PUGET SOUND
Clean Air Agency

QUALITY ASSURANCE PROJECT PLAN

Community Scale Air Toxics Ambient Monitoring Grant
XA01J87901-0

EPA Community Scale Air Toxics Ambient Monitoring Grant Project – Assessment of Seattle and Tacoma

Prepared by and for

Puget Sound Clean Air Agency
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1 Project Plan Identification and Approval

The EPA COMMUNITY SCALE AIR TOXICS AMBIENT MONITORING PROJECT – ASSESSMENT OF SEATTLE AND TACOMA quality assurance project plan is approved.

Approved by

1) Signature: Matthew Harper Date: 5/27/2021 .
Matt Harper – Project Manager, Puget Sound Clean Air Agency

2) Signature: Date: 6-1-2021 .
Erik Saganić – Technical Analysis Manager, Puget Sound Clean Air Agency

3) Signature: Date: 6/3/2021 .
Beth Friedman – Quality Assurance Coordinator, Department of Ecology, Washington

4) Signature: Date: 6/3/2021 .
EPA QA Manager or Designee, USEPA Region 10

DISCLAIMER

This Quality Assurance Project Plan has been prepared specifically to address the environmental data operations on behalf of EPA through grant agreement XA01J87901-0. The contents have been prepared in accordance with EPA QA/R-5, "EPA Requirements for Quality Assurance Project Plans". EPA/240/B-01/003 March 2001.

2 Acronyms and Abbreviations

AQS	Air Quality System
ANSI	American National Standards Institute
APTI	Air Pollution Training Institute
ASTM	American Society for Testing and Materials
CID	Chinatown International District, Seattle, Washington
CFR	Code of Federal Regulations
COC	Chain of custody
DAS	Data Acquisition System
DNPH	2,4 Di-Nitro-Phenyl Hydrazine (Brady's Reagent)
DQA	Data Quality Assessment
DQOs	Data Quality Objectives
EDO	Environmental Data Operation
EMAD	Emissions, Monitoring, and Analysis Division
EPA	Environmental Protection Agency
EtO	Ethylene Oxide
GIS	Geographical Information Systems
HAP	Hazardous Air Pollutants
IO	Inorganic
LAN	Local Area Network
LIMS	Laboratory Information Management System
MQOs	Measurement Quality Objectives
NAAQS	National Ambient Air Quality Standards
NATTS	National Air Toxics Trends Network
NCORE	NCore Multipollutant Monitoring Network
NIST	National Institute of Standards and Technology
NRNO2TAD	Near Road NO2 Technical Assistance Document
OAQPS	Office of Air Quality Planning and Standards
ORD	Office of Research and Development
PM2.5	Particle Matter – 2.5 microns or less
PQAO	Primary Quality Assurance Organization
PSCAA	Puget Sound Clean Air Agency
PUF	Poly-Urethane Foam
QA	Quality Assurance
QAC	Quality Assurance Coordinator
QAPP	Quality Assurance Project Plan
QMP	Quality Management Plan
SLAMS	State and Local Monitoring Stations
SOP	Standard Operating Procedure
SPMS	Special Purpose Monitoring Stations
STN	Speciation Trends Network
SVOC	Semi-Volatile Organic Compounds
TO	Toxic Organic
TSA	Technical System Audit
USEPA	United States Environmental Protection Agency
UATS	Urban Air Toxics Strategy
VOC	Volatile Organic Compound

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4 Distribution

This Quality Assurance Project Plan has been distributed to the individuals listed in Table 1. The document is also available upon request from the Project Manager. Any work under this project shall be initiated after the approval of the EPA Project Officer in concert with the EPA Quality Assurance Manager.

Table 1 QAPP Distribution Plan

NAME	ROLE	CONTACT
Matt Harper	Project Manager, PSCAA	matth@pscleanair.gov
Erik Saganić	Technical Analysis Manager, PSCAA	eriks@pscleanair.gov
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Audit File	Audit File for USEPA Grant (see Matt Harper for access)	https://pscleanair.sharepoint.com/:f:/s/TechAnalysisTeam/ EsyMJU7f70JClPSItc3Qt2oBZGDR0SYUE8iXv0DP7xldOw?e=Ucv9w
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Julie Swift	Senior Program Manager, ERG	Julie.swift@erg.com

5 Project Task Organization

The following paragraphs will demonstrate the plan for project roles and participant responsibilities.

PROJECT MANAGER – Responsible for all aspects of completing project tasks including accurate operational financial activities reporting, choosing fixed monitoring sites, and contracting for their use, contracting with the analysis laboratory, providing oversight for installation and operation of monitoring equipment, completing the fixed site air toxics sampling, mobile monitoring, and providing support for community directed sampling.

FOCUS COMMUNITY TEAM LEADER – Responsible for managing the PSCAA outreach/engagement team for focus communities which choose to participate in grant activities and focus communities. The engagement team responsibilities include partnering with community leaders, conducting community air quality and air toxics education sessions, soliciting, advising, and collaborating with the community leaders to provide input on monitoring site selections, make decisions about community directed sampling, following through with post sampling data evaluations, risk assessments, and collaborating with the community leaders to design mitigation strategies and action steps with the overall goal of authentic engagement with the community to help reduce community burdens to toxic air pollutants.

Community leaders – Responsible for communicating and collaborating with community members, and PSCAA community focus team members. The leaders are responsible for helping to provide information flow so that as members of the community outreach team identify opportunities for engagement, leaders can effectively share information with community members within their neighbor networks. Finally, the community leaders are responsible for collaborating with project partners to guide mitigation strategies, processes, and action steps.

USEPA REGION 10 PROJECT OFFICER – Responsible for ensuring that project budgets and expenses are reported on time, and that the project achieves the desired outcomes.

FOCUS COMMUNITY TEAM MEMBERS – The teams are cross-functional teams who are charged with being PSCAA contact touch points for the community. The team is responsible for communicating and responding to the community. The team is responsible for engaging community members about air quality concerns, providing education and air quality risk information, and providing an interface for community leaders and community members to engage in air quality improvement actions. The team does have reach-back capability so that if there are appropriate engagements that can happen with air quality experts (for example Engineering, Monitoring, Analysis, or Inspections), the team can pair community members with experts from the PSCAA staff.

PSCAA TECHNICAL ANALYSIS AND MONITORING TEAM – The analysis team is responsible for the data analysis and air toxics risk assessment that will be generated after the data has been collected. This analysis information and risk assessment will be available in the final report, and the community will have an opportunity to receive and process this information as the Community Team and PSCAA Engagement team work on outcomes from the grant associated with air quality education, risk mitigation strategies, and air quality action steps. The monitoring team is an experienced, specialized, professional team that is charged with installation, operation, quality assurance, and initial analysis of air monitoring data that is collected during this project.

QUALITY ASSURANCE OVERSIGHT – WA Department of Ecology is normally the PQAO for NAAQS air monitoring activities at the Puget Sound Clean Air Agency. Ecology has written a Quality Assurance Project Plan for its NATTS sampling at the Beacon Hill NCORE site in Seattle, Washington. PSCAA shall follow the Ecology QAPP while conducting NATTS-style sampling, adapting for the change in sampler (XONTEC to A-TEC models). Ecology will be providing a review/approval step of this project QAPP and will provide audit services of the main air toxics samplers (VOC, carbonyl samplers). However, there are monitors that are being used for this study which Ecology will not be auditing. Ecology may not have all the equipment or sufficient knowledge of every device to properly perform a performance evaluation. For this project, because it is unique and not part of the Washington State approved network, PSCAA will perform quality assurance oversight for all NON-NATTS-sampling. This document describes in detail, all the quality assurance activities and requirements that are necessary to achieve project results.

CONTRACT LABORATORY – The contract laboratory will be assigned roles of a Program manager, Program QA Officer, and various other technical advisors. The Program manager and QA Officer work together to implement the laboratory QA system according to the laboratory analysis QAPP. The QA Officer is responsible for ensuring the overall integrity and quality of the laboratory contracted results. He or she reviews the ERG and PSCAA QAPPs and determines whether procedures are executed in accordance with the QAPPs. The lines of communication between the Program manager and Program QA Officer are formally established and allow for discussion of real and potential problems, preventative actions, and corrections. At any time during the program, additional QA/QC measures may be initiated upon consultation between the Program manager and QA Officer.

Figure 1 Overall System Structure

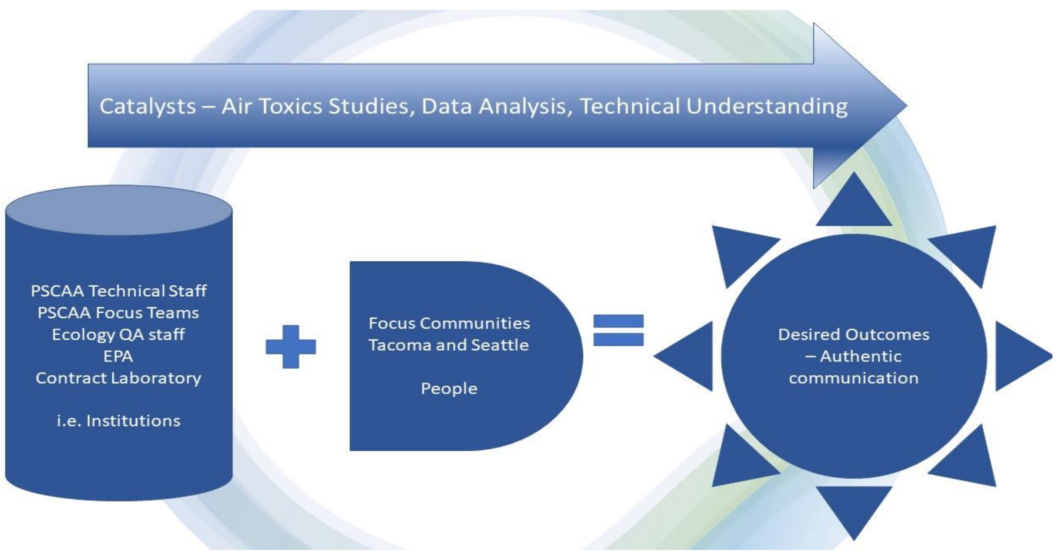


Figure 1 describes the chemical equation that will be required to make this grant work. The main ingredients will be the institutions, and the Focus Community teams working to provide the desired outcomes. The outputs (technical report) of this study will provide the catalyst for the reaction to occur. The Project teams consist of professionals working together, to bridge the gap between the science of air toxics and the communities. The PSCAA technical monitoring staff provides the sampling, air quality data, and air quality education products to allow the Focus Community Teams to connect in a meaningful way based on credible scientific work. This quality assurance project plan will put in place the elements necessary to ensure that the scientific work performed is credible, with known quality.

6 Problem Definition and Background

Problem: Understanding and Reducing Air Toxics Risk

We intend to analyze air toxics risk trends for the Puget Sound region, so that we may develop and execute strategies to reduce air toxics risk. With many different emission source changes over the years, an explosion of population growth in our region, and emerging concerns like ethylene oxide and an increase in wildfire smoke emissions, it is challenging to focus our emissions reduction efforts without more detailed air toxics data.

The agency has been working on strategies to reduce diesel exhaust sources for many years. We aim to measure current air toxics risk levels, to understand the airshed better. Sources such as diesel exhaust, wood smoke, ethylene oxide, and industrial metals have been reduced, but we have not measured air toxics risk for many years. We will produce new cancer risk estimates and compare these to past values and to the National Air Toxics Assessment. Using factor analysis on both historical data and “freshly” sampled data, we will look at changes to emissions, trends, and associated risks adjusting for weather where possible. We will use the results of this analysis to deepen our understanding of emission inventories for our region, either helping to explain the results or potentially identifying gaps where emission inventories may have mischaracterized sources.

We will engage with communities to help establish where and what air toxics we will analyze in a community-directed sampling campaign. We also propose to do an environmental justice analysis of air toxics risks over time by geography to see how gaps in equity have changed in these communities.

Background

As emission sources have changed over time, the Puget Sound region is left with many unknowns on how to characterize air toxics risk. Three factors make this a critical region to study: 1) an updated unit risk factor for ethylene oxide, 2) population growth and 3) recent changes in fleets of ships, trucks, cars, trains, industrial activities, and wood stove home heating. These factors have left open questions on how to best focus our emission reductions.

Past air toxics studies in Seattle and Tacoma showed that we are a unique area in the country. In Tacoma, we conducted a study in 2010 in which we saw higher levels of benzene in the residential area on an annual average just due to the wintertime wood smoke levels, than the large port/industrial areas of Tacoma and Seattle. Since 2006, we adopted aggressive measures to reduce wood smoke emissions, including banning and offering incentives to recycle older uncertified wood stoves and enhanced burn ban enforcement in Tacoma after its non-attainment status in 2006. With improvement in emissions reductions in shipping with the Emission Control Area and newer truck and other diesel engines, we expect air toxics risk reductions in the port/industrial areas as well. This study will help us determine how to best focus emission reductions efforts in the future.

Our prior studies have shown that the last two EPA National Air Toxics Assessment (NATA) models have performed poorly in our region, due to complex topography and meteorology. Air monitoring remains the best method to estimate local air toxics risks and extrapolate them to a wider region. Recently, the Seattle National Air Toxics Trends Stations (NATTS) site has shown lower ethylene oxide levels compared to other studied sites. Doing further ethylene oxide analysis in our region will help guide our understanding of the ambient levels of ethylene oxide.

Our 2010 study had shown that both the Seattle Duwamish Valley and Tacoma Tideflats industrial areas (Figure 2) have high levels of metals from atmospheric deposition compared to other areas in the region. A metals-in-moss sampling study led by the US Forest Service in the Seattle industrial area will be released soon, which may bring questions about what potential health risk exists if pollutant gradients are found. A similar study was completed in Portland, OR a few years ago that eventually led to the identification of an art glass maker releasing large amounts of arsenic and cadmium. PM_{10} metals sampling would be helpful to provide more definitive ambient concentrations and corresponding potential health risk.

In our last air toxics study in the Seattle Chinatown-International District, we found two types of diesel emissions from highway traffic, a "fresh" near-road diesel factor and evidence of a "background" diesel factor. To distinguish these two types of diesel emissions, we used novel approaches with positive matrix factorization (PMF) modeling using available air toxics data. Learning how the emissions are different at the near-road site in Tacoma (at the S 36th Street site) would be valuable and help us quantify the relative importance of background diesel emissions and the different vehicle fleets.

We are actively engaging with communities that face environmental and societal barriers to clean air. In our engagement with these communities, termed "focus communities", we have used monitoring tools such as our air sensor lending library, community science training, community-directed air toxics, and other emissions sampling. In this study, we will build on our experience, and continue to use community-directed sampling with our community partners.

7 Project Description and Tasks

Puget Sound Clean Air Agency will perform a study to assess air toxics trends and risk in Seattle and Tacoma (Figure 2). The study will focus on changes in air toxics concentrations from diesel exhaust sources, wood smoke, ethylene oxide, and industrial source metal emissions from a previous study conducted 10 years ago. PSCAA will monitor air toxics and produce new estimates of potential cancer risk, then compare these to past values and to the National Air Toxics Assessment. Additionally, PSCAA will perform an analysis of air toxics risks using monitoring that has been directed by the environmental justice communities to assess if there are additional equity gaps.

This study will help characterize the impact of air toxics in environmentally burdened communities in Seattle and Tacoma. We will focus on key air toxics with the highest potential health risks in our region (benzene, 1,3-butadiene, carbon tetrachloride, acrolein, formaldehyde, and acetaldehyde), as well as measuring surrogates for diesel and wood smoke particulate matter (black carbon and UV channels, and PAHs). We will also monitor for ethylene oxide, which has an updated unit risk factor. We will assess whether this would or should shift our risk reduction strategies. We will look in depth at industrial atmospheric deposition by monitoring for PM_{10} metals, and better understand the sources of emissions using factor analysis by sampling PAHs.

The measurement goal of this project is to estimate the concentration, in units of micrograms per cubic meter (µg/m^3) and parts per billion/volume (ppbv) of air toxic compounds of particulates and gases, respectively. This is accomplished by using four individual sampling methods:

- Canister sampler for volatile organic compounds (VOCs)
- Carbonyl sampler with 2, 4-Dinitro-phenyl hydrazine (DNPH) coated cartridges for carbonyl compounds
- Poly-Urethane Foam (PUF) high volume air sampler for polycyclic aromatic hydrocarbons (PAHs)
- High purity filters housed in NFRM Sampler for PM10 metals.

Figure 2 Study sites, focus community locations, $PM_{2.5}$ maintenance area, and Agency EJ tool (Community Air Tool) scores

8 Sample Process (Network) Design

Sampling Locations

We will measure at five sites for one year (Table 2), and leverage select data from some sites. We will leverage data from the NCore program and NATTS program (Seattle Beacon Hill site - full suite of VOC's, aldehydes, PM_{10} metals, gaseous parameters NO, NO_2, NO_Y and CO), the $PM_{2.5}$ monitoring program (Seattle Beacon Hill, Tacoma South L St, Tacoma Tideflats, Tacoma S 36th St, Seattle 10th and Weller, and Seattle Duwamish – $PM_{2.5}$), the Near Road monitoring program (Seattle 10^{th} and Weller and Tacoma S 36^{th} St - NO, NO_2, NOx), the Chemical Speciation Supplemental network (Tacoma South L Street, Seattle 10th & Weller), and existing meteorology data (temperature and winds at each site) (Table 3). We will engage with our focus communities and have community-led sampling.

The sites included in the study are in near road, industrial, and residential wood smoke affected areas. The latest air toxics sampling in most of these communities took place in 2008-2009 when the Puget Sound Clean Air Agency (PSCAA) conducted an Air Toxics monitoring campaign (EPA Grant XA96069801). PSCAA also gathered air toxics data during 2016-2017 in the Chinatown-International District (EPA Grant XA01J10401).

a. Two near-road sites

To compare the near-road sites, we will have sampling for select VOCs and aldehydes. This will help us in comparing the two near-road sites that have differing wind and traffic patterns. Both sites are located within 50 meters of Interstate 5, in Seattle on the corner of 10^{th} Ave and Weller St, and Tacoma S. 36^{th} Street, adjacent to Jennie Reed Elementary School. We will leverage current $PM_{2.5}$ speciation data from 10^{th} & Weller site to estimate diesel concentration.

b. Two industrial-port sites

The Puget Sound region has two port and industrial valleys, one in Tacoma and Seattle. We propose monitoring for metals, in addition to the other air toxics, as the community has raised concerns over metal deposition. We also propose adding PAHs to help better characterize the aerosols with factor analysis. We will leverage chemical speciation network (CSN) speciation data currently being collected at these sites. We have air monitoring records for the Seattle Duwamish and Tacoma Tideflats going back to the early 1970's.

c. One former nonattainment residential wood smoke impacted site

The Tacoma South L Street site historically had $PM_{2.5}$ concentrations that violated EPA's 2006 Federal Daily Standard. Since then, we have made strides to reduce wood smoke in the area, by banning uncertified stoves, implementing stove changeout programs, and enhancing enforcement. The site is representative of a "maximum concentration urban wood smoke" site in our 4-county jurisdiction.

d. Leveraged NATTS site

A sixth site, the NATTS site at Seattle-Beacon Hill, is in a residential neighborhood a few miles from the Seattle Duwamish and 10th and Weller sites, and will continue to operate without making use of funding from this grant. The Beacon Hill site is the Urban Scale monitoring site in the region, and the Washington State Department of Ecology hosts NCore and NATTS monitors here. This site has a full suite of air toxics monitors including canister (VOC) EPA Method TO-15, tube TO-11A (aldehydes), PM 10 Hi-Vol IO-3 (metals), and PUF (PAH) TO-13A samplers. Leveraged monitoring will meet NATTS quality assurance requirements for speciation samplers (including the URG3000N carbon sampler) and FEM approved NO2, CO, SO2, and PM 2.5 monitors. We will use Beacon Hill data in our analysis and conclusions as appropriate. Additionally, as shown in Table 3, we will leverage data that is already being collected through other air monitoring programs.

Table 2 Sampling sites, duration, and frequency

Sites	Measured parameters (only from this grant)	Monitoring Frequency
Tacoma S. L Street (residential)	Select VOCs (Note A) Select aldehydes (Note B) *BC*	1 in 6 1 in 6 Continuous
Tacoma Tideflats (industrial)	Select VOCs (Note A) Select aldehydes (Note B) PM-10 Metals *BC*	1 in 6 1 in 6 1 in 6 Continuous
Tacoma S. 36th street (near-road)	Select VOCs (Note A) Select aldehydes (Note B) *BC*	1 in 6 1 in 6 Continuous
Seattle 10th and Weller (near-road)	Select VOCs (Note A) Select aldehydes (Note B) *BC*	1 in 6 1 in 6 Continuous
Seattle Duwamish (industrial)	Select VOCs (Note A) Select aldehydes (Note B) PM-10 Metals PAH *BC*	1 in 6 1 in 6 1 in 6 1 in 6 Continuous
Community-directed sites	Air toxics to be determined by the community (PAH, Select VOC's, Select aldehydes, PM-10 metals) *$PM_{2.5}$ sensors*	Up to 20 samples Ad hoc

Note A: Benzene; 1,3 butadiene; carbon tetrachloride; tetrachloroethylene; ethylbenzene; acrolein; ethylene oxide
Note B: Formaldehyde and acetaldehyde

Table 3 Sampling sites and Leveraged monitoring parameters for Analysis

Sites	Leveraged parameters (not funded by this grant)	Program or QAPP
Tacoma S. L Street (residential)	*PM2.5* *PM2.5 Speciation* *Temperature, Winds*	PM2.5 grant CSN-Supplemental Met SOP
Tacoma Tideflats (industrial)	*PM2.5* *PM2.5 Speciation* *Temperature, Winds*	PM2.5 grant CSN-Supplemental Met SOP
Tacoma S. 36th street (near-road)	*NO2, NO, NOX* *PM2.5* *Temperature, Winds* *Traffic Counts*	Near Road WA State funding Met SOP WA DOT
Seattle 10th and Weller (near-road)	*NO2, NO, NOX, CO* *PM2.5* *PM2.5 Speciation* *Temperature, Winds* *Traffic Counts*	Near Road PM2.5 grant CSN-Supplemental Met SOP WA DOT
Seattle Duwamish (industrial)	*PM2.5* *PM2.5 Speciation* *Temperature, Winds*	PM2.5 grant CSN-Supplemental Met SOP
Seattle Beacon Hill	*Full suite of VOC* *PAH* *Aldehydes* *PM-10 metals* *NO2, NOx, NO, SO2, CO* *PM2.5* *PM2.5 Speciation* *Temperature, Winds*	PAMS and NATTS NATTS PAMS and NATTS NATTS NCORE PM2.5 grant STN and IMPROVE Met SOP

e. *Community-directed sampling*

In addition to the fixed sites, we will include at least six days of community-directed air toxics sampling at three locations in the Duwamish Valley and collect at least 20 samples from these locations. These locations will be decided after consultations with the community based on locations of interest. This community does not have recent air toxics data and community groups in the Duwamish Valley have expressed interest in participating in air toxics sampling. The community-directed sampling will allow the community to identify locations of interest, actively participate in collecting samples, and learn about air toxics concentrations at those locations. We will sample on the same days that fixed sites are operating to provide greater spatial gradient information. In this portion of the monitoring campaign, we will leverage continuing partnerships with the *Duwamish Community Action Program for Clean Air*, a collaborative of air quality stakeholders, that already has community networks and avenues for input to direct this portion of the sampling. Some of the initial interest has been in metal deposition (possibly PM_{10} metals and hexavalent chromium). The community-directed locations will also include the use of low-cost sensors like Dylos, AirBeam, Purple Air, etc. These low-cost sensors will only be used as a tool for creating awareness among the community members and will not be used to calculate health risks.

In addition to the Duwamish Valley targeted sampling, we will conduct outreach and educational $PM_{2.5}$ sensor sampling at sites of community interest in the Seattle and Tacoma focus communities using low-cost sampling methods to complement fixed site data collection.

Sampling Tasks

Select VOCs (Note A) - We will use an established Standard Operating Procedure as described in Appendix A - the School Air Toxics Program SOP for sampling VOC's using a passive regulator and timer for a 6L SUMMA canister. The equipment that we use will match the equipment used from the School Air Toxics Program.

Select aldehydes (Note B) - The Washington Department of Ecology previously used a carbonyl sampler called a XONTEC, and those samplers are no longer functional/available. Therefore, we will acquire the available ATEC samplers that are essentially updated XONTEC samplers. Although we will use the new ATEC samplers, we will sample using an established SOP (Appendix B) and will use the same laboratory analytical methods so that our data can be comparable to historically collected data.

PM-10 metals – We plan to sample for PM-10 metals at two fixed industrial sites by using the Rupprecht & Patashnick Model 2025 samplers that are already used in our state's Federal Reference Monitoring program. Our operators routinely operate these monitors using the Washington State Department of Ecology SOP, and we will be following the designation stated in Appendix I. These samplers are configured for collecting PM-10 filters on a 1 in 6 sampling frequency for the year of the sampling campaign. Since these samplers are limited in our inventory, and only usable at fixed sites, if we decide to use PM-10 metals sampling at community determined sites, we plan to use the N-FRM monitor provided by ARA per the procedure in Appendix L. The N-FRM monitors can be configured for short term, battery operated monitoring, and will be useful in collecting data in specific locations determined by the community.

PAH – We plan to use a standard High Volume PUF sampler to collect samples for PAH analysis at the Duwamish industrial site. The monitoring SOP that we will use is identical to what is used in the national NATTS program, and is listed in Appendix C.

BC – We plan to use the Aethalometer AE-33 model sampler to collect the 7 channel Black Carbon continuous data for use in the analysis at each of the study sites, to give us parameters that can be used (along with other data) to estimate Diesel Particulate Matter through PMF modeling.

9 Sampling Design and Objectives

Our proposed work will respond to EPA's goal "A Cleaner, Healthier Environment" by accurately measuring air toxics within disproportionally impacted communities that suffer from poor air quality in addition to substantial socio-economics challenges. With this additional dataset, we will assess risks and make sure "high air quality standards" are met.

Anticipated environmental **outputs** from the proposed work:

- Producing high quality HAP data, which will be made publicly available via EPA's AQS database
- Identification and inventory of community-specific air toxic concentrations and cancer risk
- Evaluating the NATA model and NATTS data in our region
- Evaluating progress at reducing risk and exposure, and potentially setting benchmarks for further reductions
- Disseminate results via public meetings, blog posts, social media, presentations in schools and libraries to raise awareness and present key findings to focus communities
- A final report, which will include a summary with key findings for focus communities and policy makers as well as accurate data analysis and modeling to fulfill research objectives

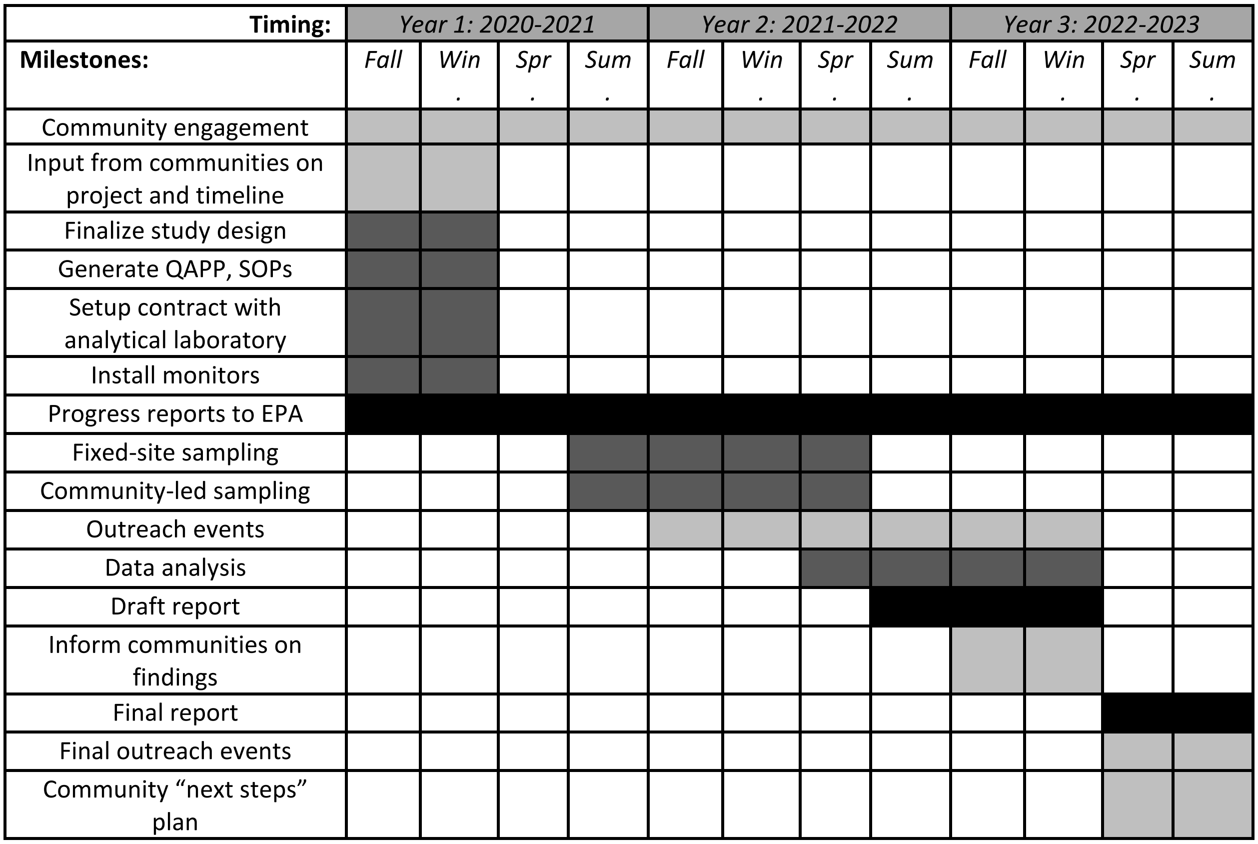
Anticipated environmental **outcomes** from the proposed work:

1. *Short-term:*
- Increase community awareness on air quality issues
- Identify air toxics sources
- Improve assessment of air toxics exposure and risk
2. *Mid-term:*
- Help identify source types to prioritize
- Empower respective communities with the report results
3. *Long-term:*
- Increase data inventory for the Puget Sound region available for researchers, policy makers, and public
- Future priorities for source emission reductions are more accurately identified

Performance measurements:

- All monitoring activities will comply with SOPs and the QAPP
- Project manager will hold routine meetings with the project team to review the work and the project timeline
- Project manager will check budget balances with managers monthly and adjust as needed
- Communication with EPA's program manager will be maintained through quarterly progress reports and check-ins as needed

Figure 3 Project Timeline



10 Quality Objectives and Criteria for Measurement Data

The purpose of the quality objectives and criteria for measurement data is to define what quality systems and requirements already exist for air monitoring data sets proposed for collection in this study, and to define what parameters need to have quality systems defined in this document.

The Plan is written using guidance from EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations (EPA QA/R5) and Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program (QA Handbook).

This plan also references two key Quality Assurance Project Plans that are already implemented in the State of Washington under the Department of Ecology's Air Quality Program quality system:

- "Ecology Air Program QAP": Air Monitoring Quality Assurance Plan document 99-201 (Rev. 01/2021)
- "Ecology Toxics QAPP": Air Toxics Monitoring Quality Assurance Project Plan document 04-02-018 (Rev. 04/2020)

Further, this plan references Quality Assurance Project Plans that already are implemented by EPA in the United States under the EPA's National Monitoring Programs. Under Contract Number EP-D-14-030 from 2016, the Category 1 Quality Assurance Project Plan for UATMP, NATTS, CSATAM, PAMS, and NMOC support is used by the contract laboratory.

- "ERG Toxics QAPP": Support for the EPA National Monitoring Programs (UATMP, NATTS, CSATAM, PAMS, and NMOC Support) Contract Number EP-D-14-030 Quality Assurance Project Plan for Eastern Research Group, Inc. 601 Keystone Park Drive, Suite 700, Morrisville, NC 27560.

Furthermore, any data collected with a mobile monitor or other low-cost air sensors during the community monitoring phase will likely not have the same quality level as data collected with a Federal Equivalent monitor at a stationary monitoring site. This is because for smaller lighter sensors, there is not a built-in designed quality assurance calibration system that is utilized on a daily or weekly basis. We will approach data results with caution from sensors that don't have as comprehensive a quality system. Also, NFRM samplers being used in this study for community directed PM_{10} metals sampling will be collocated at Seattle Duwamish site with FRM and FEM samplers. The collocated sampling times will be identified, and analyzed, so that the mobile data quality can be better measured. We'll also make recommendations to community for community-directed sampling to address quality assurance in a systematic way (for example, collocation, bias testing, etc.) so that we can learn as much from the data collected from these instruments.

Data Quality Objective (DQO)

The study is based on comparison to other well established monitoring sites in the state of Washington where air toxic pollutants are also collected. Therefore, our data quality objectives are based in the same science as the already established monitoring sites and methods. As established by Department of Ecology for their Air Toxics Monitoring Quality Assurance Project Plan, the only Data Quality Objective (DQO) for the state air toxics monitoring program is:

- To be able to detect a 15% difference between two successive 3-year annual mean concentrations (rolling averages) within acceptable levels of decision error.

The formal process of establishing the DQOs is described in EPA's Guidance on Systematic Planning Using the DQO Process (EPA, 2006). It provides a general framework for ensuring that the data collected meet the needs of the intended decision makers and data users. Since this project's data set does not allow a calculation of a 3-year annual mean, we will use an alternative DQO for this project only:

- To be able to compare the air toxics concentrations observed in this study to past studies conducted in the region and to the other National Air Toxics Trends Station (NATTS) sites.

To achieve this DQO, we will follow the same Measurement Quality Objectives (MQOs) and Data Quality Indicators (DQIs) set for NATTS sites to remain consistent and comparable with the NATTS network.

Measurement Quality Objectives (MQOs) and Data Quality Indicators (DQIs)

In order to ensure comparable data among monitoring sites, consistency is a necessary component for the NATTS Program. Inherently, such consistency needs to be reflected in a standardized set of Measurement Quality Objectives (MQOs), field and laboratory operations, specific acceptance criteria for individual monitoring methods, and stability for the selected site to collect data over the required period of time. PSCAA will implement the following MQOs to attain the DQO of the NATTS Program:

- Representativeness: Representativeness is a measure of degree to which collected data represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition (ANSI/ASQC, 1994). Components such as sampling design and siting are crucial in ensuring data collected are reliable and defensible to represent the area under study. In NATTS monitoring, sampling frequency must occur every 6 days per national sampling calendar over 24 ± 1 hours, beginning and ending at midnight in local standard time (i.e., Pacific Standard Time in Washington).
- Completeness: Completeness is defined as a measure in percentage of which data is collected and validated at a given site over a calendar year. A minimum number of valid data points is necessary to perform meaningful data analysis and compare data among monitoring sites. The MQO for completeness requires at least (≥) 85% of the annual samples be valid and reported. Make-up samples should be collected when sample results are invalid, and completeness are projected to not meeting the MQO for the calendar year. A make-up sample should be collected as close to the original sampling schedule as possible and preferably before the next sampling date. If not feasible, the make-up sample should be collected within 30 days of the original invalid sampling date, or the least preferably, but acceptable, within the same calendar year.
- Precision (CV %): Precision is a measure of reproducibility of a data population to ensure concentration results are within an acceptable uncertainty. The MQO for the network precision is calculated based on at least one year of data, and a coefficient of variance (CV) of ≤ 15% must be met. The pollutants where we have an opportunity to use this precision measurement are VOC's, carbonyls, and metals in the case of community sampling. Equipment limitations will prevent us from calculating precision for metals at fixed sampling sites, and PAH's because we are not able to run two successive samples on one sampler in these cases. Duplicates can be run for VOC's and carbonyls, and metals using the community sampling equipment.
- Bias: Bias or systematic error is a measure of the difference between a measurement ("indicated") and a true or accepted ("actual") value. Bias may be attributed to data collection or the data analysis process. Laboratory bias is assessed through the NATTS proficiency testing (PT) program, in which all the analytes selected for PT must be within ± 25% of the assigned target value (defined as the NATTS laboratory average). Field bias is largely assessed based on the flow rate of the samplers. Table 4 summarizes the acceptance limits of the indicated flow rates from a flow transfer standard or design flow rate for each pollutant class. Note that as the sampling method for VOCs involves collecting whole air into a canister using negative vacuum, a constant flow rate over the entire 24-hour sampling period is of greater importance than its accuracy.

Table 4 Acceptance limits of flow rates

Pollutant Class	Flow transfer standard	Design flow rate
Carbonyl	± 10%	± 10%
PAH	± 10%	± 10%
PM10 metal (low volume)	± 4%	± 5%

In the case of lower-cost sensors, no decisions will be based on the data, so no collocation is required. However, we do regularly compare lower-cost sensors for fine particulate matter to our network, and we often find biases that we can use for education and outreach purposes.

- Sensitivity: Sensitivity of the samplers is important to be aware of to prevent misinterpretation of the data collected. As the ambient air toxics concentrations decrease, sensitivity in the sampling method is expected to increase as well. The method detection limit (MDL) MQO has been established for each of the NATTS Tier I core analytes. Refer to the annual NATTS network workplan template, available on the virtual Ambient Monitoring Technology Information Center (AMTIC), for the latest MDL MQO values. The laboratory will provide us with laboratory blank data, and we will compare lab blanks and field blanks to minimum detection limits to gain understanding of the sensitivity of the analysis.

11 Special Training Requirements/Certification

Adequate education and training are critical to any monitoring program that strives for reliable and comparable data. EPA National Monitoring programs are performed using accepted EPA, NIOSH, and OSHA sampling and analytical protocols and requiring the efforts of field sampling personnel and analytical laboratory staff. Training is aimed at increasing the effectiveness of employees involved in the project. Personnel assigned to ambient air toxics monitoring activities and for laboratory analysis activities will meet the educational, work experience, responsibility, personal attributes, and training requirements for their positions.

