Quality Assurance Project Plan

State of Alaska
Community-Based Air Sensor Network

State of Alaska
Department of Environmental Conservation
Division of Air Quality

333 Willoughby Ave. Suite 800
PO Box 111800
Juneau, Alaska 99811-1800

Prepared by Taylor Borgfeldt

December 20, 2023
Revision: 0

1. QA PROJECT PLAN IDENTIFICATION & APPROVAL

Title: ***Quality Assurance Project Plan for the State of Alaska Community Based Air Sensor Network***

The attached Quality Assurance Project Plan for the State of Alaska Community-Based Air Sensor Network is hereby recommended for approval and commits the Alaska Department of Environmental Conservation to follow the elements described within.

Taylor Borgfeldt, Program Manager
Air Monitoring & Quality Assurance Program
Phone: 907-269-7573
Email: taylor.borgfeldt@alaska.gov
Signature: Taylor Borgfeldt Digitally signed by Taylor Borgfeldt Date: 2024.01.24 09:11:00 -09'00'
Date: 1/24/2024

Rochele Rodman, QA Manager
Air Monitoring & Quality Assurance Program
Phone: 907-465-5344
Email: rochele.rodman@alaska.gov
Signature: Rochele Rodman Digitally signed by Rochele Rodman Date: 2024.01.24 11:19:27 -09'00'
Date: 1/24/24

Will Wallace
Quality Assurance Coordinator
USEPA Region 10
Phone: 206-553-2495
Email: wallace.will@epa.gov
Signature: HENRY WALLACE Digitally signed by HENRY WALLACE Date: 2024.01.24 15:33:43 -08'00'
Date: _____

Christina Miller
Grants Management Specialist
Project Officer for Grant Number 0P- 02J06601-0
USEPA Region 10
Phone: 206-553-6512
email: miller.christina@epa.gov
Signature: Christina Miller Digitally signed by Christina Miller Date: 2024.01.25 13:12:53 -08'00'
Date: _____

Rebecca Derr
Grants Project Officer
Grant Number 5X- 02J26601
USEPA Region 10
Phone: 206-553-1599
Email: derr.rebecca@epa.gov
Signature: Derr, Rebecca Digitally signed by Derr, Rebecca Date: 2024.01.25 07:36:43 -08'00'
Date: 01/25/24

2. TABLE OF CONTENTS

2.1 List of Figures

2.2 List of Tables

2.3 Abbreviations, Terms, and Definitions

Abbreviation/Term	Definition
AAAQS	Alaska Ambient Air Quality Standards
ADEC	Alaska Department of Environmental Conservation. The department of state government with primary responsibility for management and oversight of provisions of the Clean Air Act, including EPA's National Ambient Air Quality Standards.
AQI	Air Quality Index. The AQI is an index for reporting daily air quality and what associated health concerns the public should be aware of. The AQI focuses on health effects that might happen within a few hours or days of breathing polluted air. The AQI rates the air quality in 6 steps from good to hazardous.
AMQA	Air Monitoring and Quality Assurance Program of ADEC. Responsible for coordinating all aspects (quality assurance, data collection, and data processing) with respect to ambient air quality and meteorological monitoring of the ADEC Division of Air Quality.
ANP	Air Network Plan
AQI	Air Quality Index
AQMesh	AQMesh brand ambient air quality sensor that monitors particulate matter and gaseous pollutants, meteorology is optional. Distributed by Ambilabs in the United States.
ARP	American Rescue Plan
AWS	Amazon Web Services
BAM 1020	Met-One Inc. Beta Attenuation Monitor model 1020 continuous monitoring sampler. This sampler can sample for coarse and fine particulate matter.
C	Celsius
CBSA	Core base statistical area
Criteria Pollutant	Any air pollutant for which the EPA has established a National Ambient Air Quality Standard for regulation under the Clean Air Act.
CFR	Code of Federal Regulations
CO	Carbon monoxide
CV	Coefficient of variation
DC	Data completeness
DQA	Data quality assessment
DQI	Data quality indicator
EPA	U.S. Environmental Protection Agency

FEM	Federal equivalent method
FRM	Federal reference method
>	Greater than
GSP	Gold standard pod
LOC	Limit of concentration
LOD	Limit of detection
m	Meter
µg	Microgram
µg/m^3	Microgram per cubic meter
µg/sm^3	Microgram per standard cubic meter
mB	Millibar
m/s	Meters per second
MSA	Metropolitan statistical area
MOA	Memorandum of agreement
MODULAIR™	Ambient air quality sensor by QuantAQ that monitors particulate matter and gaseous pollutants, meteorology is optional.
MQO	Measurement quality objectives
NA	No applicable
NAMS	National Air Monitoring Station. The NAMS are a subset of the SLAMS network with emphasis on urban and multi-source areas. There are no current NAMS-designated monitors in the monitoring network.
NAAQS	National Ambient Air Quality Standards.
NIST	National Institute of Standards and Technology
NO and NO_2	Nitrogen oxides
NRMSE	Normalized root mean square error
O_3	Ozone
OPC	Optical particle counter
Pb	Lead
%	Percentage
Performance Audit	An audit of one or more monitors within a monitoring network using certified calibration standards to evaluate monitor accuracy. Performance audits are conducted by an independent auditor using calibration standards provided by the auditor rather than those that are used for routine precision and accuracy checks. The ADEC QA Officer performs regular performance audits for each criteria pollutant monitored by ADEC.
+/-	Plus or minus
PM_{10}	Particulate matter less than or equal to 10 microns in size.

$PM_{2.5}$	Particulate matter less than or equal to 2.5 microns.
ppb	Part per billion
PSD	Prevention of significant deterioration
QA	Quality assurance
QAPP	Quality Assurance Project Plan. A plan which identifies data quality goals and identifies pollutant-specific data quality assessment criteria.
QC	Quality control
QuantAQ	Manufacturer of MODULAIR™ ambient air quality sensor
R^2	R squared
RH	Relative humidity
RMSE	Root mean square error
SD	Standard deviation
SIP	State Implementation Plan
SLAMS	State and Local Monitoring Station. The SLAMS consist of a network of roughly 4000 monitoring stations nationwide. Distribution depends largely on the needs of the State and local air pollution control agencies to meet their respective SIP requirements. The SIPs provide for the implementation, maintenance and enforcement of the NAAQS in each air quality control region within a state. The State of Alaska monitoring network currently has eight SLAMS sites for carbon monoxide and PM.
SO_2	Sulfur dioxide
SOP	Standard operating procedure
SPM	Special Purpose Monitoring Station. Special Purpose monitoring stations are not permanently established and can be adjusted to accommodate changing needs and priorities for special studies needed by the State and local agencies. The SPM are used to supplement the fixed monitoring network as circumstances require.
System Audit	An evaluation of an entire monitoring program including guidance documents, policies and procedures, data and site records, and components of the monitoring network.
VSCC	Very sharp cut cyclone

3. DISTRIBUTION LIST

An electronic copy of this Quality Assurance Project Plan (QAPP) has been distributed to the individuals listed in Table 3-1: Distribution List and Partner Communities involved in the project. The document is

also available via AMQA's web page (http://www.state.ak.us/dec/air/am) and is available for distribution upon request by additional agencies or groups who are working with the same sensor technology.

