$PM_{2.5}$ CHEMICAL SPECIATION/IMPROVE FIELD AUDITORS COURSE HANDBOOK

1.1 BACKGROUND

The EPA relies on State, Local, and Tribal (SLT) agencies to implement and manage the Quality Assurance program for the PM2.5 Chemical Speciation network, and in particular the requisite field activities such as technical systems audits and monitor/sampler performance audits. A team from EPA's Office of Air Quality Planning and Standards, and the Office of Indoor Air and Radiation provide oversight role for these activities.

An adjunct activity has stemmed from the similarities with the IMPROVE Monitoring Network. At IMPROVE's request the OAQPS and ORIA team has led the development of a field auditing component of their QA program. It is staffed by personnel from EPA Regions (or their contractors) and SLT agencies who have a significant interest in the IMPROVE network.

There has been little regulatory guidance for the assessment of field operations for either network, or the data that is generated by the assessments. Consequently the OAQPS and ORIA team have collaborated with the EPA Regional and SLT auditors, and the IMPROVE program to develop the necessary assessment tools and provide associated training. The tools include standard operating procedures (SOPs), evaluation criteria, recommended reference standards and instruments, and electronic forms necessary to record and report the audit results in a consistent manner. This handbook is an overview of the SOPs and other references.

1.1.1 What is PM2.5, Why is it Important, How is it Measured?

In 1997, the EPA promulgated a National Ambient Air Quality Standard (NAAQS) for $PM_{2.5}$, particulates of aerodynamic diameters less than or equal to 2.5 micrometers (µm). Visualize that a human hair is approximately 50 µm in diameter (20 times larger than $PM_{2.5}$). The current NAAQS, which was based on scientific studies of health effects of fine particulate, is 13.0 $\mu g/m^3$, annual arithmetic mean (revised from 65 $\mu g/m^3$ on January 15, 2013) and/or 35 $\mu g/m^3$, 24-hour average daily concentration (revised from 65 $\mu g/m^3$ on October 17, 2006). Asthma and heart malfunctions have been associated with elevated ambient concentrations of $PM_{2.5}$. Ambient concentration is determined by a mass of $PM_{2.5}$ that has been collected on a 47 mm Teflon® [1] (polytetrafluoroethylene or PTFE) filter at specified locations, and divided by the total volume of ambient air drawn through the filter over a 24-hour period. The level of the concentration on a daily basis or the number of average daily concentrations that exceed the prescribe level are placed in a metric to determine if the area is to be classified as "non-attainment" with respect to the NAAQS. A description of the Annual NAAQS and its calculation can be found in 40 CFR Part 50 appendix N.

[1] The term Teflon® is E.I. DuPont de Nemours' Registered Trademark for a family of polymers made from vinyl and vinylidene fluorides. The most common form is polytetrafluoroethylene or PTFE. The PM2.5 FRM filters and Speciation filters are made from PTFE but it is possible that the filter supplier in a given year may not be using Teflon® per se. Nonetheless most individuals refer to the PTFE filters as Teflon filters; therefore, this term will be

If an area exceeds the NAAQS, the jurisdictional SLT government must put measures in place to lower ambient concentrations to healthy levels. Measures might include stringent controls on industrial sources of pollution; auto inspection and maintenance programs and costly emissions offset programs for new sources of emissions. The air quality with respect to fine particulate has gained such notoriety that it is now reported as an index by all major metropolitan areas and is forecasted for most of the US.

Concurrent with promulgating the NAAQS, the EPA established a Federal Reference Method for measuring $PM_{2.5}$. Then, with funding from Congress, EPA empowered the State, Local and Tribal environmental agencies to deploy and operate a network of approved, so-called FRM samplers that measure ambient concentrations of fine particulate mass. The ambient concentrations are compared to the NAAQS to determine if local areas have unhealthy levels, i.e., concentrations above the NAAQS.

