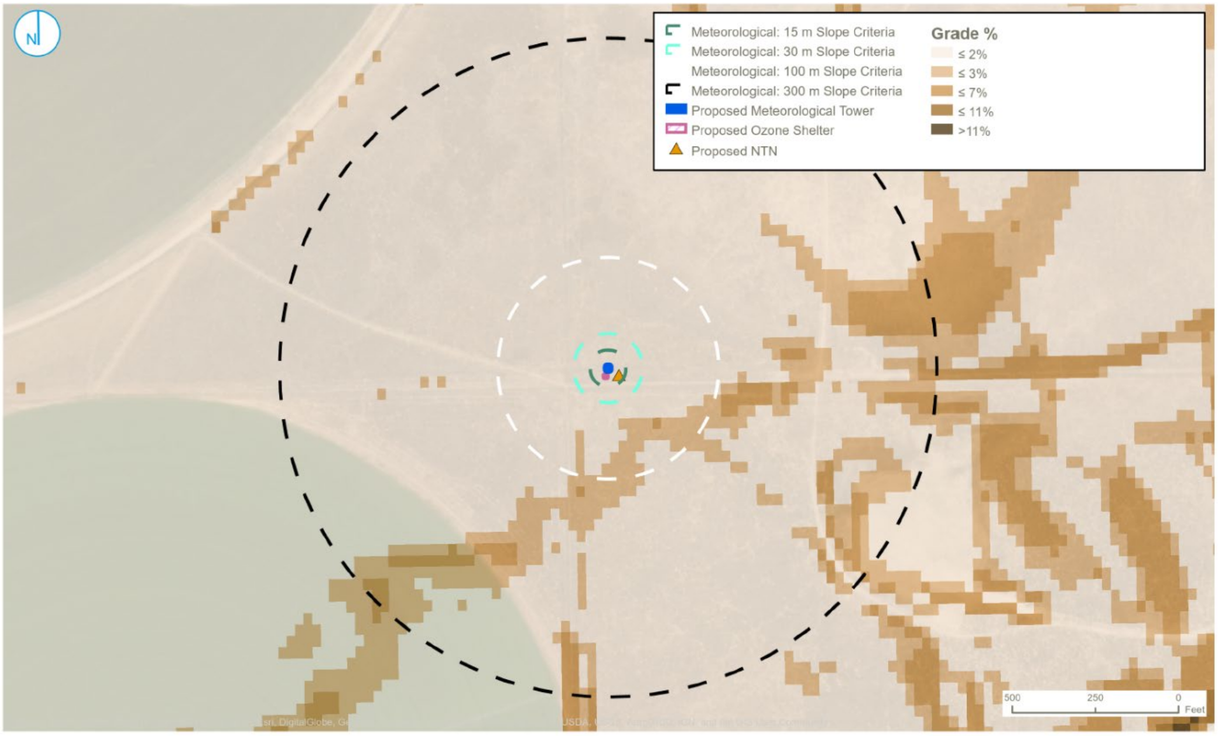

Figure 14: Orchard Monitoring Site Layout with Meteorology Tower Slope Setback Highlights- see text for detailed ring explanations

Photos of the selected monitoring site and surrounding area are shown below.

Figure 15: Photo#5: Looking North

Figure 16: Photo#6: Looking South

Figure 17: Photo#7: Looking East

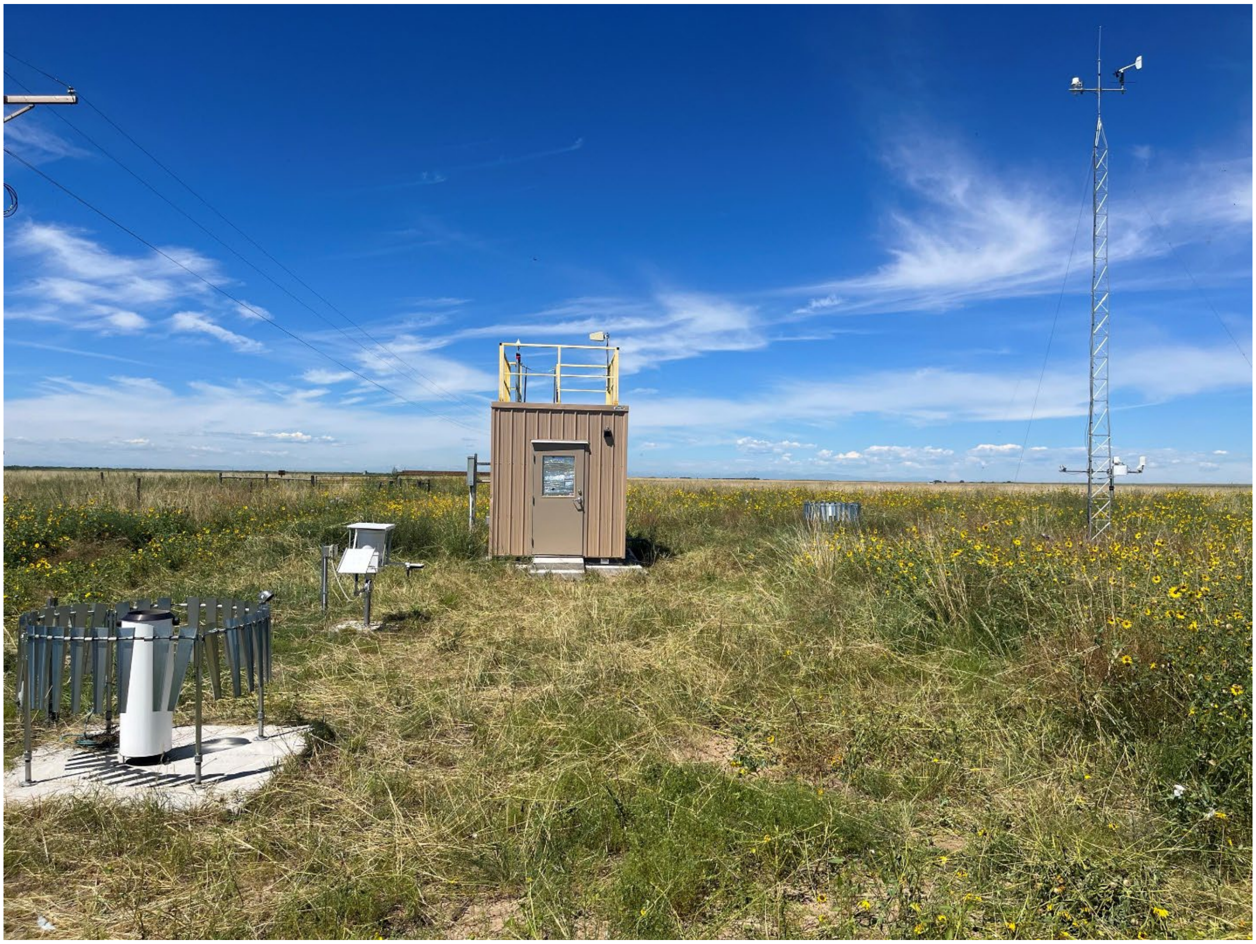

Figure 18: Photo#8: Looking West

2.1.3 Hereford Site

The Hereford Monitoring site consists of a small semi-triangular plot of land in the town of Hereford, CO. The plot is surrounded by agricultural development to the north and residential housing to the south. The nearest agricultural fields are approximately 60 m to the northeast. The nearest residential house is approximately 40 m to the southeast. On the nearest residential plot are trees that are approximately 8 m tall. The plot contains a drainage wash that is widest at its east side and narrows to the west. It occupies a majority of the plot and is approximately 1 m deep. There are two 5 m tall trees along the eastern edge of the plot. Power lines run alongside the southwestern edge of the plot.

The Hereford Monitoring shelter will be located on the southern portion of the plot, at 1619 m asl. The tower will be located approximately 10 m west of the shelter. Although there is power at the lot, a new electrical drop will likely be needed to power the 100-amp, 120/240 VAC single phase service panel in the shelter. See Figure 19 through Figure 21 for the site layout. Figure 19 and Figure 20 show the current setback at the site for the shelter and the meteorology tower, respectively. Figure 21 shows the grading of the terrain in proximity to the meteorology tower.

In Figure 19:

- For the monitoring shelter, the distance to any obstructions should be twice the height of the obstruction away. The distance to any trees should also be at least 10 m. The blue ring shows that there are no buildings or trees within 15 m of the monitoring shelter.
- For the monitoring shelter, the distance to any roadways should be 10 m. The white ring shows that there is one roadway within 20 m of the shelter. This roadway does not see more than 1,000 vehicles per day, so it is acceptable.

Figure 20:

- For temperature and relative humidity, the requirement is that no irrigated ground be present within 9 m of their location. The yellow ring represents the radius around which no irrigation should occur. This plot of land is not irrigated at all.
- For temperature and relative humidity, the requirement is that no paved surfaces be present within 30 m of their location. The black ring shows this 30 m setback and how there are no paved surfaces within this setback.
- For wind speed and direction, the distance to any obstructions should be at least 10 times the height of the obstruction away. That will not be entirely possible for the monitoring shelter, which about 10 m away. However, the blue ring shows that there are no other obstructions within 80 m of the tower. The trees southeast of the tower are below 8 m tall.

Figure 21:

- The dark blue ring represents the setback (15 m) where the ground slope should be less than 2%.
- The teal ring represents the setback (30 m) where the ground slope should be less than 3%.
- The white ring represents the setback (100 m) where the ground slope should be less than 7%.
- The black ring represents the setback (300 m) where the ground slope should be less than 11%.

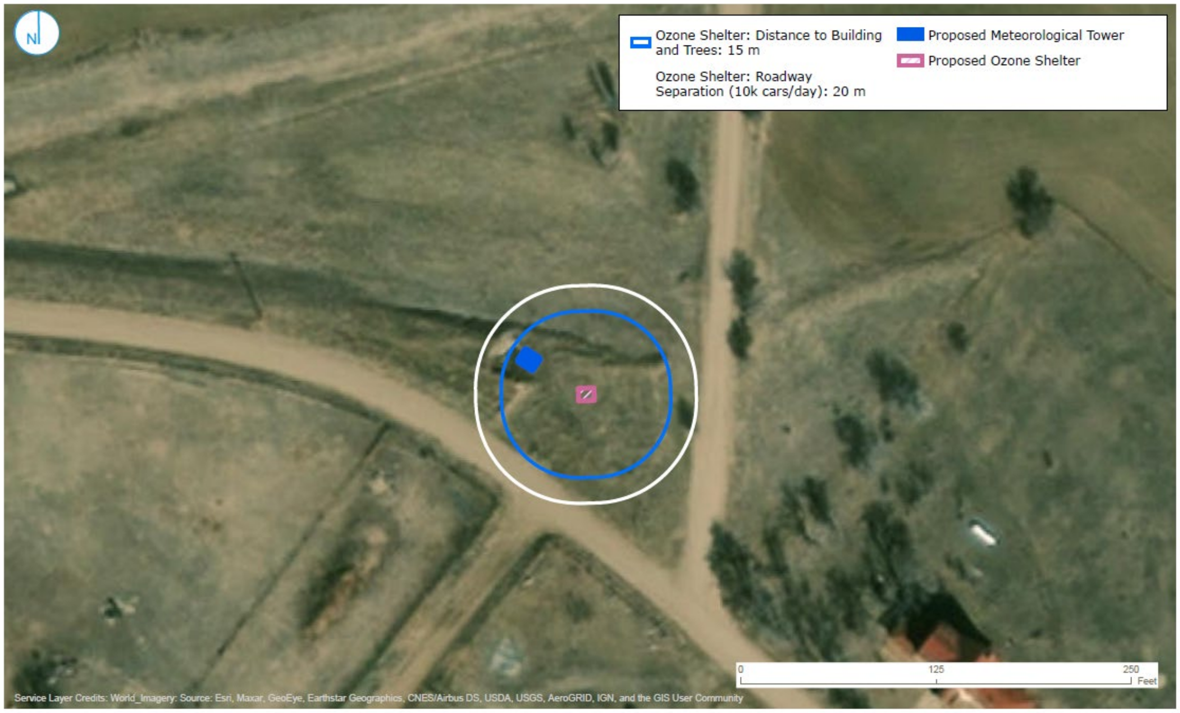

Figure 19: Hereford Monitoring Site Layout with Shelter and NTN Setback Highlights - see text for detailed ring explanations

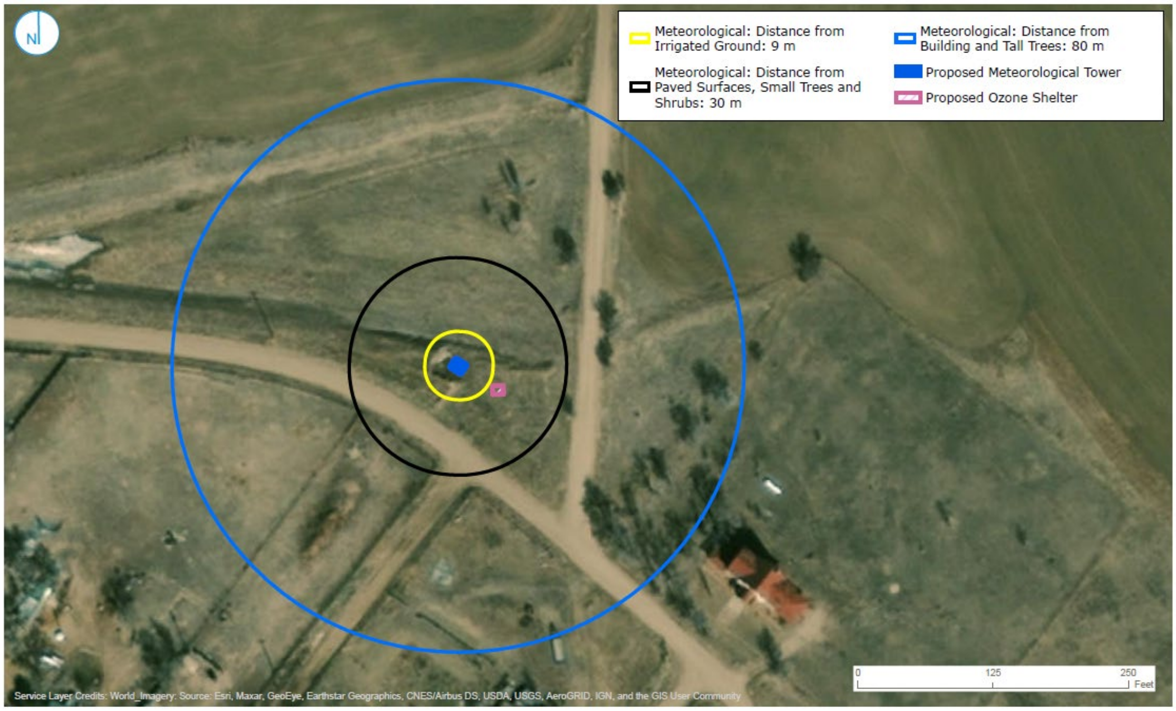

Figure 20: Hereford Monitoring Site Layout with Meteorology Tower Setback Highlights-see text for detailed ring explanations

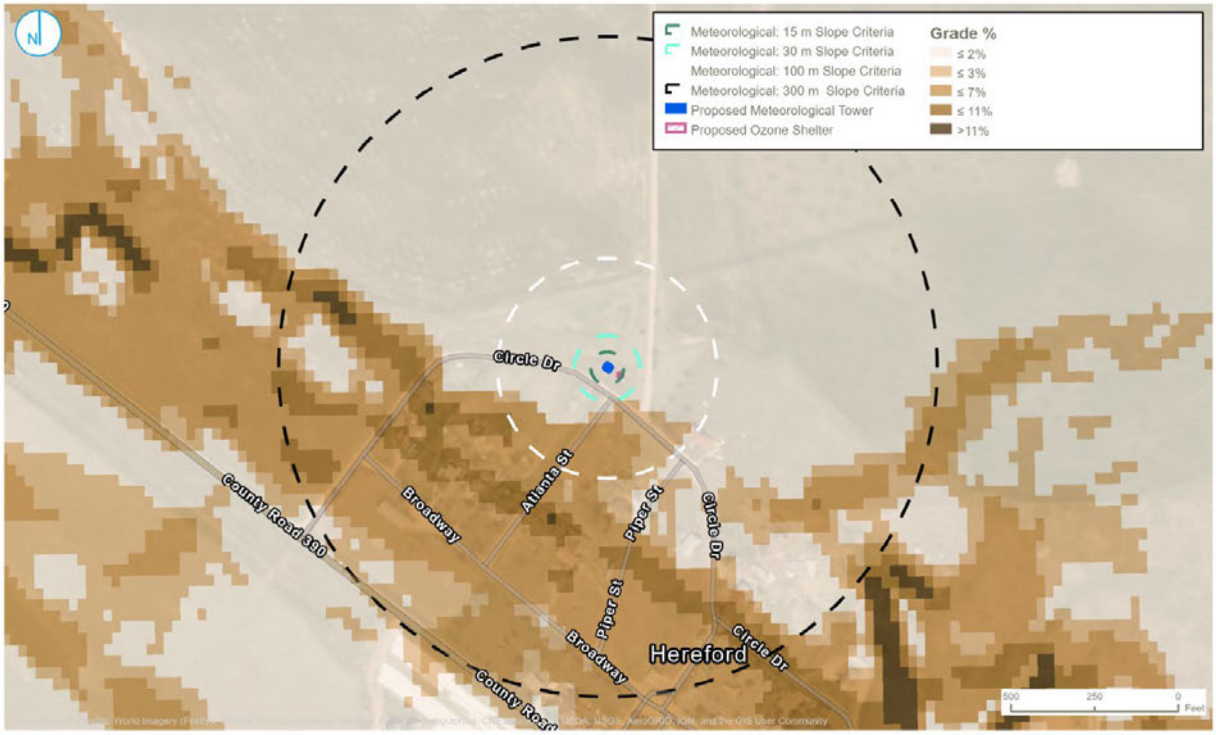

Figure 21: Hereford Monitoring Site Layout with Meteorology Tower Slope Setback- see text for detailed ring explanations Highlights

Photos of the selected monitoring site and surrounding area are shown below.

Figure 22: Photo#9: Looking North

Figure 23: Photo#10: Looking South

Figure 24: Photo#11: Looking East.

Figure 25: Photo#12: Looking West.

2.2 Sampling Methods

2.2.1 Ambient Air Quality Data Collection

The ambient air quality data will be collected with equipment listed in Table 6. At the Missile Site Park and Orchard sites, there will also be passive Radiello® samplers for ammonia monitoring that will occur via the NADP's AMoN network. There will also be precipitation collection buckets for wet deposition sampling that will occur via the NADP's NTN network. The standard operating procedures for NADP laboratory methods are listed in the two following sections. A summary of field methods are also listed in the following sections. All sites will have identical O_3 analyzers, with the Missile Site Park site also having a NO_x analyzer. The gaseous analyzers have been designated by the USEPA as Equivalent or Reference Methods. The equivalence/reference method numbers are provided in the two following sections below. Each site will include a climate-controlled instrument shelter and was installed with a glass inlet with a 4-port glass manifold to allow several instruments to sample the same air stream. On July 20, 2021 the glass inlet and manifolds at each site were bypassed with ¼" Perfluoroalkoxy (PFA) tubing. Detailed maintenance and cleaning information is provided in Section 2.5 of this QMP/QAPP. A detailed description of the equipment is discussed below.

Table 6: Ambient Air Quality Monitoring Equipment List

Measurement	Manufacturer	Model	Serial Number	Zero and Span Noise	Detection Limit	Drift Over 24-hour Period	Response Time	Units
Missile Site Park								
O_3	Teledyne Advanced Pollution Instrumentation (TAPI)	T400 (w/Nafion inlet conditioner; part number MD-110-72P-4)	5986	<0.2 ppb @ 0 ppb & <0.5% reading above 100 ppb	<0.4 ppb	<1 ppb @ 0 ppb & <1% of reading @ span	<30 seconds to 95%	ppb, ppm, µg/m^3, mg/m^3
NO_x	TAPI	T200 (w/ sample conditioner; part number KIT000262)	6727	<0.1 ppb @ 0 ppb & <0.2% reading above 50 ppb	<0.2 ppb	<0.5 ppb @ 0 ppb & <0.5% of reading @ full scale	<80 seconds to 95%	ppb, ppm, µg/m^3, mg/m^3
Gas Dilution/O_3 Transfer Standard	TAPI	T700	4969	1% of reading (linearity)	N/A	<1.0 ppb @ 0 ppb	<20 seconds to 95% (photometer response)	N/A
Zero Air Generator	TAPI	T701	1961	NO/NO2 < 0.1 ppb; O3 < 0.4 ppb	N/A	N/A	N/A	N/A
NH_3	Radiello®	N/A	N/A	N/A	0.083 mg/L (Network) 0.013 mg/L (Lab)	N/A	N/A	N/A
National Trends Network	N/A	N/A	N/A	N/A	Ca (0.023 mg/L) Mg (0.006 mg/L) K (0.005 mg/L) Na (0.010 mg/L) Br (0.006 mg/L) NH_4 (0.017 mg/L) NO_3 (0.018 mg/L) Cl (0.018 mg/L) SO_4 (0.018 mg/L) PO_4 (0.010 mg/L) Conductance (µS/cm) pH	N/A	N/A	N/A

Measurement	Manufacturer	Model	Serial Number	Zero and Span Noise	Detection Limit	Drift Over 24-hour Period	Response Time	Units
Orchard								
O_3	TAPI	T400 (w/Nafion inlet conditioner; part number MD-110-72P-4)	5985	<0.2 ppb @ 0 ppb & <0.5% reading above 100 ppb	<0.4 ppb	<1 ppb @ 0 ppb & <1% of reading @ span	<30 seconds to 95%	ppb, ppm, μg/m^3, mg/m^3
O_3 Transfer Standard	TAPI	T703	824	±1% of full scale (linearity)	N/A	<1 ppb @ 0 ppb (7 days) & <1% @ span	<20 seconds to 95% (photometer response)	N/A
NH_3	Radiello®	N/A		N/A	0.083 mg/L (Network) 0.013 mg/L (Lab)	N/A	N/A	N/A
National Trends Network	N/A	N/A	N/A	N/A	Ca (0.023 mg/L) Mg (0.006 mg/L) K (0.005 mg/L) Na (0.010 mg/L) Br (0.006 mg/L) NH_4 (0.017 mg/L) NO_3 (0.018 mg/L) Cl (0.018 mg/L) SO_4 (0.018 mg/L) PO_4 (0.010 mg/L) Conductance (μS/cm) pH	N/A	N/A	N/A

Measurement	Manufacturer	Model	Serial Number	Zero and Span Noise	Detection Limit	Drift Over 24-hour Period	Response Time	Units
				Hereford				
O_3	TAPI	T400 (w/Nafion inlet conditioner; part number MD-110-72P-4)	5984	<0.2 ppb @ 0 ppb & <0.5% reading above 100 ppb	<0.4 ppb	<1 ppb @ 0 ppb & <1% of reading @ span	<30 seconds to 95%	ppb, ppm, μg/m^3, mg/m^3
O_3 Transfer Standard	TAPI	T703	825	±1% of full scale (linearity)	N/A	<1 ppb @ 0 ppb (7 days) & <1% @ span	<20 seconds to 95% (photometer response)	N/A

Notes:

O_3	Ozone	Ppb	Parts per billion	Mg	Magnesium	NH_4	Ammonium
NO_x	Oxides of nitrogen	Ppm	Parts per million	K	Potassium	NO_3	Nitrate
NH_3	Ammonia	μg/m^3	Micrograms per meter cubed	Na	Sodium	Cl	Chloride
mg/m^3	Milligrams per meter cubed	Ca	Calcium	Br	Bromide	SO_4	Sulfate
PO_4	Phosphate	μS/cm	Micro-Siemens per centimeter	pH	Acidity		

2.2.1.1 O_3

Measurements of ambient O_3 concentrations will be made with a TAPI, Model T400, Photometric O_3 Analyzer. According to the manufacturer's instruction manual published on October 30, 2018 this analyzer has been designated by the U.S. EPA as an equivalent method for measurement of O_3, as set forth in 40 CFR Part 53. The EPA Designated Equivalent Method Number is EQOA-0992-087.

2.2.1.2 NO-NO_2-NO_x

Measurements of ambient nitrogen oxide(s) concentrations will be made with a TAPI, Model T200, Chemiluminescence NO-NO_2-NO_x Analyzer. Note, the sampler conditioner was added after the instrument had been running for 4 months. According to the manufacturer's instruction manual published on June 17, 2019 this analyzer has been designated by the U.S. EPA as a reference method for measurement of nitrogen dioxide, as set forth in 40 CFR Part 53. The EPA Designated Reference Method Number is RFNA-1194-099.

2.2.1.3 Ammonia

Measurements of ambient ammonia concentrations will be made with Radiello® passive samplers provided by the NADP as part of the AMoN program. The Radiello® samplers are diffusive samplers that are left to sample for two-week periods. After each sampling period, the samplers are sent to the NADP for Flow Injection Analysis (NADP 2020d,e). More information about AMoN laboratory methods can be found on the NADP's website (http://nadp.slh.wisc.edu/AMoN/). For detailed AMoN laboratory methods, the relevant laboratory standard operating procedures (SOPs) are listed below:

- Ammonium from the Radiello® samplers is extracted via sonication. Ammonium concentration is determined via Flow Injection Analysis (FIA) and the Berthelot reaction. More detailed information about the analysis method and sample preparation can be found in the following NADP SOPs, which are available from the NADP upon request.
    - NADP SOP 400 Preparation of Passive Ammonia Diffusive Samplers (NADP 2021)
    - NADP SOP 401 Extraction of Passive Ammonia Samplers (NADP 2020d)
    - NADP SOP 502 Determination of Ammonium by Flow Injection Analysis (NADP 2020e)

Complete instructions for AMoN field SOPs can be found on the NADP's website (http://nadp.slh.wisc.edu/siteops/amon.aspx). The instructions below are summarized from NADP 2014.