The Puget Sound Clean Air Agency monitoring team has experience and training with all the sampling methods that will be employed by the study. There may be occasion for community leaders or members to participate in data collection, or mobile monitoring. In these instances, the community members will be closely supervised by monitoring team members, and data will be reviewed during the analysis phase, so that the conditions under which the data were collected will not negatively impact the overall analysis or conclusions of the study. Later in this QAPP we will discuss recordkeeping requirements for this project. These requirements are in place so that data with unacceptable error are excluded from use in study conclusions.

The Quality Assurance Coordinator of the Washington State Department of Ecology will conduct courtesy audits of the NATTS style monitoring equipment to be used in this study. For Non-NATTS style monitors, the PSCAA staff will conduct the audits. The monitoring team will ensure that data that is not bracketed by passing audits is not allowed to be used in study conclusions. This step will ensure that the data used in the study will be of known quality.

The contract laboratory utilized in this project has trained technicians and supervisors who complete analyses according to the Compendium methods for Toxic Organic and Inorganic compounds, and report data to the AQS system. The monitoring data will be submitted to EPA's AQS database within 120 days after the end of the quarterly reporting periods and EPA Project Officer shall be notified of the same within 15 days of the required submittal date. The data reported to the AQS system will be of known quality because data is accompanied by appropriate flags, minimum detection levels, and metadata. The data entered in AQS system will comply meeting the 85% minimum data recovery requirements for the network monitors. Analytical laboratory personnel involved in this project have been trained in their tasks and have many years of experience in the duties they will be performing. Training of ERG laboratory personnel is recorded in the ERG Training Records in an Access database. It is the responsibility of the trainee and the laboratory's System Administrator to keep the Training Records up to date. Special certification is not needed for the analysis of the ambient samples through the contract.

The contract laboratory maintains appropriate SOPs for each of the analytical methods. These SOPs are presented in Appendix C of "SUPPORT FOR THE EPA NATIONAL MONITORING PROGRAMS" under Contract Number EP-D-14-030as presented in the Category 1 QAPP, approved by EPA in 2016.

12 Documentation and Records

All records produced during and throughout this work are of public record and will be retained by the Puget Sound Clean Air Agency under standard retention record laws. The Puget Sound Clean Air Agency will utilize several different types of records and will make all records available to the public. There will be a Final Report that will be submitted by the Puget Sound Clean Air Agency to the EPA and the community. Puget Sound Clean Air Agency will post this report on its website and will take steps to ensure that this report is readily available in multiple formats, so that persons of every ability can review the report. Puget Sound Clean Air Agency routinely (daily) backs-up all files kept on server following the back-up measures set up by their IT team in a standard way. As per IT team's standard practice, three copies are kept for each file: 1) original; 2) on-site backup; and 3) off-site to Azure cloud. All the changed blocks are backed up daily.

The resulting report from this work will be a highly technical report that will outline data collected, observations, analysis, recommended actions, and conclusions. The report will have a very technical Appendix that summarizes all the data collected during the study. The following figure 4 will be used by project participants in planning for document and record storage. Additionally, to communicate more effectively with the community, the Agency may summarize the technical findings into easier to read Information Sheets.

Figure 4 Reports Plan

RECORD TYPE	FORMAT	DESCRIPTION
Grant quarterlies	Electronic or Paper	Available on demand by contacting Project Manager
Final Report	Electronic or Paper	Available on www.pscleanair.org or by contacting PM
Agreements	Electronic or Paper	Available on demand by contacting PM
Finances	Electronic or Paper	Available on demand by contacting PM
Data - Network	Electronic	Available via WA Department of Ecology
Data – Lab	Electronic	Available via AQS or by contacting PM
Data – Mobile	Electronic	Available on demand by contacting PM
SOP QC checks	Electronic or Paper	Available on demand by contacting PM
Logs	Electronic	Available on demand by contacting PM

All Records	Electronic or Paper	Available by contacting PSCAA Public Records

13 Standard Operating Procedures for Sampling

This project requires the use of many different Standard Operating Procedures for Sampling and Analysis. This section focuses on Sampling SOP's, because the contract laboratory will be using the library of SOP's for analysis of samples. Much of the sampling techniques used in this project will already have WA Department of Ecology approved SOP's to draw from.

For sampling preservation requirements, please see the individual SOPs listed in our Figure 5 below. An example is the preservation required of TO-11 carbonyl sampling. Since sampling of carbonyls is done using a DNPH coated cartridge, when handling the sample, the operator caps the cartridge with plugs, places it in the aluminum foil pack to protect it from sunlight, seals with TFE-fluorocarbon tape, and refrigerates at 4 deg C until analysis. The sample is shipped to the lab right away, but not to exceed a two week period. There is a procedure for longer term storage of the sample, but we will not need to use that technique.

Some of the micro-sensing sampling techniques do not yet have SOP's, and these will be developed from existing guidance, and existing doctrine used in the monitoring field. Figure 5 summarizes the Methods that will be used, and the reference used by the operators as the SOP. Developed from these SOP's are already established Field procedures and protocols which will be followed to assess this quality component. Field procedures and protocols are provided in the Appendices to this QAPP.

Figure 5 Reference Standard Operating Procedures

METHOD	REFERENCE SOP
TO-15a	ECOLOGY AIR TOXICS QUALITY ASSURANCE PROJECT PLAN, April 2020, AQSB SOP 805, XONTECK 901 & 910PC Canister, April 2015 and EPA Schools Air Toxics, VOC SOP August 5, 2009
TO-11a	ECOLOGY AIR TOXICS QUALITY ASSURANCE PROJECT PLAN, April 2020, SOP based on WA DOE CARBONYLS with 2,4-Dinitro-phelyl hydrazine (DNPH) coated cartridges and ATEC Operator's manual for the Model 2200 air toxics sampler.
PAH - PUF	EPA Schools Air Toxics, SVOC/PAH SOP August 24, 2009
PM-10 Metals	WA DOE PM-10 Metals with R & P Partisol Samplers using the PM2.5 Sequential Sampling Procedure modified with EPA method RFPS-0509-176 using WINS impactor bypass downtube to capture PM-10 rather than PM2.5. (Same method as the Beacon Hill PM10 Metals monitor).
PM2.5 BC	WA DOE Aethalometer SOP with modification for AE-33 upgraded model (7 channel)
NOTE: These SOPs are all listed in the Appendices to this QAPP.	

For VOCs, carbonyls, PAHs and PM_{10}, sample medium preparation involves conditioning and pre-weighing sample filters and cleaning the canisters to minimize sample contamination. ERG's Quality Assurance Project Plan (QAPP) describes these laboratory activities and the SOP's provided in the appendices of this QAPP describes the field activities. After analysis, samples will not be archived by ERG or PSCAA.

Corrective action measures will be taken to ensure data quality objective is attained. Table 5 summarizes a list of common issues found during installation, quality control check and sample retrieval. If the issue is not listed in the table, the operator will use common sense to maximize the integrity of the sample while consulting with other team-mates on a potential solution.

Table 5 Common problems in measurement system and corrective actions (Air Toxics Monitoring Quality Assurance Project Plan, WA DoE, 2020)

Item	Problem	Action	Responsible party
Pre/post filter inspection	Pinholes/tears and visual defects	Void sample; document in the analysis report	Laboratory
Flow rates	Flow rate marginal to acceptance limit	Document in the datasheets; flag data	Field operator
PM_{10}, PAH or carbonyl sample flow rate exceeds limit	Leak in sampling train or flow out of calibration	Document in the log book and datasheets; recalibrate; flag data	Field operator
VOC sampler leak test failure	Canister won't hold pressure	Document in the log book and datasheet; inspect connections; flag data	Field operator
Elapsed time > ± 10 min/day or scheduled sample didn't run	Check programming; verify if power outage	Document in the log book and datasheet; reprogram; flag data	Field operator; laboratory

13.1 Sampling Custody

Custody of samples is handled in the individual SOP's for TO-15a, TO-11a, PAH-PUF, and PM-10 Metals. VOC, carbonyl, and PAH samples must be collected within three days following sample collection and be shipped from the PSCAA to ERG as soon as feasible. PM_{10} samples will be subsequently shipped to ERG for ICP-MS analysis. PM_{10} samples must be analyzed within 180 days after sampling collection. Chain of Custody forms were established to document sample conditions during lab pre-sampling, field installation, field recovery, and upon lab recovery. Sample custody sheets are used in the Field Procedures provided in this document's appendix. For PM10 filters, Chain of Custody forms for each cooler containing samples as well as Run Data Sheets for each individual sample filter are utilized.

Samples will be mailed in between the PSCAA office and the Analytical Laboratory ERG utilizing standard FedEx methods.

13.2 Analytical Methods Requirements

Under Contract Number EP-D-14-030 from 2016, the Category 1 Quality Assurance Project Plan for UATMP, NATTS, CSATAM, PAMS, and NMOC support is used by the laboratory. The reference is:

- Support for the EPA National Monitoring Programs (UATMP, NATTS, CSATAM, PAMS, and NMOC Support) Contract Number EP-D-14-030 Quality Assurance Project Plan for Eastern Research Group, Inc. 601 Keystone Park Drive, Suite 700, Morrisville, NC 27560.

Analytical methods used for each suite of air toxics parameters are as followed:

- VOCs: EPA Compendium Method TO-15.
- Carbonyl compounds: EPA Compendium Method TO-11A.
- PAHs: EPA Compendium Method TO-13A.
- Metals on PM10 filters: EPA Compendium Method IO-3.5 via ICP-MS.

All of the QA/QC requirements of the methods specified above shall be followed throughout the sample collection and analysis process of this program. All laboratory analyses will be performed by ERG.

13.3 Quality Control Requirements

Quality Control Requirements are outlined in the individual SOP's for TO-15a, TO-11a, PAH-PUF, and PM-10 Metals. For these sampling techniques, the contract laboratory will send us blanks, and we will use blanks and collocated samples to assess quality for these sampling methods as per the QA frequency given in table 6.

Table 6 Frequency of Blanks and Collocated samples

Sampler	Blanks	Collocated Samples
VOCs samples	-	One per 10 samples
Carbonyl samples	One per 10 samples	One per 10 samples for the two-channel sampler (1 site). Cannot do collocations for the single channel samplers (4 sites).
PAH samples	One per 5 samples	-
PM10 HAP Metals	One per 5 samples	-

The quality control checks for the laboratory analytical instrumentation will be performed by ERG in accordance with ERG's QAPP. The minimum required frequencies, acceptance limits, and corrective actions associated with the field operations are presented in Tables 7-9.

Table 7 QC checks for VOC sampler (Air Toxics Monitoring Quality Assurance Project Plan, WA DoE, 2020)

Procedure	Required Frequency	Acceptance Limit	Corrective Action
Leak check	Before every sampling event	Should be close to 0.0 in-Hg (< 0.5 in-Hg)	Identify leak and correct problem, flag data
Time clock	Before every sampling event	± 5 minutes of the reference time	Adjust time clock, note on data sheet
Flow check	Every 90 days	± 10%	Calibrate, flag data
Flow calibration	Initially or if flow exceeds limit	± 10% (one-point) or ± 5% (multi-point)	Calibrate
Pressure gauge check,	Annual	± 0.5 psi of the certified standard.	Adjust gauge
Sampler Certification	Annual	Within certification due date	Send equipment back to ERG for re-certification
Clean/replace tubing to manifold, replace sintered particulate filter	Annual	N/A	N/A

Table 8 QC checks for carbonyl sampler (Air Toxics Monitoring Quality Assurance Project Plan, WA DoE, 2020)

Procedure	Required Frequency	Acceptance Limit	Corrective Action
Leak check	Before every sampling event	Vendor specific	Identify leak and correct problem, flag data
Time clock	Before every sampling event	± 5 minutes of the reference time	Adjust time clock, note on data sheet
Flow check	Every 30 days	± 10%	Calibrate, flag data
Sampler Certification	Annual	Within certification due date	Send equipment back to ERG for re-certification
Replace ozone denuder	Annual	N/A	N/A
Clean/replace tubing to manifold	Annual	N/A	N/A

Table 9 QC checks for PAH sampler (Air Toxics Monitoring Quality Assurance Project Plan, WA DoE, 2020)

Procedure	Required Frequency	Acceptance Limit	Corrective Action
Inspect electrical connections, check timers	Weekly	± 5 min (digital timer) and ± 15 min (mechanical timer) of reference time	Adjust time clock, note on data sheet
Flow check	Every 30 days	± 10%	Calibrate, flag data
Flow calibration	Initially, after motor maintenance, or if flow exceeds limit	± 10%	Calibrate
Clean sampling head, inspect gaskets	Every 30 days	N/A	N/A
Siting Verification	Annual	Neighborhood scale siting criteria	Notify Air Monitoring Coordinator if siting no long meets requirements
Calibration orifice certification	Annual	Within certification due date	Send orifice back to vendor for re-certification

For the continuous monitoring methods, such as $PM_{2.5}$ BC, the Washington State Department of Ecology SOP does require a monthly QC leak check and flow verification. We will be following the SOP requirements for QC. For each of the systems that does not have an established SOP (Mobile monitoring sampling systems like AE-51 mobile, hand-held Micro-Aethalometer, or Low-cost sensors like AirBeam, Dylos, Purple Air), we will be using manufacturers procedures to establish methods to complete quality control assessments. For instance, the handheld micro aethalometer system recommends that a flow check be conducted periodically. We will conduct a flow verification prior to use in the study, and after use in the study. These low-cost sensors will only be used as a tool for creating awareness among the community members and will not be used to calculate health risks. Additionally, all data will be screened in accordance with established monitoring data protocols. Established monitoring data protocols include a monthly visual review of data on a chart, to screen for outliers.

13.4 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

Sampler and equipment testing, inspection, and maintenance requirements are generally listed in the established SOP’s. Other testing and inspection requirements will be handled through normal troubleshooting and repair operations by the Puget Sound Clean Air Agency monitoring specialists. For all systems, when indications that maintenance needs to take place, the equipment will be taken out of service, and sampling resumed when the sampler is retested satisfactorily.

13.5 Instrument Calibration and Frequency

Field Instruments

Sampler and instrument calibration will be conducted in accordance with established SOP's. Instruments used in the field are calibrated at the required frequency described in Ecology's Air Toxics Operating Procedure and summarized in Section 13.3 of this QAPP. In the case of the micro sensor systems (like AirBeam, Dylos, Purple Air, etc.) which will be used for community-directed locations, PSCAA will use manufacturer's procedures. In this case, the sensors will undergo a calibration procedure initially, and then quality control checks will establish the system's measurement quality indicators, and finally, the calibration will be checked at the end of the study. This means that the microsensor systems would be checked against higher quality "core" monitoring systems already in place in the state network. For example, CO sensors would need to be collocated with the Beacon Hill CO monitor before and after the study so that a comparison to the FEM or FRM standard can be done, to put the microsensor data into perspective.

Analytical Equipment

Analytical instruments, including GC/MS for VOCs analysis, HPLC for carbonyls analysis, ICPMS for metals analysis and GC/MS for PAHs analysis, must meet the minimum calibration frequency and acceptable limit criteria set forth in EPA's NATTS TAD. Table 10 summarizes the required calibration frequency of each analytical equipment set by Department of Ecology's Air Toxics QAPP.

Table 10 Required calibration frequency for analytical equipment (Air Toxics Monitoring Quality Assurance Project Plan, WA DoE, 2020)

Instrument	Required Calibration Frequency
GC/MS for VOCs analysis	• Initially; • Following failed continuing calibration verification (CCV) check; • Following failed bromofluorobenzene (BFB) tuning check; or when • Maintenance performed on the instrument impacts calibration response
HPLC for carbonyls analysis	• Initially; • Following failed continuing calibration verification (CCV) check; or when • Maintenance performed on the instrument impacts calibration response
GC/MS for PAHs analysis	• Initially; • Following failed continuing calibration verification (CCV) check; • Following failed decafluorotriphenylphosphine (DFTPP) tuning check; or when • Maintenance performed on the instrument impacts calibration response
ICP-MS for metals analysis	Each day of analysis

In addition to the required calibrations, the analytical systems must pass calibration verification checks to verify bias are within the acceptable limits as part of the laboratory quality control procedures. ERG have established laboratory standard procedures, as listed below, for each of the analytical instruments to ensure adequate equipment performance at ERG:

- ERG-MOR-005: VOC analysis by GC/FID/MS using Method TO-15
- ERG-MOR-024: carbonyl analytic by HPLC system using Method TO-11A
- ERG-MOR-049: PAH analysis by GC/MS using Method TO-13A
- ERG-MOR-095: metal analysis by ICP-MS using Method IO-3.5

13.6 Data Acquisition Requirements

Data will be acquired primarily by the Envidas Ultimate system. Data will be recorded in the PSCAA air quality database through either the traditional FTP import method or will be acquired using the PSCAA Air Quality Drop Application.

The PSCAA Air Quality Drop application is a tool that is designed to import and export data files into a geographical as well as temporally keyed database. The system can upload a single file, or a package of files in a zip format. The Air Quality Drop can read data from the following file formats: *AeroqualVoc, AirBeam, CarClipCo, CarClipO3No2, Dylos, Enmont, GPS, GPX, HourlyTelemetry, MicroAeth, Package, RadianceResearch, SenonicsMinnow, and TsiNanoScan*.

All data files used for the project will be organized in the Projects folder under the internal PSCAA Server using the following Master Guidance:

Master Guidance for Special Project Folder and File Naming Conventions

Folder naming:

- Chinook\TechServices\Projects\
  Inside project folder there are files for each year that hold folders for individual projects that started in that year:
  - …\YYYY\ProjectName\
  - Each individual project folder will have the following:
  - Activity Log/About/ReadMe for the project (.xlsx)
    - …\raw mobile data (these are completely unaltered files)
    - …\raw fixed site data (these are completely unaltered files)
    - …\working mobile data
    - …\working fixed data
    - …\combined working reports and presentations, please also place a copy of the final report and copies of presentations in the proper folders in Chinook\New Public Documents

Naming conventions for raw data:
dataID_LocationID_YYYYMMDDThhmmss_R#[_comments].csv
e.g.

CPCO_PSBike_20140502T163000_R1_PSCAAToHome.csv
DyCt_GtS001_20150612T124000_R1_CXLmeasure.csv

Fields are described as follows:

- dataID: 4 character abbreviation of measured parameter/species, instrument, and model (e.g., CPO3, CPCO, RHum, VOCs, DyCt, MiAt,) A reference table is located in Chinook\TechServices\Projects\
- locationID: 6-character description of site, station, platform, laboratory, institute, or individual collecting (ergo the different route) e.g., ShrBrk, Shr10t, PSBike, CrbFix. We'll need to develop a reference table.
- YYYY: four-digit year
- MM: two-digit month
- DD: two-digit day
- hh: optional two-digit hour
- mm: optional two-digit minute
- ss: optional two-digit second
- R: revision number of data
- comments: optional additional information

Where the only allowed characters are: a-z A-Z 0-9_.- (that is, upper case and lower case alphanumeric, underscore, period, and hyphen). No Spaces. All fields not in square brackets are required. All times used in file names should reflect the start time in the raw file. Notes about time zone and other time/data issues should be noted in the project's Activity Log/About/Read Me file.

All Air toxics data obtained through the Contract Laboratory will undergo a coordinated data review process and will be uploaded to the AQS system by the Contract Laboratory. All geospatial data created under this project shall be consistent with the Federal Geographic Data Committee (FGDC) endorsed standards (www.fgdc.gov). All AQS data is publicly available. All study data is publicly available, upon request.

13.7 Data Validation, Verification and Analysis

EPA has defined the terms "data verification" and "data validation" and those definitions shall be used for purposes of this project. "The term "data verification" means the process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual requirements." *See* EPA QA G-8 GUIDANCE ON ENVIRONMENTAL DATA VERIFICATION AND DATA VALIDATION. The term "data validation" means the routine process designed to ensure that reported values meet the quality goals of the environmental data operations. Data validation is further defined as examination and provision of objective evidence that the requirements for a specific *intended use* are fulfilled. *Id*. For the purposes of this grant data, PSCAA will perform both "data verification", and Level 1 "data validation." Department of Ecology personnel will conduct a Level 2 data validation process for all project data associated with the Washington network. Data submitted by the contract laboratory to EPA's AQS will be subject to a level 2 review. In the event of an audit failure using NATTS style equipment, Ecology will work with PSCAA to identify invalid data and remove it from AQS.

Data Analysis will be primarily conducted by the Puget Sound Clean Air Agency analysis team, who will produce the final technical report. Other data users may analyze data collected from this study. Other users are urged to use this data with caution. As such, the table 11 can be used to guide data users as to the anticipated quality level of the data collected as part of this study.

Table 11 Methods and Anticipated Quality Levels

Parameter	Method	Quality Level *
Volatile Organic Compounds	TO-15	Regulatory
Aldehydes	TO-11A	Regulatory
PM2.5 BC and UV carbon	Aethalometer AE-33	High
PM2.5 BAM FEM	FEM Method EQPM- 0308-170	Regulatory
PM10 Metals	IO 3.5/FEM EQL-0512-202	Regulatory
PM10 Metals- NFRM	N-FRM	Medium
PAH	TO-13A ASTM method D6209	Regulatory
PM2.5 BC mobile	Micro-Aeth AE-51	Medium
Fine Particle count mobile	Air Beam	Low
Fine/Total particle count	Dylos DC-1700	Low
Ultrafine Particle Count	Enmont PUFP-C100	Medium

* Anticipated quality level – actual level may prove to be better or worse based on Data Quality Indicators.

Data verification refers to the daily work that the air monitoring specialists will perform to ensure that data is collected according to the QAPP. Data validation refers to those activities performed after the data have been collected. The difference between the data validation and quality control techniques is that the quality control techniques attempt to minimize the amount of bad data being collected, while the data validation seeks to prevent any bad data from getting through the data collection and storage systems – to prevent incorrectly collected data from informing the results. Data validation is a combination of checking that data processing operations have been carried out correctly and of monitoring the quality of the field operations. Data validation can identify problems in either of these areas. Once problems are identified, the data can be corrected or invalidated, and corrective actions can be taken for field or laboratory operations. If possible, flags denoting error conditions or QA status are saved as separate fields in any databases, so that it is possible to recover the original data. Table 12 will be used to plan the types of data checks, and the people responsible for the checks.

Table 12 Validation Check Summaries

Type of Data Check	Responsible Team member	Manual Checks	Automated Checks
Date and Time Consistency	PSCAA Air monitoring specialist	X	
Completeness of required sample fields	Lab receiving personnel	X	X

Statistical outlier checking	PSCAA Project Manager and Analysis Team	X	X
Manual inspection of charts and reports	Lab personnel	X	
Field and Lab blank checks	Lab personnel	X	

Data Analysis

The Data Analysis Team will review all the data collected in this study. PSCAA will submit summary reports of the monitoring data collected in the study to the EPA. The report will be a summarized account of the observations and recommendations that will be available in Draft form initially. After final Technical reviews are complete, the report will be finalized. We will evaluate the data in a multi-step process.

First, we will complete a full and ongoing evaluation of the data including a full quality assurance assessment. This entails checking data completeness, trends, temporal patterns, and potential interferences. Data Quality Indicators will be used to describe the actual quality of the data sets, to evaluate the data usability. Additional review will help in the analysis, including reviewing detection limits to determine the best statistical estimation techniques needed. We will calculate summary descriptive statistics such as averages, medians, percentiles, and distributions, for all the measured air toxics.

The data analysis will focus on meeting the grant's Outputs and Outcomes, and addressing the main scientific questions:

- Has average potential cancer risk from air toxics in Seattle and Tacoma changed since 2010?
- If a change in concentrations is observed, can it be explained by meteorology rather than emissions changes?
- Can patterns be detected in the data that suggest emission sources, activities, categories, or events? (e.g., transportation, industrial sectors, residential wood burning, fireworks, etc.)
- Has there been any change in the distribution of air pollutants and risk across the focus communities?
- How do our measurements and analysis compare to other available measurements and modeling (NATA and NATTS)?
- What additional tools or analysis can be developed to improve our ability to identify pollution sources, assess risk, develop plans to reduce future risk, and address community concerns?

The more complex analyses include, and will generally progress as follows:

1. Assess the potential impact of meteorology on the observed trends and patterns. We will use available meteorological data (wind speed, direction, temperature, precipitation, etc.) to assess the potential impact of meteorological factors. The analysis will include, at a minimum, looking at distributions of wind speed, direction, and temperature, to identify potential confounding influences on long-term trends.
2. Estimate potential cancer risks for fixed sites. Based on statistical summaries described above, we will calculate potential cancer risk using the Washington State Acceptable Source Impact Levels unit risk factors. Based on these estimates, we will provide a ranking of air toxics, which will help us quantify the health hazards attributed to air toxics.

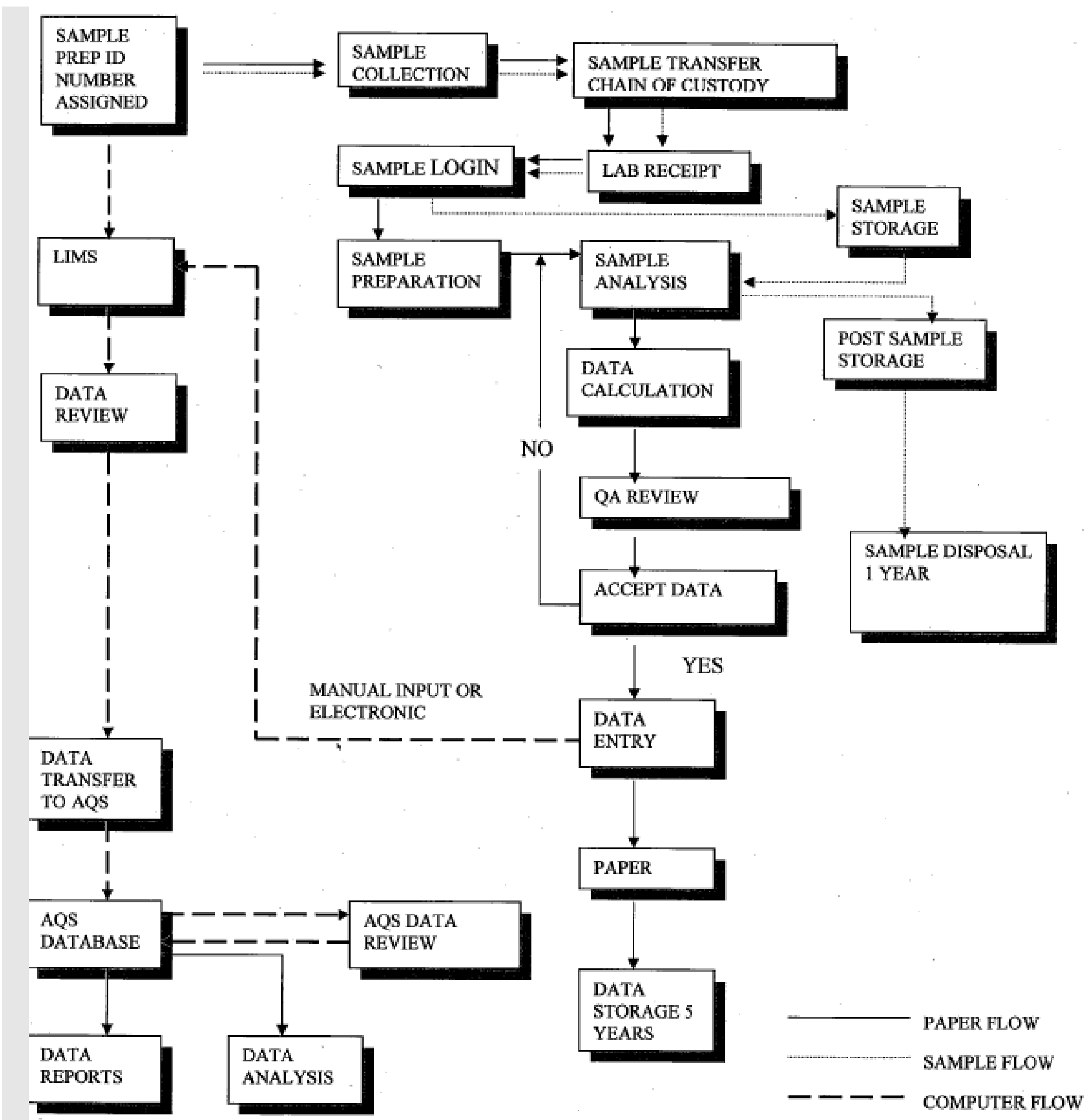
3. Compare air toxics concentrations and risks for Seattle and Tacoma from the 2010 and 2016 studies. We will use all comparable data and risk calculations to compare to the 2010 Study of Air Toxics in Tacoma and Seattle, and the 2016 study in Seattle's Chinatown-International District. We will answer how air pollution and toxic risk has changed over the last 10 years. We anticipate being able to include comparisons for diesel and wood smoke estimates at the Tacoma Alexander, Seattle Duwamish, and Beacon Hill sites. We also anticipate estimating diesel and wood smoke at 10th & Weller and Tacoma 36th sites but can't include comparisons as these sites weren't a part of the 2010 study.
4. Compare air toxics concentrations and risks to the NATTS network. We will aggregate three years of NATTS data across the country, average the results, and apply the same unit risk factors to evaluate and compare risk across the country. A key comparison will be with the nearby Seattle Beacon Hill NATTS site, which is about 1.6 miles to the east of the Seattle Duwamish site. The Beacon Hill site is at a substantially higher elevation (+ 100 m), and further away from major sources in the Duwamish Valley, providing a good regional background.
5. Compare air toxics concentrations to nearby 2017 National Air Toxics Assessment (NATA) model estimates. We will compare our results to the 2017 National Air Toxics Assessment model. The analysis will include mapping (ArcGIS or similar) and descriptive statistics for the census tracts containing or near to sampling sites, and in the focus community.
6. Identify and quantify air toxics sources through source apportionment. We will use both data collected specifically for this project and leveraged data from the existing, collocated sites. The existing instruments and data collected vary across all the fixed sites. They include aethalometers (UV to IR absorption, with2 or 7-channels), fine particulate matter (BAM and/or nephelometer), CO, NOx, and meteorological parameters (wind speed, wind direction, temperature, barometric pressure, relative humidity). We will use all of the available data in a factor analysis (e.g., PMF or Chemical Mass Balance, CMB) to identify and quantify air toxics sources such as transportation, industrial facilities, or other sectors (e.g., residential woodburning). The factor analysis will examine monitored concentrations of air toxics, metals, PAHs, black carbon, fine particles, carbon monoxide, nitric oxide, and may include supplementary data such as traffic counts, temperatures, wind speeds, and humidity. As they are available, we will also include organic carbon, elemental carbon, and many other particle fractions from any collocated speciation data provided by the Washington State Department of Ecology. We will attempt to estimate concentrations of diesel particulate matter, an important mobile source air toxic, so that we may include its estimated levels and risk (at least qualitatively) as we communicate results.
7. Extrapolate risks from the fixed sites to quantify potentially exposed populations and their potential risk. If a chemical marker or PMF pattern appears to provide relatively consistent ratios to the toxics that drive most of the risk (e.g., benzene, 1,3-butadiene, formaldehyde, ethylene oxide), we will extrapolate the air toxics levels beyond the fixed sites to the surrounding census block groups based on estimated source emissions, with associated uncertainties indicated prominently. We will investigate ratios of the marker/pattern to specific air toxics, as well as to criteria pollutants.
8. Additional multivariate geospatial analysis based on the concerns of the focus communities. Based on the concerns expressed by the focus communities, we will conduct additional analyses. The analyses could include, or be specific to, additional measurements or data requested by the communities but not specified beforehand. It could also include using existing data to produce a high-resolution gradient or map of pollutants or risk for nearby industrial

areas, the Port of Tacoma or Seattle, or gradients from the nearby roads and vehicles, or other specific concerns that the communities identify.

14 Data Management

This section describes all the aspects of data management necessary for this project. This includes an overview of the mathematical operations and analyses performed on raw, "as-collected" data. These operations include data recording, validation, transformation, transmittal, reduction, analysis, management, storage and retrieval, and reporting. Data Processing activities for air toxics data are described in the figure 6.

Figure 6 Data Management and Sample Flow Diagram



Data processing steps are integrated, to the extent possible, into the existing data processing system used for criteria pollutant monitoring. The air monitoring database resides on a dedicated database Central server at the State Department of Ecology, and a dedicated SQL database at the Puget Sound Clean Air Agency.

Sample tracking and chain of custody information is entered into a Laboratory Information Management System at two points as shown in the figure 6. Managers can obtain reports on status of samples, location of specific samples, etc. using LIMS. Different access privileges are given each authorized user depending on that person's need. The following privilege levels are defined:

- Data Entry Privilege – The individual may see and modify only data within LIMS that he or she has entered. After a data set has been "committed" to the system by the data entry operator, all further changes will generate entries into the system audit trail.
- Reporting Privilege – The individual may generate reports.
- Data Administration Privilege – Data Administrators for the LIMS can change data because of QA screening and related reasons. All operations resulting in changes to data values are logged to the audit trail.

The Data Administrators are responsible for performing the following tasks on a regular basis:

- Merging or correcting duplicate data entry files
- Running verification/validation routines, and correcting data as necessary
- Generating summary data reports for management
- Uploading validated data to EPA-AQS

All other study data will be entered into the PSCAA air quality database using tools such as automated data-loggers, and/or the Air Quality Drop tool.

Mobile Data must be uploaded using the Air Quality Drop tool, because of its dependency on spatial positioning.

Table 13 lists the routine documents and records that will be kept for this project. These documents and records will normally be kept in centralized folder structures so that the documents can be recalled later.

Table 13 List of Routine Documents and Records collected

Record/Document Types	Categories
Reporting agency information Organizational structure EPA Directives Grant allocations Support Contract	Management and Organization
Network description Site characterization file Site maps Site Pictures	Site Information
QA Project Plans Standard operating procedures (SOP) Field and laboratory notebooks Sample handling/custody records Inspection/Maintenance records	Environmental Data Operations
Any original data (routine and QC data) including data entry forms	Raw Data
Air quality index report Annual SLAMS air quality information Data/summary reports Journal articles/papers/presentations	Data Reporting
Data algorithms $PM_{2.5}$ Data	Data Management
Network reviews Data quality assessments QA reports System audits Response/Corrective action reports Site Audits	Quality Assurance

15 Assessments and Response Actions

Our analysis and results will help us better understand air toxics trends and air toxics health risks in the communities in Seattle and Tacoma. We will better understand air toxics levels at different distances to the highway, the risk context through comparisons against national monitoring sites (including the nearby Seattle NATTS site), and the NATA model. Additionally, we will engage the community to explore potential mitigation strategies beyond the time horizon of this grant.

In this study we will provide the community the unique opportunity to direct air toxics sampling based on their own concerns. Sampling will be geared toward air toxics pollution, but the community will have the latitude to identify a variety of locations and sources (for example bus stops, parking lots, intersections, loading docks, or highways).

We have already started building relationships in this community through our agency's focus community work. We also plan to continue to work in these communities to provide information and the tools to take next steps. This air toxics study provides an important part of acting against air pollution by helping to fill in identified data gaps. Ultimately this project will impact the community by informing stakeholders about the air pollution levels, the risk levels, and the potential mitigation strategies that can be employed to reduce pollution in the area over the long-term.

16 Reports to Management

PSCAA will produce a final technical report, which will be drafted, then routed to stakeholders. Feedback will be solicited, and then the final technical report will be finalized. When the report is finalized, then the report will be given to EPA, as part of the Grant Closeout Package. PSCAA will share this final technical report with all stakeholders, and will post the report to the Agency website, so that it can be publicly accessible.

Semi-annual reports on the grant progress will be forwarded to the Grant Project Officer and will be retained as part of the grant record.

17 Appendices

APPENDIX	TITLE
A	Canister Sampling Procedures
B	Carbonyl Routine Sampling Procedure
C	PUF Routine Sampling Procedure
D	The EPA 1 in 6 Sampling Calendar
E	AE-33 “7 Channel” Aethalometer Sampling Procedures
F	AE-51Micro-Aeth Quick Start Guide Procedure
G	Air-beam Operating Procedures
H	Purple Air Operating Procedure
I	PM2.5 Partisol Procedure Link and PM-10-2.5 Designation
J	Enmont Ultrafine Particle Counter Procedure
K	Air Quality Web: Air Drop Procedure
L	NFRM Metal Sampling Procedure

A. Canister Sampling Procedures

School Air Toxics, VOC SOP
August 5, 2009

STANDARD OPERATING PROCEDURE FOR THE COLLECTION OF VOLATILE ORGANIC COMPOUNDS FOR THE EPA SCHOOL AIR TOXICS PROGRAM

U.S. Environmental Protection Agency
Region 4, Science and Ecosystem Support Division
Athens, Georgia, 30605

Acknowledgement

This Standard Operating Procedure (SOP) was developed by EPA Region 4, Science and Ecosystem Support Division. This SOP is based on the Commonwealth of Kentucky's ambient monitoring SOP template. Special thanks to the State of South Carolina and ERG for operational content.

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I. INTRODUCTION

This document is designed to provide instruction on collecting volatile organic compounds in air using an evacuated canister and a passive air sampling kit.

The procedure presented is designed for sampling volatile organic compounds (VOCs) in ambient air, based on the collection of whole air samples in SUMMA® treated canisters to final pressures below atmospheric. The samples are then analyzed using EPA Compendium Methods TO14A or TO15 *Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS)* using the EPA National Monitoring Program's contract laboratory (i.e. ERG).

