A. Project Management and Information / Data Quality Objectives

A1. Title Page

Quality Assurance Project Plan:

Particulate Matter ($PM_{2.5}$) Sensor Loan Program

Category III QAPP

U.S. Environmental Protection Agency, Region 4

Air and Radiation Division, Air Analysis and Support Branch

Atlanta, Georgia

Revision 1.2

June 2024

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A2. Approval Page

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A3. Table of Contents, Document Format, and Document Control

A3.1 Table of Contents

A3.1.1 List of Acronyms

Acronym	Definition
AASB	Air Analysis and Support Branch, EPA Region 4 ARD
ADAS	Air Data and Analysis Section, EPA Region 4 ARD/AASB
ARD	Air and Radiation Division, EPA Region 4
EPA	US Environmental Protection Agency
FEMS	Field Equipment Management System (managed by EPA R4 LSASD)
LSASD	Laboratory Services and Applied Sciences Division, EPA Region 4
PM	Particulate Matter
$PM_{2.5}$	Particulate matter less than 2.5 micrometers (fine particulate)
PM_{10}	Particulate matter less than 10 micrometers (coarse particulate)
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Project Plan
R4	EPA Region 4
RCATS	Regulatory and Community Air Toxics Section

A3.2 Document Format

This document follows the format recommended in the EPA Quality Assurance Project Plan Standard (CIO 2105-S-02.0)[1]

A3.3 Document Control

This table shows changes to this controlled document over time. The most recent version is presented in the bottom row of the table. Previous versions of this document are maintained by the AASB Document Control Coordinator.

Version	Effective Date	Summary of Changes
1.0		Initial Version
1.1	May 2024	Addressed comments from DAO: • Updated AQI breakpoints to reflect revised 2024 PM2.5 NAAQS • Updated AASB manager • Added firmware to DQO section • Added additional rationale for sections that are not applicable to this QAPP
1.2	June 2024	Updated Air Sensor License Agreement (Appendix 2) based on input from ORC

[1] US EPA Quality Assurance Project Plan Standard (CIO 2105-S-02.0). July 2023.

A4. Project Purpose, Problem Definition, and Background

A4.1 Project Purpose and Problem Definition

The EPA Region 4 Particulate Matter ($PM_{2.5}$) sensor loan program supports citizens; state, local, and tribal air quality agencies; and other community partners such as academic institutions or other community groups to collect fine particulate (particulate matter less than 2.5 micrometers, or $PM_{2.5}$) data within communities where monitoring data is unavailable or additional data would be beneficial to understanding local air quality. $PM_{2.5}$ is one of six criteria pollutants for which state, local, and tribal agencies and the EPA operate a regulatory monitoring network under the Clean Air Act. This sensor loan program brings air sensor technology to the public for supplemental monitoring and educational purposes. This program will help external loanees collect their own $PM_{2.5}$ data to meet the specific objectives of their project.

PM is an aerosol mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Others are so small they can only be detected using an electron microscope. Particulate matter contains microscopic solids or liquid droplets that are so small that they can be inhaled and cause serious health problems. Some particles less than 10 micrometers in diameter can get deep into your lungs and some may even get into your bloodstream. Of these, particles less than 2.5 micrometers in diameter, also known as fine particles or $PM_{2.5}$, pose the greatest risk to health.

A4.2 Project Background

Particulate matter includes:

- PM_{10} : inhalable particles, with diameters that are generally 10 micrometers and smaller; and
- $PM_{2.5}$: fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller.
    - How small is 2.5 micrometers? Think about a single hair from your head. The average human hair is about 70 micrometers in diameter – making it 30 times larger than the largest fine particle.

The size of particles is directly linked to their potential for causing health problems. Small particles less than 10 micrometers in diameter pose the greatest problems, because they can get deep into your lungs, and some may even get into your bloodstream. Figure A4-1 shows an example size comparison of different types of particulate matter.

Exposure to such particles can affect both your lungs and your heart. Numerous scientific studies have linked particle pollution exposure to a variety of problems, including:

- premature death in people with heart or lung disease
- nonfatal heart attacks
- irregular heartbeat
- aggravated asthma
- decreased lung function
- increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing.

People with heart or lung diseases, children, and older adults are the most likely to be affected by particle pollution exposure.

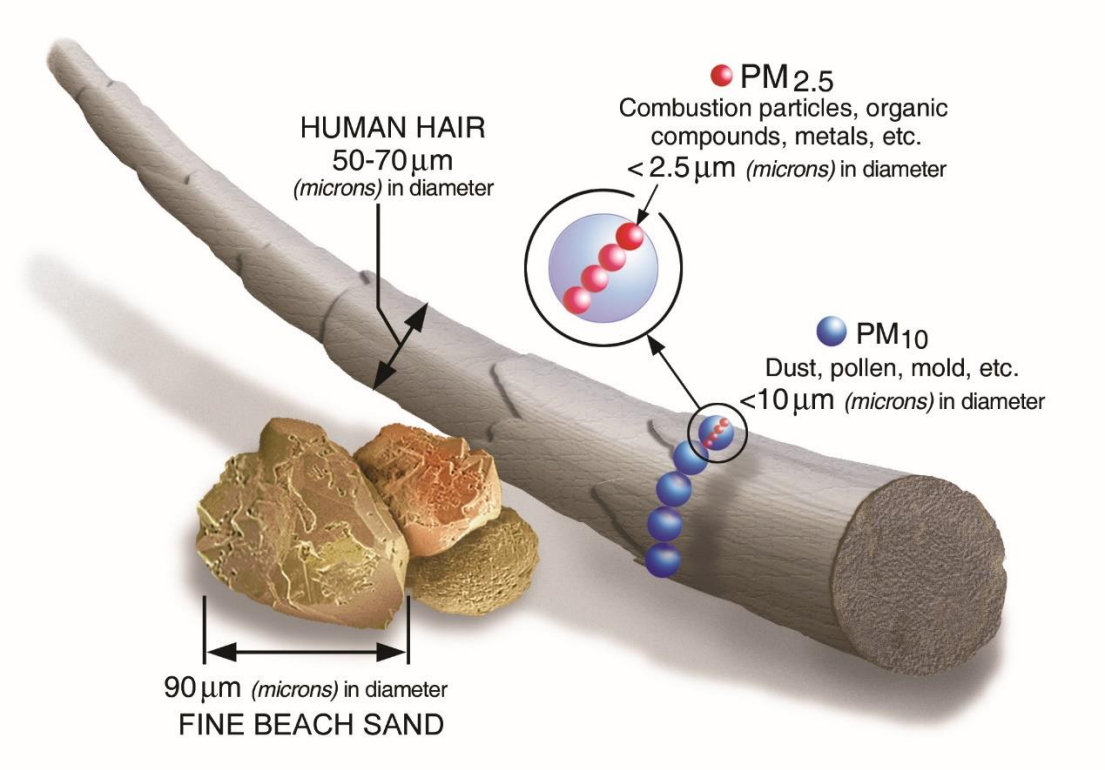

Figure A4-1: Size comparison of different types of particulate matter

Using American Rescue Plan (ARP) and Inflation Reduction Act (IRA) funding for sensor loan programs, Region 4 purchased approximately 70 Purple Air PA-II-SD sensors. These sensors will be loaned out to citizens, community groups, schools/teachers, state, local, or tribal air quality agencies, or other community organizations to help them accomplish the specific goals of their $PM_{2.5}$ monitoring projects.

The PurpleAir PA-II-SD sensor is shown in Figure A4-2. PurpleAir sensors use a fan to draw air past a laser, causing reflections from any particles in the air. These reflections are used to count particles in six sizes between 0.3µm and 10µm diameter. Using one second particle counts, estimated total mass for PM_1, $PM_{2.5}$ and PM_{10} is averaged by the PurpleAir Internet of Things control board. The data is then reported to the PurpleAir website and saved on the microSD card in the sensor. Prior collocation has indicated that the $PM_{2.5}$ data from the sensors is more accurate than the PM_{10}.[2] Therefore, it is recommended that the $PM_{2.5}$ data be primarily used and analyzed in air sensor loan projects.

[2] South Coast Air Quality Management District. Air Quality Sensor Performance Evaluation Center (AQ-SPEC) Evaluation Summary Report for PurpleAir PA-II. http://www.aqmd.gov/docs/default-source/aq-spec/summary/purpleair-pa-ii---summary-report.pdf?sfvrsn=16.

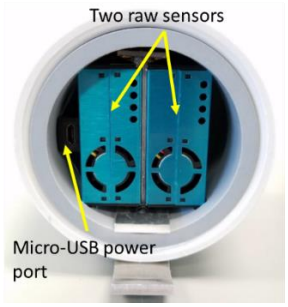

Figure A4-2: PurpleAir PA-II-SD Sensor

The PurpleAir PA-II-SD sensor contains two side-by-side Plantower™ optical PM sensors that measure particles using an optical light scattering measurement (see Figure A4-3)[3]. A low pulse is output from the sensor when the light receptor detects light scattered by particles. The particle concentration can be estimated based on a manufacturer-developed curve of concentration versus the percentage of time the sensor is reporting a low pulse. Higher sensitivity versions of optical particle counters go beyond using "percent time" as the indicator but quantify based upon the strength of the light scattering detected.