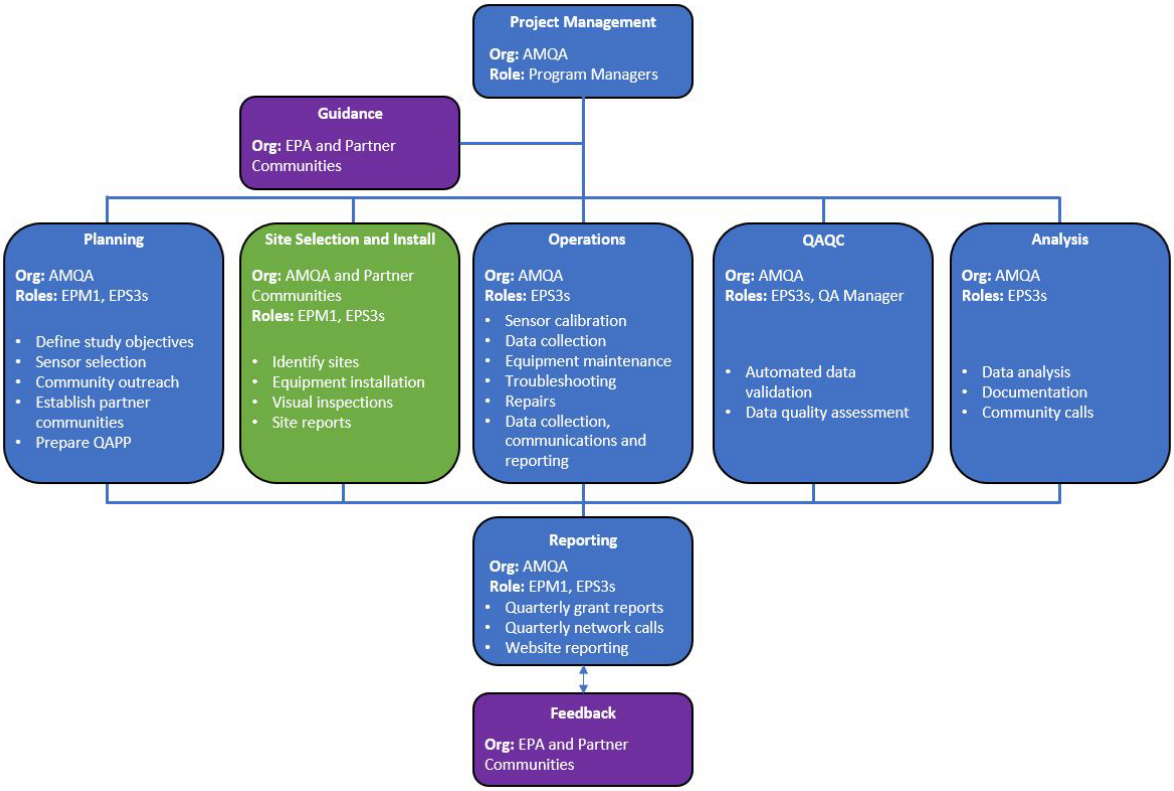
Table 3-1: Distribution List

NAME	POSITION	AGENCY	DIVISION	CONTACT INFORMATION
Barbara Trost	Program Manager	ADEC	Air Monitoring & Quality Assurance (AMQA)	907-269-6249 barbara.trost@alaska.gov
Taylor Borgfeldt	Data Manager	ADEC	Air Monitoring & Quality Assurance (AMQA)	907-269-7573 taylor.borgfeldt@alaska.gov
Rochele Rodman	QA Manager	ADEC	Air Monitoring & Quality Assurance (AMQA)	907-465-5344 rochele.rodman@alaska.gov
Mark Smith	AQ Forecaster	ADEC	Air Monitoring & Quality Assurance (AMQA)	907-269-7676 mark.smith@alaska.gov
Will Wallace	Quality Assurance Coordinator	USEPA Region 10	Environmental Characterization Branch (ECB) Laboratory & Applied Sciences Division (LSASD)	206-553-2495 wallace.will@epa.gov
Christina Miller	Grants Management Specialist	USEPA Region 10	Air and Radiation Division (ARD) Air Planning State & Tribal Coordination Branch (APSTCB)	206-553-6512 miller.christina@epa.gov
Rebecca Derr	Grants Project Officer	USEPA Region 10	Air and Radiation Division (ARD) Air Planning State & Tribal Coordination Branch (APSTCB)	206-553-1599 derr.rebecca@epa.gov

4. PROJECT/TASK ORGANIZATION

This document presents the Quality Assurance Project Plan (QAPP) for the Air Monitoring and Quality Assurance (AMQA) Program's Community-Based Air Sensor Network that is currently being implemented by the State of Alaska. AMQA is partnering with local and tribal governments, native health corporations, and educational institutions to house and maintain the AQMesh and MODULAIR™ air quality sensor pods. AMQA manages the network and makes the data available to the public on the AMQA website. The organizational structure of the ADEC Division of Air Quality for the implementation of the Ambient Air Quality Monitoring Program is shown in Figure 4-1: Flow Chart of Project Responsibilities.

Figure 4-1: Flow Chart of Project Responsibilities



AMQA Responsibilities:

Planning

- Define Study Objectives – Goals and metrics will be identified to collect baseline air quality data in rural Alaskan communities throughout the state to improve data coverage and increase outreach.
- Sensor Selection – Specifications for monitoring, communication, and storage of available sensors will be analyzed. Sensors within AMQA's inventory, as well as commercially available sensors, will be considered. Sensor purchases will be based on the following criteria: availability, cost, lead time, quality, suitability for Alaska's climate, experiences in previous AMQA studies, sensor reputation, and availability will impact sensor choice.
- Public Outreach – Information on the study design, purpose, and operation will be prepared and distributed to the public in multiple formats.
- Identify Partner Communities – AMQA will select candidate Partner Communities based on existing air quality data access, geospatial distribution, population size and sensor feasibility.

- Identify Sites – Monitoring site locations will be selected based on instrument siting requirements, low-cost sensor siting guidance, representativeness of community ambient air, and practical considerations of local conditions.

- Prepare QAPP – A Quality Assurance Project Plan will be prepared which addresses project management, data acquisition, validation, and analysis.

Operations

- Equipment Installation – Calibrated sensors will be sent to Partner Communities for deployment and installation. ADEC staff will either provide remote or in-person assistance when feasible. ADEC will provide the mounting equipment, extension cables and training on how to deploy a sensor.

- Sensor Calibration – The sensors will be calibrated by the manufacturer prior to shipment to AMQA to ensure a current calibration and proper operation of components. AMQA will conduct a collocation study with all sensors and Federal Equivalent Method (FEM) instrument to calibrate sensor performance before deployment. AMQA will initiate stabilization and rebasing when sensors are deployed and installed at their final community sites.

- Data Collection – Data collected by sensors is transmitted via cellular modem to a cloud-based database. Data will be reviewed and stored in a data management system to facilitate retrieval and analysis.

Analysis

- Data Analysis – Real-time data will be reviewed for anomalous events to review with Partner Communities. Long-term trends will be analyzed for notable trends in ambient air quality for the communities.

- Documentation – AMQA will document the Study and include discussions on results. Reports and data analysis will be publicly available on the AMQA website and sent to Partner Communities.

Partner Community Responsibilities:

Planning

- Public Outreach – The Partner Communities will be contacted to aid in the distribution of information that best fits their community's needs.

- Identify Partner Communities– The Partner Communities will be able to choose to participate in the Study and engage as Partner in work.

- Identify Sites – The Partner Communities will be contacted for inquiries about potential sites for monitor placement.

Operations

- Equipment Installation – The Partner Communities might assist in deployment of sensors or lead independent installments with remote training and assistance if it is not feasible for ADEC to access the site or community.
- Equipment Maintenance – The Partner Communities will assist in maintaining the equipment with visual inspections, power cycles, pulling data from SD card, and general appearance and upkeep (removing bird nests, graffiti, snow, etc.).

5. PROBLEM DEFINITION AND BACKGROUND

The ADEC AMQA Program is in the process of establishing a community-based ambient air quality sensor network using AQMesh[1] and QuantAQ MODULAIR™[2] sensor pods. The Alaskan community network is intended to provide baseline air quality data for areas not covered by the State's regulatory monitoring network. Almost every community in the state can be impacted by wildland fire smoke and road dust from gravel roads or other windblown dust. Wintertime inversions can exacerbate air quality impacts due to home heating emissions or local power generation. The ADEC AQMesh pods are configured to measure particulate matter (PM_1, $PM_{2.5}$, PM_4, PM_{10}), carbon monoxide (CO), sulfur dioxide (SO_2) and nitrogen oxides (NO and NO_2). The ADEC MODULAIR™ pods are configured to measure particulate matter (PM_1, $PM_{2.5}$, PM_{10}), CO, NO, NO_2, and ozone (O_3).

AMQA is responsible for planning and overseeing the State's regulatory monitoring network. The monitoring network focuses on criteria pollutants as prescribed by the Clean Air Act. The main pollutants of concern in Alaska currently are $PM_{2.5}$ and PM_{10}, followed in order of importance by CO, lead (Pb), O_3, SO_2, and NO_2. Other criteria pollutants are also emitted into the atmosphere, but they are assumed to be present in lower concentrations due to the following factors: comparatively small population centers, small number of stationary sources, the location and density of industries, and the lack of sunlight to cause pollutant formation.

Air monitoring in Alaska has historically focused on the largest population centers: Anchorage, Fairbanks, and Juneau. Stagnant or decreased funding for air quality assessments over the past ten years has required the program to decommission sampling sites and reduce monitoring to just the required regulatory sites based on EPA requirements for Core Based Statistical Areas (CBSAs). The current regulatory network consists of eight sampling sites, including four in the Anchorage metropolitan statistical area (MSA), three in the Fairbanks MSA, and one in Juneau.