- When removing or installing an AMoN sampler, gloves must be worn. The sampler must be held by the top coupler of the sampler only. Operators must not breathe or perspire directly onto the sampler. Samples are also replaced on a consistent time cycle (2 weeks, Tuesday-Tuesday) at the same time to maintain a consistent sampling period.
- Each sampler comes with its own field data sheet. The previous cycle's data sheet is completed before a new sampler is installed for a new cycle.
- After the data sheet is complete and the sampler removed, a new sampler is installed and the start date and time for the deployment is written down.
    - Other notes added to the field data sheets include weather conditions, foliage conditions, and additional observations (e.g. nearby grazing).
- In order to track potential travel contamination, travel blanks are occasionally supplied by the NADP (less than twice per year). Duplicate samples are also supplied by the NADP, but this occurs less than twice per year unless explicitly requested (more fees must be paid).

2.2.2 Meteorological Data Collection

Meteorological data will be collected at the height and with the equipment listed in Table 7. The equipment meets or exceeds the EPA specified equipment performance standards listed in Table 4. A detailed description of the equipment that will be used is discussed further in this section. As previously discussed, all three sites will use identical meteorology equipment installed at the same levels on their respective towers. Although included in Table 7, the NADP equipment is not considered standard meteorology equipment.

Table 7: Meteorological Monitoring Equipment List

Measurement	Count	Equipment Height (m)	Manufacturer	Model	Serial Number	Accuracy	Range	Description
Missile Site Park								
Wind speed & direction	1	10	R.M. Young	05305V	180188	±0.2 m/s & ±3 degrees	0-50 m/s 0-355 deg	Wind monitor
Ambient temperature/Vertical temperature difference	2	2m and 10m	R.M. Young	41342VC	32951 (2 m) 32952 (10 m)	±0.1 °C	-50 to 50°C	Temperature probe with radiation shield
Relative humidity (RH)	1	2	Campbell Scientific/E+E Elektronik	EE181	20151600125038	±1.3% RH [1]	0-100%	Relative humidity and temperature sensor
Solar radiation	1	2	Hukseflux	LP02	48019	<0.15% per °C	0-2000 W/m^2	Thermal pyranometer
Barometric pressure	1	2	Setra	278	7563464	±1.5 hPa[2]	450-825 mmHg	Barometric pressure sensor
Precipitation	1	Ground	R.M. Young	52202	TB16137	2%-3% [3]	0-50 mm/hr	Heated tipping bucket rain gauge
Precipitation-NTN	1	Ground	ETI Instrument Systems	NOAH IV	4310	±0.254 mm	0-280 in/hour	Weight-based rain gauge
Collection bucket-NTN	1	Ground	N-CON	00-120-2N	60441	N/A	N/A	Wet deposition collection buckets
Orchard								
Wind speed & direction	1	10	R.M. Young	05305V	180186	±0.2 m/s & ±3 degrees	0-50 m/s 0-355 deg	Wind monitor
Ambient temperature/Vertical temperature difference	2	2m and 10m	R.M. Young	41342VC	32953 (2 m) 32954 (10 m)	±0.1 °C	-50 to 50°C	Temperature probe with radiation shield
Relative humidity	1	2	Campbell Scientific/E+E Elektronik	EE181	201516001269F1	±1.3% RH [1]	0-100%	Relative humidity and temperature sensor

Measurement	Count	Equipment Height (m)	Manufacturer	Model	Serial Number	Accuracy	Range	Description
Solar radiation	1	2	Hukseflux	LP02	48014	<0.15% per °C	0-2000 W/m^2	Thermal pyranometer
Barometric pressure	1	2	Setra	278	7563445	±1.5 hPa [2]	450-825 mmHg	Barometric pressure sensor
Precipitation	1	Ground	R.M. Young	52202	TB16138	2% - 3% [3]	0-50 mm/hr	Heated tipping bucket rain gauge
Precipitation-NTN	1	Ground	ETI Instrument Systems	NOAH IV	4311	±0.254 mm	0-280 in/hour	Weight-based rain gauge
Collection bucket-NTN	1	Ground	N-CON	00-120-2N	60442	N/A	N/A	Wet deposition collection buckets
Hereford								
Wind speed & direction	1	10	R.M. Young	05305V	180187	±0.2 m/s & ±3 degrees	0-50 m/s 0-355 deg	Wind monitor
Ambient temperature/Vertical temperature difference	2	2m and 10m	R.M. Young	41342VC	32950 (2 m) 32869 (10 m)	±0.1 °C	-50 to 50°C	Temperature probe with radiation shield
Relative humidity	1	2	Campbell Scientific/E+E Elektronik	EE181	2015160012638F	±1.3% RH [1]	0-100%	Relative humidity and temperature sensor
Solar radiation	1	2	Hukseflux	LP02	48015	<0.15% per °C	0-2000 W/m^2	Thermal pyranometer
Barometric pressure	1	2	Setra	278	7573233	±1.5 hPa [2]	450-825 mmHg	Barometric pressure sensor
Precipitation	1	Ground	R.M. Young	52202	TB16139	2% - 3% [3]	0-50 mm/hr	Heated tipping bucket rain gauge

Notes:

%	Percent	m/s	Meters per second	W/m^2	Watts per meter squared
ºC	Degrees Celsius	RH	Relative humidity	mmHg	Millimeters of mercury
mm/hr	Millimeters per hour	deg	Degrees	in/hour	Inches per hour

[1] This accuracy range is specified when the temperature is between -15 to 40 °C and the RH is between 0 and 90%. Above 90% RH, the accuracy decreases to ±2.3% RH
[2] This accuracy range is achieved when the temperature is between -20 to 50 °C.
[3] This accuracy is 2% when the precipitation rate is 25 mm/hr or less and the accuracy is 3% when the precipitation rate is between 25 mm/hr and 50 mm/hr.

2.2.2.1 Wind Speed and Direction

Surface wind speed and direction will be measured with an R.M. Young Wind Monitor, Model # 05305. Monitors will be installed at heights of 10 meters above ground level (agl). The monitors will comply with performance requirements as outlined in the EPA document, EPA-454/B-08-002. The equipment will exhibit a starting threshold of less than 0.5 m/s wind speed (at 10 degrees deflection for direction vanes). The equipment will be accurate above the starting threshold to within 0.2 m/s or 1% of measurement reading. The damping ratio of the wind vane will be 0.45 and the distance constant will not exceed 5 m. The wind direction error will not exceed 5 degrees, including sensor orientation errors. The wind vane orientation procedures will be documented at time of installation and initial calibration.

2.2.2.2 Temperature and Temperature Difference (Delta-T)

Ambient temperature and vertical temperature difference will be measured with two identical R.M. Young Temperature probes, Model # 41342-VC. The probes will be installed at heights of 2- and 10-m agl. The probe complies with performance requirements as outlined in the EPA document, EPA-454/B-08-002. Sensor accuracy and response will be documented at time of installation and initial calibration.

2.2.2.3 Radiation

Solar radiation will be measured with a Hukseflux Pyranometer, Model # LP02. The probe will be installed at a height of 2 meters agl. The probe complies with performance requirements as outlined in the EPA document, EPA-454/B-08-002. Sensor accuracy and response will be documented at time of installation and initial calibration.

2.2.2.4 Precipitation

Precipitation will be measured with an R.M. Young, Model # 52202 heated tipping bucket precipitation gauge. This heated tipping bucket rain gauge will be installed at ground level and will be surrounded by a Novalynx Alter-Type wind screen. The gauge complies with performance requirements as outlined in the EPA document, EPA-454/B-08-002. Sensor accuracy and response will be documented at time of installation and initial calibration.

2.2.2.5 Relative Humidity

Relative humidity will be measured with an E+E Elektronik/Campbell Scientific, Model # EE181 Temperature and Relative Humidity Probe. This probe will be installed at a height of 2 meters agl. The sensor complies with performance requirements as outlined in the EPA document, EPA-454/B-08-002. Sensor accuracy and response will be documented at time of installation and initial calibration.

2.2.2.6 Barometric Pressure

Barometric pressure will be measured with a Setra Barometric Pressure Sensor, Model # CS100. This probe will be installed inside the equipment shelter. The sensor complies with performance requirements as outlined in the EPA document, EPA-454/B-08-002. Sensor accuracy and response will be documented at time of installation and initial calibration.

2.2.2.7 NTN Precipitation

An NADP-approved additional precipitation gauge, an ETI Instrument Systems Model # NOAH IV, will be located at the Missile Site Park and Orchard sites. This precipitation gauge is a weight-based measurement gauge that has been approved by the NADP for use in their network. The probe will be installed at ground level and will be surrounded by a Novalynx Alter-Type wind screen. The sensor complies with the Guidelines for Evaluation and Approval of Equipment[13] document and is one of two approved sensors on the NADP Shared Services and Responsibilities V2 document (available by request from the NADP)[14].

2.2.2.8 NTN Nitrogen wet deposition collection bucket

An NADP-approved precipitation collection bucket, an N-CON Model # 00-120-2N, will be located at the Missile Site Park and Orchard sites. The precipitation collection system consists of a collection bucket system that selectively opens when precipitation occurs. The lever arm that opens and closes the lid to the bucket is driven by an AC powered motor. The collection bucket complies with the Guidelines for Evaluation and Approval of Equipment document and is one of three N-CON approved collection buckets on the NADP Shared Services and Responsibilities V2 document (available by request from the NADP)[14]. For detailed NTN laboratory methods, the relevant SOPs are listed below:

- For NTN, the concentrations of the different ions are determined via Inductively Coupled Plasma – Optical Emission Spectroscopy, Ion Chromatography, and FIA. The pH and conductivity measurements are made with an ion meter. More detailed information of each analysis method and sample preparation can be found in the following NADP SOPs, which are available from the NADP upon request.
    - NADP SOP 402 NTN Sample Filtration (NADP 2020f)
    - NADP SOP 403 NTN Supply Preparation (NADP 2020g)
    - NADP SOP 500 ICP-OES (NADP 2020h)
    - NADP SOP 501 Ion Chromatography (NADP 2020i)
    - NADP SOP 503 Determination of Ammonium and Orthophosphate by FIA (NADP 2020j)
    - NADP SOP 504 Manual pH (NADP 2020k)
    - NADP SOP 505 Manual Measurement of Specific Conductance (NADP 2020l)

Complete instructions for NTN field operations, including text and visual guides, can be found on the NADP's website (http://nadp.slh.wisc.edu/siteops/bagsfaq.aspx). The instructions below are summarized from NADP 2020a, NADP 2020b, and NADP 2020c.

- When handling the bag sampler or associated lids, gloves must be worn. Care must be taken to ensure that the inner portion of the bag or the inside portion of the lid is not touched, even by gloved hands. Gloves must be changed out frequently, especially after handling other items. The operator must also be sure to not stand directly over an open sample bag. These precautions are in place to prevent sample contamination and must be followed when performing the routine preparation and sampling operations listed below.
- First the NTN bucket must be cleaned with distilled or deionized water.
- After the sample bag is placed in the bucket and air is vacuumed out of the bucket, the bucket, bag, strap, and plug are weighed, and the weight is recorded on the sample's associated data sheet.
    - An unused lid is then placed on the bucket/bag to protect it during transfer to the site. This ensures that the weight of sample collected is truly the weight of the sample and that the sample bag cannot be contaminated during transport.

[13] NADP (2018). Guidelines for Evaluation and Approval of Equipment for the NADP Wet Deposition Networks. Downloaded from: http://nadp.slh.wisc.edu/siteops/lib/other/NADP-2012_Guidelines_for_Evaluation_and_Approval_of_Equipment_v_2-0.pdf. Accessed September 2020.

[14] NADP (2020). NADP Shared Services and Responsibilities. Requested June 2020.

- When removing the previous week's sample, the operator must approach from the downwind side to prevent last minute contamination.
- The same lid used to transport the previous week's sample is then placed back on to the sample to avoid cross contamination.
- The previous week's sample is then removed and the date and time recorded.
  - Notes about the condition of the collector apparatus are taken as they can be crucial in identifying potential sources of contamination (e.g. a dirty collector cover).
- After cleaning measures are completed with the collector, the new sample is installed and the date and time recorded.
- All precipitation data is downloaded from the data logger and recorded onto the previous week's field data form.
  - This is to ensure that any sample collected does correspond to precipitation. Site condition notes are also recorded on the field data sheet.
- The previous week's sample is then weighed (with the lid and 'tare' weight accounted for). The sample is then decanted into a shipping bottle for shipment to the NADP labs.

2.2.3 General Site Equipment

In addition to the analyzers and calibration systems needed to collect meteorological and ambient air quality data, other equipment is also required for each monitoring site. A detailed equipment list for each site is provided in Table 8. Equipment shelters will also include a ladder (for roof access), roof safety railing, insulated flooring, roof, and walls, and an integrated heat/air conditioning system. The heating/air-conditioning system will be used to maintain the shelters between 20 and 30 degrees Celsius, which is well within the operating range that the ozone and nitrogen dioxide analyzers require to maintain their equivalence or reference status (between 5 and 40 degrees Celsius).

Table 8: General Monitoring Site Equipment

Equipment	Quantity	Manufacturer	Model	Serial #	Description
Missile Site Park					
Equipment Shelter	1	American Portable Buildings	SS1020	A-9460,61&62	8'X10'X10' shelter
Data Processing/ Management	1	Campbell Scientific	CR3000	13406	Micrologger
Communications	1	HP	14-DK1031DX	-	Laptop computer
Communications	1	Campbell Scientific	RV50X	-	Cellular modem
Shelter temperature	1	Campbell Scientific	CR3000	13406	Logger panel temperature sensor
Meteorological Tower	1	Campbell Scientific	UT30	-	10 meter tower
Equipment Rack	1	Hammond Manufacturing	C2F197031BK1	-	Rack for gas analyzers
Zero Air Supply	1	TAPI	T701	TBD	Zero air delivery system
Orchard					
Equipment Shelter	1	American Portable Buildings	SS1020	A-9460,61&62	8'X10'X10' shelter

Equipment	Quantity	Manufacturer	Model	Serial #	Description
Data Processing/ Management	1	Campbell Scientific	CR3000	13405	Micrologger
Communications	1	HP	14-DK1031DX	-	Laptop computer
Communications	1	Campbell Scientific	RV50X	-	Cellular modem
Shelter temperature	1	Campbell Scientific	CR3000	13405	Logger panel temperature sensor
Meteorological Tower	1	Campbell Scientific	UT30	-	10 meter tower
Equipment Rack	1	Hammond Manufacturing	C2F197031BK1	-	Rack for gas analyzers
Hereford					
Equipment Shelter	1	American Portable Buildings	SS1020	A-9460,61&62	8’X10’X10’ shelter
Data Processing/ Management	1	Campbell Scientific	CR3000	13408	Micrologger
Communications	1	HP	14-DK1031DX	-	Laptop computer
Communications	1	Campbell Scientific	RV50X	-	Cellular modem
Shelter temperature	1	Campbell Scientific	CR3000	13408	Logger panel temperature sensor
Meteorological Tower	1	Campbell Scientific	UT30	-	10 meter tower
Equipment Rack	1	Hammond Manufacturing	C2F197031BK1	-	Rack for gas analyzers

2.3 Sample Handling and Custody

No physical samples will be collected as part of the Weld monitoring network, except for NTN and AMoN samples at MSP and Orchard. The collection of those samples will follow NADP protocol. For AMoN, biweekly samples will be shipped to Weld County Site Operators, which also include site forms. These site forms are returned to the CAL with each sampler and include site information and operator information (NADP 2014). For the wet deposition NTN samples, supplies are also sent to the Weld County Site Operators. A weekly site visit form is filled out by the operator, even when no sample is collected. Sample forms include site information, sampler condition, operator name, and are returned to the lab even when no sample is collected (NADP 2020a, 2020b, 2020c). Gloves are required for all activities requiring sample handling. Detailed sample handling and associated quality assurance protocols are described in Section 2.2 of this QMP/QAPP, along with specific NADP laboratory SOPs.

2.4 Quality Control

QC standards are needed to ensure that the collected data meet standards of accuracy and reliability. All Critical, Operational, and Systematic Criteria as outlined in Appendix D of the document titled “EPA-454/B-17-001” will be followed. Some ozone criteria from EPA-454/B-17-001, EPA-454/B-10-001, and EPA-454/B-13-004 have been superseded with the publication of technical assistance document EPA-454/B-22-003[15] for ozone transfer standards. Table 9 below summarizes Appendix D of EPA-454/B-17-001 and includes the most recent changes to the quality control procedures for the calibration of ozone transfer standards. Meteorological data QC screening criteria and procedures are described in more detail in Section 2.8.1.

The program QC procedures will include once a week remote diagnostic checks (flow rates, sampling pressure, instrument alarm checks) of the gaseous equipment for 1-month following installation. Any required sampler maintenance or repair will also be documented in the field log. The proposed data validation frequency for this project is at 1-week intervals to allow early detection of sampler malfunctions. Any discrepancies in the data will be brought to the attention of the QA Officer, and corrective action will be implemented.

Calculations of measurement uncertainty will be carried out by the procedures listed in 40 CFR Part 58, Appendix A, and have been included below.

2.4.1 Statistics for the Assessment of QC Checks for NO_2 and O_3

2.4.1.1 Percent Difference

All measurement quality checks start with a comparison of an audit concentration to the concentration measured by the analyzer and use percent difference as the comparison statistic as described in equation 1 of this section. For each single point check, calculate the percent difference, d_i, as follows:

Equation 1

$$d_i = \frac{\text{meas} - \text{audit}}{\text{audit}} \times 100$$

Where, *meas* is the concentration indicated by the monitoring organization's instrument and audit is the audit concentration of the standard used in the QC check being measured.

2.4.1.2 Precision Estimate

The precision estimate is used to assess the one-point QC checks for NO_2 or O_3 described in 40CFR58 Appendix A, Section 4.1.2. The precision estimator is the coefficient of variation upper bound and is calculated using equation 2:

Equation 2

$$CV = \sqrt{\frac{n \cdot \sum_{i=1}^{n} d_i^2 - \left(\sum_{i=1}^{n} d_i\right)^2}{n(n-1)}} \cdot \sqrt{\frac{n-1}{X^2_{0.1,n-1}}}$$

Where, $X^{2\ 0.1,n-1}$ is the 10th percentile of a chi-squared distribution with n−1 degrees of freedom.

2.4.1.3 Bias Estimate

The bias estimate is calculated using the one-point QC checks for NO_2 or O_3 described in Section 4.1.3 of 40CFR58 Appendix A. The bias estimator is an upper bound on the mean absolute value of the percent differences as described in equation 3 below:

15 Transfer Standards for Calibration of Air Monitoring Analyzers for Ozone Technical Assistance Document. Accessed at https://www.epa.gov/system/files/documents/2023-11/o3_tad_508_20230906_final.pdf

Equation 3

$$|AB| = AB + t_{0.95,n-1} \cdot \frac{AS}{\sqrt{n}}$$

Where, *n* is the number of single point checks being aggregated; $t_{0.95,n-1}$ is the 95th quantile of a distribution with n–1 degrees of freedom; the quantity *AB* is the mean of the absolute values of the d_i's and is calculated using equation 4 below:

Equation 4

$$AB = \frac{1}{n} \cdot \sum_{i=1}^{n} |d_i|$$

and the quantity A*S* is the standard deviation of the absolute value of the d_i's and is calculated using equation 5 below:

Equation 5

$$AS = \sqrt{\frac{n \cdot \sum_{i=1}^{n} |d_i|^2 - \left(\sum_{i=1}^{n} |d_i|\right)^2}{n(n-1)}}$$

2.4.1.4 Assigning a sign (positive/negative) to the Bias Estimate

Since the bias statistic as calculated in equation 3 of this section uses absolute values, it does not have a tendency (negative or positive bias) associated with it. A sign will be designated by rank ordering the percent differences of the QC check samples from a given site for a particular assessment interval.

2.4.1.5 25th and 75th percentiles of the percent differences for each site

The absolute bias upper bound should be flagged as positive if both percentiles are positive and negative if both percentiles are negative. The absolute bias upper bound would not be flagged if the 25th and 75th percentiles are of different signs.

2.4.1.6 Validation of Bias Using the One-Point QC Checks

The annual performance evaluations for NO_2 or O_3 described in 40CFR58 Appendix A, Section 3.1.2 are used to verify the results obtained from the one-point QC checks and to validate those results across a range of concentration levels. To quantify this annually at the site level and at the 3-year primary QA organization level, probability limits will be calculated from the one-point QC checks using equations 6 and 7:

Equation 6

$$\text{Upper Probability Limit} = m + 1.96 \cdot S$$

Equation 7

$$\text{Lower Probability Limit} = m - 1.96 \cdot S$$

where, *m* is the mean (equation 8 below):

Equation 8

$$m = \frac{1}{k} \cdot \sum_{i=1}^{k} d_i$$

Where, k is the total number of one-point QC checks for the interval being evaluated and S is the standard deviation of the percent differences (equation 9) as follows:

Equation 9

$$S = \sqrt{\frac{k \cdot \sum_{i=1}^{k} d_i^2 - \left(\sum_{i=1}^{k} d_i\right)^2}{k(k-1)}}$$

2.4.1.7 Percent Difference

Percent (%) differences for the performance evaluations, calculated using equation 1 can be compared to the probability intervals for the respective site or at the primary QA organization level. 95% of the individual % differences (all audit concentration levels) for the performance evaluations should be captured within the probability intervals for the primary QA organization.

Table 9: Ambient Air Quality Monitoring Measurement Criteria and Performance Evaluation

Method	Minimum Frequency	Acceptance/ Criteria	Monitoring Network Targets
Critical Criteria			
One-Point QC Check: Single Analyzer NO_2 O_3	Once per 2 weeks	 <± 15.1% (% difference) or < ±1.5 ppb difference whichever is greater <± 7.1% (% difference) or < ±1.5 ppb difference whichever is greater	 NO2:0.005-0.08 ppm Twice per week O3: 0.005-0.08 ppm 3x per week
Zero/Span Check NO_2 O_3	Once per 2 weeks	 Zero drift < ± 3.1 ppb (24 hr) < ±5.1 ppb (>24 hr-14 day) Span drift < ±10.1% Zero drift < ± 3.1 ppb (24 hour) < ± 5.1 ppb (>24 hr-14 day) Span drift < ±7.1%	 NO2: 0.4 ppm Twice per week O3: 0.4 ppm 3x per week
Converter Efficiency (NO_2 only)	During multi-point calibrations, span and audit; Once per 2 weeks	(≥96%) 96%-104.1%[16]	Twice per week
Operational Criteria			
Shelter Temperature Range	Daily	20.0 to 30.0 °C (Hourly Avg) or per manufacturers specifications if designated to a wider temperature range	Climate control set to 23-25 °C
Shelter Temperature Control	Daily (hourly values)	< 2.1 °C SD over 24 hours	-
Shelter Temperature Device Check	Every 182 days and 2/calendar year	< ±2.1 °C of standard	Twice per year
Annual performance evaluation for NO_2, O_3	Once per year	Percent difference of audit levels 3-10 < ±15.1% Audit levels 1&2 < ± 1.5 ppb or < ± 15.1%	-

[16] Regulation states ≥96%; 96-104.1% is a recommendation (EPA-454/B-17-001, January, 2017).

Method	Minimum Frequency	Acceptance/ Criteria	Monitoring Network Targets
Federal Audit National Performance Audit Program (NPAP)	20% of sites once per year		-
NO_2		Audit levels 1&2 < ± 1.5 ppb all other levels < ± 15.1%	
O_3		Audit levels 1&2 < ± 1.5 ppb all other levels < ± 10.1%	
Verification/Calibration			
NO_2	Upon receipt/ adjustment/repair/ installation/moving Every 182 day and 2/ calendar year if manual zero/span performed biweekly Every 365 day and 1/ calendar year if continuous zero/span performed daily	Instrument residence time ≤ 2 min Dynamic parameter ≥ 2.75 ppm-min All points < ± 1.5 ppb difference of best-fit straight line whichever is greater and Slope 1 ± .05	Twice per year (NO_2 and O_3)
O_3	Upon receipt/ adjustment/repair/ installation/moving and repair and recalibration of standard of higher level Every 182 day and 2/ calendar year if manual zero/span performed biweekly Every 365 day and 1/ calendar year if continuous zero/span performed daily	All points < ± 2.1 % or ≤ ±1.5 ppb difference of best-fit straight line whichever is greater and Slope 1 ± .05	
Gaseous Standards			
NO_2	All gas cylinders	National Institute of Standards and Technology (NIST) Traceable (e.g., EPA Protocol Gas) 50-100 ppm of NO in Nitrogen with < 1 ppm NO_2	Global Calibration Gases Cylinder number EB0054584 (EPA Protocol Gas Mixture. Reference # 100620TH-6)

Method	Minimum Frequency	Acceptance/ Criteria	Monitoring Network Targets
Zero Air/Zero Air Check NO_2 and O_3	Every 365 days and 1/calendar year	Concentrations below LDL	Once per year
All Level 2 and 3 Ozone Transfer Standards			
Qualification	Commercial Devices—conducted at vendor Non-commercial Devices—1 time prior to acceptance testing	Repeatability within ±4% or 4 ppb from its indicated value (whichever is greater)	-
Acceptance Testing	Upon receipt (new), following repair, or prior to conducting Verifications or Reverifications	Per manufacturer specifications	Upon receipt (new), following repair, or prior to conducting Verifications or Reverifications
Verification	Upon receipt (new), adjustment, or major repair; all Level 2 transfer standards must be verified annually against a Level 1 SRP	Involves 3 cycles[17] Each point difference < ±3.1% (or ±1.5 ppb for concentrations points < 50 ppb) All 3 regression slopes = 1.00 ± 0.03 All 3 regression intercepts = 0 ± 3 ppb Standard deviation of the 3 slopes < 0.0075 Standard deviation of the 3 intercepts < 1.00 ppb	Upon receipt (new), adjustment, or major repair
Level 3 Bench[18] Ozone Transfer Standard			
Reverification	Annually[19]	Involves 1 cycle Each point difference < ±3.1% (or ±1.5 ppb for concentration points < 50 ppb) Regression slope from the reverification test cycle must be within ±0.015 of the mean slope from the most recent verification test	Twice per year[19]

17 A cycle consists of at least 6 concentrations and zero (EPA-454/B-22-003, January 2023).

18 A "bench" transfer standard refers to a system that is placed at a single location and remains at that location for the entire verification period (EPA-454/B-22-003, January 2023).

19 Additional checks are strongly recommended by EPA following guidance from EPA-454/B-22-003 (January, 2023). Level 3 bench standards in the Weld County network will be reverified twice per year to help reduce the risk of data loss.