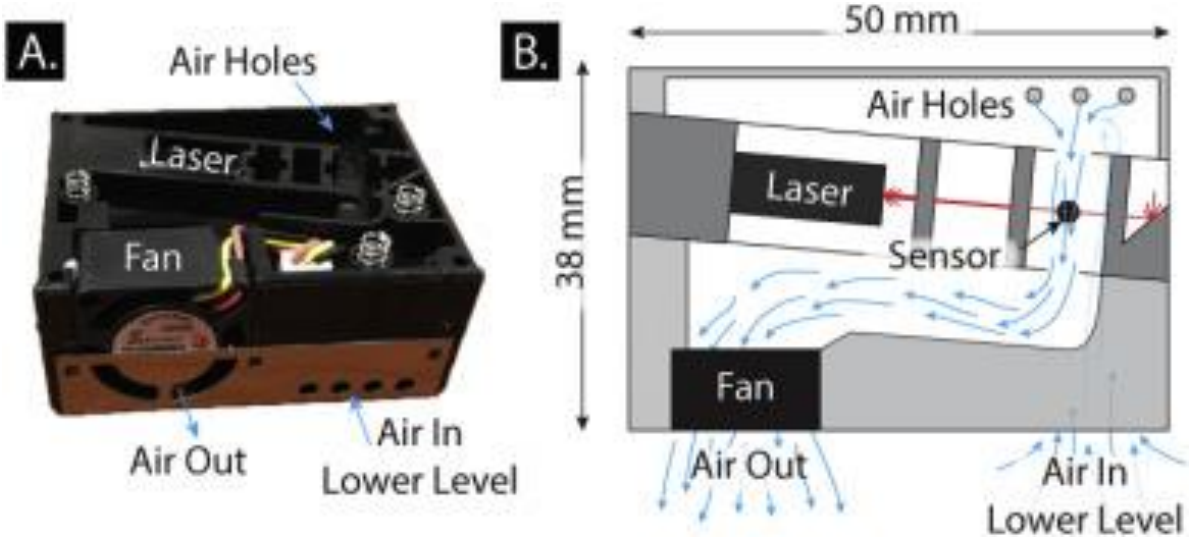

Figure A4-3: Optical Air Sensor Measurement Principle

A5. Project Task Description

[3] Figure from T. Sayahi, A. Butterfield, K.E. Kelly, Long-term field evaluation of the Plantower PMS low-cost particulate matter sensors, Environmental Pollution, Volume 245, 2019, Pages 932-940, https://www.sciencedirect.com/science/article/pii/S0269749118316129

External partners such as citizens, community groups, academic institutions, state, local, or tribal air quality agencies, or other groups can be considered for the $PM_{2.5}$ sensor loan program by contacting the EPA Region 4 sensor loan program coordinators. An online application is also in development, which once operational will serve as the main method to apply for the loan program. The external loanee organization will describe a proposed project to the EPA sensor loan team, and if selected, EPA will provide a loan of the sensors. All loanees will be expected to adhere to all requirements in the R4 QMP. The exact locations and duration of deployment will be determined using the process described below, and documented on the *Location-Specific Deployment Worksheet* (Appendix 1) that corresponds to the project objective(s) for the specific project The worksheet contains sections for the following project objectives, which will be filled out for each project as applicable, depending on the selected objectives for the project:

1. Educational Project – to conduct an educational project (usually at a school or other academic institution) utilizing $PM_{2.5}$ air sensors to learn about air quality and air sensor technology. The $PM_{2.5}$ sensor measurements will not be used to understand exact PM concentrations and local trends. The sensor measurements will be used for a qualitative descriptions of local air quality with some uncertainty. Sensor measurements may also be used to determine the 24-hour Air Quality Index category at the sensor locations.
2. Supplemental Network Project – to determine if locations may have potentially higher, lower, or similar PM2.5 concentrations to those measured at nearby regulatory $PM_{2.5}$ air monitoring site(s). The $PM_{2.5}$ sensor measurements will not be used to determine exact concentrations, but rather whether selected location(s) typically have higher, lower, or similar $PM_{2.5}$ concentrations. Measurements may also be used to determine the 24-hour Air Quality Index category at the sensor locations.
3. Source-Oriented Project – Determine if air pollution concentrations are higher or lower near a specific emissions source than farther away from the source. This level of project will characterize the duration and frequency of $PM_{2.5}$ events, and evaluate potential source activities' possible impacts. Measurements may also be used to determine the 24-hour Air Quality Index category at the sensor locations.

The worksheet and a Region 4 Revocable Air Sensor License Agreement (Appendix 2) will be signed by the external loanee and by EPA before each field deployment begins.

A5.1 Site Selection Process

Once an external loanee is selected to take part in a $PM_{2.5}$ sensor loan, the loanee will select the sensor location(s) for the project, in accordance with the requirements below and the specific objectives of the project. The air sensor location(s) will be selected by the external loanee organization by evaluating the following criteria:

1. The loanee must have permission for access from the property owner.
2. The location must have available land power access.
3. The location is strongly recommended to have access to a Wi-Fi internet connection.
4. The sensor should be installed in an open area to collect a representative air sample, and be located away from obstructions and minor emissions sources (unless characterizing a specific

source). Additional guidance is available in EPA's Guide to Siting and Installing Air Sensors[4], which is summarized in Figure A5-1.

5. Security considerations will also be important and locations with secure limited access such as fenced areas, rooftops, or elevated deployments are preferred.

For projects with a Supplemental Information Project objective, the location of the closest nearby regulatory $PM_{2.5}$ monitoring sites should be identified and listed on the Location-Specific Deployment Worksheet. The location of existing regulatory air monitoring sites can be viewed on EPA's AirData website[5].

For projects with a Source-Oriented Project objective, at least two locations are recommended. At least one air sensor location should be in an area of expected high $PM_{2.5}$ concentration near the source (as close as practical the source property boundary) in the predominant downwind direction (if possible). Proximity to the source should be prioritized over the predominant wind direction. At least one site should be identified as a background site, and be located far enough away from the from the source that source emissions would not be expected to impact the location and potentially in the upwind direction if possible. Distance from the source should be prioritized over predominant wind directions.

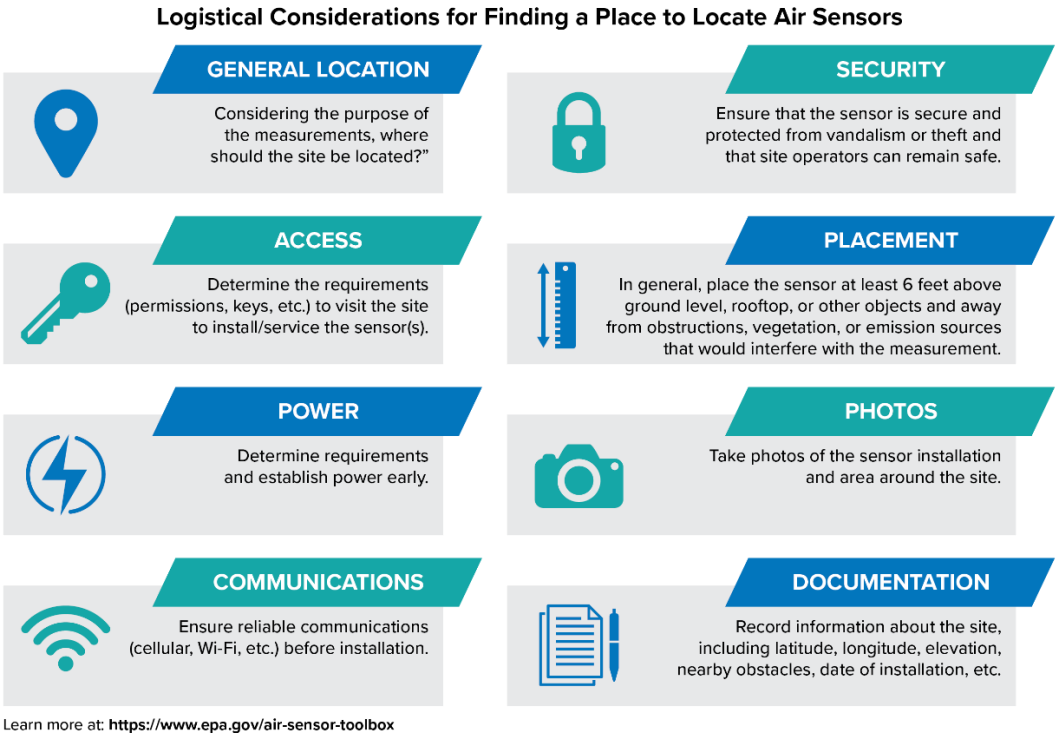

Figure A5-1: Logistical Considerations for Sensor Location Selection

[4] A Guide to Siting and Installing Air Sensors. US Environmental Protection Agency air sensor toolbox website. https://www.epa.gov/air-sensor-toolbox/guide-siting-and-installing-air-sensors.
[5] Interactive Map of Air Quality Monitors, US Environmental Protection agency AirData website. https://www.epa.gov/outdoor-air-quality-data/interactive-map-air-quality-monitors

A5.2 Project Goals

There are two primary goals of the $PM_{2.5}$ sensor loan program covered by this QAPP:

Project Goal 1: Provide PM sensors to external loanee organizations to collect $PM_{2.5}$ data to meet specific project objectives.

The project will use $PM_{2.5}$ sensors to collect $PM_{2.5}$ data in communities to meet the project-specific data needs for one or more of the project objectives listed in above (educational project, supplementary information project, or source-oriented project). At the conclusion of each project, the external loanee will summarize the data collected, and provide a summary of any findings to EPA.

Project Goal 2: Continue to test, develop, and improve $PM_{2.5}$ sensor loan, deployment, and data analysis procedures.

Since the loan program is new, and is the outgrowth of prior research projects by EPA, a secondary goal of this project is to continue to test, develop, and improve the equipment loan, deployment, and data analysis procedures, and build understanding of and deployment capacity with the PM sensor technology.

The results of these projects may be used in future training, conference presentations, or publications by EPA to further document and develop this technology and other sensor loan programs.

A5.3 Project Timeline

The specific timeline for each deployment will be documented in the Location-Specific Deployment Worksheet (Appendix 1). In general, this QAPP will cover activities from the time an agency is selected for a sensor loan to the time that the project is completed and the sensors are returned to EPA. The maximum anticipated duration of a $PM_{2.5}$ sensor loan under this program is one year (12 months).

A6. Information / Data Quality Objectives and Performance / Acceptance Criteria

A6.1 Data Quality Objectives (DQOs)

The DQOs and acceptance criteria for the project are listed in Table A6-1 below.