In addition to these CBSAs, the 'larger' communities throughout the state have populations between 1,000 and 10,000. These are considered 'hub" communities, i.e., regional transportation hubs that are served by larger commercial airlines and are jump-off points to the smaller communities serviced either by smaller commercial airlines or private transport. ADEC has allocated resources (staff time, travel funds, data access fees, supplies and equipment) for these hub communities, along with a few strategically

[1] https://www.AQMesh.com/products/AQMesh
[2] https://www.quant-aq.com/products/modulair

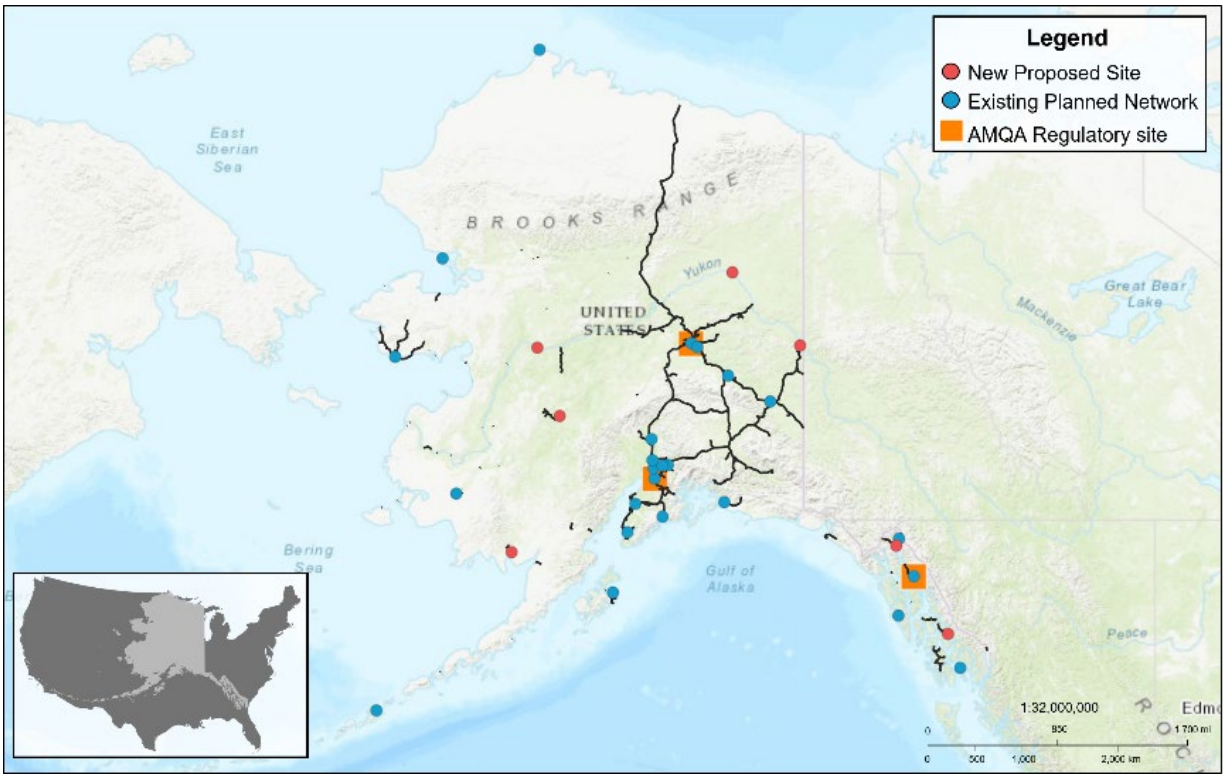
located smaller communities, to provide increased air quality monitoring and geospatial coverage to the most Alaskans possible.

6. PROJECT DESCRIPTION

AMQA is responsible for the management of this project. The objective of this project is to provide a network of publicly available air quality data across the state of Alaska, to help understand impacts and sources of air pollution on historically underserved communities, and to make that information easily available to the communities themselves. Wildfire smoke, road dust from gravel roads, and other windblown dust affect every community in the state. Wintertime inversions can exacerbate air quality impacts due to home heating emissions or local power generation. Emissions from industrial activities such as oil and gas development are a concern in some communities. The partner communities are reviewed and selected based on location, population density, community interest, and resources available (such as electricity to power the pod and access to a compatible cellular network). ADEC will prioritize partnering with tribal and native health corporations as partner organizations for community deployment.

AMQA will utilize two brands of ambient air sensor pods, AQMesh and MODULAIR^{TM}, which measure a combination of PM (PM_1, $PM_{2.5}$, PM_4, PM_{10}), CO, NO, NO_2, O_3, and SO_2. The pods are continuous samplers that measure concentrations every 15 minutes. Concentrations are reported every hour for AQMesh and every minute for MODULAIR^{TM}.

Figure 6-1: AQMesh Monitoring Sites as proposed in July 2023



Time period: The samplers are planned to run in the communities for three to five years, depending on equipment performance and available funding. ADEC received American Rescue Plan (ARP) funding in spring 2023, so the expansion of the network is dependent on procurement of additional equipment and hiring additional staff. ARP funding covers three years of monitoring, so the pods are expected to run summer 2023 – summer 2026, with timing dependent on procurement and staffing.

Data collection: The sensor pods will sample particulate matter and gaseous pollutant concentrations in a location that is considered representative of community conditions (i.e., in a neighborhood, at a gathering space like clinic, tribal office, school, etc.) for three to five years.

Data users: The anticipated data users include AMQA staff, community leaders and community members. AMQA will use long-term data for baseline air quality assessment and trend analysis. Members of the community may use the data for planning time spent outdoors, whether it be a planned school recess, hunting or fishing excursion, recreation, etc. Local organizations may use the data for education and engagement.

7. QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

The following measurement quality objectives (MQOs) will be used for the assessment of data quality: precision, bias, linearity, error, representativeness, and completeness. These MQOs will be used to evaluate and control the measurement process and minimize uncertainty.

Based on ADEC's experience with these criteria, the following data quality objectives have been chosen for this study and summarized as MQOs in Table 7-1 below:

Table 7-1: Data Quality Indicators (DQIs)

Data Quality Indicator	Quality control activities and checks	Performance Goal
Precision	Audit pods will be occasionally deployed to field sites to be collocated with the community sensor for comparison	Standard Deviation (SD) ≤ 5 µg/m^3 --- or --- Coefficient of Variation (CV) ≤ 30%
Bias	Collocation study and audit pods will assess bias of site pods. If bias is found, data will be offset to align with reference instrument.	Slope 1.0 ± 0.35 Intercept (b) -5 ≤ b ≤ 5
Linearity	Collocation study and audit pods will assess linearity of site pods. Data may be scaled to align with reference instrument.	Coefficient of Determination (R^2) ≥ 0.70
Error	Collocation study and audit pods will assess error of site pods. If high error is found, pods may be retrieved and sent for repairs or upgrades or data will be contextualized to convey trend, rather than accuracy, application.	Root Mean Square Error (RMSE) ≤ 7 µg/m^3 --- or --- Normalized Root Mean Square Error (NRMSE) ≤ 30 %

Representativeness	Evaluate sample design in terms of spatial and temporal variability for both baseline and impacted conditions	Each pod will have a documented site characterization that assesses potential local biases and similarities to average ambient air quality of community
Comparability	Compare methods to previous or existing studies. Compare data to reference method (FRM) during collocation studies.	n/a
Completeness	Evaluate the percentage of field measurements made within the time range of interest. If a sample result is missing or has been invalidated because of validation checks, it may not be counted toward completeness.	≥ 75% of 15-min readings for valid hourly average ≥ 75% of 24 hour readings for valid daily average ≥ 75% of quarterly data is valid for quarter completeness

Table 7-2: AQMesh Technical Specifications

Parameter	Type of Sensor	Units	Range	LOD[1]	LOC[2]	Precision	Accuracy
Particulate Matter[3]							
PM_1	Optical particle counter	µg/m³	0 to 100,000	0	NA	>0.9	5 µg/m³
$PM_{2.5}$	Optical particle counter	µg/m³	0 to 150,000	0	NA	>0.9	5 µg/m³
PM_4	Optical particle counter	µg/m³	0 to 225,000	0	NA	>0.9	5 µg/m³
PM_{10}	Optical particle counter	µg/m³	0 to 250,000	0	NA	>0.85	5 µg/m³
PM_Total	Optical particle counter	µg/m³	0 to 350,000	0	NA	>0.85	5 µg/m³
Gaseous							
NO	Electrochemical	ppb	0 to 20,000	<1 ppb	<5 ppb	>0.9	1 ppb
NO_2	Electrochemical	ppb	0 to 20,000	<1 ppb	<5 ppb	>0.85	4 ppb
CO	Electrochemical	ppb	0 to 1,000,000	<50 ppb	<50 ppb	>0.8	20 ppb
SO_2	Electrochemical	ppb	0 to 100,000	<5 ppb	<10 ppb	>0.7	20 ppb
Meteorology							
Parameter	**Type of Sensor**	**Units**	**Range**	**Resolution**	**Precision**	**Accuracy**	
Temperature	Solid state	Degrees C	-20 to 100C	NA	>0.9	2°C	
Humidity	Solid state	% RH	0 to 100%	NA	>0.9	5% RH	
Pressure	Solid state	Mb	500 to 1500 mb	NA	>0.9	5 mb	
Wind Speed[4]	Solid state	m/s	0 to 30	0.01 m/s	NA	+/- 2% at 12 m/s	
Wind Direction[4]	Solid state	degrees	0 to 359	1 degree	NA	+/- 2 degrees	

