Interagency Monitoring of Protected Visual Environments (IMPROVE) Network

QUALITY MANAGEMENT PLAN

Version 2.0

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Office of Air Quality Planning and Standards

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QUALITY MANAGEMENT PLAN IDENTIFICATION AND APPROVAL

The attached QMP for the IMPROVE Program is hereby recommended for approval and commits the resources and personnel to follow the elements described within.

Colorado State University

Signature: Bonne Ford Date: 01/07/2025

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DOCUMENT HISTORY

Revision	Release Date	Initials	Section(s) Modified	Brief Description of Modifications
Original	May 2002			
2.0	January 2025	BF	All	Updated all personnel, procedures, organizational chart, network descriptions, SOPs, and brought into conformance with new EPA QMP guidelines.

FOREWORD

The following document is a Quality Management Plan (QMP) for the environmental information operations of the Aerosol Monitoring Network component of the IMPROVE (Interagency Monitoring of Protected Visual Environments) Visibility Monitoring Program. This QMP outlines the roles of the many organizations involved in the IMPROVE Aerosol Monitoring Network.

This QMP was generated using the EPA Quality Assurance (QA) regulations and guidance as described in the *EPA Quality Management Plan Standard (CIO 2105-S-01).* All pertinent elements of the QMP regulations and guidance are addressed in this document.

ACKNOWLEDGMENTS

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ACRONYMS AND ABBREVIATIONS

AQMT	Air Quality Management Team at UC Davis
AQRC	Air Quality Research Center at UC Davis
AQS	Air Quality System database
ARS	Air Resource Specialists
BLM	Bureau of Land Management
CAA	Clean Air Act
CFR	Code of Federal Regulations
CIA	Class I Area
CIRA	Cooperative Institute for Research in the Atmosphere
CSN	Chemical Speciation Network
DQA	Data Quality Assessment
DQO	Data Quality Objective
DRI	Desert Research Institute
EPA	U.S. Environmental Protection Agency
FLMs	Federal Land Managers
FED	Federal Land Manager Environmental Database
HIPS	Hybrid Integrating Plate and Sphere system, an analytical technique for measuring light absorption
IC	Ion chromatography, analytical technique to determine concentration of ions
IMPROVE	Interagency Monitoring of Protected Visual Environments
MARAMA	Mid-Atlantic Regional Air Management Association
MQAG	Monitoring and Quality Assurance Group
MQOs	Measurement Quality Objectives
NAAQS	National Ambient Air Quality Standards
NESCAUM	Northeast States for Coordinated Air Use Management
NOAA	National Oceanic and Atmospheric Administration
NPS ARD	National Park Service Air Resources Division
OAQPS	Office of Air Quality Planning and Standards
PM	Particulate matter

PM2.5	Particulate matter less than 2.5 micrometers in diameter
PSD	Prevention of Significant Deterioration
QA	Quality Assurance
QAAR	Quality Assurance Annual Report
QAM	Quality Assurance Manager
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMP	Quality Management Plan
RTI	Research Triangle Institute
SIP	State Implementation Plans
SOP	Standard Operating Procedure
SQL	Structured Query Language
TI	Technical Information
TOA	Thermal/Optical Analysis
TSA	Technical System Audit
UCD	University of California-Davis
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
WESTAR	Western States Air Resources Council
XRF	X-Ray Fluorescence

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1. PROGRAM MANAGEMENT

The purpose of this section is to document the overall scope, applicability, management responsibilities, and quality assurance policy of the IMPROVE Aerosol Monitoring Network. The IMPROVE network performs work in support of the EPA's mission and national program priorities, and thus must follow the EPA's Quality Program guidelines as outlined in the IT/IM Directive No. CIO 2105-P-01.3 Environmental Information Quality Procedure (available here: https://www.epa.gov/irmpoli8/environmental-information-policy-procedures-and-standards).

This section describes the program, organization, and management as it relates to quality assurance as required by the directive.

1.1. INTRODUCTION

Visibility impairment is an effect of air pollution in the atmosphere caused by the scattering and absorption of light by particles and gases in the air. Under the Clean Air Act (CAA), Congress recognized that good visibility is a resource to be valued and preserved, now and for future generations. In Section 169A of the Act, Congress set forth a national goal that calls for "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory federal Class I Areas (CIAs), which impairment results from man-made air pollution." The U.S. Environmental Protection Agency (EPA) is responsible for establishing regulations ensuring that "reasonable progress" toward the national goal is achieved in the 156 mandatory CIAs (primarily national parks and wilderness areas) identified under the Act. In 1999, the EPA promulgated Regional Haze Regulations requiring states to develop state implementation plans (SIPs) that include reasonable progress goals for improving visibility in Class I areas, and present strategies to achieve those goals.

Monitoring of visibility-related parameters has and will be used to document existing conditions and identify trends in ambient visibility. The IMPROVE Program was established in 1985 in response to the 1977 Clean Air Act Amendments. Federal Land Management agencies (FLMs) responsible for CIAs joined the EPA in a collaborative program known as the Interagency Monitoring of Protected Visual Environments (IMPROVE) Program. Three primary visibility monitoring networks operate under the IMPROVE Program:

Aerosol Monitoring Network: Applies speciation filter samplers to measure the physical properties of visibility-related ambient atmospheric particles (chemical composition, size, concentration, distribution, and other properties).

Optical Monitoring Network: Applies nephelometers to measure the ability of the ambient atmosphere to scatter light.

Scene Monitoring Network: Applies digital camera systems to document the appearance of a scene viewed through the atmosphere.

Data from the Aerosol Monitoring Network are used for calculating trends as reported in the IMPROVE Report (https://vista.cira.colostate.edu/Improve/improve-reports/). Data

and descriptions of the monitoring activities from these three networks are available on the IMPROVE and Federal Land Manager Environmental Database (FED) websites (https://vista.cira.colostate.edu/Improve/ and https://views.cira.colostate.edu/fed/). Digital photographs from the scene monitoring network are available on the National Park Service website (https://www.nps.gov/subjects/air/webcams.htm).

Visibility is also protected under Section 109 (relating to the National Ambient Air Quality Standards, or NAAQS) and Section 165 (requirements for new or reconstructed sources) of the Act. Section 109 calls for the EPA to establish primary and secondary NAAQS to protect public health and public welfare, respectively. For many years, visibility has been recognized as a "welfare effect" of particulate matter. The current annual (averaged over a period of 3 years) $PM_{2.5}$ (particulate matter less than 2.5 micrometers in diameter) primary standard is 9.0 micrograms per cubic meter and the secondary standard is 15.0 micrograms per cubic meter. The 24-hour standard is 35 micrograms per cubic meter for the 98th percentile of the 3-year average.

The $PM_{2.5}$ monitoring regulations of 40 CFR Part 58 recognize the importance of monitoring for protection of secondary NAAQS and allow the use of the IMPROVE protocols for the purpose of characterizing background or transported levels of $PM_{2.5}$. The $PM_{2.5}$ and IMPROVE programs are closely related through this provision. It is important to understand the regional nature of $PM_{2.5}$ levels to improve the accuracy of regional PM models and ultimately to develop effective control strategies. Section 165 of the Act provides for pre-construction review of air quality impacts associated with new or modified major sources. The Prevention of Significant Deterioration (PSD) program protects CIAs by allowing only a small increment of air quality deterioration in these areas and by providing for assessment of potential impacts on the air quality related values (AQRVs) of CIAs. AQRVs include visibility and other fundamental purposes for which these lands have been established.

1.2. QUALITY STATEMENT

The IMPROVE Aerosol Monitoring Network is a key component of the EPA's national fine particle monitoring and is critical for tracking progress related to the Regional Haze Rule (RHR). IMPROVE is considered a regulatory monitoring network and has the responsibility of providing regional haze monitoring representative of all visibility-protected CIAs, where practical, and tracking progress in each CIA toward returning visibility to natural conditions by 2064. In addition to tracking and documenting visibility conditions, the IMPROVE network's mission includes assessing the causes of impairment by measuring particulate mass and its chemical composition and identifying chemical species and emission sources responsible for human caused visibility impairment.

The implications of this mission and of the IMPROVE network's role as a regulatory network for the RHR, are that the measurements taken need to be useful for quantifying all changes in concentrations of haze forming species and for determining which portions of haze forming species are anthropogenic over long periods of time at varying concentration levels. Anthropogenic emission have, on average, declined across the U.S., leading to corresponding decreases in haze in many CIAs, such that some sites are already considered

equivalent to or below natural conditions on the most impaired days. Thus, the monitoring methods must be reliable at high concentrations and low concentrations and must be useful for detecting both large and subtle changes in visibility. CIAs are also located across the U.S. in a variety of different climates and are impacted by a variety of different emission sources. Thus, techniques need to be suitable for ensuring quality of data under a variety of environmental conditions and be able to accurately capture each of the different components of light scattering that may be indicative of these different emission sources.

It is essential to ensure that the methodologies used to collect and analyze visibility-related aerosol data are consistent and applicable for tracking progress toward visibility goals under these various conditions. All methods need to be scientifically credible and capable of tracking multi-decadal trends in rural settings. This QMP documents the procedures for ensuring that the network is: (1) achieving high data capture (both in the collection and handling of samples and through use of high precision analytical techniques), (2) using consistent monitoring and analytical techniques, and (3) being transparent in communicating all knowledge gained from the network. The quality of the data is essential to the mission of the IMPROVE network, and the IMPROVE network is committed to focusing their quality assurance efforts on the consistent minimization of measurement bias.

The IMPROVE network is committed to following quality management principles and practices to ensure that data are of acceptable quality, that appropriate QA/QC systems are in place, that problems are identified and corrected in a timely manner, that personnel have required training, and that operational improvements are continuous, as further outlined in this QMP and as required by the EPA's *Environmental Information Quality Policy* (CIO 2105.4) and detailed in the *Environmental Information Quality Procedure* (CIO 2105-P-01.4). The IMPROVE network commits to ensuring that resources are allocated to support the quality program (section 1.4.7). All participants in the IMPROVE network have a responsibility to implement the quality system elements, as appropriate, to ensure the quality of decisions made.

This QMP deals strictly with the IMPROVE Aerosol Monitoring Network. The QMP also documents the roles and responsibilities of the organization as it pertains to the management and quality assurance activities of the network. The IMPROVE Steering Committee, which serves as the senior management of the network, is ultimately responsible for implementing the QMP and providing the quality assurance manager (QAM) with the authority to carry out quality assurance activities. All organizations involved in the network must agree to the procedures and management structure outlined in the QMP. The QAM reviews the QMP annually to determine if updates should be made. The QMP will be thoroughly reviewed for re-approval every 5 years from the date approved to determine if the information remains relevant and effective.

1.3. PRIMARY ACTIVITIES OF THE IMPROVE NETWORK

Before explaining the roles and responsibilities of the people and organizations of the IMPROVE network, it is important to briefly delineate the different technical activities of the network. There are three main activities covered by this QMP, as shown in the

Organizational Chart (Figure 1): (1) field activities, (2) laboratory activities, and (3) data product activities (compilation, analysis, and reporting). Quality assurance of the whole network requires the quality assurance of each component. Thus, there are specific quality assurance procedures and documentation for each activity.

1.3.1. Field Activities

In 2024, the IMPROVE network consisted of 229 sites (155 current and 74 discontinued sites). The 155 current sites represent 155 of the 156 mandatory Class I areas (Bering Sea Wilderness being the exception). Fine particle monitoring at each site is achieved by using the IMPROVE aerosol sampler to collect filter samples. The standard IMPROVE sampler has four sampling modules (A, B, C, D), designed to obtain a complete signature of the composition of the airborne particles that affect visibility. Coordination of field activities is led by the Field Team [current contract to the Air Quality Research Center (AQRC) at the University of California, Davis (UC-Davis)]. Once installed, field operators conduct routine sampling and document site-specific activities. Quality assurance for field operations include analysis of filters, tracking of sampler performance, routine maintenance and calibration, and field site audits.

1.3.2. Laboratory Activities

Filter samples are shipped from IMPROVE network sites to laboratories for analysis of specific aerosol species. Module A filters are analyzed for $PM_{2.5}$ mass, elemental concentrations, and filter light absorption. Module B filters are analyzed for ions. Module C filters are analyzed for organic and elemental carbon. Module D filters PM_{10} particles and are analyzed for mass. Each laboratory has internal Quality Assurance (QA) procedures in addition to QA procedures conducted across laboratories for the network.

1.3.2. Data Product Activities

The principal products of the IMPROVE monitoring program are the speciated data and related visibility metrics. Routine and novel data analyses and products are also generated, such as the Regional Haze Rule (RHR) metrics generated for each complete calendar year of data and the IMPROVE Report. These data and all associated metadata and reports are made available through the IMPROVE (https://vista.cira.colostate.edu/Improve/) and FED (https://views.cira.colostate.edu/fed/) websites. Data are also available from the EPA's AQS database (https://www.epa.gov/aqs). Data Validation for filter samples is the responsibility of the coordinating laboratory (currently AQRC). The IMPROVE Network Operations Subcommittee oversees the data QA/QC procedures. The IMPROVE Data Analysis and Reporting Subcommittee (Section 1.4.2) oversees coordinating QA studies and reviewing QA documents to determine when additional data audits or analysis studies should be conducted.

1.4. ROLES, RESPONSIBILITIES, AND AUTHORITY

The organizational chart is provided in Figure 1 and highlights the relevant organizations involved in the activities of the IMPROVE Network. Primary funding comes from the U.S. Environmental Protection Agency (EPA), who also provides oversight for the project, including final approval of the quality documents and proposed procedures. Additional

funding comes from the National Park Service, U.S. Forest Service, Bureau of Land Management, Department of Energy. This additional funding can be used to support IMPROVE Protocol sites (also funded by states or other entities), additional data analysis, special studies, and additional quality assurance procedures.