Table A6-1: Data Quality Objectives

Project Goal	Data Quality Objectives	Acceptance Criteria
1	Acceptable location selection and installation	A location is acceptable if it meets all or most of the criteria listed in Section A5.1. Recommend to take photos of each installed sensor and upload them to the SharePoint project file.
1	Functioning Sensor	Sensor turns on and successfully records data to the online data platform. Sensor will automatically update to latest firmware version when it is connected to Wi-Fi at the beginning of the loan project.
1	$PM_{2.5}$ concentration data is acceptable for intended project objective(s)	Collected data meets the Measurement Quality Objectives listed for the selected project objective(s) for the project.

Project Goal	Data Quality Objectives	Acceptance Criteria
1	Final data summary report	External loanee organization develops a final data summary report and uploads it to the project file within 120 days of completing data collection and returning the sensors to EPA.
2	Test and improve the $PM_{2.5}$ sensor loan program processes	Acceptance criteria is met if: • Project documentation is compiled in accordance with Section A12, and • Feedback from the external loanee organization on equipment, procedures, and possible areas for improvement has been obtained.

A6.2 Measurement Quality Objectives (MQOs)

To ensure that the $PM_{2.5}$ sensor data are of sufficient quality to meet the intended air sensor project objectives in project goal 1 (educational project, supplementary information project, or source-oriented project), the Measurement Quality Objectives (MQOs) listed below are established for this project.

The MQOs and criteria to meet the goals of this project are based on data quality indicators (DQIs) including bias, precision, and completeness metrics, which are defined in Table A6-2 below. The project MQOs are listed in Table A6-3. These tables are adapted from the *EPA Performance Testing Protocols, Metrics, and Target Values for Fine Particulate Matter Air Sensors: Use in Ambient, Outdoor, Fixed Site, Non-Regulatory Supplemental and Informational Monitoring Applications*[6] which is included in Appendix 4 (see Tables 3-1 and 4-2). Table A6-3 includes references to the sections in the performance targets document in Appendix 4 that include the applicable equations and methods for calculating each metric.

It is recommended to evaluate the MQOs using PurpleAir $PM_{2.5}$ sensor data after applying the US EPA national correction equation[7] shown in Equation A6-1. The national correction equation was developed by comparing data from PurpleAir sensors collocated with regulatory $PM_{2.5}$ monitors across the US, in an effort to reduce bias in the raw sensor data and calculate concentrations that more closely agree with regulatory monitors. The US EPA national correction equation for PurpleAir $PM_{2.5}$ sensors is used in the EPA AirNow Fire and Smoke Map[8] and can be applied in the PurpleAir map or data download tool. It is recommended that all sensor data be downloaded with the EPA national correction equation applied for use in the EPA Region 4 Sensor Loan program.

$$PM_{2.5\,Corrected} = 0.524 \times PA_{PM2.5\_cf\_1} - 0.0862 \times RH + 5.75 \qquad \text{(A6-1)}$$

[6] Duvall, R., A. Clements, G. Hagler, A. Kamal, Vasu Kilaru, L. Goodman, S. Frederick, K. Johnson Barkjohn, I. VonWald, D. Greene, and T. Dye. Performance Testing Protocols, Metrics, and Target Values for Fine Particulate Matter Air Sensors: Use in Ambient, Outdoor, Fixed Site, Non-Regulatory Supplemental and Informational Monitoring Applications. U.S. EPA Office of Research and Development, Washington, DC, EPA/600/R-20/280, 2021. https://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=350785&Lab=CEMM.

[7] Barkjohn, K. K., Gantt, B., and Clements, A. L.: Development and application of a United States-wide correction for $PM_{2.5}$ data collected with the PurpleAir sensor, Atmos. Meas. Tech., 14, 4617–4637, https://doi.org/10.5194/amt-14-4617-2021, 2021.

[8] US EPA AirNow Fire and Smoke Map, version 3.1. https://fire.airnow.gov. Accessed December 20, 2023.

Table A6-2: Data Quality Indicators

Metric	Description
Precision	Variation around the mean of a set of measurements reported concurrently by three or more sensors of the same type collocated under the same sampling conditions. Precision is measured here using the standard deviation (SD) and coefficient of variation (CV).
Bias	The systematic (non-random) or persistent disagreement between the concentrations reported by the sensor and reference instruments. Bias is determined here using the linear regression slope and intercept.
Linearity	A measure of the extent to which the measurements reported by a sensor are able to explain the concentrations reported by the reference instrument. Linearity is determined here using the coefficient of determination (R_2).
Error	A measure of the disagreement between the pollutant concentrations reported by the sensor and the reference instrument. Error is measured here using the root mean square error (RMSE) and normalized root mean square error (NRMSE).
Completeness	A measure of representativeness expressed as a percentage of the number of valid measurements compared to the total number of measurements expected.
Exploring Meteorological Effects	A graphical exploration to look for a positive or negative measurement response caused by variations in ambient temperature, relative humidity, or dew point, and not by changes in the concentration of the target pollutant.

Table A6-3: Measurement Quality Objectives

Performance Metric	Statistic	Acceptance Criteria	Assessment Description and Performance Targets (Appendix 4) Section Reference	Required for which Project Objectives?	Frequency of Assessment
Precision	Standard Deviation (SD) -OR-	≤ 5 µg/m^3	Sensor to sensor collocation (3.1.3)	Supplemental Network, Source-oriented	End of data collection (required), Conclusion of collocation periods (recommended)
	Coefficient of Variation (CV)	≤ 30%	Sensor to sensor collocation (3.1.3)	Supplemental Network, Source-oriented	
	Absolute difference and relative % difference of hourly PM2.5 CF_1 A and B channel values	Absolute Difference ≤ 5 µg/m3 and Relative Percent Difference ≤ 35%	Comparison of sensor's A and B channels. Recommend flagging data that do not meet acceptance criteria. (QAPP Eq. A6-3 and A6-4)	Supplemental Network, Source-oriented	End of data collection (required), Conclusion of collocation periods (recommended)
	None – qualitative assessment of A & B channel agreement.	A & B channel general agreement and "confidence score" >70%	On PurpleAir map, check that A and B channel graphs visually agree, and check sensor's A and B channel "confidence" score.	Educational (recommended), Supplemental Network, Source-oriented	Once every two weeks (bi-weekly)
Bias	Slope	1.0 ± 0.35	Sensor to FRM/FEM collocation (3.1.4)	Supplemental Network, Source-oriented	End of data collection (required), Conclusion of collocation periods (recommended)
	Intercept (b)	-5 ≤ b ≤ 5 µg/m^3	Sensor to FRM/FEM collocation (3.1.4)		
Linearity	Coefficient of Determination (R^2)	≥ 0.70	Sensor to FRM/FEM collocation (3.1.4)	Supplemental Network, Source-oriented	End of data collection (required), Conclusion of collocation periods (recommended)
Error	Root Mean Square Error (RMSE) or Normalized Root Mean Square Error (NRMSE)	RMSE ≤ 7 µg/m^3 or NRMSE ≤ 30%†	Sensor to FRM/FEM collocation (3.1.5)	Supplemental Network, Source-oriented	End of data collection (required), Conclusion of collocation periods (recommended)
Completeness	% Completeness	> 75% of valid hourly average PM2.5 and RH values for > 50% of sensors.	Assessed for each 1-hr and 24-hr avg, and for each sensor for the project time period. (QAPP Eq. A6-2)	Educational, Supplemental Network, Source-oriented	End of data collection (required)

The calculations described above to assess the project MQOs can be performed using the EPA Excel-based Air Sensor Collocation Macro Analysis Tool[9], using the sensortoolkit package[10] for the Python programming language, or using other data analysis software.

Completeness is calculated using Equation A6-2 below for each 1-hr and 24-hr data average, and is calculated for each sensor for the entire project period using the number of complete 24-hr averages.

$$\%\ Completeness = \frac{Number\ of\ valid\ measurements}{Number\ of\ expected\ measurements} \times 100 \quad \text{(A6-2)}$$

Absolute difference between a sensor's hourly average A and B channel concentrations is calculated by subtracting the two hourly values using Equation A6-3:

$$Absolute\ Difference = \left|A_{PM2.5\_cf1} - B_{PM2.5\_cf1}\right| \quad \text{(A6-3)}$$

Relative percent difference between a sensor's hourly average A and B channel concentrations is calculated using Equation A6-4:

$$Relative\ \%\ Difference = \frac{A_{PM2.5\_cf1} - B_{PM2.5\_cf1}}{(A_{PM2.5_{cf1}} - B_{PM2.5_{cf1}})/2} \times 100 \quad \text{(A6-4)}$$

A7. Distribution List

Table A7-1: Distribution List

Name	Title	Email
Donnette Sturdivant	Acting Air Analysis and Support Branch Manager, EPA R4	Sturdivant.Donnette@epa.gov
Katy Lusky	Air Data and Analysis Section Manager, EPA R4	Lusky.Kathleen@epa.gov
Ryan Brown	Regulatory and Communities Air Toxics Section Manager, EPA R4 ARD	Brown.Ryan@epa.gov
Katherine Beck	Life Scientist, EPA R4 ARD	Beck.Katherine@epa.gov
Daniel Garver	Physical Scientist, EPA R4 ARD	Garver.Daniel@epa.gov
Katherine Meiser	Environmental Engineer, EPA R4 ARD	Meiser.Katherine@epa.gov
Corinna Wang	Physical Scientist, EPA R4 ARD	Wang.Corinna@epa.gov
Nick Barnett	Community Planner, EPA R4 ARD	Barnett.Nicholas@epa.gov

The QAPP will also be provided to external loanee organizations upon their selection for a sensor loan. External loanee contact information will be documented on the Location-Specific Deployment Worksheet in Appendix 1. For each project, a copy of the QAPP and the completed Location-Specific Deployment Worksheet (Appendix 1) will also be provided to the state or local air agency with jurisdiction for the project area.