[1]LOD – Limit of Detection – lowest level sensor is able to detect in ambient air
[2]LOC – Limit of Concentration
[3]When used with optional heated inlet for PM monitoring, as the ADEC sensors are configured
[4]Wind speed and wind direction only included on AQMesh pods configured with wind sensors.
Source: AQMesh Technical Specification V6.6, Gas Algorithm V5.3.2, PM algorithm V3.0h*, https://www.aqmesh.com/techsupport/aqmesh-technical-support/

Table 7-3: QuantAQ MODULAIR™ Technical Specifications

Parameter	Units	Range	Accuracy
PM_1	$\mu g/m^3$	0 to 2,000	R^2 = 0.899; CV = 0.29
$PM_{2.5}$	$\mu g/m^3$	0 to 2,000	R^2 = 0.936; CV = 0.14
PM_{10}	$\mu g/m^3$	0 to 2,000	R^2 = 0.810; CV = 0.32
Particle size distribution	µm	0.25 to 40.0	Not yet determined
O_3	ppb	0 to 500	5 ppb or 20%
CO	ppb	0 to 13,000	40 ppb or 20%
NO	ppb	0 to 5,000	5 ppb or 20%
NO_2	ppb	0 to 5,000	6 ppb or 35%
Temperature	Degrees C	-40 to 85	+/- 0.2°C
Relative Humidity	% RH	0 to 100	+/- 2%

Source: https://docs.quant-aq.com/modulair-datasheet

Table 7-4: *AQMesh Operating Specifications*

Parameter	Details
Weatherproof rating	IP65
Operating temperature	-20 to 40°C
Operating humidity	15 to 85% RH
Dimensions	170 mm x 220 mm x 430 mm
Weight	2 to 2.7 kg

Source: AQMesh Technical Specification, V6.7

Table 7-5: *QuantAQ MODULAIR™ Operating Specifications*

Parameter	Details
Weatherproof rating	IP68
Operating temperature	-20 to 50°C
Operating humidity	5 to 95%, non-condensing
Dimensions	11.04” x 9.04” x 5.72”
Weight	6 lbs (2.72 kg)

Source: https://docs.quant-aq.com/modulair

8. TRAINING

8.1 ADEC Staff

Air monitoring personnel working with the sensor pods will be trained on operation, setup, sensor siting, installation, maintenance, and troubleshooting for the AQMesh and MODULAIR™ pods.

8.2 Partner Communities

'Partner communities' are any organization or individual (tribal council, local organization, community member, etc.) who volunteers to assist in the deployment and upkeep of the sensor pods. Participants are not required to have any standardized qualifications or training but will be offered training at the beginning of engagement and will be given ongoing opportunities throughout the project. Partners who do want to take a more active role in the deployment and upkeep will receive an introductory training from AMQA that includes an introduction to the project goals, equipment, pod siting criteria, responsibilities, and methods of communication. DEC will tailor training based on the Partner's interest and availability.

Table 8-1: Training Topics, Providers, and Recipients

Project Function	Description of Training	Training Provided by	Training Provided to
Equipment Handling	How to hold, move, transport the pod and basic items	• AMQA	• AMQA Staff • Partner Communities
Equipment Handling – Packing for shipment	Pack sensor pod and related equipment into dedicated packing materials to safely transport without damage	• AMQA	• AMQA Staff • Partner Communities
Equipment Handling – Annual maintenance	Clean optical particle counter, routine inspections and cleaning	• AMQA • Sensor company online tutorials and guidance documents	• AMQA Staff
Equipment Handling – Basic Troubleshooting	Checking for power, power cycling instrument, listening for functionality, repositioning antenna, etc.	• AMQA	• Partner Communities
Equipment Handling – Advanced Troubleshooting	Command prompts to download error logs from sensor, internal repairs	• AMQA • AQMesh Technical Support	• AMQA Staff • Partner Communities only as needed
Collocation Studies	Set up collocation study with AQMesh sensors and FRM instrument. Review data and analyze results. Apply actions to AQMesh data.	• AMQA • AQMesh SOP • Outside agency documentation	• AMQA Staff
Data Processing	Average interval samples based on timestamp, summary statistics, time-series plots	• AMQA	• Partner Communities
Data Analysis	Data reduction, limitations of data collection and data set, outliers, trends, patterns. Data comparison tools such as EJSCREEN, AirNow, AQS	• AMQA	• Partner Communities

9. DOCUMENTS AND RECORDS

Data is transmitted via cellular network to the respective company's web portal. AMQA's Agilaire data acquisition system downloads all sensor data on an hourly basis via API requests, and all data is backed up nightly on DEC servers. Hourly concentrations and PM2.5 AQI values are displayed on the AMQA real-time AQI website (https://dec.alaska.gov/air/air-monitoring/alaska-air-quality-real-time-data). AMQA will provide semiannual data reports to partner communities, post the documents on the ADEC website for public review, and store them on the AMQA server. Summary data will be presented at quarterly network participant calls, and the slides will be posted on the ADEC website for public reference. The raw data are available to any interested party via a data request that may be submitted via email (amqa-data-request@alaska.gov) or by phone.

DEC will establish a Memorandum of Agreement (MOA) with all Partner Communities to outline responsibilities of each party and address liability for equipment damage should any occur. If a financial reimbursement is necessary for utility costs, labor and/or parts to install power supply, or for labor to maintain equipment, a reimbursement agreement of up to $500 per fiscal year will be addressed in the MOA. The MOAs will cover the three-year guaranteed term of sensor deployment and may be extended if needed.

Each sensor company, AQMesh and MODULAIR™, has readily available standard operating procedures (SOPs) on their company websites for reference and use. AMQA will develop internal SOPs for applied use of the technologies and publish these on the ADEC website. The SOPs will also be kept on the AMQA server.

Field documentation, notes, troubleshooting logs, shipping information will be digitized and kept on the AMQA server for the duration of the project.

Project records including interim progress reports, final reports, validated monitoring data, QA/QC data, billing receipts, presentations made during and after the project will be kept on the AMQA server for length of project and for ten years after conclusion.

The AMQA server is backed up nightly.

10. NETWORK DESCRIPTION (OR SAMPLING PROCESS DESIGN)

10.1 Selection of Partner Communities

The ADEC ambient air quality monitoring network is designed to protect the health and welfare of its residents and visitors. Commitments were made in the State of Alaska 2020 Ambient Air Quality Network Assessment (Assessment) (July 2020) to collect baseline air quality data in hub communities of Alaska that currently have no air quality monitoring. Alaska only has four communities of 15,000 people or more: Anchorage, Fairbanks, Wasilla/Palmer, and Juneau. AMQA operates permanent monitors in Anchorage, Fairbanks, and Juneau. To meet the community monitoring objective of the 2020 Assessment, hub communities with populations of less than 3,000 people were reviewed for geospatial distribution and availability of community partners. The monitoring is intended to capture air quality trends year-round to assess potential risks in the communities, so the stations will be deployed for a duration of at least one year. The selection process for communities within the ARP grant is dependent on a partnership with tribal council, rural location, and access to a partner cellular network that is compatible with available sensor technology. In addition to these requirements, ADEC will utilize additional funding to increase geospatial coverage and use partnerships with tribal entities to increase monitoring coverage throughout the state.

10.2 Selection of Monitoring Sites and Placement of Sensor Pods

Community monitoring locations will be based on access gained by partnerships with local tribes or native corporations. The specific locations for pod installation will adhere to standard siting criteria for air monitors and will be representative of the community's ambient air quality. When possible, sensor pods will be in a community gathering area or a building centrally located in the community, such as a clinic, tribal office, school, etc. Sample pods should be installed in locations that will minimize bias by ensuring they are representative of ambient air conditions and are sufficiently protected from possible damage or degradation. The AMQA real-time AQI website will reflect all currently deployed and actively reporting, i.e., not down for maintenance, sensor pods throughout the state (https://dec.alaska.gov/air/air-monitoring/alaska-air-quality-real-time-data).
Considerations such as probe height (above ground) and physical influences nearby (e.g., proximity to sources, physical obstructions, etc.) are factors that can influence collection of a representative sample. Table 10-1: Siting Criteria for Sensor Pods lists general guidelines for placement of sample probes and manifolds. If a site becomes inaccessible, AMQA will conduct remote operations as long as possible to wait and see if access can be regained later. Personnel will not be put at risk to retrieve equipment.