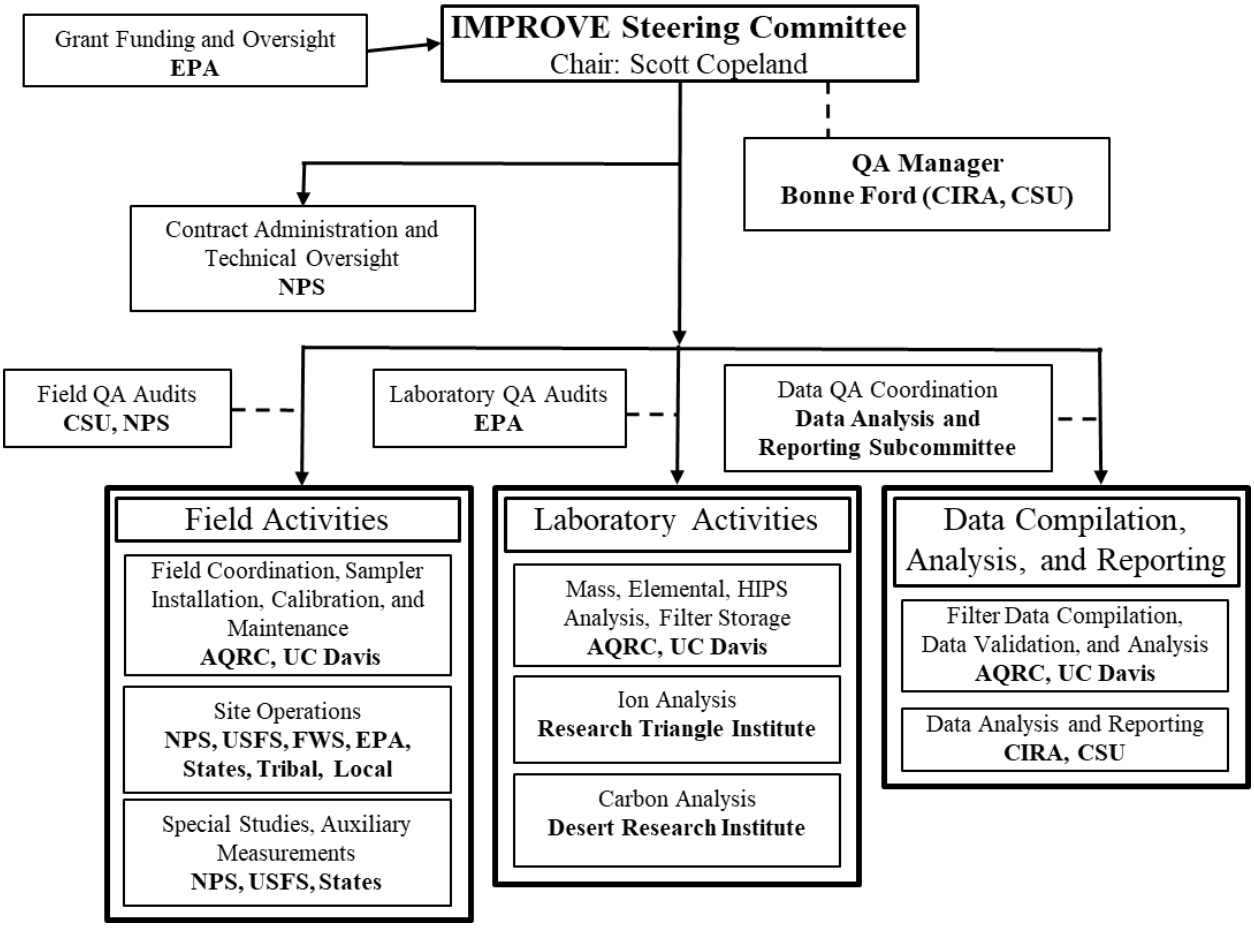

Figure 1. IMPROVE Organizational Chart. The IMPROVE Steering Committee, whose current chair is Scott Copeland, serves as the senior management of the IMPROVE organization while the National Park Service (NPS) handles most program and contract management. Dashed lines indicate QA activities with Bonne Ford serving as the IMPROVE Quality Assurance Manager. Major activities of the IMPROVE Network are listed along with the entities currently responsible.

1.4.1. IMPROVE Steering Committee (Senior Management)

The IMPROVE Steering Committee oversees all program activities, develops guidance and procedures governing IMPROVE samples and data, and makes recommendations to the EPA and the NPS related to funding, expansion or reduction of the network, and all other technical and non-technical issues. It coordinates subcommittee activities and provides a forum for the interaction between stakeholders and other interested parties.

These activities are conducted with direct interaction with the laboratories conducting analyses.

The IMPROVE Steering Committee consists of representatives from the ten voting member organizations and the non-voting associate members (Table 1). Members of the Steering Committee are appointed by their organizations and serve an indefinite term determined by their organization. Information on how new organizations can be added to the Steering Committee are provided in the IMPROVE charter, available on the IMPROVE website (https://vista.cira.colostate.edu/Improve/). These representatives provide oversight to the entire program and meet at least annually to discuss any issues that concern the program. In addition, they interact with the QAM and the organizations involved in field, laboratory, and data reporting activities. Contracted laboratories participate in steering committee meetings and subcommittees but are not voting members of the IMPROVE steering committee.

Table 1. List of IMPROVE Steering committee member organizations.

Steering Committee Member Organizations
U.S. Environmental Protection Agency (EPA)
National Park Service (NPS)
U.S. Forest Service (USFS)
U.S. Fish and Wildlife Service (FWS)
Bureau of Land Management (BLM)
National Oceanic and Atmospheric Administration (NOAA)
Western States Air Resources Council (WESTAR)
Northeast States for Coordinated Air Use Management (NESCAUM)
Mid-Atlantic Regional Air Management Association (MARAMA)
National Association of Clean Air Agencies (NACAA)
Associate Members
State of Arizona
Environment and Climate Change Canada
Republic of Korea Ministry of Environment

The current chair of the IMPROVE Steering Committee is Scott Copeland, who represents the U.S. Forest Service. The duties of the chair are outlined in the IMPROVE charter available on the IMPROVE website (https://vista.cira.colostate.edu/Improve/) and include: preparing meeting agendas and presiding over Steering Committee meetings, managing external filter sample requests, organizing and managing subcommittees and workgroups, and keeping the broader IMPROVE community informed of important network changes, events, and data updates.

1.4.2. IMPROVE Subcommittees

Three subcommittees support the Steering Committee and provide guidance needed to evaluate and advance the IMPROVE monitoring program, help oversee the quality of data and operations of the network and ensure the timely and transparent dissemination of measurement data and analysis results. Each subcommittee is composed of members from the Steering Committee and the broader IMPROVE community (scientists, federal partners, and state partners) and has a specific mission and objectives defined by the subcommittee. Standing subcommittees include (1) network operations; (2) data analysis and reporting; and (3) communication and outreach. Ad-hoc workgroups may also be formed to work on timely issues related to IMPROVE. Structure of the subcommittees and full details on responsibilities, management practices, and structure are provided in the IMPROVE charter.

Table 2. List of IMPROVE Steering Committee subcommittees with their purpose and tasks.

Subcommittee	**Purpose and Tasks**
Network Operations	1. Ensure network operations and sample analysis are following procedures outlined in Standard Operating Procedures (SOP) and Quality Assurance Plan (QAPP). 2. Oversee the data QA/Quality Control (QC) procedures. 3. Evaluate and recommend any necessary changes to network operations.
Data Analysis and Reporting	1. Develop policies for generating and distributing the IMPROVE data, metadata, and data products. 2. Review and oversee all quality control assessments as defined in the QAPP, assess irregular/suspect data, and make recommendations for data disposition. 3. Oversee the generation of routine reports and data products and help with novel IMPROVE data analyses and assessments. 4. Coordinate with Outreach and Communication Subcommittee for the distribution of the IMPROVE data, metadata, data analyses and reports via the IMPROVE FED, and AQS websites.

Subcommittee	Purpose and Tasks
Outreach and Communication	1. Keep the broader IMPROVE community informed about IMPROVE activities and monitoring data analyses. 2. Coordinate with the Data Analysis and Reporting Subcommittee on the generation of reports. 3. Oversee the publication and dissemination of various reports and outreach materials. 4. Help with organization of meetings.

1.4.3. Quality Assurance Manager

The EPA's *Environmental Information Quality Procedure* (CIO 2105-P-01.4) requires organizations to assign a QAM. The current QAM is Bonne Ford at CIRA at Colorado State University. The QAM reports QA activities and results directly to the IMPROVE Steering Committee who designates the authority of the QAM to manage the overall Quality Program of the network. The QAM is not a member of the Steering Committee but can attend and participate in Steering Committee and Subcommittee meetings. The QAM is not directly involved in the management of the network activities, does not perform any laboratory filter analysis, and does not oversee the validation or generation of data products. Instead, the primary role of the QAM is to ensure the quality procedures outlined in this QMP are followed. The QAM is not a full-time role; thus, the QAM may participate in analysis of IMPROVE data for research studies and conduct other ancillary activities if it is independent of the environmental information operations being overseen. Research activities may be overseen by the QAM's agency/university supervisor, but all QA activities can be conducted independently and directly under the authority of the Steering Committee. The QAM may coordinate quality assurance activities and discuss quality-related issues with the IMPROVE Steering Committee and other QA staff without their direct supervisor.

The QAM is responsible for reviewing the QMP annually and determining if updates should be made. The QMP will be thoroughly reviewed for re-approval every 5 years from the date approved to determine if the information remains relevant and effective. The QAM is also responsible for creating an annual report to be presented at the annual meeting and submitted to the Steering Committee outlining the quality assurance activities that have been conducted and reporting any concerns that may have arisen during the auditing process. While many of the QAM activities are done in conjunction with other QA staff, the IMPROVE network QAM is ultimately responsible for ensuring that all QA procedures are being followed and QA documentation is complete and up to date.

Each laboratory is responsible for internal audits; however, the QAM coordinates with the laboratories to receive documentation related to quality procedures and ensures that all quality-related documents (QAPPs, TIs, SOPs) are up to date. The QAM conducts audits of field sites and/or coordinates with other entities/agencies conducting the field site audits. The QAM creates an annual audit report and maintains records on all site audits. The QAM

also coordinates with the Data Analysis and Reporting subgroup to review quality control assessments as defined in the QAPP.

1.4.4. The U.S. Environmental Protection Agency

Funding for the network primarily comes from the U.S. EPA. The EPA approves QA documentation, such as the QMP and QAPP, and provides oversight for the IMPROVE program by having EPA staff serve on the IMPROVE Steering Committee. The EPA reviews QA reports and aids in the coordination of external audits of laboratories participating in the IMPROVE network.

1.4.5. National Park Service (Operations Management)

The NPS is the key operational agency of the IMPROVE Program. The agency is responsible for implementing and overseeing the technical direction of the Steering Committee. It also operates many of the IMPROVE monitoring sites through cooperating national parks and maintains IMPROVE samplers and sampling structures. NPS is in charge of program management by issuing and administering IMPROVE contracts and cooperative agreements for the following activities:

(1) Aerosol Monitoring Network support and mass and elemental speciation, optical HIPS analysis (current contract to University of California-Davis Air Quality Research Center – AQRC)
(2) Ion filter analysis (current contract to Research Triangle Institute – RTI)
(3) Carbon filter analysis (current contract to University of Nevada; Desert Research Institute - DRI)
(4) Data quality assurance, analysis, and data dissemination (through FED database) and reporting (current contract to AQRC and cooperative agreements with AQRC and CIRA, Colorado State University)

The NPS staff also perform detailed data analyses, including the preparation of scientific papers and presentations, and participate in the IMPROVE Steering Committee and Subcommittees. In addition, NPS plans and coordinates special studies, including conducting auxiliary measurements in conjunction with other agencies.

The NPS, as the operation manager, is not directly involved with the specific QA activities of the IMPROVE network, and the QAM's work is independent of NPS oversight. The QAM does not require approval from the NPS (with the exception of approval for access to monitoring sites from local site operators) for conducting site audits or require review of results before submitting findings. However, the NPS is responsible for supporting QA activities by providing funding and:

(1) Ensuring contractor participation in preparation of quality assurance documents, such as the QAPP and any necessary SOPs.
(2) Reviewing all QA documentation.
(3) Verifying that QA procedures are met by the contractors.
(4) Reviewing QA/QC study results.

The NPS may also participate in the logistics planning of QA/QC studies.

1.4.6. Entities Carrying out the Environmental Information Operations

As stated in section 1.4.5., the NPS has contracted or created cooperative agreements with different institutions/agencies to perform the environmental monitoring activities of the network as set forth by the IMPROVE Steering Committee.

1.4.6.1. University of California-Davis Air Quality Research Center – AQRC

The UC Davis Air Quality Research Center (AQRC) is currently contracted to manage the IMPROVE Network operations and conduct gravimetric, elemental, and optical absorption analysis on the collected filters. AQRC also coordinates filter pre-sampling, shipping, sampling, and post-sampling activities. AQRC is responsible for the following field, laboratory, and data activities:

(1) Tracking and recording all samples as they move through the program.
(2) Performing gravimetric, optical absorption, and elemental analysis on IMPROVE Module A filters and gravimetric analysis on Module D filters.
(3) Coordinating the manufacturing of IMPROVE samplers.
(4) Installing instrumentation at new monitoring sites and removing instrumentation from discontinued sites.
(5) Communicating with site operators for shipment and sampling instructions.
(6) Creating annual data quality reports, annual site metadata reports, and quarterly site status reports
(7) And under their cooperative agreement, performing scientific analyses of IMPROVE data and other scientific research as directed by the NPS and preparing scientific papers and presentations.

AQRC is responsible for many QA procedures such as:

(1) Preparing and following all laboratory SOPs, TIs, and contributing to the preparation of the IMPROVE QAPP.
(2) Coordinating with other contract laboratories (RTI and DRI) to ensure sampling supplies and samples are properly specified, handled, and delivered in a timely manner.
(3) Final validation and delivery of IMPROVE data as outlined in the QAPP.
(4) Performing internal audits of AQRC and other QA activities as detailed in the IMPROVE QAPP.
(5) Supervising QA/QC studies, including those conducted at field sites.
(6) Performing biennial (once every two years) calibrations, adjustments, and major repairs of the field samplers.
(7) Participating in external audits and reviewing results.
(8) Providing an annual QA Report to the IMPROVE Steering Committee, QAM, EPA, and NPS.