[9] Air Sensor Collocation Macro Analysis Tool. US EPA Air Sensor Toolbox Website. https://www.epa.gov/air-sensor-toolbox/air-sensor-collocation-macro-analysis-tool.
[10] Frederick, S., K. Barkjohn, R. Duvall, AND A. Clements. sensortoolkit: A Python Library for Standardizing the Ingestion, Analysis, and Reporting of Air Sensor Data for Performance Evaluations. https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=CEMM&dirEntryId=354997. Available for download: https://pypi.org/project/sensortoolkit/.

A8. Project Organization

The EPA Region 4 $PM_{2.5}$ sensor loan team will mostly not have an active role in project execution for each sensor loan. Staff will provide study design review, project selection, equipment management, and technical support as needed. The loanee will be responsible for study design and execution, and for following the procedures and requirements of this QAPP. The specific design for each loan project will be documented on the Location-Specific Deployment Worksheet (Appendix 1).

Specific project roles and responsibilities are defined in Table A8-1: Roles and Responsibilities below.

Table A8-1: Roles and Responsibilities

Project Personnel	Role	Responsibility
Ryan Brown	R4 Sensor Loan Management Champion and RCATS Supervisor	Responsible for supporting study design, execution, documentation, and interpretation of results in collaboration with project participants. In collaboration with the project team, selects applicants to receive sensor loans. Assists in QAPP development and updates.
Daniel Garver	Operations Manager R4 Sensor Loan Program Co-Lead	Project co-lead responsible for supporting study design, execution, documentation, and interpretation of results in collaboration with project participants. In collaboration with the project team, selects applicants to receive sensor loans. Serves as data/documentation steward for the overall project. Responsible for QAPP development and updates.
Katie Marie Beck	R4 Sensor Loan Program Co-Lead	Project co-lead responsible for supporting study design, execution, documentation, and interpretation of results in collaboration with project participants. In collaboration with the project team, selects applicants to receive sensor loans. Serves as data/documentation steward for the overall project. Responsible for QAPP development and updates.
Donnette Sturdivant	EPA R4 Acting AASB Manager	EPA R4 management oversight, review of QAPP
Katy Lusky	EPA R4 ADAS Supervisor	EPA R4 management oversight, review of QAPP, participates in selection of applicants to receive sensor loans.
Katherine Meiser	EPA R4 Environmental Engineer	Participates in selection of applicants to receive sensor loans, and QAPP review.
Mary Reynolds	EPA R4 AASB Quality Assurance Coordinator	Independent QA oversight. Reviews and approves the project QAPP, as delegated by the R4 QA Manager. Provides recommendations to project participants on QA practices.
Marshall Varnum	EPA R4 LSASD Physical Scientist	Maintains the inventory of sensors, checking sensors before shipping, shipping sensors, and inspecting sensors upon completion of a project.

Project Personnel	Role	Responsibility
Contacts Specified on Location-Specific Worksheet	External Loanee Organization: Different Organization for Each Deployment	Identifies source(s) to be characterized and applies for sensor loan program. Is responsible for project execution, field support, pre-deployment preparation, field install, equipment maintenance, ongoing QA documentation, and sensor operation. Provides feedback to EPA R4 on utility of project data and processes, and recommends areas for improvement.
State or Local Air Agency	Project support on a case-by-case basis	At the agency's discretion, assists with coordination of collocation of sensors with regulatory monitors, and may assist in source-oriented projects depending on the specific project.

A9. Project Quality Assurance Manager Independence

The AASB QA coordinator will serve as the QA Manager for the project, and will review and approve the QAPP as a Designated Approving Official delegated by the R4 QA Manager. The AASB QA coordinator is independent of environmental information operations, and reports to the Mobile Sources and Indoor Air Quality Section Manager, not the RCATS and ADAS section managers who are in charge of environmental information operations. This independence is further described in the Region 4 Quality Management Plan (QMP)[11]. This project will adhere to all requirements in the R4 QMP.

A10. Project Organization Chart and Communications

A10.1 Project Organization Chart

The project organization chart is shown in Figure A10-1. The Region 4 ARD project leads and ARD management are responsible for conducting environmental information operations during the project. The external loanee organization (specified for each deployment in the Location-Specific Worksheet in Appendix 1) will collect environmental data to meet the specific project objective(s) of their sensor loan. The AASB QA coordinator will provide independent QA oversight to the ARD management and project leads. Any nonconformances with the QAPP requirements will be raised to the R4 project leads and the AASB QA coordinator manager as soon as they are identified, to determine the appropriate corrective actions.

[11] U.S. Environmental Protection Agency Region 4 Quality Management Plan. November 2020. R4QMP001-112020.

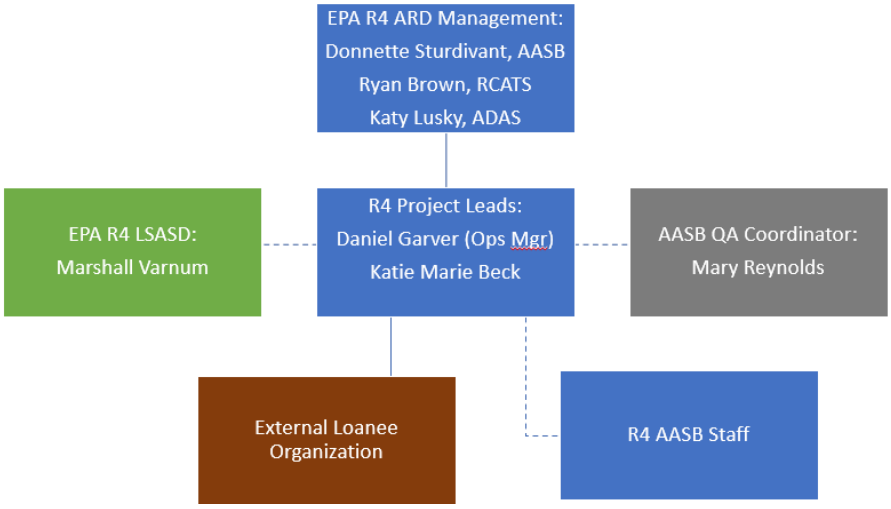

Figure A10-1: Project Organization Chart

A10.2 Non-EPA Organizations

The external loanee organization and internal communication plan will be specified for each deployment in a signed Location-Specific Worksheet (Appendix 1). The external loanee organization will follow the procedures and requirements outlined in this QAPP and the associated SOPs, and will report any nonconformances with QAPP requirements to the EPA R4 Project Leads. External loanees are expect to collect data and to email ARD Project Lead if and when issues arise with their project. External loanees are expected to submit a final report when the project is complete. There will be a chance for meetings between ARD project leads and external loanee after project completion to discuss potential process improvement initiatives.

The state, local, or tribal air quality agency specific to each project location will receive a copy of the study design for review and the opportunity to comment. If participating in the project, the air agency will assist with collocation of the sensors at a regulatory air monitoring site near the project location. The specific agency will be listed on each project location worksheet.

A11. Personnel Training / Certification

After a project is selected for a loan, Region 4 ARD staff will provide a basic overview of sensor operation and the QAPP requirements with the loanee. This will be recorded in the project logbook. The EPA ORD Purple Air Quick Start Guide is included in Appendix 3, and can be used by the loanee during the project to assist with sensor operation. EPA ARD staff will be available to answer specific questions that arise during a loan. If a loanee experiences malfunctions with one or more sensors during the loan, they should contact the EPA air sensor loan program leads to determine the appropriate corrective actions.

Participants are also encouraged to review and utilize the following resources to assist with their sensor loan projects:

1. US EPA Air Sensor Guidebook[12]
2. South Coast AQMD Air Sensor Toolkit and Guidebook[13] (developed under a grant from EPA)
3. EPA's air sensor installation and siting guidance[14]
4. South Coast AQMD's air sensor installation video[15] (developed under a grant from EPA)

A12. Documents and Records

The primary records repository for this project will be the Region 4 Air Sensor Loan SharePoint / Teams site. The site has separate channels and records repositories that are internal to EPA, and that are shared with the external loanee organizations. A new project file will be created for each sensor loan deployment. Records generated by the external loanee organizations will be uploaded to the R4 SharePoint site. Records security will be maintained by only granting project file folder access on SharePoint to the specific EPA staff and external loanee organization staff that need to add or modify records. Additionally, all file edits, additions, and deletions are automatically tracked on SharePoint, an audit trail can be produced if needed, and any changes made in error can be rolled back.

This QAPP will be controlled in accordance with the Region 4 Operating Procedure for Document Control (R4PROC-001). All records will be maintained for at least five years in accordance with the EPA Records Schedule 1035 (Environmental Programs and Projects), Item d (Short-term environmental program and project records) and the Region 4 QMP.

Table A12-1: Project Recordkeeping Requirements

Record Type	Format	Storage Location	Custodian
EPA R4 Quality Management Plan	Electronic	R4 QA SharePoint site	EPA R4
Quality Assurance Project Plan	Electronic	R4 Sensor Loan SharePoint site and ARD SharePoint site (houses all ARD QA documents)	EPA R4
Location-Specific Deployment Worksheets	Electronic	Completed and signed worksheet is saved in the project file on the R4 Sensor Loan SharePoint site	EPA R4
Site maps, photos, and metadata	Electronic	R4 Sensor Loan SharePoint site	EPA R4 and External Loanee Organization

[12] Clements, A., R. Duvall, D. Greene, AND T. Dye. The Enhanced Air Sensor Guidebook. U.S. Environmental Protection Agency, Washington, DC, 2022.
[13] Polidori A., Papapostolou V., Collier-Oxandale A., Hafner H., and Blakey T. (2021) Community in Action: A Comprehensive Guidebook on Air Quality Sensors. April. Available on the South Coast AQMD's AQ-SPEC website: http://www.aqmd.gov/aq-spec/special-projects/star-grant
[14] US EPA Air Sensor Toolbox Website. A Guide to Siting and Installing Air Sensors. Accessed December 21, 2023. https://www.epa.gov/air-sensor-toolbox/guide-siting-and-installing-air-sensors.
[15] South Coast Air Quality Management District. Air Sensor Training #3: PurpleAir PA-II Sensor Installation. Accessed December 21, 2023. https://www.youtube.com/watch?v=cOZgyDRFc4U.