1.1.2 What is $PM_{2.5}$ Chemical Speciation; why is it important, how is it measured?

Chemical speciation of $PM_{2.5}$ is the identification and quantification of individual chemical elements, compounds or classes of compounds that make up $PM_{2.5}$ aerosols. Speciation samplers are not used to determine attainment or non-attainment with the $PM_{2.5}$ NAAQS per se. There are two major $PM_{2.5}$ speciation networks in the US. They are differentiated primarily by the regulatory programs that they support, and by the type of samplers used to gather the aerosol samples to be analyzed. One network was commissioned by regulations promulgated in 1997 at 40 CFR Part 58 to be a companion network to the FRM network described previously. It is referred to as the $PM_{2.5}$ Chemical Speciation Network (CSN). The other network, the Interagency Monitoring of Protected Visual Environments (IMPROVE), primarily serves the Regional Haze and visibility protection programs. In 2007, 2008 and 2009 EPA deployed a single channel carbon sampler the URG 3000N in the CSN to replicate the carbon sampling procedures of the IMPROVE samplers. After a brief collocation period, carbon sampling using the existing speciation sampler (Metone SASS, module C or 3) was suspended, and the URG 3000N became the primary carbon sampler for the CSN.

Succinctly stated, the programmatic objectives of the chemical speciation monitoring network are to provide data that allows for:

- Annual and seasonal spatial characterization of aerosols;
- Air quality trends analysis and tracking the progress of control programs;
- Evidence as to the sources of $PM_{2.5}$ and therefore the development of emission control strategies.
- Comparison of chemical speciation data collected by the speciation network with data collected by the IMPROVE network for the Visibility and Regional Haze Program.

1.1.3 The Chemical Speciation Network

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used for the balance of this course under the assumption that it is the predominant brand. This in no way suggests that EPA endorses or favors Teflon over other brands of PTFE.

In the 1997 rulemaking, it was stated that the Chemical Speciation network was expected to grow to about 300 monitoring sites. Approximately fifty sites were to be established as long-term trends sites at National Air Monitoring Sites (NAMS), which were to be predominantly, located in large population areas. The so-called Speciation Trends Network reached fifty-four in 2002. The balance of the 300 chemical speciation sites, dubbed "supplemental," were to be deployed at State and Local Air Monitoring Sites (SLAMS) for better spatial representation of community scale and even rural background air sheds. Selection of supplemental SLAMS locations and specific instrumentation was left up to the particular monitoring organization.

Approximately 60 of the supplemental "SLAMS" speciation sites were outfitted with IMPROVE samplers as described in Section 1.0.4, below. These are called IMPROVE protocol sites. The STN and supplemental network reached its zenith in 2004 at with at around 325 speciation trends, supplemental speciation and IMPROVE protocol sites.

Originally, the supplemental chemical speciation sites were operated to provide information for the development of control strategies in implementation plans and then to track the success of the plans. Now that the $PM_{2.5}$ program has matured, most of the non-attainment areas have been identified, albeit the revised daily $PM_{2.5}$ Standard in 2006 and the downward revised primary standard in 2013 may result in a few more. As some areas progress back into attainment and the national monitoring strategy continues to evolve, some of the original chemical speciation sites will be suspended. In the October 17, 2006 rulemaking, EPA revised the monitoring regulations in addition to the $PM_{2.5}$ daily standard. The new rules required States to establish and operate a network of NCore multi-pollutant monitoring stations. These stations were to be operational by 2011. The rule requires between 62 and 71 such stations; however, the NCore network has grown to approximately 75 stations. About 55 NCore sites are in urban areas and about 20 sites in the rural areas. Most of the Speciation Trends Network (STN) sites from the old SLAMS/NAMS network become part of the new NCore network, which will focus on trace gas as well as criteria pollutants. Speciation sites under the NCore/TRENDS and Supplemental strategy will be simply referred to collectively as the Chemical Speciation Network (CSN) and the number will stabilize around180.