1.4.6.2. Research Triangle Institute (RTI)

RTI is contracted to perform ion chromatography on all IMPROVE Module B nylon filters. Specifically, RTI is responsible for:

(1) Receiving all Module B nylon filters and associated files with sample identification information from AQRC.
(2) Performing ion chromatography on all sample filters and blanks.
(3) Validating Module B ion analysis data (final validation is conducted by the QA team at AQRC).
(4) Reporting all results to AQRC.
(5) Maintaining internal documentation on laboratory procedures.

Their specific QA requirements also include:

(1) Preparing and following all ion chromatography laboratory SOPs, TIs, and contributing to the preparation of the IMPROVE QAPP.
(2) Performing internal audits of RTI and other QA activities as detailed in the QAPP.
(3) Participating in external audits and reviewing results.
(4) Preparing an annual report of ion measurement QA, forwarding it to NPS, and presenting results to the Steering Committee.

1.4.6.3. Desert Research Institute (DRI)

DRI is contracted to analyze all IMPROVE Module C quartz filters for carbon. Specifically, DRI is responsible for:

(1) Pre-firing all Module C quartz filters, testing for contamination after pre-firing, and sending prepared filters to AQRC.
(2) Receiving all sampled Module C filters and associated files with sample identification information from AQRC.
(3) Performing carbon analyses on all sample filters and blanks.
(4) Validating Module C carbon analysis data (final validation is conducted by the QA team at AQRC).
(5) Reporting all results to AQRC.
(6) Performing scientific analyses of IMPROVE data as directed by the NPS.

Their specific QA requirements also include:

(1) Preparing and following all laboratory carbon SOPs, TIs, and contributing to the preparation of the IMPROVE QAPP.
(2) Performing internal audits and other QA activities as detailed in the QAPP.
(3) Participating in external audits and reviewing results.
(4) Preparing an annual report of carbon measurement QA, forwarding it to the NPS, and presenting results to the Steering Committee.

1.4.6.4. Cooperative Institute for Research in the Atmosphere (CIRA)

Under a cooperative agreement with the NPS, the Colorado State University – Cooperative Institute for Research in the Atmosphere is tasked with database management, analysis, and reporting functions for IMPROVE. Specifically, CIRA is responsible for:

(1) Maintaining all IMPROVE data, reports, and program documentation on the IMPROVE and FED websites.

(2) Performing scientific analyses of IMPROVE data and preparing scientific papers, presentations, and reports.
(3) Performing visibility research and calculating RHR metrics.
(4) Preparing IMPROVE Reports that detail the spatial and temporal variability in haze and its components across the U.S.

Their specific QA requirements include:

(1) Verifying that all data and documentation posted on the IMPROVE website meets all QA standards.

1.4.6.5. Site Sponsors and Field Operators

The majority of sites are sponsored by the NPS, USFS, or FWS. However, some sites are also sponsored by the EPA, tribes, states, or other entity. Site sponsors are responsible for providing funding as well as logistics planning for site installation (including access to electrical power) and maintenance.

The site sponsor must also provide a field operator. Field operators are an integral part of the operation of the IMPROVE network. Field operators must be trained in the proper operations of IMPROVE samplers and provided with necessary resources (e.g., training videos, and scheduling calendars). Field operators must be trained by the Field Team or previous site operator (with additional training conducted by the Field Team during biannual site visits). Specific duties include:

(1) Operating and maintaining the IMPROVE samplers.
(2) Filling out log sheets.
(3) Following the filter change schedule.
(4) Submitting to and participating in field audits and reviewing results.

1.4.7. Resource Allocation for QA Program

The IMPROVE Steering Committee is overall responsible for ensuring that resources are being allocated for the QA program for the IMPROVE network, while the NPS is responsible for managing contractors and cooperative agreements so that there is proper funding for the IMPROVE Network QA program. Each contractor is required to demonstrate that they will have the resources for internal quality assurance in terms of funding, organization, and personnel in accordance with FAR contract agreement regulations. Funding for the QAM and Field Technical System Audits is provided through a cooperative agreement between NPS and CIRA at CSU.

Funding for the QA program is provided primarily by the NPS with additional funding from other Steering Committee members (USFS, BLM). The EPA OAQPS also provides funding for Technical System Audits of contracted laboratories.

1.5. EXTERNAL QUALITY ASSURANCE

The U.S. EPA provides additional oversight. Quality Assurance documents, such as this QMP are reviewed and approved by the EPA Office of Air Quality Planning and Standards (OAQPS). The EPA OAQPS Project Officer works with the contracted laboratories to coordinate audits and assign contractors for the laboratory TSAs.

2. QUALITY PROGRAM DESCRIPTION

A quality program is defined as a structured and documented management system describing the policies, objectives, principals, organizational authority, responsibilities, accountability, and implementation of an organization for ensuring quality in its work processes, products (items), and services. The quality program provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required QA and QC. This section describes the principal components comprising the quality program and how they are used to implement the quality program. In addition, this section briefly discusses the monitoring system and how samples and data flow through the system. The IMPROVE network follows the policy and program requirements outlined in the EPA's *Environmental Information Quality Policy* (CIO 2105.4) and the management principles for its implementation in the *Environmental Information Quality Procedure* (CIO 2015-P-01.4)

2.1. DESCRIPTION OF THE AEROSOL MONITORING NETWORK

The current IMPROVE Aerosol Monitoring Network locations are shown in Figure 2. In 2024, the IMPROVE network consisted of 229 sites (155 currently operating and 74 discontinued sites). The 155 current sites are under the supervision of the IMPROVE Steering Committee and represent 155 of the 156 mandatory CIAs.

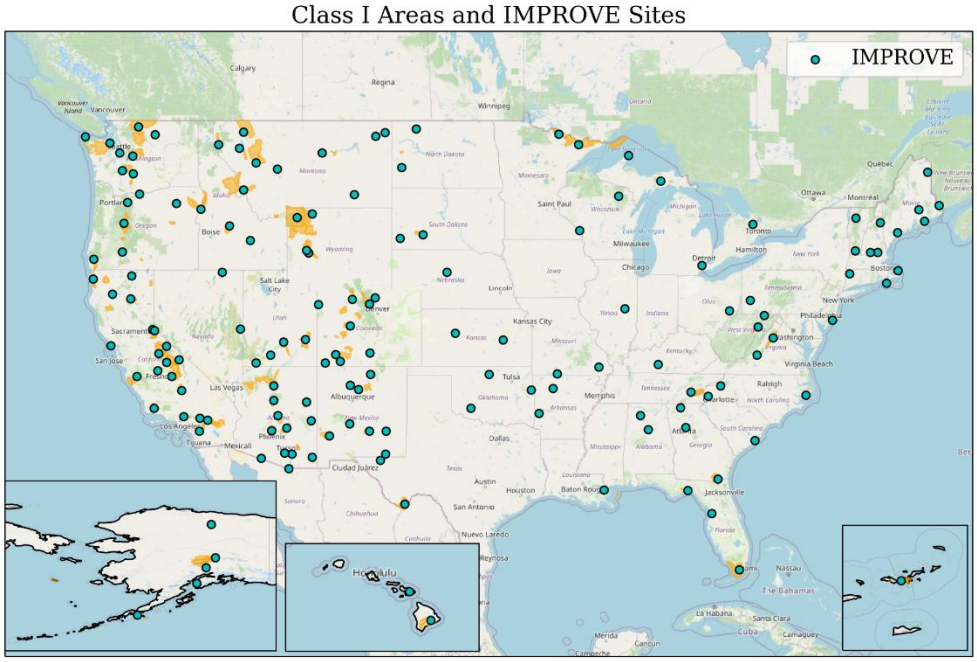

Figure 2. IMPROVE Aerosol Monitoring Network as of 2024. Orange shaded areas denote Class 1 Areas while circles designate currently operating IMPROVE sites.

Adding, decommissioning, or movement of sites is decided by the IMPROVE Steering Committee with input specifically from the Network Operations Subcommittee. As protocol sites are separately funded by other entities, adding or decommissioning is

ultimately determined by that entity's available funding. However, the IMPROVE Steering Committee should evaluate the impact of losing the data from the protocol site and determine if another site should be established in its place. Coordinating of specific site location and installation of sampling structures is handled by site sponsor (NPS, USFS, FWS, tribe, or state), while installation of the sampler modules is done by the Field Team. Sites are operated by employees of a variety of agencies (NPS, USFS, FWS, EPA, state government, tribes, local governments, etc.).

Currently, filter measurements are collected on a 1-in-3-day sampling schedule throughout the year, with consistent sample days across the network. Sampling occurs from midnight-to-midnight local time, providing a 24-hour sample. Initialization of each filter is automated, requiring a filter cartridge change by site operators only once a week (Tuesdays). Filter cartridges are sent in groups of threes.

2.2. ENVIRONMENTAL SAMPLE AND DATA FLOW

AQRC is contracted as the coordinating laboratory for all field operations and speciation laboratory work. AQRC coordinates filter pre-sampling, shipping, sampling, and post-sampling activities. Figure 3 outlines the flow of filter samples and data through the different entities. Filters are pre-weighed and Module C filters are pre-fired. Filter samples are organized and packaged and sent to field operators at all sites. Field operators install/change filters and then return the filters after sampling. AQRC analyzes Module A and D filters and sends Module B filters to RTI for ion analysis and Module C filters to DRI for carbon analysis. RTI and DRI return results to the Data Processing Team (at AQRC), who then validates all the filter mass and composition results and adds quality flags to the data. The data are then sent to both AQS and to CIRA for distribution on the FED website.

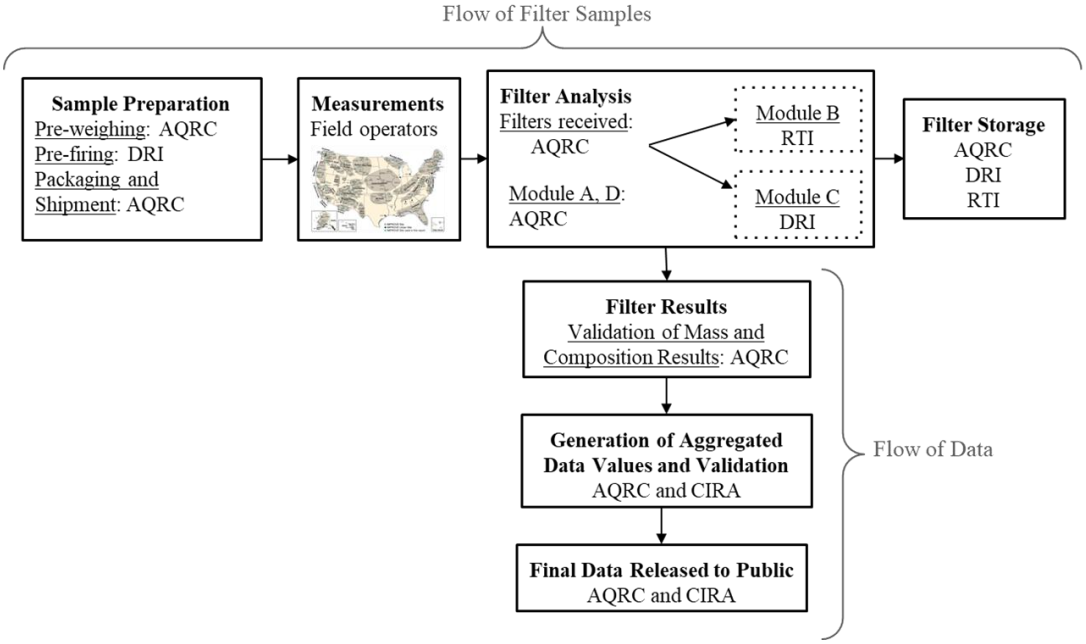

Figure 3. Flow chart of environmental measurement procedures depicting both the flow of filter samples and the flow of data after analysis of filter samples. Flow chart also notes the party responsible for each process.

2.3. QUALITY ASSURANCE PROGRAM

The high-level Quality Assurance program is highlighted in the Organizational Chart in Figure 1 (shown with dashed lines). However, each technical activity (field, laboratory, and data) has internal QA procedures.

2.3.1. Field-based QA/QC Procedures

The routine sampling process includes several QA/QC steps. Field operators check that pumps are turning on and operating normally when installing or replacing filters. Additionally, field site operators must ensure that the vacuum and pressure volume values fall within an acceptable range; filter sampling will not start unless the operator confirms that the values are acceptable. Any issues are to be reported to the Field Team on the Field Log Sheet as well as by email or phone (to avoid delays as field logs are only mailed back after three weeks of sampling). Operating procedures are reviewed with each operator during Technical System Audits and Routine Maintenance visits. The Field Team also remotely checks sampling sites every weekday morning.

2.3.1.1. Technical System (Field) Audits

Field sites must be audited periodically, with the goal of auditing each site at least once in every ten-year cycle. The QAM organizes field site audits and either performs the audit or coordinates with a trained designee. Field site audit forms (Section 2.5.5.2) are used for each individual site audit. Based on the results of these audits, the IMPROVE Operations contractor should address any minor problems found. Major problems are addressed by a

joint committee including the PI of the IMPROVE Operations contractor (currently AQRC), the Steering Committee Chair, and the Contracting Officer Representative at NPS.

The QAM summarizes all Field Audit results in an Annual Report (Section 2.5.10) which is presented to the Steering Committee and provided to NPS and Filed Team manager.