The canisters are 6-liter stainless steel vessels whose internal walls are SUMMA® treated with an inert pure chrome-nickel oxide compound to reduce the reactivity of the air sample in the canister. The canisters are outfitted with a stainless steel bellows valve, equipped with a 1/4" Swagelock® fitting on the inlet. Prior to use, all canisters are cleaned in accordance with the specifications presented in the EPA NATTS Technical Assistance Document Rev. 2 (April 2009). Once certified as clean, the canisters are evacuated to approximately 29.5 inches of mercury ("Hg) and are ready for use. The collection approach is passive, meaning no 110 volt AC power is required. The canister is attached to a programmable timer/solenoid, a veriflow vacuum regulator, and a sample probe. Figure 1 presents the complete VOC sampling system. When the programmable timer opens the solenoid at a preset time, the canister is filled with ambient air at an integrated collection rate across the 24-hour sampling duration.

This SOP is designed to be a step by step procedure for operating the sampling system described, and is to be used in conjunction with the manufacturer's operator's manual(s). Laboratory Analysis Methodology using the TO-15 method may be referenced by contacting the Eastern Research Group (ERG) directly at 919-468-7800 or by email Julie.Swift@erg.com. Maintenance and troubleshooting should be conducted using the relevant operator's manual(s).

FIGURE 1. Photograph of Total VOC Sampling System
With Timer and Probe

II. INSTALLATION

A. Sampler Siting

Inspect the site area to ensure there will be enough physical space for the operator to move freely while working, and ensure there is nothing at the location that will negatively impact the safety of the operator.

The sampler should be mounted in a location that is unobstructed on all sides. There should be no tree limbs or other hanging obstructions above the sampler. It is suggested that the horizontal distance from the sampler to the closest vertical obstruction higher than the sampler be at least twice the height of the vertical obstruction. The inlet of the sampling system must be positioned at least 2 meters above grade (ideal), but not more than 15 meters above grade.

B. Sampler Installation

1. The sampling system consists of three components: a sample canister, a programmable timer/solenoid (Nutech 2701), and a passive vacuum regulator (Veriflow with gauge and sample inlet probe). All components will be received from the ERG laboratory where: the cans will have been cleaned, tested for contamination and evacuated; flow controllers will have been cleaned, tested for contamination, and calibrated for 24 hour sampling; and the sample inlet will have been tested for contamination.

2. The complete sampling system must be securely mounted on a support structure which ensures that the sample inlet meets the siting criteria (at least 2 meters above grade, but not more than 15 meters above grade).

   Note: If the support structure is to be located on a roof top, efforts must be made to protect the roof covering (i.e. membrane, etc.). This can be accomplished by securely attaching the support structure to a wooden frame and then using weight (i.e. sandbags) to hold the entire mounting structure in place.

3. For collocated samplers, horizontal spacing should be between one (1) and four (4) meters, and inlet heights within one (1) meter vertically. .

III. OPERATING PROCEDURE

A. Equipment and Supplies

6 liter sample collection canister
Veriflow vacuum regulator/gauge/inlet probe
Nutech 2701 programmable timer/solenoid
Support structure with holder for assembled sampling apparatus
Logbook
ERG sample paperwork

B. Sampler and Sample Media Receipt Activities

Complete Sampling System

1. Check parts and components against the packing list.

2. Ensure all fittings are present and in good condition.

3. Prior to sampling keep all components in a clean area free of contamination.

Nutech 2701 Programmable Timer/Solenoid – Battery Charge

1. Charge the internal battery by opening the front cover and plugging the supplied USB adapter cable into the labeled USB port located on the bottom right of the front panel (mini USB).

2. Plug the other end of the USB cable into a USB port on a computer (standard USB). Allow the timer to charge for at least 12 hours. A battery charge indicator is located at the top center left of the display. The battery will display [full battery icon] after a full charge is reached.

   Note: The display will show [empty battery icon] when the battery is drained. To ensure that there is always a sufficient charge on the battery, recommend recharging every six days.

Sample Collection Canister

1. The sample collection canister and associated sample data sheet will arrive from ERG in a cardboard box.

   Note: The canisters do not need to be refrigerated after receipt or during return shipping.

2. Ensure the canister is not damaged. Confirm that the valve remained in the closed position during shipping and that the top plug is secured on the bellows valve inlet fitting.

C. Preparing for a Sampling Event

Initial Steps

1. Ensure the Nutech 2701 timer battery is fully charged. If there are not at least two (2) bars displayed, the timer must be recharged before conducting the sampling event.
2. Prepare sample paperwork. On the ERG Toxics/SNMOC Sample Data Sheet, supply all required information in the "Lab Pre-Sampling" section. Record any pertinent observations in the notes section at the bottom of the form.
3. Remove the plug attached to the bellows valve inlet. Retain the plug in a clean place so that it can be used to reseal the bellows valve inlet after the sampling event.
4. Assemble the complete sampling system.
   a. Attach the outlet fitting of the Nutech 2701 timer/solenoid to the canister bellows valve inlet.

      Note: Do not over tighten the nut. When the nut feels snug, another quarter turn should be sufficient to secure the timer inlet to the can.

   b. Attach the outlet fitting of the Veriflow vacuum controller to the inlet fitting of the Nutech 2701 timer/solenoid.

      Note: Again, do not over tighten the nut. When the nut feels snug, another quarter turn should be sufficient to secure the timer inlet to the can.

Measuring and Documenting the Pre-Collection (Set-up) Canister Pressure

The following steps are to be performed prior to programming the Nutech 2701 timer/solenoid for the initial/subsequent collection event:

1. On the timer control panel, press the bubble switch labeled "Enter" once. This will take the timer out of the power-saving/hibernation mode.

2. On the timer control panel, press the bubble switch labeled "Manu" once. This places the timer in the manual operation mode. On the display in the center of the bottom zone, the word "Open" should be present. If the word "Closed" is present, press the "Manu" bubble switch again and it should shift to the word "Open". This action manually opens the solenoid and clears a flow/pressure path between the canister valve and the Veriflow control orifice and pressure gauge.

3. Fully open the canister bellows valve. Observe the pressure (i.e., "Hg vacuum) indicated on the gauge. Fully close the canister bellows valve.

   Note: The bellows valve should be kept open for as short of a duration as possible – 10 seconds or less.

4. Record the Pre-collection Canister Pressure in the appropriate space on the supplied Chain-of-Custody.

Programming the Timer

At this point, the Nutech 2701 timer/solenoid is ready to be programmed to automatically conduct the next scheduled collection event. Follow the programming steps provided below.

1. Set the current time *(local standard time)*

   a. Push the "Set" key twice.

   b. The LCD will show flashing digits that can be changed by pushing the left or right arrow keys. When finished, press the set button to move to the day of the week.

   c. Change the day by pushing the left or right arrow keys. An arrow will be present above the selected day. When finished, press the "Enter" key to finish the time and day setting.

2. Set the sample start and end date / times

   a. Program the sampling event by pushing the "set" button once to enter event setting.

   b. Set event number (SEG on the display). Select 1 as your event number using the arrow keys. Once the event number is set, "Open" will be flashing to set the valve function.

c. Press "Enter" to confirm the open function. The time will flash. Set the sampling start time, followed by the day of the week using the arrow keys. Confirm the settings by pressing "Enter" to complete the program.

*Note: It's critically important that **00:01** be entered for the event start time (the timer will not recognize a start time of 00:00 and will not actuate).*

d. The valve icon on the timer should appear as indicating that the valve is in the closed position. During the sampling event, the icon on the timer will appear as .

3. To set the event stop time, push "Set" once to enter event setting. Set event number (SEG) first. Select 1 as your event number. Once you set the event number the (Open) will flash. Using right arrow key to move flashing to (Close), now (Close) is flashing for you to set the valve function. Push (Enter) to confirm the close function. Then the time will be flashing. You now set your sampling stop time [use **23:50**], followed by day of the week. Select the day of the week then push (Enter) to finish.

D. Sample Recovery and Data Collection

1. Activate the timer display by pressing the "Enter" button once. This will activate the screen with the current day of the week and current time of day (in Standard Time not Daylight Savings Time). The valve icon on the timer should appear as indicating that the valve is in the closed position. The display will also indicate the total elapsed time for the previous sampling event.

2. Record the total elapsed time on the ERG Toxics/SNMOC Sample Data Sheet in the "Elapsed Time" blank in the "Field Recovery" section.

3. Open the solenoid valve by pressing the "Manu" button once.

4. Fully open the canister bellows valve.

5. Read the gauge and record the remaining pressure left in the can on the ERG Toxics/SNMOC Sample Data Sheet and record the reading in the "Field Recovery", "Field Final Can. Press. ("Hg)" blank. If the pressure is zero, note the lack of pressure in the "Comments" section of the form.

6. Close the canister bellows valve by turning the knob until it is snug.

   Note: The canister bellows valve should not be opened for any longer than is required to get an accurate pressure measurement (i.e. approximately 10 seconds).

7. Close the timer solenoid valve by pressing the "Manu" button again.

8. Disconnect the canister from the Nutech 2701 timer/solenoid by unfastening the bellows valve inlet fitting from the timer outlet fitting.

9. Replace and secure the retained plug on the canister bellows valve.

10. On the ERG Toxics/SNMOC Sample Data Sheet, supply all required information in the "Field Recovery" section. Be sure to record any observations that were made during the run period.

11. Sample Shipping

    a. Remove the pink copy of the ERG Toxics/SNMOC Sample Data Sheet and file in a site record.

    b. Pack the can and the completed white copy of the ERG Toxics/ SNMOC Sample Data Sheet in the original cardboard shipping box and tape it closed. The can does NOT need to be shipped cold.

    c. Use the pre-filled out FedEx label provided by ERG, and fill out the Sender" section with the sampling agency's address and phone number. Send priority overnight to ERG at the address below.

       ERG
       601 Keystone Park Drive
       Suite 700
       Morrisville, NC 27560
       919-468-7924

       Note: if the shipping form is lost, use the address below for shipping to ERG, and contact them directly for the FedEx accounting.

IV. QUALITY ASSURANCE

To ensure that quality data is being collected the following checks should be considered:

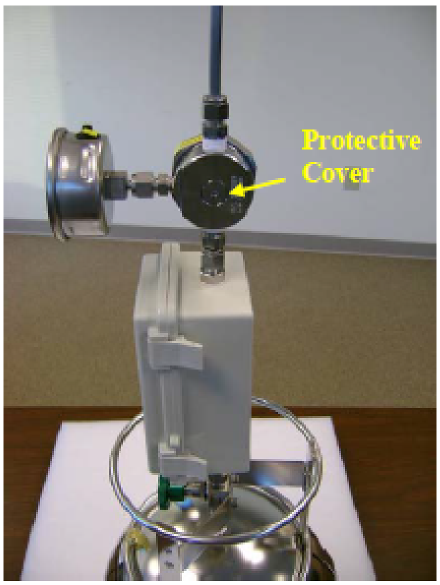
A. Flow Calibration

Prior to deployment each Veriflow must be calibrated to a collection flow rate of approximately 3.2 cc/min to insure that the final pressures obtained over a 24-hour collection duration are appropriate. This calibration will be performed by EPA Contract Laboratory prior to shipment of each Veriflow to the field. Ideally, with a collection flow rate set-point of 3.2 cc/min, a 6L canister will attain a final volume of approximately 4,700 cc over a 24-hour (i.e. 1440 min) collection duration. The final volume of 4,700 cc equates to a final sample pressure in the canister of between 6 and 7 "Hg, which is the target final pressure for the EPA SAT program.

Because the Veriflows were calibrated at the EPA Contract Laboratory in Research Triangle Park, NC, variations in elevation, temperature, and barometric pressure between the calibration site and the field deployment site can cause variations in the final flow rate set-point realized. This variation in flow rate may necessitate adjustment of the collection flow rate set-point in the field. The following procedure presents the steps to accomplish the in-the-field set-point adjustment.

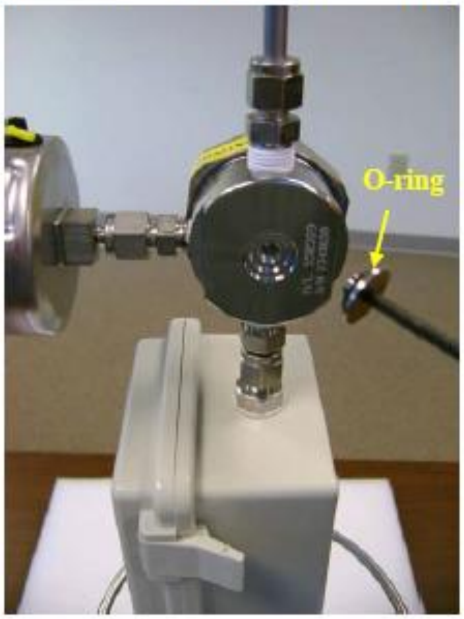
1. On the right hand side of the Veriflow unit, locate the adjustment screw protective cover (1/2 inch diameter disk with a 1/8 inch hex port located in the center) as shown in Figure 2.

Figure 2. Veriflow adjustment screw protective cover



2. Insert a 1/8 inch hex key into the hex port and rotate the protective cover counter-clockwise until it can be removed from the protective cover. Please note that the protective cover has an o-ring attached to it, as shown in Figure 3. The purpose of the o-ring is to ensure that the unit remains weather-tight while deployed. It is important that the o-ring be present when the protective cover is reattached to the Veriflow.

Figure 3. Removed protective cover with o-ring

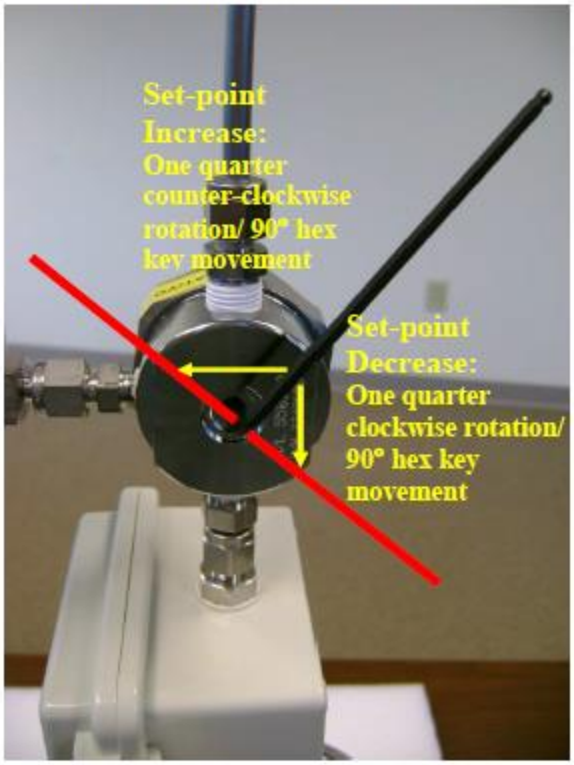


3. Under the cover is the actual flow rate adjustment screw (3/16 inch black circle with hex port located in the center), as shown in Figure 4.

Figure 4. Flow rate adjustment screw

4. To make adjustment to the flow rate set-point, insert a 1/8 inch hex key into the hex port on the adjustment screw. The Veriflow unit utilizes 5 full rotations to take the set-point from the bottom of its operational range (i.e. approximately 2 cc/min) to the top of its operation range (i.e. approximately 4 cc/min). As stated earlier, the units have been pre-calibrated for approximately 3.2 cc/min and should yield a final sample pressure is between 6 and 7 "Hg. However, it should be noted that final pressures between 1 and 10 "Hg are considered valid samples. If a final sample pressure between 1 and 10 "Hg is achieved, no adjustment is required. If the final sample pressure achieved is outside the acceptable range, or if a final pressure closer to the ideal set-point of 6 to 7 "Hg is desired a set-point adjustment will need to be made. To increase the flow rate, insert a 1/8 inch hex key into the hex port located in the center of the adjustment screw. Rotate the adjustment screw counter-clockwise. To decrease the flow rate, rotate the adjustment screw clockwise. It is recommended that adjustments be made in one quarter rotation increments between collection events, until the desired final sample pressure is achieved. The quarter turn adjustment can be easily gauged by observing the handle of the hex key so that it is positioned 90 degrees before or past its original position. See Figure 5.

Figure 5. Flow rate set-point adjustment



5. After adjustment replace the o-ring and protective cover. The Veriflow unit is now ready for use on the next sample collection episode.

B. System Cleanliness

All equipment, with the exception of the timer, will be cleaned by ERG before shipment to the agency. If anomalies are observed, the ERG laboratory will notify the agency and a course of action will be identified. The operator should take care not to touch or contaminate the inlet, fittings, and other parts of the sampling train. These areas should be kept covered if possible when sampling is not occurring.

V. DATA FORMS

All sample related run data forms will be supplied by ERG. Check the data sheets for completion after every setup or retrieval event. The operator is expected to keep a logbook to document all site activities, quality assurance activities, and sampling activities. Figure 6 presents the ERG Toxics / SNMOC Sample Data Sheet.

FIGURE 6. ERG Toxics/SNMOC Sample Data Sheet

ERG Lab ID # ____

TOXICS/SNMOC SAMPLE DATA SHEET

Lab Pre-Sampling	Site Code: ____	Canister Number: ____
	City/State: ____	Lab Initial Can. Press. ("Hg): ____
	AQS Code: ____	Date Can. Cleaned: ____
	Collection Date: ____	Cleaning Batch # : ____
	Options	
	SNMOC (Y/N): ____	Duplicate Event (Y/N): ____
	TOXICS (Y/N): ____	Duplicate Can # : ____
Field Setup	Operator: ____ Sys. #: ____	MFC Setting: ____
	Setup Date: ____	Elapsed Timer Reset (Y/N): ____
	Field Initial Can. Press. ("Hg): ____	Canister Valve Opened (Y/N): ____
Field Recovery	Recovery Date: ____	Sample Duration (3 or 24 hr): ____
	Field Final Can. Press. ("Hg): ____	Elapsed Time: ____
	Status: Valid Void (Circle one)	Canister Valve Closed (Y/N): ____
Lab Recovery	Received by: ____ Date: ____	Lab Final Can. Press. ("Hg): ____
	Status: Valid Void (Circle one)	
	If void, why: ____	
SNMOC	Analyst: ____	Date: ____
	Batch I.D.: ____	
Toxics	Analyst: ____	Date: ____
	Batch I.D.: ____	

Comments: ____

White: Sample Traveler Canary: Lab Copy Pink: Field Copy

Endnotes to School's Air Toxics Protocol

Detailed procedures are outlined in the EPA TO method TO-15. This is a description for regular field runs for passive canister samplers. ERG ships the required materials in a box to PSCAA. PSCAA then ships the collected samples back to ERG for analysis.

The stand-alone timers used with a flow control device may sometimes cause leaks and hence the following guidance should be considered prior to and during the study:

- Upon each sampling event, ensure all fittings (canister to timer, timer to flow controller, and flow controller fittings, particulate filter) are tight. Some fittings require an extra quarter turn after the fitting is finger tight. Consult tightening guidance of the fitting vendor.
- Leak test the sampling apparatus (canister, timer, and flow controller) every sampling run as per the protocol in TO-15A described below:
  - Tightly cap the inlet.
  - If the gauge is upstream of the solenoid, manually activate the solenoid (if so equipped).
  - Open and close the canister valve to generate a vacuum at the gauge.
  - Observe the gauge to assess the leak rate. There should be no perceivable pressure increase.
  - If there is a leak, gently snug the fittings and retest. If the leak persists, replace the sampling apparatus and/or canister and test.
  - Following a successful leak check, remove the inlet cap.
- Leak check timer every 10 runs.
- Replace the batteries frequently.
- Conduct a flow check on the flow controller to ensure that vacuum (4 to 11 inches of Hg) will remain in the can following the sampling duration.
- Immediately report samples that end the sampling run at ambient pressure (0 inches of Hg) to the QA staff for corrective action.

In summary, a field technician needs to go out to the field to setup the run. The technician will conduct the leak and flow tests as described above. Using the timer, the samples can be setup to run at the programmed start and stop time. The technician needs to then pick up the canister from the field after the run. The samples are collected once every 6 days.

Required Materials:

- 2 Crescent Wrenches
- Black or Blue Pen
- Canister and a backup in case of a faulty canister
- Chain of Custody Sheet
- Cell Phone

Sample Drop-off and Pickup:

- Record the city and state on the chain of custody sheet.
- Record the AQS code for the site as in the table below:

Site	AQS Code	Four Digit Site Code
Seattle 10th&Weller	05303300301	BKWA
Seattle 10th&Weller Collo	05303300302	BKWB
Seattle Duwamish	05303300571	CEWA
Seattle Duwamish Collo	05303300572	CEWB
Tacoma Alexander	05305300311	EQWA
Tacoma Alexander Collo	05305300312	EQWB
Tacoma South L St	05305300291	ESWA
Tacoma South L St Collo	05305300292	ESWB
Tacoma S 36th St	05305300241	YFWA
Tacoma S 36th St Collo	05305300242	YFWB

- Record the date that the sampler will run on in the chain of custody sheet for the respective canister.
- Write “N” for SNMOC, “Y” for Toxics.
- If this is a duplicate event, record the duplicate canister number on the custody sheet.
- Record the date of the sample set up.
- For Sample Setup, use the Schools Air Toxics SOP to set up the sample and timer in Section C. For Sample Recovery, use the Schools Air Toxics SOP to recover the sample in Section D Steps 1 through 11.

Duplicate Samples:

- ERG will ship an extra canister for the collocated samples.

Shipping

- All canisters from ERG will be shipped back to ERG in the same boxes with a postage paid FedEx return label included.
- ERG does not accept shipments on the weekends, so **shipments must be sent Monday through Thursday only**.
- In case of emergency, the lab address and phone contact are: 919-468-7923, Randy Bower, 601 Keystone Park Dr., Suite 700, Morrisville, NC 27560
- All labels should be marked "Priority Overnight" shipping if not already.

General Sampling Calendar:

If Sample run is on a:	Take out to field on:	Return from the field on:	Ship out with FedEx by 4:30PM on:
Monday	Friday	Tuesday	Tuesday
Tuesday	Monday	Wednesday	Wednesday
Wednesday	Tuesday	Thursday	Thursday
Thursday	Wednesday	Friday	Monday
Friday	Thursday	Monday	Monday
Saturday	Friday	Monday	Monday
Sunday	Friday	Monday	Monday

B. Carbonyl Routine Sampling Procedure

Detailed procedures are outlined in the EPA TO method TO-11A. This is a description for regular field runs for carbonyl samplers. ERG ships the required materials in a cooler to PSCAA. PSCAA then ships the collected samples back to ERG for analysis. In summary, the field technician needs to go out to the field to setup the unit before the run. A technician then needs to go to the field to pick up the sample as quickly as possible after the run. The sampler runs every 6 days.

We will be using ATEC model 2200 carbonyl sampler for this study. There will be one Two Channel model, which will be installed at Tacoma South L Street, and four Single Channel models used, which will be installed at the other sites. Duplicates will be run at the Tacoma South L Street site, and blanks will be used at all the sites.

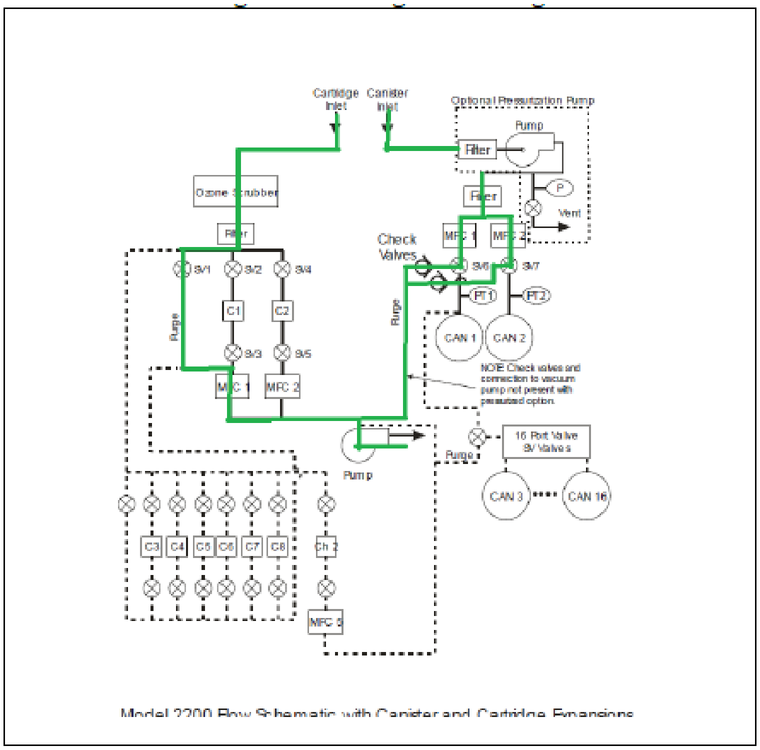
Figure: ATEC model 2200 2-channel carbonyl sampler

Summary of Method:
Using the ATEC Model 2200 Toxic Air Sampler, a 24-hour ambient air sample will be taken. Air will be drawn into cartridges for later analysis of Carbonyl compounds. The monitor has been pre-programmed to comply with EPA Methods TO-11A. Section 7.2 of EPA method TO-11A describes the DNPH adsorbent cartridges in detail. The sampler consists of a single pump that pulls ambient air into the sampler. To control and monitor the cartridge flow rates, there is an independent mass flow controller for each channel.

PSCAA operators will go into the field with a carbonyl adsorbent cartridge (cartridges to be kept cool to < 4°C), supplied by ERG's lab. **(Note: Lab will supply materials to field operators at least two days in advance of sampling).** The operator will install the collection media, program sampler, retrieve collection media, fill out appropriate paperwork, and return samples to ERG's lab for analysis. Prior to sampling, the Model 2200 will purge the sample line. The default purge time is one hour. Sampled carbonyl cartridges should be placed in cooler with ice packs after sampling for transport to maintain a temperature of <4°C.

The following materials are required:
- ATEC Model 2200 Toxic Air Sampler
- 1/8" and 1/4" Stainless Steel Sampling Tubing
- 1 - 7/16 wrench and 1 - 9/16 wrench
- 1 pair - Polyethylene gloves

• NIST Traceable BIOS Defender (100ml/min – 7 L/min)
• Carbonyl adsorbent cartridge(s) (**Note-DNPH cartridges should not be exposed to sunlight.)**
• Field data sheets
• Sampler Maintenance/Log book
• Computer with 2200 Data Retrieval Software or USB
• NIST Traceable Barometer
• NIST Traceable Thermometer
• Cooler and Ice Packs for Transport of DNPH Cartridges
• Site AIRS codes
• Calculator



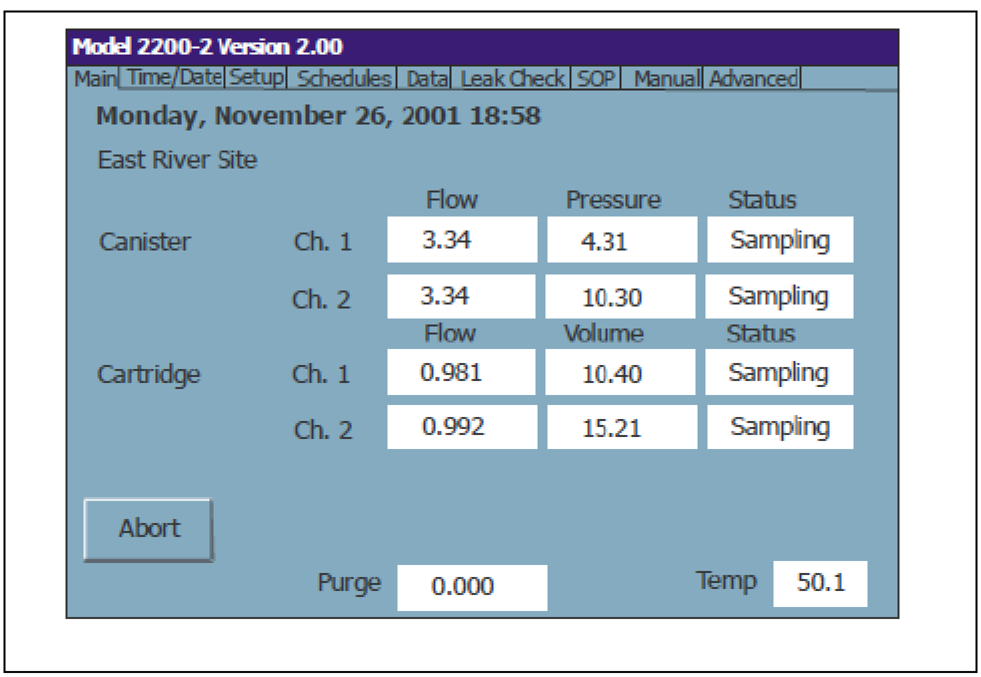
Purge Flow Diagram: Purge flow paths are shown in green. Sampler is purged for 60 minutes prior to the start of each sampling event.

Equipment Installation
The ATEC Model 2200 Toxic Air Sampler should be set up in a weather protected area with 115 VAC current. Although not necessary, a controlled environment of 20-30°C is suggested for operation of the sampler.
Mobilize the unit to the field-sampling site and plug into a 115 VAC outlet. Move power switch to "On". The system will "boot up" in ~ 30 seconds. The system is operated using the ¼ VGA LCD color touch screen display, which shows current status, and allows entry of information into the system's computer. A pen may be used as a "stylus" to operate the touch screen's buttons.
Run a ¼" diameter SS tube to the exterior of the sampling enclosure as a sample line. Using a ¼" Swagelok connector and ferrule, connect the sample line to the back of the sampler labeled "Input".

Cut two pieces of 1/8" SS tube to a length of ~ 2ft. (or other length as needed to reach the sampling storage area for the Summa Canisters). Place 1/8" Swagelok connectors and ferrules on both ends of this canister line. Hook one end of each line to the positions labeled "Channel 1" and "Channel 2" on the back of the sample unit. The other end of these lines has quick connectors to attach to the Summa canisters for sampling.

Sample Set-up Operation

The following steps are necessary for the daily sample set-up. Values are entered or are pre-set and may be viewed on the Model 2200's touch screen.



Sampler Program Setup

Press the **Setup** button on the touch screen. This will show a green screen with "Canister and Carbonyl Parameters".

Set "Cartridge Parameters" to the following numbers:

Ch. 1 MFC Set Point: **.800 lpm**
Ch. 2 MFC Set Point: **.800 lpm**
Flow Leak Limit: **0.03 lpm**
Flow Tolerance: **0.05 lpm**
Data Write Interval: **5 min**
Site Label: **(Insert site name)**

Press **Set**.

NOTE: Model 2200 Mass flow controllers measure flow in Standard cc/min and L/min at 0°C and 1 atmosphere.

Installation of Carbonyl Cartridge

NOTE: Polyethylene Gloves should be worn whenever the DNPH-Carbonyl cartridges are being handled.

On the display screen select **Schedules** button. Change the date to the current date on the carbonyl cartridge Channel 1, change the start time to 5-minutes ahead of the current time, and leave the duration to 24-hour. Press **Exit**. The ATEC 2200 machine will begin to purge itself and then perform a leak check. Once this is complete the machine goes into sampling mode, disconnect the sample line and connect the BIOS Defender to the Channel 1 cartridge position on the exit side of the DNPH cartridge in the Carbonyl cartridge sample line. Initiate the flow using the manual control and measure local flow rate. Record the ATEC current flow in L/min.Std 0°C on the Carbonyl Cartridge Field Sheet (Appendix A, Form 1). Recording the average BIOS Defender flow rate in L/min local. Stop the BIOS Defender from taking reading and abort sampling on ATEC. NOTE: The ATEC is reading in Standard Conditions while the BIOS Defender is reading in Local. Therefore, it is necessary to take the barometric pressure and temperature readings to convert the local flow reading to Standard Condition Flow (0°C, 760 mmHg) using the following equation:

$$\text{Flow Rate Std (0°C)} = \text{Flow Rate}_{\text{Local}} \times \frac{P_{\text{site}}\ \text{mmHg}}{760\text{mmHg}} \times \frac{273°\text{K}}{(\text{Temp}_{\text{site}}°\text{C} + 273)}$$

This will give a comparison to the flow reading on the Model 2200. Record Standard BIOS Defender flow in L/min Std 0°C. If the percent difference is no greater than ± 2% between the ATEC and converted BIOS Defender reading then, with Polyethylene gloves on, attach the carbonyl cartridge to the appropriate Teflon sample line (Position 1 Sample/Position 2 Duplicate). Repeat this process for channel 2 if it is a duplicate sampling day. NOTE: If the percent difference is greater than ± 2%, a calibration will need to be performed. Instructions are in the ATEC Model No.2200 Operations and Maintenance Manual, pg. 40, Appendix A.

8.7.3 Perform Leak Checks/Setup.

Press SOP. A screen will appear. Select carbonyl(s) to run, and press Next to get to the Leak Screen. The instrument will run leak checks on any carbonyls that were selected in the first screen. Press Next to run the leak check. The carbonyl leak check will run for 20-seconds. Acceptance limit is set in Section 8.7.1. If leak rate is not met, connections on lock fittings should be checked and leak check re-run. If this does not solve the problem, ATEC should be contacted. Record all leak rates on the field sheets. Cartridge leak check will test the portion of the sample train from the closed upstream solenoid valves (SV1, SV2 & SV4) through the cartridge (C1 & C2), downstream solenoid valves (SV3 & SV5) and mass flow controllers (MFC1 & 2) on to the pump. See Figures 8-4 and 8-5 for details.

When the leak checks are complete, continue navigating through the SOP screens to schedule the next sample run. Enter start dates, start times, and durations of the carbonyls scheduled to run. Press Next after each carbonyl is scheduled to continue on to the next one. Upon completion, the SOP Summary Page will appear with a summary of everything scheduled to run. Confirm that the schedule is correct, and press Next. The instrument will return to the Main Screen. The status box for the carbonyls scheduled to run should say “waiting”.

NOTE: If a problem is recognized while performing any maintenance, diagnostic, or flow checks which has or could affect data, a corrective action form is to be filled out describing the problem identified and the action taken to correct the problem. See Appendix A, Form 3.

Figure 8-4: Model 2200 Flow Diagram

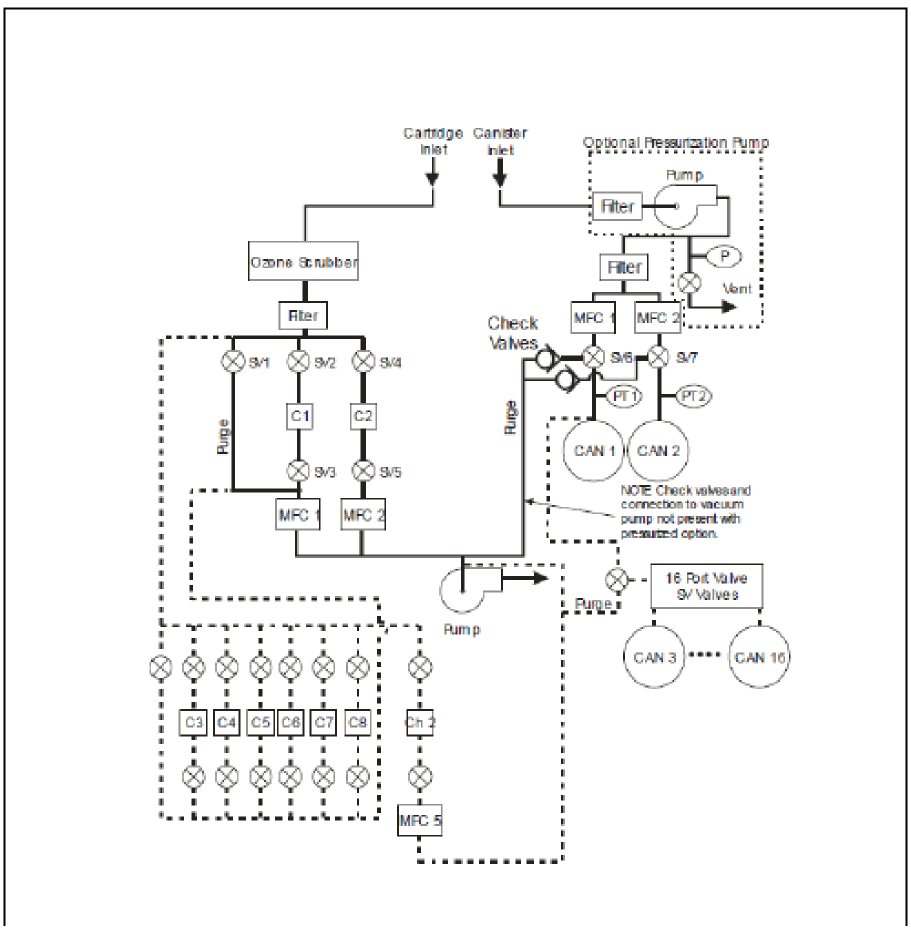
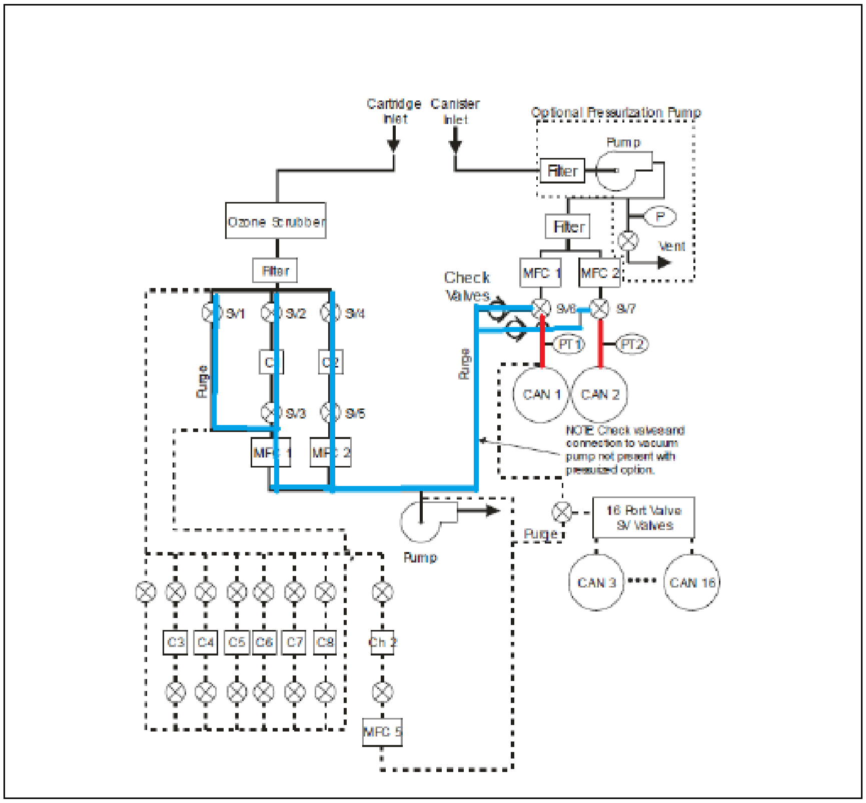


Figure 8-5: Leak Check Vacuum Train



Blue lines show sampling train under vacuum during cartridge leak check.