Method	Minimum Frequency	Acceptance/ Criteria	Monitoring Network Targets
		Regression intercept from the reverification test cycle must be within ±1.5 ppb of the mean intercept from the most recent verification test Regression slope from the reverification test cycle = 1.00 ± 0.03 Regression intercept from the reverification test cycle = 0 ±3 ppb	
Levels 2 and 3 Field[20] Ozone Transfer Standards			
Reverification	Every 6 months	Same as Level 3 Bench Ozone Transfer Standard (above)	-
Detection (FEM/FRMs) Noise and Lower Detectable Limits (LDL) are part of the FEM/FRM requirements. It is recommended that monitoring organizations perform the LDL test to minimally confirm and establish the LDL of their monitor. Performing the LDL test will provide the noise information.			
Noise (NO_2 and O_3)	Every 365 days and 1/calendar year	NO2: ≤ 5 ppb O3: ≤ 2.5 ppb (standard range); ≤ 1 ppb (lower range)	
Lower detectable limit (NO_2 and O_3)	Every 365 days and 1/calendar year	NO2: ≤ 5 ppb O3: ≤ 2.5 ppb (standard range); ≤ 2 ppb (lower range)	
Systematic Criteria			
Standard Reporting Units	All data	NO2: ppb (final units in AQS) O3: ppm (final units in AQS)	-
Rounding convention for data reported to AQS	All routine concentration data	NO2: 1 place after decimal with digits to right truncated O3: 3 places after decimal with digits to right truncated	-
Completeness NO_2	 Annual Standard 1-hour standard	 ≥ 75% hours in a year 1) 3 consecutive calendar years of complete data	-

[20] A "field" transfer standard refers to a system that is transported to field sites for use. If a transfer standard is not placed at one location as a bench standard, it is a field standard (EPA-454/B-22-003, January 2023).

Method	Minimum Frequency	Acceptance/ Criteria	Monitoring Network Targets
		2) 4 quarters complete in each year 3) ≥ 75% sampling days in a quarter 4) ≥ 75% of hours in a day	
O_3 (seasonal)	3-year comparison	≥ 90% (avg) daily max available in ozone season with min of 75% in any one year	
	8-hour average	≥ if at least 6 of the hourly concentrations for the 8-hour period are available	
	Valid Daily Max	≥ if valid 8-hour averages are available for at least 13 of the 17 consecutive 8-hour periods starting from 7:00 am to 11:00 pm	
Sample Residence Time Verification (NO_2 and O_3)	Every 365 days and 1/calendar year	≤ 20 seconds	
Sample Probe, Inlet, Sampling train (NO_2 and O_3)	All Sites	Borosilicate glass (e.g. Pyrex®) or Teflon®	Teflon®
Siting (NO_2 and O_3)	Every 365 days and 1/calendar year	Meets siting criteria or waiver documented	-
EPA Standard Ozone Reference Photometer (SRP) Recertification (Level 1) (O_3 only)	Every 365 days and 1/calendar year	Regression slope = 1.00 ± 0.01 and intercept < 3 ppb	-
Precision (using 1-point QC checks)	Calculated annually and as appropriate for design value estimates	NO2: 90% CL CV < 15.1% O3: 90% CL CV < 7.1%	-
Bias (using 1-point QC checks)	Calculated annually and as appropriate for design value estimates	NO2: 95% < ± 15.1% O3: 95% CL < ± 7.1%	-

*Table information obtained from EPA-454/B-17-001, Appendix D

The audit/performance checks listed in Table 9 will be met by automated zero, precision, and span checks for NO_2 (at Missile Site Park) and O_3 (at all sites). This data will be entered into a control chart to monitor the zero/span and one-point QC drift (precision) performance for each analyzer. The chart will visually represent and statistically monitor drift by calculating total cumulative drift, average of the absolute values of the individual drift, and the standard deviation of the individual drifts for each analyzer on a quarterly basis. Figure 26 represents the ranges and control chart limits to decide if calibration is warranted.

Note, a sample conditioner was added to the NO_2 instrument at Missile Site Park after the instrument had been in operation for about four months. The conditioner was added to mitigate 'NO_2 holdup,' a phenomenon that causes high NO_2 readings and is especially noticeable during zero-point calibration events. A detailed description is provided in the T200 instrument manual in Section 2.3.2.5 (TAPI 2019b). This phenomenon impacted the first four months of automated NO_2 calibrations.

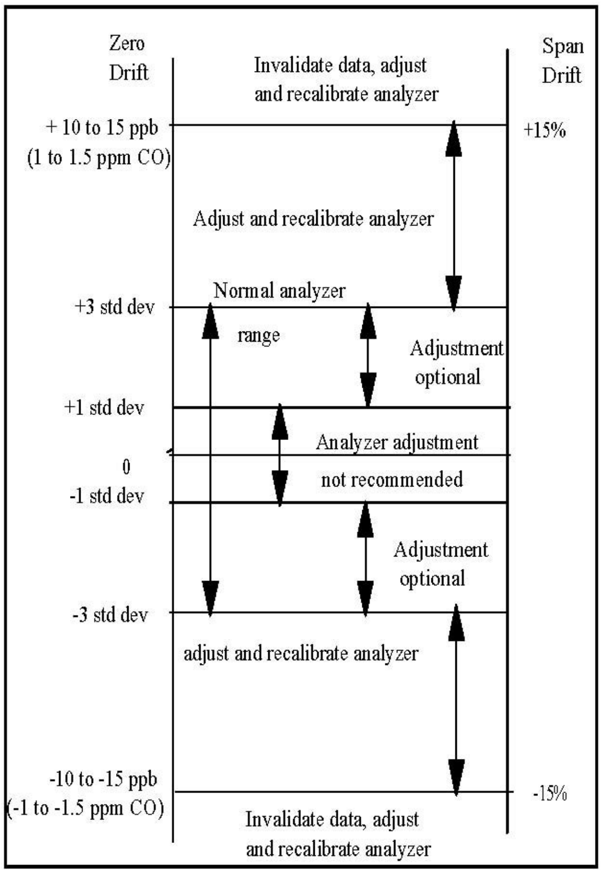

Figure 26: Zero/Span Drift Limits

2.4.2 NADP Quality Control Procedures

Quality control procedures for the NADP programs (NTN and AMoN) are set in place by the NADP. Laboratory quality control procedures are documented by the NADP, are available by request from the NADP, and relevant ones are listed in Section 2.2 of this QMP/QAPP. Field quality control procedures must be followed by site operators in order to maintain sample integrity. They are described in Section 2.2 of this QMP/QAPP.

2.5 Equipment Testing, Inspection, Maintenance

This section describes the procedures and documentation activities that will be performed to ensure that all field analytical instrumentation and equipment are available and in working condition.

Instrument maintenance logs will be maintained and all instrumentation will be checked prior to use. Field personnel will also be responsible for ensuring that critical parts are included with the field instruments. Critical spare parts will be immediately available to reduce potential downtime. The inventory will primarily contain parts that are subject to frequent failure, have limited useful lifetimes, and/or cannot be obtained in a timely manner.

Periodic maintenance that should be followed will adhere to the schedule recommended by the manufacturer and include, but are not limited to, the actions explained in Table 10.

Table 10: Maintenance, Testing, and Inspection

Equipment	Manufacturer	Model	Corrective Action (and Frequency)
AQ- Wind Monitor	R.M. Young Company	#05305	• Replacement of flange and vertical shaft bearings (once per year, or as needed) • Reconditioning wind direction potentiometer when noisy of non-linear signal is produced (as needed)
Temperature Probe	R.M. Young Company	#41342VC	• Cleaning of the temperature sensor radiation shield (once every six months, or as needed)
Relative Humidity	E+E Elektronik	EE181-L	• Cleaning of the radiation shield (once every six months, or as needed)
Barometric Pressure	Setra	278	• Cleaning of the pressure sensor inlet (once every six months, or as needed)
Solar Radiation	Hukseflux	LP02	• Cleaning of the solar radiation sensor (once every quarter, or as needed)
Zero Air	Teledyne API	T701	• Replace charcoal scrubber (annually) • Replace purafil NO-NO_2 scrubber (annually) • Replace regenerative dryer (as needed) • Replace particulate filter (annually)
Multigas Calibrator	Teledyne API	T700	• Flow checks of MFCs (annually)
O_3 Analyzer	Teledyne API	T400	• Particulate filter replacement (every two weeks) • Lamp needs inspected and replaced (as needed) • Pump diaphragm replacement (as needed)
O_3 Photometer	Teledyne API	T700	• Absorption tube needs inspected and cleaned (as needed)
O_3 Photometer	Teledyne API	T703	• Dry air pump replaced (as needed) • UV photometer lamp replaced (as needed)
NO, NO_2, NO_x Analyzer	Teledyne API	T200	• Particulate filter replaced (every two weeks) • O_3 cleanser replaced (annually)

Equipment	Manufacturer	Model	Corrective Action (and Frequency)
			• Pump diaphragm replaced (as needed) • Reaction cell o-rings replaced (annually) • NO_2 converter replaced (every 3 years)

2.6 Equipment Calibration and Frequency

This section of the plan summarizes the calibration procedures and frequency of calibrations that Ramboll will design for representative data. All calibration procedures will follow the requirements of PSD monitoring outlined in EPA documents EPA-454/B-08-002, EPA-454/B-17-001, EPA-454/B-22-003, and manufacturer specifications. SOPs for the calibration processes of each air quality monitoring instrument are provided in Appendix B. The exception is with gaseous analyzers. PSD-rigor sites require quarterly audits on gaseous analyzers; the gaseous analyzers in this network will be calibrated semi-annually by Ramboll and audited annually by CDPHE.

Calibrations, audits, and calculations will be reviewed by a QA Officer at least bimonthly to ensure that:

- The QA procedures are being followed;
- The performance of all equipment is within the limits specified in this document;
- All calculations are being performed properly; and
- All data are reasonable and technically consistent.

2.6.1 Ambient Air Quality Equipment

Proper calibration of ambient air quality monitoring equipment produces accurate useful data. All ambient air monitoring equipment will be calibrated at initial installation. If any repairs, interruption in operation of more than three days, or indication of analyzer malfunction occur, calibrations will be performed again. Any such calibration activities will be recorded by the operator at the time of the calibration, as well as the purpose for the calibration.

In addition, the operator shall make entries in the field logbook describing the date, circumstance, and purpose for any significant change in the configuration of the air monitoring site should they occur. The operator shall make entries for the following examples: 1) in the event that tubing is re-routed or new fittings or other components are added or removed (in any stream of sample air or calibration gas between analyzers, the calibrator, or sampling ports on the site manifold), 2) the relative positions of the analyzers' sample ports on the manifold is changed, 3) the location of a sampler or sampling port is moved, or 4) any similar change in the air monitoring site's configuration. Figure 27 illustrates the layout of the equipment located within each of the three monitoring shelters.

Specific calibration requirements for each air quality monitoring instrument are discussed in the following sections. The SOPs for the calibration processes of each air quality monitoring instrument are provided in Appendix B.

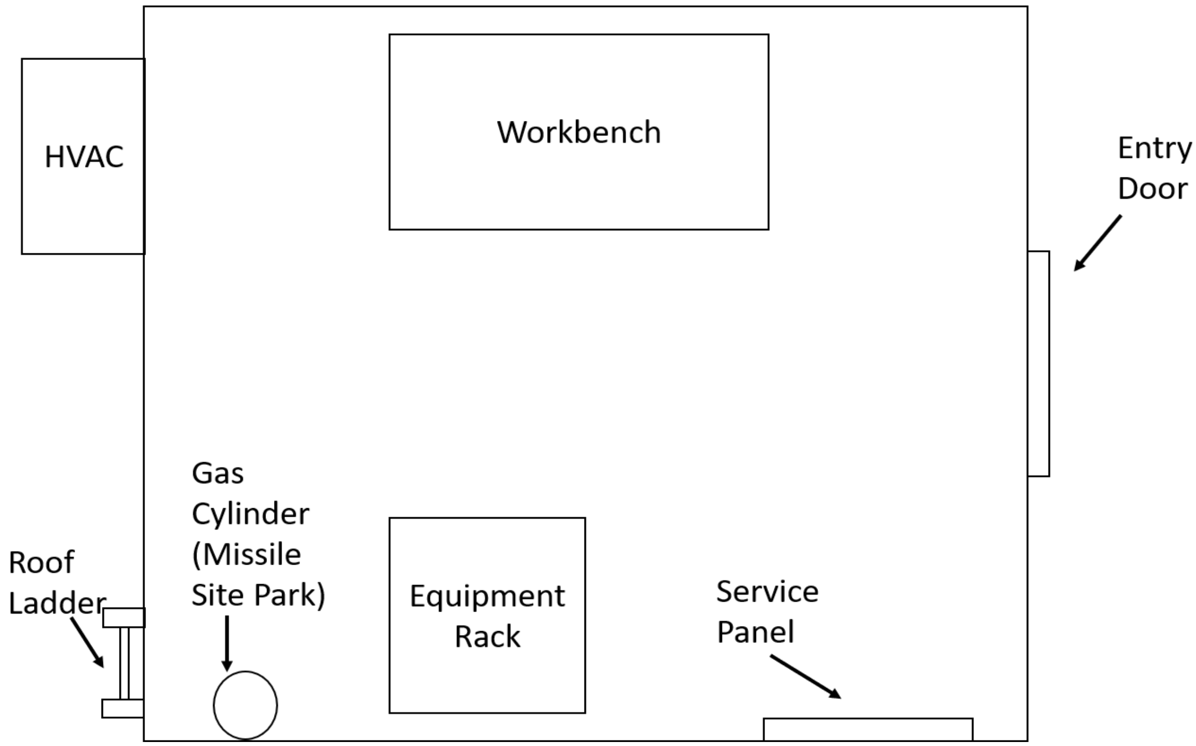

Figure 27: Monitoring Shelter Layout

2.6.1.1 O_3

The O_3 analyzer at each site will be a TAPI Model # T400. This unit utilizes UV Absorption in order to measure the amount of O_3 in air. An on-site transfer standard photometer will be used for overnight and multipoint calibration checks performed in accordance with the Appendix D of EPA-454/B-17-001. The transfer standard photometer at each site will be certified as a Level 3 Bench Transfer Standard through an EPA-approved independent certification protocol following guidance from EPA-454/B-17-001 and EPA-454/B-22-003. A Level 2 transfer standard photometer verified by the EPA Region 8 Laboratory will be used for verification of the Level 3 Bench Transfer Standard. The standard concentration for the Level 3 Bench Transfer Standard will be determined via adjustment of the internal calibration factors, which will be based on the standard concentration of the Level 2 transfer standard photometer. This is Option #1 of Section A8 of EPA-454/B-22-003. All overnight calibration and multipoint checks will be 'through the probe,' which means that calibration gas is introduced near the sampling inlet.

A multipoint (a minimum of six points) calibration of the photometric O_3 analyzer at each site will be performed immediately following installation, and once every 6 months thereafter. The target points of the multi-point checks and the nightly calibration checks are detailed in Table 11 below. Calibration will also be performed should any repairs or service, interruption of operation for more than three days, and/or malfunction or change in calibration occur within the first month following installation. A complete calibration sequence for the O_3 system can be found in the instruction manual for the Model T400 analyzer, Chapter 9 (TAPI 2019a).

Table 11: Target Multi-Point and Nightly Calibration Checks for Ozone

Nightly Calibration Check Targets	
Zero	0 ppb
Precision	60 ppb
Span	400 ppb
Multi-Point Calibration Check Targets	
Zero	0 ppb
1	60 ppb
2	100 ppb
3	200 ppb
4	300 ppb
5	400 ppb

2.6.1.2 NO, NO_2, NO_x

The NO_X analyzer will be a TAPI Model # T200. This unit uses chemiluminescence to detect the gas phase reaction between NO and O_3. This reaction produces NO_2 and O_2 in stoichiometric quantities. Therefore, with a known NO concentration, the NO_2 concentration can be determined.

In order to perform the calibration, zero air must be used, which will be supplied from a TAPI Model # T701 Zero Air System. Zero air is required for dilution, calibration, and gas phase titration. In addition, for the gas phase titration, a TAPI Model # T700 Dynamic Dilution Calibrator will be utilized to generate NO_2 concentrations from NO delivered from an EPA protocol pressurized gas cylinder to generate O_3 for carrying out the required reaction. EPA protocol gases are comparable to a reference standard within ≤1% of the reference standard's concentration.[21] This calibration system will be used for both overnight and multipoint calibration checks. All dilution and gas phase titration checks, both overnight and multipoint, will be 'through the probe,' which means that calibration gas is introduced near the sampling inlet.

A multipoint (five points) dilution calibration of the NO, NO_2, NO_x analyzer will be performed upon installation, and once every 6 months following installation. The target points of the nightly checks and the multi-point calibration checks are detailed in Table 12 below. Calibration may occur more frequently depending on review and comparisons of calibration zero and span data. Calibrations will also be performed following repairs or service, interruption of operation for more than three days, and/or upon any malfunction or change in calibration within the first month following installation. A

[21] US EPA (2012). EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards. Downloaded from: https://nepis.epa.gov/Exe/ZyNET.exe/P100EKJR.TXT?ZyActionD=ZyDocument&Client=EPA&Index=2011+Thru+2015&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C11thru15%5CTxt%5C00000004%5CP100EKJR.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL#. Accessed September 2020.

complete calibration procedure for the NO, NO_2, NO_x analyzer can be found in the instruction manual for the Model T200 analyzer, Chapter 9 (TAPI 2019b).

Table 12: Target Multi-Point and Nightly Calibration Checks for NO/NO_2/NO_x

	NO	NO_2	NO_x
Nightly Dilution Point Targets			
Zero	0 ppb	0 ppb	0 ppb
Precision	60 ppb	0 ppb	60 ppb
Span	400 ppb	0 ppb	400 ppb
Nightly Gas Phase Titration Targets			
Gas Phase Titration Zero	60 ppb	0 ppb	60 ppb
Gas Phase Titration	12 ppb	48 ppb	60 ppb
Multi-Point Dilution Targets			
Zero	0 ppb	0 ppb	0 ppb
1	50 ppb	0 ppb	50 ppb
2	100 ppb	0 ppb	100 ppb
3	200 ppb	0 ppb	200 ppb
4	400 ppb	0 ppb	400 ppb
Multi-Point Gas Phase Titration Targets			
1	10 ppb	40 ppb	50 ppb
2	20 ppb	80 ppb	100 ppb
3	40 ppb	160 ppb	200 ppb

2.6.2 Meteorological Equipment

The meteorological sensors are fully calibrated by the manufacturer at the time of purchase. Additional calibrations for all meteorological equipment will be conducted at the time of installation and should be performed on a semi-annual (6-month) basis thereafter. Table 13 summarizes the calibration and accuracy criteria for the meteorological equipment. The various components are discussed independently in more detail below. The SOPs for the calibration process of each meteorology sensor are provided in Appendix B.

Table 13: Calibration and Accuracy Criteria

Measurement	Calibration			Accuracy		
	Type	Acceptance Criteria	Frequency	Type	Acceptance Criteria	Frequency
Ambient Temperature	3 pt. Water Bath with NIST-traceable thermistor or thermometer	±0.5ºC	Semi-annually	3 pt. Water Bath with NIST-traceable thermistor or thermometer	±0.5ºC	Annually
Vertical Temperature Difference	3pt. Water Bath with NIST-traceable thermometer	±0.1ºC	Semi-annually	3pt. Water Bath with NIST-traceable thermometer	±0.1ºC	Annually

Measurement	Calibration			Accuracy		
	Type	Acceptance Criteria	Frequency	Type	Acceptance Criteria	Frequency
Relative Humidity	NIST-traceable Psychrometer or standard solutions	±7%RH	Semi-annually	NIST-traceable Psychrometer or standard solutions	±7%RH	Annually
Dew Point	NIST-traceable Psychrometer or standard solutions	±0.5°C	Semi-annually	NIST-traceable Psychrometer or standard solutions	±0.5°C	Annually
Barometric Pressure	NIST-traceable Aneroid Barometer	±3mb	Semi-annually	NIST-traceable Aneroid Barometer	±3mb	Annually
Wind Speed	NIST-traceable Synchronous Motor, certified transfer standard (CTS) Method [a]	±0.2m/s	Semi-annually	NIST-traceable Synchronous Motor	±0.2m/s	Annually
Wind Direction	Solar Noon, GPS Magnetic Compass, CTS Method[a]	±3-5 degrees includes orientation error	Semi-annually	Solar Noon, GPS Magnetic Compass	±3-5 degrees includes orientation error	Annually
Solar Radiation	NIST-traceable Pyranometer	10w/m3 below 200 w/m3 above 200w/m3 ±5%	Semi-annually	NIST-traceable Pyranometer	10w/m3 below 200 w/m3 above 200w/m3 ±5%	Annually
Vertical Wind Speed	NIST-traceable Synchronous Motor	±0.2m/s	Semi-annually	NIST-traceable synchronous Motor	±0.2m/s	Annually
Vector Data Wind Speed Wind Direction Sigma Theta Sigma W	Voltmeter and Voltage Generator	±0.2m/s ±5degrees ±5degrees ±0.2m/s	Semi-annually	Voltmeter and Voltage Generator	±0.2m/s ±5degrees ±5degrees ±0.2m/s	Annually
Precipitation	Separatory funnel and graduated cylinder	±10% of input volume	Semi-annually	Separatory funnel and graduated cylinder	±10% of input volume	Annually

*Information copied from EPA-454/B-08-002, Tables 0-8 & 0-10

[a]Method is described in Section 2.72-2.74 of EPA-454/B-08-002

2.6.2.1 Wind Speed and Direction

The wind speed and direction for the R.M. Young Model # 05305-AQ will initially be calibrated by the manufacturer. The manufacturer's calibration uses a fourteen-point wind speed calibration from 0 to 30 m/s, carried out in a test section open return wind tunnel.

On-site calibrations will be performed immediately following installation and on a 6-month basis thereafter and will consist of removing the propeller and using an NIST-traceable synchronous motor to rotate the wind monitor. The average rate of rotation of the motor must be known in order to convert the rotation rate to the equivalent wind speed. Wind direction will also be calibrated, as described in EPA document EPA-454/B-08-002 and the user's manual.

2.6.2.2 Ambient Temperature and Vertical Temperature Difference

The two identical R.M. Young Model # 41342VC Temperature Probes will initially be calibrated by the manufacturer. The manufacturer's calibration uses a three-point calibration at approximately -50 °C, 0 °C, and 50 °C. These probes will be mounted at 2 and 10 m agl to measure temperature difference in order to determine atmospheric stability.

The on-site calibration will consist of a three-point calibration using water baths of approximately 0 °C, 25 °C, and 50 °C using a NIST-traceable thermistor or thermometer. The three-point calibration will be performed immediately following installation and on a 6-month basis thereafter. Additional details regarding the calibration of the ambient and delta temperature probes can be found in the EPA document EPA-454/B-08-002 and the user's manual.

2.6.2.3 Net Radiation

The solar radiation detector being utilized for measuring sun plus sky radiation will be the Hukseflux Model # LP02 thermal pyranometer. The initial field calibration of the detector will be conducted over a consecutive 24-hour period and will include a side-by-side comparison of the field unit to a NIST-certified solar radiation sensor. The calibration will be performed immediately following installation of the sensor and on a 6-month basis thereafter. Additional details regarding the calibration of the pyranometer can be found in the EPA document EPA-454/B-08-002 and the user's manual.

2.6.2.4 Precipitation

The precipitation gauge for measurement of rain and snow precipitation will be an R.M. Young Model # 52202 electrically heated rain gauge. This is a tipping bucket, recording type precipitation gauge. Calibration of the unit is conducted based upon the introduction of a known volume of water that is dripped into bucket at a consistent rate. The calibration will be performed immediately following installation and on a 6-month basis thereafter. Additional details regarding the calibration of the precipitation gauge can be found in the EPA document EPA-454/B-08-002 and the user's manual.

2.6.2.5 Relative Humidity

Relative humidity will be measured using an E+E Elektronik Model # EE181 temperature and relative humidity probe. This unit will be housed in a gill-plate radiation shield in order to protect it from the elements and excessive solar radiation. The calibration will be performed by collocating a NIST-certified hygrometer and comparing the output of the site sensor to the reference hygrometer. The calibration will be performed immediately following installation and on a 6-month basis thereafter. Additional details regarding the calibration of the probe can be found in the EPA document EPA-454/B-08-002 and the user's manual.

2.6.2.6 Barometric Pressure

Barometric pressure will be measured with a Setra Model # 278 Barometric Pressure Transducer. The on-site calibration will consist of side-by-side comparisons with a NIST-traceable aneroid barometer. The calibration will be performed immediately following installation and on a 6-month basis thereafter. Additional details regarding the calibration of the barometric pressure sensor can be found in the EPA document EPA-454/B-08-002 and the user's manual.

2.7 Inspection/Acceptance of Supplies and Consumables

This section of the plan identifies all expendable materials that will be used for sampling, product and vendor information, and the procedures that will ensure the integrity of these materials.

2.7.1 Expendable Materials

Details on expendable materials used in the operation and maintenance of the facility are included in this section. This section is divided into three subsections: 1) Air Quality Equipment expendables, 2) Meteorological Equipment expendables, and 3) General supplies. The senior data and field analyst is responsible for the purchase of all expendables and general supplies.

2.7.1.1 Air Quality Equipment Expendables

Items required for operation, calibration, and maintenance are listed in Table 14. Listing is by equipment name and model number.

Table 14: Air Monitoring Expendables

Site(s)	Equipment	Expendable Items	Supplier
Missile Site Park	Teledyne Advanced Pollution Instrumentation, Model T200 Nitrogen Oxide Analyzer	Single Mixed Tank - 15 PPM NO Particulate filter replaced every 2 weeks O_3 cleanser replaced annually Pump diaphragm replaced as needed Reaction cell o-rings replaced annually NO_2 converter replaced every 3 years	Rocky Mountain Air Solutions/TAPI
Missile Site Park	Teledyne Advanced Pollution Instrumentation, Model T700 Dynamic Dilution Calibrator	N/A	TAPI
Missile Site Park	Teledyne Advanced Pollution Instrumentation, Model T701 Zero Air Generator	Charcoal scrubber media replaced annually Purafil replaced annually Regenerative dryer replaced as needed Particulate filter replaced annually	TAPI
Missile Site Park/Orchard/Hereford	Teledyne Advanced Pollution Instrumentation, Model T400 Ozone Analyzer	Particulate filter replaced every 2 weeks Pump diaphragm replaced as needed UV bench lamp replaced as needed	TAPI
Orchard/Hereford	Teledyne Advanced Pollution Instrumentation, Model T703 Photometric Ozone Calibrator	Dry air pump diaphragm replaced as needed UV photometer lamp replaced as needed	TAPI

2.7.1.2 Meteorological Expendables

Items include water and ice for calibration of the R.M. Young Model # 41342VC Temperature Probes and water for calibration of the R.M. Young Model # 52202 heated tipping bucket rain gauge. These items will be used in general operation or for equipment calibration. No special handling of materials is required for these items.