2.3.1.2. Routine Maintenance and Calibration of Samplers

Each IMPROVE site receives biennial maintenance (with half of the network visited one year and the other half visited the next). Maintenance is the responsibility of the Field Team, which is composed of the field manager and field technicians (currently at AQRC). The Field Team establishes and announces a rough maintenance schedule each year. This schedule is shared with site operators, the NPS, the IMPROVE Steering Committee's subcommittee on Network Operations, and the QAM. All procedures for routine maintenance are described in the Site Maintenance Standard Operating Procedure (SOP) and the associated Technical Information (TI) (available here: https://vista.cira.colostate.edu/Improve/particulate-monitoring-network/)

2.3.1.3. Collocated (Duplicate) Field Measurements

Beginning in 2003, IMPROVE began co-located measurements at select IMPROVE sites. At most of these selected sites, a fifth sampling module (Module X, which is an identical sampler to one of the A, B, C, or D modules) is added to the aerosol sampler; while at a few sites, a complete set of samplers has been installed. Comparing sample data from the duplicate module allows for an estimate of the overall uncertainty from all sources.

2.3.2. Laboratory-based QA/QC Procedures

Full details of the QA/QC procedures are outlined in the IMPROVE QAPP (https://vista.cira.colostate.edu/Improve/quality-assurance/) and IMPROVE SOPs with associated TIs (all available here: https://vista.cira.colostate.edu/Improve/sops/). In brief, laboratory staff monitor performances of instruments using test and reference filters and by replicate measurements of filters.

2.3.3. Data QA/QC Procedures

Full details of the data QA/QC procedures are provided in the QAPP and the Data Processing and Validation SOP (https://vista.cira.colostate.edu/Improve/sops/). Laboratory staff assign status flags to sample data during analysis. Flags are assigned, for example, when the sample flow rate is out of limits, when there were equipment failures or malfunctions, or when there is obvious filter preparation or site operator error.

After laboratory analysis, data undergo validation checks by the Data & Reporting Group technical staff (currently at AQRC) who function independently of the routine laboratory operations. Data validation is performed in batches of processed data. Some validation checks involve cross-comparisons from independent measurements, comparison to historical averages, and comparison to nearby sites. During the data validation process the data analysts have the authority to request reanalysis of suspect samples. Data are released only after all issues have been resolved.

Minimum detection limits are provided for all sample values along with status flags that are assigned during data import.

2.4. MANAGEMENT REVIEW

Management reviews are conducted at several different levels. Managers at each institution/agency are responsible for reviewing and reporting results from all internal QA/QC work and evaluating staff compliance with the Quality Program. Each laboratory has their own QAM to review and report on internal QA processes. All institutions/agencies should inform staff of organizational structure and how to report any quality concerns or suggested improvements.

NPS is responsible for reviewing all contractor and cooperative agreement reports. The IMPROVE Steering Committee is also responsible for reviewing all quality reports, audit results, and/or memos from the QAM about Quality Program activities during Steering Committee meetings. Subcommittees are responsible for specific oversight and meet throughout the year to conduct their designated tasks. The subcommittee on Network Operations is specifically in charge of overseeing the QA/QC procedures in the field and laboratory, ensuring that SOPs are in place and followed, and recommending any necessary changes to the network to the full IMPROVE Committee. The Data Analysis and Reporting group is responsible for reviewing data, metadata, and data products; overseeing data quality control assessments as outlined in the QAPP; and determining the need for additional analysis or reports.

2.5. QUALITY DOCUMENTS

2.5.1. Quality Management Plan (QMP)

This QMP (described herein) outlines the management structure and how the QA system is implemented. A QMP is required as part of the *Environmental Information Quality Procedure* (CIO 2105-P-01.4). The QMP follows the EPA IT/IM Directive Plan Standard (Directive No. CIO 2105-S-01.1, available here: https://www.epa.gov/irmpoli8/environmental-information-policy-procedures-and-standards).

The IMPROVE QMP is reviewed annually by the IMPROVE QAM to determine if updates are necessary. However, as outlined in the IMPROVE Steering Committee Charter (current version available on the IMPROVE website: http://vista.cira.colostate.edu/improve/), the QMP must be updated and re-approved at least every 5 years. It is the responsibility of the Steering Committee to ensure that this occurs. All updates must be approved by the full list of signees and submitted to the EPA OAQPS QAM for approval.

2.5.2. Quality Assurance Project Plan (QAPP)

The IMPROVE QAPP (https://vista.cira.colostate.edu/Improve/quality-assurance/) details the quality assurance measurements, tolerances, and methods that pertain to IMPROVE network measurements. The QAPP also contains a list of SOPs and TIs necessary to complete the work. The QAPP must be reviewed annually and updated and re-approved every 5 years. The IMPROVE Steering Committee is responsible for ensuring this occurs,

with the Data Subcommittee specifically tasked with organizing the update and submitting it to OAQPS QAM for approval. The current QAPP can be found on the IMPROVE website (https://vista.cira.colostate.edu/Improve/quality-assurance/). The contracted laboratories must, as part of their contracts, help with the preparation of the QAPP. NPS must also review the QAPP and ensure conformance with contracting requirements (section 5).

Any new updates to the QAPP will follow the EPA IT/IM Directive Standard (Directive No. CIO 2105-S-02.0, available here: https://www.epa.gov/irmpoli8/environmental-information-policy-procedures-and-standards)

2.5.3. Standard Operating Procedures (SOP)

Each contractor must maintain SOPs for all laboratory and field activities. As the key operational agency in charge of overseeing the technical operation of the network, the NPS is responsible for making sure contractors create and maintain SOPs for all activities. SOPs are required for any complex tasks associated with the collection of environmental measurements that must conform to regulatory standards. The IMPROVE network has SOPs for all field and laboratory activities. Appendix 1 provides a list of all SOPs used in the IMPROVE network.

The field and laboratory SOPs written by AQRC are available at: http://vista.cira.colostate.edu/Improve/particulate-monitoring-network/. The SOPs for carbon analysis written by DRI are available here: https://vista.cira.colostate.edu/Improve/carbon-analysis/. The SOP for ion analysis written by RTI is here: https://vista.cira.colostate.edu/Improve/ion-chromatography-analysis-of-module-b/. QAMs and/or laboratory managers at each institution are responsible for ensuring that SOPs are being followed and maintained and updated versions are approved and submitted to the NPS.

Air Resource Specialists, Inc. (ARS) carries out all tasks associated with optical monitoring. SOPs for site selection, installation, maintenance, calibration, and data reporting are available on the IMPROVE website (http://vista.cira.colostate.edu/Improve/optical-monitoring/).

2.5.4. Technical Information (TI)

Many of the SOPs have supporting TI documents that describe specific procedures in further detail. Each TI is reviewed and updated as needed. TI documents are listed with SOPs on the IMPROVE website (http://vista.cira.colostate.edu/Improve/sops/).

2.5.5. Forms

A variety of other forms are used in the operation of the network by field personnel. These do not require the same amount of oversight and annual review as the above quality documents but are used to aid in conducting necessary procedures and collecting reporting data.

2.5.5.1. Field Log Sheet

Field log sheets are included with each filter sample (3 sets) in sample boxes shipped to field operators. These forms require field operators to check vacuum and pressure values when installing and removing filters. Field site operators should also note the date, time, and temperature on the form during installation and removal. Forms should be returned with the samples along with any operational notes. Any issues that arise during routine operation should be noted on the log sheet and reported by phone/email to the Field Team.

2.5.5.2. Technical System Audit Form

Field Technical System Audit (TSA) forms are used to audit field sites. Blank forms (as excel workbooks) are available through the IMPROVE website (https://vista.cira.colostate.edu/Improve/technical-system-audits/). These forms are emailed to site operators prior to a scheduled TSA. Site operators fill out the first section of the workbook ("operator form") and the QA Manager (or audit designee) fills out the other three sections/sheets. The TSA form includes instrument checks and questions for the site operator. Final TSA forms are held by the QAM manager (if QAM does not perform the TSA, the TSA must be forwarded to the QAM on completion of the audit and any issues discussed). Any issues from the TSA report regarding procedures or maintenance that require immediate attention must be discussed with the site operator and relayed to the IMPROVE Steering Committee and AQRC or NPS as appropriate. Procedures for disputes over findings are detailed in Section 7.4.4. All TSA reports are held by the QAM and used to generate the Annual Field Site Audit Report (Section 2.5.10). As audits may only occur once every ten years, TSA forms should be held at least until a new TSA is completed to compare findings.

2.5.6. External Audit Reports

External laboratory audits are described in 7.3.2. These audits are organized by the U.S. EPA OAQPS Project Officer, laboratory program managers, and laboratory QAMs and then conducted by an assigned audit contractor approved by the EPA OAQPS Project Officer. An audit report is produced by the assigned auditor following each audit. Laboratory staff and the QAM review and comment on a draft of the audit report before it is finalized by OAQPS. After the audit, the laboratory works with the OAQPS Project Officer to implement any corrective action plans.

2.5.7. Annual Data Quality Reports

Data quality reports are produced by the contracted laboratories annually for the IMPROVE network to summarize findings and provide recommendations for changes that could improve data quality. Reports are sent to the IMPROVE Steering Committee, NPS, EPA, and QAM. Data quality reports are posted on the IMPROVE website: http://vista.cira.colostate.edu/Improve/quality-assurance/.

2.5.8. Annual Site Metadata Reports

IMPROVE site metadata reports are produced and presented annually at the IMPROVE Steering Committee Meeting summarizing general site and equipment problems, maintenance visits and audits, and other changes at a site.

2.5.9. Quarterly Field Status Reports

A summary of IMPROVE site status relative to the Federal Regional Haze Rule criteria is assembled and reported quarterly to the IMPROVE Steering Committee, NPS, the QAM, and other stakeholders. Quarterly field status reports are created as excel workbooks and are available on the IMPROVE website: http://vista.cira.colostate.edu/Improve/quality-assurance/.

2.5.10. Audit Reports

Field sites must be audited periodically. The QAM organizes field site audits, by either performing the audit or coordinating with a trained designee. Field site audit forms (Section 2.5.5.2) are used for each individual site audit. The QAM provides an annual field site audit report (also referred to as a "Technical System Audit") detailing the sites that have been audited and the results. The report is presented to the IMPROVE Steering Committee and provided to NPS and stakeholders. The report is also made publicly available on the IMPROVE website (https://vista.cira.colostate.edu/Improve/technical-system-audits/).

3. SOFTWARE AND HARDWARE

3.1. AIR QUALITY RESEARCH CENTER, UC DAVIS SYSTEMS

AQRC has an Information Technology (IT) manager who is responsible for the overall operation of the computer system and for performing nightly backups of all data. The Software & Analysis Group Manager at AQRC is responsible for the database and for the code used to process the data and perform quality control assessments. The Software & Analysis Group Manager through coordination with the IT manager and systems administrator is responsible for ensuring compliance with the EPA Enterprise Architecture Policy (EPA CIO 2122.3) and IT Standards and Procedure (EPA CIO 2122-P-03.2).

In accordance with the EPA CIO 2104.1 IT/IM Directive Policy Software Management and Piracy Policy (EPA IT/IM Directive: Software Management and Piracy Policy, Directive # CIO 2104.3) and Procedure (Directive No: 2104-P-01.2), the IT manager ensures that all software is properly licensed, approved for use, and is not pirated or illegally copied software. The Software & Analysis Group Manager is responsible for ensuring that all software is used in accordance with applicable licenses and, in conjunction with the IT manager, ensures that systems utilize IT standard technologies as appropriate. All work is done on university-owned and evaluated computers/servers. All UC Davis employees are required to complete annual cybersecurity awareness training through the university. Unique passwords are issued to each employee by the UC Davis campus system administrator who also manages password integrity. The university has a ticket system to report and information security concerns. UC Davis also requires multi-factor authentication through Duo with risk-based authentication for access to many system applications (including email accounts, Microsoft 365 applications, and PulseSecure VPN).

To accommodate the large number of samples from IMPROVE and CSN, AQRC has developed a sample handling and tracking system designed around a SQL-based relational

database to maintain an audit trail for each filter. The system is described in the Data Processing and Validation SOP and Data and Records Management TI (https://vista.cira.colostate.edu/Improve/particulate-monitoring-network/). Access to databases and computers associated with the IMPROVE project is limited to authorized personnel by use of access control lists for files, programs, and database access. Physical access to computers in laboratories and office spaces is controlled by key cards.

3.2. RESEARCH TRIANGLE INSTITUTE (RTI) and DESERT RESEARCH INSTITUTE (DRI) COMPUTER SYSTEMS

Both RTI and DRI store their respective filter analyses results on process-specific computer databases. The databases are queried to yield analysis and QA files compatible with the AQRC system import routines. RTI and DRI create data files for each processed filter batch and electronically submit the files to AQRC for input. RTI and DRI each maintain active databases and archives of all filter data.

In accordance with the EPA CIO 2104.1 IT/IM Directive Policy Software Management and Piracy Policy (EPA IT/IM Directive: Software Management and Piracy Policy, Directive # CIO 2104.3) and Procedure (Directive No: 2104-P-01.2), the IT manager at each institute must ensure that all software is properly licensed, approved for use, and is not pirated or illegally copied software. All employees at RTI and DRI have mandatory annual cybersecurity awareness training through their institutes.

3.3. COOPERATIVE INSTITUTE FOR RESEARCH IN THE ATMOSPHERE (CIRA), COLORADO STATE UNIVERSITY (CSU) COMPUTER SYSTEMS

All data analysis at CIRA is conducted on CSU-owned and evaluated computers. CIRA IT ensures that installed software is properly licensed, approved for use, and is not pirated or illegally copied software in accordance with the IT/IM Directive Policy Software Management and Piracy Policy (EPA IT/IM Directive: Software Management and Piracy Policy, Directive # CIO 2104.3) and Procedure (Directive No: 2104-P-01.2). All employees at CSU are required to complete annual cybersecurity training through the university. Unique passwords are issued to each employee by the CSU system administrator who also manages password integrity. The university has a ticket system to report and information security concerns. CSU requires multi-factor authentication through Duo for access to CSU system applications (including email accounts, Microsoft 365 applications, and CSU's GlobalProtect VPN).