Sample Pickup Procedure

8.7.4.1 Downloading Data

Note: Data must be downloaded prior to proceeding with post-sampling checks. Otherwise, five minute data will be lost in the process.

Connect the USB Drive to the sampler's "Data" port on the front of the sampler. Press the **Data** button on the sampler. A screen will appear with the start date, stop date, flow, and time on it. Press the **Store** button on the sampler. When data transmission is complete, a screen will appear stating data was downloaded. Press **OK**. If during sampling a power failure occurs, the sampler will remain sampling according to schedule after power is resumed. No data should be lost, however on the downloaded data, a "power loss" error will show and there will be no data given for the powerless interval. For a 24-hour run, there will be approximately 300 lines of data. Figure 8-6 gives an example of the five minute data files.

Sample Carbonyl Download

Ch. 1 Cartridge

Started Saturday, January 07, 2017 0:00:04
Flow Rate Set Point 0.80 l/min
Stopped Sunday, January 08, 2017 0:00:23
Total Volume 1151.16 liters
Total Sample Time 24.00 hours
Average Flow Rate 0.800 l/min
Minimum Flow Rate 0.799 l/min
Maximum Flow Rate 0.800 l/min
Pre Start Leak Rate 0.010 l/min
Ending Leak Rate -0.003 l/min
Flow Controller Zero -0.004 l/min
Error Code 0
Error Status OK No Errors

Time	Flow Rate	Volume	Temp
Saturday, January 07, 2017 0:00:21	0.128	0.10	49.7
Saturday, January 07, 2017 0:05:24	0.800	4.13	50.1
Saturday, January 07, 2017 0:10:26	0.800	8.17	50.2
Saturday, January 07, 2017 0:15:29	0.799	12.21	50.1
Saturday, January 07, 2017 0:20:31	0.800	16.23	50.1

Cartridge Pickup:

- Record the recovery date on the sample custody sheet. Put 24 hours under “Sample Duration”.
- Record the post sampling Rotameter reading on the custody sheet.
- Record elapsed time.
- Check the actual data from the sampler versus what you expected the data to show to identify any mismatches.
- Remove the cartridge(s) and cap them with the provided caps.
- Place them in the RTI provided silver colored bags. Ensure that the washer is still in the black capsule.
- Record anything unusual that you may notice in the “Comments” section of the provided custody sheet. This may include instrument behavior, nearby emission sources, etc.
- Ensure that the custody sheet is fully filled in.
- When in the lab, calculate the average flow rate and total collection volume on the custody sheet as in the calculations section below.
- Store the sample at < 4ºC until shipping in the cooler, which should also be < 4ºC.
- This sample must be extracted for analysis within 14 days of sample collection, so ship the cooler out as quickly as possible.

Duplicate Samples:

- ERG will ship an extra sample for the collocated sampler.

Applicable AQS Codes for the chain of custody:

Site	AQS Code	Four Digit Site Code
Seattle 10th&Weller	05303300301	BKWA
Seattle Duwamish	05303300571	CEWA
Tacoma Alexander	05305300311	EQWA
Tacoma South L St	05305300291	ESWA
Tacoma South L St Collo	05305300292	ESWB
Tacoma S 36th St	05305300241	YFWA

Shipping:

- All samples from ERG will be shipped back to ERG in the same coolers with a postage paid FedEx return label included.
- Replacement cold icepack and max T logger will be placed prior to shipping.
- ERG does not accept shipments on the weekends, so **shipments must be sent Monday through Thursday only**. If it appears that shipment will not be picked up (too late), put the sample back in the refrigerator until the shipment can be made.
- In case of emergency, the lab address and phone contact is: Randy Bower, 919-468-7923, 601 Keystone Park Dr., Suite 700, Morrisville, NC 27560

Figure: QC Checks for carbonyl Sampler (Air Toxics Monitoring Quality Assurance Project Plan, WA DoE, 2020)

Procedure	Required Frequency	Acceptance Limit	Corrective Action
Leak check	Before every sampling event	Vendor specific	Identify leak and correct problem, flag data
Time clock	Before every sampling event	± 5 minutes of the reference time	Adjust time clock, note on data sheet
Flow check	Every 30 days	± 10%	Calibrate, flag data
Sampler Certification	Annual	Within certification due date	Send equipment back to ERG for re-certification
Replace ozone denuder	Annual	N/A	N/A
Clean/replace tubing to manifold	Annual	N/A	N/A

General Sampling Calendar:

If Sample run is on a:	Take out to field on:	Return from the field on:	Ship out with FedEx by 4:30PM on:
Monday	Friday	Tuesday	Tuesday
Tuesday	Monday	Wednesday	Wednesday
Wednesday	Tuesday	Thursday	Thursday
Thursday	Wednesday	Friday	Monday
Friday	Thursday	Monday	Monday
Saturday	Friday	Monday	Monday
Sunday	Friday	Monday	Monday

ERG

ERG Lab ID # ______

CARBONYL COMPOUNDS DATA SHEET

Lab Pre-Samp.

Site Code: ______ Collection Date: ______

City/State: ______ Cartridge Lot #: ______

AQS Code: ______ Duplicate Event (Y/N): ______

Field Setup

Set-Up Date: ______ Operator: ______ Sys. #: ______

Pre-Sampling Rotameter Reading (cc/min): ______ Elapsed Timer Reset (Y/N): ______

Field Recovery

Recovery Date: ______ Sample Duration (3 or 24 hr): ______

Post Sampling Rotameter Reading (cc/min): ______ Elapsed Time: ______

Cartridges Capped (Y/N): ______

Lab Recovery

Received by: ______ Date: ______ Refrigerator No: ______

Status: Valid Void (Circle one)

If void, why: ______

Sample Volume (total Liters): ______

PAMS

Sample Date	Sample Time	Sample Duration	Sample Volume	Cartridge Lot #	Sample ID	Lab ID

Comments: ______

White: Sample Traveler Canary: Lab Copy Pink: Field Copy

C. PUF Routine Sampling Procedure

Detailed procedures are outlined in the EPA TO method TO-13A. This is a description for regular field runs for PUF samplers.

ERG ships the required materials in a cooler to the PSCAA office. PSCAA then ships the collected samples back to ERG for analysis.

If there is an extra PUF sampling module available, the setup of the filter can be completed in the lab. Otherwise, the preparation needs to be done with the module in the field.

In summary, the field technician needs to go out to the field to setup the unit before the run. A technician then needs to go to the field to pick up the sample as quickly as possible after the run. The sampler runs every 6 days.

Setup of the Module:

- Setup a clean workspace. A work bench disposable cover is a good option.
- Open the contents of the ERG shipment.
- Disassemble the module.
- Put on nitrile gloves.
- Open the Petri-dish containing the quartz filter so that the filter is facing “up” (the more textured surface).
- Place the filter in the module with the 2 white Teflon gaskets on either side with the filter facing “up” on the module. Use the lab supplied tweezers for this step as they are cleaned for each use for this purpose. Avoid all contact of the filter with anything else. Secure the filter retaining ring and filter in place using the 3 plastic thumb screws. If the unit requires transport to the site, put on the module shield before tightening the thumb screws.
- Open the jar shipped from ERG with the glass PUF cartridge. Remove the aluminum foil and insert the cartridge into the lower chamber (frit on the bottom) and tightly screw the top and bottom of the module together.
- If assembled in the lab, cap the bottom with aluminum foil to avoid potential diffusion of semi-volatiles.

Module Installation into Sampler:

- Remove the foil from the bottom of the module if there is any.
- Place the module into the sampler and lower the 2 clamps to secure the unit.
- Inspect the exhaust hose and check to see if it is clogged or plugged.
- If the sampler is a duplicate sampler, make sure it is plugged in.
- Open the ball valve all the way open (arm pointing downward).
- Turn the unit on with the manual switch.

- Read the magnehelic gauge and record the result on the chain of custody sheet (an example chain of custody is at the end of this document). If there is no reading on the magnehelic gauge, make sure that the aluminum cap on the top of the filter was removed.
- Adjust the timer to the necessary start day at midnight using only PST (Pacific Standard Time - not daylight savings). Also set the timer to run for 24 hours.
- Record the start time on the timer on the chain of custody sheet.
- Turn the manual switch off.
- Make sure that everything is locked at the site, that samplers are shielded from rain.

Figure: The Module Assembly and Parts

Method TO-13A PAHs

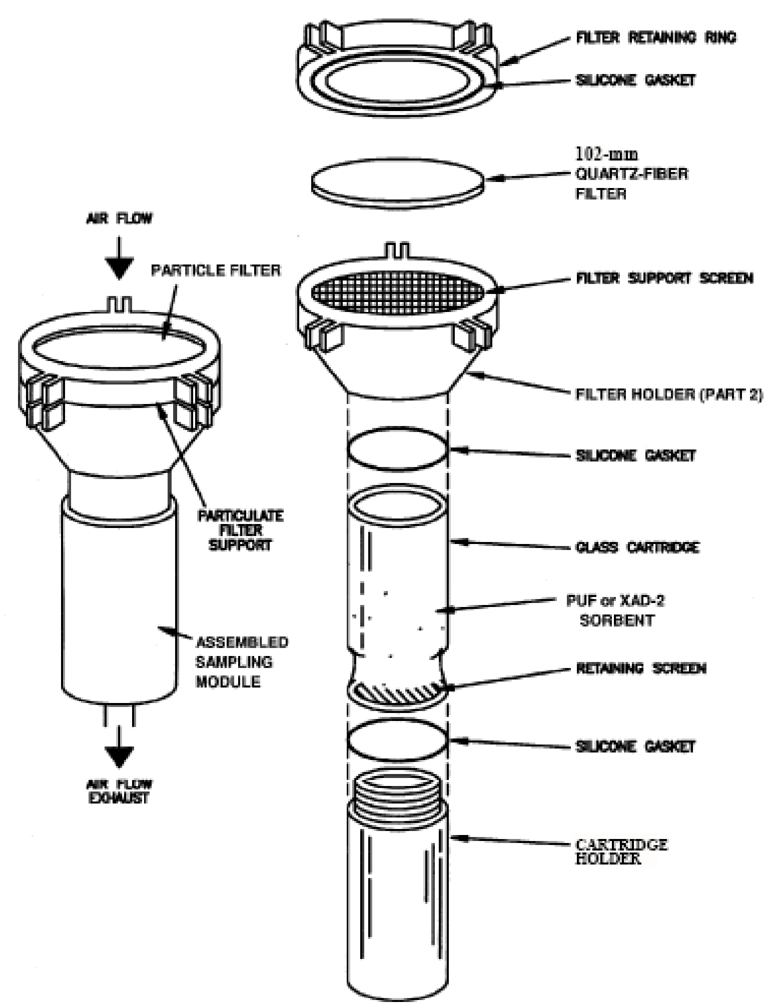


Figure 3. Typical absorbent cartridge assembly for sampling PAHs.

Module Pickup:

- Record the end sample time on the timer on the chain of custody sheet.
- Turn the unit on with the manual switch.
- Record the final magnehelic gauge reading.
- Turn off the unit with the manual switch.
- From a Partisol sampler nearby, retrieve the average pressure and average temperature for the sampling duration on the custody sheet. To retrieve the data:
    - Hit any button to “awake” the interface.
    - Press “Data”.
    - Then Press “More Data” 3 times and record the average temperatures and not the maximum 1-hour data.
    - Press “Esc” until the main screen appears.
- Record the recovery date on the custody sheet.
- Record anything unusual that you may notice in the “Comments” section of the provided custody sheet. This may include instrument behavior, nearby emission sources, etc.
- Remove the module and if being transported to the lab, cover the bottom with foil and cover the top with the aluminum plate. Try to keep the module in a cold, dark place until it is in the laboratory. Label the module for simplicity of processing in the lab.
- Call Mary before leaving the site.
- When in the lab, calculate the average flow rate and total collection volume on the custody sheet as below:

Calculations:

Flow Rate

$$Y5 = [\text{Average Magnehelic Reading } (\Delta H)\ (P_a/T_a)(T_{std}/P_{std})]^{1/2}$$

$$X2 = \frac{Y5 - B2}{M2}$$

where:

Y5 = Corrected average magnehelic reading
X2 = Instant calculated flow rate, scm

P_a = Average Pressure in mmHg
P_{std} = 760 mmHg
T_a = (Average Temperature in ºC + 273)
T_{std} = 298 K
B2 = Calibration Intercept
M2 = Calibration Slope

Total Collection Volume

$$V_{std} = \text{elapsed time} * X2$$

The B2 and M2 (calibration intercept and slope respectively) can be found at the site and PSCAA will have the original copy in their office. Calibrations are done with every motor replacement, which is done quarterly. PSCAA will provide you with these numbers for each site after any change.

Below are the current values (TBD):

Site	Sampler ID	M2 (Slope)	B2 (Intercept)
Seattle 10th&Well	tbd	tbd	tbd

Module Disassembly:

- Disassemble the top quartz filter first.
- Fold the filter with the particulate on the inside. Place the filter on top of the PUF/XAD inside of the thimble. Then, cover it with aluminum foil.
- Unscrew the bottom half of the module and remove the glass PUF cartridge, avoiding as much UV-light as possible. Put the thimble in the cooler.
    - Be careful not to ship the 2 white gaskets that retain the quartz filter to the lab.
- Cap the ends of the glass cartridge with the included Teflon caps. Then, wrap the cartridge in foil and put it in the provided bubble wrap, and put the wrapped cartridge into the plastic shipping jar.
- Store the sample at < 4ºC until shipping in the cooler, which should also be < 4ºC.
- This sample must be extracted for analysis within 14 days of sample collection, so ship the cooler out as quickly as possible.

Duplicate Samples:

- Once per month, ERG will ship an extra sample for the collocated sampler in Tacoma Alexander.
- Follow the routine procedures for this sampler but remember to plug in the unit on setup and unplug the unit for sample pickup. This will reduce unnecessary wear on the motor.

The sites will be decided after consultation with the community and appropriate AQS Codes will be used for the chain of custody.

Shipping:

- All samples from ERG will be shipped back to ERG in the same coolers with a postage paid FedEx return label included.
- All that is required is a replacement cold icepack prior to shipping.
- ERG does not accept shipments on the weekends, so **shipments must be sent Monday through Thursday only**. If it appears that shipment will not be picked up (too late), put the sample back in the refrigerator until the shipment can be made.

- If not already checked off, mark the shipping label as “Priority Overnight”.
- In case of emergency, the lab address and contact is: Randy Bower, 919-468-7923, 601 Keystone Park Dr., Suite 700, Morrisville, NC 27560

Figure: QC Checks for PAH Sampler (Air Toxics Monitoring Quality Assurance Project Plan, WA DoE, 2020)

Procedure	Required Frequency	Acceptance Limit	Corrective Action
Inspect electrical connections, check timers	Weekly	± 5 min (digital timer) and ± 15 min (mechanical timer) of reference time	Adjust time clock, note on data sheet
Flow check	Every 30 days	± 10%	Calibrate, flag data
Flow calibration	Initially, after motor maintenance, or if flow exceeds limit	± 10%	Calibrate
Clean sampling head, inspect gaskets	Every 30 days	N/A	N/A
Siting Verification	Annual	Neighborhood scale siting criteria	Notify Air Monitoring Coordinator if siting no long meets requirements
Calibration orifice certification	Annual	Within certification due date	Send orifice back to vendor for re-certification

General Sampling Calendar:

If Sample run is on a:	Take out to field on:	Return from the field on:	Ship out with FedEx by 4:30PM on:
Monday	Friday	Tuesday	Tuesday
Tuesday	Monday	Wednesday	Wednesday
Wednesday	Tuesday	Thursday	Thursday
Thursday	Wednesday	Friday	Monday
Friday	Thursday	Monday	Monday
Saturday	Friday	Monday	Monday
Sunday	Friday	Monday	Monday

ERG Lab ID #

SVOC SAMPLE DATA SHEET

Lab Pre-Sampling

Site Code: ____________ Collection Date: ____________

City/State: ____________ Collocated Event (Y/N): ____________

AQS Code: ____________

Field Setup

Site Operator: ____________ Sampler ID: ____________

Set-Up Date: ____________ Elapsed Timer Reset (Y/N): ____________

Collection Date: ____________

Batch I.D. No.: ____________

Batch Certification Date: ____________

Field Recovery

Collection System Information:

	Elapsed Time	Temp (°C)	Barometric ("Hg)	Magnehelic ("H_2O)	Flowrate (std. m^3/min)
Start					
End					
Average					

Total Collection Time (Minutes) ____________ Total Collection Volume (std. m^3) ____________

Lab Recovery

Received by: ____________ Date: ____________ Refrigerator No.: ____________

Status: Valid Void (Circle one)

If void, why: ____________

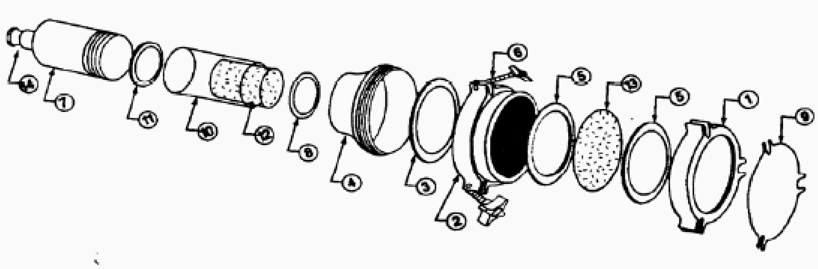
Comments: ____________

White: Sample Traveler Canary: Lab Copy Pink: Field Copy

Figure: Parts List for PUF Sampler

POLY URETHANE FOAM SAMPLER

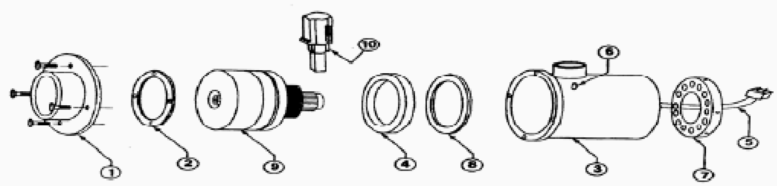
	TE-1000PUF	**P**oly Urethane **F**oam Sampler for Pesticide Particulate/Vapor. Includes anodized aluminum shelter, 4" particulate/vapor sampling module, flow venturi, blower motor assembly, Magnehelic® pressure gage, motor speed control/elapsed time indicator and 7-day mechanical timer. Complete system.	$2,645.00
	TE-1000-BL	**Brushless Poly Urethane Foam PUF system Same as TE-1000**	$3,525.00
	TE-1008-9-2.5	PUF 2.5 Dual Cyclone Kit	$1,650.00
	TE-1001	PUF Anodized Aluminum Shelter w/Gabled Roof	$780.00
	TE-1002	Particulate/Vapor Sampling Module less Glass Cartridge	$485.00
1)	TE-1008-1	4" Hold Down Frame	$60.00
2)	TE-1008-2	4" Filter Holder Body w/Stainless Steel Screens	$95.00
3)	TE-1008-8	Filter Holder Gasket (Silicone 4 1/2" OD)	$11.00
4)	TE-1002-2	Module Reducer	$140.00
5)	TE-1008-5	Teflon Gasket each (2 required)	$11.00
6)	TE-1002-14	Plastic Thumb Nut, Brass Bolt, Washer and S/S Bolt each (3 required)	$15.00
7)	TE-1002-3	Module Body	$150.00
8)	TE-1002-6	Upper Module Gasket (Silicone 2 7/8" OD)	$11.00
9)	TE-1008-9	Aluminum Cover for 4" Filter Holder	$17.00
10)	TE-1009	Glass Cartridge w/Stainless Steel Screens	$25.00
11)	TE-1002-8	Lower Module Gasket (Silicone 2 9/16" OD)	$11.00
12)	TE-1010	3" Long Polyurethane Vapor Collection Substrate, (unwashed) package of 10 "FR" free	$37.00
	TE-1011	2" Long Polyurethane Vapor Collection Substrate, (unwashed) package of 10 "FR" free	$26.00
	TE-1012	1" Long Polyurethane Vapor Collection Substrate, (unwashed) package of 10 "FR" free	$19.00
	TE-1014	PUF DISK 5 ½" Long X 1/2" thick, Use with TE-200 Passive Sampler	$6.00
13)	TE-QMA4	Micro-Quartz Filter Media 4" Round for PUF (100 per box)	$270.00
14)	TE-1002-4	Module Plug Coupler	$20.00
	TE-1008	4" Round Filter Holder Complete	$160.00
	TE-1003	Flow Venturi & Calibration Valve System	$285.00
	TE-1003-1	Quick-Disconnect (between floor flange and module)	$29.00
	TE-1003-1-1	Gasket for Quick Disconnect	$3.00
	TE-1003-4	Flow Venturi	$250.00
	TE-1003-6	Calibration Valve	$70.00
	TE-1005	Magnehelic® Pressure Gage (0-100" of water)	$122.00
	TE-5010	Motor Speed Voltage Control/Elapsed Time Indicator	$275.00
	TE-5010BL	Brushless Voltage control/ETI	$385.00
	TE-5007	7-Day Mechanical Timer	$197.00
	TE-1023	Exhaust Hose, 10 Ft. Length with Hose Clamp	$55.00
	TE-5040	PUF Calibration Kit w/Calibration Orifice, Slack-Tube® Manometer, NIST Traceable Calibration Certificate and Carrying Case.	$610.00
	TE-5040A	PUF Calibration Orifice Only w/ NIST Traceable Calibration Certificate and Tubing	$435.00
	TE-P-Recal	**Re-Calibration of Calibration Orifice for PUF System (Required Annually)**	$195.00



Tisch Environmental, Inc. – 145 South Miami Avenue, Cleves, OH 45002 U.S.A.
Tel: 513 467 9000 Toll Free: 877 263 7610 Fax: 513 467 9009 E Mail: sales@Tisch-env.com 2

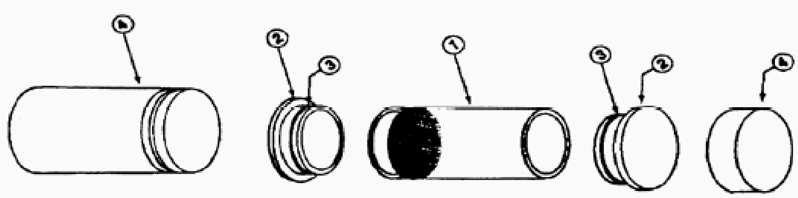
PUF BLOWER MOTOR ASSEMBLY

	TE-1004	PUF Blower Motor Assembly	$490.00
	TE-1004BL	Brushless PUF Blower Motor Assembly	$1,295.00
1)	TE-1004-1	Blower Motor Flange	$65.00
2)	TE-1004-2	Flange Gasket	$10.00
3)	TE-1004-3	Aluminum Blower Motor Housing with Integral Side Exhaust	$156.00
4)	TE-5005-4	Motor Cushion	$10.00
	TE-5005-4BL	Silicone Cushion, Use with Brushless Blower	$40.00
5)	TE-5010-4	Power Cord	$12.00
6)	TE-5005-8	Pressure Tap with Nut	$5.00
7)	TE-1004-7	Back Plate	$42.00
8)	TE-1004-8	Motor Spacer Ring	$14.00
9)	TE-116336	Motor for 110V PUF System	$97.00
	TE-116125	Motor for 220V PUF System	$112.00
10)	TE-33384	Motor Brushes (2 per set) for 110V Motor TE-116336	$9.00
	TE-33378	Motor Brushes (2 per set) for 220V Motor TE-116125	$10.50



GLASS CARTRIDGE AND TEFLON END CAPS

	TE-1009	Glass Cartridge w/Stainless Steel Screens	$25.00
2)	TE-1026	Teflon End Cap with Silicone "O" Ring each (2 required)	$23.00
3)	TE-1026-1	Silicone End Cap "O" Ring each (2 required)	$4.00
4)	TE-1027	Aluminum Screw Top Shipping Container	$19.00



MASS FLOW CONTROLLED PUF SAMPLING SYSTEM

TE-PNY1123	**Mass Flow** Controlled **PUF** PolyUrethane Foam Sampler. Includes 8" x 10" stainless steel filter holder with probe hole, 6" long spool piece, with endcaps, blower motor assembly, 8" well type manometer, 7-day mechanical timer, filter media holder filter paper cartridge, elapsed time indicator, mass flow controller with 20 to 30 SCFM air flow probe, and anodized aluminum shelter.	$3,450.00
TE-PNY1123BL	Same as above but BRUSHLESS	$4,950.00
TE-5004PNY	PNY Special Filter Holder to use with glass cartridge	$325.00
TE-1123-1	6" Long Spool Piece with end caps (To Hold Foam)	$398.00
TE-1123-2	Female End Cap (For Spool Piece)	$71.00
TE-1123-3	Male End Cap (For Spool Piece)	$71.00
TE-1123-4	Foam 3" by 3 3/8" Dia. Poly Urethane Vapor Collection Substrate (10 per pack)	$48.00
TE-1123-5	Glass Cartridge w/Stainless Steel Screens	$48.00
TE-1123-6	Foam 3" x 3" Dia. to fit Glass Cartridge (10 per package)	$48.00
TE-1123-7	Silicone Gasket to Fit Glass cartridge 2 ½" id x 2 3/8" od x 1/8"	$10.00
TE-1123-8	Silicone Gasket Between 8 x 10 and Glass 4" id x 2 ¾" od x 1/8"	$10.00

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D. The EPA 1 in 6 Sampling Calendar

2021-2022 1-in-6 Day Sampling Calendar

July '21

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

August '21

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

September '21

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

October '21

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

November '21

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

December '21

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

January '22

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

February '22

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28					

March '22

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

April '22

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

May '22

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

June '22

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

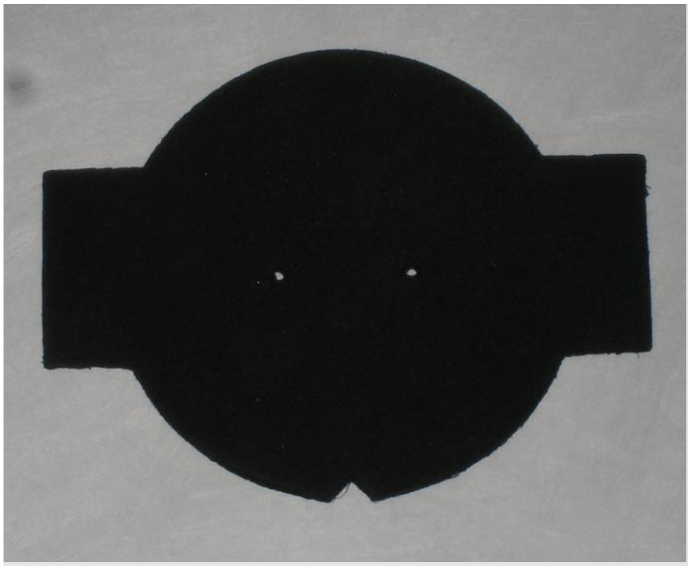
Sampling Day   Field Blank Sampling Day

E. AE-33 "7 Channel" Aethalometer Sampling Procedures

Instrument Settings
1. Time base: 1-minute (default), never 1-second
2. Max Attn: 120 (default)
3. Flow: usually 5 lpm (with BGI 1.829 cyclone for PM2.5)
4. Other settings (see setup file)
"DST off" is important, DateFormat=US
"Measure Time Stamp" = before
Recommend 1-minute "warmup" (default is 3)
Flow Standards for reporting data - Use EPA "STP" (25C) defaults are (70F or 21.1 C)
==> Settings are not saved until you start a run
Prompt to save changes

Operational Checks and the Leak Test / Flow Verification (LT/FV) Done Monthly:
1. Instrument date/time check/set: monthly and after power failure
SET clock monthly even if time is ok
Time may change on reboot
2. Tape visual inspection check: at least monthly (each LT/FV)
Look for neat, evenly grey, evenly spaced spots with sharp edges. Also: how much tape left?
. USB thumb drive data download: Use USB Key, and bring files back to the designated Folder.
Monthly - QC files can be useful (log [FVRF], FV, LT, setup, etc.)
Data/Export menu, enter date of last download
Thumb drive must not have other files on it
a ".exe" file in the root dir will cause the Aeth to stop
All data are stored internally (50 years' worth) on CF card

3. Perform Leak Test and Flow Verification together
Stop the AE33 by pressing OPERATION > STOP
Take the time to inspect and clean the sampling head, removing carbon, debris, or bugs from the cyclone.
CAUTION: DO NOT BLOCK THE INLET FOR A LEAK TEST, this will only shut down the variable pump.
Perform the wizard in the instrument for the LEAKAGE TEST.
Use flowmeter without pressure pulses (TSI-4100)
For all flow verification, leak test or flow verifications, remember to always re-enter 25C for the Temperature of the flow measurement. Also note that the flow is entered into the instrument in milliliters per minute, not LPM (so use 5100 mlpm for 5.1 LPM).
Follow the steps that the instrument provides to measure the flow through the filter, and then the flow through the FLOW PAD, (shown below).
Some leakage is normal: 7% filter "lateral" leak assumed and used in data calculations
AE33 Flow Pad: goes in with notch facing out towards you



(Picture of the LT/FV Pad)

Example of filter leak test report (LT*.dat file)

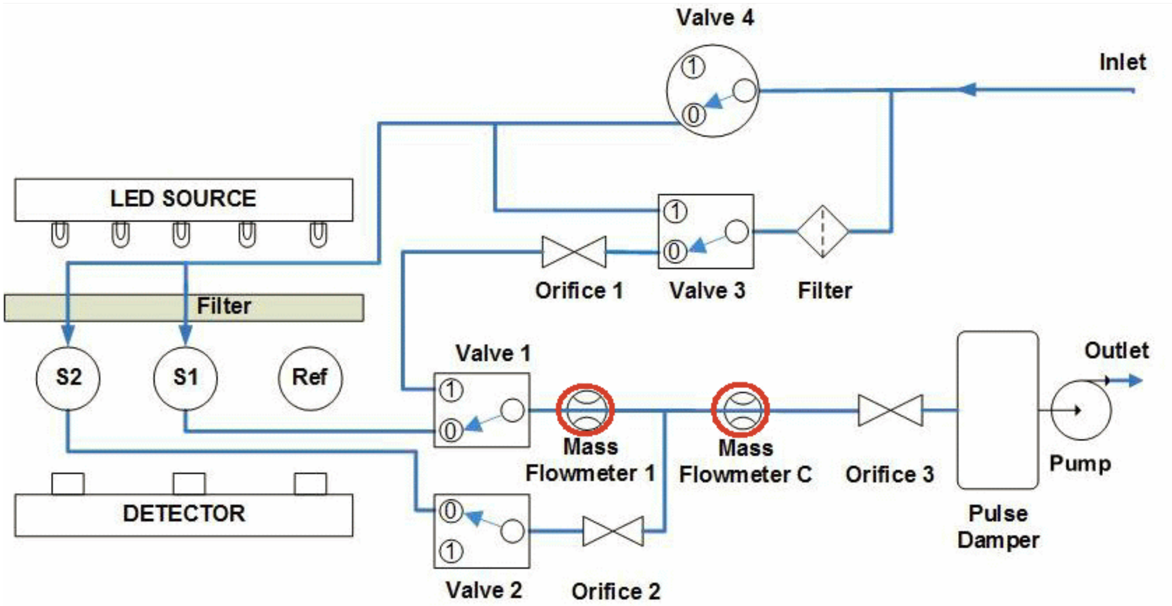
Manual leakage test report
Serial number: AE33-S02-00XXX
Date and time: 06 Mar 2015 10:12:15
Selected flow: 5000 mlpm
Flow through tape: 4920
Flow through calibration pad: 5140
Instrument leakage is: 4.3 %
Result should be ~3 to 7% and if you have leak > 10%: then take corrective action [new tape roll, mechanical problems]

AE33 Flow Check (If Flow calibration is needed, then follow procedures in the Magee Scientific Operator's Manual).

Once LT is complete, keep the Flow Verification Pad in the chamber, and then proceed onto the Wizard for the FV, which then happens at three flow levels.

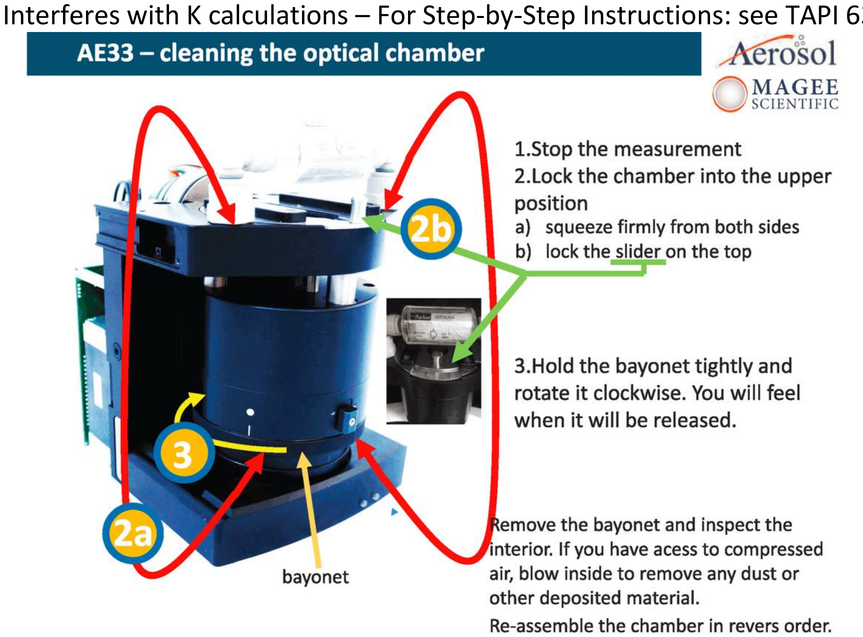
Example of AE33 / 633 Flow Verification result.
Fin" is external flow measurement (at the inlet)
F1" is flow for sensor 1 (higher loading)
Fc" is total ("control") flow, or "Flow 3" – controls the pump
Flow reporting standard: EPA 101325 Pa 25 °C
Fin F1 (%) Fc (%)
736 746 (101) 742 (101)
2470 2394 (97) 2387 (97)
4120 4190 (102) 4190 (102)

Explaining F1 and Fc: instrument flow diagram



=1 for flow cal (adjustable - sets F2/F1 ratio)
Note location of F1 and Fc flowmeters (in series for flow cal) - red circles
Fc is controlled to total flow set point
Spot 2 (Sensor 2) flow not measured directly (only used for K calc)

4. TAPE CHANGE. When you do a Tape change, then perform an Optical Chamber Clean according to the Magee Scientific Manual. (Or AS NEEDED).
About Every 3 months
AE33 / 633 Optical Chamber Cleaning - Easy, Important - AE33 is more sensitive to “stuff” in chamber
Interferes with K calculations – For Step-by-Step Instructions: see TAPI 633 Manual, section 5.6



Aethalometer Model 633 QC Check Data Sheet

Station #
Location:
Sampler #

Date: ______________
Time: ______________
Operator: ______________

Instrument S/N: ______________

Flow Standard Serial # ______________

- Certification Date: ______________

QC Check

1. Perform the leak verification prior to the flow verification.
2. Set any Temperature inputs to 25 degrees C.

Leak Verification:

Selected Flow		ml/m
Flow through tape		ml/m
Flow through calibration pad		ml/m
Instrument Leak is		%

7% leak is normal. Leak Action is >10%.