2.7.1.3 General Expendables

These items are used on a day to day or monthly basis and may be used by more than one piece of equipment. These items are for maintaining a clean working area, cleaning equipment parts and cases, and maintaining equipment internal parts. General expendable items that will be used and stored at this site include lint free towels, distilled water, mild soap, cotton swabs, rubbing alcohol, methanol, compressed air dusting canisters, and trash bags.

2.7.2 Procedures to Ensure Integrity of Expendables

The following procedures will be utilized to ensure integrity of the materials to be consumed and replaced during operation and maintenance of the facilities.

- When expendable items are purchased and/or received, they shall be inspected for damage, cleanliness, proper labeling, expiration date, and appropriate grade. Compressed gases will be checked for proper packaging, and transport cap and seal integrity. No audible noise from leaking compressed gas containers should be noted. Items shall be logged into an expendable materials log with the item's name, time and date received, supplier name, quantity of items received, shelf life if applicable, and storage location.
- Only laboratory grade calibration gases in supplier provided containers, compliant with NIST standards will be used. Ramboll will purchase two compressed calibration gas cylinders of NO gas (balance in nitrogen) on behalf of Weld County for this monitoring program. The calibration gas certifications will be valid for 36 months after initial certification. One primary tank will be used and the 2nd tank will serve as a backup in case the primary tank leaks or gas becomes unstable.
- The gas cylinders will be plumbed to the T700 gas dilution system and will be anchored per equipment manufacturer recommendations.
- T200 and T400 in-line particulate filters will be left in supplier's packaging until they are ready for use. Any torn, damaged, or opened packages will be removed from the site and filters from these packages will not be used on this project.
- Other expendable items shall be stored within the equipment building to prevent damage to containers and to prevent cross contamination.
- All expendable materials will be properly labeled.
- Expendable items will be transported to the site in appropriate containers to prevent damage or contamination.
- Materials purchased and used during the first month of operations following installations will be inventoried in a logbook. This logbook will be maintained by the project field coordinator to track supplies purchased, quantities used, "use by" dates, and items removed from the site. The intent of the logbook is for the permanent routine operator to easily determine when to restock certain items.
- Expendable items that are not used before "use by" dates should be removed from the site and not used.

2.8 Data Management

Proper data collection followed by management of the data as it is being collected is an indispensable requirement. Data must be reliable, of known quantity, easily accessible, and organized and reduced in an appropriate manner. The amount of data collected will continue to grow, and therefore must be properly managed as it is acquired.

2.8.1 Data Recording and Validation

Figure 28 and Figure 29 depict the communications pathway for the data generated at each site. Data for gaseous species are collected on site and reduced using the LoggerNet main data logger support software package by Campbell Scientific ™. LoggerNet consists of a server application and several client applications integrated into a single product. This software creates custom data logger programs, displays real-time or historic data, and saves data in various formats.

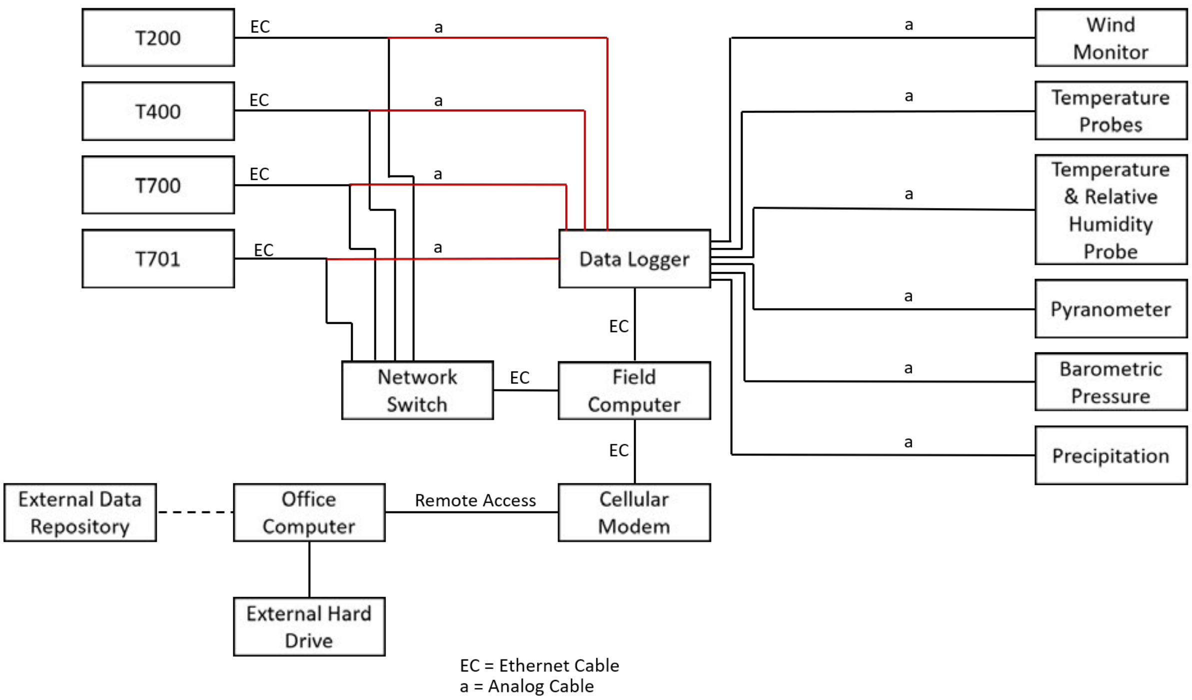

Figure 28: Data Communications Pathway for Missile Site Park

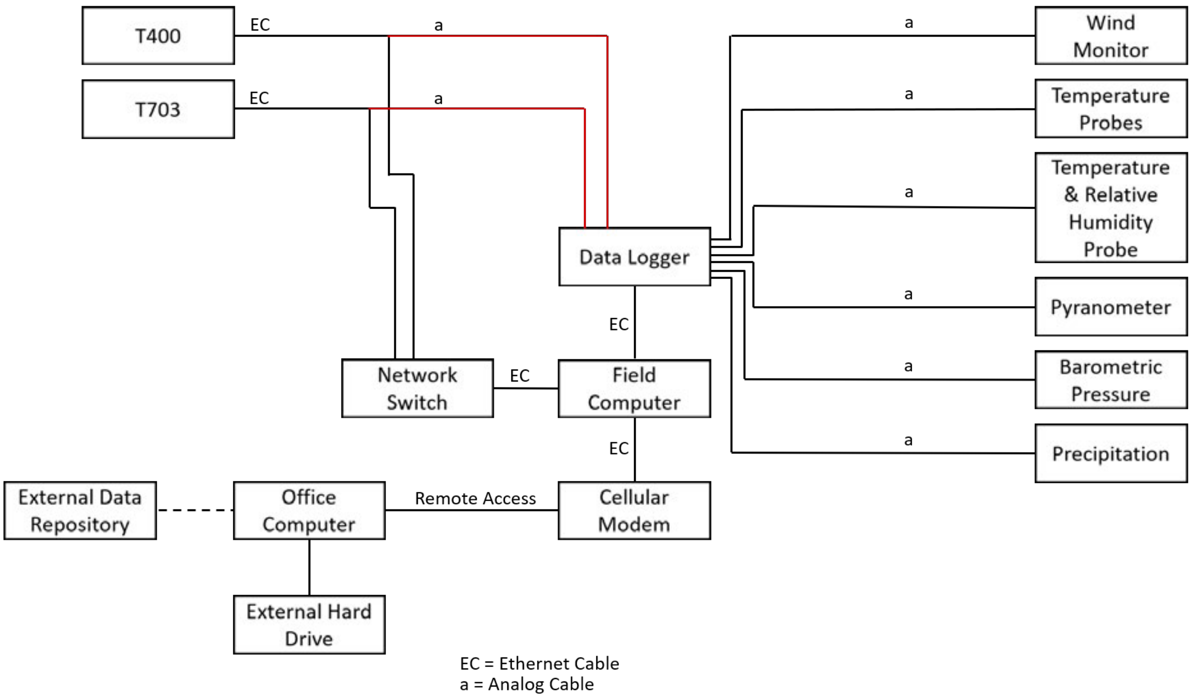

Figure 29: Data Communications Pathway for Orchard and Hereford

Air quality monitoring data will initially be downloaded by two different office computers, for the sake of data backup, and reconciled every several days to verify proper operation of the instrumentation and the integrity of the monitoring data. This schedule will subsequently be relaxed to once a week depending on equipment performance. This schedule will not exceed two weeks. This process will continue under the supervision of the data administrator. The air quality data will also be reviewed for trends, anomalies, reasonableness, and values out of typical ranges at a minimum of once per week. The data may be reviewed in both tabular and graphical formats. Examples of typical data checks include the following in Table 15. The screening checks below will be performed by an automated Python tool that will highlight data outside of the screening criteria for further review. Note this list is not exhaustive as unexpected issues can arise, and the automated screening tool only performs checks on hourly data. The minute data checks are performed separately with Excel as ‘spikes’ and ‘dips’ require QC team review.

Table 15: Screening Criteria for Gaseous Pollutants

Pollutant	Screening Criteria

Ozone	• Values below 10 ppb or above 70 ppb
	• The same value for two or more consecutive hours
	• Minute data checks
	  ○ Large (subjective) 'spikes' or 'dips' in the minute data
	  ○ Nightly calibration reviews
	  ○ Span, Precision, or Zero deviations (bounds provided in Table 9)

NO/NO2/NOx	• Values below 0 ppb or above 60 ppb
	• The same value for two or more consecutive hours
	• Minute data checks
	  ○ Large (subjective) 'spikes' or 'dips' in the minute data
	  ○ Nightly calibration reviews
	    ▪ Span, Precision, or Zero deviations (bounds provided in Table 9)
	    ▪ Gas phase titration deviations

Any data outside the QC limits will be flagged for further investigation and/or invalidation and reported to the project lead for follow-up. This review will be performed by one or more members of the project data management review team, with oversight from the project QA team leader. Data reconciliation will be performed in general compliance with guidance document EPA-454/B-17-001 and is further described in Section 4 Data Validation and Usability.

Meteorological data will initially be downloaded by two different office computers, for the sake of data backup, and reconciled every several days to verify proper operation of the instrumentation and the integrity of the monitoring data. This schedule will subsequently be relaxed to once a week depending on equipment performance. This schedule will not exceed two weeks. The meteorological data will be reconciled and reviewed for trends, anomalies, reasonableness, and values out of typical ranges once per week. The data may be reviewed in both tabular and graphical formats. Examples of typical data checks include the following in Table 16. The formatted tool mentioned above will also be used for the meteorology screening checks and will highlight data that does not meet the screening criteria for further review. Note this list is not exhaustive as unexpected issues can arise.

Table 16: Screening Criteria for Meteorological Parameters

Parameter	Screening Criteria
Wind Speed	• Values below 0.1 or above 25 m/s • Differences less than 0.1 m/s for three or more consecutive hours • Differences less than 0.5 m/s for twelve or more consecutive hours
Wind Direction	• Values below 0 or above 360 degrees • Differences less than 1 degree for three or more consecutive hours
2 & 10 m Temperature	• Values below local minima or above local maxima • Differences less than 0.5 degrees Celsius for twelve hours or more • Differences greater than 5 degrees Celsius from one hour to the next
Delta Temperature	• Values less than -2 degrees Celsius or greater than 0.8 degrees Celsius during daytime hours • Values less than -0.8 degrees Celsius or greater than 6 degrees Celsius during nighttime hours

Parameter	Screening Criteria
Solar Radiation	• Values less than 0 Watts per meter squared or greater than 1250 Watts per meter squared • Values above 0 Watts per meter squared during nighttime hours
Precipitation	• Values above 1.97 inches during any hour
Relative Humidity	• Values below 0% or above 105%
Barometric Pressure	• Values below 600 millimeters of Mercury or above 675 millimeters of Mercury

Any data outside the QC limits will be flagged for further investigation and/or invalidation and reported to the project lead for follow-up. This review will be performed by one or more members of the project data management review team, with oversight from the project QA team leader. Data reconciliation will be performed in general compliance with guidance document EPA-454/B-08-002 and is further described in Section 4 Data Validation and Usability.

2.8.2 Data Transformation and Reduction

Data transformation and reduction are processes that aggregate and summarize the data such that they can be properly interpreted. Also, ambient air monitoring regulations require the data to be summarized and reported so it can conform with the data requirements by the EPA AQS monitoring network. The screening criteria described above are used by tools that take the raw unprocessed data and create 'copies' of the raw data with appropriate flags. Any data validation and reduction occur on the copy to ensure raw data can remain unchanged.

Data collected can be classified in two main categories:

- Data collected using a manual method that requires subsequent laboratory analysis of samples. This is going to be performed for NADP samplers for the collection of wet deposition (NTN) and ammonia (AMoN). Once samples are collected for both the AMoN and NTN, the site operations and sample changeout manuals will be followed closely to conform with the QA/QC procedures established by the support programs for the NADP. The NADP then provides this data in Excel and pdf formats after it has been analyzed. This process can take months. The data are also stored by the NADP and can be downloaded from the NADP's website (http://nadp.slh.wisc.edu/data/).
- Data collected using in-situ methods which requires no further laboratory analysis. These mostly refer to ozone and NO_2 measurements which are handled through the specification presented in this document. Notice that data reduction is performed in part using the LoggerNet software from Campbell Scientific ™. Additional data reductions will be determined as needed by the secondary reviewer

2.8.3 Data Formatting

Data formatting is performed to conform with the needs of the project but importantly, the data will be reformatted as required for AQS submittal. The meteorology and gas phase data will be saved using comma separated values (CSV) formats. The data will be kept considering three different average periods: 15-minute, 1-hour, and daily averages. Additionally, 1 and 15-minute tables will also be created to support gas phase QC checks and public data access. Appendix A in this document provides detailed descriptions of each of these formats.

The meteorological data will be formatted to conform with Colorado's Air Pollution Control Division (APCD) requirements. APCD requires a minimum time resolution of 15-minute meteorological data and a 90% data capture rate for each parameter by quarter to use the meteorological data for permit modeling applications.[22] This is consistent with the provisions of the "Meteorological Monitoring Guidance for Regulatory Modeling Applications" (EPA-454/R-99-005).

2.8.4 Data Transmittal and Storage

Data transmittal refers to the information exchange or transfer from the data keeper to another entity by hand or electronically. Ramboll will function as a data keeper and expects to provide data electronically following the process shown in Figure 30.

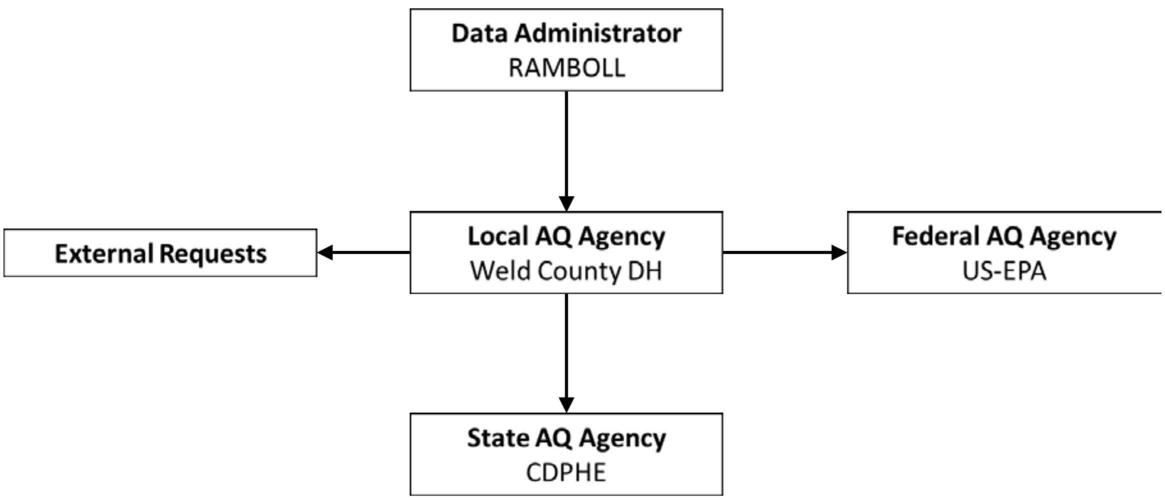

Figure 30: Data Transmittal

The data administrator (Ramboll) will be responsible for retaining electronic copies of the raw data collected from the multiple sites for the length of the program plus 3 additional years if/when it is decided to discontinue the monitoring program. The administrator will ensure all data will be fully proofed for accuracy. QA/QC will involve comparing original data to the data input into the master spreadsheet or reports in order to detect any discrepancies. The data administrator will perform adequate storage and keep a flexible and clear organization of all records. Data will be obtained by, or sent to, the Ramboll Fort Collins, CO office, with further distribution when necessary. The data administrator will assume the responsibilities necessary to upload the data to the EPA's AQS database should Weld County plan to obtain EPA reviews and approvals necessary for inclusion in AQS.

[22] Ambient Air Pollution and Meteorological Monitoring Guidance. The Colorado Air Pollution Control Division, October 2021. Available at: https://www.colorado.gov/airquality/documents/air_pollution_and_met_monitoring_guidance_oct_2012.pdf

3 ASSESSMENT AND OVERSIGHT

3.1 Assessments and Response Actions

The data administrator (Ramboll) will perform performance evaluations for field activities to ensure the sampling and analyses are being performed in accordance with the procedures outlined in this QMP/QAPP. The performance evaluations are listed in Table 17 below. The assessments will consider the following aspects discussed in more detail in subsequent sections:

- Network Reviews;
- Performance Evaluation (Weld/CDPHE);
- Performance Evaluation (EPA independent audits); and
- Technical Systems Audits.

Table 17: Tentative Assessment Schedule

Assessment	Performing/Organizing Entity	Tentative Schedule
Corrective Action Report	Ramboll	As Needed
Semi-annual visit	Ramboll	Quarters 2 and 4 annually
Independent audit	CDPHE	Quarter 3 annually
Data Quality Assessments	Ramboll	Quarterly & annually
Site Evaluations	Weld County Operator/Ramboll	Annually
Network Survey for AMoN	Weld County Operator/Ramboll	Annually
National Performance Audit Program	EPA	20% of sites annually
Network Survey for NTN	NADP/Contractor	Every 3-4 years
Network Review	Ramboll	Every 5 years

3.1.1 Network Reviews

Weld County's monitoring program will conduct network reviews every five years. Network reviews and assessments are conducted to determine how well the ambient air quality monitoring system is achieving the required monitoring objectives.

3.1.1.1 Network Review Process and Goals

Prior to the network review, relevant information related to the review will be compiled and evaluated including:

- Date of last review;
- Modifications proposed by agencies since the last network review;
- Pollutant specific priorities;
- Network files;
- AQS reports;
- Air quality summaries for the past five years for all monitors in the network;
- Emissions trends and information relevant to the pollutants measured and the objectives of the network including location of major sources.

This information will be collected and will be the most up-to-date information available. Any discrepancies will be noted and resolved during the review. The stated objective for each monitoring site will be assessed relative to the current location and determine if these objectives are being achieved.

On site visits will help to determine compliance with established requirements, including appropriate distance from trees, roads, other buildings and surrounding vegetation. Many of these conditions will not change frequently so they can be evaluated on each site every 3 to 5 years.

Other subjects that should be discussed by Ramboll and Weld County during the network review include:

- Location of existing monitors;
- Siting criteria problems and suggested solutions;
- Problems with data submittals and data completeness;
- Maintenance and replacement of existing monitors and related equipment;
- Quality Assurance problems;
- Air quality studies and special monitoring programs;
- Other issues, such as community concern; and
- Funding.

The network review will be documented in a report written within two months of the review and filed and distributed to management (Weld County Manager see Figure 1) after it is finalized.

3.1.1.2 Conformance to Network Siting Design (40 CFR Part 58 Appendix D)

Using requirements of 40 CFR Part 58 Appendix D, the network should be evaluated to ensure that the number of sites meets the design criteria requirements and that monitors are properly located based on the objective and spatial scale representativeness required by the network.

3.1.1.3 Conformance to Network Siting Design (40 CFR Part 58 Appendix E)

Siting criteria are specified in 40 CFR Part 58 Appendix E. Using these criteria, on-site physical measurements and observations are made to determine compliance with sample probe/monitor criteria such as: probe height and distance from potential obstructions, paved or vegetative ground cover, potential sources of point-source pollution, etc.

An on-site checklist will be developed based on the EPA documentation listed in Section 2.1 of this QMP/QAPP to evaluate the Weld County monitoring network. This site evaluation is conducted annually by site operators and the completed checklist included in the annual network plan. In addition to items on this checklist, the reviewer should also:

- Ensure manifold and inlet probes are clean and free of obstructions;
- Estimate sample manifold and probe inside diameters and lengths;
- Inspect monitoring shelters for weather leaks, safety and security;
- Check to ensure all sample lines are connected and free of kinks;
- Check to ensure that monitor exhausts are not likely to be reintroduced back to the sample inlet;
- Check to ensure that monitor exhausts are vented properly so as not to be a safety concern;

- Check equipment physical state, including missing parts, frayed cords, etc;
- Record findings/observations in a field notebook and/or checklist;
- Take photographs in each cardinal direction, (both looking at and looking away from sample probe as well as the shelter's interior layout;
- Record monitoring site's GPS location (latitude/longitude/elevation); and
- Document site conditions (include any additional photographs/videotape).

3.1.2 Bias – Performance Evaluations

Performance evaluations are audits that use quantitative data generated in a measurement system obtained independently.

The APCD provides auditing services to local government entities at the request of the local government entity. Weld County/Ramboll will request an audit for the Weld County network once per year. These will serve as an independent audit.

3.1.2.1 Technical Systems Audits

Technical system audits are thorough, systematic, on-site qualitative audits of facilities, equipment, personnel, training, procedures, record keeping, data validation, data management, and reporting aspects of a system. They may be conducted by US EPA Region 8 every 3 years. These audits may also be conducted when necessary and if resources are available. The audit results will be summarized and reported to CDPHE Air Control Division and the QA officer when finalized by US EPA Region 8.

3.1.3 Data Quality Assessments

Data quality assessments are a statistical analysis of air quality, or other environmental data, that are used to determine whether data generated by the air monitoring network have met the established DQOs and MQOs, and in doing so, are of adequate quality. The assessment results will be summarized and reported to Weld County Department of Public Health and Environment and the QA offer in quarterly and end of the years reports. The reports provide statistical evaluations on completeness, precision, accuracy, and bias for all parameters monitored by the network. Additionally, details of all system and performance audits performed on the network and specific information about the corrective actions, data adjustments, and data invalidation performed in response to these audits will be included in the reports.

3.1.4 NADP Network Surveys

Wet deposition sites (NTN) are surveyed once every 3-4 years to verify-among other items-correct operation of the instrumentation, site conditions, siting criteria, and operating procedures. The survey is conducted by an independent contractor who is contracted by the NADP. Information gathered from site surveys for each site is made available on the NADP website. Any recommended changes will need to be made by the site operators, in this case it will be Ramboll.

AMoN conditions are to be documented annually by the site operator and submitted to the NADP. They include photographs of the site and AMoN housing. A checklist of site changes will also be included.

3.1.5 Corrective Actions and Response

The need for corrective action may be identified during data validation, data assessment or as a response to an audit. If data recovery thresholds for gaseous species or meteorological data are not met, the reasons will be investigated, and actions will be taken to correct identified issues as needed. The corrective actions are taken so the goals and objectives set for the Weld County monitoring program can be achieved satisfactorily. As part of corrective actions and follow-up, an audit finding response will be generated for each finding submitted by the US EPA or the internal auditing process. The QA Officer and Program Manager will review and accept the corrective actions. The audit response will be completed within 30 days of acceptance of the audit report. The next audit of the monitoring network will ensure that the stated corrective action(s) were implemented, and that corrective action(s) were taken to return routine monitoring operations to acceptable levels of precision, bias, completeness, representativeness, comparability, and detectability.

All corrective action reports will include at least this information:

- Audit finding(s),
- Cause(s) of the problem(s),
- Actions taken to rectify the problem(s),
- Responsibilities and timetable for the above actions taken,
- Project manager's printed name, title, signature and date,
- Organization's QA Officer approval (printed name, signature, and date of approval),
- Statement that finding is closed or further following action is required.

All corrective action reports are to be filed with the official audit records and copies sent to the auditing agencies as needed or requested.

3.2 Reports to Management

Reports to management (Weld County Manager see Figure 1) will follow the guidelines provided in the EPA document EPA-454/B-17-001. Table 18 below defines the frequency of the reports that will be prepared. It is expected that the data administrator will continue this data reporting.

Table 18: Reports to Management

Type of QA Report to Management	Contents	Suggested Reporting Frequency			
		As required	Monthly	Quarterly	Yearly
Corrective action request	Description of problem; recommended action required; feedback on resolution of problem.	X			
Control chart with summary	Repetitive field or lab activity; control limits versus time. Prepare monthly of whenever new check or calibration samples are used.	X	X	X	X
State and local organization performance audits	Summary of audit results; recommendations for action, as needed	X			X
QA report to management	Executive summary. Precision, bias, and system and performance audit results.	X		X	X
Network Reviews	Review results and suggestions for actions, as needed.				Every 5 years

4 DATA VALIDATION AND USABILITY

4.1 Data Review, Verification, and Validation

This section provides a Quality Assurance and Quality Control plan that would ensure the reliability and usability of the data collected. The verification and validation of data will be successful based on the implementation of the prior-described sampling design, sample collection procedures, sample handling, analytical procedures, corrective actions, calibration procedures, QC procedures, and data reduction and processing procedures.