IMPROVE data are managed and stored at CIRA in the FED database (Section 3.3.1). These IMPROVE data, which include the raw IMPROVE aerosol data, the raw IMPROVE nephelometer data, the raw IMPROVE special studies data, and the IMPROVE RHR metrics, are stored on two different servers at CSU and are backed up monthly and annually.

3.3.1. IMPROVE Database

IMPROVE data are stored in FED (https://views.cira.colostate.edu/fed/Membership/Login.aspx), which is an online repository of air quality data and metadata sponsored by the NPS and the USFS. Ongoing development and maintenance of FED is conducted at CIRA. In addition to importing and maintaining data from the IMPROVE network (and other networks), the FED website also offers a variety of online air quality analysis and visualization tools that were developed at CIRA. The data are backed up monthly and annually.

3.3.2. IMPROVE Website

CIRA supports and maintains the IMPROVE website. The IMPROVE data, program plans, guidance documents, SOPs, QAPP, QMP, special announcements, and related documents are posted on the IMPROVE Website (http://vista.cira.colostate.edu/Improve/).

4. PERSONNEL QUALIFICATIONS AND TRAINING

4.1. PERSONNEL QUALIFICATIONS

The IMPROVE program has several diverse agencies and institutions that interact at many levels. The Steering Committee ensures the overall competence and functioning of the network, while each agency/institution/organization ensures the competence of individual personnel assigned to the IMPROVE program at their own institution, following all institutional requirements for hiring and performance review procedures. Managers at each institution should ensure that each employee has measurable performance goals for their position. Personnel assigned to the IMPROVE Program should meet the educational, work experience, responsibility, personal attributes, and training requirements for their positions. Each IMPROVE organization should provide training to all who participate in this program and regularly assess performance through internal audits and reviews (section 4.2).

Site operators have no minimum technical or educational requirements. Site operators are generally chosen by the local site sponsor based on availability and access to site. Performance of site operators is monitored by the Field Team with respect to completeness of duties (number of collected samples over possible samples) and communication. Site operators are also assessed during TSAs.

All individuals responsible for the management of the QA/QC system, such as the Program Managers and the QAM must be knowledgeable of the EPA Quality Program Requirements for Environmental Programs and the Management System Review Process. Staff uses the EPA Environmental Information Quality Policy (CIO 2105.4) and the QA/G-3: Guidance for the Management Systems Review Process, March 2003 (EPA/240/R03/002). Applicants for QA positions must demonstrate that they have the required knowledge, skills, and abilities to meet the qualifications of the position. It is essential that the manager over employees with QA responsibilities ensure that they have measurable performance goals and objectives for each year.

Personnel leading TSAs should have experience or familiarity with the technical procedures they are auditing, including reviewing QMPs, QAPPs, and SOPs as appropriate.

4.2. TRAINING

Appropriate training is made available to persons supporting the IMPROVE Program, commensurate with their duties. Training should cover both technical demonstrations and review of pertinent documents. Each contractor is responsible for providing adequate training to all employees working on the IMPROVE project and maintaining a record of training. Program managers at each contracted laboratory identify mandatory training required by staff to comply with program requirements and take the lead in ensuring that the necessary levels of technical proficiency and QA knowledge are maintained. All QA staff are required to be trained on documentation and record-keeping procedures. Internal and external audits are used to identify any new training or retraining needs. Each laboratory manager must document that laboratory staff have the appropriate training and certifications as required by their institutions.

The Field Team Manager in conjunction with the Principal Investigator at the laboratory contracted to manage field operations is responsible for determining the amount of training necessary for site operators. Site operators are given training on routine equipment operations, sample collection, log recording, preventive maintenance, and troubleshooting by Field Team technicians. A training session is conducted during new site installations and repeated during bi-annual maintenance visits. The Field Team manager maintains records of all trained site operators and backup operators. The Field Team also provides ongoing telephone and email support to site operators. Written SOPs provide detailed guidance for all procedures and operator instructor videos are available online at https://aqrc.ucdavis.edu/resources-for-operators. The QAM will assess the training of site operators during a TSA and determine if additional training is necessary. Any update to a procedure which requires an update to an SOP or TI is communicated to the site operator and requires that new documents and the option for additional training are provided.

The IMPROVE Steering Committee is responsible for determining the necessary knowledge and training required for the QAM. The QAM is trained on field audits by the previous QAM and by the Field Team manager. The QAM should report these trainings to the IMPROVE Steering Committee and the NPS. Training on quality documentation is conducted through meetings with the IMPROVE Steering Committee, the Operations Manager (NPS), EPA, and the contracted laboratories.

The Field Team manager trains the field technicians on all instrument calibration, maintenance, and site operator training procedures at the time of employment. SOPs and TIs provide guidance for all procedures, and field technicians should be familiar with these documents before conducting any field work. The Field Team manager in conjunction with the Principal Investigator at the laboratory contractor for Field Operations is responsible for documenting and assessing field technician training.

The individual laboratory managers train their respective lab technicians in sample handling, filter analysis, data validation, and reporting at the time of employment. Written, laboratory-specific SOPs and TIs provide detailed guidance for all procedures; staff are required to be familiar with these documents and follow the outlined procedures. Staff are assessed on their use and knowledge of SOPs and TIs during any internal or external audit

or evaluation. Laboratory managers, in conjunction with each laboratory's Principal Investigator, are responsible for defining employee responsibilities, providing necessary training to lab technicians and their internal laboratory quality managers, and keeping records on training and job responsibilities. Laboratory managers are responsible for determining and enforcing compliance with all required safety training.

CIRA staff working on the IMPROVE Program are trained in their respective data validation, analysis, reporting, documentation, and web management duties by senior CIRA staff and by NPS scientists. The Principal Investigator at CIRA is responsible for defining job responsibilities, outlining necessary training, and assessing performance of CIRA employees.

Field staff for various organizations that perform technical systems audits receive training from the QAM. This training includes the calibration and use of flow audit devices, sampler design, and IMPROVE siting requirements. Additionally, the QAM explains the TSA form and requirements as well as discussing record keeping and reporting of results. The QAM will provide a certificate to trainees and document all trainings. Any update to a procedure which requires an update to an SOP or TI is communicated to the partner auditor and requires new documents and the option for additional training to be provided.

4.3. EVALUATIONS

Each listed institute with a contract or cooperative agreement (DRI, RTI, AQRC, CIRA) is responsible for annual evaluations of staff as outlined by their own Human Resource departments. Evaluations of laboratory staff are conducted by supervisors at each laboratory. Evaluation of site operators is formally done during a TSA and informally assessed during routine maintenance trips. However, sites are also regularly tracked with regards to incomplete or missing samples, which provides some insight into site operator performance. Issues with site operators are reported to the IMPROVE Steering Committee, NPS, and the agency that operates the IMPROVE site to determine a solution (retraining or replacement of the site operator). NPS is responsible for evaluating contractor performance, and the IMPROVE Steering Committee is responsible for evaluating the performance of the network overall and the QA program, with input from NPS and the QAM.

5. PROCUREMENT OF ITEMS AND SERVICES

5.1. FUNDING AGREEMENTS

5.1.1. National Park Service

The NPS, as the operational agency of the IMPROVE Program, oversees program management by issuing and administering contracts to carry out network activities. The NPS Contracting Officer Representative (COR, currently James Miller) oversees these activities. The Agreements Technical Representative (ATR, currently Bret Schichtel) oversees all activities related to cooperative agreements. The NPS Air Research Division (ARD) Research and Monitoring Branch Lead (currently Anthony Prenni) works with both

the COR and ATR on IMPROVE-related contracts and agreements. Funding for the NPS comes through an Interagency Agreement with the EPA.

The COR is responsible for ensuring that all contracts include quality requirements, and the ATR is responsible for ensuring that all cooperative agreements include quality requirements. Thus, the NPS is responsible for:

(1) Ensuring that all procurement documents contain the EPA quality requirements and are in accordance with Federal Acquisition Regulations before posting the solicitation. The COR and ARD Research and Monitoring Branch Lead write the requirements for the solicitation.
(2) Ensuring that all responses to solicitations describe how the applicant will satisfy both the technical and quality requirements. The COR, ATR/NPS Technical Lead, and ARD Research and Monitoring Branch Lead review the responses to solicitations to determine responsible prospective contractors.
(3) Reviewing evidence (i.e., quality reports, financial reports, facility overviews, etc.) and verifying that a supplier can indeed meet IMPROVE Quality Program requirements. The COR, ATR/NPS Technical Lead, and ARD Research and Monitoring Branch Lead, along with the IMPROVE Steering Committee Chair and IMPROVE QAM review quality assurance reports provided the by contractors semi-annually. Further, this group does a data review with the IMPROVE Operations Contractor (UC Davis) monthly and with the IMPROVE Ion Analysis (RTI) and IMPROVE Carbon Analysis (DRI) contractors on an as-needed basis to review data and to ensure that quality requirements are met. Note that as the IMPROVE Operations Contractor, UC Davis provides quality checks on data from RTI and DRI, and these data are reviewed monthly and reported to the group.
(4) Clearly documenting the contractor's responsibilities for the Quality Program requirements in all contract documents (responsibility of the COR and NPS ARD Research and Monitoring Branch Lead).
(5) Confirming that contractors are meeting quality requirements and following quality procedures through review of submitted quality reports and audit results. IMPROVE operates using a network-wide QAPP and QMP, which includes activities for all contactors. These documents are reviewed by the COR, ATR, and ARD Research and Monitoring Branch Lead. The acceptance criteria outlined in the QAPP and QMP must meet the data specifications from the EPA Guidance documents (https://www.epa.gov/visibility/visibility-guidance-documents) for the Regional Haze Rule (40 CFR 51).

5.1.2. Environmental Protection Agency

The EPA provides funding for the IMPROVE network through an Interagency Agreement with the NPS. The EPA OAQPS PO and NPS ARD Research and Monitoring Branch Lead oversee this agreement. The EPA PO is responsible for:

(1) Following the EPA quality program requirements during the funding of the Interagency Agreement.

(2) Ensuring the EPA quality program requirements are included in the Interagency Agreement Statement of Work.
(3) Ensuring that work completed under the Interagency Agreement is covered by the Statement of Work.

5.2. PROCUREMENT

5.2.1. Direct Purchase

The NPS has the responsibility to procure all equipment and services for the IMPROVE network. The NPS procures equipment in two ways. The NPS may direct a contractor to purchase the equipment (FAR 45.102(a)) or the NPS may procure equipment directly from a vendor (FAR 45.102 (b)).

5.2.2. Contracts

The NPS utilizes contractors to coordinate, operate, and maintain the IMPROVE Program (FAR 37.102). Laboratories are contracted to perform mass, elemental, optical, ion, and carbon analyses of the IMPROVE samples. Current aerosol-related IMPROVE contracts administered by the NPS include:

(1) Network Operations; including sampler fabrication, field operations, particle mass and elemental analysis of Module A filters and gravimetric analysis of Module D samples, coordination with ion (Module B) and carbon (Module C) analysis laboratories, and data validation of all samples. The current contractor is the University of California at Davis (UCD). AQRC is responsible for ensuring that laboratory equipment and supplies are of acceptable quality by conducting tests and quality checks.
(2) Ion Analysis; including laboratory analysis of Module B filter samples for ions. The current contractor is Research Triangle Institute (RTI).
(3) Carbon Analysis; including filter preparation and laboratory analysis of Module C filter samples for organic and elemental carbon. The current contractor is the University of Nevada, Desert Research Institute (DRI).
(4) Optical Monitoring Network; including the installation and maintenance of nephelometers. The current contractor is ARS.

NPS typically awards five-year contracts that include all potential tasks to be conducted during the life of the contract. Individual task orders are awarded off these contracts, based on the anticipated needs in any given year. It is the responsibility of the NPS COR and NPS ARD Research and Monitoring Branch Lead to ensure that services are procured according to the aforementioned Federal Acquisition Regulations.

5.2.3. Cooperative Agreements

Assistance agreements are used when both parties, a federal agency and the group providing the service, derive benefit from the service. Federal grants or cooperative agreements with universities or states are a common example of mutually beneficial assistance agreements.

There is an IMPROVE cooperative agreement (DIAR 1426.7101) between the NPS and CIRA, located at Colorado State University in Fort Collins, Colorado. The IMPROVE-related services provided by CIRA include scientific analyses; preparation of reports, products, and presentations; and maintenance of the IMPROVE database and website. The QAM is employed by CIRA.

The NPS also has a cooperative agreement (DIAR 1426.7101) with UC Davis AQRC to perform analyses of IMPROVE data, conduct other scientific research, and prepare scientific papers and presentations.

6. DOCUMENT AND RECORDS PROCESSES

Section 2.5 describes the different quality documents in place for the IMPROVE network. This section describes the processes for generating, reviewing, revising, and verifying all the planning documents (QMP, QAPP, SOPs, IMPROVE Charter, etc.) and for record keeping. It is ultimately the responsibility of the IMPROVE Steering Committee to ensure that the documents are created, implemented, and revised in accordance with the EPA standards.

6.1. Planning Document Processes

The IMPROVE Steering Committee, Subcommittees, and NPS assesses the need for planning documents in accordance with the EPA. The IMPROVE Steering Committee is responsible for ensuring that there is a QAPP and QMP, which are annually reviewed by the QAM and updated at least every 5 years. SOPs are required for any complex task proposed by contractors to perform environmental measurements and must be updated whenever equipment or procedures change. NPS is responsible for ensuring that SOPs have been drafted and approved before the tasks are performed. All contractors are responsible for assigning relevant staff to the preparation and approval of SOPs and TIs in conjunction with internal quality assurance managers. The QMP, QAPP, and SOPs are controlled documents and must have the appropriate approval before being implemented.

When reviewing planning documents, the QAM must ensure that all documents are in conformance with any updated requirements or EPA policy, regulation, or standard and with all terms and conditions of any extramural agreements. Any revisions to planning documents must be documented. When revised versions have been approved, previous versions of documents should be archived. All planning documents (IMPROVE Charter, QMP, QAPP, and SOPs) are electronically stored and publicly available on the IMPROVE website. Planning documents (SOPs and TIs) written by contractors (AQRC, RTI, DRI, ARS) are also available on the IMPROVE website. All staff and members of the IMPROVE network should be made aware of and provided with these documents during training.