Table 10-1: Siting Criteria for Sensor Pods

Siting Criteria
• At least 10 feet of lateral and vertical separation from air outlets or fans. Avoid: exhaust fan openings, heating vents
• Away from pollutant sources, such as: - Smoking areas - Building boiler exhausts - Chimneys - Car idling zones - Equipment staging areas - Diesel engines
• A minimum of 180 degrees of unobstructed air flow. This means the pod can be installed on a wall but cannot be in a corner with two sides obstructing air flow.
• Avoid areas where the pods can be easily accessed or vandalized
• Between 10 to 40 feet above ground
• Within range of a cellular data network (4G, 5G, LTE) of compatible cellular provider (AQMesh – Telefonica, QuantAQ – AT&T)
• Less than 50 feet from available power outlet
• If possible, deploy under a roof overhang to reduce snow accumulation.

11. SAMPLING METHODS

11.1 AQMesh

This section describes the sample collection methods and continuous measurement methods for AQMesh sensor pods to ensure reliable data capture to be used for trend analysis.

For gaseous measurements, the AQMesh pods utilize Alphasense electrochemical sensors and proprietary data processing algorithms. The AMQA AQMesh pods are configured to measure CO, NO, NO_2 and SO_2. The electrochemical sensors are "designed for measuring a range of gases at ppb levels"[3] and each Alphasense sensor measures a single parameter. The surface of the electrochemical sensor reacts with the target gas and produces an electrical output that corresponds to the concentration of gas present. The sensors have an additional electrode that measures the reaction from environmental effects (temperature, humidity) that subsequently mitigates the effects of temperature and humidity on the resultant gas concentration. AQMesh utilizes these two outputs in their algorithm to produce a gas concentration in parts per billion (ppb). Alphasense sensors are sensitive to transient temperature and humidity conditions.

[3] https://www.aqmesh.com/resources/user-manual/

For particulate measurements, the AQMesh pods use an optical particle counter (OPC) to measure the concentration of PM_1, $PM_{2.5}$, PM_4 and PM_{10} in the sample stream. The sample stream consists of the inlet, inlet heater, OPC, and outflow. An internally mounted pump pulls in ambient air through the inlet, through the heated portion of the inlet and then through the measuring chamber with the internally mounted and optically focused laser. The particles that pass through the laser deflect light, which is quantified by a photo detector that counts the number and size of deflections as particles. The counts are sorted into the PM_1, $PM_{2.5}$, PM_4 and PM_{10} bins to measure concentrations. The assumptions are the particles are spherical and have a standardized density[4]. The heated inlet is intended to reduce moisture clinging to particles, which would artificially bias the particle size high.

11.2 QuantAQ's MODULAIR™

This section describes the sample collection methods and continuous measurement methods for QuantAQ's MODULAIR™ sensor pods to ensure reliable data capture to be used for trend analysis.

For gaseous measurements, MODULAIR™ pods utilize Alphasense electrochemical sensors and QuantAQ proprietary data processing algorithms. The AMQA MODULAIR™ pods are configured to sample CO, NO, NO_2 and O_3. As with the AQMesh Alphasense sensors, the surface of the electrochemical sensor reacts with the target gas and produces and electrical output that corresponds to the concentration of gas present. The sensors have an electrode that measures the reaction from environmental effects that subsequently mitigates the effects of temperature and humidity on the resultant gas concentration. QuantAQ utilizes these two outputs in their algorithm to produce a gas concentration in ppb.

To measure particulate matter, the MODULAIR™ pods utilize a nephelometer and OPC for particulate matter measurements. The OPC is "used to count and size particles above 350 nm and a nephelometer is used to estimate the mass below the detection threshold of the OPC"[5]. The OPC works as described in 11.1 AQMesh. The nephelometer gathers the "total light scattered by a population of particles across a wide range of angles, avoiding near-forward and near-backward scattered light… The scattered light signal – a scalar – is converted to mass via a linear correlation to a reference measurement, either in a laboratory setting or an ambient co-location"[5]. The MODULAIR™ does not utilize a heated inlet, but data is corrected for environmental factors during automated data processing by use of mathematical correction factors that account for density of water, density of the aerosol, and water activity (sensor's relative humidity measurement).

11.3 Data Collection, Processing, and Utilization

Although the smallest interval of data available for an AQMesh is 15-min and QuantAQ is 1-min, analyses will use 1-hr intervals for identifying trends and to compute Air Quality Index (AQI) values. For an AQMesh, raw data is reported to the web portal for storage up to one year. Hourly data can be stored locally for approximately 11 to 22 months depending on the device's hardware setup. If the cellular network outage extends past this window, data will be overwritten, continuously overwriting the oldest data onboard. The QuantAQ raw data is reported to the web portal for storage up to two years and is stored on a local µSD for temporary storage for averaging computations and in case of cellular network outage. The local µSD card can store approximately 3-years' worth of 5-second data points.

[4] AQMesh, AQMSOP3.1 - AQMesh Standard Operating Procedure, Gas algorithm V5.0, 11/4/2019.
[5] David H. Hagan & Eben S. Cross. (2022). Introduction to the MODULAIR-PM (2022.09). https://doi.org/ 10.5281/zenodo.7062168

AMQA will routinely download data from the AQMesh and QuantAQ web portals and store the hourly data in the AMQA Agilaire AirVision data acquisition system (DAS) for long-term storage. The DAS is backed up nightly.

11.4 Damaged or Broken Sensor Pods

If a sensor pod is damaged, worn, or broken, AMQA staff will report incidents to the Project Manager and conduct repairs. Instrument parts will be purchased as necessary to conduct maintenance and repairs. To minimize data gaps due to broken or damaged pods, AMQA will keep an inventory of available replacement pods that will be ready to deploy.

12. SAMPLING HANDLING AND CUSTODY

A strict "Chain of Custody' system is not being implemented for this project, but AMQA will maintain an internal tracking system for pods that are being moved to/from the field. The tracking system will utilize the sensor pod serial number, State Tag number, serial numbers of individual parts (such as electrochemical sensors), maintenance schedule, replacement schedule, hours of operation (when data is available), and deployment location.

13. ANALYTICAL METHOD

Analytical methods are those methods requiring laboratory analysis of samples collected under field monitoring conditions. This project does not necessitate laboratory analysis.

14. QUALITY CONTROL

The AQMesh and QuantAQ MODULAIR™ sensor pods do not have a means of quality control testing or instrument-direct calibrations. Instead, DEC will use a pair of dedicated sensors for instrument-to-instrument performance review. The pods will be housed at the NCore site or another suitable site. One set of pods will be collocated year-round at the comparison site. The 'gold standard pod'(GSP) is an AQMesh or QuantAQ MODULAIR™ pod that is collocated with an FRM monitor and then brought to a sampling site to run temporary collocation studies between the 'gold standard pod' and on-site pod. ADEC will use this method to 'audit' the community pods as time and funding allows. The data quality objectives are used as quality control of the performance of sensors (see Table 7-1).

14.1 Collocation - Schedule

A factory calibration is conducted before shipment to users for quality assurance and quality control (QA/QC) of the equipment by installing the AQMesh pod ordered in their reference station.
AMQA will conduct collocation studies of pods when:

- Multiple pods are purchased together. These pods will undergo a collocation study prior to deployment.
- Pods are retrieved from the field for maintenance. These pods will undergo a collocation study at an AMQA regulatory site prior to redeployment.
  "Gold standard pods" (GSPs) are used for auditing deployed sensor pods.

14.2 Collocation - Definition & Purpose

Collocation is defined as:

"The process by which a reference monitor, Federal Reference Monitor (FRM)/ (FEM), and non-reference monitor (sensor) are operated at the same time and place under real world conditions for a defined evaluation period. Sensor performance can be evaluated, and data accuracy improved by comparing sensor data with reference monitor data."

- U.S. EPA, National Exposure Research Laboratory, Office of Research and Development (2018)

In addition to collocation studies, inter-sensor comparisons may also be conducted, where an AQMesh sensor is collocated alongside another AQMesh pod that has previously undergone collocation with an FRM/FEM instrument (known as a "Gold-Standard Pod" (GSP) or audit pod). This allows the GSP to act as a quality control measure to confirm the functionality of other AQMesh pods.

The results of the collocation can be applied to the AQMesh data as offsets or scaling values. Slope and offset values used to calculate measurement values can be set in the AQMesh data portal to apply real-time scaling to raw data. Both the raw data and scaled data can be downloaded from the AQMesh data portal[6]. AQMesh pods come with factory-set slope and offset values factored into the calculation algorithm, which provides a variance of +/- 5% of the measured range.