Record Type	Format	Storage Location	Custodian
Purple Air sensor raw and validated data files	Electronic	Raw data stored on the PurpleAir website, and downloaded by the loanee. Validated data files maintained by the loanee.	External Loanee Organization
Data Summary Report	Electronic	R4 Sensor Loan SharePoint site	EPA R4 and External Loanee Organization
Secondary meteorological data (if used)	Electronic	Retrieved from source (e.g., NOAA) and maintained by external loanee organization	External Loanee Organization
E-mail communications related to the project	Electronic	EPA email server, maintained according to EPA records schedules.	EPA R4

B. Implementing Environmental Information Operations

B1. Identification of Project Environmental Information Operations

Each sensor loan deployment is an observational study with the following planned configuration. After a loan application is accepted by EPA, the specific sensor location(s) and project objective(s) for each deployment will be documented in a completed Location-Specific Worksheet (Appendix 1), and saved in the project file on the R4 air sensor loan SharePoint site. The worksheet contains separate sections for each of the following project objectives, which will be completed as applicable for each project:

- Educational Project
- Supplemental Network Project
- Source-oriented Project

Each sensor loan project will be conducted as follows:

1. After an External Loanee Organization completes the Location-Specific Deployment Worksheet (Appendix 1) and the Region 4 Revocable Air Sensor License Agreement (Appendix 2), the EPA project lead will request EPA R4 LSASD to ship the sensors to the loanee.
2. LSASD will check out the requested number of sensors from the LSASD Field Equipment Tracking System (FETS), conduct a check to ensure the sensors are operational (as described in Section B6) and ship them to the External Loanee Organization.
3. A member of the EPA project team will meet with the external loanee and provide an overview of the QAPP requirements and training resources, and answer any questions.
4. The External Loanee Organization will collect $PM_{2.5}$ sensor data for the location(s), time period(s) and Project objective(s) specified in the Location-Specific Deployment Worksheet.
5. During the loan, the external loanee will download sensor data at least every two weeks to verify that the sensors are reporting data and that the A and B channel agreement is acceptable.
6. At the conclusion of the specified project period (up to one year), the external loanee will analyze the data collected to answer the question(s) stated at the beginning of the project for the applicable project objective(s). The results of the analyses will be included in the final data summary report. Details on this report and recommended analyses for each project objective type are included in Section C2.1. This data analysis will also include a data quality assessment to determine whether the project MQOs were met. It is required that the External Loanee Organization develop the final data summary report and upload it to the project file at the conclusion of the project.
7. The External Loanee Organization will ship the sensors back to EPA R4 LSASD. LSASD will again check to ensure the sensors are operational, and check them back in in the FETS so they can be used for a subsequent loan.

B2. Methods for Environmental Information Acquisition

B2.1 Field Activities Environmental Measurements

This project will collect continuous $PM_{2.5}$ sensor data. No field samples will be collected for laboratory analysis under this QAPP.

B2.2 Laboratory Analyses

No laboratory analyses will be conducted under this QAPP.

B2.3 Existing Information

Existing air quality monitoring data from EPA's Air Quality System (AQS) or AirNow databases will be used for projects that conduct collocation of air sensors with existing regulatory $PM_{2.5}$ monitors. Data in AQS has been quality-assured by the state, local, or tribal monitoring agency that collected the data, so use of AQS data is recommended if it is available. However, this data is not required to be reported until 90 days after the end of the calendar quarter in which it is collected, and so AQS data may not be available in time for use in air sensor loan projects. Preliminary real-time data from regulatory continuous PM2.5 monitors is reported to EPA's AirNow database, and can be downloaded by the external loanee organization.

AQS data can be obtained in multiple ways:

- Pre-generated data files are available on EPA's AirData website.
- The AQS API can be used to query raw data.
- An interactive map of air quality monitors is available on EPA's AirData website.
- The RAQSAPI R package[16] can be used to query AQS API data natively in the R programming language.
- The pyaqsapi Python package[17] can be used to query AQS API natively in the Python programming language.

Real-time data can be obtained from AirNow in multiple ways:

- The AirNow API can be used to query raw data.
- The AirNow Fire and Smoke Map can be used to view current data from AirNow monitors and PurpleAir sensors.

The project Purple Air raw data is initially polled by the PurpleAir website, and the project team members can access the data via the website or using the PurpleAir data download tool. The raw data is downloaded from this website and maintained by the External Loanee Organization, and processed as described in Section B7.

Projects with a source-oriented objective may also use existing wind speed and wind direction data. The closest weather station that is determined to be meteorologically representative of the project area will be selected. Weather data from this station will be downloaded and maintained by the external loanee organization. A summary of the weather data will be included in the final data summary report.

Possible sources of existing meteorological data include:

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[16] McCrowey, C., Sharac, T., Mangus, N., Jager, D., Brown, R., Garver, D., Wells, B., Brittingham, H. (2021). *An R Interface to the US EPA Air Quality System Data Mart API*. https://cran.r-project.org/web/packages/RAQSAPI/index.html.

[17] McCrowey, C. *A Python Interface to the US EPA Air Quality System Data Mart API*. US Environmental Protection Agency. https://github.com/USEPA/pyaqsapi.

- NOAA Global Surface Hourly Integrated Surface Database (ISD),[18] accessible using the rnoaa R package.[19]
- EPA Air Quality System (AQS) database[20] (for meteorological data collected at existing air monitoring sites).
- Iowa State University Iowa Environmental Mesonet[21]: provides wind roses from historical weather data across many weather station networks.

B2.4 Environmental Technology

This project does not employ environmental technology as defined in the EPA Guidance on Quality Assurance for Environmental Technology Design, Construction and Operation.[22]

B3. Integrity of Environmental Information

Integrity of environmental information collected during the project will be maintained by downloading the continuous air senor and meteorological data collected to the EPA Air Sensor Loan SharePoint site. The project does not involve any field samples or laboratory analysis, so chain of custody and analytical requirements do not apply to this project.

B4. Quality Control

The quality control (QC) activities for this project are based on the DQIs and MQOs defined in Section A6.2., reproduced below, lists the project MQOs and summarizes the assessments that will be conducted to meet the quality objectives.

Table B4-1: Measurement Quality Objectives

Performance Metric	Statistic	Acceptance Criteria	Assessment Description and Performance Targets (Appendix 4) Section Reference	Required for which Project Objectives?	Frequency of Assessment

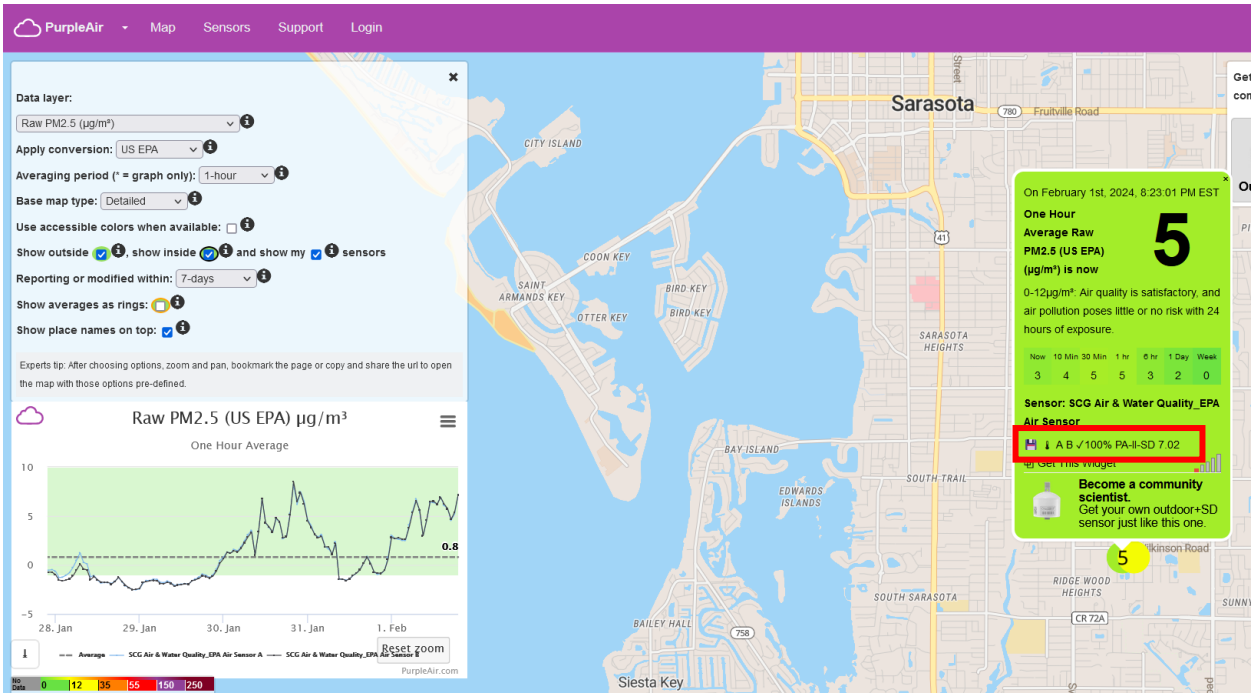
[18] NOAA National Centers for Environmental Information: Global Surface Hourly Integrated Surface Database. https://www.ncei.noaa.gov/products/land-based-station/integrated-surface-database.
[19] Chamberlain, Scott (2021). rnoaa: 'NOAA' Weather Data from R. R package version 1.3.8. https://CRAN.R-project.org/package=rnoaa
[20] U.S. Environmental Protection Agency Air Quality System (AQS) Database. https://www.epa.gov/aqs
[21] Iowa State University College of Agriculture, Department of Agronomy. Iowa Environmental Mesonet (IEM). https://mesonet.agron.iastate.edu/
[22] EPA Guidance on Quality Assurance for Environmental Technology Design, Construction and Operation. EPA QA/G11. US EPA Office of Environmental Information. January 2005. https://www.epa.gov/sites/default/files/2015-06/documents/g11-final-05.pdf