6.2. Record-keeping

The IMPROVE network is committed to making and preserving records containing proper documentation of the network organization, functions, procedures, and transactions in compliance with the EPA Records Management Policy (Directive No: 2155.5). Records

are valuable both for historical purposes as well an ensuring that the organization continues to function effectively and efficiently. Records are treated as an asset and managed throughout their life cycle (creation, maintenance, and disposition). The IMPROVE Steering Committee, and in particular the Steering Committee Chair, is responsible for managing the custody and confidentiality of evidentiary quality-related documents and records as pertains to the IMPROVE Steering Committee and network as a whole. Program managers at the NPS and each contracted laboratory are also responsible for managing their own evidentiary records that pertain to the project. The IMPROVE Steering Committee may request these records from the NPS or a contracted laboratory as part of their oversight of the project.

Quality documents for the IMPROVE network each have a "sponsor" that is ultimately responsible for management of the document. The QAPP and QMP are "sponsored" by the IMPROVE QAM who must review these documents annually for maintenance. The QAPP and QMP will be thoroughly reviewed for re-approval every 5 years from the date approved to determine if the information remains relevant and effective.. SOPs and TIs are "sponsored" by the QAMs at each contracted laboratory. The NPS is responsible for ensuring that the contracted laboratories are fulfilling their record-keeping responsibilities; thus, while the contracted laboratories will ultimately create and maintain SOPs, the NPS can specify which SOPs need to be created and their maintenance schedule and must be informed when SOPs are disposed or replaced.

The NPS retains all contract documentation for a minimum of 6 years after the end of the contract period. All contractors for the IMPROVE network are required to keep documents for the duration of their contract period. All environmental measurement documentation (written or electronic) is retained for at least five years from the date that it was generated. All environmental measurement data are kept indefinitely and are publicly available through the FED and the EPA-AQS databases.

QA documents such as SOPs, QAPPs, QMPs, and TSAs are held electronically for the duration of the project and made available through the IMPROVE website. Quality-related documents are archived on the IMPROVE website when new versions are generated or, in the case of SOPs, the document no longer applies. The IMPROVE Steering Committee, in conjunction with the NPS, determines when QA documents should be updated.

IMPROVE Steering Committee meeting presentations, meetings, and participation lists are made publicly available through the IMPROVE website.

7. PLAN, DO, CHECK, ACT (PDCA) MODEL

The Plan, Do, Check, and Act or PDCA quality model or cycle is an iterative process for managing, planning, implementing, and administering continual improvement in environmental information operations.

7.1. PDCA MODEL- PLAN

The EPA requires that systematic planning, such as the Data Quality Objectives (DQO) process, be used to develop performance and/or acceptance criteria for the collection and

evaluation of environmental data (*Environmental Information Quality Policy* CIO 2105.4) to ensure that the data collected is of the appropriate type and quality for the intended use. This section outlines the systematic planning that is used in the IMPROVE Program following the *Guidance on Systematic Planning Using the Data Quality Objectives Process*, *EPA QA/G-4* to develop DQOs. This section discusses several key elements of systematic planning such as the project goal (section 7.1.1), determining data needs and defining acceptance and/or performance criteria (section 7.1.2), organization (section 7.1.6), and setting a project schedule (section 7.1.4).

7.1.1. Project Goal

The goal of the IMPROVE Network is to monitor visibility in CIAs. Objectives of the aerosol component of the IMPROVE Program are to:

(1) Establish baseline data and trends of fine particulate concentrations.
(2) Determine the relationship between visibility impairment and various atmospheric particulate constituents.
(3) Determine the existing sources of particles producing visibility impairment.
(4) Determine the sensitivity of visibility impairment at individual sites to varying concentrations of particles.

7.1.2. Development of Acceptance Criteria using the DQO Process

DQOs are qualitative and quantitative statements of a study's technical and quality objectives that define the appropriate type of data and specify tolerable levels of potential decision or estimation errors. The DQO process is used by the IMPROVE network to ensure that the type, quality, and quantity of appropriate data are collected to meet the Project Goal (section 7.1.1). Performance and acceptance criteria for the IMPROVE network are discussed further in the IMPROVE QAPP. DQOs for the IMPROVE network must meet the data specifications from the EPA Guidance documents (https://www.epa.gov/visibility/visibility-guidance-documents) for the Regional Haze Rule. The objective for IMPROVE network as a total is a recovery rate (number of valid samples out of number of possible samples) of 90%. However, performance of the IMPROVE network is also assessed for the representativeness of the IMPROVE network, the performance of individual monitoring sites and for the accuracy and precision of measurement and analysis techniques of specific parameters.

The minimum number of sites necessary for the network is determined by the number of Class I Areas in the US (currently 156). However, monitoring sites may be representative of more than one Class I Area. The number of monitoring sites has expanded and contracted over time; the analysis of the necessary number of sites and site location is undertaken as part of the network review using the DQO process. The IMPROVE site selection criteria and determination of CIA representativeness are given in the IMPROVE QAPP.

Because the measurements are to be used for tracking trends in visibility and, in particular, determining the anthropogenic portion of haze, the parameters measured must be representative of the major constituents to haze in the different regions of the CONUS. Currently, the filter measurements are used to estimate coarse mass, fine soil, elemental carbon, organic mass, fine particle nitrate, and fine particle sulfate. The MQOs for the

measured parameters and completeness criteria for filter measurements are given in the IMPROVE QAPP.

Measurements are taken at each site for a 24-hour period on a 1-in-3-day measurement cycle throughout the year. This balances the amount of measurements necessary to determine trends in visibility that are not biases by weekday/weekend and/or seasonal cycles with the high cost of daily measurements across the network and was determined through previous modeling efforts. The objective for completeness for each site reflects the criteria established by the RHR and EPA guidance: at least 75% completeness within a calendar year, at least 50% completeness within each calendar quarter, and no more than 10 consecutive samples lost.

Each contracted laboratory must analyze their data and procedures and provide a QA/QC report to the NPS, EPA PO, IMPROVE QAM, and IMPROVE Steering Committee annually. The Data Processing Staff (at AQRC) provided quarterly and annual summaries of the data quality. The IMPROVE Steering Committee Chair also provides an overview to the IMPROVE network on the performance of the network as a whole and a summary of the data with respect to the Regional Haze Rule requirements. The IMPROVE Steering Committee, in conjunction with the NPS and the EPA, use the IMPROVE Steering Committee meetings as a time for reviewing network performance and project planning.

The DQO is an iterative process; analysis of the environmental data that is collected may suggest reassessment of the DQOs. In addition to changing atmospheric concentrations, availability of resources, technical advances, and policy changes may also lead to reassessment of the DQOs in order to continue to balance the level of uncertainty in the measurements with the time and financial resources available. The IMPROVE network is committed to iterating this process as necessary. Ongoing project planning is discussed in section 7.1.5.

7.1.3. Initial Planning and Conceptualization and Early Milestones

The NPS Visibility Monitoring Program started in 1978 without particulate measurements. A program administered by the Las Vegas office of the EPA began monitoring particulate concentrations in 1979 at several NPS CIAs areas in the Rocky Mountain region. Using the samplers and protocols from the EPA network largely developed at U.C. Davis, the NPS Visibility Monitoring Program added a particulate component in 1981.

In 1985, the EPA established Federal Implementation Plans for states without approved visibility provisions in the State Implementation Plan. To assist states in meeting CAA objectives, in 1987, FLMs joined with the EPA in a collaborative monitoring program called IMPROVE. The IMPROVE committee consists of representatives of the four FLMs, the EPA, and regional-state agencies.

The 1990 amendments to the CAA reaffirmed the importance of visibility protection. Section 169B included provisions for the EPA to conduct visibility research with the NPS and other federal agencies, to develop interim findings reports on the visibility research, to develop a Report to Congress on expected visibility improvements due to implementation of other air pollution programs, and to provide periodic reports to Congress on trends in visibility improvements.

In 1991, three organizations were formally added to IMPROVE: 1) the State and Territorial Air Pollution Program Administrators, 2) the Western States Air Resources Council, and 3) the Northeast States for Coordinated Air Use Management. Also in that year, 10 sites in the eastern U.S. were added to the IMPROVE network. In 1997, the EPA published proposed amendments to the 1980 regulations (62 FR 41138) to set forth a program to address regional haze visibility impairment. The EPA also established secondary National Ambient Air Quality Standards (NAAQS) for particulates with an aerodynamic diameter less than or equal to 2.5 µm ($PM_{2.5}$) as part of a final decision on revision of the existing NAAQS for particulate matter under Section 109(d) of the CAA. IMPROVE sites had begun $PM_{2.5}$ measurements a decade earlier.

In 1999 and 2000, the total number of sites in the IMPROVE network increased to 110, (there are now 155 in operation). In addition, the sampling frequency changed from Wednesday-Saturday to 1-day-in-3. These changes required the design and fabrication of the Version II IMPROVE sampler. All sites now operate with IMPROVE samplers and use identical methods for sample collection and analysis. All sites are under the supervision of the IMPROVE Steering Committee and represent 155 of the 156 mandatory CIAs (Bering Sea Wilderness being the exception). The IMPROVE network also includes additional sites that use the same instrumentation, monitoring, and analysis protocols (called IMPROVE protocol sites) but are funded by a Federal Land Manager, state agency, or other entity.

7.1.4. Project Schedule and Resources

Section 7.1.3 details the initial planning, implementation, and early milestones of the IMPROVE network. The network is 40 years old in 2025, but as it is considered an essential part of the implementation of the RHR, the goal is to maintain the network and continue the data record well into the future. Maintaining the network requires significant funding and careful resource allocation. Funding support for the IMPROVE network comes primarily from the EPA through an interagency agreement with the NPS. Additional funding for QA activities is provided by the NPS and USFS; and for protocol sites by the NPS, USFS, BLM, and DOE.

The annual IMPROVE budget covers the IMPROVE operations (currently led by AQRC, UC Davis), the carbon analysis (DRI), the ion analysis (RTI), the cooperative agreements for data analysis between the NPS and AQRC, UC Davis and the NPS and CIRA, CSU, the QAM, program overhead, and funding for the IMPROVE Steering Committee Meetings. The NPS COR provides an overview of the budget to the EPA Project Officer and IMPROVE Steering Committee at the annual IMPROVE Steering Committee Meeting. Contracts are for 5-year periods and the RFPS for the IMPROVE operations, ion analysis, and for nephelometers will be released and awarded in 2026 for the period through 2030.

These contracts are firm fixed price; however, costs can alter significantly over a contract period. Part of the DQO process (section 7.1.2) is balancing the data desired with the budgetary constraints. Discussion of the budget occurs annually at the IMPROVE Steering Committee meeting, but it is seen as an ongoing discussion necessary for the longevity of

the network. Additional meetings called by the IMPROVE Steering Committee Chair may be called to discuss budgets and resources.

The IMPROVE network also has several other important timelines in its project schedule. Technical System Audits are on a 10-year cycle, in which each site must undergo a TSA once in the 10-year period. The first cycle started in 2016, and the next cycle will begin in 2026. The QMP and QAPP must be updated every 5 years going forward, which provides an opportunity to evaluate organizational structure, the quality program, and DQOs.

7.1.5. Ongoing Program Planning and Design

The IMPROVE Network has expanded and contracted over time, and analysis methods and instrumentation have changed. Additionally, the levels and composition of haze have changed. Thus, the DQO process is iterated over time in order to continue to refine the data requirements necessary during the different phases of the network.

The IMPROVE Steering Committee makes all executive decisions regarding the program implementation and design. Potential changes to the network, such as funding of contractors, expansion or reduction of the network, and all other technical and non-technical issues; along with future directions of the network are decided on and planned for by the Steering Committee. The Steering Committee can task the Data Analysis and Reporting Subcommittee with conducting specific data analysis to support the planning process.

Planning for the network occurs during the IMPROVE Steering Committee meetings, which are held semi-annually with one in-person meeting and one remote. Steering Committee Meetings are an opportunity for all members to congregate and discuss previous results and anticipate any upcoming challenges.

In addition to annual meetings, organizations are in regular communication. Monthly meetings are held between IMPROVE Committee members, AQRC, NPS, CIRA, and the QAM to discuss short term updates and any data or operational issues. Subcommittees also meet annually (apart from the Steering Committee Meetings).

7.1.6. Systematic Planning Organization and Key Personnel

7.1.6.1. IMPROVE Steering Committee

The IMPROVE Steering Committee has the responsibility to make the final decision on the implementation of the program. The agencies that are represented on the IMPROVE Steering Committee are listed in Table 1. Currently, the Committee Chair is Scott Copeland. He has the responsibility to set agendas, call meetings to order, and present technical and financial information to the committee.

7.1.6.2. National Park Service

The NPS is the key operational agency of IMPROVE. The agency is responsible for implementing the technical direction of the IMPROVE Steering Committee; issuing and administering all IMPROVE contracts; operating IMPROVE sites; reviewing QA reports; performing data analyses; and distributing data, analyses, and all project information

through the IMPROVE website. The NPS should be involved in any operational decisions and coordinate any planned field operations with the managing agency.

7.1.6.3. IMPROVE QAM

The IMPROVE QAM oversees the implementation of the program from a technical perspective and therefore should be included in any planning discussions to ensure that changes or additions to the program still follow the quality assurance plan and protect the integrity of the program. The QAM should also plan for regular QA activities, including external and field site audits. The IMPROVE QAM is also responsible for planning updates to the QAPP and QMP.

7.1.6.4. Organization Program Managers

Each of the organizations within the IMPROVE Program needs to commit to planning for the program. The program managers must verify that the agency has enough manpower to perform the duties, whether they be field or laboratory, and communicate with NPS and the IMPROVE Steering Committee to ensure that operations are uninterrupted.