14.3 Collocation - Siting

There are siting requirements for a collocation study when deploying AQMesh or QuantAQ pods with a reference instrument or GSP:

- The trial location's environment should have some air pollution present. Preferably, this site will have at least several weekly peaks above 10 ppb for gas parameters and 10 µg/m^3 for particle fractions.
- All pods being collocated for scaling or validation should be placed within 1 meter of the reference station inlet (or GSP).
- Pods should be mounted away from any reflective or known oxidizing surfaces or air conditioning exhausts which cause the pod's local environment to be different from ambient conditions (i.e., 0.5 m or greater from the floor).
- Pods should be placed in a position with free movement of air (i.e., unaffected by air turbulence from local barriers, including other instrumentation/sensors).

The full siting criteria for sensor deployments are listed in Table 10-1: Siting Criteria for Sensor Pods

14.4 Collocation - Data Analysis

Sensor collocation data will be utilized to compare the accuracy and precision of the pods to a GSP or FRM/FEM with known accuracy and precision. This comparison is accomplished by using linear regression

[6] https://www.aqmesdata.net

models to determine the correlation between the AQMesh pod and reference pod values (Figure 14-1) with a coefficient of determination (R^2 value). The closer the R^2 value is to 1, the stronger the correlation.

Figure 14-1: Example of Linear Regression Showing Strong Correlation Between Reference and Sensor

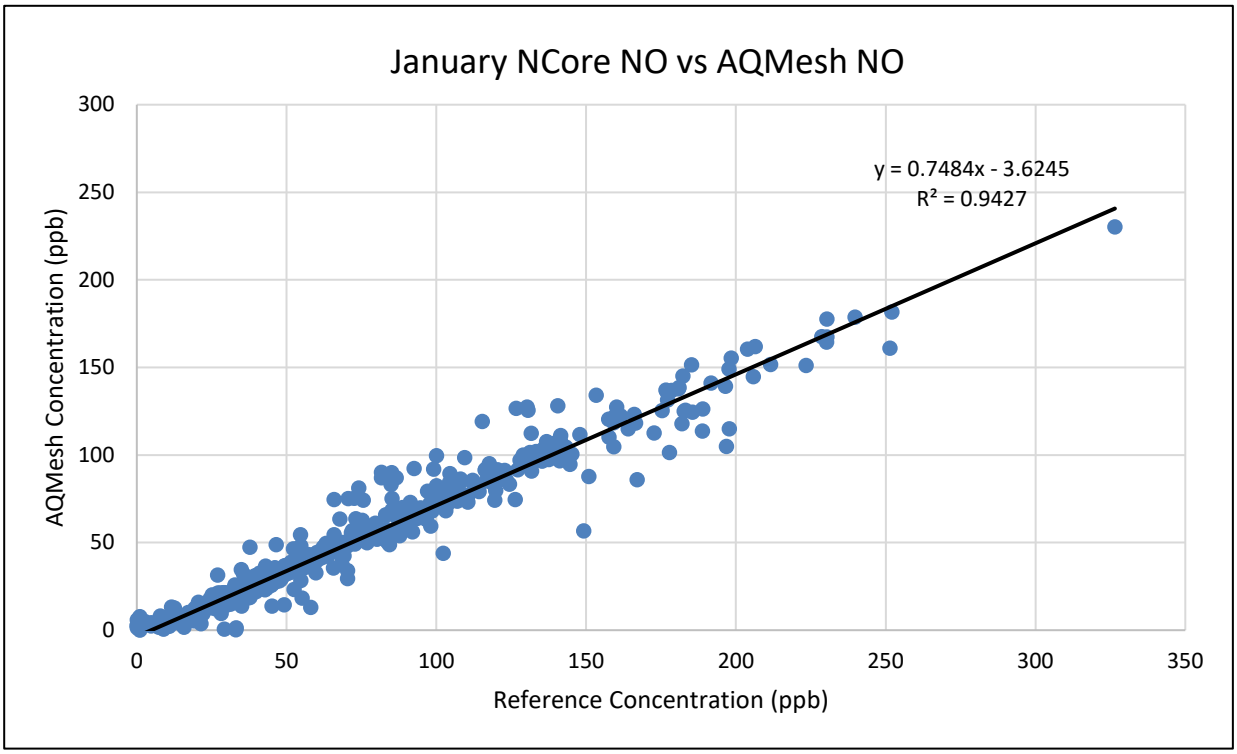
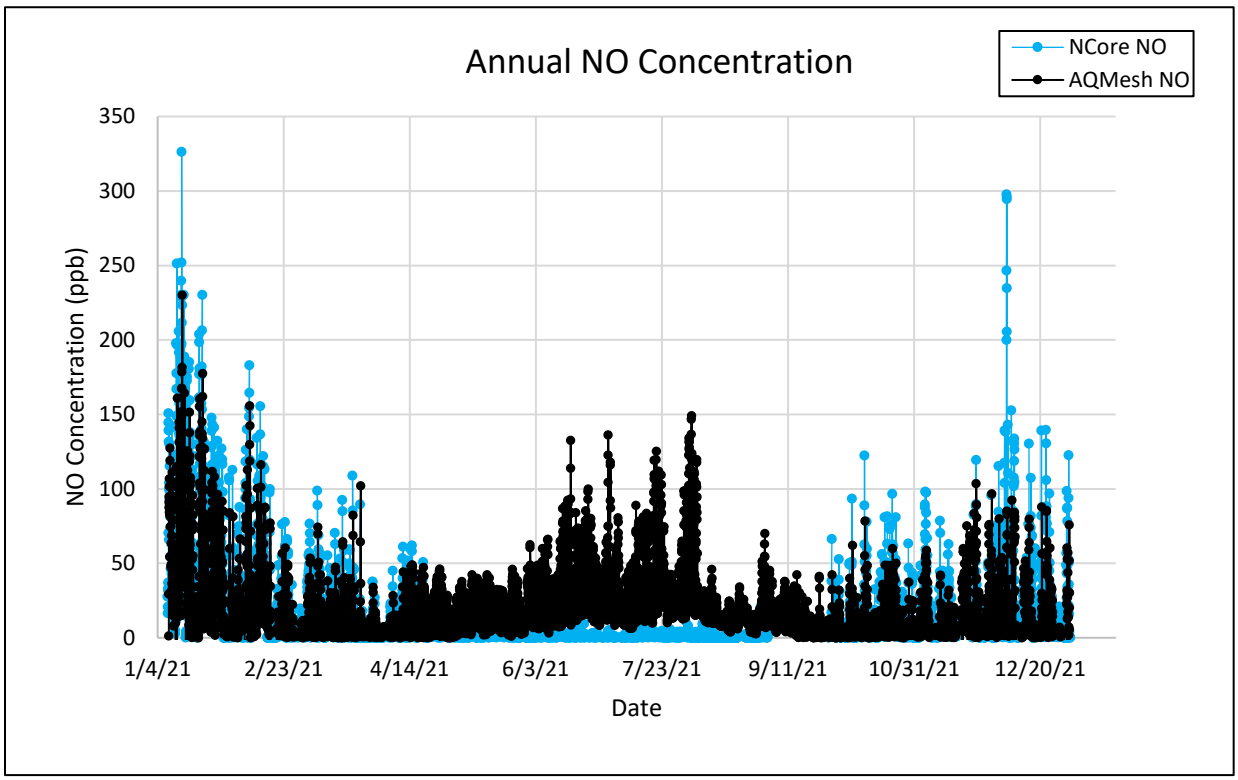


Figure 14-2: Comparison Example of NO Concentration Between FRM Instrument and Collocated AQMesh Sensor



15. INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

This section details the procedures used for inspecting, testing, and accepting instruments, supplies and consumables that directly or indirectly affect data quality.

15.1 Acceptance Testing of Equipment

The equipment will be tested to ensure that it meets the requirements listed in the purchase specifications, i.e., checking zero drift, span drift, voltage stability, temperature stability, and linearity.

15.2 Maintenance of Equipment

AMQA is responsible for the maintenance of the sensors but may request local assistance for retrieval of equipment or to conduct basic troubleshooting. Maintenance and repair of sensors are tracked in AMQA digitized systems, including AirVision and SalesForce.

Sensor pods will be visually inspected by Partner Community contacts intermittently. Additional inspections will occur if data communication issues arise.

During a visual inspection, any findings, observations, and notes should be documented on a field log document provided by AMQA. Example observations include:

- The power cable is plugged in at the sensor and outlet
- An intermittent 'whirring noise' is present, which indicates that the sensor pump is running
- The power cable is connected, secure, and not damaged
- Document any missing parts, frayed cords, loose fittings, etc.