Manual Flow Verification:

Pressure	Temp	Fin	F1	%	F2	%
1013	25					
1013	25					
1013	25					

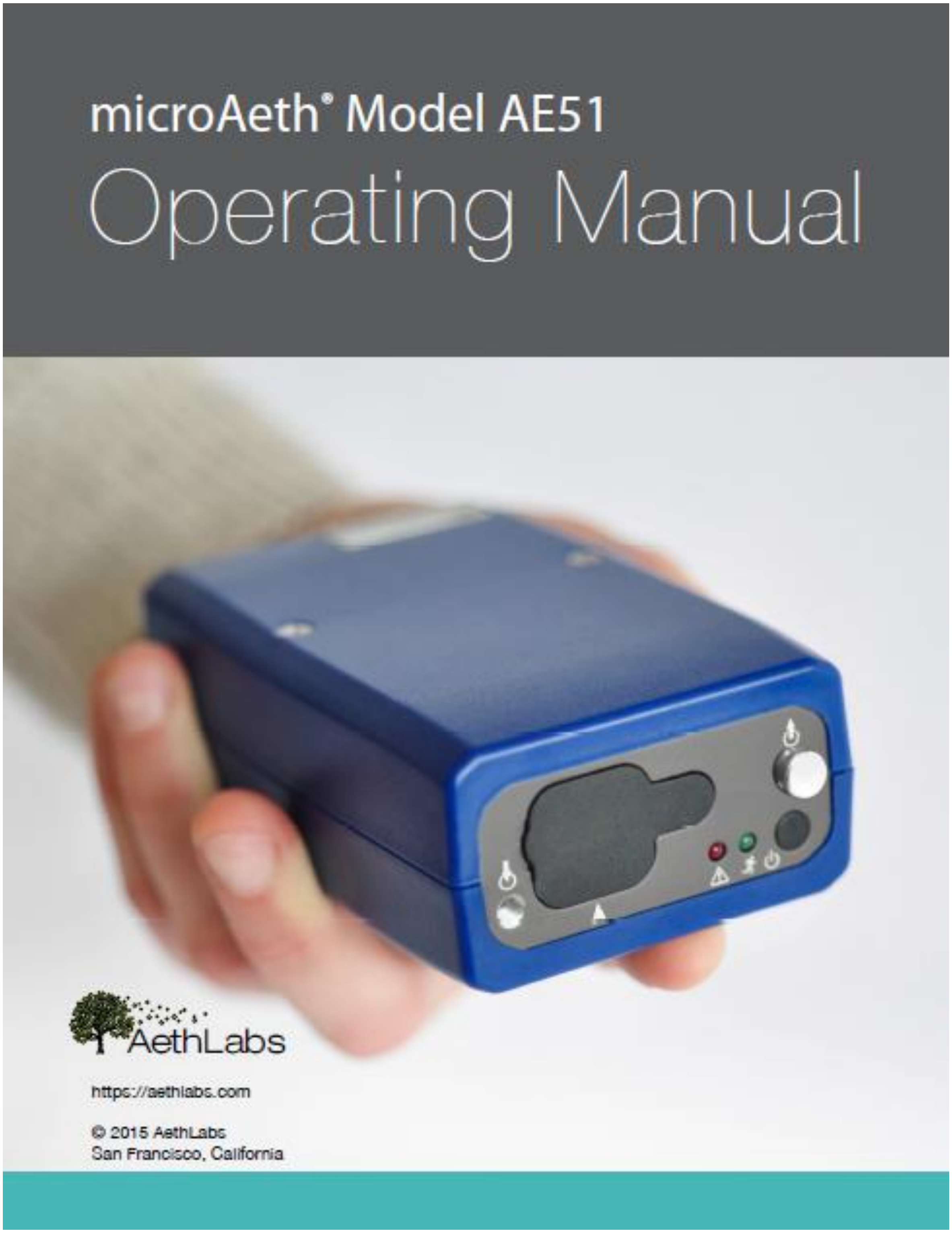
Normal Flow % is 95-105%. Flow Action is <95 or >105. Flow Invalidation is <90 or >110.

As Needed:

1. Assess the status of the tape and the spots on the tape.
2. If the tape needs to be changed, then perform both an Optics Clean procedure, and a Tape Change procedure.
3. The tape will need to be changed about once every quarter.

Notes:

F. AE-51 Micro Aeth Quick Start Guide



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1. INTRODUCTION

1.1 Serial Number

The model and serial number are located on the back panel. Record the serial number in the space provided below. Refer to these numbers whenever you call for service.

Model No.: microAeth® Model AE51
Serial number: AE51-S__-_____-______

1.2 Overview

Real-time Aerosol Black Carbon Personal Exposure Measurement Device

- Pocket-size, lightweight Aethalometer (250 g)
- Fast response: 1 second measurement timebase
- Low power consumption: 24 hour run time on one charge
- Onboard data processing, logging and diagnostics
- Flexible sampling options and wide dynamic range
- Filter strips for accurate sample tracking

The microAeth Model AE51 is designed specifically for investigation of personal exposure to carbonaceous particles found in ambient air. The instrument is based on Aethalometer technology that is widely used for studying indoor or outdoor air quality, and for the mobile mapping of the air quality impacts of localized sources. The instrument provides high quality, short time resolved data essential for assessing the real-time concentration of Black Carbon aerosols in a micro-environment.

The package includes:

- microAeth Model AE51 Personal Exposure Monitor
- Self-powered, LED source (880nm-IR), user-selectable measurement timebase settings of 1, 10, 30, 60, 300 seconds, flow rate settings of 50, 100, 150, 200 ml/min with internal active mass flow measurement and control
- Sample collected and analyzed on a filter strip consisting of a T60 Teflon coated borosilicate glass fiber media housed in a protective casing
- USB-based power charger with AC adapter (100-500mA) for internal 5VDC lithium ion battery.
- USB charging / interconnect cable
- Flexible conductive sample tubing (40 inches) with swivel tube connector
- Pack of 5 sample filter strips
- CD containing
  - microAethCOM communications software and USB driver
  - Operating Manual
- Quick Start Guide (hard copy)

For further information on this instrument or Black Carbon measurement, please contact:

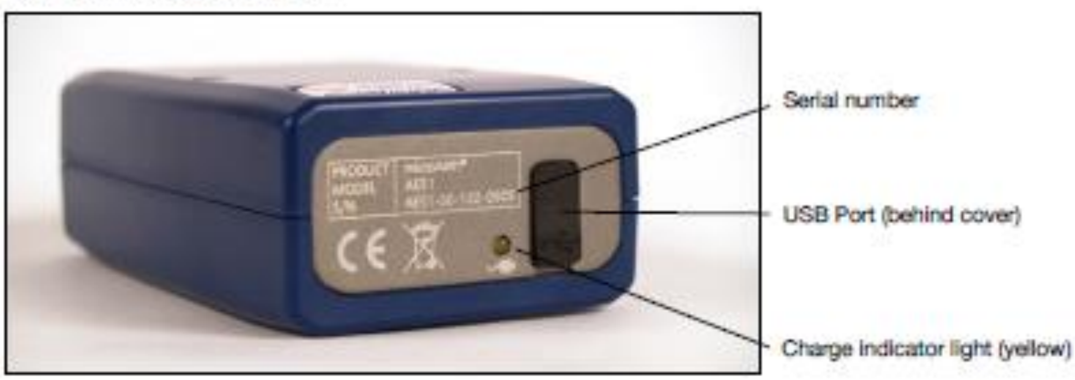
AethLabs
San Francisco, California
https://aethlabs.com

1.3 Instrument Diagram

Figure 2: Filter strip slot

Figure 1: microAeth front panel

Figure 3: microAeth rear panel



1.4 Technical Specifications

Measurement Principle
Real-time analysis by measuring the rate of change in absorption of transmitted light due to continuous collection of aerosol deposit on filter. Measurement at 880 nm interpreted as concentration of Black Carbon ("BC").

Measurement Range
0-1 mg BC/m³, filter life time dependent on concentration and flow rate setting:
avg. 5 µg BC/m³ for 24 hours @ 100 ml/min
avg. 100 µg BC/m³ for 3 hours @ 50 ml/min
avg. 1 mg BC/m³ for 15 minutes @ 50 ml/min

Measurement Resolution
0.001 µg BC/m³

Measurement Precision
±0.1 µg BC/m³, 1 min avg., 150 ml/min flow rate

Measurement Timebase (User setting)
1, 10, 30, 60, or 300 seconds

Flow Rate (User setting)
Internal pump provides 50, 100, 150, or 200 ml/min, monitored by mass flow meter and stabilized by closed-loop control.

Sampling
3 mm spot created on filter strip containing insert of T60 Teflon-coated borosilicate glass fiber filter material. PM2.5 size selective inlet available.

Consumables
Filter strip: 1 filter strip per sampling event, typically one per day. High concentration sampling may require more than one filter per day.

Data Storage
4 MB internal flash memory, providing up to 1 month data storage when operating on a 300 second timebase, and 1 week when operating on a 60 second timebase.

Communications
USB connectivity to Windows®-based PC with microAethCOM.

Data Output
Internal data files are uploaded to microAethCOM PC software and stored on local disk.

PC Software
microAethCOM software is included. Provides visual interface including real-time BC mass concentration values. Facilitates settings configuration, calibration routines, downloading data, and uploading new instrument firmware.

Dimensions
4.6 in (117 mm) L x 2.6 in (66 mm) W x 1.5 in (38 mm) D

Weight
Approximately 0.62 lbs (280 g).

Power
Internal rechargeable lithium-ion battery.

Power Supply Adapter
Input: 100~240 VAC 50/60 Hz 0.2 A
Output: 5VDC / 0.5A

Charging Time
4 hours to full charge (using AC adapter, instrument turned off).

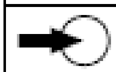
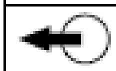
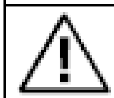
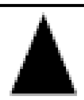
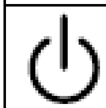
Total Run Time (Single battery charge)
Minimum 24 hours @ 300 second timebase at 100 ml/min flow rate. Run time may vary due to PM concentrations.

Operation Environment
0 ~ 40 °C operating, non-condensing.

Specifications are subject to change without notice.

1.5 Symbols and Cautions

1.5.1 Explanation Operation Symbols

	Operation indicator
	Charging indicator
	Aerosol inlet
	Aerosol outlet
	System alert indicator
	Filter strip orientation arrow (point indicates orientation of upstream face of filter strip)
	On/Off
	USB port

1.5.2 Important Safeguards

Please read these safety instructions completely before operating the instrument, and keep this manual for future reference. Carefully observe all warnings, precautions and instructions on the instrument, or as described in the operating manual and product literature.

Do not expose the microAeth or its batteries to sources of excessive heat such as sunshine or fire.

1.5.2.1 Power Source

The microAeth should be operated only from the type of power source indicated in the instrument specifications. If you are not sure of the type of electrical power supplied to your home, consult your dealer or local power company. For those devices designed to operate from battery power, or other sources, refer to the operating instructions. Also, the connections on both ends of the USB interface cable are designed to be inserted into the AC power/charger adapter or the microAeth only one way. These are safety features. If you are unable to insert the AC plug fully into the outlet, try reversing the plug. If the plug should still fail to fit, contact AethLabs.

1.5.2.2 Object and Liquid Entry

Never push objects of any kind into the AC power/charger adapter or into the microAeth (except for the filter ticket) through openings as they may touch dangerous voltage points or short out parts that could result in a fire or electric shock. Never spill liquid of any kind on the microAeth or its electrical accessories. This instrument should not be exposed to rain or moisture, and objects filled with liquids, such as vases, should not be placed on this instrument.

1.5.2.3 Accessories

Do not use accessories not recommended by the manufacturer, as they may cause hazards.

1.5.2.4 Servicing

Use extra care when servicing the instrument yourself as opening or removing covers exposes sensitive internal hardware to potential damage. Refer to all service documentation and trained, authorized service personnel for assistance.

1.5.2.5 Replacement Parts

Only genuine AethLabs parts should be used in the microAeth. Only trained, authorized service personnel should make repairs or install replacement parts.

Lithium-Ion batteries are recyclable and should be disposed of properly. **Caution:** Do not handle damaged or leaking Lithium-Ion batteries.

2. CONFIGURATION AND OPERATION

2.1 Overview

The AethLabs microAeth® Model AE51 is a high sensitivity, miniature, portable instrument designed for measuring the optically-absorbing Black Carbon ('BC') component of aerosol particles. The instrument is based on the well-established Aethalometer principle used for over 30 years in laboratory-sized analyzers.

The microAeth draws an air sample at a flow rate of 50, 100, 150 or 200 ml/min through a 3 mm diameter portion of filter media. Optical transmission through the 'Sensing' spot is measured by a stabilized 880 nm LED light source and photo diode detector. The absorbance ('Attenuation, ATN') of the spot is measured relative to an adjacent 'Reference' portion of the filter once per timebase period. The gradual accumulation of optically-absorbing particles leads to a gradual increase in ATN from one period to the next. The air flow rate through the spot is measured by a mass flow sensor which is also used to stabilize the pump. The electronics and microprocessor measure and store the data each period to determine the increment during each timebase. This is then converted to a mass concentration of BC expressed in nanograms per cubic meter (ng/m^3) using the known optical absorbance per unit mass of Black Carbon material.

The instrument's operating parameters are set up by an external software application (microAethCOM) and uploaded to the microAeth by a USB interface cable. Operation is completely automatic after the instrument is switched on. During operation, the microprocessor performs the optical measurements, measures and stabilizes the air flow, calculates the BC mass concentration and records data to internal non-volatile memory. The data may be downloaded at a later time by the same external software package.

The microAeth derives its power from an internal rechargeable battery. The same USB interface cable serves to recharge the battery from either the USB port of a connected external computer, or an AC power supply. The instrument will operate for 6 to 24 hours on a single charge, depending on operational settings.

2.2 Recommendations for Best Use Practices

The small size and light weight of the microAeth® Model AE51 allow it to be used to gather data in a wide range of operational scenarios, not always possible using larger instruments. Optimization of performance across this breadth of applications requires an understanding of operational settings, precautions, and maintenance procedures. The following recommendations provide general guidelines.

2.2.1 Instrument Settings: Measurement Timebase and Flow Rate

In order to get the best data from the microAeth for the sampling campaign, we highly recommend that the **instrument warm up for approximately 10-15 minutes** so that it can equilibrate to its environment. The microAeth can aquire data on five timebase settings: 1, 10, 30, 60, and 300 seconds. The 1 second timebase should only be used under special circumstances where a decreased signal-to-noise ratio is acceptable. At this setting, instrumental noise is larger and typically requires post-processing. The microAeth pump can operate at four sampling flow rate settings: 50, 100, 150, and 200 ml/min. The choice of these parameters affects the operation and data as follows.

Battery Run Time on Single Charge: Affected by flow rate and timebase.

NOTE: Battery life will gradually diminish after many cycles (~ 1 year of use). The following are approximate runtimes which can vary based on individual microAeth instruments and specific environments.

	50 ml/min	100 ml/min	150 ml/min	200 ml/min
1 second	> 21 hours	> 18 hours	> 14 hours	> 12 hours
10 seconds	> 21 hours	> 19 hours	> 15 hours	> 12 hours
30 seconds	> 23 hours	> 19 hours	> 15 hours	> 13 hours
60 seconds	> 28 hours	> 24 hours	> 20 hours	> 15 hours
300 seconds	> 30 hours	> 24 hours	> 21 hours	> 15 hours

Individual Data Point Noise: At 150 ml/min, primarily affected by timebase setting.

1 second	60 seconds	300 seconds
< 5 ug/m³	< 0.1 ug/m³	< 0.05 ug/m³

Effects of Contamination, Vibration, and Impact: Primarily affected by timebase setting.

1 second	10 seconds	30 seconds	60 seconds	300 seconds
very large	large	moderate	moderate	least effect

2.2.2 Recommended Settings of microAeth® Model AE51 for Different Scenarios

Different Black Carbon measurement scenarios require different operational settings for optimum performance. The 1 second timebase setting is a 'Data Acquisition Mode' intended for subsequent processing, and should NOT be used for routine monitoring. Data collected on a 1 second timebase should always be smoothed or averaged over longer periods, in order to optimize the signal-to-noise ratio at the desired time resolution.

	Longest ←	Filter Life		→ Shortest
	50 ml/min	**100 ml/min**	**150 ml/min**	**200 ml/min**
1 s	'Data Acquisition Mode' for immediate emissions and impacts at high concentrations.	'Data Acquisition Mode' for emissions and impacts in typical urban and traffic environments.	'Data Acquisition Mode' for higher time resolution at lower BC concentrations.	'Data Acquisition Mode' for higher time resolution at lower BC concentrations or shorter sampling durations.
10 s	Traffic and transporation impacts in high BC concentrations.	Traffic and transporation impacts.	Traffic and transporation impacts at lower BC concentrations.	Traffic and transporation impacts at lower BC concentrations.
30 s	Personal Exposure Monitoring in high BC concentrations. Occupational Exposure.	Recommended Setting for General Applications. Personal Exposure Monitoring. Traffic impact. High time resolution ambient monitoring.	Personal Exposure Monitoring. Traffic impact. High time resolution ambient monitoring.	Personal Exposure Monitoring. Traffic impact. Ambient monitoring. Higher sensitivity for low BC concentrations.
60 s	Personal Exposure Monitoring. Occupational Exposure. High BC concentrations.	Personal Exposure Monitoring. Indoor Air Quality.	Personal Exposure Monitoring. Indoor Air Quality. Low BC concentration.	Personal Exposure Monitoring. Higher sensitivity for low BC concentrations.
300 s	Epidemiology. Area monitoring. Indoor air quality. High BC concentration.	Epidemiology. Area monitoring. Indoor air quality.	Epidemiology. Area monitoring. Indoor air quality. Low BC concentration.	Epidemiology. Area monitoring. Indoor air quality. Lowest BC concentration. Lowest data noise.

2.2.3 Contamination, Maintenance & Cleaning of Sample Chamber

If a loose particle of contamination enters the microAeth's sample chamber or the instrument experiences vibration or impact, the data will be degraded. Shaking or tapping a "dirty" instrument will create data excursions that are far larger than those of a "clean" unit. These effects are amplified greatly at the shorter timebase settings. Our recommendations for cleaning are based upon the likelihood of contamination and the nature of use.

Contamination Probability for Various Use Scenarios

Sampling Scenario	Contamination Probability
Dry, dusty environment	High
Occupational settings with combustion exhaust	High
Exposure to "oily" smokes such as biomass-burning plumes, 2-cycle engine exhaust	High
Presence of suspended fluff, fibers, pollen	High
Immediate vicinity of traffic and roadways	Medium
Outdoor urban environments	Medium
Outdoor rural environments (without dust, fluff, pollen)	Low
Residential indoor environments	Low

Recommended Hours of Operation Between Cleaning & Maintenance

Sampling Scenario	Contamination Probability		
	High	**Medium**	**Low**
Mobile sampling with impacts: on person or in vehicle	100	200	400
Mobile sampling on cushioned support	150	300	500
Stationary sampling, relocated during operation	500	800	1200
Stationary sampling, not moved during operation	800	1200	2000

NOTE: If a microCyclone™ is being used with your microAeth, please clean it on a frequent basis, depending on sampling environment and concentrations.

2.3 Filter Media

IMPORTANT NOTE:

- **Always make sure that a filter strip is installed in the microAeth when it is operating.**
- **Whenever the filter strip is exchanged, the microAeth should be turned off to prevent dust or debris from being drawn into the inlet and analysis chamber.**

2.3.1 General

The sample collection and analysis is performed on a filter strip, consisting of a small section of filter material held between and supported by a specially designed filter holder to create the filter strip assembly. As the aerosol sample is drawn through the filter media by the instrument's integrated, internal sample pump, the aerosol sample collects gradually on the filter medium to create a gray spot 3 mm in diameter. The microAeth determines the attenuation of the source light as the accumulated black carbon increases the optical density of the filter spot. After the optical density reaches a certain level, the filter strip must be replaced to maintain measurement integrity.

To maintain a leak-free sample path, the filter strip is clamped between two halves of the spring-loaded sampling head. A release button opens the clamp to allow the filter strip to be inserted and removed. A locating pin in the head engages in a matching hole in the filter strip holder to ensure correct placement.

2.3.2 Filter Strip Installation and Removal

1. The sample deposit side of the filter strip is the white side. When the filter strip is installed in the sample chamber, the white side of the filter strip should be facing the same direction as indicated by the white arrow on the faceplate of the microAeth.

Figure 5: Top of microAeth

Figure 6: Bottom of microAeth with filter strip release button.

Figure 7: White sample deposit side of filter strip faces the top.

Figure 8: Metal side of filter strip faces the bottom.

2. Hold the microAeth in one hand so that the filter chamber release button is on the bottom of the enclosure (Figure 9) (all of the icons will be right side up).

3. Loosen the rubber cover on the front of the microAeth by pulling the tab away from the instrument. This will expose the filter strip slot.

Figure 9: Inserting and removing filter strip while depressing filter release button on bottom of microAeth.

4. If there is a filter strip already installed, depress the release button with your thumb and pull the filter strip out of the sampling head.

5. Install a new filter strip by pressing and holding the release button and then inserting the new filter strip into the sample chamber opening with the white plastic side facing up (Figure 9).

6. Make sure to push the new filter strip all the way into the slot and that the locating pinhole on the filter strip is not visible.

7. Release the release button and verify the locating pin has registered properly in the filter strip locating hole.

8. Replace the rubber cover. A tight fit is essential to prevent the entry of contamination and stray light into the sample chamber.

2.4 Power

The power switch is located on the front panel of the instrument. There are two options for recharging:

- USB to PC-USB port (500mA): 4 hours to full charge
- USB to AC-USB wall adapter (500mA): 4 hours to full charge.

The instrument uses a USB-based power charger (100-500mA) for internal 5VDC lithium ion battery. The yellow charging light illuminates when the microAeth is connected to an external power source and is recharging the battery. When the battery is fully charged, the yellow light turns off.

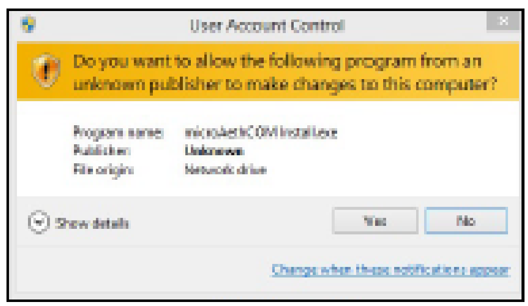
2.5 microAethCOM PC Software Installation

The microAethCOM software application is designed to install and operate on a PC using Windows® XP with Service Pack 3, Windows® 7, and Windows® 8. All software components are included in the installer named microAethCOM Install.exe which is located on the CD included with the microAeth or can be downloaded from the AethLabs website. This installer will install the microAethCOM, manual flow calibration software and the firmware file.

1. Do not connect the microAeth to the USB port on the computer until the software installation is complete.

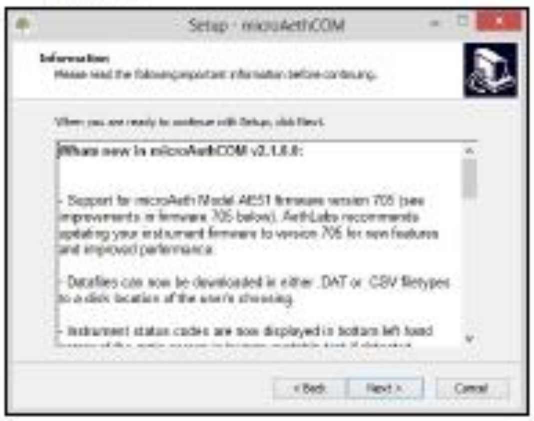
2. Make sure that you have the necessary user privileges on your computer to install software.

3. Locate and double click microAethCOM Install.exe to start the install. The installer will prompt you through the setup.

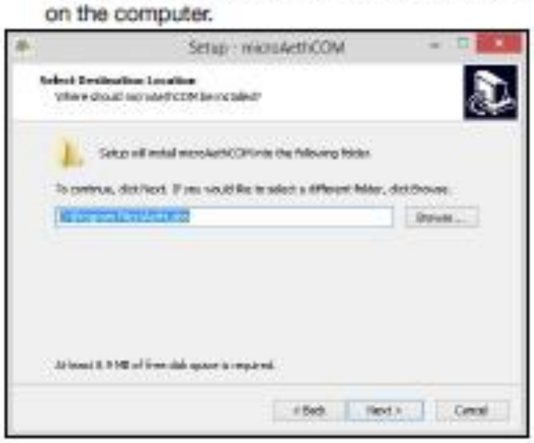


4. In order to install the microAethCOM software, please read and accept the license agreement.

5. Please review changes to microAethCOM and firmware.



6. Select the directory location where microAethCOM, manual flow calibration software and the firmware file should be installed on the computer.



7. The communication drivers will need to be installed next. The installer will prompt you through this section of the setup.

8. Once all the correct drivers are installed, the setup will be complete.

2.6 Operation and Communication

Before starting a sampling run, it is recommended that the user verify all parameter settings. A description of each operating parameter and its configuration is described in section 2.6.2 Configuration of Instrument Operating Parameters.

The microAeth startup sequence automatically begins when the power is turned on. Sampling and data collection begin starting the next minute after the startup process is complete. A new measurement data file is created for the new sampling session. The microAeth will continue sampling and storing data until the instrument is shutdown. At shutdown, the data file is closed. Any active sampling session and data file will also be closed if data is downloaded or erased or if settings are saved to the microAeth. In order to start a new sampling session, the microAeth must be restarted.

Status indicator lights located on each end panel of the microAeth provide information regarding the instrument operating status. Please read section 2.6.8.1 LED Status Indications for more information.

2.6.1 microAeth Operation

IMPORTANT NOTE:

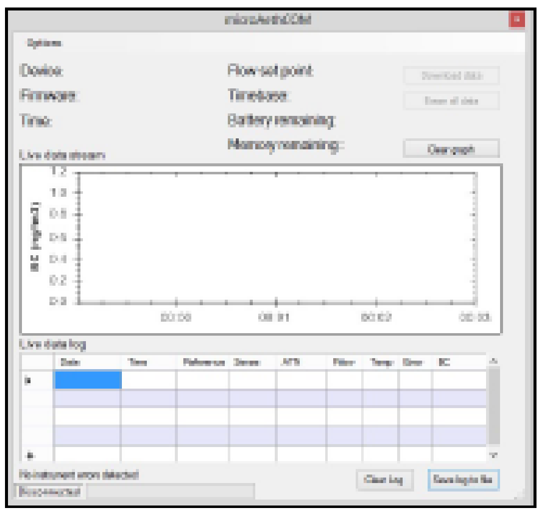
- **Always make sure that a filter strip is installed in the microAeth when it is operating.**
- **Whenever the filter strip is exchanged, the microAeth should be turned off to prevent dust or debris from being drawn into the inlet and analysis chamber.**
- **A new sampling session and data file is created each time the microAeth is turned on and completes the automatic startup sequence.**
- **Any active sampling session and data file will be closed if the microAeth is shutdown, data is downloaded or erased, or if settings are saved to the microAeth. In order to start a new sampling session, the microAeth must be restarted.**

1. Make sure that a filter strip is installed in the microAeth. Turn on the microAeth by depressing the power button for 4 seconds until the microAeth beeps for the second time and the red and green LEDs illuminate together.

2. Release the power button and wait for a few seconds. The pump will turn on and the LEDs will then begin to blink on and off in unison about every second until the beginning of the next minute. When the LEDs stop blinking, the instrument will chirp indicating the start of data collection.

3. While the unit is operating, the green LED will blink periodically. If the unit is set to store data to its internal memory, the green LED will emit single blinks every few seconds. If it has been set to store data internally and stream data, the green LED will blink twice every few seconds.

4. Start the microAethCOM software.

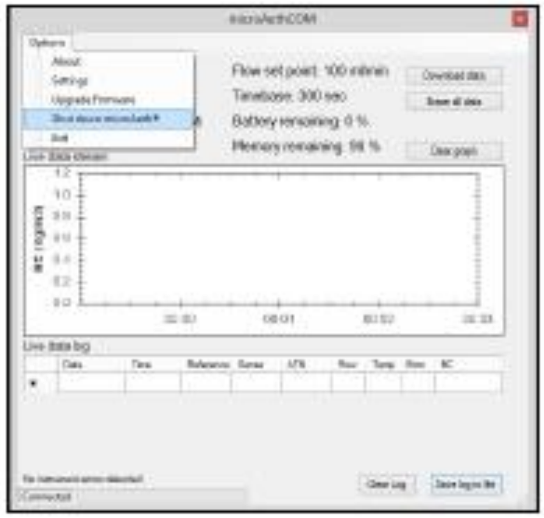


5. Connect the USB cable to the microAeth and your computer.

6. After the microAeth establishes communication with the microAethCOM software, the connection status in the bottom left corner of the main screen will change to Connected and the microAeth serial number, status, and settings will be displayed.

7. If the serial number, status, and settings are not displayed, disconnect the USB cable and reinsert it.

8. To shut down the microAeth through the microAethCOM software, click Options then Shut down microAeth. Depending on the current settings of the microAeth, the power button on the front of the instrument can be used to shut down the instrument.



2.6.2 Configuration of Instrument Operating Parameters

IMPORTANT NOTE:

- **The microAeth will not collect data with new saved settings until it has been restarted.**

All instrument parameters are configured through the microAethCOM user interface. The various parameters are accessed through Settings in the Options menu on the tool bar.

1. Turn on the microAeth.

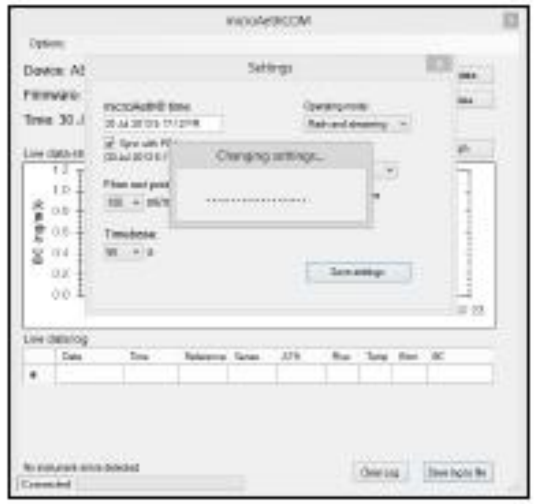
2. Start the microAethCOM software.

3. Connect the USB cable to the microAeth and the computer. Wait until the microAeth establishes communication with microAethCOM.

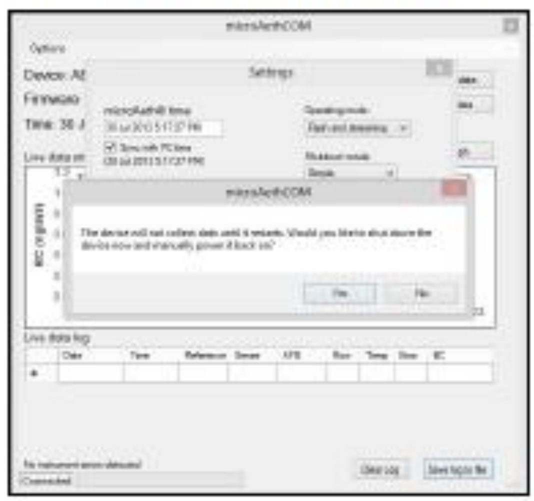
4. Click Options then Settings

5. On the Settings screen, the microAeth can be configured.

6. When all settings are selected as desired, click the Save settings button.



7. Once the settings have been saved, you will be prompted to shut down the microAeth. **The microAeth will not collect data with the new saved settings until it has been restarted.**



2.6.2.1 microAeth Time & Time Sync

The time on the microAeth is displayed. In order to sync the time on the microAeth with the PC time, click the Sync with PC time check box.

It is very important to confirm the date and time of the PC prior to synchronizing to the microAeth. Once confirmed, it is good operating practice to always synchronize the date and time when configuring the microAeth before starting a new sample session.

2.6.2.2 Flow Set Point

The flow set point permits the user to select a flow rate set point of 50, 100, 150, or 200 ml/min.

We recommend using lower flows in areas with high BC concentrations, and higher flow rates when maximum sensitivity is required in areas of low BC concentration. A lower flow rate should also be selected for longer run times and extended battery life. Please read section 2.2 Best Use Practices Recommendations for more information.

2.6.2.3 Timebase

The timebase permits the user to select an analysis timebase period of 1, 10, 30, 60, or 300 seconds.

We recommend 30 or 60 seconds for most 'human exposure' or 'ambient monitoring' use. Faster timebases will result in higher noise on each measurement point, and are most useful either for direct source monitoring (tailpipe analysis) or for other applications requiring extremely rapid data. A 300 second timebase can be used to extend battery life and run time. Please read section 2.2 Best Use Practices Recommendations for more information.

2.6.2.4 Operating Mode

The operating mode permits the user to configure data storage and streaming options.

- **Store to flash** saves data to the internal memory only.
- **Flash and streaming** saves data to the internal memory and outputs a continuous data stream through the USB port.

2.6.2.5 Shutdown Mode

The shutdown mode permits the user to configure how the instrument is shutdown.

- **Simple** mode will allow the microAeth to be shut down by depressing the power button for 3 seconds.
- **USB only** mode will only allow the microAeth to be shut down using the microAethCOM software.
- **Secure** mode will allow the microAeth to be shut down by pressing and releasing the power button three times in succession. The smoothly-timed sequence is coordinated by a simultaneous beep and blink of the red and green LED indicator lights.

Each cycle of the Secure mode takes about 1 second as follows:

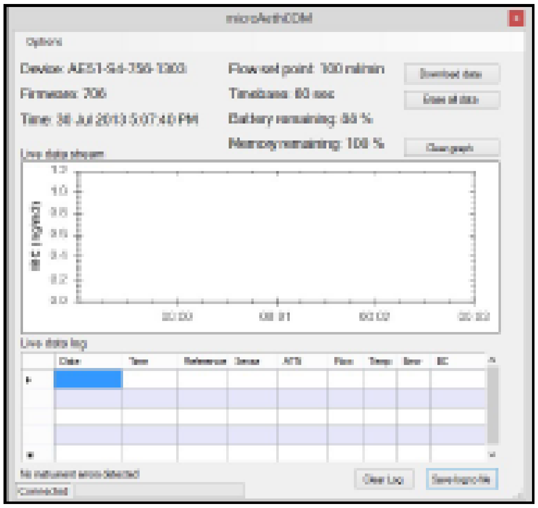
1. Press and hold the power button.
2. When you hear/see the first 'beep/blink' release the button quickly.
3. When you hear/see the next 'beep/blink' quickly press and hold the power button.
4. When you hear/see the next 'beep/blink' release the button quickly.
5. When you hear/see the next 'beep/blink' quickly press and hold the power button.
6. When you hear/see the next 'beep/blink' release the button quickly.
7. The microAeth will then shut down.

2.6.2.6 Sound Notifications

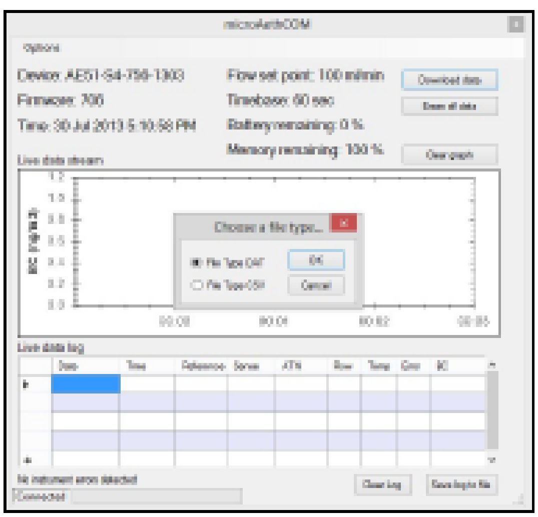
The sound notifications setting permits the user to select if the audible notifications issued by the microAeth are turned On or Off.

2.6.3 Downloading Data

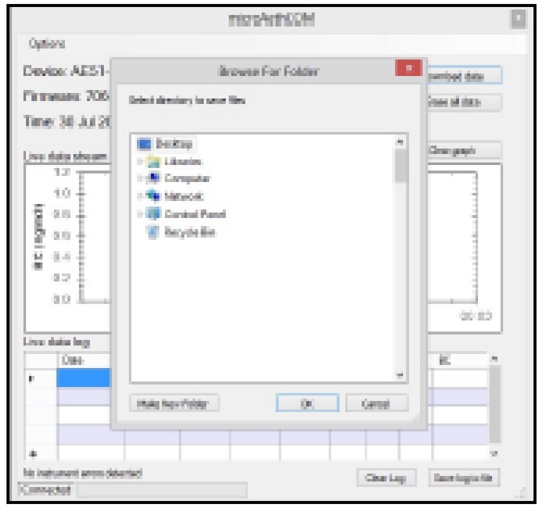
1. Turn on the microAeth.
2. Start the microAethCOM software.
3. Connect the USB cable to the microAeth and the computer. Wait until the microAeth establishes communication with microAethCOM.



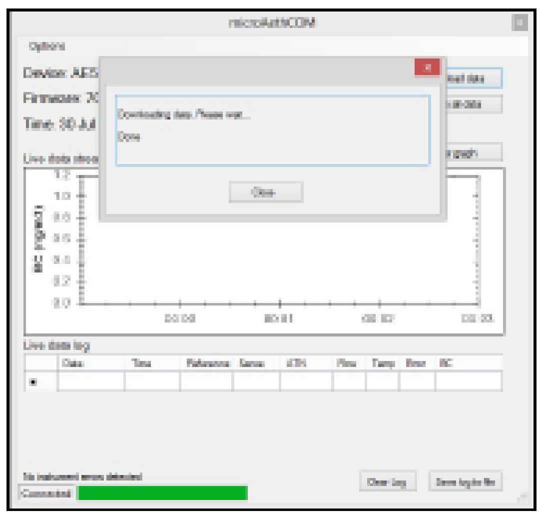
4. Click the Download data button to download the data stored on the internal memory of the microAeth.
5. Select .DAT or .CSV data file type to download.



6. Select the directory to save the data. The data will be saved in a folder named **AE51-SX-XXX-YYMM** in this directory.



7. Wait until the download has completed. The progress bar in the bottom left corner of the main screen will show you the progress of the download. The status window will also inform you when the download is complete.

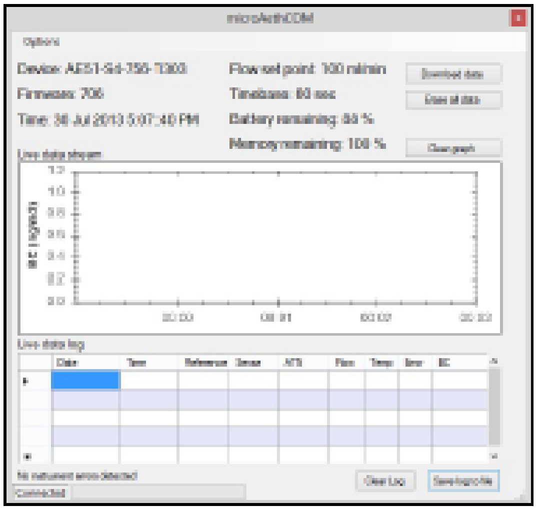


2.6.4 Erasing Data

1. Turn on the microAeth.

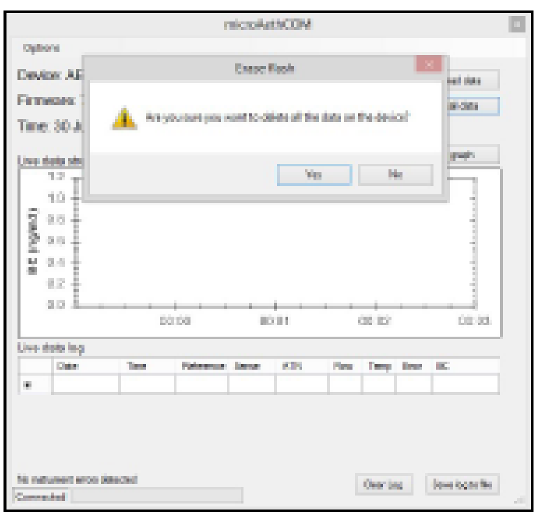
2. Start the microAethCOM software.