7.2. PDCA MODEL- DO (Implementation)

To achieve the objectives of the IMPROVE network, there are many processes that have been developed and need to be implemented and documented. The specific measurement and data production activities central to the IMPROVE network objectives are shown in Figure 3. The QAPP (https://vista.cira.colostate.edu/Improve/quality-assurance/), developed by the Steering Committee in conjunction with the contracted laboratories, further discusses these processes and the necessary quality assurance procedures that must be done with each activity. The different organizations and agencies involved in the IMPROVE network and the procedures that they are specifically responsible for implementing are detailed in Section 7.2.1. Section 7.2.2 describes the documents that outline these procedures and the parties responsible for updating those documents.

7.2.1. Implementation Roles

7.2.1.1. National Park Service

The NPS is the primary operational agency for the IMPROVE Program. The NPS implements the decisions of the IMPROVE Steering Committee and helps provide technical oversight of the IMPROVE program. In addition, funding for all contracted work passes through the NPS, and the NPS awards and administers all operational contracts for IMPROVE. The NPS is also responsible for ensuring that all contractors create and maintain SOPs and TIs for all operations. The NPS also routinely analyzes data from the network. Finally, NPS operates many IMPROVE sites.

7.2.1.2. Field Team

The Field Team (currently at AQRC) is responsible for coordinating site set-up, routine maintenance, and calibration of instruments. The Field Team must ensure that the site meets the Site Selection criteria as outlined in the Site Selection SOP and follow the Site Maintenance SOP available on the IMPROVE website

(https://vista.cira.colostate.edu/Improve/particulate-monitoring-network/). The Field Team is also responsible for recording and reporting all site maintenance activities.

7.2.1.3. Field Operators

Field operators are generally employed by the agency responsible for the monitoring site and are responsible for most work performed at the monitoring sites. Field operators are responsible for:

(1) Operating and maintaining the IMPROVE samplers.
(2) Filling out log sheets.
(3) Following the filter change schedule.
(4) Returning sampled filters to UCD in a timely manner.
(5) Submitting to and participating in field audits and reviewing results.

Full details on these responsibilities are all outlined in the Sampler Maintenance by Site Operators SOP (https://vista.cira.colostate.edu/Improve/particulate-monitoring-network/). The SOP is reviewed annually by the AQRC QAM and any revisions must be approved by the Field Team Lead and AQRC QAM. Revisions to SOPs must be relayed to the NPS and IMPROVE QAM and announced to field site operators.

7.2.1.4. Laboratory Staff

AQRC is currently contracted to manage the distribution, sampling, and collection of filter samples. The AQRC laboratory staff also perform the filter analysis of the Module A and D samples and distribute the filters from the B and C modules to RTI and DRI, respectively. RTI and DRI analyze module B and C filters, respectively, and forward the analysis results to the Data Processing team. Laboratory staff are responsible for the following duties:

(1) Preparing and analyzing the filters according to the laboratory QAPP and SOPs.
(2) Coordinating the sending and/or receiving of filters for analysis.
(3) Long-term storage of filters and data records.

Laboratory roles and responsibilities are further detailed in SOPs and associated TIs for each process, which are all available on the IMPROVE website (https://vista.cira.colostate.edu/Improve/particulate-monitoring-network/). SOPs for the ion and carbon analysis are also available on the IMPROVE website (https://vista.cira.colostate.edu/Improve/ion-chromatography-analysis-of-module-b/ and https://vista.cira.colostate.edu/Improve/carbon-analysis/). Any changes to processes must be approved by the lab supervisor and manager and revised in the SOP, which is reviewed at least annually by the laboratory QAM to determine if updates are necessary. Revised SOPs must be relayed to the NPS and IMPROVE QAM.

7.2.1.5. Data Processing Staff

Data processing staff (currently at AQRC) perform the statistical and screening analysis on the sample data. These duties include but are not limited to:

(1) Reviewing data for completeness.
(2) Performing analysis on the data set and flagging data that do not conform to the screening test norms.

(3) Reporting on data validation.
(4) Sending validated data to CIRA and AQS for distribution.

All data processing duties are outlined in the Data Processing and Validation SOP (https://vista.cira.colostate.edu/Improve/particulate-monitoring-network/). Updates to the data processing procedures must be approved by the (AQRC) QAM and group supervisor. Revised SOPs must be relayed to the NPS and IMPROVE QAM.

7.2.1.6. Data Reporting and Distribution

Staff at CIRA are currently responsible for loading the final data into the IMPROVE FED database (https://views.cira.colostate.edu/fed/) for distribution. CIRA also provides a Data User Guide (http://vista.cira.colostate.edu/Improve/data-user-guide/) for the general user on routine monitoring, aerosol sampling and analysis, accessing and downloading data, descriptions of methods for determining concentrations, minimum detection limits, uncertainties, calculated variables, mass and aerosol extinction reconstruction algorithms, and other applicable information for obtaining, analyzing and interpreting IMPROVE data.

CIRA also performs specific data analyses and reports (e.g., http://vista.cira.colostate.edu/Improve/improve-reports/) that are posted on the IMPROVE website (http://vista.cira.colostate.edu/Improve/). CIRA analysts are also responsible for the Regional Haze Rule Metric dataset. Data and guidance documents are available on the IMPROVE website (http://vista.cira.colostate.edu/Improve/rhr/).

7.2.2. Development of Procedural Documents

SOPs are required for any complex tasks associated with the collection of environmental measurements that must conform to regulatory standards. The IMPROVE network has SOPs for all field, laboratory, and data activities. As the key operational agency in charge of overseeing the technical operation of the network, the NPS is responsible for making sure contractors create and maintain SOPs for all activities. Any minor task that does not directly relate to taking or analyzing an environmental measurement but is repeatedly performed by the same or different individuals should have a checklist associated with it (e.g., laboratory checks or audit checklists). Templates should be created and used for all reports (e.g., audit reports, site reports, quality reports). All blank checklists and form templates should be electronically available and linked to the associated SOP.

SOPs should be developed by the entity overseeing the operation. AQRC is in charge of creating SOPs for their field, laboratory, and data activities. SOPs are specifically prepared and approved by the manager/supervisor of the group (e.g., Field Group, Data and Management Group, Lab Group). RTI is responsible for creating and maintaining the SOP for the ion analysis, and DRI is responsible for creating SOPs the carbon analysis. Each SOP should be reviewed annually by the laboratory QAM to determine if updates are necessary. If updates are warranted, the SOP must be version controlled and re-approved. Previous versions of the SOP should be archived and updated versions are submitted to the NPS and IMPROVE QAM. The QAPP and QMP must also be updated to note new versions of SOPs. The IMPROVE Steering Committee, in conjunction with the NPS, can determine if new SOPs, not already provided by the contracted laboratories, are necessary.

Generally, the contracted laboratories will determine when SOPs are no longer valid but must notify and get final approval from the NPS.

7.2.3. Deviations and Waivers from Approved Procedures

All measurements and analysis methods should follow approved procedures. Procedures should be outlined in SOPs that have been submitted to the NPS, IMPROVE QAM, and IMPROVE Steering Committee. However, contractors may apply for permission to the IMPROVE Steering Committee and NPS to deviate from approved procedures before updating documentation. This may occur in the case of instrument malfunction or testing and implementation of new technologies or methods. However, contractors must provide justification. Any update which becomes a routine procedure must be documented in a new or updated TI or SOP.

7.3. PDCA MODEL- CHECK (Assessment and Oversight)

There are many routine quality-related activities necessary to assess if the IMPROVE network is meeting its monitoring objectives, that procedures are followed, and to ensure the quality level of the data produced. The IMPROVE organizational chart (Figure 1) depicts the overall management structure of the network and the levels of oversight for the different activities of the network. Informal assessment of activities should occur at all levels and by all participants of the IMPROVE network to ensure that they are correctly following procedures. Formal assessments of the network are also conducted and include the following: technical system audits (TSAs), performance audits, data quality assessments (DQAs), and performance evaluations, which are detailed in the following subsections.

7.3.1. Assessment Planning

The IMPROVE Steering Committee is ultimately responsible for ensuring that appropriate and timely assessments of the network occur. Authority is given by the Steering Committee to the QAM to carry out necessary assessments and audits.

The QAM works in conjunction with the appropriate technical personnel (e.g., Field Team Manager) to develop an audit plan and checklist that corresponds to the QA objectives outlined in the QAPP and that accurately checks that the procedures in the SOPs are being followed. The audit plan is approved by the NPS and the IMPROVE Steering Committee. The Network Operations Subcommittee is responsible for determining when updates to the audit procedure need to be made and recommending updates to the IMPROVE Steering Committee at IMPROVE Steering Committee Meetings. All audits must follow the approved audit approach and use the approved audit workbook. The annual audit report summarizes the findings of the individual audits. The IMPROVE Steering Committee reviews the annual audit report which summarizes the audit results submitted by the QAM to ensure that the assessment goals are being met.

The QAM coordinates the necessary field site audits in the first quarter of every year. A schedule is submitted to the NPS, AQRC, and the field operators who are scheduled to be assessed. The QAM is responsible for ensuring that all audit instruments and forms are prepared in advance for a scheduled audit. Usually, one month before the assessment, the

agency to be assessed is notified of the exact dates and times and provided with the necessary forms. This allows the agency time to review the forms and gather the necessary information. This has a two-fold objective: (1) it allows those to be assessed knowledge of what is required and (2) it can minimize the time that auditors are in the field and site operators are away from their other duties. The QAM must either personally perform the audit or coordinate with a trained auditor.

The QAM provides reports to the agency and NPS after the audit and submit a final Technical System Audit report to the IMPROVE Steering Committee, EPA, and NPS annually (and present at the IMPROVE Steering Committee meeting annually).

The EPA OAQPS Project Officer coordinates with the contracted laboratories (with the Laboratory Program Manager and Laboratory QAM) to schedule external technical system audits. Virtual meetings are held between the EPA OAQPS, the contracted laboratories Program Manager, laboratories QAM, and the IMPROVE QAM to discuss the goals of the intended audit, coordinate the audit logistics, and review necessary documentation. The OAQPS Project Officer is responsible for selecting auditors for the laboratories and working with the auditors to create and approve the audit procedures and checklist that are provided to the laboratory in advance of the audit. The audited laboratory reviews is provided with a draft of the audit findings and given opportunity to respond to the auditor. The final report is sent to the IMPROVE Steering Committee, EPA, and NPS.

The QAM reviews all QA reports and data validation results and confers with the IMPROVE Data Analysis and Reporting Group to determine when additional measures or analysis are required.

7.3.2. Assessment/Audit Tools and Assessors

The goal of the assessment tools is to independently confirm the implementation and effectiveness of procedures and/or to identify any problems that require corrective actions. The assessment tools listed below are targeted toward each of the IMPROVE network activities. Each procedure and outcome should be documented and presented to the QAM, NPS, EPA, and IMPROVE Steering Committee. The IMPROVE Steering Committee annually reviews the results and findings of the Quality Program as outlined in this QMP as well as annually assessing the Quality Program as a whole. The QAM relays all planned QA activities (as described below) to the IMPROVE Steering Committee annually and reports results at the annual IMPROVE Steering Committee meeting.

To be qualified to conduct field audits, the field auditor must have experience and knowledge in aerosol monitoring, be familiar with all IMPROVE field site operations and SOPs, be properly instructed in the audit procedure (by the previous or current IMPROVE QAM) and be committed to maintaining appropriate records. Partner auditors are state or other government agency employees that already conduct audits of other monitoring network sites and thus have experience in conducting field site audits. However, the IMPROVE Steering Committee and NPS must approve any partner auditors and can decide if they have the appropriate qualifications. Any partner auditor must be in regular contact with the IMPROVE QAM and be retrained in-person whenever there is an update to the sampling procedures or at least every five years. The field auditor must not be personally

responsible for the routine operation of a field site or be responsible for the regular collection of IMPROVE environmental data (with the exception of the QAM who may participate in collection of IMPROVE environmental data for test sites or special studies as it relates to QA procedures).

7.3.2.1. External Laboratory Technical System Audits

External audits of the laboratories are performed by an auditor who is not affiliated with the laboratory being audited and is designated by the EPA OAQPS Project Officer. These audits may be done specifically for the IMPROVE network or in conjunction with an audit of the CSN network (which uses similar same laboratory procedures). The contracted auditor must be qualified to review quality systems both in terms of documentation and laboratory procedures. The auditors should examine all aspects of operations to determine if processes and quality assurance programs being implemented are in alignment with the QMP, QAPP, laboratory SOPs, TI documents, and with program requirements.

After each audit has been completed, the following post-audit activities are conducted to document the audit findings and corrective actions following details documented in Section 15.3.3 and Section 15.3.4 of the *EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II*. The audit report should be prepared and delivered to the audited laboratory within 30 days. The report should include:

(1) Audit title, number, and any other identifying information;
(2) Audit team leaders, audit team participants, and audited participants;
(3) Background information about the project, purpose of the audit, dates of the audit, particular measurement phase or parameters that were audited, and a brief description of the audit process;
(4) Summary and conclusions of the audit and corrective action requirements; and
(5) Attachments or appendices that include all audit evaluations and audit finding forms.

The organization being audited has 30 days (or a shorter time period if agreed upon at the time of the audit) to respond to the audit report with comments and/or questions, following which the audit team lead will finalize the audit report. The organization being audited must respond to the findings documented in the final audit report within 30 days, providing a corrective action report that documents actions taken, timeline, responsibility, and status.

Finalized external audit reports are also be reviewed by the IMPROVE QAM as it relates to both previous internal and external audits. The QAM documents in the form of a memo any trends in nonconformity, the effectiveness of any previous corrective actions, and any suggested improvements. The memo is sent to the IMPROVE Steering Committee with the external audit report.