- Photographs of the issue and entire sensor pod will be taken if any changes or disturbances are noticed upon inspection.

15.3 Audit sensor pod

At least one pod of each technology (AQMesh, MODULAIR) will be in AMQA possession and collocated at a regulatory site. Additionally, one sensor each will be dedicated as an audit pod (GSP). If a deployed sensor presents unusual or questionable data, the audit pod may be deployed as a collocation in the field location to assess validity of the data.

16. INSTRUMENT CALIBRATION AND FREQUENCY

The AQMesh and QuantAQ sensors arrive factory-calibrated. AQMesh sensor pods use scaling and calibration to improve accuracy of the measurements. The AQMesh SOP[7] outlines how to conduct scaling in the 'Calibration & Improving Accuracy' section of the document. Scaling is used to increase the level of accuracy by direct comparison of the sensor pod to a locally serviced and calibrated reference station. The results of the collocation study will be used to find the R-squared (r^2) value between each sensor pod to the reference station and will provide the slope and offset to apply to sensor pod data for accuracy improvement. Based on the AQMesh SOP, the scaling (referred to as 'rebasing' in AQMesh documentation) of sensors is recommended to occur every six months, or following a sensor change, or following a significant change in environmental conditions, e.g., a change in average temperature of 10 degrees Celsius or more, compared to when it was scaled. However, due to the remote nature of the various hub communities and limited FEM equipment, a GSP will be used to scale the pods in hub communities on a rotating basis. The AQMesh SOP also states that the sensor pods should run undisturbed for at least two days before data is collected. To ensure that enough data is collected under local conditions, AMQA will treat the first four days of data collected at a new site as 'calibration data' and will not use this in data analysis. The QuantAQ MODULAIR™ do not provide manufacturer specific guidance on how to conduct a post-factory calibration, but there is less emphasis on 'in-situ' calibration from this manufacturer.

To provide performance and accuracy data, a collocation study will be conducted at an AMQA regulatory monitoring site prior to and upon completion of the hub community deployments. These will serve to bracket the data with QC checks. Due to limited space and power availability, an alternative configuration option is to collocate all sensors with each other and then deploy one representative 'control' sensor at a regulatory site for comparison. This process is referred to as 'harmonization'. The sensor pods will be

[7] AQMesh, AQMSOP3.1 - AQMesh Standard Operating Procedure, Gas algorithm V5.0, 11/4/2019.

deployed at a regulatory monitoring site to compare the PM_{10} and $PM_{2.5}$ measurements between pods and a reference FEM MetOne BAM 1020 instrument with a $PM_{2.5}$ very sharp cut cyclone (VSCC) and PM_{10} inlet. This study will run for 10 to 60 days, with a goal of 75% data comparison between each sensor pod and reference instrument. Due to troubleshooting of instruments and possible power outages or unforeseen complications, it is likely that the sensor pods or FEM instrument will have data gaps. Upon completion of each collocation study, correlation analysis will be conducted to provide sensor pod performance data before and after deployment to their respective communities.

When collocation or scaling does occur, documentation will include:

- Sensor pod serial number
- Person conducting the calibration/scaling
- Collocation duration (start and end dates/times)
- GSP serial number
- Data comparison and subsequent r^2 values

17. INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

The following consumables are needed for conducting annual cleaning of AQMesh and possible work with MODULAIR:

- Compressed air duster
    - Used for gently removing dust and other particulates from sensitive computer components and sampling instrumentation
- Dielectric grease
- Used to prevent water from infiltrating electrical connections, i.e., extension cords

18. NON-DIRECT MEASUREMENTS

Once the sensor pods have been sited, GPS coordinates will be used to mark the location on the ADEC data website and in internal tracking systems (AirVision, SalesForce, etc.).

19. DATA MANAGEMENT

AQMesh data is temporarily stored on a local SIM card within the sensor pod and transmitted hourly to the cloud-based data platform, AQMeshData (https://www.aqmeshdata.net/). AMQA staff have user credentials to access and view the data in either tabulated or plotted form. AMQA's Agilaire data acquisition system downloads all sensor data on an hourly basis via API requests, and all data is backed up nightly on DEC servers. Hourly concentrations and PM2.5 AQI values are displayed on the AMQA real-time AQI website (https://dec.alaska.gov/air/air-monitoring/alaska-air-quality-real-time-data).

MODULAIR™ data is temporarily stored on a micro-SD card within the sensor pod and transmitted hourly to the cloud-based platform, QuantAQ[8]. AMQA staff have user credentials to access and view the data in either tabulated or plotted form. AMQA's Agilaire data acquisition system downloads all sensor data on

[8] https://app.quant-aq.com

an hourly basis via API requests, and all data is backed up nightly on DEC servers. Hourly concentrations and PM2.5 AQI values are displayed on the AMQA real-time AQI website[9].

The AMQA AQI website[10] displays real-time time series plots of all AQMesh sensors deployed in communities for public review. The data is retrieved from AQMeshData and the QuantAQ data platform via API GET request from AirVision, then parsed and stored in the AirVision database. The AMQA website requests the data via the Umbraco platform and displays the data in a time series plot, showing the last 24 hours of data. The user may select or de-select any combination of parameters and sites to display in the plots based on their interest and needs.

20. ASSESSMENTS AND CORRECTIVE ACTIONS

Assessments are evaluation processes used to measure the performance or effectiveness of a system and its elements. These processes may include audits, performance evaluations, management system review, peer review, inspection, and surveillance.

20.1 Data Quality Assessments

Data quality assessments are statistical and scientific tests of the data set to determine validity, evaluate performance of the data collection system, and assess the adequacy of the data set for the project's goals. Due to the widespread and remote nature of the Community-Based Sensor Network, parameters that are easily QC'd against local conditions (temperature, barometric pressure, relative humidity) will be utilized to assess general reliability of the sensor pod. Other 'common sense' tests of data quality will be utilized to assess parameters concentrations, such as:

- Baseline average
  - If the average of the baseline concentration for a parameter is unreasonable, an offset should be applied to re-zero the instrument. For example, if the average baseline concentration is -5, an offset of +5 should be applied to the data to bring the baseline to 0.
- Behavior
  - If there are patterns in the data that do not reflect diurnal patterns or other known factors, the sensor pod will be investigated for noise that affects the data.

20.2 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount expected to be obtained under correct, normal conditions. The sensors are non-regulatory, but a completeness criteria of 75% is standard for measurements to be considered valid. For example, with an hour of data, 75% of the sub-hour interval measurements must be valid and complete.

20.3 Bias

Bias is defined as a "systematic or persistent distortion of a measurement process that causes uncertainty in one direction". *Precision* is defined as a "measure of mutual agreement among individual

[9] https://dec.alaska.gov/air/air-monitoring/responsibilities/database-management/alaska-air-quality-real-time-data/
[10] https://dec.alaska.gov/air/air-monitoring/responsibilities/database-management/alaska-air-quality-real-time-data/

measurements of the same property". *Accuracy* is a term that is frequently used to represent closeness to truth, and incorporates the properties of bias and precision.

21. REPORTS TO MANAGEMENT

An annual QA memorandum is written at the end of the data collection period and will be added to the latest quarterly report. This memorandum summarizes the QA activities conducted during that year, including:

- Summary of QA/QC objectives,
- Description of training activities,
- Conformance to QAPP requirements/procedures, descriptions of deviations, and suggested or approved amendments,
- Limitations of data, and
- Documentation of usable data versus the amount of data collected.

List of reasons why data may not be usable. This includes a review of any of the following:

- Precision
- Accuracy
- Representativeness
- Completeness
- Comparability
- Sensitivity

22. DATA REVIEW, VALIDATION AND VERIFICATION REQUIREMENTS

AMQA will conduct the data review, validation and verification of sensor data but does not have separate QC staff for this work. The EPS 3 staff are responsible for reviewing and analyzing the data, but the AMQA Auditor will oversee the data review and management process to ensure adherence per the QAQC criteria outlined below.

Data review, verification, and validation are assessment techniques used to accept, reject, or qualify data in an objective and consistent manner.

Data review, validation and verification

Generally, there are four "levels" of air quality and meteorological data validation. When a data set has undergone a level of review, it is appropriately labeled as such, and it passes on to the next level. The process is used to determine the validity of the data.

- Level 0 validated data are raw data obtained directly from the field by the respective data platform. Data are automatically flagged using the criteria in Table 22-1 and 22-2 respectively. Data that do not meet these criteria are flagged as invalid pending review.

- Level 1 data validation involves quantitative and qualitative reviews for accuracy, completeness, and internal consistency. Data Analysts and/or Project Quality Assurance Officer reviews the data for outliers and other anomalies. Any flags from Level 0 are reviewed. Quality control flags are assigned, as necessary, to indicate the data quality.