Additional detail on how data is recorded is provided in the next subsection, but once this step has taken place, various air quality staff are responsible for the separate aspects of the data management process:

- Site operators are responsible for the first level preparation and recording of the data including initial checks to ensure monitor equipment is working according to specification
- Automated screening tools provide basic bounds flagging to draw attention to suspect data.
- Secondary reviewers are responsible for QC review including data flagging reconciliation and invalidation decisions
- The program manager is responsible for final certification before distribution to Weld, EPA AQS, and other stakeholders.

4.2 Verification and Validation Methods

4.2.1 Field and equipment logs

Records of field events will be made throughout the project to document field data and field activities. Field data, site conditions, and personnel activities will be recorded on field logbooks and equipment calibration logs. The field operations team will consist of Ramboll and Weld County personnel. They will be responsible for maintaining the various logs. These documents must be accurate and detailed as they will serve as a basis for reports and data validation decision-making.

The field logbook will be kept on a shared drive as a combined Excel document so that anyone accessing the site can record their activities and timing. This shared drive will be hosted by Ramboll and will be accessible to routine visitors of the sites, which will include the field operations team. The field logbook will contain a time-record of data collection activities. They shall contain date, start time, weather, names of personnel present, a chronology of activities performed, and any other pertinent site observations. Field logbooks will be maintained by project personnel for work applicable to each monitoring station.

Equipment calibration logs are logbooks detailing major and routine maintenance and calibration activities on each gas analyzer in the Weld County Monitoring Network, as defined by this QMP/QAPP. They contain start and stop times of activities, analyzer response and logger recording, and details of certain instrument diagnostics. They also contain analyzer slope and intercept information to as an additional drift tracking device. These logs are mainly accessed by Ramboll field staff as they are the ones who will perform any calibration activities.

4.2.2 Automated Screening Tool

Air quality data will be evaluated weekly by an automated Python-based screening tool. The screening tool will perform operational bounds, flatline, and measurement bounds checks on all parameters. The operational bounds checks were developed based on the operational range of an instrument. Any data collected outside of the operational range of an instrument will be immediately invalidated by the screening tool. The flatline and measurement bounds checks were developed based on the criteria listed in Appendix C, of the Quality Assurance Handbook for Air Pollution Measurement Systems (EPA - 454/B-08-002), local site criteria, and the measurement quality objectives. Any data outside of the measurement bounds or potentially 'flatlined' will be flagged by the screening tool. The screening tool creates an Excel document of the data and plots it. Any data that is flagged by the screening tool is flagged in both the plot and the Excel document. A complete list of U.S. EPA AQS null value codes and QA qualifier flags that will be applied to the data as flags can be found on EPA's website (https://aqs.epa.gov/aqsweb/documents/codetables/qualifiers.html). These automated checks are designed to be reviewed by a member of the data management team for validity. The tool is overly conservative to bring attention to any potentially invalid data.

4.2.3 Secondary Reviews

Once data has been scanned by the screening tool it is investigated by a member of the project data management team with oversight from the project QA Officer, for possible invalidation. Data invalidation will be a multi-step and well-documented process. It will include reviewing the plots and Excel document generated by the screening tool, reviewing field logbooks for additional insight into field data, reviewing gaseous analyzer minute data, and reviewing external resources (e.g. the Community Collaborative Rain, Hail & Snow Network-CoCoRaHS). The benefit provided from each resource is detailed below:

- The screening tool's Excel document and plots provide both tabular and graphical representations of the data with flags. Simultaneous review of both allows for quick decisions on validation for the overly conservative flags. It also draws attention to data that has not been flagged but looks suspect.
- Field and equipment calibration logbooks are helpful for confirming potentially invalid data and for drawing attention to data issues that have not been flagged by the screening tool.
- One-minute resolution data collected from the gas analyzers allows for precise invalidation of automated calibration events, filter changes, and power failures. It also helps with data recovery when one of the previously mentioned events only occurs during a partial hour.
- External resources can help confirm potentially isolated events, like precipitation.

Once the decision to invalidate data has been made, it will be documented by site and include time period, reason for invalidation, and a suggestion on the appropriate AQS code. Data that has been invalidated will be removed from the Excel document created by the screening tool. Data that has been flagged but determined to be valid will have flags removed. An invalidation appendix will be added to the quarterly report and along with the validated data Excel document, the information is provided to the QA Officer for final review.

4.2.4 Final Certification

The QA Officer provides a final review of the data. If there are discrepancies, the QA Officer and secondary reviewer enter a back-and-forth process to discuss materials and reasons for invalidation. If data needs to be re-validated, the data is reintroduced from the raw record. If data needs to be invalidated, the appropriate AQS Qualifier Code will be used. Once a final data set has been agreed upon, the QA Officer makes recommendations to the program manager to allow for distribution of the dataset to Weld County and other stakeholders.

4.3 Reconciliation with User Requirements

The Weld County program will monitor air quality to assess compliance with the NAAQS, to develop or modify control strategies to prevent or alleviate pollution episodes, to observe pollution trends, and to provide a database for research and evaluation of effects of air pollution. The quality of the data collected will be based on the highest priority objective, the determination of violations of the NAAQS.

Ramboll will prepare a quarterly Air Monitoring Data Quality Assessment Report for the monitoring network that describes data quality in terms of precision, accuracy, and data completeness. The report will also include as needed the steps followed in the verification and validation of the date. This report will be sent to the Weld County Board of County Commissioners and will be made available to the general public.

The Data administrator will submit quarterly monitoring data to the EPA AQS database after Weld County reviews and approves the reports. All monitoring data will be reviewed and validated by site operators and second level reviewers. Data will again be spot-checked for validity by the AQS Specialist when entered into the database.

Data will be compared with the established MQOs and DQOs to ensure requirements and guidance set from this QMP/QAPP have been met. Only data that have been validated, verified and qualified, as necessary, shall be accepted and submitted to AQS. If the data reviews reveal that data sets are inconsistent with the MQOs, or the underlying assumptions of the statistical tests are not supported by the data and fail to meet the criteria or objectives of the monitoring projects, then steps will be immediately taken to identify shortcomings, rectify discrepancies, and reconsider sampling design or adjustment to QC procedures as described in this QMP/QAPP.

If investigation reveals the need to modify the monitoring network or adjust QC procedures, Weld County will remain in close communication with CDPHE and EPA Region 8 for assistance and to ensure proper notification.

5 REFERENCES

EPA-454/B-17-001. Quality Assurance Handbook for Air Pollution Measurement Systems. Volume II. US EPA Ambient Air Quality Monitoring Program. Office of Air Quality Planning and Standards, Research Triangle Park, NC. January 2017.

EPA-454/B-17-001 Appendix D. QA Handbook Volume II, Appendix D: Measurement Quality Objectives and Validation Templates. Office of Air Quality Planning and Standards, Research Triangle Park, NC. March 2017.

EPA-454/B-08-002. Quality Assurance Handbook for Air Pollution Measurement Systems

EPA-454/B-22-003. Transfer Standards for Calibration of Air Monitoring Analyzers for Ozone Technical Assistance Document. Office of Air Quality Planning and Standards, Research Triangle Park, NC. January 2023.

Volume IV: Meteorological Measurements Version 2.0 (Final). US EPA Ambient Air Quality Monitoring Program. Office of Air Quality Planning and Standards, Research Triangle Park, NC. March 2008

EPA-454/R-99-005. Meteorological Monitoring Guidance for Regulatory Modeling Applications. US EPA. Office of Air Quality Planning and Standards, Research Triangle Park, NC. February 2000.

EPA-450/4-87-007. Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD). US EPA. Office of Air Quality Planning and Standards, Research Triangle Park, NC. May 1987.

EPA-QA/R-2. EPA Requirements for Quality Management Plans. Office of Environmental Information, Washington, DC. March 2001.

NADP (2021) NADP SOP 400 Preparation of Passive Ammonia Diffusive Samplers. Available from the NADP by request.

NADP (2020a) NTN Bag Sampling Preparation. Downloaded from: http://nadp.slh.wisc.edu/siteops/bagSampling/NTN-2120_Bag_Sampling_Preparation_v_2-1.pdf. Accessed December 2020.

NADP (2020b) NTN Bag Sample Change-out. Downloaded from: http://nadp.slh.wisc.edu/siteops/bagSampling/NTN_2121_Sample_Changeout_v_2-1.pdf. Accessed December 2020.

NADP (2020c) Sample Decanting SOP, NTN Bag Sampling. Downloaded from: http://nadp.slh.wisc.edu/siteops/bagSampling/NTN_2122_Bag_Sample_Decanting_v_2-1.pdf. Accessed December 2020.

NADP (2020d) NADP SOP 401 Extraction of Radiello® Passive Ammonia Diffusion Air Samplers. Available from the NADP by request.

NADP (2020e) NADP SOP 502 Determination of Ammonium (NH_4^+) by Flow Injection Analysis. Available from the NADP by request.

NADP (2020f) NADP SOP 402 NTN Sample Filtration. Available from the NADP by request.

NADP (2020g) NADP SOP 403 NTN Supply Preparation. Available from the NADP by request.

NADP (2020h) NADP SOP 500 ICP-OES. Available from the NADP by request.

NADP (2020i) NADP SOP 501 Ion Chromatography. Available from the NADP by request.

NADP (2020j) NADP SOP 503 Determination of Ammonium (NH_4^+) and Orthophosphate (PO_4^{3-}) By Flow Injection Analysis (FIA). Available from the NADP by request.

NADP (2020k) NADP SOP 504 Manual Determination of pH. Available from the NADP by request.

NADP (2020l) NADP SOP METHOD 505 Manual Measurement of Specific Conductance. Available from the NADP by request.

NADP (2014) Ammonia Monitoring Network (AMoN) Sampler Change-out. Downloaded from: http://nadp.slh.wisc.edu/lib/manuals/AMON_sampler_change-out_v_1-6.pdf. Accessed December 2020.

TAPI (2019a) User Manual Model T400 Photometric Ozone Analyzer with NumaView™ software. Downloaded from: http://www.teledyne-api.com/prod/Downloads/T400%20NVS%20Manual-083730400.pdf. Accessed August 2021.

TAPI (2019b) User Manual Models T200 and T200U NO/NO2/NOx Analyzers with NumaView™ software. Downloaded from: http://www.teledyne-api.com/prod/Downloads/T200%20%26%20T200U%20NVS%20Manual%20-%20083730200.pdf. Accessed August 2021.

APPENDIX A: DATA FORMATTING TEMPLATES

This appendix presents examples of the data using the three different average periods: 15 minute, 1 hour, and daily in which it will be reported along with a detailed description of its metadata

15-Minute Average

The following table provides an example of the first 5 lines of a 15-minute average file. Each line field is described below.

Line	Sample File
1	"TOA5","MSP_DC","CR3000","13406","CR3000.Std.32.05","CPU:MSP_CR3000.CR3","44096","Table_15min"
2	"TIMESTAMP","RECORD","WS_m_s_S_WVT","WD_deg_D1_WVT","WD_deg_SD1_WVT","WS_m_s_Max","Temp_2m_Avg"," Temp_10m_Avg","DeltaT_Avg","AirTC_Avg","RH_Avg","SlrW_Avg","SlrkJ_Tot","BP_mmHg_Avg","Rain_in_Tot ","O3_Avg","NO_Avg","NO2_Avg","NOx_Avg"
3	"TS","RN","M/S","Deg","Deg","M/S","Deg C","Deg C","","Deg C","%","W/m^2","kJ/m^2","mmHg","inch","ppb","ppb","ppb","ppb"
4	"","","WVc","WVc","WVc","Max","Avg","Avg","Avg","Avg","Avg","Avg","Tot","Avg","Tot","Avg","Avg" ,"Avg","Avg"
5	"2020-12-10 16:45:00",0,6.442,63.71,7.028,8.93,0.925,0.849,-0.076,1.103,65.85,0.157,0.1060885,634.425,0,26.57,0.175,2.689,1.934 "2020-12-10 17:00:00",1,6.472,69.09,6.033,9.07,0.612,0.527,-0.085,0.793,67.81,0,0,634.4283,0,26.3,0.172,2.424,1.61

Line 1. Contains the following 8 fields

- TOA5. Table Oriented ASCII format type 5. Characterized by multi-line header and comma separated data values
- MSP_DC. Name of connection between computer and logger, given by operator who set up the connection
- CR3000. Data logger model that created the data file
- 13406. Serial number of data logger
- CR3000.Std.32.05. Operating System version of the data logger
- CPU: MSP_CR3000.CR3. name of the DLD
- 44096. DLD signature
- Table_15min. Table name, given by the operator who set up the table

Line 2. Contains the following 19 fields that describe the columns for data provided

- TIMESTAMP. Date in format YYYY-MM-DD HH:MM:SS
- RECORD. Record number. The value in the last data row shows the total number of records in the file
- WS_m_s_S_WVT. Vector average wind speed
- WD_deg_D1_WVT. Vector average wind direction
- WD_deg_SD1_WVT. Standard deviation of wind direction
- WS_m_s_Max. Maximum wind gust in 15minute period
- Temp_2m_Avg. Average temperature at 2 m from RTD probe.
- Temp_10m_Avg. Average temperature at 10 m from RTD probe.
- DeltaT_Avg. Average difference between temperature at 10m and 2m from RTD probe
- AirTC_Avg. Average temperature from combination temperature/relative humidity sensor
- RH_Avg. Average relative humidity from combination temperature/relative humidity sensor

- SlrW_Avg. Average solar radiation flux density
- SlrkJ_Tot. Total solar radiation flux density in 15-minute period
- BP_mmHg_Avg. Average barometric pressure
- Rain_in_Tot. Total precipitation in 15-minute period
- O3_Avg. Average ozone mixing ratio (reported for all sites)
- NO_Avg. Average nitric oxide mixing ratio (only reported for MSP site)
- NO2_Avg. Average nitrogen dioxide mixing ratio (only reported for MSP site)
- NOx_Avg. Average nitrogen oxides mixing ratio (only reported for MSP site)

Line 3. Contains the following 19 fields that describe the units for data provided

- TS. Timestamp
- RN. Record numbers
- M/S. meters per second
- Deg. Degrees, ranges from 0° to 360° with 0° representing wind coming from the north.
- Deg. Degrees.
- M/S. meters per second
- Deg C. Degree Celsius.
- Deg C. Degree Celsius.
- Empty.
- Deg C. Degree Celsius.
- %. Percentage.
- W/m^2. Watt per square meter
- kJ/m^2. Kilojoule per square meter
- mmHg. Millimeter of mercury
- inch. Inches
- ppb. Mixing ratio.
- ppb. Mixing ratio.
- ppb. Mixing ratio.
- ppb. Mixing ratio.

Line 4. Contains the following 24 fields that describe the statistic used for reporting the data provided

- Empty
- Empty
- WVc. Wind vector calculation
- WVc. Wind vector calculation
- WVc. Wind vector calculation
- Max. Maximum
- Avg. Average
- Avg. Average
- Avg. Average
- Avg. Average
- Avg. Average
- Avg. Average
- Tot. Total

- Avg. Average
- Tot. Total
- Avg. Average
- Avg. Average
- Avg. Average
- Avg. Average

Line 5 and all other subsequent lines. Contain the reported data, consistent with the columns described in lines 2 to 4 above.

1 Hour Average

The following table provides an example of the first 5 lines of a 1-hour average file. Each line field is described below.

Line	Sample File
1	"TOA5","MSP_DC","CR3000","13406","CR3000.Std.32.05","CPU:MSP_CR3000.CR3","44096","Table_60min"
2	"TIMESTAMP","RECORD","BattV_Min","PTemp_C_Avg","WS_m_s_S_WVT","WD_deg_D1_WVT","WD_deg_SD1_WVT","WS_m_s_Max","WS_m_s_TMx","Temp_2m_Avg","Temp_10m_Avg","DeltaT_Avg","AirTC_Avg","RH_Avg","SlrW_Avg","SlrW_Max","SlrW_TMx","SlrkJ_Tot","BP_mmHg_Avg","Rain_in_Tot","O3_Avg","NO_Avg","NO2_Avg","NOx_Avg"
3	"TS","RN","Volts","Deg C","M/S","Deg","Deg","M/S","","Deg C","Deg C","","Deg C","%","W/m^2","W/m^2","","kJ/m^2","mmHg","inch","ppb","ppb","ppb","ppb"
4	"","","Min","Avg","WVc","WVc","WVc","Max","TMx","Avg","Avg","Avg","Avg","Avg","Avg","Max","TMx","Tot","Avg","Tot","Avg","Avg","Avg","Avg"
5	"2020-12-10 17:00:00",0,13.11,20.13,6.459,66.78,6.695,9.07,"2020-12-10 16:59:39",0.746,0.665,-0.081,0.926,66.97,0.067,0.804,"2020-12-10 16:33:48",0.1060885,634.4268,0,26.41,0.173,2.538,1.749 "2020-12-10 18:00:00",1,13.07,21.15,5.954,60.7,7.833,9.14,"2020-12-10 17:44:09",-0.269,-0.379,-0.111,-0.093,72.43,0,0,"2020-12-10 17:00:03",0,634.5614,0,25.12,0.16,2.942,2.11

Line 1. Contains the following 8 fields

- TOA5. Table Oriented ASCII format type 5. Characterized by multi-line header and comma separated data values
- MSP_DC. Name of connection between computer and logger, given by operator who set up the connection
- CR3000. Data logger model that created the data file
- 13406. Serial number of data logger
- CR3000.Std.32.05. Operating System version of the data logger
- CPU: MSP_CR3000.CR3. name of the DLD
- 44096. DLD signature
- Table_60min. Table name, given by the operator who set up the table

Line 2. Contains the following 24 fields that describe the columns for data provided

- TIMESTAMP. Date in format YYYY-MM-DD HH:MM:SS
- RECORD. Record number. The value in the last data row shows the total number of records in the file
- BattV_Min. Internal logger battery voltage

- PTemp_C_Avg. Internal logger temperature
- WS_m_s_S_WVT. Vector average wind speed
- WD_deg_D1_WVT. Vector average wind direction
- WD_deg_SD1_WVT. Standard deviation of wind direction
- WS_m_s_Max. Maximum wind gust in 60minute period
- WS_m_s_TMx. Timestamp for maximum wind gust
- Temp_2m_Avg. Average temperature at 2 m from RTD probe.
- Temp_10m_Avg. Average temperature at 10 m from RTD probe.
- DeltaT_Avg. Average difference between temperature at 10m and 2m from RTD probe
- AirTC_Avg. Average temperature from combination temperature/relative humidity sensor
- RH_Avg. Average relative humidity from combination temperature/relative humidity sensor
- SlrW_Avg. Average solar radiation flux density
- SlrW_Max. Maximum solar radiation flux density in 60-minute period
- SlrW_TMx. Timestamp for maximum solar radiation flux density
- SlrkJ_Tot. Total solar radiation flux density in 60-minute period
- BP_mmHg_Avg. Average barometric pressure
- Rain_in_Tot. Total precipitation in 60-minute period
- O3_Avg. Average ozone mixing ratio (reported for all sites)
- NO_Avg. Average nitric oxide mixing ratio (only reported for MSP site)
- NO2_Avg. Average nitrogen dioxide mixing ratio (only reported for MSP site)
- NOx_Avg. Average nitrogen oxides mixing ratio (only reported for MSP site)

Line 3. Contains the following 24 fields that describe the units for data provided

- TS. Timestamp
- RN. Record numbers
- Volts. Volts
- Deg C. Degree Celsius.
- M/S. meters per second
- Deg. Degrees, ranges from 0° to 360° with 0° representing wind coming from the north.
- Deg. Degrees.
- M/S. meters per second
- Empty
- Deg C. Degree Celsius.
- Deg C. Degree Celsius.
- Empty.
- Deg C. Degree Celsius.
- %. Percentage.
- W/m^2. Watt per square meter
- W/m^2. Watt per square meter
- Empty.
- kJ/m^2. Kilojoule per square meter
- mmHg. Millimeter of mercury
- inch. Inches
- ppb. Mixing ratio.
- ppb. Mixing ratio.

- ppb. Mixing ratio.
- ppb. Mixing ratio.

Line 4. Contains the following 19 fields that describe the statistic used for reporting the data provided

- Empty
- Empty
- Min. Minimum
- Avg. Average
- WVc. Wind vector calculation
- WVc. Wind vector calculation
- WVc. Wind vector calculation
- Max. Maximum
- TMx. Timestamp for maximum
- Avg. Average
- Avg. Average
- Avg. Average
- Avg. Average
- Avg. Average
- Avg. Average
- Max. Maximum
- TMx. Timestamp for maximum
- Tot. Total
- Avg. Average
- Tot. Total
- Avg. Average
- Avg. Average
- Avg. Average
- Avg. Average

Line 5 and all other subsequent lines. Contain the reported data, consistent with the columns described in lines 2 to 4 above.

Daily Average

The following table provides an example of the first 5 lines of a daily average file. Each line field is described below.

Line	Sample File
1	"TOA5","MSP_DC","CR3000","13406","CR3000.Std.32.05","CPU:MSP_CR3000.CR3","44096","Table_24hr"
2	"TIMESTAMP","RECORD","WS_m_s_S_WVT","WD_deg_D1_WVT","WD_deg_SD1_WVT","Temp_2m_Avg","Temp_2m_Min", "Temp_2m_TMn","Temp_2m_Max","Temp_2m_TMx","Temp_10m_Avg","Temp_10m_Min","Temp_10m_TMn","Temp_10m_ Max","Temp_10m_TMx","DeltaT_Avg","AirTC_Avg","RH_Avg","RH_Min","RH_TMn","RH_Max","RH_TMx","SlrW_A vg","SlrW_Min","SlrW_TMn","SlrW_Max","SlrW_TMx","SlrkJ_Tot","BP_mmHg_Avg","BP_mmHg_Min","BP_mmHg_ TMn","BP_mmHg_Max","BP_mmHg_TMx","Rain_in_Tot","O3_Avg","O3_Max","O3_TMx","NO_Avg","NO_Max","NO_T Mx","NO2_Avg","NO2_Max","NO2_TMx","NOx_Avg","NOx_Max","NOx_TMx"
3	"TS","RN","M/S","Deg","Deg","Deg C","Deg C","","Deg C","","Deg C","Deg C","","Deg C","","","Deg C","%","%","","%","","W/m^2","W/m^2","","W/m^2","","kJ/m^2","mmHg","mmHg","","mmHg","","inch", "ppb","ppb","","ppb","ppb","","ppb","ppb","","ppb","ppb",""
4	"","","WVc","WVc","WVc","Avg","Min","TMn","Max","TMx","Avg","Min","TMn","Max","TMx","Avg","Avg" ,"Avg","Min","TMn","Max","TMx","Avg","Min","TMn","Max","TMx","Tot","Avg","Min","TMn","Max","TMx ","Tot","Avg","Max","TMx","Avg","Max","TMx","Avg","Max","TMx","Avg","Max","TMx"
5	"2020-12-11 00:00:00",0,3.672,48.43,15.28,-1.612,-3.04,"2020-12-10 23:59:54",1.061,"2020-12-10 16:34:42",-1.804,-3.186,"2020-12-10 23:59:15",0.986,"2020-12-10 16:34:30",-0.192,- 1.467,82.9,64.63,"2020-12-10 16:33:54",96,"2020-12-10 23:56:39",0.004,0,"2020-12-10 16:37:39",0.804,"2020-12-10 16:33:48",0.1060885,635.1985,634.3765,"2020-12-10 16:50:15",635.8391,"2020-12-10 20:29:03",0,26.9,31.52,"2020-12-10 23:39:54",0.135,0.388,"2020-12- 10 16:38:15",2.045,4.247,"2020-12-10 17:12:33",1.177,3.437,"2020-12-10 17:13:24" "2020-12-12 00:00:00",1,1.827,41.09,60.19,-5.122,-8.75,"2020-12-11 21:38:57",-3.029,"2020-12-11 00:02:06",-5.14,-8.85,"2020-12-11 23:49:30",-3.186,"2020-12-11 00:00:03",-0.018,- 5.076,"NAN","NAN","2020-12-11 17:20:27","NAN","2020-12-11 17:20:27",62.89,0,"2020-12-11 00:00:03",413.1,"2020-12-11 13:03:42",5433.566,634.3472,633.3854,"2020-12-11 13:17:06",635.5707,"2020-12-11 19:28:48",0.071,40.49,500.1,"2020-12-11 15:56:00",12.02,375.4,"2020-12-11 10:08:27",6.341,97.9,"2020-12-11 10:48:12",17.56,376.3,"2020- 12-11 10:08:21"

Line 1. Contains the following 8 fields

- TOA5. Table Oriented ASCII format type 5. Characterized by multi-line header and comma separated data values
- MSP_DC. Name of connection between computer and logger, given by operator who set up the connection
- CR3000. Data logger model that created the data file
- 13406. Serial number of data logger
- CR3000.Std.32.05. Operating System version of the data logger
- CPU: MSP_CR3000.CR3. name of the DLD
- 44096. DLD signature
- Table_24hr. Table name, given by the operator who set up the table

Line 2. Contains the following 46 fields that describe the columns for data provided

- TIMESTAMP. Date in format YYYY-MM-DD HH:MM:SS
- RECORD. Record number. The value in the last data row shows the total number of records in the file
- WS_m_s_S_WVT. Vector average wind speed
- WD_deg_D1_WVT. Vector average wind direction
- WD_deg_SD1_WVT. Standard deviation of wind direction
- Temp_2m_Avg. Average temperature at 2 m from RTD probe.
- Temp_2m_Min. Minimum temperature at 2 m from RTD probe.
- Temp_2m_TMn. Timestamp for minimum temperature at 2 m from RTD probe in 24-hour period

- Temp_2m_Max. Maximum temperature at 2 m from RTD probe
- Temp_2m_TMx. Timestamp for maximum temperature at 2 m from RTD probe in 24-hour period
- Temp_10m_Avg. Average temperature at 10 m from RTD probe.
- Temp_10m_Min. Minimum temperature at 10 m from RTD probe.
- Temp_10m_TMn. Timestamp for minimum temperature at 10 m from RTD probe in 24-hour period
- Temp_10m_Max. Maximum temperature at 10 m from RTD probe
- Temp_10m_TMx. Timestamp for maximum temperature at 10 m from RTD probe in 24-hour period
- DeltaT_Avg. Average difference between temperature at 10 m and 2 m from RTD probesAirTC_Avg. Average temperature from combination temperature/relative humidity sensor
- RH_Avg. Average relative humidity from combination temperature/relative humidity sensor
- RH_Min. Minimum relative humidity from combination temperature/relative humidity sensor
- RH_TMn. Timestamp for minimum relative humidity from combination temperature/relative humidity sensor in 24-hour period
- RH_Max. Maximum relative humidity from combination temperature/relative humidity sensor
- RH_TMx. Timestamp for maximum relative humidity from combination temperature/relative humidity sensor in 24-hour period
- SlrW_Avg. Average solar radiation flux density
- SlrW_Min. Minimum solar radiation flux density
- SlrW_TMn. Timestamp for minimum solar radiation flux density in 24-hour period
- SlrW_Max. Maximum solar radiation flux density
- SlrW_TMx. Timestamp for maximum solar radiation flux density in 24-hour period
- SlrkJ_Tot. Total solar radiation flux density in 24-minute period
- BP_mmHg_Avg. Average barometric pressure
- BP_mmHg_Min. Minimum barometric pressure
- BP_mmHg_TMn. Timestamp for minimum barometric pressure in 24-hour period
- BP_mmHg_Max. Maximum barometric pressure
- BP_mmHg_TMx. Timestamp for maximum barometric pressure in 24-hour period
- Rain_in_Tot. Total precipitation in 24-hour period
- O3_Avg. Average ozone mixing ratio (reported for all sites)
- O3_Max. Maximum ozone mixing ratio (reported for all sites)
- O3_TMx. Timestamp for maximum ozone mixing ratio in 24-hour period
- NO_Avg. Average nitric oxide mixing ratio (only reported for MSP site)
- NO_Max. Maximum nitric oxide mixing ratio (only reported for MSP site)
- NO_TMx. Timestamp for maximum nitric oxide mixing ratio in 24-hour period (only reported for MSP site)
- NO2_Avg. Average nitrogen dioxide mixing ratio (only reported for MSP site)
- NO2_Max. Maximum nitrogen dioxide mixing ratio (only reported for MSP site)
- NO2_TMx. Timestamp for nitrogen dioxide mixing ratio in 24-hour period (only reported for MSP site)
- NOx_Avg. Average nitrogen oxides mixing ratio (only reported for MSP site)
- NOx_Max. Maximum nitrogen oxides mixing ratio (only reported for MSP site)

- NOx_TMx. Timestamp for nitrogen oxides mixing ratio in 24-hour period (only reported for MSP site)

Line 3. Contains the following 24 fields that describe the units for data provided

- TS. Timestamp
- RN. Record numbers
- M/S. meters per second
- Deg. Degrees, ranges from 0° to 360° with 0° representing wind coming from the north.
- Deg. Degrees.
- Deg C. Degree Celsius.
- Deg C. Degree Celsius.
- Deg C. Degree Celsius
- Empty.
- Deg C. Degree Celsius.
- Empty.
- Deg C. Degree Celsius.
- Deg C. Degree Celsius
- Empty.
- Deg C. Degree Celsius.
- Empty.
- Empty
- Deg C. Degree Celsius.
- %. Percentage.
- %. Percentage.
- Empty.
- %. Percentage.
- Empty
- W/m^2. Watt per square meter
- W/m^2. Watt per square meter
- Empty.
- W/m^2. Watt per square meter
- Empty
- kJ/m^2. Kilojoule per square meter
- mmHg. Millimeter of mercury
- mmHg. Millimeter of mercury
- Empty
- mmHg. Millimeter of mercury
- Empty
- inch. Inches
- ppb. Mixing ratio.
- ppb. Mixing ratio.
- Empty
- ppb. Mixing ratio.
- ppb. Mixing ratio.
- Empty

- ppb. Mixing ratio.
- ppb. Mixing ratio.
- Empty
- ppb. Mixing ratio.
- ppb. Mixing ratio.