7.3.2.2. Field Technical System Audits

Field TSAs (https://vista.cira.colostate.edu/Improve/technical-system-audits/) are performed by the QAM or by IMPROVE partner auditors trained by the QAM (and approved by the NPS and IMPROVE Steering Committee). TSAs focus primarily on evaluating the sampling sites and the particle samplers in the field but also assess the site

operators' knowledge and training on the routine operation of the samplers. In conducting a field TSA, the auditor:

(1) Assesses whether the sampling site meets siting criteria for an IMPROVE sampler (according to "Site Selection" SOP available here: https://vista.cira.colostate.edu/Improve/particulate-monitoring-network)
(2) Observes the technique of the site operator to ensure that they are following the "Sampler Maintenance by Site Operators" SOP (available here: https://vista.cira.colostate.edu/Improve/particulate-monitoring-network/)
(3) Asks the site operator to complete a questionnaire to ensure that (s)he has adequate sampler and sample change knowledge, that all safety concerns have been addressed, and that the IMPROVE Operations Contractor (currently AQRC) is providing adequate support to run the site.

In addition, the auditor conducts a performance audit by measuring the flow rate of each channel using a NIST certified flow meter (as described in the Flow Check Technical Information document available here: https://vista.cira.colostate.edu/Improve/technical-system-audits/) and verifying the ambient and instrument temperature, time and date indicators, and barometric pressure gauges. All audit devices are independently calibrated and maintained (it is the responsibility of the QAM to make sure all audit devices are calibrated annually). Any deviations from the Measurement Quality Objectives as stated in the project QAPP are to be reported to the Field Team (AQRC) and reported in the annual Technical System Audit Report. Corrective actions (such as scheduling replacement of parts or calibration of instruments, retraining of field site operators, or scheduling site maintenance) is performed as stated in the QAPP. TSA reports are provided to NPS, the Field Team, and the IMPROVE Steering Committee as well as made available on the IMPROVE website (https://vista.cira.colostate.edu/Improve/technical-system-audits/).

Along with the TSA results, the QAM can include any comparisons to previous TSAs to document any trends in nonconformity, the effectiveness of any previous corrective actions, and any suggested improvements. Memos are sent to the IMPROVE Steering Committee along with the external audit report.

The field TSA procedures are developed by the Field Manager and QAM in order to ensure that the audit accurately assesses the procedures in the SOP and QAPP. Audit procedures, checklists, and acceptance criteria are also approved by the NPS and IMPROVE Steering Committee.

7.3.2.3. Data Validation

The data validation process is described in detail in section 9.1. Data validation is considered at each step of the process, from laboratory analysis of individual filters, reported "raw" values, and of calculated values. Routine analysis of spatial and temporal trends for IMPROVE reports and comparison to other measurements (e.g., from CSN, from nephelometers, etc.) are also used to investigate validity of data. In addition to routine data validation, data may be validated in special studies as determined by the IMPROVE Subcommittee on Data Analysis and Reporting. Quality of collected data should be documented with appropriate quality flags. Measurement data of undocumented quality

should be reviewed by the IMPROVE Subcommittee on Data Analysis and Reporting and the IMPROVE Steering Committee Chair before use or distribution. A data advisory should be provided with the data.

7.3.3. Management Reviews

The IMPROVE Steering Committee is responsible for reviewing all audits and documentation from the IMPROVE QAM, and the IMPROVE Steering Committee annual meeting serves as the designated time for reviewing the IMPROVE network and Quality Program. The QAM sends audit reports and memos to the IMPROVE Steering Committee and reports results at the IMPROVE Steering Committee Meeting annually. Each agency/institution also presents QA results at the IMPROVE Steering Committee Meeting and all presentations and meeting minutes are retained and available electronically (http://vista.cira.colostate.edu/Improve/steering-committee-meetings/).

7.4. PDCA MODEL- ACT (Corrective Actions and Improvements)

7.4.1. Processes for Identifying Non-conformance

Section 2.3 describes the Quality Assurance Program for all areas of the network. The Quality Assurance Program includes many processes for identifying non-conformance with quality objectives. These include routine QA/QC procedures for field work, laboratory work, and data management, as well as formal audits of the laboratory and field network system. Routine procedures include duplicate measurements, testing and calibrating instruments, and performing multiple data validation steps.

All contractors are obligated to evaluate staff performance, ensure quality assurance procedures are being followed, and report all quality related activities to the IMPROVE Steering Committee, NPS, and IMPROVE QAM.

Laboratory and field audits are intended to provide external review of processes and identify areas of improvement and non-conformance. Audits evaluate the processes, instruments, and staff involved in environmental measurements. The IMPROVE Steering Committee's annual meeting provides the opportunity for reviewing all aspects of the network.

7.4.2. Corrective Actions and Documentation

When non-conformance with quality program requirements is noted either through routine formal or informal evaluations or through formal quality assessments such as audits, corrective actions should be suggested by the auditee and then agreed upon by the necessary staff, managers of the auditee. Depending on the magnitude of the issue, the IMPROVE steering committee may also suggest and approve corrective actions.

If non-conformance is found at a specific institution/agency, it is the responsibility of the supervising manager (or QAM) of that specific institution/agency to investigate the root cause of the issue to determine whether the problem is unique or has systemic implications and to propose corrective action or further analysis of the issue. In addition, the supervising manager is required to document the issue, outcomes of the investigation, the proposed corrective action, and expected timeline. If the issue is systemic and has broad implications

on data quality, the supervisor must alert the QAM and IMPROVE Steering Committee of the issue in a timely manner and the matter should be discussed at an IMPROVE Steering Committee meeting. If the issue is minor and easily resolved at the institution-level (e.g., staff requiring retraining or incomplete documentation), it is at the discretion of the managing supervisor to inform the QAM and/or Steering Committee.

Non-conformance discovered during an audit requires more documentation and stricter timelines as outlined in Section 7.3.2. The QAM or assessor must provide documentation of the results of the audit and allow the laboratory or site operator an opportunity to review and respond within 30 days. Audits should include suggestions for corrective actions and timelines for implementing the corrective action. Finalized results of audits and any responses are submitted to the IMPROVE Steering Committee.

7.4.3. Opportunities for Improvement

During evaluations or assessments, the assessor may note procedures that are not out of conformance but that could potentially be improved. The assessor may suggest changes to the procedure during their assessment. However, implementation of these suggestions is at the discretion of the party responsible for the procedure, with the understanding that all participants of the IMPROVE network are striving for continual improvement.

7.4.4. Follow-up Actions

The follow-up required after a formal assessment depends on the magnitude of the issue. In general, the follow-up should include a re-evaluation of the staff, process, or instrument after an appropriate amount of time has been given to implement a corrective action. Results of the re-evaluation should be documented and reported to the necessary parties.

7.4.5. Dispute Resolution

Occasionally, findings in an assessment report may be disputed by laboratory or field staff, the NPS, AQRC, RTI, DRI, or CIRA. Staff should be provided with the report in a timely manner and given adequate time to respond (usually 30 days). The assessment report should state the who, what, where and when of the assessment in addition to the findings of the assessment. Staff should discuss results with their supervisor and respond to the assessor in writing regarding any disputes to the assessment. The NPS and laboratory/institution can work to investigate the findings if the results show that the system is outside of the Measurement Quality Objectives (MQO) or requirements of the QAPP. All responses are reviewed by the QAM and/or the assessor (or OAQPS if the assessor was contracted by the OAQPS). The assessor then responds in kind.

If the dispute is still unresolved, the matter is referred to the IMPROVE Steering Committee, which has the final authority concerning a dispute. The initial assessment, staff dispute, and assessor responses are transferred to the IMPROVE Steering Committee along with any additional findings or responses made by the NPS or laboratory/agency. The IMPROVE Steering Committee may schedule meetings or teleconferences to discuss the dispute. The outcome is documented in a memo to the assessor, staff member, agency/institution, and NPS and any additions/revisions to the report documented.

8. CONTINUAL IMPROVEMENT

The IMPROVE network works to continually improve the Quality Program through assessment and analysis of procedures and results. The IMPROVE Steering Committee meets annually to review all Quality Program results, including TSAs, laboratory audits, and quality reports.

Staff at each agency, institution, or organization in the IMPROVE network should have clear paths and means of communicating with management and be encouraged to voice concerns or suggest improvements. Each agency can bring concerns or suggest improvements during IMPROVE Steering Committee meetings.

The IMPROVE Steering Committee annual meeting is the primary opportunity for evaluating the overall effectiveness of the quality program and should include presentations and discussions from all contractors, the QAM, and all subcommittees.

9. DATA REVIEW AND DATA USABILITY REPORTING

9.1. DATA VERIFICATION AND VALIDATION

Data verification and validation happens at multiple steps in the measurement and analysis process. Full details of the field, laboratory, and data QA/QC procedures are provided in the QAPP and contractor SOPs. Laboratory staff are tasked with clearly documenting and tracking samples for shipment to field operators who are responsible for checking samples, documenting instrument performance, and returning samples to the laboratory in a timely manner. Laboratory staff track filters at each step during the measurement and analysis process and assign status flags when necessary.

After laboratory analysis, data undergo validation checks by the Data & Reporting Group (currently at AQRC) technical staff who function independently of the routine laboratory operations. Data validation is performed in batches of data. The analytical data are processed to ambient concentrations and undergo various validation checks. During the data validation process the data analysts have the authority to request reanalysis of suspect samples. Data are released only after all issues have been resolved.

Minimum detection limits (MDLs) are provided for all sample values along with status flags that are assigned during data import. Quality of collected data should always be documented with appropriate quality flags. Historical data that have not been assessed or validated are available in the FED database but are flagged as such. Measurement data of undocumented quality, such as this historical data, are reviewed by the IMPROVE Subcommittee on Data Analysis and Reporting and the IMPROVE Steering Committee Chair before use or distribution. A data advisory should be provided with the data.

The IMPROVE Subcommittee on Data Analysis and Reporting is responsible for determining when additional analysis and data validation is required.

9.2. DATA USABILITY

9.2.1. Data User Guide

The IMPROVE Data User Guide is available on the IMPROVE website and provides information for the general user on routine monitoring, aerosol sampling and analysis, accessing and downloading data, descriptions of methods for determining concentrations, minimum detection limits, uncertainties, calculated variables, mass and aerosol extinction reconstruction algorithms, and other applicable information for obtaining, analyzing, and interpreting IMPROVE data.

9.2.2. Peer-Review of IMPROVE Data

The IMPROVE network commits to regularly submitting analysis results for peer review in academic publications in addition to generating internally reviewed reports.

9.2.3. Community-supported Data Advisories

The IMPROVE network data has a wide user base. Users of the data may find unreported data anomalies, problems, or propose new uses for the data. To document these findings, the IMPROVE network has a community-supported Data Advisories webpage on the IMPROVE website (https://vista.cira.colostate.edu/Improve/ data-advisories/). These are briefly reviewed by the IMPROVE Steering Committee but not validated. The advisories are not meant to be complete and are not necessarily endorsed by the IMPROVE Steering Committee or NPS but are provided for transparency.

9.2.4. Requests for Measurement Data by Other Organizations

The IMPROVE network is occasionally contacted by outside institutions or agencies for access to filters to be used in different research studies. It is ultimately the decision of the IMPROVE Steering Committee to grant the release of these filters. Researchers must submit a research plan and the dates and sites of filters that they want to analyze. The IMPROVE Steering Committee chair is the primary point of contact and consults with other members of the committee to make a determination, which generally takes into account the magnitude of the request and the potential scientific significance (in alignment with IMPROVE interests) of the request and weighs it against the duty to maintain filters for future internal or external studies.

9.2.5. Analysis of IMPROVE Data and Publications by Other Organizations

All IMPROVE data are publicly and freely available for analysis. The IMPROVE network welcomes use of IMPROVE data by outside agencies and organizations and provides the Data User's Guide (Section 9.2.1) to aid in data useability and interpretation. The IMPROVE network does not serve as gatekeepers to the use or interpretation of data but does ask to be informed of any planned publications as a courtesy and method for tracking data usage (NPS is the current point of contact). Publications using IMPROVE data obtained from the FED website should include a product citation, a citation to the *Malm et al.* (1994) paper and an acknowledgment. This information is included in downloads from the FED website. IMPROVE network researchers may review drafts of publications upon request to check for any issues that could affect the data interpretation.

10. REFERENCES

Malm, W. C., J. F. Sisler, D. Huffman, R. A. Eldred, and T. A. Cahill (1994), Spatial and seasonal trends in particle concentration and optical extinction in the United States, J. Geophys. Res., 99, 1347-1370.

11. APPENDIX

Appendix A. List of Standard Operating Procedures used in IMPROVE network operations.

Authoring Organization	Number	Title	Link To Webpage with Document
UCD QRC	126	Site Selection	https://vista.cira.colostate.edu/Improve/particulate-monitoring-network/
UCD AQRC	151	Installation of Samplers	https://vista.cira.colostate.edu/Improve/particulate-monitoring-network/
UCD AQRC	201	Sampler Maintenance by Site Operators	https://vista.cira.colostate.edu/Improve/particulate-monitoring-network/
UCD AQRC	226	Site Maintenance	https://vista.cira.colostate.edu/Improve/particulate-monitoring-network/
UCD AQRC	251	Sample Handling	https://vista.cira.colostate.edu/Improve/particulate-monitoring-network/
UCD AQRC	276	Optical Absorption Analysis of PM2.5 Samples	https://vista.cira.colostate.edu/Improve/particulate-monitoring-network/
UCD AQRC	301	XRF Analysis of Aerosol Deposits on PTFE Filters	https://vista.cira.colostate.edu/Improve/particulate-monitoring-network/
UCD AQRC	351	Data Processing and Validation	https://vista.cira.colostate.edu/Improve/particulate-monitoring-network/
RTI		Determination of Anions and/or Cations Extracted from Nylon® Filters by Ion Chromatography	https://vista.cira.colostate.edu/Improve/ion-chromatography-analysis-of-module-b/
DRI	2-106.5	Pre-firing and Acceptance Testing of Quartz-Fiber Filters Number for Aerosol and Carbonaceous Material Sampling	https://vista.cira.colostate.edu/Improve/carbon-analysis/
DRI	2-226r1	DRI Model 2015 Multiwavelength Carbon Analysis (TOR/TOT) of Aerosol Filter Samples - Method IMPROVE_A	https://vista.cira.colostate.edu/Improve/carbon-analysis/