The chemical speciation network samplers (other than the IMPROVE samplers) were designed to use the same basic sampling principle as the FRM--collecting an integrated 24- hour $PM_{2.5}$ aerosol filtrate on a 47 mm filter. The speciation network samplers, however, utilize up to four channels to expose four separate filters, each composed of a different material, in order to isolate and identify the constituents

Both Speciation and IMPROVE networks use one channel to collect elemental carbon and carbon compounds on a quartz filter. Due to an unresolved debate over the most accurate protocol for identification and quantification of carbon constituents, in 2007 EPA decided to collect $PM_{2.5}$ carbon in a manner that closely replicates the IMPROVE sampler described below. The project to deploy the URG 3000N Sequential Particulate Speciation System was completed in 2009. The only significant difference with an IMPROVE module C is that the URG 3000N is a single channel sampler that uses a mass flow controller to maintain a constant flow rate.

that comprise $PM_{2.5}$.[2] Flow rates vary by sampler. The dominant CSN sampler is the Metone SASS (SPIRAL AMBIENT SPECIATION SAMPLER). It samples at 6.7 Lpm on all channels. Table 1 provides a break-down of the basic operational characteristics of all the samplers known to be routinely deployed in the Chemical Speciation Network.

TABLE 1. SPECIATION NETWORK SAMPLERS AND OPERATIONAL CHARACTERISTICS

Sampler	Channels*	Filter media	Flow rates (Lpm)
Metone SASS	1 -- 5	Teflon®, Nylon, Quartz	6.7
Metone SuperSASS	1 – 4, 5 -- 8	Teflon®, Nylon, Quartz	6.7
URG 3000N†	1	Quartz	22.00

† The URG 3000N has replaced all Carbon Channels at Trends, NCore sites, and supplemental sites (if SLTs desire), except for a few historical Speciation Trends sites where a carbon channel is still run on the SASS/SuperSASS sampler coincident with the URG 3000N.

Several wet chemistry analyses coupled with chromatography and high and low energy spectroscopy are used to identify and quantify the constituent species. Table 2 provides a matrix of the filter media, analyses and analytes that are quantified.

[2] Currently 2 or 3 channels are used on the Metone SASS and SuperSASS and 1 on the URG 3000N. Metone is making firmware changes that will enable the SuperSASS to utilize any or all of its 8 channels simultaneously and independently. The URG 3000N can be used in a restricted sequential mode but is not capable of controlling multiple channels simultaneously.

[3] Auditors and persons interested in the QA documentation for the PM2.5 chemical speciation network should refer to several documents at <http://www.epa.gov/ttn/amtic/specgen.html>. The development of the DQOs for speciation was described in the "Data Quality Objectives (DQOs) for the proposed 53 Trends Sites of the 300 site PM2.5 Speciation 4

TABLE 2. $PM_{2.5}$ SPECIATION FILTER MEDIA, ANALYSES, AND RESULTANT ANALYTES

Filter Media	Analyses	Analytes
Teflon®	Gravimetric; XRF	$PM_{2.5}$ Mass; S, Si, Ca, Mn, Fe, Cu, Zn, Pb, Groupings of metals, etc.
Nylon	Ion Chromatography	$SO_4^{=}$, NO_3^{-}, NH_4^{+}, others
Quartz	Thermal/Optical Ref. Method	Elemental Carbon Organic Carbon

1.1.4 The IMPROVE Network

The IMPROVE network supports the Visibility and Regional Haze regulatory programs. IMPROVE Samplers were originally designed to help quantify visibility impairment in our Nation's Class 1 areas. When the Regional Haze rules were promulgated in 1999 the IMPROVE sampler was adopted as the monitor to measure the baseline year concentrations and subsequent trends of haze-forming aerosols in Class 1 areas. IMPROVE samplers measure essentially the same attributes of fine particulate as the Chemical Speciation Network samplers. It uses a flow rate of 22.7 Lpm; however it employs a smaller filter (25 mm). A standard IMPROVE station also incorporates a PM_{10} collection channel. The primary analytical protocols for total mass, trace metals and anions are very similar, but carbon quantification historically has been significantly different. The URG 3000N bridges the gap. It uses the sample filter media, sampler module and flow rate as the IMPROVE sampler. The only significant difference is that the URG uses a mass flow controller to assure the flow remains constant over the 24-hr. sampling period.