- Level 2 data validation involves comparisons with independent datasets. This function includes, for example, making comparisons to the sensor pods at the NCore station, the gold standard pods or other meteorological measurement systems.

- Level 3 data validation involves a more detailed analysis and final screening of the data. The purpose of the final step is to verify that there are no inconsistencies among the related data Graphics programs may be run to examine the overall consistency among related data (i.e., checking diurnal patterns against other parameters or reviewing strip charts for final analysis). Data sets that pass Level 3 review are appropriate for use to compare against reporting thresholds or regional comparisons.

Table 22-1: AQMesh Flags and Nullification Codes for Data

Code	Label	Description	Effect on Data
Gas Sensor			
-999	Stabilization	Period of 2 days from installation of a new sensor which needs to settle in its new environment	Data classified as stabilizing will remain as non-viewable
-998	Rebasing	Typically, this is a 2-day period where local variables are calculated for use in the AQMesh algorithm are found	During the flagged period, the coded flag will remain, however upon completion of this process, valid data will write over the code
-996	Sensor Failure	In the event of a sensor failure, all post-failure results will be removed from view as the data is classed as erroneous	Data from a failed sensor will remain as non-viewable
-995	Cross Gas Error	If a sensor fails which is relied upon for the removal of interferences on another sensor, data from the reliant sensor becomes invalid	Data will remain as non-viewable until compensating sensor is replaced and 6producing good results, data gathered while compensating sensor was failed will remain as non-viewable
-994	No Data	If a sensor has been removed or data cannot be processed by the server due to a fault the “No Data” flag will alert the user to that further investigation can take place	If sensor is working, then data will be processed as soon as any fault has been fixed. Causing no data loss.
-993	Destabilization	Rapid changes in environment can cause the sensors to provide erroneous data until they settle into their new environment, this can take either 1 or 6 hours, depending on the severity of the rapid change in temperature or humidity	Data classified as destabilizing will remain as non-viewable
-992	Extreme Environment	Following intensive testing of all electrochemical sensors we have determined the combination of extremes in climate in which the electrochemical sensors do not provide consistent outputs. As such precise and accurate measurement is not possible.	Data classified as within the extreme ranges of environment will remain as non-viewable

-991	Condensation	NDIR sensor affected by condensation on the detector	Data classified as being affected by condensation will remain as non-viewable
Particle Counter			
DELIQUESCENCE	Deliquescence	When not using the heated inlet option, outlying data points caused by hydroscopic particle size growth will be removed following analysis of the particle count distribution	Data classified as being affected will only be viewable by request on the server, i.e. this "flag" can be turned on or off by the user depending on their needs
-892	Other fault zero	There is a chance that the particle counter is unable to provide a particle reading following a power-cycle and/or a change in the pod settings	Occasional loss of data
-893	Misread	Particle counter misread	N/A

Table 22-2: MODULAIR™ Flags and Nullification Codes for Data

Code	Value	Description	What to do?
FLAG_STARTUP	1	This flag is set when the device powers on.	Remove any rows where this flag is set.
FLAG_OPC	2	This flag is set when the OPC has indicated the data failed to transfer correctly. This can be caused by the fan being off, the laser being off, or the checksum not validating properly.	Remove any rows where this flag is set.
FLAG_NEPH	4	This flag is set when the nephelometer has indicated the data failed to transfer correctly.	Remove any rows where this flag is set.
FLAG_RHTP	8	This flag is set when the relative humidity and temperature sensor has failed.	Remove any rows where this flag is set.
FLAG_CO	16	This flag is set when the CO sensor has failed or data does not meet initial on-board QA/QC.	Remove any rows where this flag is set.
FLAG_NO	32	This flag is set when the NO sensor has failed or data does not meet initial on-board QA/QC.	Remove any rows where this flag is set.
FLAG_NO2	64	This flag is set when the NO2 sensor has failed or data does not meet initial on-board QA/QC.	Remove any rows where this flag is set.
FLAG_O3	128	This flag is set when the O3 sensor has failed or data does not meet initial on-board QA/QC.	Remove any rows where this flag is set.
FLAG_CO2	256	This flag is set when the CO2 sensor has failed or data does not meet initial on-board QA/QC.	Remove any rows where this flag is set.
FLAG_SO2	512	This flag is set when the SO2 sensor has failed or data does not meet initial on-board QA/QC.	Remove any rows where this flag is set.
FLAG_H2S	1024	This flag is set when the H2S sensor has failed or data does not meet initial on-board QA/QC.	Remove any rows where this flag is set.
FLAG_BAT	2048	This flag is set when the internal LiPo battery is low or dead.	None.

Quality Control

Validated data are compared to the data collected by the Gold Standard Pod, see section 14. Primarily the GSP will be used to determine if corrective actions or repairs are needed. Additionally, the GSP data will be used to assess the data set as well as the network as a whole, and to develop scaling factors if appropriate.

Calibration

AQMesh and QuantAQ sensors come factory-calibrated, see 14.1 and 16. AMQA does not conduct calibrations on sensors – only possible scaling and offset after collocations.

Data Reduction and Processing

Data processing and reduction is performed according to the needs of the project. An example of a standard data reduction step is to average the 15-minute sample measurements into one-hour averages for comparison to the AQI values. Further data reduction will occur to allow for calculations of AQIs. Members of the public may request AQMesh data at any point. AMQA will provide raw data and reduce the data to provide meaningful and usable data for the users' needs.

AMQA will perform routine data reduction and validation after the pods are deployed for at least six months. Depending on the findings, AMQA may compile a trend report and publish it on the ADEC website.

23. DATA VERIFICATION AND VALIDATION METHODS

The following data verification and validation processes will provide for data that meets the Alaska Community-Based Air Sensor Network quality assurance criteria. AMQA EPS 3 staff will conduct the data verification and validation in adherence to the requirements outlined below, and the AMQA Auditor will oversee the process.

Data verification is a two-step process:

1. Identify project needs for records, documentation, and technical specifications for data generation, and determining the location and source for these records.

2. Verify records that are produced or reported against the method, procedural, or contractual requirements, as per the field and analytical operations (i.e., sample collection, sample receipt, sample preparation, sample analysis and data verification records review).

The Alaskan community network is intended to provide baseline air quality data for areas not covered by the State's regulatory monitoring network. As such the raw data, data reduction and analysis products, data visualization and reports will be stored in the AMQA data acquisition system, websites, and the AMQA network drive. Reports and data will be provided regularly to the network participants and on

request. A final project report will be provided to EPA. All reports will include descriptions of the data validation and verification process, along with an QA/QC procedures and data.

A. Data Validation Methods

Prior to the AMQA officially reporting or using the data to make decisions concerning air quality, air pollution abatement, or control, the data will be verified and certified by the AMQA project manager in consultation with the Air Quality Assurance Officer.

For the data to be considered valid, the following conditions must be satisfied:

- The air monitoring instrumentation must be calibrated and operated according to standard methods that have been approved.
- The data must be accompanied by back up documentation which meet the specifications outlined in Sections 7 and 14 of this plan, and be identified with respect to station name, station number, date, time, operator, instrument identification, parameter, scale and units.

Data which is reviewed and found to satisfy these criteria will be considered valid. Data that does not will be invalidated or appropriately qualified ("flagged").

24. RECONCILIATION WITH USER REQUIREMENTS

Data review

As part of the data review and validation process, all data will be reviewed by the Project Manager to determine if the data meets the objectives as outlined in the QAPP. Decisions will be made to accept or reject the data before it's provided in any presentations or reports. Errors in data entry will be corrected and any outliers will be flagged for further review.

Data usability

Data quality objectives and validation procedures for this program have been designed to ensure that volunteers and/or the Project Manager will be able to identify and correct problems in the data collection and reporting process. Should the results of data validation measures or quality assurance reviews indicate that the integrity of data is questionable or that data quality objectives are not being met, the data set (or the portion which is deficient) must be flagged as unacceptable for inclusion in the Program Data File.

The Project Manager is responsible for deciding if any corrective actions are needed and for ensuring any recommended corrective measures from QA reviews are implemented. The Project Manager has the authority to question data, assign re-training, and recommend replacement of monitors when necessary.

The AMQA program will monitor air quality and collect air samples to create a baseline dataset for areas previously unmonitored. If the data suggest that air quality conditions may violate the National Ambient Air Quality Standards (NAAQS) and Alaska Ambient Air Quality Standards (AAAQS), AMQA and other Programs within the Division of Air Quality will investigate further. These investigations could include creating specific emissions inventories to determine specific sources as well as setting up additional

monitoring studies with more sophisticated measurement technologies. Should air quality impacts be documented, ADEC will 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.