Precision	Standard Deviation (SD) -OR-	≤ 5 µg/m^3	Sensor to sensor collocation (3.1.3)	Supplemental Network, Source-oriented	End of data collection (required), Conclusion of collocation periods (recommended)
	Coefficient of Variation (CV)	≤ 30%	Sensor to sensor collocation (3.1.3)	Supplemental Network, Source-oriented	
	Absolute difference and relative % difference of hourly PM2.5 CF_1 A and B channel values	Absolute Difference ≤ 5 µg/m3 and Relative Percent Difference ≤ 35%	Comparison of sensor's A and B channels. Recommend flagging data that do not meet acceptance criteria. (QAPP Eq. A6-3 and A6-4)	Supplemental Network, Source-oriented	End of data collection (required), Conclusion of collocation periods (recommended)
	None – qualitative assessment of A & B channel agreement.	A & B channel general agreement and "confidence score" >70%	On PurpleAir map, check that A and B channel graphs visually agree, and check sensor's A and B channel "confidence" score.	Educational (recommended), Supplemental Network, Source-oriented	Once every two weeks (bi-weekly)
Bias	Slope	1.0 ± 0.35	Sensor to FRM/FEM collocation (3.1.4)	Supplemental Network, Source-oriented	End of data collection (required), Conclusion of collocation periods (recommended)
	Intercept (b)	-5 ≤ b ≤ 5 µg/m^3	Sensor to FRM/FEM collocation (3.1.4)		
Linearity	Coefficient of Determination (R^2)	≥ 0.70	Sensor to FRM/FEM collocation (3.1.4)	Supplemental Network, Source-oriented	End of data collection (required), Conclusion of collocation periods (recommended)
Error	Root Mean Square Error (RMSE) or Normalized Root Mean Square Error (NRMSE)	RMSE ≤ 7 µg/m^3 or NRMSE ≤ 30%[†]	Sensor to FRM/FEM collocation (3.1.5)	Supplemental Network, Source-oriented	End of data collection (required), Conclusion of collocation periods (recommended)
Completeness	% Completeness	> 75% of valid hourly average PM2.5 and RH values for > 50% of sensors.	Assessed for each 1-hr and 24-hr avg, and for each sensor for the project time period. (QAPP Eq. A6-2)	Educational, Supplemental Network, Source-oriented	End of data collection (required)

B4.1 Qualitative Precision Check of Sensor A and B $PM_{2.5}$ Channels

The qualitative precision check of each sensor's A and B channel agreement should be conducted using the following procedure. The PurpleAir sensor contains two optical PM2.5 sensors, and it is useful to compare the measurements to ensure that the sensor is operating properly. It is recommended that the QC check be conducted every two weeks (bi-weekly), but the exact frequency for each loan project is specified on the Location-Specific Deployment Worksheet (Appendix 1). Conducting this QC check will improve the overall quality of the data collected, and allow the loanee to identify and correct any problems with the sensors sooner and avoid data loss or incomplete data.

1. Open your web browser to map.purpleair.com
2. Click on the circle icon of the desired sensor.
3. Verify the following (see figure below for an example of a properly functioning sensor):
    a. Verify that the sensor A and B channel timeseries data graphs visually agree. The plot should show lines plotted mostly on top of each other, indicating good agreement. Occasional differences are acceptable, but if one channel differs significantly from the other, or for a prolonged period, this indicates a problem with the sensor and the sensor should be cleaned.
    b. Verify that the SD card icon is green and not red. Red indicates that the sensor is not writing data to the SD card.
    c. Verify that the thermometer icon is green and not red. Red indicates that the sensor's temperature, pressure, or humidity sensor is not functioning properly.
    d. Verify that the A B channel icons A B ✓100% show a percentage above 70%, and show "A" "B" and a checkmark. If the percentage is below 70%, or if the "A" or "B" is missing, then this indicates that the sensor may not be functioning properly and further evaluation and troubleshooting is needed.



B5. Instrument / Equipment Calibration, Testing, Inspection, and Maintenance

Upon initial receipt from the manufacturer, and upon receipt after the completion of a loan, $PM_{2.5}$ sensors will be inspected by EPA Region 4 LSASD using the following process to ensure the sensor is operational.

1. LSASD will perform a visual inspection of the sensor to ensure that it is clean and free from debris. If debris is observed, the sensor will be cleaned with an electronic duster, vacuum, or compressed air.
2. A visual inspection of the power supply will be completed to ensure that it is intact and free from damage or debris.
3. The sensor will be powered on and LSASD will verify that the unique sensor ID appears on a cellular device or computer Wi-Fi connection. This confirms that the sensor is powered on and ready to connect to a Wi-Fi network.

After passing the inspection, the sensor will be checked back in to the LSASD FETS. If any part of the inspection fails, the issue will be logged in the Corrective Action Log on the project SharePoint site.

B6. Inspection / Acceptance of Supplies and Services

This section is not required for a Category III QAPP. This project does not involve supplies and services that require inspection / acceptance criteria.

B7. Environmental Information Management

For each new deployment, a new project folder will be created on the R4 Air Sensor Loan SharePoint Site. The following subfolder hierarchy will be created in each project folder:

- [Project / Location Name]
    - Project Forms (Region 4 Revocable Air Sensor License Agreementand Location-Specific Deployment Worksheet)
    - Site Photos and Maps
    - Final Data Summary Report

Environmental data and information generated under this field data acquisition QAPP will be managed as follows for this project.

1. The completed Location-Specific Deployment Worksheet and signed Region 4 Revocable Air Sensor License Agreement will be uploaded to the “Project Forms” folder of the project file at the beginning of the loan.
2. Photos of each of the installed sensors and a map of the selected sensor sites are recommended to be uploaded to the SharePoint project file in the “Site Photos and Maps” folder. The external loanee organization will verify that the installed locations follow the site selection process requirements in Section A5.1.
3. Raw and processed sensor data will be archived in by the external loanee organization. At a minimum, the following will be maintained:
    - Raw data files downloaded from PurpleAir containing minute-by-minute sensor data (see detailed instructions below)

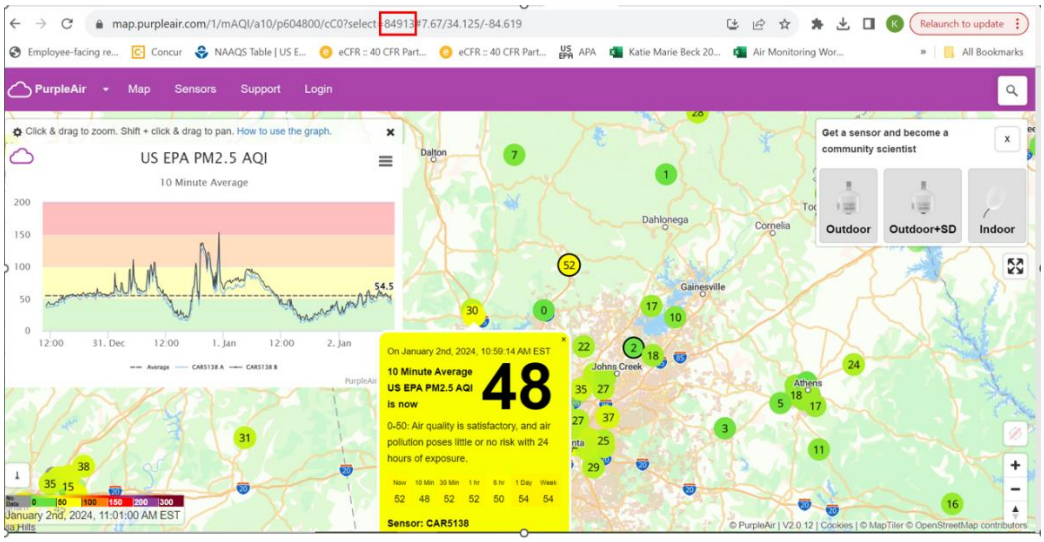
- Processed data files of corrected 1-hr and 24-hr average PM2.5 sensor data. The raw data will be processed in accordance with the procedures in Section D.

4. There are two ways to download PurpleAir sensor data described in the sections below: from the PurpleAir API, and from the PurpleAir map.