Line 4. Contains the following 46 fields that describe the statistic used for reporting the data provided

- Empty
- Empty
- WVc. Wind vector calculation
- WVc. Wind vector calculation
- WVc. Wind vector calculation
- Avg. Average
- Min. Minimum
- TMn. Timestamp for minimum
- Max. Maximum
- TMx. Timestamp for maximum
- Avg. Average
- Min. Minimum
- TMn. Timestamp for minimum
- Max. Maximum
- TMx. Timestamp for maximum
- Avg. Average
- Avg. Average
- Avg. Average
- Min. Minimum
- TMn. Timestamp for minimum
- Max. Maximum
- TMx. Timestamp for maximum
- Avg. Average
- Min. Minimum
- TMn. Timestamp for minimum
- Max. Maximum
- TMx. Timestamp for maximum
- Tot. Total
- Avg. Average
- Min. Minimum
- TMn. Timestamp for minimum
- Max. Maximum
- TMx. Timestamp for maximum
- Tot. Total
- Avg. Average
- Max. Maximum
- TMx. Timestamp for maximum
- Avg. Average

- Max. Maximum
- TMx. Timestamp for maximum
- Avg. Average
- Max. Maximum
- TMx. Timestamp for maximum
- Avg. Average
- Max. Maximum
- TMx. Timestamp for maximum
-

Line 5 and all other subsequent lines. Contain the reported data, consistent with the columns described in lines 2 to 4 above.

Additional: 1-minute Average

The following table provides an example of the first 5 lines of a 1-minute average file. Each line field is described below.

Line	Sample File
1	"TOA5","MSP_Remote","CR3000","13406","CR3000.Std.32.05","CPU:MSP_CR3000_c.CR3","9060","CalibrationTable"
2	"TIMESTAMP","RECORD","NO_Avg","NO2_Avg","NOx_Avg","O3_Avg"
3	"TS","RN","ppb","ppb","ppb","ppb"
4	"","","Avg","Avg","Avg","Avg"
5	"2021-01-21 15:38:00",0,0.143,4.783,4.347,31.84 "2021-01-21 15:39:00",1,0.159,4.729,4.326,32.38 "2021-01-21 15:40:00",2,0.144,4.65,4.313,32.54 "2021-01-21 15:41:00",3,0.159,4.642,4.344,31.57

Line 1. Contains the following 8 fields

- TOA5. Table Oriented ASCII format type 5. Characterized by multi-line header and comma separated data values
- MSP_Remote. Name of connection between computer and logger, given by operator who set up the connection
- CR3000. Data logger model that created the data file
- 13406. Serial number of data logger
- CR3000.Std.32.05. Operating System version of the data logger
- CPU: MSP_CR3000_c.CR3. name of the DLD
- 9060. DLD signature
- CalibrationTable. Table name, given by the operator who set up the table

Line 2. Contains the following 6 fields that describe the columns for data provided

- TIMESTAMP. Date in format YYYY-MM-DD HH:MM:SS

- RECORD. Record number. The value in the last data row shows the total number of records in the file
- NO_Avg. Average nitric oxide mixing ratio (only reported for MSP site)
- NO2_Avg. Average nitrogen dioxide mixing ratio (only reported for MSP site)
- NOx_Avg. Average nitrogen oxides mixing ratio (only reported for MSP site)
- O3_Avg. Average ozone mixing ratio (reported for all sites)

Line 3. Contains the following 6 fields that describe the units for data provided

- TS. Timestamp
- RN. Record numbers
- ppb. Mixing ratio.
- ppb. Mixing ratio.
- ppb. Mixing ratio.
- ppb. Mixing ratio.

Line 4. Contains the following 6 fields that describe the statistic used for reporting the data provided

- Empty
- Empty
- Avg. Average
- Avg. Average
- Avg. Average
- Avg. Average

Line 5 and all other subsequent lines. Contain the reported data, consistent with the columns described in lines 2 to 4 above.

Additional: 15-minute Average

Line	Sample File
1	"TOA5","MSP_Remote","CR3000","13406","CR3000.Std.32.05","CPU:MSP_CR3000_Rev2_5-19-2021.CR3","51102","Table_15min_MSP_pub"
2	"TIMESTAMP","RECORD","WS_m_s_S_WVT","WD_deg_D1_WVT","SEVolt_2_WVc","WS_m_s_Max","Temp_2m_Avg","RH_Avg","SlrW_Avg","BP_mmHg_Avg","Rain_in_Tot"
3	"TS","RN","M/S","Deg","Deg","M/S","Deg C","%","W/m^2","mmHg","inch"
4	"","","WVc","WVc","WVc","Max","Avg","Avg","Avg","Avg","Tot"
5	"2021-05-19 14:30:00",0,3.066,111.5,23.71,5.584,22.73,32.12,"NAN",632.1983,0 "2021-05-19 14:45:00",1,2.266,178.8,42.26,4.358,22.24,32.06,"NAN",632.1728,0

Line 1. Contains the following 8 fields

- TOA5. Table Oriented ASCII format type 5. Characterized by multi-line header and comma separated data values
- MSP_Remote. Name of connection between computer and logger, given by operator who set up the connection

- CR3000. Data logger model that created the data file
- 13406. Serial number of data logger
- CR3000.Std.32.05. Operating System version of the data logger
- CPU: MSP_CR3000_Rev2_5_19-2021.CR3. name of the DLD
- 51102. DLD signature
- Table_15min_MSP_pub. Table name, given by the operator who set up the table

Line 2. Contains the following 11 fields that describe the columns for data provided

- TIMESTAMP. Date in format YYYY-MM-DD HH:MM:SS
- RECORD. Record number. The value in the last data row shows the total number of records in the file
- WS_m_s_S_WVT. Vector average wind speed
- WD_deg_D1_WVT. Vector average wind direction
- SEVolt_2_WVc.
- WS_m_s_Max. Maximum wind gust in 15minute period
- Temp_2m_Avg. Average temperature at 2 m from RTD probe.
- RH_Avg. Average relative humidity from combination temperature/relative humidity sensor
- SlrW_Avg. Average solar radiation flux density
- BP_mmHg_Avg. Average barometric pressure
- Rain_in_Tot. Total precipitation in 15-minute period

Line 3. Contains the following 11 fields that describe the units for data provided

- TS. Timestamp
- RN. Record numbers
- M/S. meters per second
- Deg. Degrees, ranges from 0° to 360° with 0° representing wind coming from the north.
- Deg. Degrees.
- M/S. meters per second
- Deg C. Degree Celsius.
- %. Percentage.
- W/m^2. Watt per square meter
- mmHg. Millimeter of mercury
- inch. Inches

Line 4. Contains the following 11 fields that describe the statistic used for reporting the data provided

- Empty
- Empty
- WVc. Wind vector calculation
- WVc. Wind vector calculation
- WVc. Wind vector calculation
- Max. Maximum
- Avg. Average
- Avg. Average

- Avg. Average
- Avg. Average
- Tot. Total

Line 5 and all other subsequent lines. Contain the reported data, consistent with the columns described in lines 2 to 4 above.

APPENDIX B: STANDARD OPERATING PROCEDURES

CONTENTS

Ozone Calibration

The standard operating procedure for the twice per year ozone analyzer calibration and multi-point check is detailed below. The ozone analyzer is a TAPI Model T400 analyzer. The following equipment will be required to perform a calibration on the TAPI T400. Information has been adapted from Section 12 of EPA-454/B-17-001.

- Zero-air source
- Level 2 or 3 bench transfer standard photometer

Ozone Analyzer Maintenance

The ozone analyzer requires periodic maintenance in order to provide trouble-free operation. It involves the following (list is not exhaustive):

- Monthly particulate filter changes
- Flow checks every 6 months
- Absorption tube cleaning annually
- Leak checks after maintenance or repair
- Pump rebuilds as needed

Ozone Analyzer Calibration

The ozone analyzers are calibrated using Level 3 bench transfer standard photometers. Although the calibration systems used at the sites are different (T703 at Hereford and Orchard and T700 with an internal photometer at MSP), each system is certified as a Level 3 bench transfer standard photometer by Air Resource Specialists (ARS), and the procedure described below is the same regardless of calibration system.

Step 1: Generate calibration gas with the T703/T700 (internal ozone generators are available in each Weld T703 or T700) and push calibration gas 'through the probe,' e.g. push gas up to the inlet opening to challenge both the analyzers and the inlet systems. While calibration gas flows up to the inlet, the internal pneumatics of the T703/T700 allow the transfer standard photometers to subsample the gas without any inlet bias. It also allows the calibration systems to remain contaminant free by not being exposed to the inlet sampling system. To perform this procedure properly, enough calibration gas must be generated 'flood' the inlet and ensure that no ambient air dilutes the calibration gas. To verify 'flooding' the inlet, a hand covering the inlet will result in a whistling noise, indicating that gas is attempting to find a vent.

Step 2: A zero point is first generated, and the analyzer is allowed to stabilize. The analyzer is considered stable once the 'Stab' (Stability) is below 0.5 ppb.

Step 3: Once stable, the response of the ozone analyzer **on the data logger** is compared to the response of the transfer standard photometer's **front panel display**.

Step 4: If necessary (difference between data logger and transfer standard photometer is greater than 1 ppb), the zero or span point can be adjusted on the analyzer using the internal 'M-P Calibration' menu.

Step 5: Steps 2-4 are then repeated for the span point (in this case, span is 400 ppb ozone).

Step 6: Following the zero-span calibration, the analyzer response is checked with a multi-point verification to ensure the calibration was successful. For each point in the multi-point verification check, the analyzer response on the data logger is compared to the T703/T700's front panel display. The pass fail/criteria is based on Appendix D of EPA-454/B-17-001, specifically, the 'Ozone Validation Template' table under 'Verification/Calibration.' To summarize, each point should be less than +/- 2.1% difference or less than or equal to +/- 1.5 ppb difference of a best-fit straight line, whichever is greater. The slope of this best fit straight line should also be 1 +/- 0.05. The multi-point verification targets are:

- 0 ppb ozone
- 50 ppb ozone
- 100 ppb ozone
- 200 ppb ozone
- 300 ppb ozone
- 400 ppb ozone

Ozone Transfer Standard Traceability Scheme

1. The traceability of ozone transfer standards for each monitoring station in the Weld County is maintained in accordance with EPA guidance document EPA-454/B-22-003. A Level 3 bench transfer standard (using a model T703 at Hereford and Orchard and a model T700 at MSP) is located at each site for daily calibration and quality control checks of the on-site ozone monitoring system. The traceability of ozone transfer standards used in this network is described below and illustrated in Figure 1:All Level 2 transfer standards must be verified against a Level 1 SRP annually.
2. All Level 3 transfer standards can initially be verified against a Level 2 bench standard or Level 2 field standard.
3. Level 3 bench standards must be reverified against a standard of higher authority (Level 2 bench or field standard) annually.
4. All Level 2 field standards are QC checked (reverified) against a Level 2 bench standard every 6 weeks. Failure of QC checks require the Level 2 field standard to be reverified against the Level 1 SRP.

The acceptance criteria and frequency of verifications/reverifications of each system described above are summarized in Table 9 of this QAPP and follow from those detailed in Table 4-1 of EPA-454/B-22-003. The method employed to determine standard concentration values from the transfer standards in the network follows Option #1 as outlined in EPA-454/B-22-003. That is, the transfer standard's photometer is calibrated based on the higher authority transfer standard during the (re)verification process.

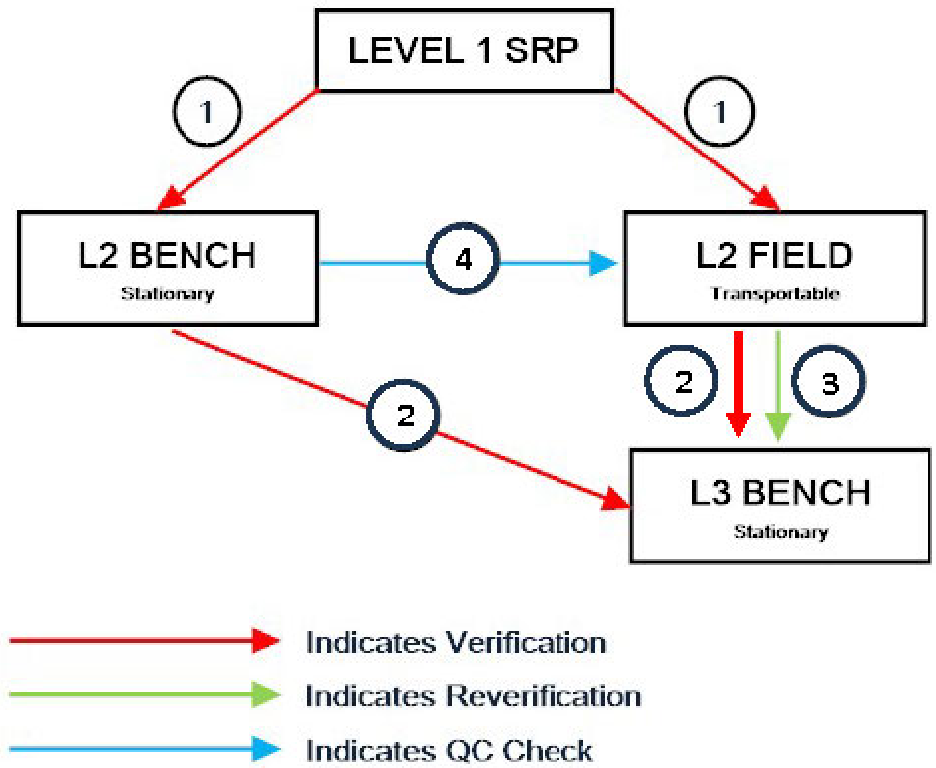

Figure 1: Ozone transfer standard traceability diagram for the Weld County network.

Standard Operating Procedure for the Reverification of Ozone Level 3 Bench Transfer Standards

The standard operating procedure for the reverification of ozone Level 3 Bench Transfer Standards has been drafted and shared by Air Resource Specialists for inclusion in this QAPP. It is available below:

NO/NO2/NOx Calibration

The standard operating procedure for the nitrogen dioxide analyzer twice per year calibration and multi-point check is detailed below. The nitrogen dioxide analyzer is a TAPI Model T200 analyzer. The following equipment will be required to perform a calibration on the TAPI T200. Information has been adapted from Section 12 of EPA-454/B-17-001.

- Zero-air source
- T700 dynamic dilution box
- EPA Protocol gas cylinder

Nitrogen Dioxide Analyzer Maintenance

The nitrogen dioxide analyzer requires periodic maintenance in order to provide trouble-free operation. It involves the following (list is not exhaustive):

- Monthly particulate filter changes
- Annual ozone dryer particulate filter changes
- Annual ozone cleanser chemical changes
- Annual servicing of critical flow orifices
- As needed pump rebuilds

- As needed cleaning of the reaction cell
- As needed flow checks
- Leak checks after maintenance or repair
- Cleaning/changing the nitrogen dioxide converter every 3 years

Nitrogen Dioxide Analyzer Calibration

The nitrogen dioxide analyzer is calibrated using a T700 dynamic dilution box. The T700 has two mass flow controllers that dilute calibration gas from an EPA Protocol gas cylinder (https://www.epa.gov/air-research/epa-traceability-protocol-assay-and-certification-gaseous-calibration-standards). These gas cylinders are designed to contain highly accurate concentrations of their target gas. The gas cylinder was obtained from Rocky Mountain Air Solutions. Note, the gas cylinder contains mostly NO gas since NO_2 is too unstable for gas cylinders. Therefore, NO_2 checks are made with the titration described in Step 6b. The T700 generates different NO concentration levels by mixing air from the gas cylinder with air from a zero-air generator. Similar to ozone, the calibration gas floods the inlet to challenge the entire sampling system.

Step 1: Ensure mass flow controllers of T700 are calibrated. ARS calibrates the mass flow controllers of the Weld County T700 on a semi-annual basis with a NIST-traceable flow standard.

Step 2: A zero point is first generated, and the analyzer is allowed to stabilize. Note, allow both NO and NOx to stabilize. NO and NOx are stable once the ‘Stab’ (Stability) parameter is below 0.5 ppb.

Step 3: Once stable, the response of the nitrogen dioxide analyzer **on the data logger** is compared to the **calculated value of the T700’s front panel display**.

Step 4: If necessary (difference between data logger and the T700 is greater than 1 ppb), the zero or span point can be adjusted on the analyzer using the internal ‘M-P Calibration’ menu. Note: For span calibration, calculate the amount of NOx with the actual NO value on the T700. Enter the NO and NOx target values into the T200, then calibrate. This gives NO and NOx different slope values.

Step 5: Steps 2-4 are then repeated for the span point (in this case, span is 400 ppb NO).

Step 6a: Following the zero-span calibration, the analyzer must be checked with a multi-point verification to ensure the calibration was successful. The pass/fail criteria for the multi-point verification is based on Appendix D of EPA-454/B-17-001, specifically the ‘NO2, NOx, NO Validation Template’ table under ‘Verification/Calibration.’ To summarize, each point should be less than +/- 2.1% difference or less than or equal to +/- 1.5 ppb difference of a best-fit straight line, whichever is greater. The slope of the best-fit straight line should also be 1 +/- 0.05. The multi-point verification gas targets are:

- 0 ppb NO
- 50 ppb NO
- 100 ppb NO
- 200 ppb NO
- 400 ppb NO

Step 6b: The nitrogen dioxide analyzer also requires gas phase titration (GPT) checks to check the NO2 converter efficiency. During a GPT check, the calibration system turns on an ozone generator to titrate a stoichiometric amount of NO and therefore produce a stoichiometric amount of NO2. The GPT checks can be performed immediately following certain dilution point checks. They are:

- 100 ppb of NO and 40 ppb of ozone
- 200 ppb of NO and 80 ppb of ozone
- 400 ppb of NO and 160 ppb of ozone

The pass/fail criteria for the multi-point verification is based on Appendix D of EPA-454/B-17-001, specifically the 'NO2, NOx, NO Validation Template' table under 'Verification/Calibration.' Based on federal guidance (40 CFR Part 50 App F Sec. 1.5.10 and 2.4.10), converter efficiency should be greater than 96% and EPA's recommended range is between 96-104.1% (EPA-454/B-17-001). Converter efficiency is calculated as 100 times the slope of the curve fit to $[NO_2]_{CONV}$ (y-axis) versus $[NO_2]_{OUT}$ (x-axis) following 40 CFR Part 50 App F Sec. 1.5.9 and 1.5.10, where:

$$[NO2]_{CONV} = [NO2]_{OUT} - \left([NOx]_{orig} - [NOx]_{rem}\right)$$

$$[NO2]_{OUT} = [NO]_{orig} - [NO]_{rem} + \frac{F_{NO} - [NO2]_{IMP}}{F_{NO} + F_O + F_D}$$

Where NO_{orig} and NOx_{orig} are the NO and NOx responses, respectively, during the dilution; NO_{rem} and NOx_{rem} are the NO and NOx responses, respectively during the titration; $NO2_{IMP}$ is the NO2 impurity in the gas cylinder; and F_{NO}, F_O, and F_D are the flow rates of the audit gas, ozone, and zero air, respectively.

Wind Speed and Direction Calibration

Introduction and Necessary Materials

The standard operating procedure for the twice per year wind sensor calibration and multi-point check is detailed below. The assumed wind sensor is an R.M. Young 05305 combination vane and propeller sensor. The following equipment will be required to perform a calibration on the R.M. Young 05305. Information has been adapted from Section 2 of EPA-454/B-08-002.

- R.M. Young 18802 Anemometer Drive
  - NIST-traceable certification not expired on final day of calibration
  - Including drive controller
  - Including drive holder
  - Batteries or DC power source
- R.M. Young 18310 Propeller Torque Disc
  - Including 1 gram screw
- R.M. Young 18112 Vane Angle Bench Stand or Model 18212 Vane Angle Fixture-Tower Mount
  - Including vane holder
- R.M. Young 18331 Vane Torque Gauge
- Compass & tripod stand
- Magnetic Declination Map or sun angle measurement system

Wind Sensor Maintenance

The 05305 is designed to provide interruption free use for several years. A visual inspection of the vane and propeller should be performed to ensure the sensor has not been damaged during normal operation. Replacement parts are available from R.M. Young. The most common replacement items are the ball bearings on the nose cone and the wind direction potentiometer. Both of these components are available from R.M. Young and should be 'on hand' for quick repairs in the field. If not, the sensor should be returned to R.M. Young for repair and recalibration.

Wind Direction Calibration

Before lowering the tower, or the instrument booms of the tower, it is a good idea to measure the sensor's orientation relative to a reference point (normally true north). Orientation error is a systematic bias in wind direction measurements that must be no higher than ±2 degrees.

Adjusting for Local Magnetic Declination

Due to magnetic north not being equal to true north, the deviation from magnetic north must be known in order to adjust a magnetic compass to read true north. This magnetic declination can be determined using either a magnetic declination map, magnetic declination calculator, or by using sun angles. Due to potential errors from local sources of magnetism (e.g. high iron content in the soils or proximity to a fence), the sun angle method described below is recommended. The magnetic declination calculator method is also described for situations when the sun angle method cannot be used (e.g. overcast days).

1.1.1.1.1 Sun Angle Method

A few different solar methods exist for determining true north. The one presented below requires a tripod-mounted compass, and a program that can calculate solar azimuth (e.g. LunaSolCal).
Step 1: Position your compass/tripod away from the base of the tower, aligned with the instrument boom, cross-arm or alignment rod, such that when you look towards it, you are looking at it straight on, as opposed to length-wise. The farther away you are from the tower, the easier this is.

Step 2: Open the compass and look through the cross hairs. Make sure you are still looking 'through' the boom, cross-arm, or rod. If you aren't looking directly 'through' it as in Figure 2, readjust your tripod position and repeat Steps 1 & 2 until you do.