1.2 THE QUALITY SYSTEMS FOR THE $PM_{2.5}$ SPECIATION NETWORKS

Ambient $PM_{2.5}$ speciation data derived by the "chemical speciation network" is used to gauge the healthiness of the ambient air; whereas, the IMPROVE network produces data to quantify and measure trends in visibility impairment. Both sets of data are used to inform the STL agencies as they develop strategies and programs for improvement and maintenance ambient air quality. Consequently, high quality data from both networks is of premium importance. In general, the first goal of any quality system is to identify the factors that reduce or impede data quality, so that network managers can eliminate them or minimize their effect. Since we are measuring natural phenomenon using imperfect instruments with human effort, absolute accuracy is not an attribute easily determined in the ambient monitoring world. Consequently a second goal of the quality system is to determine the uncertainty of the data and publish it for the data analysts and political decision makers. The data quality system accomplishes this through a dynamic iterative process that generates

- a set of data quality objectives (DQOs),
- a set of measurement quality objectives (MQOs), and

- an assessment program which determines if the MQOs are being met so that the data that is generated or collected meets the desired DQOs.

Data quality objectives (DQOs) are a full set of performance constraints needed to design an environmental data operation (EDO), including a specification of the level of uncertainty that a decision maker (data user) is willing to accept in the data to which the decision will apply.

Once a DQO is established, quality control criteria are established for all activities, measurements and instrument performance parameters that have some influence over data quality and its uncertainty. This is to enable network managers to put best practices and procedures in place that ensure that the quality of the data is maintained at a level that meets the DQOs. These criteria are called Measurement Quality Objectives (MQOs). MQOs can be defined in terms of the following data quality indicators.

Precision - a measure of mutual agreement among individual measurements of the same property usually under prescribed similar conditions. This is the random component of error.

This is accomplished by collocating samplers of the same make and design together to collect samples simultaneously in the same immediate area. Precision is determined by comparing the quantitative results for a statistically acceptable number of sampling events.

Bias - the systematic or persistent distortion of a measurement process that causes error in one direction. Bias will be determined by estimating the positive and negative deviation from the true value as a percentage of the true value. If the true value is unknown a surrogate value may be chosen or derived from a value concluded to be closest to or most representative of the "true value."

Practically speaking bias is determined by collocating a given sampler with another sampler that is supposed to achieve a "near perfect" result or "the truth". For $PM_{2.5}$ monitoring it is acknowledged that the measurement is close to "the truth" but it is not an exact measure. Consequently, the best measure of bias is a comparison of a sampler's results to the average of results derived from multiple samplers collocated in the same immediate area and ostensibly measuring the same value during the same time frame.

Representativeness - a measure of the degree which data accurately and precisely represent a characteristic of a population, parameter variation at a sampling point, a process condition, or an environmental condition. For example natural variability that occurs with seasonal and meteorological changes. Also, the chemical composition of direct emissions and precursor emissions may change with demographic trends and the development or exodus of industrial sources.

Detectability- The determination of the low range critical value of a characteristic that a method specific procedure can reliably discern. It is the characteristic of a measurable entity (e.g., concentration or level of a chemical species) at which can it be quantified with confidence.

Completeness - a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct and normal conditions. The regulations are vague on a specific value for completeness for chemical speciation. Since speciation data are used in conjunction with FRM data for SIP development, similar expectations with respect to completeness would be appropriate for chemical speciation. The completeness requirement for the $PM_{2.5}$ FRM network is 75%. See 40 CFR Part 50 Appendix N.

For example if a State is sampling on a 1-in-3-day schedule, sites under perfect conditions would collect 121 sets of filters. Seventy-five percent completeness would mean that the State had collected at least 91 sets of valid data sets associated with the site of reference.

Comparability - a measure of confidence with which one data set can be compared to another.