B7.1 Data Download from the PurpleAir API

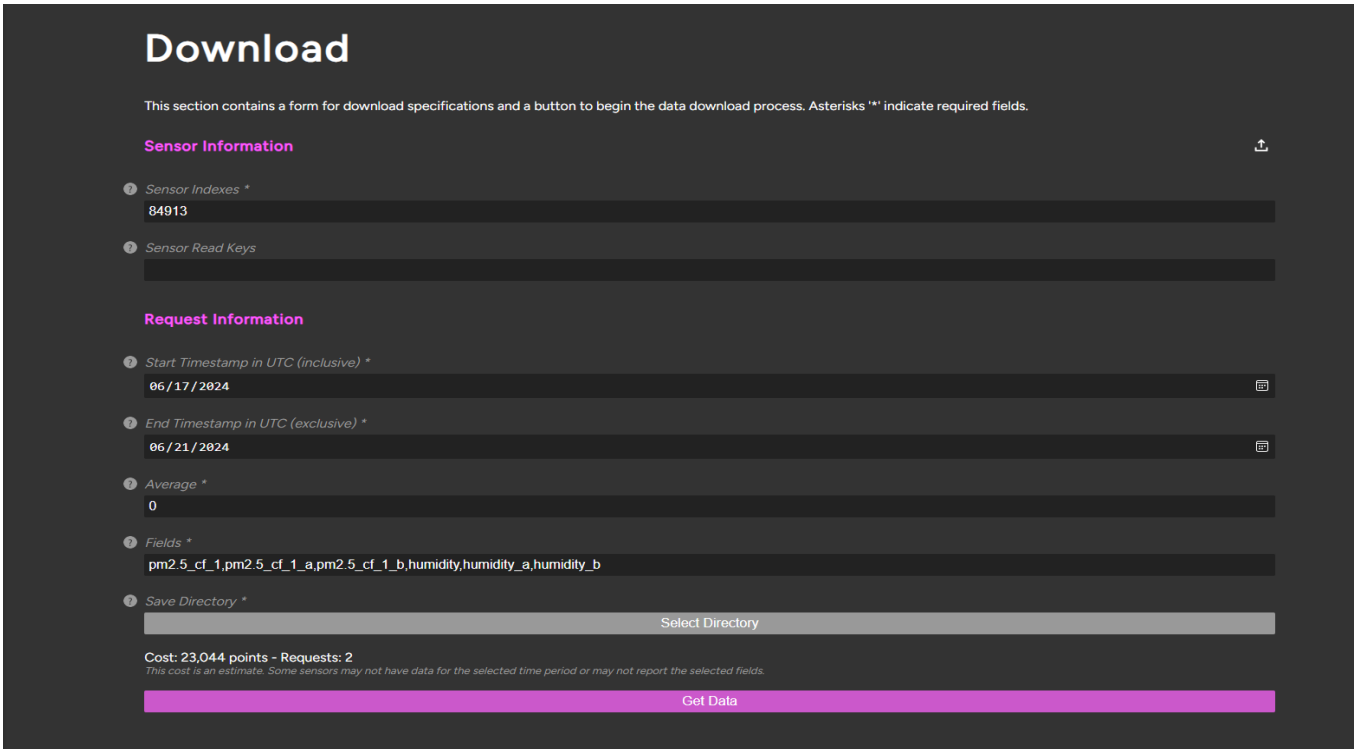
PurpleAir sensor raw data can be downloaded according to the following instructions using the PurpleAir data download tool (requires installation). The PurpleAir API is the best way to download raw data with all supporting metadata, for use in final data validation. The API also allows for downloading large datasets at once, for a precise selection of sensors and date range(s). However, it is not possible at this time to download data with the US EPA national correction equation[7] (Equation A6-1) already applied. The national correction equation should be applied to the raw data after downloading from the API in a spreadsheet or other data analysis software.

d. Download the PurpleAir data download tool from https://community.purpleair.com/t/purpleair-data-download-tool/3787 and install it on your computer (requires admin privileges).
e. Set up the data download tool using the instructions on the PurpleAir website: https://community.purpleair.com/t/setting-up-the-purpleair-data-download-tool/4999. Please note that if you do not already have a login account with PurpleAir, you will be prompted to create one. These instructions describe how to create API keys and enter them into the data download tool, which is required before data download can begin.
f. Find the Sensor index number(s) on the PurpleAir Map (for sensors displayed as public) using the steps below. To find the public sensor index number(s):
    a. Go to PurpleAir Map and select sensor
    b. Look in URL and find “select=”
    c. Index number is right behind “select=”
    d. Example: Sensor index in red box



g. Download data for the desired time period using the data download tool

a. Copy sensor index number(s) or private sensor read keys into the corresponding fields.
b. Select start and end dates
c. Select average “0” for minute by minute data
d. Select fields to download. It is recommended to download all fields, but at a minimum the following fields are needed:
    - pm2.5_cf_1
    - pm2.5_cf_1_a
    - pm2.5_cf_1_b
    - humidity
    - humidity_a
    - humidity_b
e. Select Directory: choose a directory to save the downloaded files to.

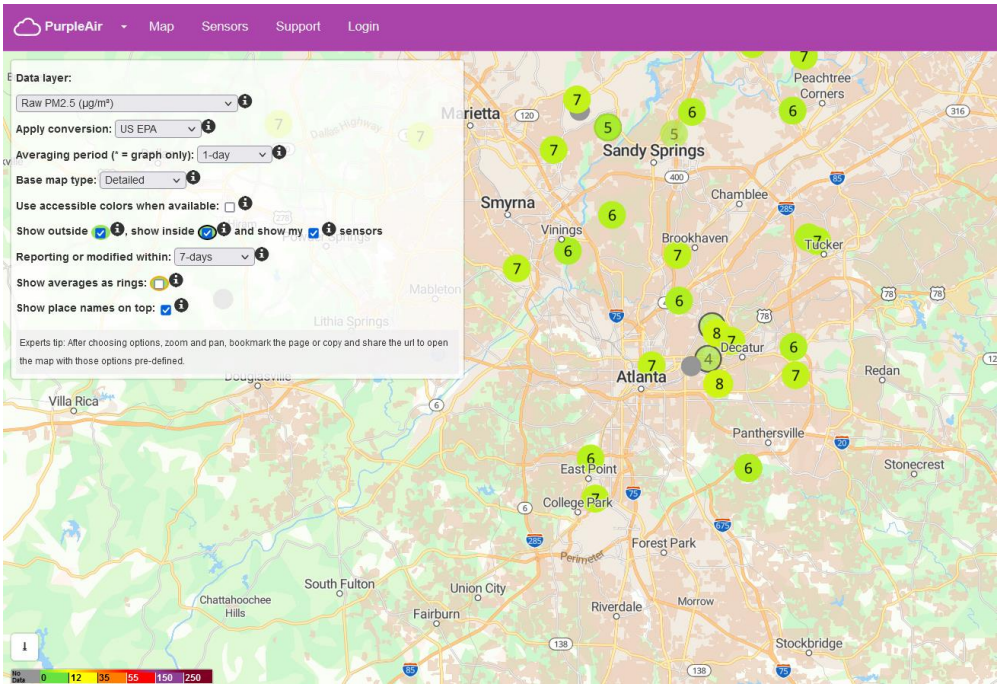


B7.2 Data Download from the PurpleAir Map

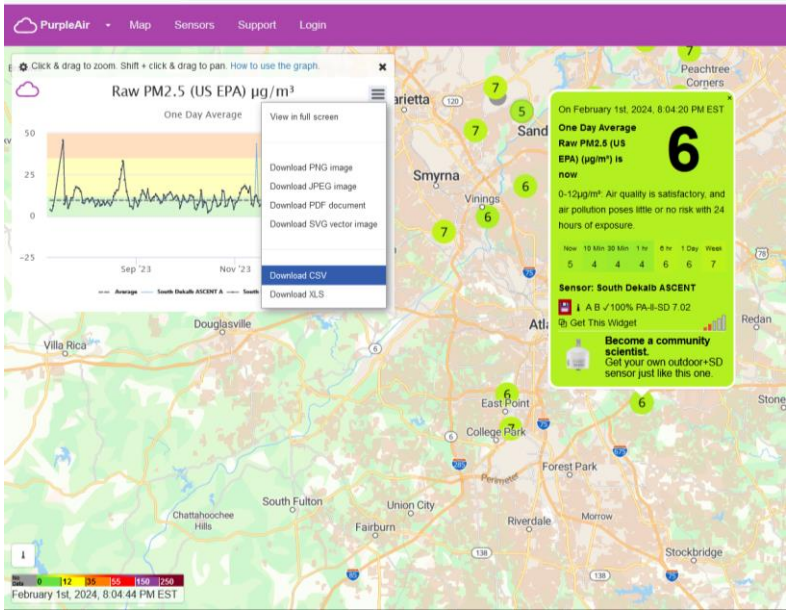
PurpleAir sensor data can also be downloaded according to the following instructions using the PurpleAir interactive map: map.purpleair.com (no installation required). The interactive map allows data to be downloaded with the EPA national correction equation already applied. However, hourly data can only be downloaded for the most recent 14 days. Daily average data can be downloaded for the most recent 365 days. The only data that can be downloaded from the map are the sensor’s A and B channel and average PM2.5 concentration. Additional raw data collected by the sensor can only be downloaded using the PurpleAir API (see above section). To download data from the PurpleAir Map:

1. Open your web browser to map.purpleair.com.

2. Click on the gear icon in the top left.
3. Select the following options from the map settings (see figure below)
    a. Under “Data Layer” select “Raw PM2.5 (µg/m^3)”
    b. Under “Apply Conversion” select “US EPA”
    c. Under “Averaging Period” select “”Real time”



4. Select the sensor on the map to download data from. Then, select the three lines icon next to the concentration graph, and select “Download CSV” or “Download XLS”


PurpleAir
Map
Sensors
Support
Login
Click & drag to zoom. Shift + click & drag to pan. How to use the graph.
Raw PM2.5 (US EPA) µg/m³
One Day Average
View in full screen
Download PNG image
Download JPEG image
Download PDF document
Download SVG vector image
Download CSV
Download XLS
Sep '23
Nov '23
On February 1st, 2024, 8:04:20 PM EST
One Day Average
Raw PM2.5 (US EPA) (µg/m³) is now
6
0-12µg/m³: Air quality is satisfactory, and air pollution poses little or no risk with 24 hours of exposure.
Sensor: South Dekalb ASCENT
Get This Widget
Become a community scientist.
Get your own outdoor+SD sensor just like this one.
Douglasville
Villa Rica
Smyrna
Vinings
East Point
College Park
Forest Park
South Fulton
Union City
Fairburn
Riverdale
Morrow
Stockbridge
Peachtree Corners
February 1st, 2024, 8:04:44 PM EST

C. Assessment, Response Actions, and Oversight

C1. Assessments and Response Actions

Category III QAPPs do not require internal or external systems audits, and there are no audits planned for this project. EPA is loaning equipment to project participants but does not plan to conduct audits of the loanees as part of the program. EPA Region 4 does have the authority to conduct any audits or assessments as needed, and any audits will be documented in accordance with the Region 4 QMP requirements.

C1.1 Assessments

This section is not required for a Category III QAPP. No assessments are planned as a part of the project.

C1.2 Response Actions

This section is not required for a Category III QAPP. No response actions are required as no assessments are planned.