3. Connect the USB cable to the microAeth and the computer. Wait until the microAeth establishes communication with microAethCOM.



4. Click the Erase all data button to erase all the data stored on the internal memory of the microAeth.

5. You will be prompted to confirm to erase all the data stored on the microAeth.



6. Wait until the data erase has completed. The status window will show that the memory is being erased.

7. The status window will disappear when the memory has been erased.

2.6.5 Viewing and/or Analyzing Measurement Data

Data files are named using the following naming convention: AE51-SX-XXX-YYYYMMDD, where XXX is the instrument unique indentifer number. Data files are formatted such that they can be imported directly into Microsoft Excel® or can be uploaded to the AethLabs website. Please note that when opening data files in Microsoft Excel®, formatting may automatically be changed, making it difficult to upload to the website.

2.6.6 Data File Structure

The data files are plain text with the extension .dat or .csv. The file consists of a header containing descriptive information; a line identifying the columns; and then a number of data lines with each item separated by a semicolon or comma depending on the file format chosen at the time of download.

An example of the header is:

"Delimiter = ;"
AethLabs
Device ID = AE51-S4-558-1204
Application version = 2.2.4.0
Flow = 100 ml/min
Timebase = 60 s
Start date = 2015/05/07
Start time = 18:10:00
Original date format = yyyy/MM/dd
Original time format = hh:mm:ss
Flow units = ml/min
PCB temp units = deg C
Battery units = %
BC units = ng/m^3

Date;Time;Ref;Sen;ATN;Flow;PCB temp;Status;Battery;BC

The first line of data does not contain the final BC calculation; all subsequent lines show this expressed in units of ng/m^3 of BC. A typical excerpt of data lines is shown below:

2015/05/07;18:10:00;922087;869206;5.906;100;30;0;74;
2015/05/07;18:11:00;922264;869322;5.912;100;30;0;74;332
2015/05/07;18:12:00;922279;869287;5.917;100;29;0;74;321
2015/05/07;18:13:00;922294;869215;5.927;100;29;0;74;563
2015/05/07;18:14:00;922301;869151;5.935;100;29;0;73;461
2015/05/07;18:15:00;922399;869175;5.943;100;29;0;73;447
2015/05/07;18:16:00;922409;869110;5.952;100;29;0;73;486
2015/05/07;18:17:00;922388;869037;5.958;100;28;0;73;348
2015/05/07;18:18:00;922336;868932;5.964;100;28;0;73;366
2015/05/07;18:19:00;922458;868999;5.970;100;28;0;73;313
2015/05/07;18:20:00;922424;868920;5.975;100;28;0;73;307

2.6.7 Status Indications

2.6.7.1 LED Status Indications

The microAeth has one yellow LED located on the rear panel that turns on when the microAeth is charging. The microAeth has two LED indicators, one green and one red, located on the front panel immediately to the left of the filter chamber. These lights indicate the instrument's current operating status. The green LED generally indicates that the instrument is functioning properly and is or is not collecting data. The red LED indicator generally indicates that the unit is not operating in a normal sampling state. The status indications signaled by the LEDs are given in the following table.

Run Modes		
Green	1 long blink & beep sound	Start of data storing to internal memory.
Green	1 blink every 3 sec	Acquiring data to internal memory.
Green	2 blinks every 3 sec	Acquiring data to internal memory and streaming.
Green	1 long blink every 1 or 5 min	Data write to internal memory (1, 5 min timebase).
Status Warnings during Run Modes (see above)		
Green indicates Run Mode (see above), Red indicates Warning (see below)		
Red	1 blinks every 1 sec	Warning - Change filter strip
Red	2 blinks every 1 sec	Warning - Battery low
Red	3 blinks every 1 sec	Warning - Flow error
Stop Modes		
Red & Green	synchronous 1 blink every 1 sec	Startup - Beeping, Not collecting data until ready. Idle - No Beeping, Not collecting data, Restart Req'd
Red Only	Repeat blink on/off sequence; on time is same as off time. Emits one series of 3 triple beeps.	Critical hardware error: • Main supply voltage too high or too low • Light source current too high or too low • Light source feedback circuit error.

2.6.7.2 Data File Status Codes

Reported Status Code in Data File	Reason / Indication
1	Battery Low
2	Flow out of range
4	Change filter ticket / Sense signal out of range
8	Optical signal feedback out of range
16	Power supply 5V out of range
32	LED current out of range
64	Flash memory full
128	Automatic shutdown occurred on configured schedule
0	OK - Instrument operating within specifications

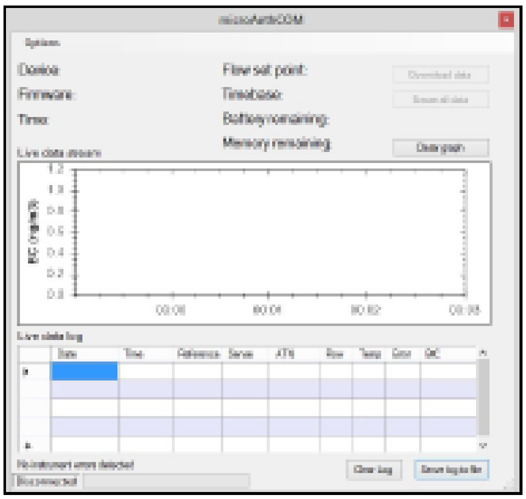
NOTE: If more than one status error code is active simultaneously, the resulting code written to the data file is the sum of the error codes shown in the table above. For example, if the battery is low (status code = 1) and the flow is out of range (status code = 2), the status code shown in the data file will be 3.

2.7 Upgrading microAeth Operating System Firmware

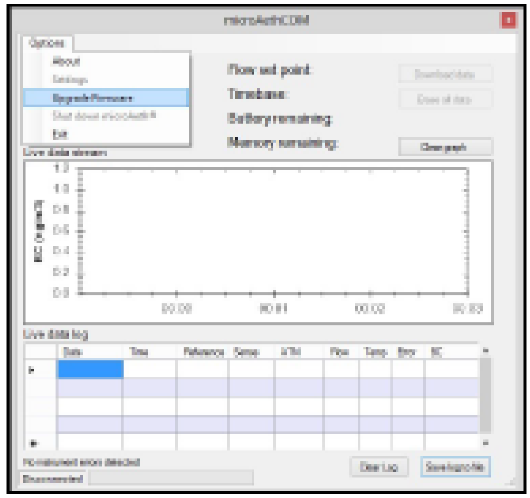
Before upgrading the microAeth operating system firmware, make sure that all data on the instrument has been downloaded. After the new firmware has been installed, the memory of the microAeth will need to be erased.

1. Start the microAethCOM software.

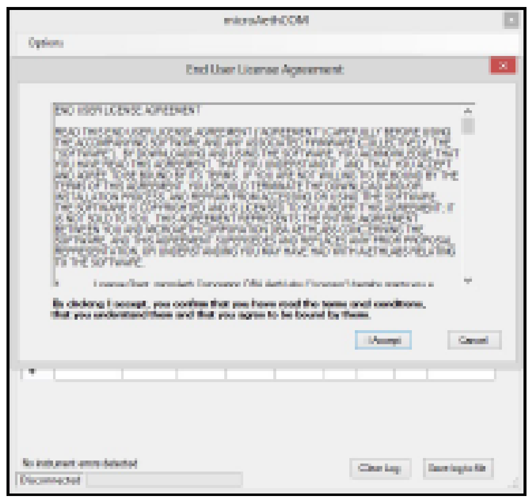
2. Connect the USB cable to the microAeth and the computer. **Do not turn on the microAeth.** The microAethCOM software will show that the microAeth is Disconnected.



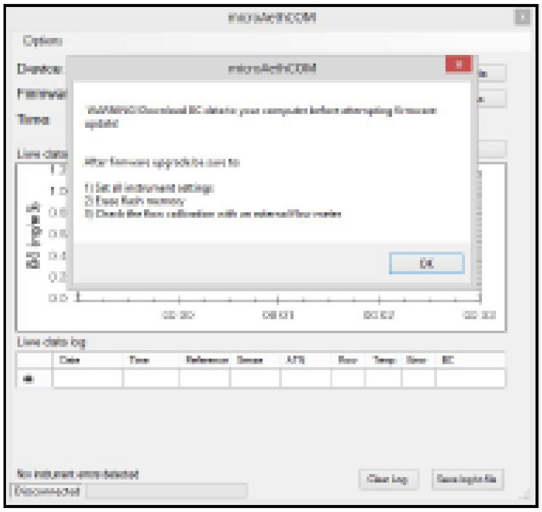
3. Click Options then Upgrade Firmware



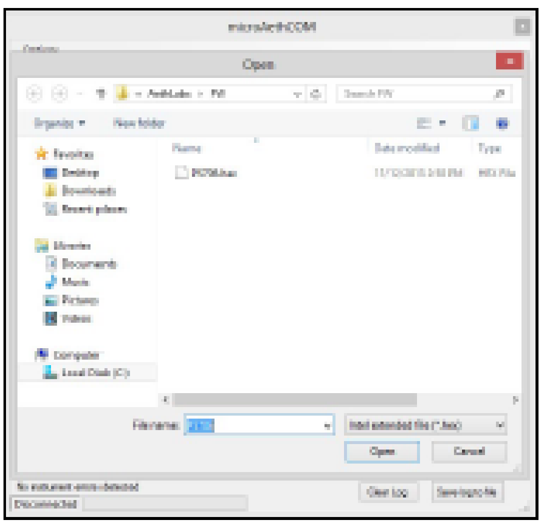
4. In order to install the firmware on the microAeth, please read and accept the license agreement.



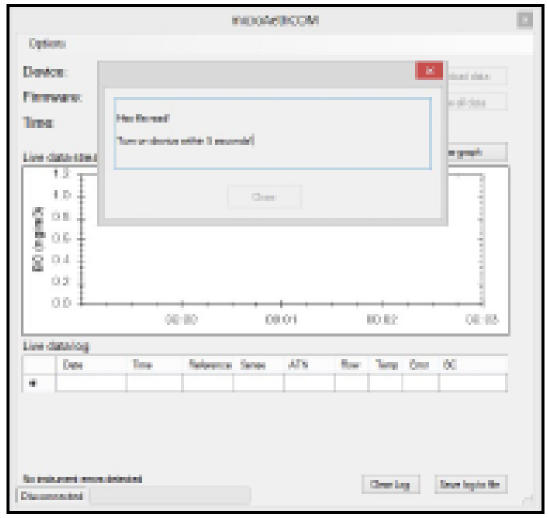
5. A warning window will appear to make sure that all data on the device has been downloaded and to inform the user of what should be completed after the upgrade.



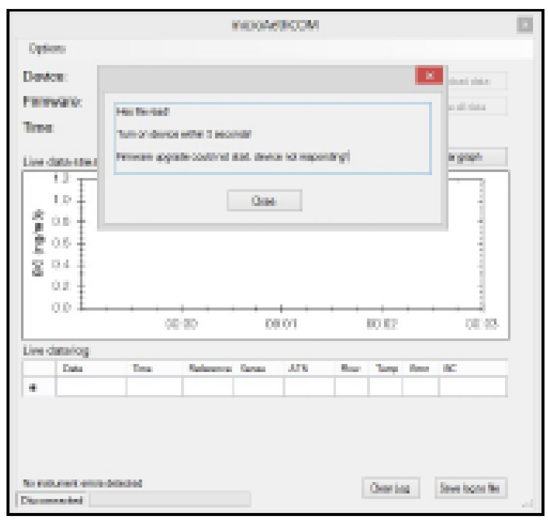
6. Select the hex file PSxxx.hex where xxx refers to the version number to install on the microAeth.



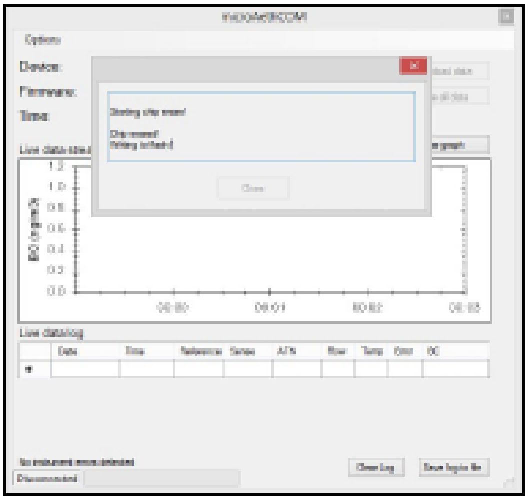
7. When prompted, turn on the microAeth within 5 seconds.



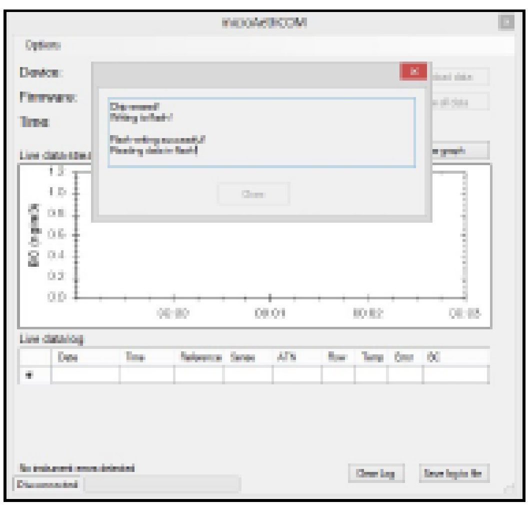
8. If the microAeth is not turned on within 5 seconds, the user will be told that the device did not respond. The user will have to close the window and start the firmware upgrade over again. If this occurs, go back to step 3.



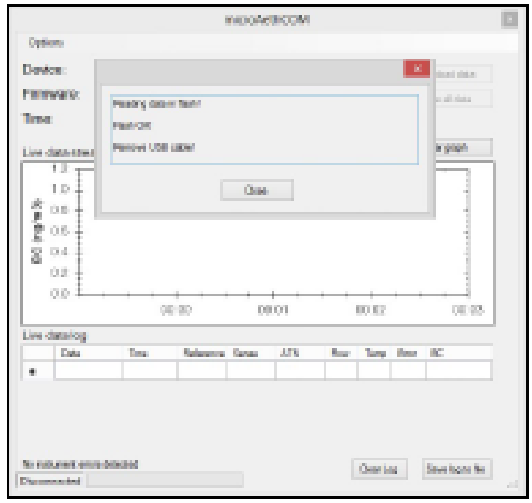
9. If the microAeth is turned on within 5 seconds, the firmware installation will begin. The memory will be erased and the new firmware will be written to memory.



10. Once the firmware has been installed, the microAethCOM software will check the memory for errors.



11. If no errors are found, the firmware installation will complete and the user will be prompted to unplug the microAeth.



12. After a successful firmware upgrade, the following should be completed before using the microAeth for a new sampling session:

- **Set all instrument settings.** Please read section 2.6.2 Configuration of Instrument Operating Parameters for more information.
- **Erase all data on flash memory.** Please read section 2.6.4 Erasing Data for more information.
- **Check the flow calibration with an external flowmeter.** Please read section 2.8 Flow Calibration Procedure for more information.

2.8 Manual Flow Calibration Procedure

In order to complete a manual flow calibration of the microAeth, you will need to use the AE51 FlowCal software. The installation of the microAethCOM PC software automatically installs the AE51 FlowCal software into the directory chosen by the user during the installation process. Please read section 2.5 microAethCOM PC Software for more information about the installation process.

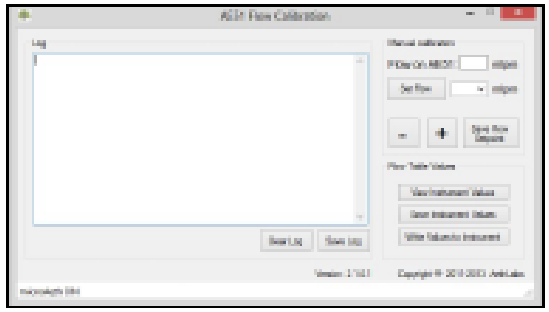
1. **Install a clean, unused filter strip into the microAeth.** Please read section 2.3.2 Filter Strip Installation and Removal for more information. **NOTE:** A pre-used filter strip with heavy loading may create an offset in the flow calibration table of the microAeth.

2. Connect the external flowmeter to the inlet of the microAeth.

3. Turn on the microAeth and the external flowmeter. Let the flowmeter stabilize for at least 10 minutes before use.

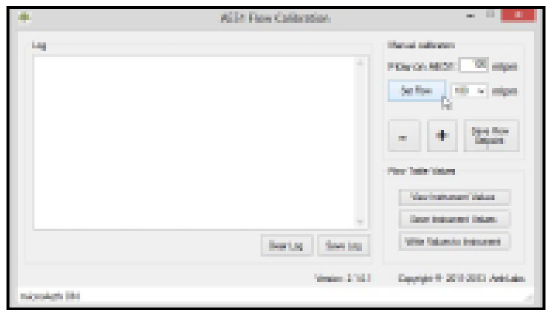
4. Start the AE51 FlowCal software.

5. Connect the USB cable to the microAeth and the computer. Wait until the microAeth establishes communication with AE51 FlowCal software. The status bar in the bottom left corner of the software will show the connection status of the microAeth and AE51 FlowCal software. If the status bar does not show microAeth ON status, check your connections and ensure that communication with the microAeth has been initiated as previously described and disconnect the USB cable from the computer and reinsert it.



6. Select the flow setpoint to calibrate from the dropdown menu in the Manual calibration section of the software. Then click the Set Flow button.

7. The flow rate of the microAeth will change and the text box to the right of Flow on AE51: should be populated with the desired flow setpoint.



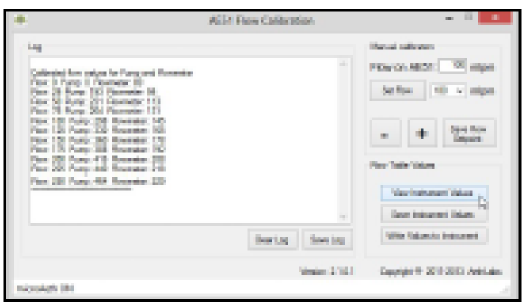
8. Use the + and - buttons to adjust the pump speed of the microAeth until the flow rate on the external flowmeter closely matches the selected flow setpoint in the software.

9. Then click the Save Flow Setpoint button to save the setpoint calibration in the microAeth flow calibration table stored in the instrument.

10. Repeat steps 6-9 for all flow setpoints in the dropdown menu in the Manual calibration section of the software.

    NOTE: If the internal pump of the microAeth cannot reach the highest flow rate setpoint, contact AethLabs for further assistance.

11. Click the View Instrument Values button. This will display all the values of the flow calibration table.



12. **Please check the values to make sure that as the flow setpoint increases from 0 to 250 ml/min, the pump drive and internal flowmeter values also increase.** If this is not the case, please try again to calibrate the microAeth. If this issue persists, please contact AethLabs for further assistance.

View Instrument Values

The View Instrument Values button requests the contents of the flow calibration table stored in the microAeth.

The flow calibration table shows the pump drive values and internal flowmeter values for the specified flow setpoints.

VERY IMPORTANT: As the flow setpoint increases from 0 to 250 ml/min, the pump drive and internal flowmeter values should increase. If this is not the case, please try again to calibrate the microAeth. If this issue persists, please contact AethLabs for further assistance.

Save Instrument Values

The Save Instrument Values button will prompt the user to select a location to save the flow calibration table file.

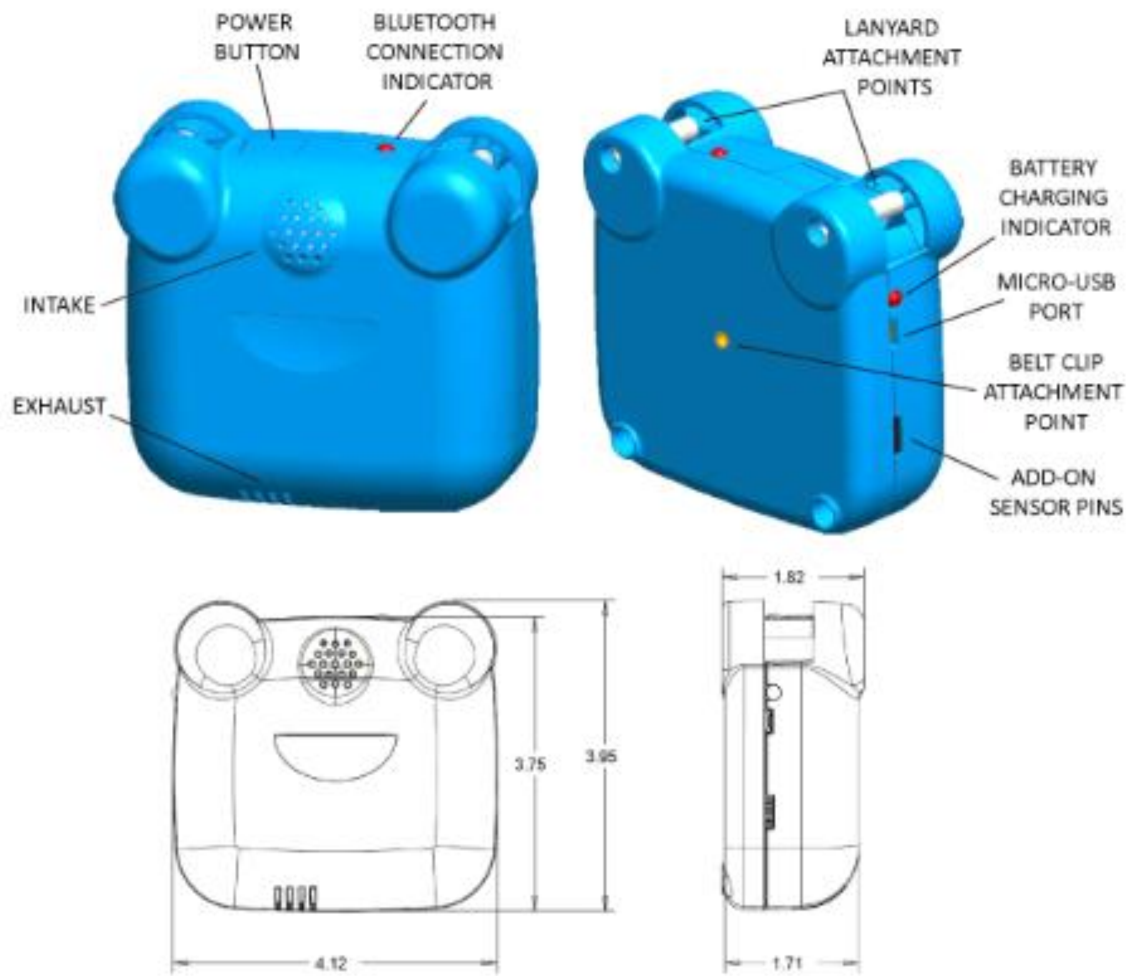
The flow calibration table values will be read from the microAeth and saved to a selected location where it can be kept for archival purposes and comparison, or can be retrieved and uploaded to the microAeth at a later time.

Write Values to Instrument

The Write Values to Instrument button will prompt the user to select a previously saved flow calibration table file for upload to the microAeth.

G. AirBeam Operating Procedures

AirBeam Technical Specifications, Operation & Performance



<u>Hardware Specifications</u>

Weight: 7 ounces

Particle Sensor: Shinyei PPD60PV

Temperature & Relative Humidity Sensor: MaxDetect RH03

Bluetooth: Nova MDCS42, Version 2.1+EDR

Microcontroller: Atmel ATmega32U4

Bootloader: Arduino Leonardo

About the AirBeam

HabitatMap worked with a community of scientists, educators, engineers, and other non-profits to create the AirBeam. The AirBeam measures fine particulate matter (PM2.5), temperature, and relative humidity. The AirBeam uses a light scattering method to measure PM2.5. Air is drawn through a sensing chamber wherein light from an LED bulb scatters off particles in the airstream. This light scatter is registered by a detector and converted into a measurement that estimates the number of particles in the air. Via Bluetooth, these measurements are communicated approximately once a second to the AirCasting Android app, which maps and graphs the data in real time on your smartphone. At the end of each AirCasting session, the collected data is sent to the AirCasting website, where the data is crowdsourced with data from other AirCasters to generate heat maps indicating where PM2.5 concentrations are highest and lowest. As an open-source platform, modifying our components to take other measurements and or transmit the data to other websites or apps is easy and encouraged. We've even included *Add-on Sensor Pins* on the AirBeam to make adding sensors simple.

Power

The AirBeam has a 2000 mAh 3.7V rechargeable lithium battery. When the battery is fully charged, the AirBeam can operate for 10 hours. The battery charges via the micro-USB port, which can also be used to power the AirBeam directly. The *Battery Charging Indicator* turns solid green when the AirBeam is charging and turns off when the AirBeam is either fully charged or unplugged.

Power On/Off

To power on the AirBeam, press down on the *Power Button*. The AirBeam is on when the *Bluetooth Connection Indicator* blinks red. Push the *Power Button* a second time to power off the AirBeam.

Intake & Exhaust

While operating the AirBeam, be sure to keep the *Intake* and *Exhaust* free from obstructions.

Connect the AirBeam to the AirCasting Android App

Download the AirCasting app from the Google Play store. Launch the app, then navigate: menu button > "Settings" > "External devices" > "Pair with new devices" > "Search for Devices" > pair with the device labeled "AirBeam . . . " (note that you only need to pair once) > return button > press "AirBeam . . . " > press "Yes" when prompted to connect. The AirBeam is connected to the AirCasting Android app via Bluetooth when the *Bluetooth Connection Indicator* is solid red and the AirBeam sensor streams appear on the AirCasting App Sensors Dashboard.

Acquire AirBeam Data via Serial Monitor

You can acquire the AirBeam data via the *Micro-USB Port* or Bluetooth using a serial monitor.

Programming
The AirBeam board is based on the Arduino Leonardo, so you can reprogram your AirBeam using the Arduino IDE.

Add Another Sensor
You can add another sensor to the AirBeam using the *Add-on Sensor Port*. When the AirBeam is resting on it's back the five pins, from left to right, are: Ground, 5V, 3.3V, Analog 2, Analog 1. Note that you must insert a tiny screwdriver into the slot above the pin to release the pin.

Open Source
The AirBeam firmware and electronic schematics are available on GitHub. The STL files for 3D printing the AirBeam enclosure can be downloaded from Shapeways.

FCC Compliance Statement
This device complies with part 15 of the FCC Rules. Operating is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. Caution: Modifying or tampering with internal components can cause a malfunction and will void FCC authorization to use these products.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the manufacturer's instructions, may cause interference harmful to radio communications. There is no guarantee, however, that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures: reorient or relocate the receiving antenna; increase the separation between the equipment and receiver; connect the equipment to an outlet on a circuit different from that to which the receiver is connected; and/or consult the dealer or an experienced radio or TV technician for help.

Performance Data
The below claims and disclaimers are based on comparisons between the AirBeam, a Thermo Scientific pDR-1500 with a PM2.5 cut-point inlet, and teflon filter samples subjected to gravimetric analysis. The pDR-1500 is a $5,000, 2.5 lb air quality monitor frequently used by government and academic researchers to evaluate personal exposure to fine particulate matter or PM2.5. Teflon filter samples were taken with a Leland Legacy 10L pump and PM2.5 cut-point inlet and weighed at the NYU School of Medicine's filter weighing room, which meets EPA guidelines for filter conditioning, storage, and gravimetric measurement of PM2.5 and PM10 filters. Filters subjected to gravimetric analysis are the "gold standard" for measuring PM2.5. Additional research is required to fully characterize the performance of the AirBeam and we look forward to working with the AirCasting community to "fill in the gaps".

When presenting our performance data on the AirBeam below, we include R2 or R-squared values to indicate how the AirBeam compares with other methods for measuring PM2.5. R2 is a statistical measure that indicates how well data fit a statistical model, in this case, the prediction of the Y-axis (AirBeam) from the X-axis (pDR-1500) using a linear (straight) or nonlinear (curved) line. The R2 value is a fraction that ranges from 0.0 to 1.0 with higher values indicating that the regression came more closely to the points. An R2 value of 1.0 means that the predictive power of the model is perfect, that all the points lie along the line or curve with no scatter.

Below 100 micrograms per cubic meter (μg/m³), samples collected in ambient air in Manhattan (samples were collected on 11 different occasions and averaged over 12 hour periods) and while burning cardboard indoors (samples were collected over a 1 hour period and averaged every minute) both showed a strong linear relationship between the AirBeam and pDR-1500 measurements. As illustrated in Figure 1, the R2 values below 24 μg/m³ for two AirBeams in ambient air in Manhattan were .98 or better.

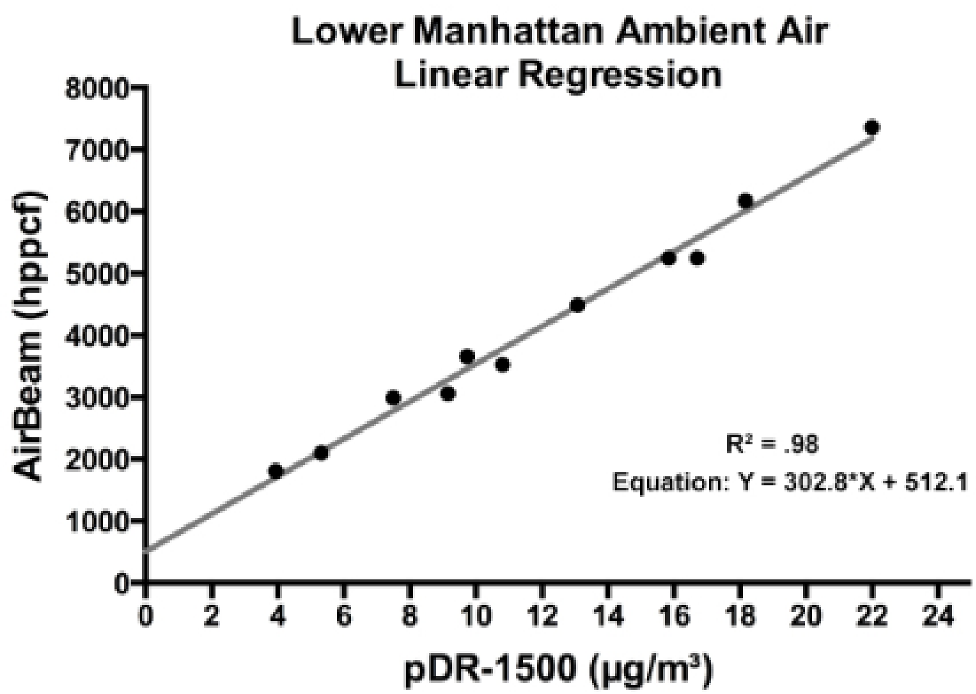


Figure 1

As illustrated in Figure 2, the R2 values below 100 μg/m³ for four AirBeams while burning cardboard indoors were .94 or better. Also shown in Figure 2, "out-of-the-box" variability between AirBeams is more pronounced as the measurements climb above 30 μg/m³. Meaning that measurements recorded by two AirBeams exposed to identical air samples may begin to drift apart as PM2.5 concentrations increase. Out-of-the-box variability can be substantially reduced by using the AirCasting app calibration feature (still in beta) and adjusting the side-facing potentiometer on the Shinyei PPD60PV.

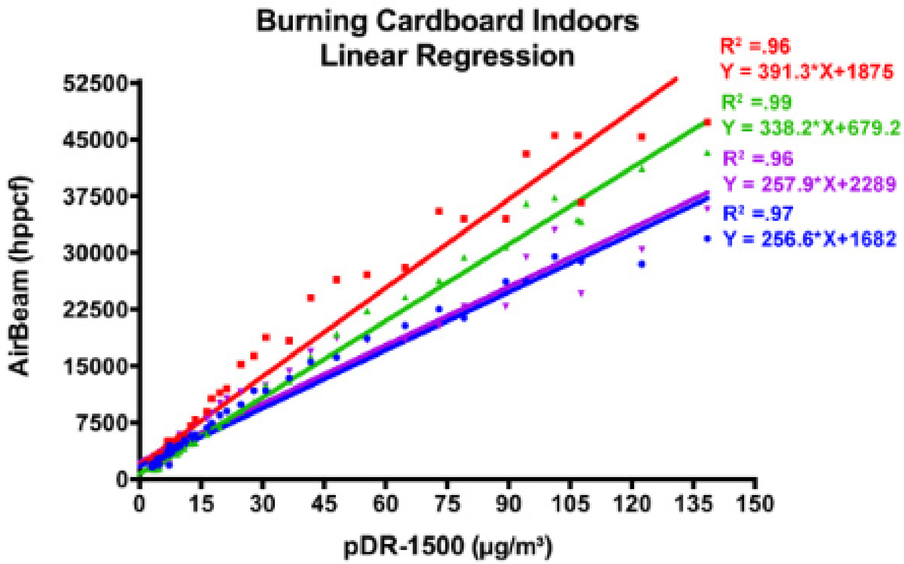


Figure 2

Because the relationship between the AirBeam and pDR-1500 measurements becomes increasingly non-linear above 100 µg/m³, a nonlinear regression curve was used to determine the relationship between the AirBeam and pDR-1500 measurements at higher concentrations, see Figure 3 (samples were collected over a 1 hour period and averaged every minute). During separate sampling runs, we calculated R2 values for the nonlinear regression curve ranging from 0.60 to 0.80. The decrease in R2 values as compared to the linear regression is likely attributed to higher variability near and above the AirBeam's maximum limit of detection, which we estimate to be approximately 400 µg/m³.

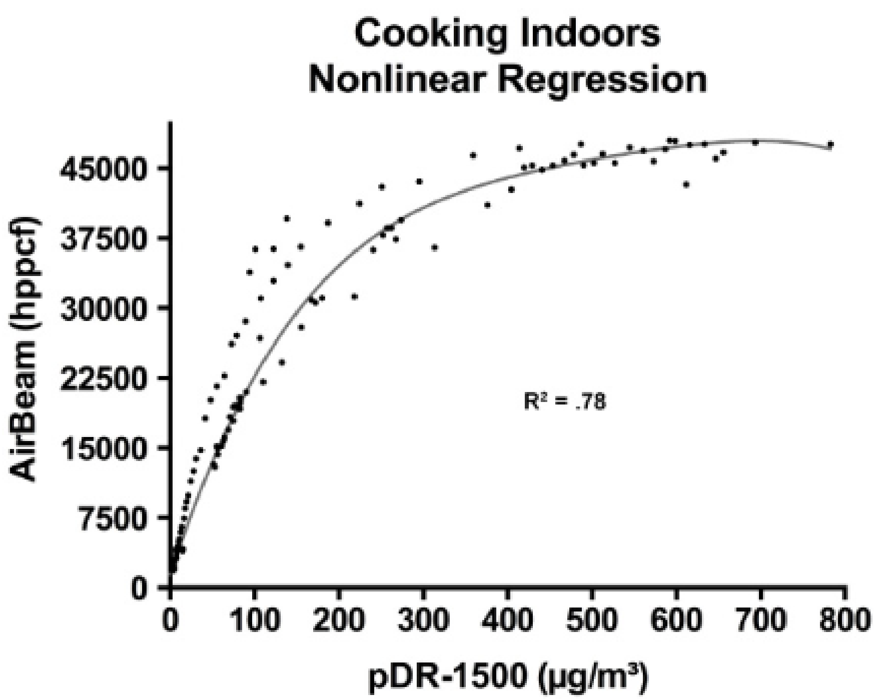


Figure 3

Additional research is required to see how the maximum limit of detection is impacted by the reflectivity of the aerosol being sampled. The relative reflectivity of aerosols impacts the AirBeam measurements. Highly reflective aerosols, like wood smoke, bias the AirBeam measurements upwards, whereas less reflective aerosols, like diesel exhaust, bias the AirBeam measurements downwards.

During ambient air sampling in Lower Manhattan during the summer months, measurements from a pDR-1500 and two Airbeams were compared against a teflon filter subjected to gravimetric analysis, see Figure 4. Sampling was done in 12-hour averages each day for 11 days and averaged to compare the real time instruments against the gravimetric filters. When compared against the gravimetric filters, the R2 value of AirBeams was found to be 0.70 compared to 0.76 for the pDR-1500. Time weighted averages of the gravimetric filter data showed consistently higher values as compared to the pDR-1500 at ambient levels. We assume this downward bias is also in effect with the AirBeam, since both are light scattering particle counters. Further, we assume part of this this bias can be attributed to the relative reflectivity of the aerosol being measured. The R2 value of the pDR-1500 measured against the AirBeams during these 12-hour day averages was found to be 0.98.