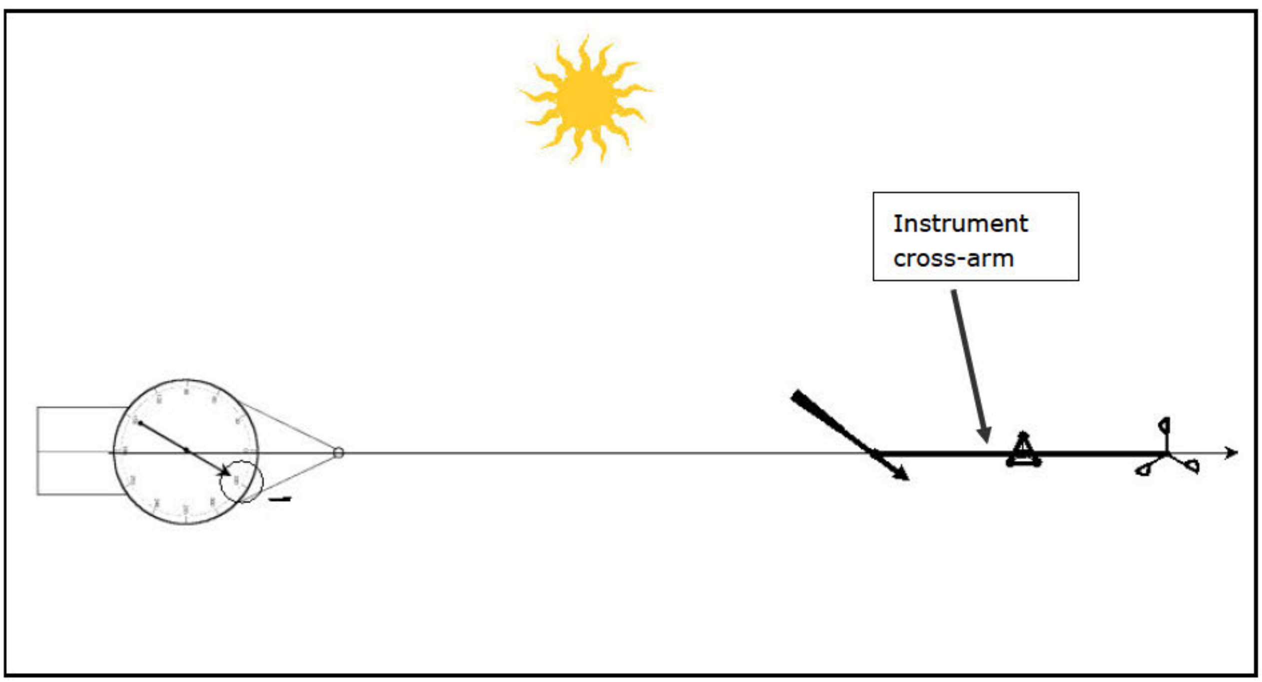

Figure 2: Ensuring that the cross hairs of the compass are looking 'through' the instrument boom or alignment rod. Adapted from Figure 2.14 of EPA-454/B-08-002.

Step 3: If your compass has a leveling bubble, ensure that the bubble is within the leveling outline. If it is not, level your compass and recheck the boom, cross-arm, or rod through the compass cross hairs. Repeat Steps 1, 2, and 3 as necessary until the compass is level and aligned. This process is often referred to as 'shooting' the alignment reference.

Step 4: Rotate the compass on the tripod and reflect the vertical black line on the compass's mirror onto the compass's cross hairs. It may help to hold a white sheet of paper behind the compass cross hairs to visualize the reflection, as in **Figure 3**. Be sure not to unlevel the compass during this procedure.

Figure 3: Measuring the Sun's azimuth. Ensure that the black line's reflection is centered on the cross hairs in the reflection. Taken from Figure 2.16 of EPA-454/B-08-002.

Step 5: Using your solar azimuth calculation software (which should take into account your exact location and time), calculate the sun's azimuth.

Step 6: Adjust your compass's declination screw until the needle of the compass points towards the calculated azimuth angle. You may need to repeat this several times. Between getting the reflection, and calculating the sun's azimuth, the reflection may change, so you may need to rotate the compass and recalculate the azimuth. It is helpful to already have your program ready to go before centering the reflection in Step 4. Many phone applications like LunaSolCal take into account your time and location using your phone's clock and GPS functionality, and provide you an instantaneous azimuth reading, which allows you to do Steps 4 and 5 quickly.

Once the reflection is centered and the compass needle's reading agrees with the calculated sun azimuth, you have corrected for local magnetic declination. Note, if you move the compass from the location, you may need to repeat the process to take into account unforeseen magnetic aberrations.

You can also doublecheck your new declination setting with the Magnetic Declination Calculator in Section 2.1.2.

1.1.1.1.2 Magnetic Declination Calculator

The National Geographic Data Center (NGDC) website can calculate magnetic declination for a user based on the user's latitude and longitude (https://www.ngdc.noaa.gov/geomag/calculators/magcalc.shtml#declination). Go to the NGDC website, and type in the latitude and longitude of your location. Note, if you are using LunaSolCal, you can gather this information from the main application screen, and even in poor cellular service locations, a phone's GPS will still work. Ensure that you have accounted for the hemisphere you are in (e.g. N, S, E, or W) and that your date is correct. Then click Calculate (see Figure 4).

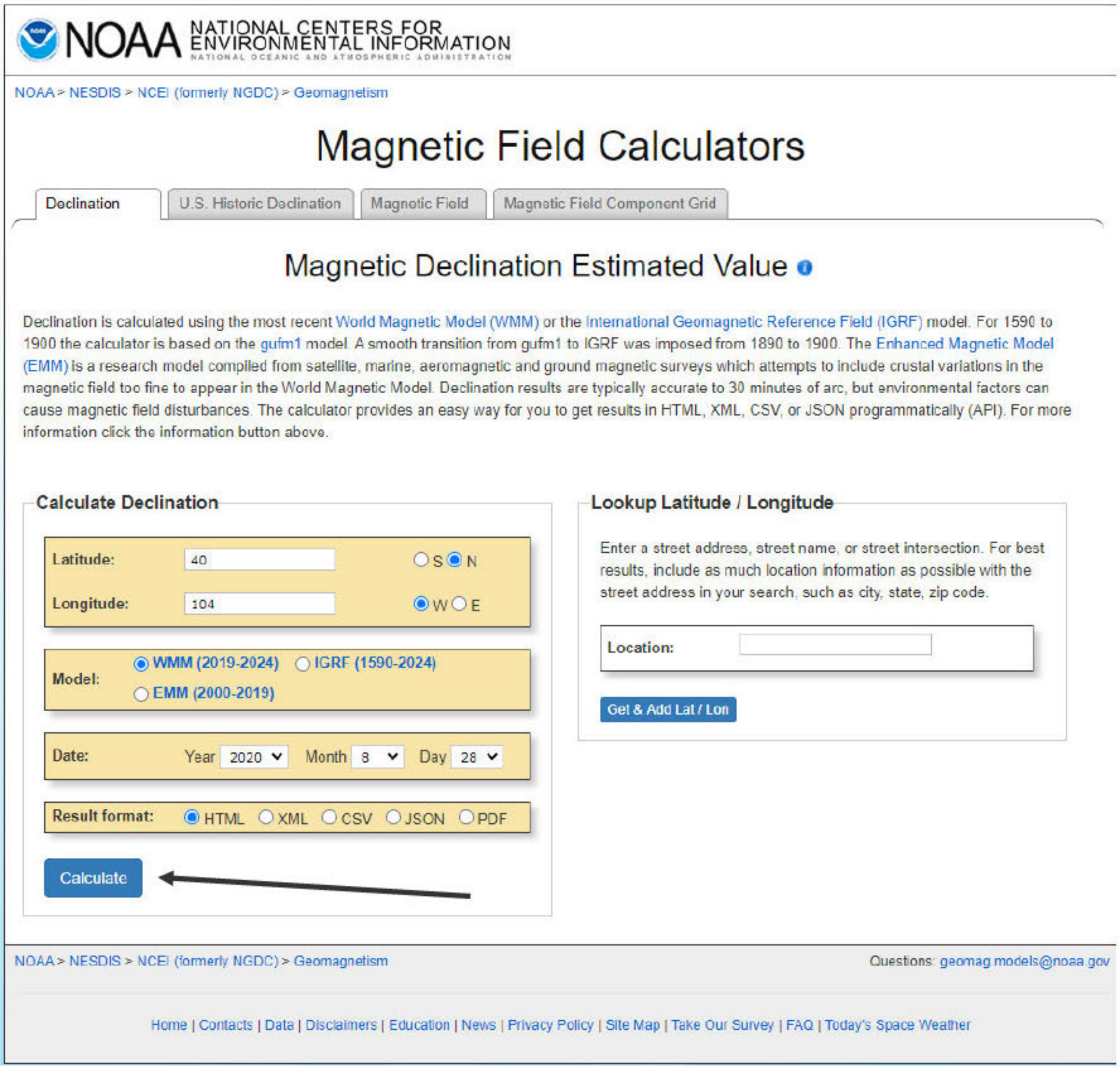

Figure 4: The NFDC's declination calculator.

After pressing Calculate, you will get the popup window in Figure 5. The declination is given under Declination, and you can adjust your compass's declination needle to that angle. Once adjusted, your compass has been corrected for the area's magnetic declination.

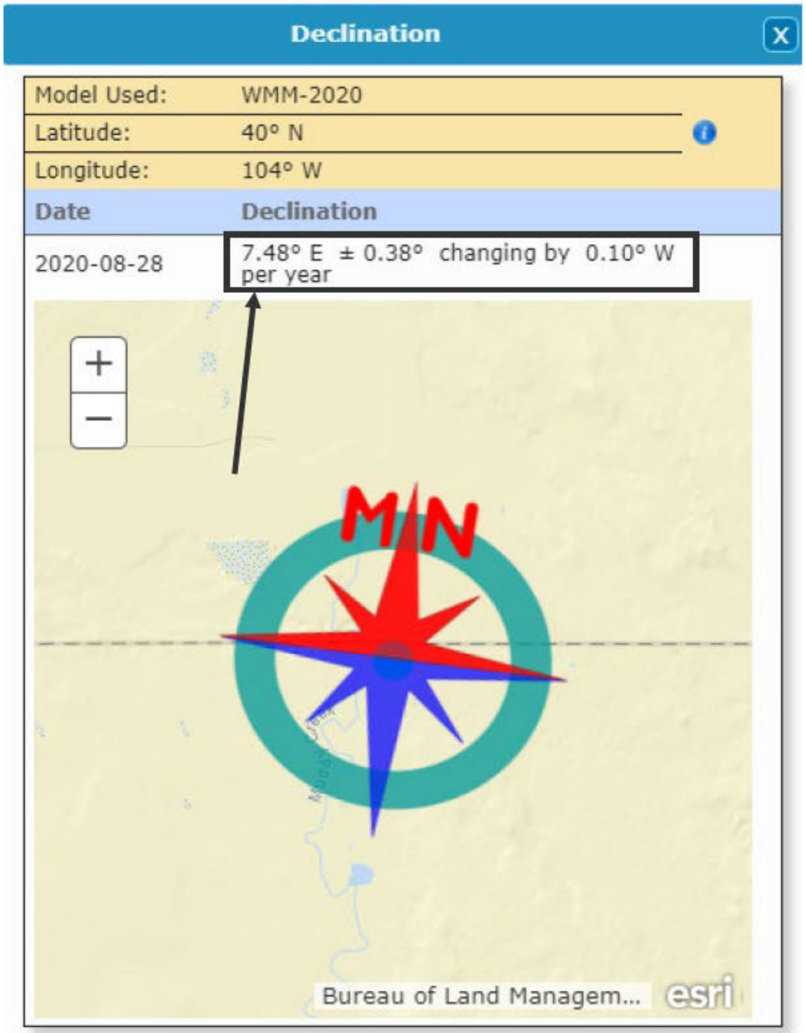

Figure 5: Magnetic declination from the NGDC.

Calibrating Wind Direction Alignment

Without changing the physical location of the tripod, the compass can now be rotated to 'shoot' the reference point again. The needle should point to 0 ± 2 degrees (or 180 ± 2 degrees if the siting occurred from the north). After checking the alignment of the reference point (boom, cross-arm, or rod), the tower or instrument boom may be lowered.

Step 1: Hold the vane such that it is parallel with the reference point and pointing north. If an R.M. Young Model 18212 Vane Angle Fixture-Tower Mount is available, it can be mounted between the wind vane and the alignment collar, with notches lining up, and held in place with the clamp. Note, before removing the wind sensor, ensure that the sensor is mounted with a secure alignment collar. This way the alignment collar stays in place, and the tower mount can be seated between the alignment collar and the wind vane, maintaining the 'as found' orientation. If there is no alignment collar, a second pair of hands will be needed to hold the sensor while the auditor checks the reading. DO NOT REMOVE THE SENSOR IF NO ALIGNMENT COLLAR EXISTS, OR IF THE ALIGNMENT COLLAR IS LOOSE. WAIT UNTIL YOU COMPLETE CARDINAL DIRECTION CHECKS. With the sensor held in place, record the reading on the Data Acquisition System (DAS). It should be near 0. There are 5 degrees of total allowable error. For example, a vane off by -2 degrees, and a DAS reading of +7 degrees is still within error limits.

Step 2: Repeat Step 1 but with the vane held in the opposite direction.

Step 3: Repeat Step 1 but with the vane held perpendicular to the reference point.

Step 4: Repeat Step 3 but with the vane held in the opposite direction.

1.1.1.1.3 Wind Direction Linearity

If a wind direction linearity check is necessary, make sure to complete the alignment check first. With either the R.M. Young 18112 Vane Angle Bench Stand or Model 18212 Vane Angle Fixture-Tower Mount, a multi-point linearity check of the sensor response can be completed.

Step 1: Mount the 05305 to the linearity wheel (18112 or 18212), making sure to align the notch of the sensor to the notch of the wheel.

Step 2: Clamp the vane with the provided clamp to secure in place.

Step 3: Rotate the vane to the required point and record the reading from the DAS.

Step 4: Repeat for the necessary number of points.

Wind Direction Torque

This should be the final test performed in the 'as found' check list for wind direction measurements. It requires the vane to be placed on level ground with no influence from ambient wind or drafts from an HVAC system. If this is not possible, this test will not provide useful results.

Step 1: Remove the wind vane and find a level plane with zero influence from wind.

Step 2: Place the R.M. Young 18331 Vane Torque Gauge on the vane, such that the 'cross hairs' on the vane gauge are right over the top of the potentiometer.

Step 3: Pull the string straight and make sure the metal tab is reading 0.

Step 4: Slowly pull to one side and note when the wind vane starts to turn. The reading on the vane gauge should be less than the manufacturer's specification for wind vane torque. If it is not, then the bearings on the wind vane will need to be replaced.

Wind Speed Calibration

With the tower lowered, inspect the propeller for damage. Also ensure that the nut is holding the propeller securely in place. If the propeller can spin without spinning the nose cone, then all previously collected data must be invalidated.

Step 1: Remove the nut and propeller.

Step 2: Attach the R.M. Young 18802 Anemometer Drive holder to the body of the vane.

Step 3: Slide the 18802 Anemometer Drive onto the holder and secure the rubber gromet to the metal nose of the nose cone. Be sure that the drive and the metal portion of the nose cone are aligned. If they are not, it can lead to premature shutoff of the Anemometer Drive.

Step 4: Power on the Anemometer Drive and set the speed to the desired output. The rotation rate of the drive should correspond to a certain reading on the DAS. This is determined from the transfer function, or the manufacturer's manual.

Step 5: Repeat Step 4 until the desired number of points have been checked. DAS output should be within ±0.2 m/s of the value determined from the transfer function.

Wind Speed Torque

The starting threshold of the nose cone to the 05305 is checked with the R.M. Young 18310 Propeller Torque Disc. A 1 gram screw is provided that can be inserted into different holes at different positions on the disc. Each position, starting in the center and moving out, corresponds to an increasing amount of torque necessary to spin the propeller.

Step 1: Remove the propeller if it has not yet been removed.

Step 2: Place the screw on the innermost position of the disc and mount the disc to the metal rod of the nose cone.

Step 3: Hold the disc with the screw being parallel to the ground. Let go. If the disc spins, then the starting threshold is below 1 gram-centimeter.

Step 4: Move the screw to the next position and repeat until releasing the disc does not cause it to spin. This is your starting threshold. It should be below the manufacturer's specifications for starting threshold. If it is above it, then the nose cone bearings should be replaced.

Temperature and Temperature Difference (Delta T) Calibration

Introduction and Necessary Materials

The standard operating procedure for the temperature and delta temperature twice per year calibration and multi-point check is detailed below. The temperature sensors are RM Young Model 41342VC units. The following equipment will be required to perform a calibration on the RM Young 41342VC. Information has been adapted from Section 3 of EPA-454/B-08-002.

- Certified transfer standard of similar design
    - NIST-traceable calibration not more than 1 year old on final day of calibration
- Water, ice, method for heating water
- Thermos or similar apparatus for a water bath

Temperature Sensor Maintenance

The 41342VC is designed to provide years of data collection with little to no maintenance. It is also designed to be housed in a protective radiation shield. Dust can collect on both the sensor and the radiation shield. The radiation shield can be wiped clean with a damp towel. The sensor can also be wiped clean with a damp towel, provided that no moisture affects the internal electronics. This can be avoided by keeping the sensor top tightly screwed closed and by not getting excess water near where the metal tip that enters the white PVC of the sensor.

Temperature and Delta Temperature Calibration

A side-by-side comparison of the 41342VC and the certified transfer standard must be performed in three water baths of varying temperature, ideally near 0 degrees Celsius, near 25 degrees Celsius, and near 45 degrees Celsius. For delta temperature, the two 41342VC units are also placed side-by-side in three water baths of varying temperature. Usually, the temperature audit and delta temperature audit are performed at the same time, with the two 41342VC units and the certified transfer standard all in the same water baths at the same time. A field calibration check should be performed twice per year (once every six months).

Step 1: Prepare the first water bath by placing water in a thermos (or similar) at a level in which both 41342VC units and the certified transfer standard can be properly submerged. Usually, the first bath is an ice bath, so ice is added. However, this can be performed in any order.

Step 2: Place the 41342VC units and the certified transfer standard into the water bath and allow all three sensors to stabilize before taking a reading. Be careful not to submerge the metal-PVC junction of the 41342VC units.

Step 3: Remove the units and prepare the second water bath. Usually, this is the room temperature bath. If enough water is available, simply dump out the first bath and add room temperature water at a level in which all three sensors can be properly submerged.

Step 4: Place the 41342VC units and the certified transfer standard into the water bath and allow all three sensors to stabilize before taking a reading. Be careful not to submerge the metal-PVC junction of the 41342VC units.

Step 5: Remove the units and prepare the final water bath. Usually, this is the hot temperature bath. If a heating element is available, heat the room temperature (or ice bath) with the heating element to the desired temperature (usually near 45 degrees Celsius).

Step 6: Place the 41342VC units and the certified transfer standard into the water bath and allow all three sensors to stabilize before taking a reading. Be careful not to submerge the metal-PVC junction of the 41342VC units.

Step 7: For PSD or similar quality stations, the acceptance criteria is 0.5 degrees Celsius between each individual 41342VC and the certified transfer standard, for each water bath, and the two 41342VC units should also compare to within 0.1 degrees Celsius of one another for each water bath. A well-mixed water bath will allow readings to stabilize quickly. If readings are not meeting criteria, stirring the water will usually allow for stabilization at a quicker rate. A cover for the thermos such that only the metal probes are submerged can also help.

Solar Radiation Calibration

Introduction and Necessary Materials

The standard operating procedure for the solar radiation twice per year calibration and multi-point check is detailed below. The solar radiation sensor is the Hukselflux Model LP02. The following equipment will be required to perform a calibration on the LP02. Information has been adapted from Section 6 of EPA-454/B-08-002.

- Certified transfer standard of similar design
    - NIST-traceable calibration not more than 1 year old on final day of calibration

- Logging system for the transfer standard
- Mounting system for the transfer standard

Solar Radiation Maintenance

The Hukseflux LP02 has a conical glass dome that protect the sensor. This glass dome should be kept clean (ideally daily).

Solar Radiation Calibration

A side-by-side comparison of the LP02 and the certified transfer standard must be performed. Ideally, one full diurnal cycle should be observed. If a full diurnal cycle cannot be observed, the side-by-side test should cover several hours before and after peak radiation, and should involve some sort of zero check. If a side-by-side comparison is not possible, then the LP02 should be returned to the manufacturer for a calibration check. A field calibration check should be performed twice per year (once every six months).

Step 1: Power on audit logger and ensure battery is fully charged or power source is stable. It is recommended that if a battery is used it is charged prior to deployment.

Step 2: Connect to audit logger with LoggerNet. It is recommended to setup the connection to the logger prior to deployment.

Step 3: Sync the logger clock on the audit logger to the logger clock for the on-site logger. This is important to ensure you are comparing the same values during the data review process.

Step 4: Mount the transfer standard in a position such that it is subjected to the same radiation conditions as the on-site sensor.

Step 5: Wire the transfer standard to the audit logger.

Step 6: Allow both sensors to collect data as described above.

Step 7: Compare data collected from the on-site sensor and the transfer standard. For PSD or similar quality stations, the acceptance criteria is an absolute difference between on-site sensor and transfer standard of 10 W/m^2 when radiation is below 200 W/m^2, and a 5% difference between the two when radiation is above 200 W/m^2.

Precipitation Calibration

Introduction and Necessary Materials

The standard operating procedure for the precipitation sensor twice per year calibration is detailed below. The precipitation sensor is an RM Young Model 52202. The following equipment will be required to perform a calibration on the RM Young 52202. Information has been adapted from Section 4 of EPA-454/B-08-002.

- Precision volume measuring device (graduated cylinder)
- Drip funnel or similar
- Water

Precipitation Maintenance

The RM Young 52202 should be inspected for dirt and debris that could impact water collection. Debris should be removed and dirt should be cleaned off with a damp towel. Dirt may also be present on the tipping apparatus inside of the funnel, which could impact measurements. The tipping apparatus should be periodically cleaned as well. This can be accomplished with a damp towel and a tool to get into the corners of the tipping apparatus (usually a small screwdriver). Be careful not to damage the tipping apparatus. Usually after cleaning of the tipping apparatus, the tipping bucket calibration screws may need to be adjusted as well. Turning them may raise or lower them (e.g. clockwise may lower and counter-clockwise may raise them), which will affect the level-ness of the tipping apparatus. This is how calibration adjustments are made. Note, every precipitation sensor is designed to tip at a specific volume of water. For the 52202, the buckets should tip at 2 mL of water. A precision syringe can be used to ensure the buckets are tipping at the correct volume of water. If adjustments are made to the buckets, they should be tested to ensure they are tipping at the correct volume.

In addition, the entire sensor may need to be leveled periodically. A level bubble and leveling screws make this possible.

If the sensor has a heater, cold spray on the thermostat can be used to check its operation.

Precipitation Calibration

The calibration is performed by introducing a known volume of water to the sensor via a drip funnel. The volume is usually measured with a graduated cylinder. The drip funnel ensures a slow, but constant, flow of water to allow the sensor's tipping apparatus to tip evenly without missing water. A field calibration check should be performed twice per year (once every six months).

Step 1: Measure out a known volume of water with the graduated cylinder. Usually, between 300 and 900 milliliters are used.

Step 2: Add the water to the drip funnel or similar apparatus, making sure to not spill any water.

Step 3: Place the drip funnel or similar into the precipitation sensor's funnel and allow the water to drip through. It is usually prudent to wait for the first few 'tips' to occur to make sure water is flowing evenly. Note, different precipitation sensors can handle different flow rates. Make sure you are not exceeding the flow rate limits for your sensor.

Step 4: Using the volume of water introduced and the 'volume per tip' parameter for the sensor, one can calculate the number of tips the sensor recorded. This information plus the sensor's resolution (e.g. x inches or x mm per tip) one can calculate the expected amount of precipitation. For PSD or similar quality stations, the acceptance criteria is a 10% difference between the calculated and recorded value.

Relative Humidity and Barometric Pressure Calibration

Introduction and Necessary Materials

The standard operating procedure for the relative humidity and barometric pressure sensor's twice per year calibration and multi-point check(s) are detailed below. These standard operating procedures are combined since the process is the same. The relative humidity sensor is an E+E Elektronik Model EE181. The barometric pressure sensor is a Setra Model 278. The following equipment will be required to perform a calibration on the E+E Elektronik EE181 and the Setra 278. Information has been adapted from Section 5 of EPA-454/B-08-002 (for relative humidity) and Section 7 of EPA-454/B-08-002 (for barometric pressure).

- Certified transfer standard of similar design
  - NIST-traceable calibration not more than 1 year old on final day of calibration
- Radiation housing for the certified relative humidity transfer standard

Maintenance

The EE181 relative humidity sensor is designed to provide years of data collection with little to no maintenance. It is also designed to be housed in a protective radiation shield. Dust can collect on both the sensor and the radiation shield. The radiation shield can be wiped clean with a damp towel and any debris should be removed. The sensor has a mesh screen filter that prevents dirt and debris from impacting the actual sensor element. This mesh screen filter occasionally requires cleaning. It can be removed and cleaned using warm soapy water. Be sure not to damage the sensor element while mesh screen filter is removed for cleaning.

The 278 barometric pressure sensor is designed to provide years of data collection with little to no maintenance. It should be housed in a weather-proof enclosure.

Field Calibration

A side-by-side comparison of the EE181/278 and the certified transfer standard must be performed. Ideally, several hours of collocated data can be gathered. If several hours of collocated data cannot be gathered, then several spot (instantaneous) comparisons can be made. A field calibration check should be performed twice per year (once every six months).

Step 1: For relative humidity, install the radiation shield onto the certified transfer standard

Step 2: Collocate the certified transfer standard with the on-site sensor.

Step 3: Allow both sensors to collect data (either several hours or several spot measurements) as described above.

Step 4: Compare data collected from the on-site sensor and the transfer standard. For PSD or similar quality stations, the acceptance criteria for relative humidity is an absolute difference between sensor and transfer standard of 7% relative humidity, and for barometric pressure the acceptance criteria is an absolute difference between the on-site sensor and transfer standard of +/- 2.25 millimeters of Mercury.

Site To Do List

Review previous site access log entries to see when previous filter and desiccant changes occurred. Be sure to note times of arrival and departure of sites. Be sure to note times that pumps are unplugged and plugged back in when conducting a filter change. Be sure to update site access logs when returning to office for accurate record keeping.

1. Take note of time arrived on site and fill out site access log.

2. Perform all National Atmospheric Deposition Program (NADP) activities first
   a. Refer to the NADP Standard Operating Procedures (SOPs) document for instructions. SOPs are located in shelter binder on the desk.

3. Review the site access log prior to leaving for site will let you know when the last filter change occurred. Since Hereford visits are less frequent, it's a good idea to schedule once per month visits. If filter and/or desiccant changes are required, then perform those.
    a. Filter changes for the Ozone/NOx analyzers need to be performed once per month. Its best to keep the same schedule and replace the filter at the beginning of the month.
        i. Refer to Teledyne Filter Changes SOP for instructions. SOPs are located in shelter binder on the desk.
        ii. Take note of time analyzer pumps are unplugged and plugged back in for filling out site access log.
    b. Desiccant changes are performed as needed once the desiccant is used up. Refer to the T703 Desiccant Change SOP to determine if the desiccant is used up. It's a good idea to always have desiccant supplies on hand in case a change is needed (see site supplies section below).
        i. Refer to T703 Desiccant Change SOP for instructions. SOPs are located in shelter binder on the desk.