C2. Oversight and Reports to Management

EPA R4 ARD management will be informed of the progress of the $PM_{2.5}$ sensor loan program during recurring Air Sensor Loan check-in meetings.

EPA R4 may meet with the external loanee organization during the loan on an as-needed basis, and the external loanee organization will provide any updates on project progress or issues encountered. The external loanee will upload records to the EPA project SharePoint site as described in Sections A12 and B7.

C2.1 Final Data Summary Report

At the conclusion of the project, each external loanee organization is required to develop and submit a final data summary report. There is no required format for the report, but recommended content is included below, including which sections are recommended for each type of project objective. The external loanee organization may also include other relevant information or data analysis that is not described below. EPA Region 4 can also provide example final data summary reports from previous loan projects. The final data summary report will be uploaded to the corresponding folder on the SharePoint project file within 120 days of completion of data collection and returning the sensors to EPA.

C2.1.1 Date and Location

Recommended for all project objectives

Define the location of each sensor during the project (recommend including a map) and list the start date and end date of sampling at each project location. It is recommended to include at least one photo of the location of each installed sensor.

C2.1.2 Data Completeness

Recommended for project objectives: supplemental network, source-oriented

For each sensor, summarize the % data completeness for the project. Data completeness is calculated using Equation A6-2, by comparing the number of valid 24-hr average values to the number of expected values (the number of days that the sensor was operating) for each sensor.

C2.1.3 PM2.5 Air Quality Data Analysis

Recommended for project objectives: supplemental network, source-oriented

Summarize the $PM_{2.5}$ concentrations observed by each sensor or location over the duration of the project. One recommended analysis to include is to calculate the number of days in each Air Quality Index (AQI) category[23] for each sensor based on the 24-hr average $PM_{2.5}$ data. This is an effective way to compare $PM_{2.5}$ concentrations between different sensors and locations during the project. The below table defines the $PM_{2.5}$ concentrations that correspond to each AQI category. EPA's AirNow AQI Calculator[24] can be used to calculate the AQI for a given PM2.5 concentration. The AQI is calculated according to the procedures in 40 CFR Part 58, Appendix G[25]. Air sensor data is not necessarily accurate enough to calculate an AQI for health purposes, but this analysis should assist in comparing concentrations between sensors. For real-time information about air quality and health, please visit EPA's AirNow website[26].

The final data summary report may also include other types of air quality data analyses specific to the project. These may include but are not limited to timeseries analyses and combining air quality and wind speed and wind direction data.

Table C2-1: PM2.5 Air Quality Index (AQI) Categories

AQI Category	Index Values	PM2.5 Concentration Ranges ($\mu g/m^3$, 24-hour average)	Description of Air Quality
Good	0 - 50	0.0 – 9.0	Air quality is satisfactory, and air pollution poses little or no risk.
Moderate	51 - 100	9.1 – 35.4	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 – 150	35.5 – 55.4	Members of sensitive groups may experience health effects. The general public is less likely to be affected.

[23] US EPA AirNow Website. Air Quality Index (AQI) Basics. https://www.airnow.gov/aqi/aqi-basics/.
[24] US EPA AirNow Website. AQI Calculator. https://www.airnow.gov/aqi/aqi-calculator/.
[25] 40 CFR Part 58 Appendix G. Uniform Air Quality Index (AQI) and Daily Reporting. https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-58/appendix-Appendix%20G%20to%20Part%2058
[26] US EPA AirNow Website. https://www.airnow.gov/.

AQI Category	Index Values	PM2.5 Concentration Ranges ($\mu g/m^3$, 24-hour average)	Description of Air Quality
Unhealthy	151 – 200	55.5 – 125.4	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 – 300	125.5 – 225.4	Health alert: The risk of health effects is increased for everyone.
Hazardous	301+	225.5+	Health warning of emergency conditions: everyone is more likely to be affected.

C2.1.4 Weather Data Analysis

Recommended for project objectives: source-oriented

For projects with a source-oriented objective, it is recommended to include data analysis pairing hourly $PM_{2.5}$ sensor data with hourly wind speed and wind direction data. Hourly wind data can be obtained from existing weather stations as described in Section B2.3. One potential analysis to include is the distribution (boxplot or range) of concentrations observed for each sensor, grouped by wind direction: when the wind is blowing from the direction of a nearby source (defined as a range or arc of direction degrees), when the wind is blowing from other directions, and during calm winds (i.e. wind speeds below 2 meters/second when wind direction is more difficult to measure). Inclusion of a wind rose plot for the duration of the project period is also encouraged. Wind rose plots can be generated using the Iowa State University Iowa Environmental Mesonet website[21].

C2.1.5 Results of Data Quality Assessment

Recommended for project objectives: supplemental network, source-oriented

For each sensor, calculate the statistics listed in Table A6-3: Measurement Quality Objectives, and state whether the acceptance criteria were met. This analysis provides a data quality assessment that indicates whether the project Measurement Quality Objectives were met. In the data summary report, it is recommended to present this information in the recommended format in Appendix H of the EPA Performance Testing Protocols, Metrics, and Target Values for Fine Particulate Matter Air Sensors report, which is included in Appendix 4 of this QAPP.

C2.1.6 Educational Outcomes

Recommended for project objectives: educational

For educational projects, include a summary of the educational outcomes. For example, provide a summary of the number of students that participated, the number classes or seminars provided, and a description of the educational programs supported and how the air sensors advanced learning.

C2.1.7 Outcomes and Conclusions

Recommended for all project objectives

Summarize the outcomes of the project and any conclusions drawn from the data collected. Did the data meet the project objectives and help answer the project questions?

C2.1.8 Challenges and Feedback for EPA

Recommended for all project objectives

Summarize any challenges experienced during the air sensor loan project. This can include logistical challenges, communication challenges, or any other challenges. Please provide any feedback to EPA about the project and the air sensor loan program that can be used to improve the program in the future.

D. Environmental Information Review and Usability Determination

D1. Environmental Information Review

For each air sensor loan project, the external loanee organization will be responsible for reviewing and validating the PM2.5 sensor data collected.

A summary of the QA/QC activities conducted during the project is shown in Table D1-1. The outputs of these activities will be used by the external loanee organization to validate the data collected.

Table D1-1: QA/QC Activities Used in Data Validation

QA or QC Activity	Frequency	Details
Siting and Installation Review of Purple Air Sensors	Conducted during first day of data collection.	Performed by the external loanee organization. This review will document whether each site meets the requirements of Section A5.1. A map and photos of the site locations will be included in the final data summary report.
Purple Air Functionality (QC check)	Bi-weekly	Performed by external loanee organization. Verify sensor is collecting data, and compare A and B channel precision as described in project MQO Table A6-3.
Comparison of Purple Air collocated data (sensor to sensor collocation comparison, and sensor to reference monitor comparison if available)	Conclusion of collocation period, or quarterly if ongoing collocation.	Performed by external loanee organization. Include results in final data summary report. Calculate MQO statistics as described in Table A6-3 and Section C2.1.5.
Review of documentation	Beginning and end of project	EPA R4 will review the SharePoint project file documentation of new sensor loan projects. EPA will review the file and the final data summary report at the conclusion of the project.

Data will be downloaded using the Purple Air data download tool at least every two weeks. Data download packages will be verified by the external loanee organization for transcription errors, calculation errors, and data completeness.

Data validation will be conducted by the external loanee organization. Any data that does not meet the MQOs defined in Table A6-3 will be invalidated and not used in final analysis. A uniform completeness goal of 75% will be used for 1-hour and 24-hour averages. This means that $PM_{2.5}$ averages will only be considered valid if 75% of the expected data are present (at least 30 of 40 90-second raw sensor readings, and at least 18 of 24 1-hr average readings). Data that do not meet these completeness criteria should be excluded from final analysis. Data will also be screened for problems with the sensors. If the sensor is found to be reporting zeros or repeating values, then those data will be invalidated and corrective action will be taken (e.g., cleaning sensor, or shipping back to EPA for replacement).

A siting review will be performed at the initiation of a sampling or analysis activity to ensure proper data collection and adherence to the procedures described in this QAPP, and to document proper installation of the sensors as described in Section A5.1. The siting review will be documented by the external loanee organization. It is recommended to upload site photos of each sensor location to the SharePoint project file. One photo of each sensor location will also be included in the final data summary report.

A review of the project file will also be conducted at the start of the field deployment, to ensure that the file is properly organized as specified in Section B7 and that all required documentation is present.

D2. Useability Determination

The external loanee organization will review the collected data to verify that QC checks have been documented as described in the project QAPP, and that acceptance criteria have been met, and that data has been downloaded from the PurpleAir website.

At the conclusion of each project with a supplemental network or source-oriented objective, the external loanee will conduct a data quality assessment. A data quality assessment is not required for an educational project, but may be conducted at the external loanee organization's discretion.

To conduct the data quality assessment, for each sensor, calculate the statistics listed in Table A6-3: Measurement Quality Objectives, and state whether the acceptance criteria were met. This analysis provides a data quality assessment that indicates whether the project Measurement Quality Objectives were met. It is recommended to present this information in the recommended format in Appendix H of the EPA Performance Testing Protocols, Metrics, and Target Values for Fine Particulate Matter Air Sensors report, which is included in Appendix 4 of this QAPP.

The data quality assessment calculations to assess whether the project MQOs can be performed using the EPA Excel-based Air Sensor Collocation Macro Analysis Tool[9], using the sensortoolkit package[10] for the Python programming language, or using other data analysis software. The results of the data quality assessment should be included in the final data summary report, as described in Section C2.1.5.

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Appendices

1. Location-Specific Deployment Worksheet
2. Region 4 Revocable Air Sensor License Agreement
3. PurpleAir Quick Start Guide
4. EPA Performance Testing Protocols, Metrics, and Target Values for Fine Particulate Matter Air Sensors: Use in Ambient, Outdoor, Fixed Site, Non-Regulatory Supplemental and Informational Monitoring Applications