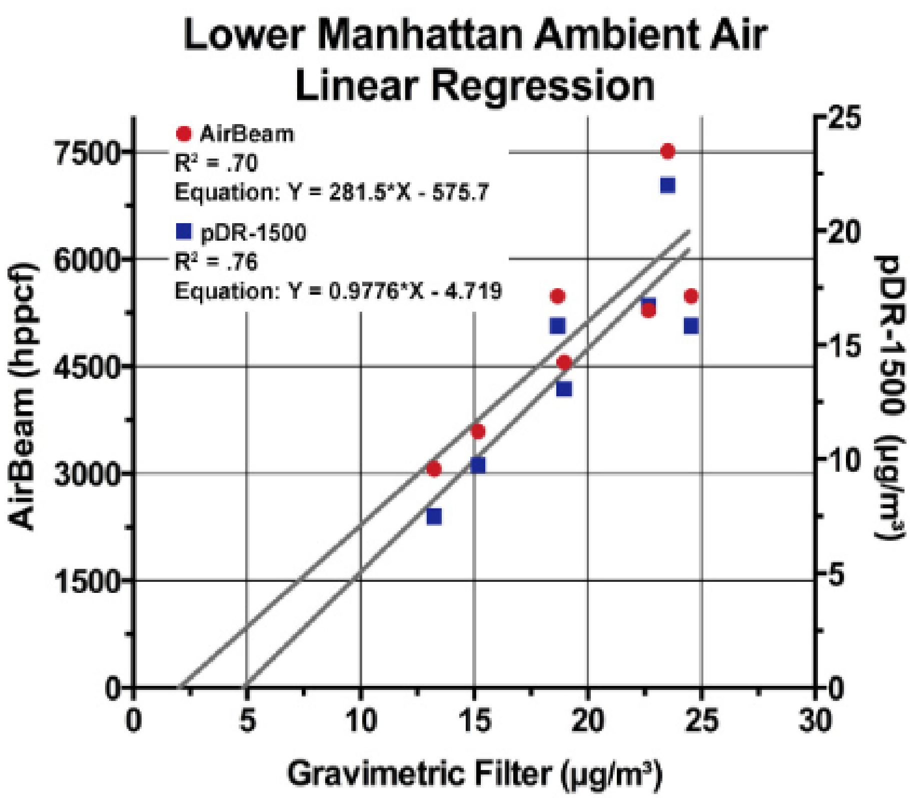


Figure 4

Research conducted by others on light scattering particle counters indicates that high relative humidity (>80%) is likely to have a negative impact on the accuracy of the AirBeam. When relative humidity is high, aerosols take on water becoming more reflective. Additional research is required to better characterize this effect as it applies to the AirBeam.

AirBeam performance data collection, analysis, and findings are the work of Alex Besser and Michael Heimbinder. Alex is a graduate student in Environmental Toxicology at New York University. Michael is the Founder and Executive Director of HabitatMap and AirBeam Lead Developer. Dr. George Thurston, Alex's academic adviser and professor of Environmental Medicine at New York University School of Medicine, provided the material resources and guidance that made this research possible.

PSCAA Comments about the purpose and use of the AIRBEAM monitor

CAUTION: The Air Beam monitors are used for primarily educational purposes. The Air Beam monitor measurement is NOT regulatory in nature. This data CANNOT be used as evidence to force regulatory change. However, the Air Beam monitors can be very useful as screening tools, and as educational tools.

This light scattering measurement technique is highly susceptible to bias associated with the nature of the aerosol, as noted in the operating notes from the manufacturer. Further, the technique is also sensitive to Relative Humidity. As RH goes up, hygroscopic growth can occur, and the measurements can be biased high.

For this study, the Air Beam monitor is to be used for Educational purposes. The data may also be used to confirm other measurements, but shall not be used to draw any conclusions, or primarily drive any recommendations.

H. Purple Air Operating Procedure

About PurpleAir

What do PurpleAir sensors measure?

PurpleAir sensors measure airborne particulate matter (PM). Particulate matter describes solid particles suspended in air; this includes dust, smoke, and other organic and inorganic particles. PurpleAir sensors use laser particle counters to count the number of particles by particle sizes 0.3, 0.5, 1, 2.5, 5, and 10 µm, and use the count data to calculate mass concentrations of PM1.0, PM2.5, and PM10.

How do PurpleAir sensors work?

PurpleAir sensors use laser counters to measure particulate matter in real time. A laser counter uses a fan to draw a sample of air past a laser beam. Any particles in the air will reflect some light from the laser beam onto a detection plate, like dust shimmering in a sunbeam. The reflection is measured as a pulse by the detection plate, and the length of the pulse determines the size of the particle while the number of pulses determines the particle count. The PM1.0, PM2.5, and PM10 mass concentrations are calculated from these particle counts.

Who uses PurpleAir data?

PurpleAir sensors are used by a wide variety of individuals and groups from government air districts, school districts, and universities to industrial and commercial organizations to home enthusiasts and concerned citizens.

Our Technology

PurpleAir sensors are an "Internet of things" (IOT) air quality sensor or particulate sensor consisting of a network of elements

Laser Particle Counter:
PurpleAir uses PMS5003 and PMS1003 laser particle counters. These sensors count suspended particles in sizes of 0.3, 0.5, 1.0, 2.5, 5.0, and 10um. These particle counts are processed by the sensor using a complex algorithm to calculate the PM1.0, PM2.5, and PM10 mass concentration in ug/m3. PMS5003 and PMS1003 sensors come factory calibrated.

Before deploying any devices, we verify that they are giving out readings that are consistent from sensor to sensor during tests in a smoke chamber. So far, all sensors we tested have produced consistent output using laser particle counters.

ESP8266 and Arduino:
PurpleAir sensors use an ESP8266 chip to talk to the particle counter and provide all functionality, including connecting to a WiFi network and uploading data to the cloud. This ESP8266 chip runs code developed using Arduino. PurpleAir firmware has remote update features, meaning we can modify the software and the Arduino air quality sensor device will download the new version and update itself. Each device checks for updates from time to time.

ThingSpeak and HighCharts:
ThingSpeak provides the cloud storage for PurpleAir sensor data. PurpleAir uses HighCharts and data stored on ThingSpeak to create graphs on the PurpleAir map.

Google:
Using services from Google makes for a robust, reliable, and secure system. Google maps provides the map interface for sensor registration. Google App Engine provides the processing power to place the sensor icons on the PurpleAir map and create the graphs and other elements to display sensor data on the PurpleAir map.

Mapbox:
Mapbox provides the PurpleAir map interface.

BME280 Sensor:
Each PurpleAir sensor includes a BME280 pressure, temperature, and humidity sensor. Where these are present, there will be graphs for these values.

The temperature values may be elevated due to the case and other factors that do not provide ideal temperature sensing. These values are provided as is and are just for interest.

Power Supply:
PurpleAir sensors are powered by a 5v USB power source.

How do PurpleAir sensors compare to regulatory particulate matter sensors?

There are two major differences between PurpleAir sensors and regulatory sensors: the method of measuring particulate matter and the averaging time of the data collected.

Methods:

PurpleAir sensors use a laser particle counter to count the number of airborne particles in the air. That count is used to calculate a mass concentration, assuming an average particle density in an algorithm developed by the laser counter manufacturer, Plantower. An average density must be used because not all PM of a particular size is made of the same stuff. For instance, PM2.5 from wildfire smoke will have a different density than PM2.5 from dust blowing off a gravel pit. This means that mass concentration reported by a PurpleAir sensor can vary depending on the specific composition of PM for a given area thus making the sensors appear to "read high." So far, two different research groups have completed studies for their areas and created conversion factors specific to the composition of particulates in their air: AQ&U and LRAPA.

Federal reference sensors typically measure mass concentration of PM by drawing air through a filter and weighing the filter. This method is expensive, difficult to install, requires a specialist to maintain the sensor, and reports on an hourly scale. Because of this, many cities have a limited number of these sensors (or none at all) and it's not feasible for the general public to have their own.

Averaging Time:

PurpleAir uses the AQI breakpoints established by the US EPA to convert the mass concentration into the AQI published on the PurpleAir map. However, most regulatory groups report AQI as a 24-hour average that gets updated every hour or so. If you look at particulate matter data on a website like AirNow, a PM2.5 AQI of 150 means the average AQI in the last 24 hours was 150.

PurpleAir sensors use laser particle counters to count the number of particles in sizes from 0.3um up to 10um. These get converted into a mass concentration (ug/m3) and reported every 120 seconds. Since air quality can fluctuate greatly throughout the day, the real time PurpleAir AQI reading may appear "high" when compared to 24-hour averaged AQI data.

If you want to compare 24-hour averaged AirNow data with 24-hour averaged PurpleAir data, you can look at longer term averages on the PurpleAir map by selecting the averaging period from the options in the bottom left, or by checking the "Averages as Rings" in the map legend in the lower left-hand corner of the map.

Each ring represents an average for a time range:

Center of the circle = Real time average
1st ring = Short-term average
2nd ring = 30-minute average
3rd ring = 1-hour average
4th ring = 6-hour average
5th ring = 24-hour average
6th ring = 1-week average

Startup Guide for PurpleAir Sensors

Getting started with WiFi configuration, registration, and installation.

Before you begin

Before connecting your sensor to WiFi, please ensure you are connecting to the right type of network. PurpleAir sensors only support 2.4Ghz WiFi networks. They will need special authorization from the network administrator to allow them to communicate on captive portal networks, such as those used by coffee shops, universities, etc. PurpleAir sensors do not support WPA2-Enterprise networks at this time. Supported networks types are WPA and WPA2-PSK (Pre-Shared Key). WPA2-PSK is the most common type of WiFi network.

We recommend configuring WiFi on your sensor indoors, near your computer or where you have a good WiFi signal. You should also check that there is a reasonable WiFi signal where you intend to mount the sensor. This can be done by browsing the internet using WiFi with a phone or computer near the desired location.

PURPLEAIR PA-II OR PA-II-SD SENSOR

In the box

- Sensor
- Outdoor power supply
- Optional mounting screw (1 per sensor)
- Optional mounting zip ties (3 per sensor includes spares)

Powering your sensor

1. Plug the Micro USB end of the power supply into the base of the sensor.
2. Plug the power supply into a functioning wall outlet.
3. Look for a very dim red glow up inside the sensor housing to confirm the sensor is receiving power. (You may have to cup your hands around the sensor and peer inside to see it.)

CONNECTING YOUR SENSOR TO WIFI

The WiFi configuration process is the same for all PurpleAir sensors.

1. It's best to configure your sensor to WiFi with the router, computer/phone/tablet, and sensor in the same room. After plugging in your device and confirming it is receiving power (look for the dim red glow inside the sensor housing, or for indoor sensors, make sure the device itself is glowing), on a WiFi-enabled device, open the list of available WiFi networks.
2. Connect to the sensor's network, PurpleAir-****. The **** is a 2-4 character code determined by your sensor. (It may take up to up to 10 minutes after the sensor is plugged in for this network to appear.)
3. Depending on your operating system or device, you may get a pop-up window or a message to sign in to the network. If you receive a message to sign in to the network, press it to make the pop-up window appear. The pop-up window will list all available WiFi networks.
   Note: If the pop-up window does not appear, after making sure you've selected the "PurpleAir-****" network and waiting a bit, if you still don't get the pop-up, try opening a web browser and loading a webpage. If you are indeed connected to the PurpleAir network, this will load the sensor interface with the WiFi settings for the sensor. Another option is to open a webpage and in the address bar, enter the default IP address for the sensor: http://192.168.4.1/config.
4. Choose the WiFi network you would like the sensor to connect to, enter the password for that network, and click **Save**. A hidden WiFi network can be entered by selecting the option at the bottom of the list.
5. The WiFi status bar will turn green once your PurpleAir sensor is connected to WiFi and transmitting data. Once your device is configured to your local WiFi network, it will no longer appear in the list of available networks - the fact that it has disappeared means that the sensor is successfully configured to WiFi.

   Important: If your sensor network name is AirMonitor_****, you will need to go to www.purpleair.com/configure to configure WiFi on your sensor.

REGISTERING YOUR SENSOR ON THE PURPLEAIR MAP

Registering your sensor places a map marker on the PurpleAir map. You will only need to do this once. If you would like to change any registration details, please complete the registration form again. You will need to use the same "Owner's Email" that was used in the first registration to make changes.

1. Go to www.purpleair.com/register.
2. Enter the sensor's Device-ID exactly as printed on the sensor's label.
3. Enter the associated email address, which is usually the email that was used to purchase the sensor. If you do not know the correct email address, please contact us for help or to associate a new email address. PurpleAir will need the Device-ID in order to help you.
4. Complete the rest of the registration form. For additional help, you can view a full explanation of registration fields or read our registration tips below.
5. Click register and look for a green "successful registration" notice. A registration confirmation email is sent to the Associated Email and Owner's Email. This email includes a link to view your sensor on the PurpleAir map.

Tips on PA-II and PA-II-SD installation

- Choose a location that is convenient to reach, has access to a power outlet, and falls within range of the WiFi network.
- If possible, mount the sensor away from vents, local sources of pollution such as BBQs, and any foliage that would increase the likelihood of insects getting inside the laser counters.
- Install the sensor in the vertical position, with the open end facing toward the ground. The housing is designed to protect the device from the elements while allowing air to flow freely past the two laser counters.
- Be sure to mount the sensor high enough off of any surface that would allow rain water to splash up into the underside of the sensor.
- The power supply should be mounted so that it will not be submerged in water or covered by snow.
- Use either cable ties or a screw to mount the sensor and power supply, and fashion a "drip loop" to prevent water from running down the wires and into the electronics.
- PurpleAir outdoor sensors can withstand direct sun without being damaged. Mounting the sensor in a shady spot will produce temperature readings that are not affected by direct sunlight.
  Please note that temperature readings are already elevated by as much as 10 degrees Fahrenheit due to heat generated by the WiFi module inside the sensor.
- Connect the power supply to a power outlet and tuck the wires away.

PurpleAir sensors employ a dual laser counter to provide some level of data integrity. This is intended to provide a way of determining sensor health and fault detection. Some examples of what can go wrong with a laser counter are a fan failure, insects, or other debris inside the device or just a layer of dust from long term exposure. If both laser counters (channels) are in agreement, the data can be seen as excellent quality. If there are different readings from the two channels, there may be a fault with one or both. In the case of a fault, the channel may be marked as flagged or downgraded (suspect or known faulty).

PurpleAir provides ways to get direct access to the data and there are a few different ways to do this. The simplest way to download the data is using the download page available at https://www.purpleair.com/sensorlist. This page provides an easy-to-use interface to download data based on a date range. You access this page by zooming into the map, then using the download button in the bottom right of the screen. Alternatively, a download link is available per sensor in the “Get this widget” section after clicking a map icon.

- Select the sensor/s in the list you want to download.

- At the top of the page, enter the desired date range, then click Download Selected.

Correction Factors for Purple Air data:

PurpleAir sensors use laser particle counters that measure the particle count, before converting that count into a mass concentration. The purpose of this is to make it comparable to data reported by regulatory sensors. To do this, the laser counters must assume an average particle density. An average density must be used because, as mentioned above, not all particulate matter of a certain size has the same density. For example, if you weighed 1000 particles of wildfire smoke and 1000 particles generated from gravel dust, the wildfire smoke would be much lighter. In the case where the predominant source of PM2.5 is from wildfire smoke that has a lighter density than the assumed density used by the sensor, the sensor data will predictably overestimate the mass concentration and read higher than the regulatory monitor. Similarly, if the predominant source of PM2.5 was a denser material like gravel dust, the sensor data would predictably underestimate the mass concentration and read lower than the regulatory monitors.

EPA and Oregon's Lane Regional Air Protection Agency (LRAPA) have created their correction factors to make Purple Air data more comparable to regulatory monitors and avoid over-estimating the PM2.5 concentrations. We will be using one of these conversion factors for the data collected during our study period.

PSCAA Comments about the purpose and use of the Purple Air monitor

CAUTION: The Purple Air monitors are used for primarily educational purposes. The Purple Air monitor measurement is NOT regulatory in nature. This data CANNOT be used as evidence to force regulatory change. However, the Purple Air monitors can be very useful as screening tools, and as educational tools. This particular light scattering measurement technique is highly susceptible to bias associated with the nature of the aerosol, as noted in the operating notes from the manufacturer and by EPA.

For this study, the Purple Air monitor is to be used for Educational purposes. The data may also be used to confirm other measurements, but shall not be used to draw any conclusions, or primarily drive any recommendations.

I. PM2.5 Partisol Procedure Link and PM-10-2.5 Designation

The link below goes to the $PM_{2.5}$ Partisol sampling procedure for sequential sampling. The PSCAA has been using this procedure since 1999 and is very familiar with this sampling equipment.

PSCAA will modify this equipment to sample for PM_{10} rather than $PM_{2.5}$ by installing the WINS bypass downtube (RFPS-1298-127). This method replicates the sampling method for PM_{10} metals at the Beacon Hill monitoring site, so this procedure is chosen to maintain the ability to compare data from the fixed study site (10th & Weller) to the Beacon Hill monitoring site, which is sampling that is already in place due to the NCORE requirements.

https://apps.ecology.wa.gov/publications/documents/1802020.pdf

Thermo Scientific Partisol®-Plus 2025 Sequential PM10-2.5 Air Sampler Pair or Thermo Fisher Scientific Partisol® 2025i Sequential PM10-2.5 Air Sampler Pair
Manual Reference Method: RFPS-0509-176
"Thermo Scientific Partisol®-Plus 2025 Sequential PM10-2.5 Air Sampler Pair" or "Thermo Fisher Scientific Partisol® 2025i Sequential PM10-2.5 Air Sampler Pair," for the determination of coarse particulate matter as PM10-2.5, consisting of a pair of Thermo Scientific Partisol®-Plus 2025 sequential samplers or a pair of Thermo Fisher Scientific Partisol® 2025i sequential samplers, with one configured as a PM2.5 sampler (RFPS-0498-118) and the other configured as a PM10c sampler with the PM2.5 separator replaced with a Thermo Scientific Partisol® 2025 downtube (RFPS-1298-127). Partisol®-Plus 2025 to be operated with any software version 1.003 through 1.5 and Partisol® 2025i with firmware version 2.0 or greater, with the modified filter shuttle mechanism. Method to be operated in accordance with the Partisol®-Plus 2025 or Partisol® 2025i instruction manual supplement, as appropriate.
Federal Register: Vol. 74, page 26395, 06/02/2009
Latest modification: 06/ 2011

J. Enmont Ultrafine Particle Monitor Procedure

PUFP

Personal Ultrafine Particle Counter

Contents

Safety Information 2

Unpacking and Parts Identification 3

PUFP Sensor Setup 5

Operating the PUFP Sensor 8

Data Management 11

Maintenance 13

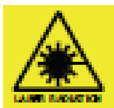
Notes and Cautions

Notes are helpful information that can help you make better use of the PUFP Sensor and its components.

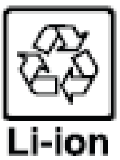
Cautions are warning about potential damage to the PUFP Sensor if used improperly.

Safety Information

Important safety messages are provided in this manual for the purpose of avoiding personal injury or instrument damage.



Laser Radiation: This device contains a Class I laser product. To avoid harmful laser radiation DO NOT open or perform services on the PUFP sensor.



Rechargeable Battery: This device contains a lithium-polymer battery pack with capacity of 7.4V and 10A. To avoid fire, keep the PUFP sensor away from high heat areas (≥ 60°C). When the battery power is low, charge PUFP with the included power cable and power adapter (12 VCD and 5A). Do not charge or use PUFP in any area with a potentially explosive atmosphere, such as a fueling area, or in areas where the air contains chemicals.

The PUFP sensor contains sensitive electronics and should not be operated in the rain or snow.

Repairing: Don't open PUFP and don't attempt to repair PUFP by yourself. Disassembling PUFP may damage it or may cause injury to users. If PUFP is damaged, malfunctions, or comes in contact with liquid, contact Enmont (enmont@enmont.com).

Operating and Storing Temperature: One of the internal components of the sensor is a water cartridge. To avoid damage to the PUFP sensor, do not store PUFP in temperatures below freezing. PUFP is designed to work and be stored in ambient temperatures between 10º and 35 ºC.

Unpacking & Parts Identification

1 PUFP C100
2 Optional Silicon Exhaust Tube
3 Syringe to refill water cartridge
4 USB cord
5 EView Software
6 Water bottle
7 Power adapter and cord
8 Additional Aerosol Inlet Fitting

1 Air intake
2 Water refill OUTLET
3 Water refill INLET
4 Micro SD card port
5 USB connection
6 Charging port
7 Exhaust
8 Air Outlet
9 Fan / Air Inlet

PUFP Sensor Setup

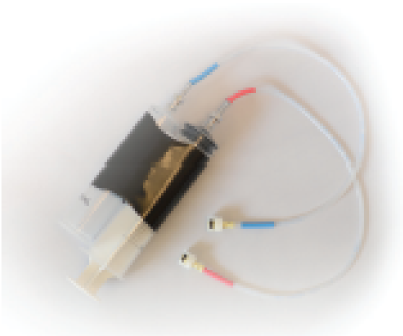
Battery and Charging

A battery pack is installed in a PUFP. The battery allows up to 6 hours of continuous operation. Operation hours can shorten over time. The length of operating hours is dependent on the age of the battery. The percentage of battery remaining is shown on the bottom of the sensor display screen. When fully discharged, the battery will take approximately 8 hours to charge fully. To charge the sensor, attach the power cord to the charging port on the sensor and plug the cord into an electrical outlet. When connected to a power source the sensor display screen will show "CHG" during operation. The screen will display "DSG" when the sensor is in operation and not connected to a power source.

Refilling Water

⚠ Caution: Purified water like distilled or de-ionized water should be used in the PUFP sensor. Using tap or other types of water may result in damage to the sensor.

The device for filling the sensor with water consists of two syringes, one with a plunger, and one without. The syringe with the plunger is used to transport water into the sensor. Small tubes are connected to each syringe.



To refill the sensor with water, submerge the end of the small tube attached to the syringe with the plunger in water. Pull the plunger back to draw the desired amount of water into the syringe. Once the desired amount of water is achieved, pull the tube out and remove excess water on the tube and plastic tip with a paper towel or other absorbent material.

Position the sensor on a flat surface such that the air intake and IN and OUT water ports are pointing skyward. Connect the tube (blue) of the syringe with the plunger to the IN port by pressing downward and turning the plastic tip clockwise. You will hear a click when the tip is locked in position with the IN port. ⚠ DO NOT PRESS THE PLUNGER DOWN YET TO FILL THE SENSOR.

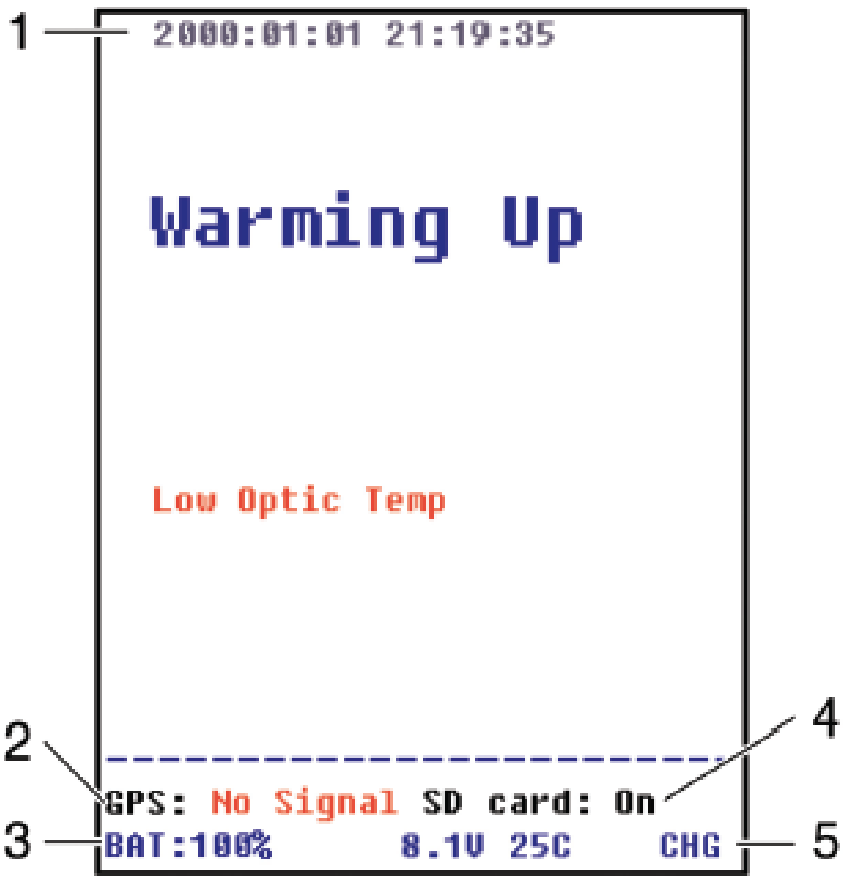
Connect the plastic tip of the tube (red) without the plunger to the OUT port by pressing down. Lock the tube into position by turning clockwise. Gently and slowly push the plunger down to move water into the sensor. When the sensor is completely refilled, water will begin to accumulate in the side without a plunger. ⚠ DO NOT REMOVE THE TUBES FROM THE WATER PORTS YET.

To avoid dripping water and damaging the sensor, turn the sensor on its side so that the air intake and water ports are pointing horizontally near the edge of the flat surface. Hold the water filling device level with or below the water ports. Remove the IN tube by turning the plastic tip counter clockwise and pulling gently. Remove the OUT tube and keep tip pointed upward. ⚠ Caution, water will leak out of the OUT tube if left to hang.

Replace excess water in container. Remove excess water from IN and OUT ports with a paper towel or absorbent material. Water level should be monitored carefully. A warning will appear if the amount of water is low. However, it is recommended that the PUFP sensor be refilled prior to each use. ⚠ Caution, sensor may be damaged if run while dry.

Sensor Display

Information regarding GPS signal, battery life, date and time, PUFP concentration, and amount of water is shown on the display screen.



Display information:

1 Date and time
2 GPS Status
3 Battery life
4 SD Card notification
5 Charging (CHG) or Discharge (DSG)

Operating the PUFP Sensor

⚠ Caution: During operation, keep objects clear of the air intake, fan, and air outlet. Obstructing these ports will result in damage to the sensor.

⚠ Caution: The PUFP sensor is assembled with a protective black plastic covering on the air intake. This must be removed before operation to avoid damage to the PUFP sensor.

Turning on the sensor

Turn on the PUFP sensor by pressing and holding the power button (⏻) at the center of the key pad (about 2 seconds). The sensor must operate for a short period of time (~10 minutes) before measurements can be made in order heat to the internal components of the sensor. During this period, the sensor display will show "Warming Up." The time remaining for the warm up process will appear on the sensor display.

When the warm up is complete "Measuring" will appear on the sensor display. The sensor will begin making measurements and recording data. During operation, it is normal for water to drip from the air outlet. Water can be directed away from the sensor by attaching the provided 1/8" silicon tubing.

User Settings

To adjust the settings of the sensor, press down and hold the right arrow (▶) approximately two seconds. A screen will appear, showing "SELECT KEY"—press down (▼). Date and time, screen brightness, and resetting options will appear. Use the up (▲) and down (▼) keys to scroll through menu options. As you scroll downward, the selected menu item will be highlighted blue. Continuing to scroll up or down will take you to a new page that shows "GPS Time Difference." This is covered in the next section.

To select a parameter, press the right arrow (▶). Selected parameters will appear in red. Use the up (▲) and down (▼) keys to adjust the parameter. To save the desired settings, press the right arrow key (▶) and the parameter will again turn blue. Press the left (◀) arrow to exit to the main display.

GPS Status

The PUFP sensor will indicate whether a GPS signal has been received. The sensor display will show "GPS Active" when GPS data is being recorded. When the GPS signal is inactive, "GPS No Signal" will be shown at the bottom left side of the display screen.

Date and Time Setting

The PUFP provides two ways for the user to set the date and time: 1) Manual setting and 2) GPS-based setting. The PUFP has an internal clock to track the date and time, which is powered by a token battery on an electronic board. The format is YYYY:MM:DD HH:MM:SS.

Manual Setting: The date and time of the PUFP sensor can be modified manually. To manually manage the time and date, set "GPS Time Difference" to 13. Date and time parameters will then need to be adjusted to the desired time at the user settings screen.

The time and date for the sensor can automatically sync when the GPS signal is active. Time and date are calculated based on Greenwich Mean Time (GMT). In order sync properly, the time difference must be specified to indicate the current time zone. To do this, first press and hold the right arrow (▶) to get to the user settings menu. Scroll through all options (year, month, day ect.) until a new screen appears and "GPS Time Difference" is highlighted blue. Press the right arrow (▶) key to select the parameter and use the up and down arrows on the keypad to specify the time difference (hours) from GMT respective to the current time zone. Press the right arrow (▶) to save the settings.

Turning off the PUFP Sensor

The sensor must go through a short shut down process to clear moisture from and cool down the internal components (~3 min). Begin the shutdown process by pressing and holding the ⏻ button in the center of the keypad for two seconds. The display screen will indicate when the shutdown has begun and the time remaining for the process to be complete. The sensor will automatically turn off.

In case of emergency, the sensor can be turned off immediately without going through the shutdown process by pressing and holding down the up (▲) and down (▼) arrow keys simultaneously for two seconds.

Reset the PUFP Sensor

There is a user option to reset the PUFP sensor. When the PUFP is reset, all the parameters are reset to the original factory setting.

Data Management

Measurements taken by the PUFP sensor are recorded on a micro SD card as tab delimited text files. A new file is created each time the sensor is turned on. The names of the data files correspond to the date and time at which the sensor began operation. For example, a file named "07300826" means that data recording began on July 30th at 8:26 AM. Real time and previously recorded data can be displayed directly on a computer using EView software. EView software will generate graphs, tables and Google Earth KML files.

Micro SD Card Recording

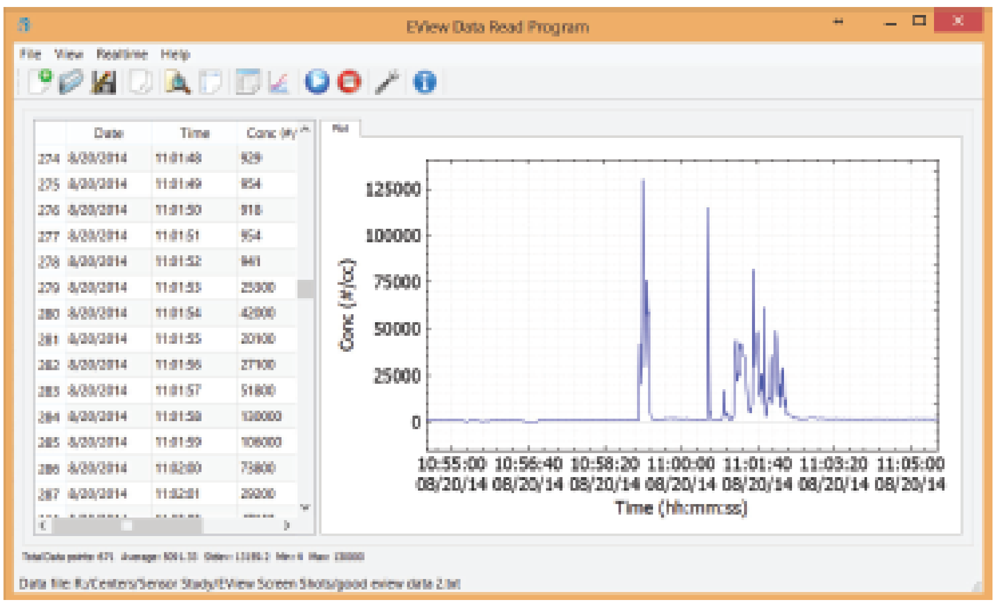
The PUFP sensor comes equipped with a micro SD card and adapter. If not connected to a computer using EView software, the micro SD card must be inserted into the PUFP sensor for data to be recorded. Gently press the SD card into the port until it clicks into place. To remove the SD card, gently press down until it clicks and release.

Data from the micro SD card can be downloaded to a computer or other electronic device by using the adapter. Insert the micro SD card into the adapter, and insert the adapter into the SD port of your electronic device.

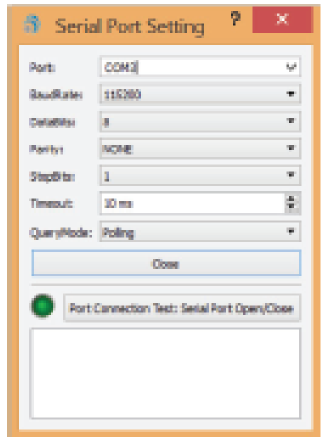
EView Software

EView software can be installed on either Mac or Windows computers. Graphs and charts can be generated from previously recorded data or can be used to record and show real time UFP measurements.

Previously measurements can be opened by going to File>Open. When the desired file is opened, a chart and graphed data will appear. The data can be navigated by clicking on the graph area and dragging up and down and side to side.



To record data in real time, connect the PUFP sensor with the USB cable to your Mac or Windows computer while EView software is running. Driver software from the PUFP sensor will begin to install on your computer. Once complete, click on the wrench icon on the toolbar at the top of the EView screen. A screen will appear named "Serial Port Setting."



Turn on the port connection by selecting “Port Connection Test: Serial Port Open/Close.” Measurements should begin to appear in the dialogue box. If text does not appear, adjust the port options. When text begins to appear, close the window.

To begin recording data, select the blue play button on the toolbar or select the “Realtime” option on the menu bar and then “Realtime Mode.” To stop recording data, select the red stop button.

Save data by selecting File> Save/Save As. Data can be saved in multiple formats. For example, data can be kept as tab delimited or CSV files and imported into statistical software for analysis. Graphs can be saved as picture files (PDF, JPEG, PNG). Exposure data can also be saved as KML files and loaded into Google Earth software to show the spatial distribution of measured UFP concentrations.

Maintenance

Air intake nozzle with dust-mesh filter

The PUFP sensor comes equipped with an additional air intake nozzle. The air intake nozzle has a mesh covering to catch large particles and dust. This should be cleaned periodically by using an air canister.

Enmont
environmental monitoring technology

PSCAA Comments about the purpose and use of the Enmont monitor

CAUTION: The Enmont monitors are used for primarily educational purposes. The Enmont monitor measurement is NOT regulatory in nature. This data CANNOT be used as evidence to force regulatory change. However, the Air Beam monitors can be very useful as screening tools, and as educational tools.

For this study, the Air Beam monitor is to be used for Educational purposes. The data may also be used to confirm other measurements, but shall not be used to draw any conclusions, or primarily drive any recommendations.

K. Air Quality Web: Air Drop Procedure

Air Quality Web: Air Drop

March 2016

Version 1.0.0

Puget Sound Clean Air Agency

1904 Third Avenue – Suite 105

Seattle, WA 98101

Document Revisions

Date	Version Number	Document Changes
6/18/16	1.0.0	Initial draft

Air Drop Overview

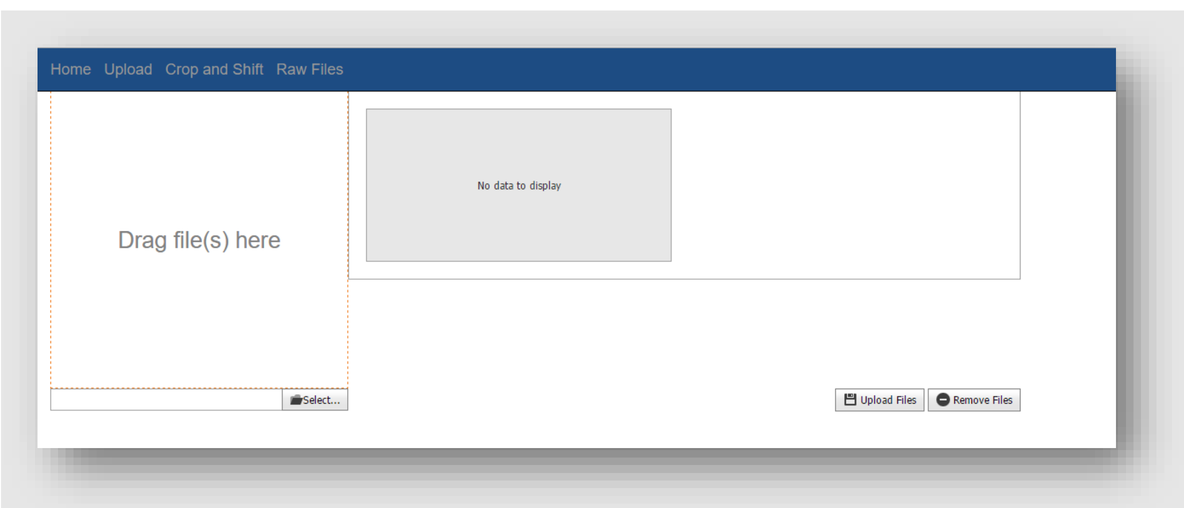
Air Drop is a tool that can be used to upload, crop, and shift data from mobile air quality studies. Once you have uploaded your data and made any necessary changes to the observation times, your data will be ready for review in our Telemetry database. You can retrieve your raw files from this application at any time.

Navigating to Air Drop

Air Drop is a web app that is available via this URL: https://secure.pscleanair.org/AirQualityWeb/. While this app is responsive to different screen sizes, it is for intended desktop and not optimized for mobile use.

Uploading Data

Overview



Accepted formats

You can upload a single file or a package of files in a .zip file. The current version of Air Drop can read data from these file formats: *AeroqualVoc, AirBeam, CarClipCo, CarClipO3No2, Dylos, Enmont, GPS, GPX, HourlyTelemetry, MicroAeth, Package, RadianceResearch, SenonicsMinnow, and TsiNanoScan*. **If additional formats need to be supported, please let Ross or Nate know so the work can be planned**.