With respect to monitoring, comparability means data produced by one type of sampler can be compared to the data from another type of sampler. (The concept also extends to networks that use fleets of samplers that collect or generate the same type of data). "Comparability" is based on the following:

1) Similarity of operating parameters of the samplers, e.g, flow rates, temperature controls, and particle size selection
2) Similarity of filter sizes and composition,
3) Similarity of analytical procedures used to derive the end data, and
4) The ability to determine bias(es) and uncertainties with enough confidence to make the appropriate adjustments to use the data in aggregate for models and statistical analyses of air quality.

For example, the filter-based sulfate data produced by IMPROVE and the CSN are believed to be comparable. But, considering how $PM_{2.5}$ carbon is formed, the differences in sampler flow rates, shipping procedures and the analytical methodologies do not provide as much confidence that the carbon measurements when compared will yield similar quantitative results in all circumstances.

These following sections are designed to provide a brief overview of the Quality System for each of the major networks. Because the chemical speciation and IMPROVE networks serve different regulatory programs, there are commonalities and differences in monitoring objectives, data quality objectives, measurement quality objectives, and therefore methods of operation. A field auditor should have a general understanding of the similarities and differences because they will influence the assessments of network characteristics such as siting criteria, filter handling and shipping, and acceptance criteria for sampler operating parameters, and record-keeping. In some cases, where an IMPROVE sampler is used as a chemical speciation network sampler, certain other quality assurance requirements are superimposed. Also the newly deployed URG 3000N carbon sampler nearly replicates the IMPROVE Sampler Module C, but it is a sampler in the CSN. Both URG 3000N and IMPROVE protocol samplers would follow the MQO requirements for the CSN.

For example, if you were to audit a site that has a complete IMPROVE sampler, collocated with a combination of a conventional speciation sampler and URG 3000N, the audit would go like this. The complete IMPROVE sampler would be subject to the MQOs and acceptance criteria established for the IMPROVE network and the Regional Haze program. The URG 3000N, even though it operates much like an IMPROVE sampler is included as part of the chemical speciation network site and would be evaluated against the performance parameters established specifically for that sampler. Its siting criteria and operational MQOs acceptance criteria would be derived from the Chemical Speciation Network and the NAAQS attainment and maintenance programs.

1.2.1 The Quality System for the Chemical Speciation Network.

The Chemical Speciation Quality System is patterned after the quality assurance requirements for $PM_{2.5}$ monitoring 40 CFR Part 50 Appendix L and Part 58 Appendices A-D, and numerous implementation and guidance documents subsequently published by the EPA.[3]

1.2.1.1 Data Quality Objectives for the $PM_{2.5}$ Speciation Network

In 1998, the EPA determined that the primary DQO for the $PM_{2.5}$ speciation network would be based on the detection of air quality trends. The DQO for ascertaining trends was defined by a workgroup of stakeholders for the program as follows:

"... to be able to detect a 3 to 5 percent annual trend in the concentrations of selected chemical species with 3 to 5 years of data on a site-by-site basis after adjusting for seasonality, with power of 0.80." (U.S. EPA, 1999a)

It should be noted that although the DQO statement says "3 to 5 percent" and "3 to 5 years," the default assumption by the speciation network managers has been the "detection of a **5 percent** trend after **5** years."

The DQO study also concluded that by sampling every 3rd day for 5 yr, trends greater than 5 percent (or less than -5 percent) per year can be detected for sulfate, calcium, and total carbon, on a single-site basis. For nitrate, however, the annual trend must exceed ±6.3 percent to be detected with a power of 80 percent. The decision-

[3] Auditors and persons interested in the QA documentation for the PM2.5 chemical speciation network should refer to several documents at <http://www.epa.gov/ttn/amtic/specgen.html>. The development of the DQOs for speciation was described in the "Data Quality Objectives (DQOs) for the proposed 53 Trends Sites of the 300 site PM2.5 Speciation Monitoring Network" and officially published in ""Particulate Matter (PM2.5) Speciation Guidance," Edition 1, October 7, 1999. Other QA requirements and practices are addressed in the "Redbook," the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II: Part 1; Ambient Air Quality Monitoring Program Quality System Development and Quality Assurance Guidance; Document 2.12 Monitoring PM in 2.5 Ambient Air Using Designated Reference or Class I Equivalent Methods. See <http://www.epa.gov/ttn/amtic/qabook.html> and <http://www.epa.gov/ttn/amtic/pmqainf.html >, respectively.