4. Check site supplies:
    a. Number of filters left
        i. Once there are 2 filters remaining for an analyzer, reach out to Jake Zaragoza [redacted] for purchasing more.
    b. Amount of desiccant left
        i. Once a quarter of the large desiccant bucket is left, reach out to Jake Zaragoza [redacted] for purchasing more.
        ii. If the desiccant in the large desiccant bucket ever turns pink, reach out to Jake Zaragoza [redacted] for purchasing more.
    c. Kimwipes
        i. Once you use the final wipe, reach out to Jake Zaragoza [redacted] for purchasing more.
    d. NADP site supplies
        i. Follow NADP guidance and procedures for reporting and requesting more supplies.

5. The following are checks that should be completed prior to leaving the sites:
    a. **Gaseous Analyzers**
        i. The gas analyzers that require filter changes are the T200 NOx analyzer (Missile Site Park only) and the T400 ozone analyzers. Check if both the T200 NOx analyzer and the T400 ozone analyzer to see if either has an alarm, which are displayed as an exclamation point within a yellow triangle (as seen in the bottom right corner of **Figure 6** below).

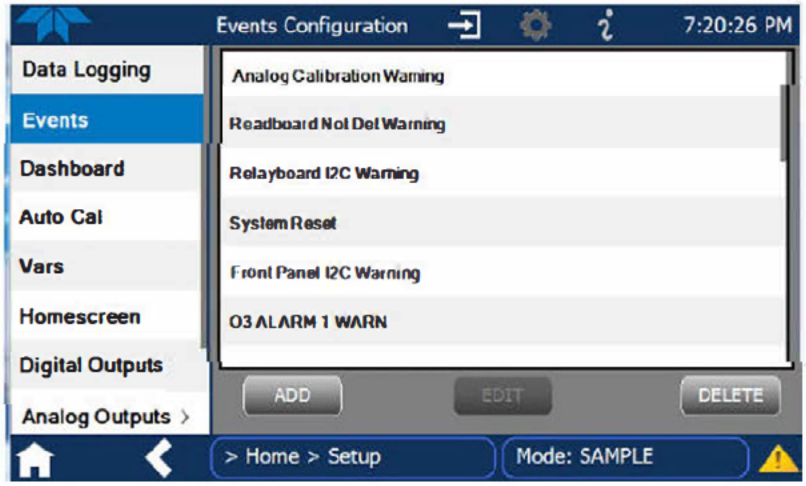

Figure 6: Example of gas analyzer alarm[1]

ii. **Instructions to Resolve**: If an analyzer is found with an alarm, call Jake Zaragoza [redacted] They will provide further instruction.

b. **Site maintenance such as brush clearing**

i. Refer to Site Maintenance SOP for instructions. SOPs are located in shelter binder on the desk.

c. **Weld County owned precipitation equipment (non-NADP)**

i. The precipitation sensors that are closest to the meteorology towers are the main precipitation sensors for the sites. They sit on a ~2 foot tall pipe and have a debris screen sitting in their funnel.

Figure 7: Example of Weld operated precipitation equipment

[1] Borrowed from Figure 2-43 of the T200 Instrument Manual. Available at: https://www.teledyne-api.com/prod/Downloads/T200%20%26%20T200U%20NVS%20Manual%20-%2008373020 0.pdf

1. **Check**: at times dirt and debris can get past the screen and clog the funnel's hole. This should be checked when on-site to ensure there is no debris blocking the hole.
2. **Instructions to Resolve**: If found, all debris should be removed carefully, ensuring that none fall into the hole. Dirt can be wiped clean with Kimwipes or paper towels. Kimwipes have been left in each shelter on the desks for this purpose. Debris removal or cleaning should be noted in the site access log, with the time it occurred.
3. **Issues:** If there is debris blocking the hole, remove the debris and report to Jake Zaragoza [redacted] Also, be sure to note in the site access log.
4. **Issues:** If debris falls into the hole while cleaning, call Jake Zaragoza [redacted]. You will likely be instructed to pour water through the funnel and record the time that this occurred. This will flush out debris, and any precipitation recorded by the equipment during this will be invalidated by the QA team. Be sure to note in the site access log.

d. Solar Radiation

ii. The solar radiation sensors sit on cross-arms on the towers at ~6 foot height. They are on the end of the cross arms with no other equipment on it.

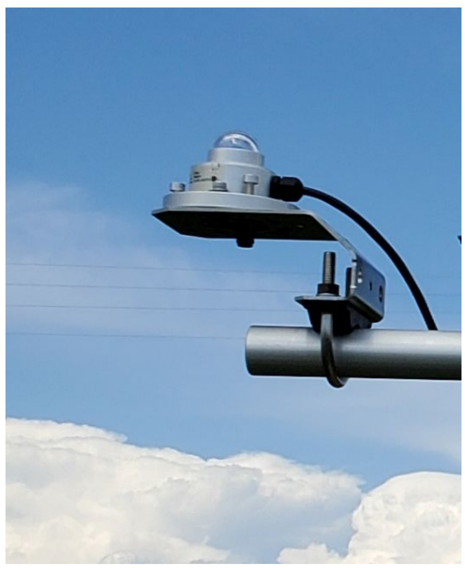

Figure 8: Example of solar radiation sensor

1. **Check**: at times dirt, snow, or ice can form on the glass dome of the sensor. The sensor should be checked when on-site to ensure there is nothing on the glass dome. Debris removal or cleaning should be noted in the site access log, with the time it occurred.
2. **Instructions to Resolve**: If any debris is found, it should be wiped off with a Kim wipe or carefully with a paper towel. Kim wipes have been left inside each shelter on the desks for this purpose.
3. **Issues**: If there is debris on the glass dome, remove the debris and report the time it was removed to Jake Zaragoza [redacted] Be sure to note cleaning and time in the site access log.

e. Wind speed and direction

i. The wind speed and direction sensors sit on cross-arms on the towers at ~30 foot height. They are the vane/propellor sensors (the one on the right in **Figure 9** below).

Figure 9: Example of wind speed and direction sensor

1. **Check**: Ensure that the sensors appear to be operating within reason. For example, if it is windy and the vane or propellor aren't moving, there might be an issue. Or if either the vane or propellor look damaged, there might be an issue. Take a photograph if visual damage is apparent.
2. **Issues**: If you suspect an issue with the wind speed and direction sensors, call Jake Zaragoza [redacted]. If visual damage is apparent send photos to Jake Zaragoza [redacted] Be sure to note confirmed damage in the site access log.

f. Temperature

i. There are two temperature sensors at each site. One sits at ~ 6 foot height and the other sits at ~ 30 foot height. The main item to observe for these is whether or not their aspirator fans sound operational.

Figure 10: Example of temperature sensor

1. **Check**: Ensure that you are able to hear the aspirator fans spinning. It is difficult to hear the fan at 30 feet, as long as a fan can be heard spinning then all should be ok.
2. **Issues**: If you suspect the aspirator is not working, call Jake Zaragoza [redacted]. They will provide further instruction. If the fan is confirmed to be not operational, be sure to note in the site access log.

6. Be sure to note the time site is left.
7. When returning to the office, be sure to update the site access log.

Filter Changes for T400/T200 Teledyne Ozone and NOx Instruments

Filter changes should occur once per month.

Before beginning, be sure to have gloves or Polytetrafluoroethylene (PTFE) coated tweezers on hand. The **housing, new filter, PTFE o-ring, glass cover, or flexible o-ring should not be handled with bare hands**. Instructions provided below are based on Section 5.6.1 of the T200 Instrument Manual (Section 5.6.1 of the T400 Instrument Manual provides the same instructions).

1. Unplug the pump to the analyzer
    a. At MSP, the NOx and ozone pumps are labeled. At Orchard and Hereford, the analyzer pumps are mounted to a bracket.
2. Open the front panel display of the T400/200 analyzer
3. Unscrew the knurled retaining ring on the filter assembly

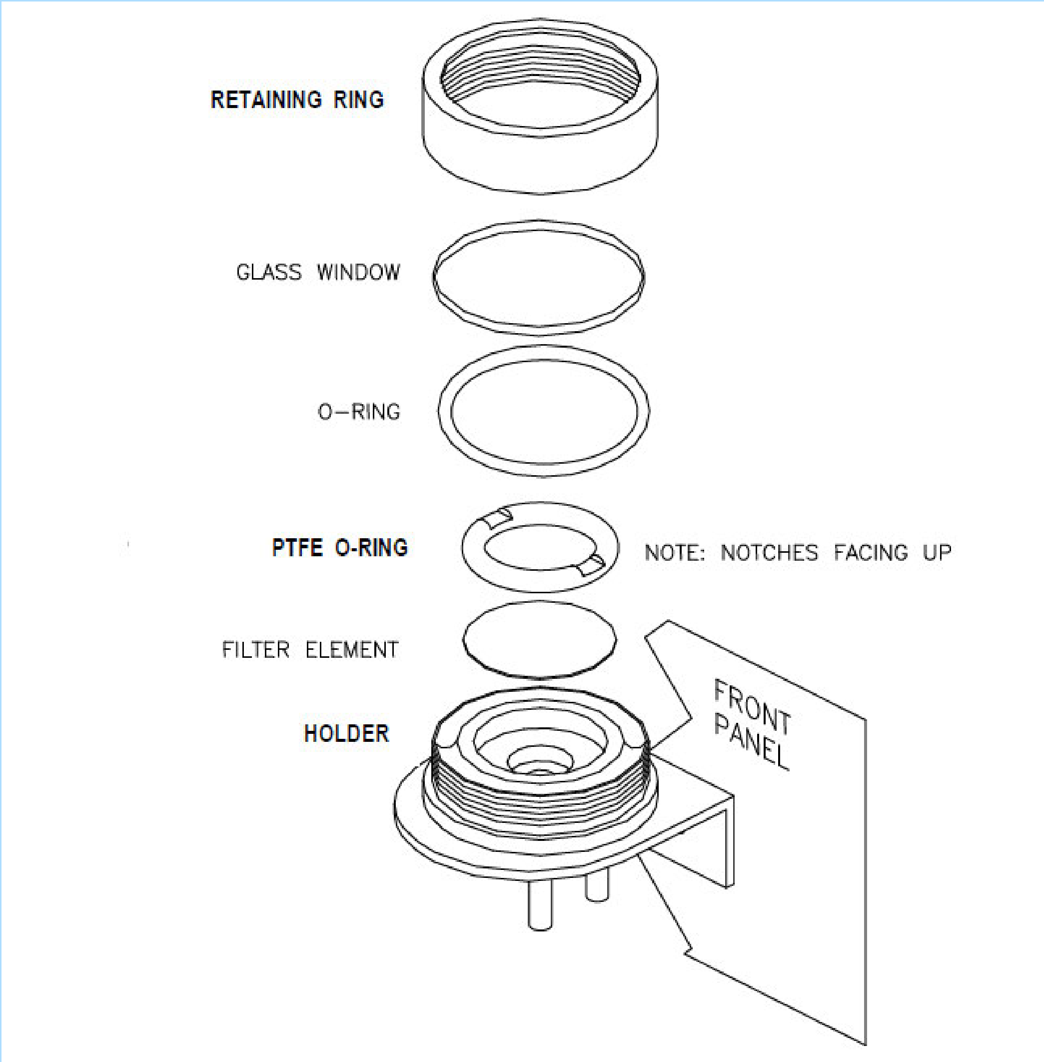

Figure 11: Figure 5-6 of the T200 Instrument Manual: "Replacing the Particulate Filter"

4. Remove the following:
    a. Retaining ring
    b. Glass window
    c. PTFE o-ring
    d. Old filter
5. Replace the filter
    a. Ensure it is fully seated and centered on the holder
6. Reinstall the following:
    a. The PTFE o-ring with notches facing up
    b. The glass window and flexible o-ring if it fell off the window
    c. The knurled retaining ring
        i. Hand tighten the knurled retaining ring as tight as it was found.
7. Inspect the seal between the edge of the filter and the o-ring to ensure a proper seal was made
8. Close the panel
9. **Plug in the pump**

Desiccant Changes for T703 Teledyne Ozone Calibrator Box

There are only 2 T703 calibrator boxes, one at Hereford and one at Orchard. Therefore, this SOP only applies to the Hereford and Orchard sites. The desiccant canisters used at Hereford and Orchard provide dry air to the calibrator and allow for more stable calibration checks at those sites. MSP does not use a desiccant canister since it has a dedicated zero-air generation system. Gloves should be worn during this procedure.

Desiccant changes only need to happen when the desiccant is exhausted.

1. The desiccant has a color changing indicator that indicates when it is exhausted. Normally, the desiccant is blue. It turns a pinkish color when it has been exhausted. **When the canister is more than 80% used up, it should be changed.** Figure 12 provides an example of when the desiccant should be changed. Note that the canister is mostly pink.

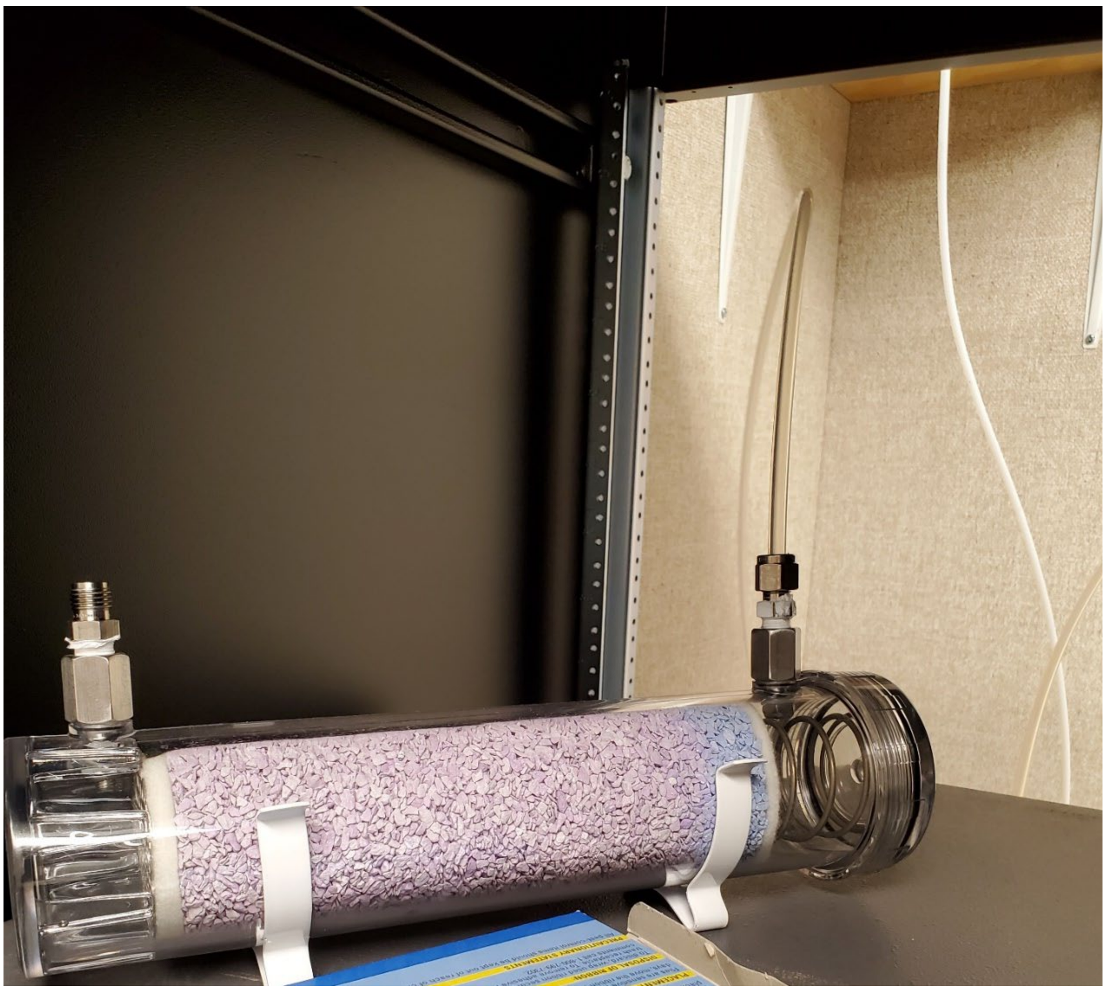

Figure 12: Photo of mostly used desiccant

2. When it is time to replace the desiccant, it is recommended that the tubing between the canister and the T703 calibrator be removed since it is easier to replace the desiccant when you can handle the canister at ground level. To remove the tubing line, two adjustable wrenches can be used. Back up the port fitting while you remove the tubing nut.

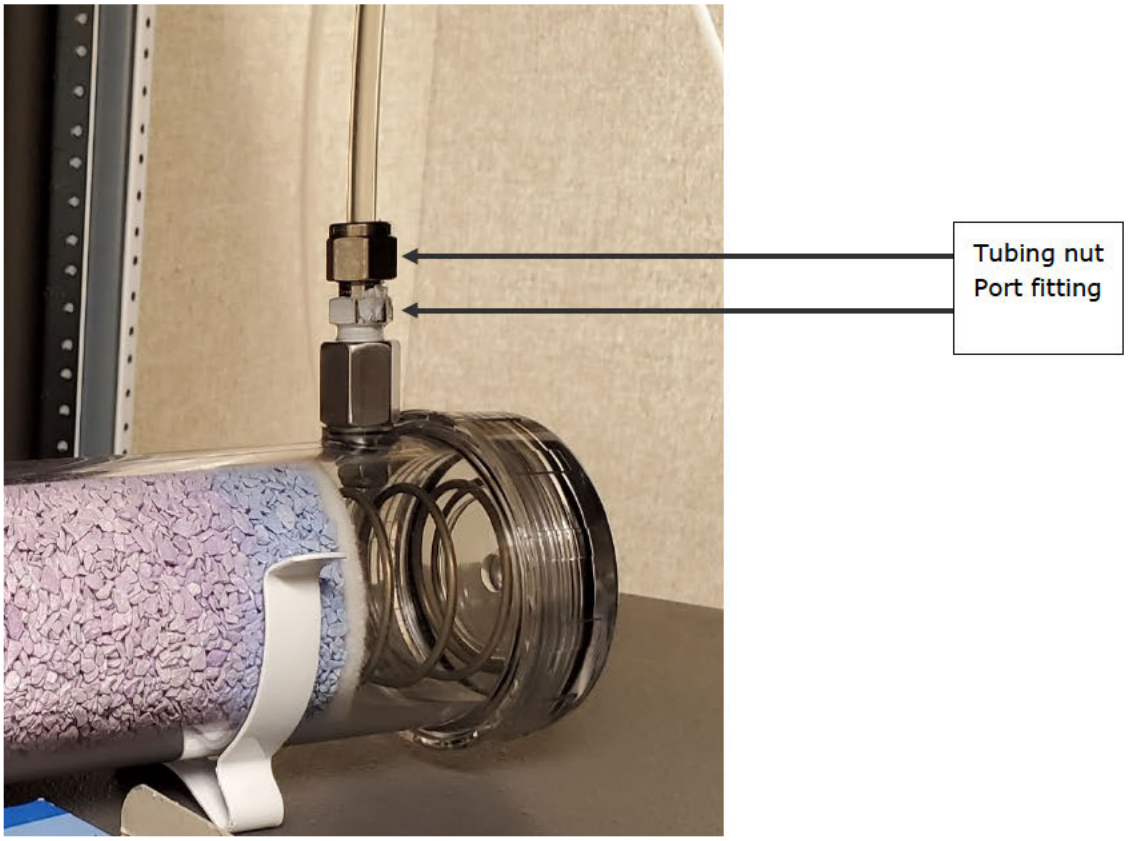

Figure 13: Photo of tube fitting on desiccant canister

3. Remove the canister cap. There are 4 parts inside the canister (o-ring, spring, backing plate, filter), in addition to the desiccant (sometimes the spring is welded to the backing plate). The spring, felt filter backing plate, and felt filter must be removed.

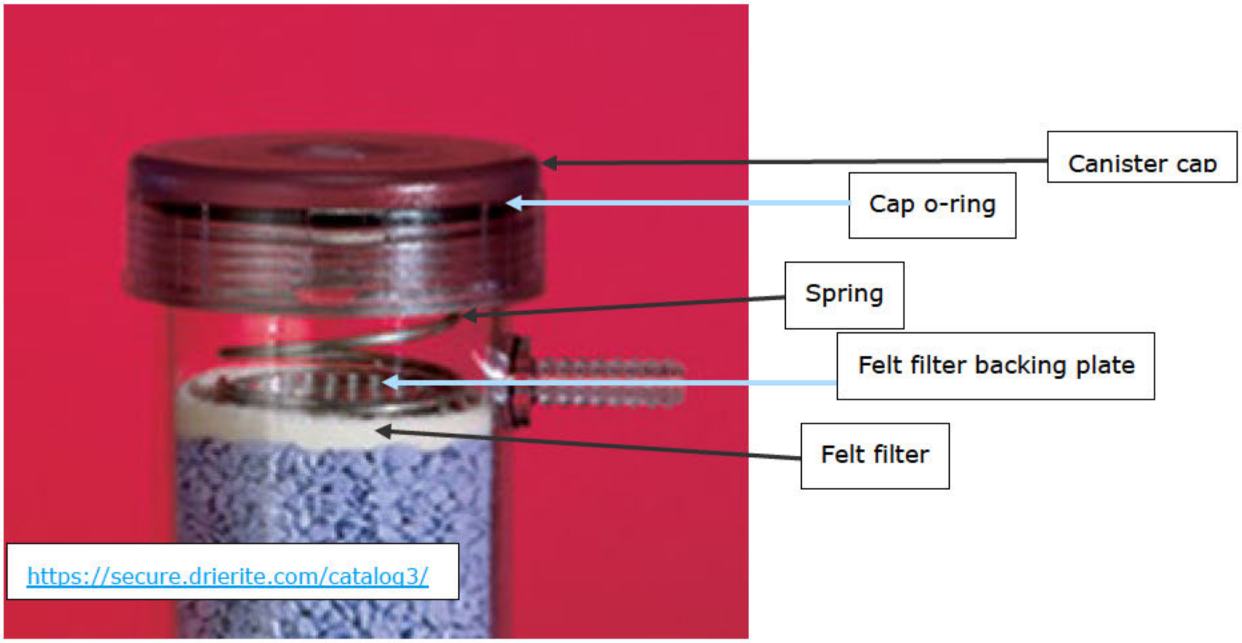

Figure 14: Photo of desiccant canister assembly

4. Once those parts are removed, the used desiccant can be thrown away or put away for regeneration. For desiccant regeneration, see: https://secure.drierite.com/catalog3/page19b.cfm
5. New desiccant can be added. Fill the canister to just below the port opening without blocking the port. Ensure that the addition of the felt filter does not block the port opening.
6. Replace the felt filter, felt filter backing plate, and spring. If the canister cap o-ring has fallen out, replace it as well. Screw the cap back on until it is hand tight. Refer to the image above for the correct order.
7. Reconnect the calibrator tubing line. Be sure to back up the port fitting to ensure that it is not overtightened when screwing on the tubing nut.

Site Maintenance

There is a single pair of shears located inside the shelter at Hereford. Additional sets will be left inside the shelters at the other two sites if need be.

- Weld Operated Precipitation Equipment and NADP equipment
  - Weld Operated Precipitation Equipment
    - **Check** for vegetation taller than the height of the wind screen (~3 feet) within ~3 feet of the wind screen and remove if necessary.
      - When removing brush with shears, other tools, or by hand, ensure that you are not damaging signal cables. **If signal cables are damaged or severed, there will be no data collection until they are fixed. Fixing of signal cables will require removal of ALL other signal cables from underground conduit**. Be sure you are aware of all signal cables prior to beginning work. In general, all signal cables will be coming from service entrance caps and going to their respective equipment.

Figure 15: Example of service entrance cap[2]

- **Ensure** there is nothing caught in the wind screen (see **Figure 16** below). At Orchard, tumbleweeds can get caught in the wind screen. They should be removed.
- **Report Issues** to Jake Zaragoza [redacted]

Figure 16: Left) Example of tall vegetation that should be removed. Note that vegetation is taller than the height of the wind screen. Right) Example of cleared vegetation. Note, this is the Weld Operated Precipitation Equipment.

[2] https://static.grainger.com/rp/s/is/image/Grainger/19L552_AS02?$adapimg$&hei=536&wid=536

- NADP Equipment
  - **Check** for vegetation surrounding the NADP equipment at MSP and Orchard. There should be no vegetation taller than ~2 feet (0.6 m to be exact) within ~16.4 ft (5 m) of either the collection bucket or the NADP precipitation sensor. There should be no vegetation taller than ~2 feet (0.6 m to be exact) within ~6.5 ft (2 m) of the ammonia dry deposition sampler. Note, a tape measure may be needed to measure distances. See **Figure 16** through **Figure 18** below for examples of NADP precipitation sensor, collection bucket, and ammonia sampler.
    - When removing brush with shears, other tools, or by hand, ensure that you are not damaging signal cables. **If signal cables are damaged or severed, there will be no data collection until it is fixed. Fixing of signal cables will require removal of ALL other signal cables from underground conduit**. Be sure you are aware of all signal cables prior to beginning work. In general, all signal cables will be coming from service entrance caps and going to their respective equipment.
  - **Ensure** there is nothing caught in the wind screen.
  - **Report** issues to Richard Tanabe (Richard.tanabe@slh.wisc.edu).

Figure 17: NADP Precipitation Sensor

Figure 18: NADP Precipitation Collection Bucket

Figure 19: NADP Ammonia Sampler. https://nadp.slh.wisc.edu/siteops/#AMoN

- Tower
  - **Check** for vegetation surrounding the meteorology tower and guy wires. There should be a 2 ft clearing around tower base and tower guy wires (see **Figure 20** below).
    - When removing brush with shears, other tools, or by hand, ensure that you are not damaging signal cables. **If signal cables are damaged or severed, there will be no data collection until it is fixed. Fixing of signal cables will require removal of ALL other signal cables from underground conduit**. Be sure you are aware of all signal cables prior to beginning work. In general, all signal cables will be coming from service entrance caps and going to their respective equipment.
  - **Report** issues to Jake Zaragoza.

Figure 20: Example of tall overgrowth near tower