Uploading

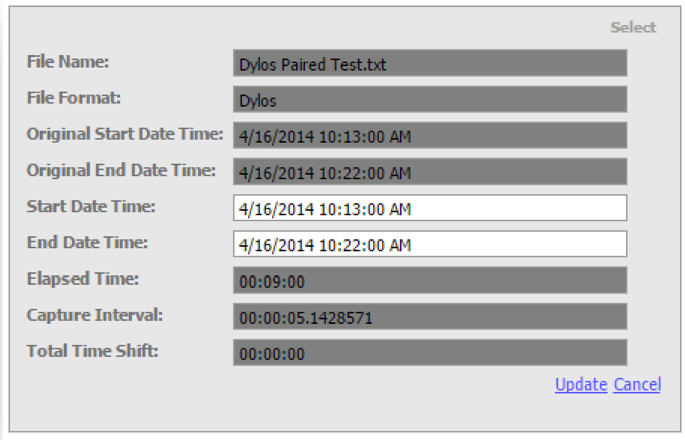
You can upload your file(s) via the drag and drop feature or by browsing for them. To use the drag and drop feature, drag your file(s) from their file location to the drop zone on the web page. If you wish to use the browsing feature, click the select button under the drop zone and navigate to your file(s). After a successful upload you will be taken to the page where you may crop and shift your data.

Cropping and Shifting Data

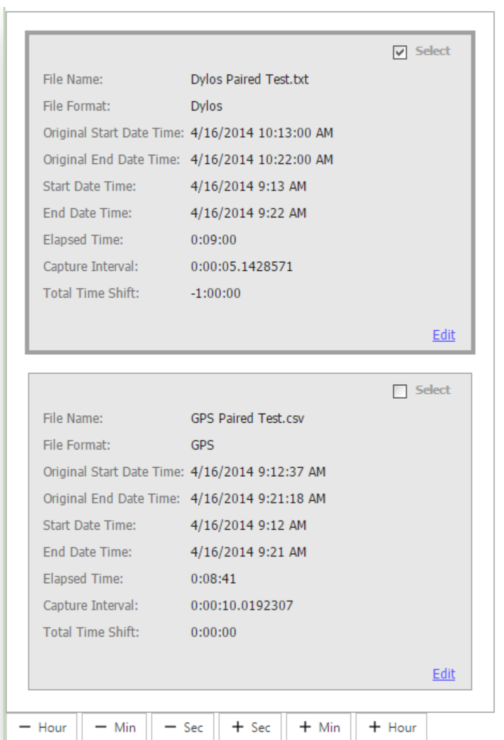
Overview

On this page, your data will be displayed on a line chart. If you have multiple QMUs in your data set, they will be displayed on separate panes. This allows you to visualize any time discrepancies in your data. You can see details about your files on the left side of the page. Each file will have a separate “card view”. This view allows you to edit the start and end date/times of your files, thereby cropping your data set. By selecting the file’s card view, you can use the shift buttons to adjust the observation times of your study.

Crop

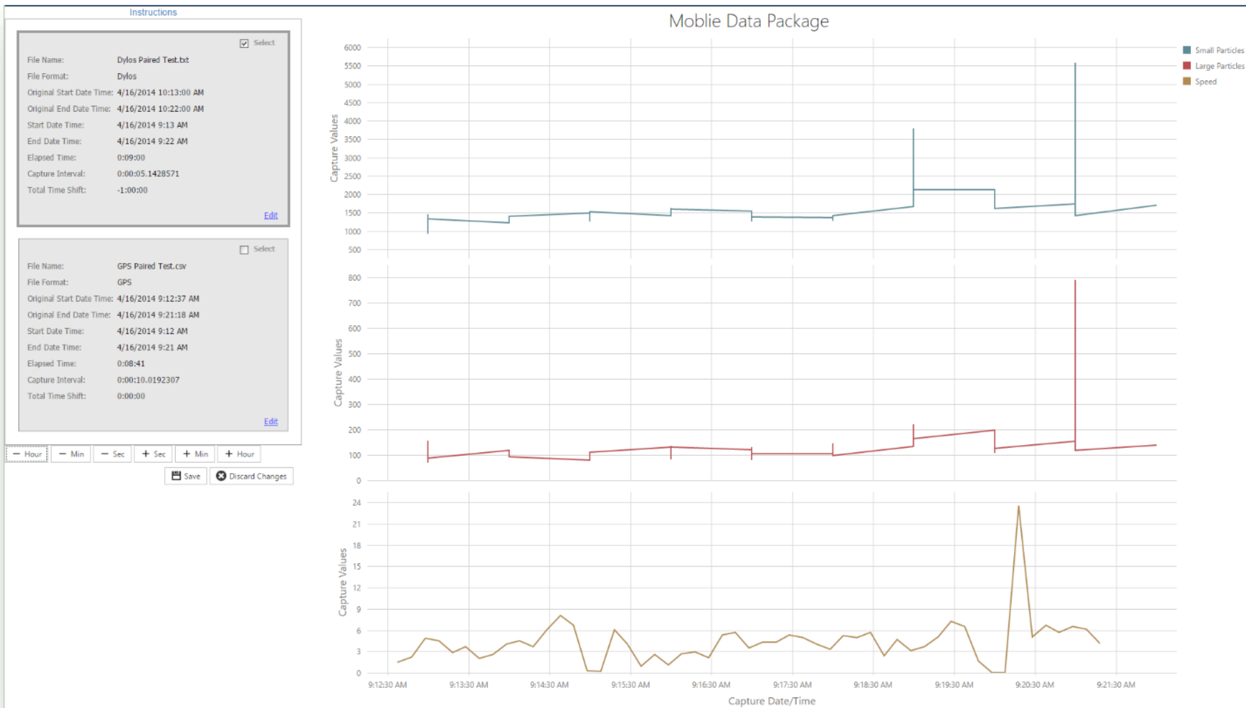


If all sensors did not start or end at the same time and you would like to trim remaining data points from display, you can do that with this card view. Select edit in the bottom right and you will see what is displayed in the screen shot to the right. As you can see, only the start and end date fields are editable. Select update after you have made your changes and you will see your modified data displayed. Please note: your data is not being deleted when it is cropped. It will still exist in our database and ignored in display.



Shift

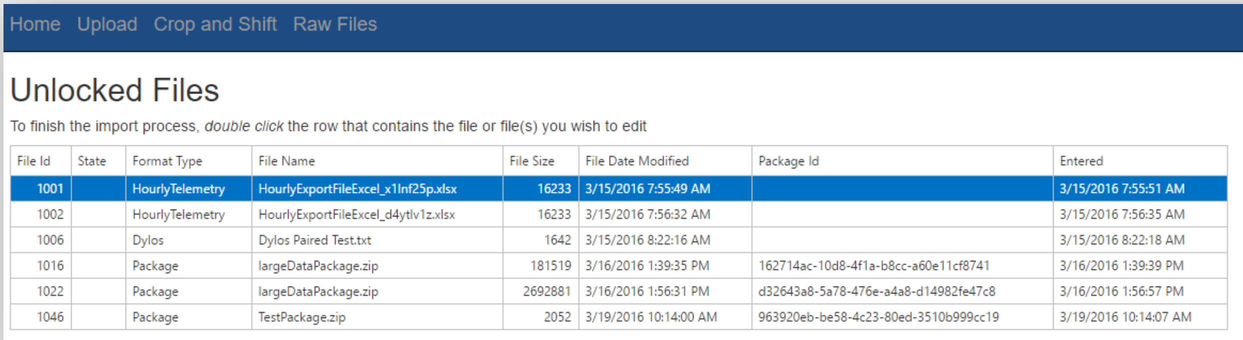
If your sensors' internal clocks are not in sync, you can shift all the observation times in a file by hour, minute, or second. To do this, select one or more files by checking *Select* in the upper right of the card view and clicking the time adjustment buttons below the card view(s). In this example you can see the Dylos monitor was an hour ahead of the GPS device. I have applied a one-hour shift and the screen shot below is the result. The Dylos file recorded two QMUs and the time shift was applied to both since they are contained in the same file. Now you can visualize this data set is in sync.



Save and Discard

Once you are satisfied with your changes simply select the save button that is also located below the card view. At this point, your raw data is being adjusted according to your changes and moved into a permanent structure. Depending on your data size this may take a few moments. After saving, your raw files will become locked, preventing any adjustments to the time shift as well as the start and end dates. If you wish to discard changes you may do so my clicking the discard changes button.

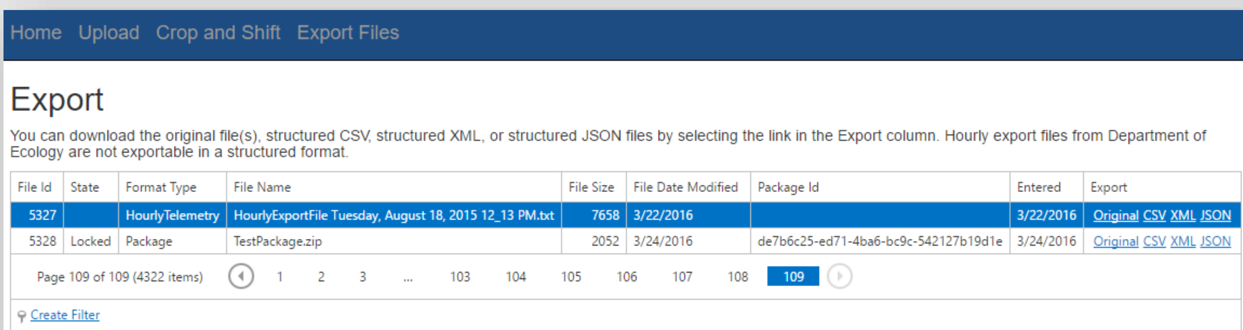
Unlocked Files



File Id	State	Format Type	File Name	File Size	File Date Modified	Package Id	Entered
1001		HourlyTelemetry	HourlyExportFileExcel_x1lnf25p.xlsx	16233	3/15/2016 7:55:49 AM		3/15/2016 7:55:51 AM
1002		HourlyTelemetry	HourlyExportFileExcel_d4ytlv1z.xlsx	16233	3/15/2016 7:56:32 AM		3/15/2016 7:56:35 AM
1006		Dylos	Dylos Paired Test.txt	1642	3/15/2016 8:22:16 AM		3/15/2016 8:22:18 AM
1016		Package	largeDataPackage.zip	181519	3/16/2016 1:39:35 PM	162714ac-10d8-4f1a-b8cc-a60e11cf8741	3/16/2016 1:39:39 PM
1022		Package	largeDataPackage.zip	2692881	3/16/2016 1:56:31 PM	d32643a8-5a78-476e-a4a8-d14982fe47c8	3/16/2016 1:56:57 PM
1046		Package	TestPackage.zip	2052	3/19/2016 10:14:00 AM	963920eb-be58-4c23-80ed-3510b999cc19	3/19/2016 10:14:07 AM

If you upload your file(s) and were not able to complete the crop and shift process you can pick your file(s) from this list and continue. You can navigate here by selecting the *Crop and Shift* link in the header. Simply find your file or package and double click to be directed to the crop and shift page.

Exporting Files



File Id	State	Format Type	File Name	File Size	File Date Modified	Package Id	Entered	Export
5327		HourlyTelemetry	HourlyExportFile Tuesday, August 18, 2015 12_13 PM.txt	7658	3/22/2016		3/22/2016	Original CSV XML JSON
5328	Locked	Package	TestPackage.zip	2052	3/24/2016	de7b6c25-ed71-4ba6-bc9c-542127b19d1e	3/24/2016	Original CSV XML JSON

You can retrieve your files at any time via this page. You can get the original unmodified data or structured CSV, XML, and JSON formats.

L. NFRM Metal Sampling Procedure

ARA N-FRM Sampler

Operation Manual

March 19, 2020

Overview

In response to the need for a low cost alternative to traditional site-based particulate monitors, ARA Instruments introduced a sampler that establishes a new class of air sampler we call "Near FRM" (N-FRM). The ARA N-FRM Sampler is a portable, rapidly deployable, battery powered particulate sampling and monitoring device that delivers Federal Reference Method (FRM) level of performance. It integrates with many additional components for unmatched versatility. The compact sampler collects 24-hour TSP, PM10, or PM2.5 filter samples and can simultaneously measure local meteorological parameters. It can also be equipped with a Real-Time Particulate (RTP) Profiler to log temporal particulate variations. For added versatility, the N-FRM Sampler can be operated in directional wind sampling mode or collect only sensor data in meteorological mode.

The N-FRM Sampler offers near FRM performance, while costing a fraction of traditional site-based air samplers. Its compact size and battery-powered function, gives the N-FRM Sampler many advantages over traditional air samplers. Deployment and relocation is quick and easy, and allows monitoring in locations that are inaccessible with traditional air samplers. Flexible mounting options allow for stand–alone support or the use of existing poles and structures. The ability of the N-FRM to operate on rechargeable batteries also significantly reduces the cost of establishing a monitoring site.

The N-FRM is designed for easy operation and maintenance. The intuitive user interface makes programming and calibrating the sampler simple. PM10 and PM2.5 inlets are field serviceable and require only monthly cleanings. Filter holders accept standard 47mm FRM cassettes for easy handling of various filter media. Batteries can be recharged in approximately 1-hour. Data log files with 5-min averages for all sensors can easily be downloaded to a USB Flash drive.

Cities and governments are deploying networks of N-FRM Samplers to survey unmonitored areas and validate permanent Reference Method equipment. Researchers and consultants use the N-FRM in air quality studies and environmental impact assessments. They are also utilized in industrial pollution applications, such as mines and quarries, and in large construction projects for fence line and roadside monitoring. The small and quiet N-FRM air sampler is also a great tool for indoor and industrial workplace sampling that requires high accuracy.

1.1 Principles of Operation

The N-FRM Sampler is specifically designed to meet the US-EPA operational specifications for PM10 and PM2.5 air sampling. To meet the EPA specifications, the N-FRM Sampler is designed to operate at 16.7 LPM and collect 24-hour samples to compare to EPA National Ambient Air Quality Standards. The ARA N-FRM Sampler is a microprocessor-controlled portable air sampler, which can be operated manually or programmed to collect scheduled samples. As specified by the EPA, all critical air sampling parameters are continuously monitored and logged as time indexed 5-min averages to validate the sample. These parameters include: flow rate, temperature, barometric pressure, and accumulated volume. Other sampler related performance parameters are also logged. If the N-FRM Sampler is equipped with the Real-Time Particulate (RTP) Profiler and meteorological sensors, then PM10, PM2.5, wind speed, and wind direction are also included in the data record.

The N-FRM sampler can be easily deployed. It can be mounted on a variety of structures using our universal mounting bracket that can be screwed, clamped, or attached to utility poles, trees, fence posts, etc. Another option is to use a freestanding tripod.

The N-FRM Sampler is equipped to operate from either AC or DC power sources. In the DC mode, the sampler operates from an internal battery pack. A charged battery pack is capable of operating the sampler for about 30-40 hours. This robust capacity allows the sampler to be used in cold weather and high altitude applications. A charger is supplied so the batteries can be re-charged in approximately one hour.

1.2 Particulate Matter Sampling

The N-FRM Sampler can be set up for TSP, PM10, or PM2.5 particulate sampling by configuring the sampling inlet components prior to the filter medium. To measure TSP, the omnidirectional Louvered Inlet is all that is required. For PM10 sampling, an FRM style inertial separator (PM10 Impactor) is added. To collect PM2.5, the sharp-cut ARA VIS-A Cyclone is attached, which physically selects particles 2.5 microns and below. Common N-FRM inlet configurations are shown in FIG. 1.

The N-FRM inertial separators (PM10 Impactor) are designed to operate at a nominal sampling rate of 1 cubic meter per hour (16.7 liters per minute). The N-FRM Sampler incorporates a microprocessor-based active flow control to maintain the sampling rate as ambient conditions and filter loading changes. The sampling rate is monitored and adjusted several times a second and logged at 5-min intervals along with all other important sampling parameters.

To allow for unattended operation, the N-FRM Sampler is easily programmed to initiate and stop sampling. For each sampling event, the N-FRM Sampler generates a summary of important sampling parameters such as start and stop times, total sampling volume, and average ambient temperature and pressure as well as 5-min averages of all ambient and sampler operational parameters. The logged data file can be easily downloaded to a USB flash drive by the operator. The “csv” (comma separated value) file can easily be imported into a spreadsheet.

2 Hardware Description

2.1 PM10 Inlet

The ARA omnidirectional PM10 Inlet is a compact version of the EPA prescribed Reference Method Inlet. It features a screened inlet, wind deflector, and precision PM10 inertial separator (impactor) with moisture trap. The PM10 Inlet is designed to operate at 1 cubic meter per hour (16.67 LPM). The inlet can be used alone for PM10 sampling or in combination with the ARA VIS-A sharp-cut vortex inversion separator for PM2.5.

2.2 PM2.5 Cyclone

The ARA VIS-A (Vortex Inversion Separator) is a precision engineered and compact sharp-cut cyclone fitted to the N-FRM inlet that physically selects particles 2.5 microns and below. This ensures precise measurement of only the PM2.5 size fraction. The PM2.5 separator is designed to operate at 1 cubic meter per hour (16.67 LPM) and requires the ARA PM10 omnidirectional inlet to collect accurate PM2.5 samples.

2.3 Filter Holder

The aluminum filter holder is precisely manufactured for a tight seal and no contamination of the filter media. The filter holder is designed to use common EPA specified 47mm cassettes for PM2.5 sampling.

2.4 Flow Control System

The N-FRM Sampler incorporates a microprocessor-based active flow control to maintain the sampling rate as ambient conditions and filter loading changes. The sampling rate is monitored and adjusted several times a second and logged at 5-min intervals along with all other important sampling parameters. Under normal conditions the active flow control will maintain the sampling well within +/- 2%. If the sampling rate cannot be maintained within +/- 5% a flow error is generated and logged, and if the error continues for 5-minutes the sampler will shut down.

3.3 Power Source

3.3.1 Batteries

Each N-FRM Sampler is equipped with two 18V/5Ah DeWalt lithium-ion batteries.

Check Battery Charge

Each battery has a Charge Gauge on the front, consisting of three green LED lights and a button. Press and hold the Charge Gauge button. The LED lights will illuminate designating the level of charge left. See Figure 4 to determine if your batteries need to be charged.

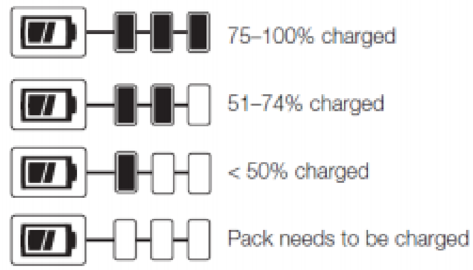


Figure 4. Battery Charge Levels

Charge Batteries

Plug the charger into an appropriate AC outlet. The charger provided by ARA Instruments is rated for 220VAC. If you prefer a 110VAC charger, we recommended DeWalt DCB105.

Insert the battery into the charger as shown in Figure 5. The red charging light will blink continuously, indicating the charging process has started. Batteries should be fully charged within 1 hour. Completion of the charging cycle is indicated by the red light remaining ON continuously. The battery is fully charged and may be used at this time or left in the charger.

The charger is designed to detect certain problems that can arise. Problems are indicated by the red charging light flashing at a fast rate. Try a different battery to determine if the charger is working properly. If the new battery charges correctly, then the original battery is defective and cannot be used.

Figure 5. Battery Charger

Please read all of the DeWalt instructions for the batteries and charger included with your sampler for more details about charging and storing batteries.

Install Batteries

Insert two charged batteries into the ARA N-FRM Battery Holder as shown in Figure 6. Make sure the batteries are fully seated and latched to the Battery Holder.

Insert the Battery Holder into the ARA N-FRM.

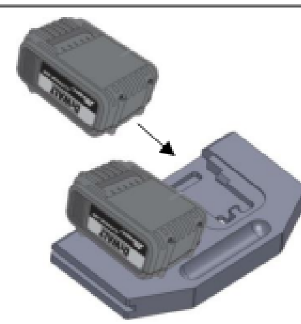


Figure 6. Battery Inserted Into Holder

3.3.2 AC Power Supply

Each N-FRM Sampler is also equipped with a 120/240V AC Power Supply to be used when an outlet is available.

3.3.3 Using Batteries and AC Power Supply

The AC Power Supply **does not** charge the batteries. The batteries can only be charged with the included Dewalt Battery Charger.

When both the AC Power Supply and Batteries are connected, the N-FRM Sampler will run off the AC Power Supply. If the AC Power Supply is interrupted, the Batteries will take over until AC Power Supply is restored.

3.3.4 Solar Panel System

The ARA N-FRM Sampler utilizes a Zamp 24V Solar Panel System.

3.4 Powering N-FRM Sampler On/Off

Place the Power ON/OFF Rocker switch at the lower right of the front panel of the air sampler in the **ON** position. The Sampler will boot up into the Home Screen. The default operational mode is **MODE:OFF**.

3.5 Navigation

Navigate through the menus by rotating the selector knob to highlight a desired selection. Press the knob to select. The menu system is intuitive, especially to those with air sampling experience. To exit any menu, rotate the selector knob to highlight the top item of all menus and select **EXIT**. **MODE: OFF** takes you back to the Home Screen.

3.6 Sleep Mode

The N-FRM Sampler enters power saving "sleep mode" after a few minutes of no input from the selector knob. In this mode, the LCD screen is blank. To wake up the N-FRM Sampler, press and hold the selector knob for 3-seconds.

3.7 Setting Time and Date

On the Home Screen, confirm that the date and time are accurate. If necessary, follow these steps to set the correct Time and Date:

- Select **SETUP** from the Home Screen
- Scroll down, highlight **SYSTEM SETUP** and select
- Scroll down, highlight **DATE/TIME** and select
- Scroll down until the Day is highlighted and select
- Rotate the selector knob until the correct date is highlighted and select
- Repeat for Month, Year, Hour, Minute, and Second
- Select **DATE/TIME:EXIT**
- Select **YES** to save Date/Time
- Select **SYSTEM:EXIT** and then **SETUP:EXIT** to return to Home Screen

3.8 Filter Media

3.8.1 Choosing Filter Media

The ARA N-FRM Sampler is designed to use the filters specified by the US-EPA Federal Reference Method for PM2.5 Sampling. These types of filters work best for sampling…

- 2 um PTFE Teflon Filter w/support ring – Recommended if chemical analysis for non-carbon based compounds will follow gravimetric analysis**. Several manufacturers produce Teflon filters that meet the US-EPA specifications, and work well in the N-FRM Sampler. The key specification to meet for operation on battery power for is: Filter Resistance of < 30 cm-H2O @ 16.7 LPM. If you will be running samplers on battery power, we recommend the PALL Teflo Filters (#R2PJ047) as they have a very low resistance and will maintain battery charge beyond 24 hours.**
- Teflon-Coated Glass Filter – Ideal for gravimetric analysis.
- Pure Quartz Filter – Recommended if chemical analysis for carbon based compounds will follow gravimetric analysis.

For the sampler to maintain flow and run efficiently, use filters with a maximum pressure drop (with a clean filter) of 30 cm H2O column @ 16.67 LPM clean air flow. If filter media is too restrictive, the sampler will not be able to complete a 24-hour run and will automatically shut-off if batteries are depleted.

3.8.2 Installing a Filter

Note: This procedure should take place in a laboratory or clean area. Contact and handling of all filter media should be limited to the non-exposed outer edge with smooth tipped forceps (non-serrated) or plastic tipped forceps. Filter media should never be handled with fingers.

- Unscrew the Filter Holder Top from the Filter Holder Bottom
- Remove Filter Cassette
- Use ARA Cassette Separator to open the cassette. The top and bottom of the Filter Cassette are machined for a press fit. The Filter Cassette Top has a large beveled interior edge. See Figure 7 for appropriate use of Cassette Separator.

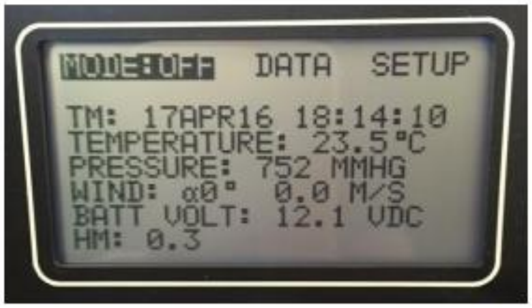
Warning: Manually prying the cassette apart with fingers can result in the cassette violently opening, causing damage to filter media or support screen.

Figure 7. Open 47mm Cassette

- With forceps, place a pre-weighed, clean filter media onto the Support Screen in the Filter Cassette Bottom. Install the Filter Cassette Top, firmly and evenly pressing down to complete the assembly.
- Place the Filter Cassette into the Filter Holder and reassemble by firmly screwing together the Filter Holder Top and Filter Holder Bottom. *Note: Cassettes can be handled with fingers. But make sure not to touch filter media.*

4 Operational Overview

4.1 Home Screen



Once the N-FRM Sampler is powered ON, the Home Screen appears. The Home Screen displays the Time, Temperature, Barometric Pressure, Wind Speed, Battery Voltage, and Hour Meter (Total Pump Operating Hours).

There are three menu selections across the top of the Home Screen: OFF, DATA, SETUP. These are the Administrative Modes.

4.2 Operational Modes

4.2.1 Mode: OFF

When the N-FRM Sampler is powered on, Mode: OFF is the default setting.

Select this administrative mode to move between the Operational Modes: OFF, ON, MET, PROGRAM, SECTOR and REMOTE.

4.2.2 Mode: ON

Select to manually turn the N-FRM pump ON.

4.2.3 Mode: MET

Select to view and log current meteorological parameters and particle sensor data if the Wind Sensor and RTP Profiler are installed. In this mode, data logging begins after 5 minutes. The pump will not run in **MET MODE**.

4.2.4 Mode: PROGRAM

Select to set the sampler to run at user-defined parameters: time, date, duration, interval, and flow rate. This mode logs all standard parameters, in addition to real-time particle data and meteorological data (if installed). This mode also allows the user to set parameters for conditional sampling. Options include: minimum wind speed, wind direction (defined sector), and minimum PM2.5 and PM10 concentrations (if Real Time Profiler is installed).

4.3 Data

The **DATA** administrative mode allows the user to view or erase summaries of the last few sampling events.

VIEW SUMMARIES – In this selection, the last 10 sampling events are stored and organized by Start Time. The summary data for each event is viewed by scrolling down the LCD screen. To change and view other events, scroll and select **ST** (start time and date). Each press of the selector knob changes the event data to view.

EXPORT LOG – Scrolling to the bottom of the **VIEW SUMMARIES** screen and selecting **EXPORT LOG** allows the user to export a summary, including 5-minute averages of sensor data and sampling parameters of the selected event to a USB flash drive.

ERASE ALL SUMMARIES – Selecting this option allows the user to erase all sampling event data. Note: It is not necessary to erase summaries. The newest sampling event will overwrite the oldest summary data once the maximum has been reached.

4.4 Setup

The **SETUP** administrative mode has various options relating to the sampler program and system setup.

SET PROGRAM: Allows the user to set the program for the next sampler run. Instructions that are more specific can be found in Section 5.1.1.

CLEAR ALL DATA: Will delete all sampler runtime data.

EXPORT SETUP: Using USB drive, the user can download sampler settings.

IMPORT PROGAM: A program may be imported from the USB drive.

SYSTEM INFO: Lists sampler information, including the Serial Number and latest Firmware version.

UPDATE FIRMWARE: With the correct file on a USB drive the user can update the firmware of the sampler. The latest firmware is available on the ARA Instruments website – www.arainstruments.com

SYSTEM SETUP: This menu allows the user to set the date and time and other sampler parameters.

DATE/TIME: User can set the current date and time. ***Note: When the sampler battery is removed, the sampler will hold the current date and time for approximately two weeks.***

FLOW RATE: User can turn the pump on and off and set the flow rate. This mode is useful for flow audits and calibration. There is a user adjustable SLOPE and INT (Intercept) if flow calibration is needed.

AMBIENT TEMPERATURE: This mode allows the user to turn ON or OFF the ambient temperature sensor if desired. If turned OFF the sampler defaults to a user adjustable, standard temperature of 25° C. The user can also enter an offset for calibration purposes.

BAROMETRIC PRESSURE: This mode allows the user to turn ON or OFF the ambient pressure sensor. If turned OFF the sampler defaults to a user adjustable, standard pressure of 760 mmHg. The user can also enter an offset for calibration purposes.

STANDARD TEMP PRESS: This mode allows the user to adjust the standard temperature and pressure used to calculate "standard" flow and volume, and also the default conditions if the temperature and/or ambient pressure sensors are turned off. Also, in this screen the user can select to sample at standard conditions or local conditions. The default for the sampler is sample at actual conditions of local temperature and pressure (LTP).

LCD BRIGHTNESS: Allows adjustment of the LCD backlight.

RESTORE DEFAULTS: Will set sampler back to factory defaults ***(be cautious in using this option since it will erase all user input calibration data)***.

BLUETOOTH CONTROL: For future use.

PARTICLE COUNTER: The N-FRM Sampler comes with default mass values for PM2.5 and PM10 particulates. Users can adjust these values proportionally to match their local aerosol characteristics.

BOOT HISTORY: This mode is for troubleshooting firmware issues.

REBOOT: Will reboot the sampler.

5 Operating the N-FRM Sampler

5.1 User-Defined Programming

5.1.1 Creating a Program to Operate at a Specific Time Interval

There are two methods to view the **SET PROGRAM** screen.

Method 1: On the Home Screen, highlight **SETUP** and select by pushing the selector knob. Scroll down to **SET PROGRAM** and select.

Method 2: On the Home Screen, highlight **MODE: OFF** and select. Rotate the knob until **MODE: PROGRAM** is highlighted and select. Scroll down to **ST** (start date and time) and select to open the **SET PROGRAM** page.

You can now select the fields you desire to edit as you setup the sampler to run:

CLEAR PROGRAM: Select this option if you want to clear the current program. This is not necessary but can be helpful if you plan to change most of the parameters.

SAMPLE ID: A unique 4-digit ID can be entered but is not necessary. Sometimes used to identify site or filter media.

START: Select this option to enter the Start Date and Time. Scroll to the field that you would like to edit and push to edit. Turn the selector knob to choose the desired date or time variable, then select and continue to scroll through the fields until the START Date and Time are set as desired.

DURATION: Select this option to enter the duration of the sample event. Enter hours and minutes by turning the selector knob and pushing to edit the desired field.

INTERVAL: This option is used to setup a repeating sample event. Enter the hours and minutes from the end of the programmed run that you would like the event to repeat. An entry of 72:00 would repeat the sample every 72 hours. For a single non-repeating event set the INTERVAL to 00:00.

SET FLOW: Use this field to set the desired flow for the programmed event. The nominal flow rate for ARA PM10 and PM2.5 inertial separators is 16.7 LPM.

CONDITIONS: Select this field to open a sub-menu for conditional sampling. When conditions are set the sample pump will run after the condition has been met for 5-min, and will turn off when condition has not been met for 5-min. If multiple conditions are set all conditions must be met for the sample pump to run.

MINIMUM WIND: Set a minimum wind speed threshold. The default is 0.0 meters/sec.

SECTOR AZIMUTH: Works with Central Angle for Directional Sampling. Set a centerline azimuth wind direction (direction wind is from) . The default is 0 degrees.

CENTRAL ANGLE: Set the size of the central angle (bisected by Sector Aziumth). The default is 0 degrees. *For example, if the Sector Azimuth was set to 90 degrees, and the Central Angle was set to 40 degrees, the sampler pump would only turn on when the wind direction was between 70 and 110 degrees.*

PM2.5: Set a minimum PM2.5 Concentration threshold. The default is 0 micrograms/cubic meter.

PM10: : Set a minimum PM10 Concentration threshold. The default is 0 micrograms/cubic meter.

REMOTE TRIGGER: Allows user to turn on the sampling pump with a external relay. (requires factory modification). The default is NO.

CLEAR CONDITIONS: Select this option to reset all conditions to default.

NOTE ON SAMPLING AT STANDARD CONDITIONS: If the method requires sampling at standard conditions, this can be changed in **SETUP** -> **SYSTEM SETUP** -> **STANDARD TEMP PRESS**. (See Section 4.4)

5.1.2 Running a Program

To activate the sampler at the programmed time and interval the sampler must be set to the Program Operational Mode.

On the Home Screen, select **MODE: OFF**. Rotate the knob until **MODE: PROGRAM** is highlighted and select.

The LCD screen displays **TM** (current date and time) and **ST** (start date and time) of the programmed event. Confirm that these parameters are correct and leave the sampler in Program Mode.

5.1.3 Ending a Program

After a programmed sampling event, the sampler remains in **MODE: PROGRAM** unless manually changed.

Highlight **MODE: PROGRAM** at the top of the LCD screen and select. Rotate the selector knob until **MODE: OFF** is highlighted and select. The Home Screen will appear.

5.4 View Summaries

A summary of the programmed event can be viewed and downloaded by selecting **DATA** from the Home Screen. Scroll down until **VIEW SUMMARIES** is highlighted and select. The LCD screen shows the **ST** (start date and time) of the last programmed event and the important sample parameters. *Note: Repeated selecting of **ST** will scroll through the last ten sample events.*

- Sample Duration, hrs:min
- Sample Volume, cubic meters (at sampling conditions)
- Average Sample Flow Rate, LPM
- Average Ambient Temperature, °C
- Average Barometric Pressure, mm-Hg
- Error Codes, if any
- Sample Volume, cubic meters (at standard conditions for PM10 sampling)
- Starting Battery Voltage
- Ending Battery Voltage

5.5 Export Data

In the **VIEW SUMMARIES** menu, scroll down and select **EXPORT LOG**. Follow the prompts and insert a USB Flash Drive.

Warning: The USB port has low power capabilities. Plugging in devices other than USB Flash Drives, such as cell phone chargers and portable hard drives, can damage the port. The best option for data removal is using a USB 2.0 Flash Drive.

The LOG file is a CSV (Comma Separated Value) file suitable for import into a Spreadsheet Program for viewing, printing, and analyzing. In addition to the summary of key sampling parameters at the top, the file contains time delimited 5-minute averages of all sensors for analysis and sample validation. See Figure 8 for an N-FRM Sampler CSV file imported into Excel.

FILENAME: L0416026.CSV
SERIAL: 16026
SAMPLE: 0000
MODE: PROGRAM
START: 20/JUL/16 at 13:10
PROG DURATION: 01:00:00
SAMPLE DURATION: 1:00:00
SAMPLE VOLUME: 1.002
STANDARD VOLUME: 0.981
AVERAGE FLOW: 16.70
AVERAGE TEMP: 28.9
AVERAGE PRESS: 754
AVERAGE PM2.5: 0.000
AVERAGE PM10: 0.000
SET FLOW: 16.7
START VDC: 17.8
END VDC: 17.8

DATE	TIME	SECONDS	LPM_SET	LPM_ACT	VOL_M3	VOL_STD	TEMP_EXT	MMHG	WIND_AZ	WIND_MP	VOLTS	AMPS	TEMP_INT	P1	P2	PM2.5	PM10	FLAGS
20-Jul-16	13:15	300	16.7	16.71	0.084	0.082	27.7	754	0	0	17.8	0.191	30.1	0	0	0	0	NONE
20-Jul-16	13:20	300	16.7	16.7	0.167	0.165	27.3	754	0	0	17.8	0.187	31	0	0	0	0	NONE
20-Jul-16	13:25	300	16.7	16.7	0.251	0.246	28.4	754	0	0	17.8	0.185	31.4	0	0	0	0	NONE
20-Jul-16	13:30	300	16.7	16.7	0.334	0.328	28.6	754	0	0	17.8	0.184	31.8	0	0	0	0	NONE
20-Jul-16	13:35	300	16.7	16.7	0.418	0.408	29.4	754	0	0	17.8	0.183	32.4	0	0	0	0	NONE
20-Jul-16	13:40	300	16.7	16.7	0.501	0.492	28.1	754	0	0	17.8	0.182	32.7	0	0	0	0	NONE
20-Jul-16	13:45	300	16.7	16.7	0.585	0.572	28.9	754	0	0	17.8	0.182	32.8	0	0	0	0	NONE
20-Jul-16	13:50	300	16.7	16.7	0.668	0.652	29.7	754	0	0	17.8	0.18	33.1	0	0	0	0	NONE
20-Jul-16	13:55	300	16.7	16.71	0.752	0.734	29.8	754	0	0	17.8	0.18	33.3	0	0	0	0	NONE
20-Jul-16	14:00	300	16.7	16.71	0.835	0.816	29.6	754	0	0	17.8	0.18	33.5	0	0	0	0	NONE
20-Jul-16	14:05	300	16.7	16.7	0.919	0.896	30.1	754	0	0	17.8	0.179	33.8	0	0	0	0	NONE
20-Jul-16	14:10	300	16.7	16.71	1.002	0.979	29.6	754	0	0	17.8	0.179	33.9	0	0	0	0	NONE

Figure 8. CSV file imported into Excel

The LOG file name is an 8-digit number designated as 'NNNNJJJH'.

NNNN = Last 4 digits of Sampler serial number

JJJ = Start day of sampling event , Julian (Ordinal) Day Number (Example: February 5th = 36)

H = Start hour of sampling event, Letter (Example: 2 a.m. = B)

The following is a description of the sampling parameters found in the exported LOG file:

PARAMETER	DESCRIPTION
DATE	Sample Date (Day-Month-Year)
TIME	Sample Time Interval (5 minute averages)
SECONDS	Interval Time (seconds)
SLPM_STD	Flow Rate (standard conditions, SLPM)
LPM_LTP	Flow Rate (Local Temp and Press, LPM)
VOL_M3	LTP Sample Volume (cubic meters, accumulated)
VOL_STD	Sample Volume at Standard Conditions (cubic meters, accumulated)
TEMP_EXT	External Temperature (degrees Celsius)
MMHG	Barometric Pressure (mmHg)
WIND_AZ	Wind Azimuth (degrees)
WIND_MPS	Wind Speed (meters per second)
VOLTS	Battery Voltage
AMPS	Battery Amps
TEMP_INT	Internal Temperature (degrees Celsius)
PM2.5	Estimated Concentration (micrograms per cubic meter)
PM10	Estimated Concentration (micrograms per cubic meter)
AQI	US-EPA PM2.5 Air Quality Index
FLAGS	NONE – No errors during sampling B – Battery failed, not enough voltage F – Flow rate could not be maintained W – Wind direction is in programmed sector A – Amps are too high. Possible pump failure. V – External Valve activated (cartridge sampler option)