makers concluded that this was not sufficiently different from the 5 percent goal to require adjustment to the sampling design. Sampling daily instead of every 3rd day provides little improvement in the ability to detect trends; however, the model showed that cutting the sampling rate to every 6th day begins to impair the ability to detect concentrations trends within 5 yr. Speciation Trends sites and NCore sites, which are required to include chemical speciation, are therefore required to sample every 3rd day at a minimum.

It was mentioned earlier that chemical speciation also supports:

- Model evaluation, verification, and/or validation
- Emission inventory validation, and
- Source attribution

The desirable data quality characteristics for these secondary uses are probably not significantly different from those applicable to the trends assessment. They were not evaluated quantitatively by the workgroup; however, the DQOs that were established for the trends data were considered to be reasonably applicable for these secondary applications.

1.2.1.2. Measurement Quality Objectives

Table 3 is a list of the measurement quality objectives that were adopted for the speciation trends network (and therefore also expected of the supplemental chemical speciation and IMPROVE Protocol sites).

TABLE 3. MQOs AND ASSOCIATED QC ACTIVITIES FOR THE $PM_{2.5}$ CSN FIELD OPERATIONS[a]			
Measurement	**Current Frequency**	**Current Acceptance Criteria (MQO)[a]**	**Samples or Channels**
Collocation with another chemical speciation monitor at 7 of 54 sites	One-in-three days or one-in-six, EPA may specify location and duration	CV between instruments for major chemical species has been set at 10%	all sampling media
Temperature: Operator Check	Monthly	+/-2 degree C of a certified transfer standard	all temperature sensors
Pressure Operator Check	Monthly	+/-10 mmHg vs. certified transfer standard	Barometric pressure sensor
Flow Rate, single-point compare with Std. Operator check	Monthly	+/-5 percent* of working standard	all flow channels
Temperature Independent audit	semi-annual	+/-2 degree C of a certified transfer standard	all temperature sensors
Pressure Independent Audit	semi-annual	+/-10 mmHg vs. independent certified transfer standard	Barometric pressure sensor
Flow rate, Single-point compare with Std. Independent audit	semi-annual	+/-10% percent vs. independent transfer standard	all flow channels
Flow rate, Single-point Compare with design flow rate independent audit	semi-annual	+/-10% percent vs. sampler design flow rate	all flow channels
Trip Blanks	NA**	**	one per channel
Field blanks	Metone-- set every 33 sampling days (3%) URG 3000N—10% ***	SASS: 20 µg per filter (gravimetric); URG: 11 µg per filter (IMPROVE A Total Carbon analysis)	one per channel

[a] MQOs and DQOs stated here are found in the QAPP for the NCore and TRENDS CSN sites, found at http://www.epa.gov/ttn/amtic/specguid.html. The supplemental CSN site's are governed by the current QAPP "in force " within the host monitoring agency. MQOs and acceptance criteria are subject change and should be reviewed with the TSAs.

* The original STN QAPP specified ± 10% for monthly flow checks but data collected from the network from 2001 through 2005 indicates that 5% is easily obtainable and it also provides a better baseline from which calibration drift or other operating problems of the sampler may be detected. Note the independent audit acceptance criterion is still set at ±10%.

** Routine issuance of Trip blanks has been eliminated CSN operations. If the field- blank average exceeds the 95th percentile values, then Trip blanks should reinstituted to help pinpoint the source of contamination.

*** Collection of field blanks may also be increased if abnormal contamination is observed.

1.2.1.3 The Significance of Flow Rate

Flow rate is the most important parameter for determining the accuracy of $PM_{2.5}$ concentration measurements using a filter-based collection method. Speciation samplers utilize the physics of particles in motion to separate the undesirable larger particles in ambient air from the smaller particles that are of interest to scientists and regulators.

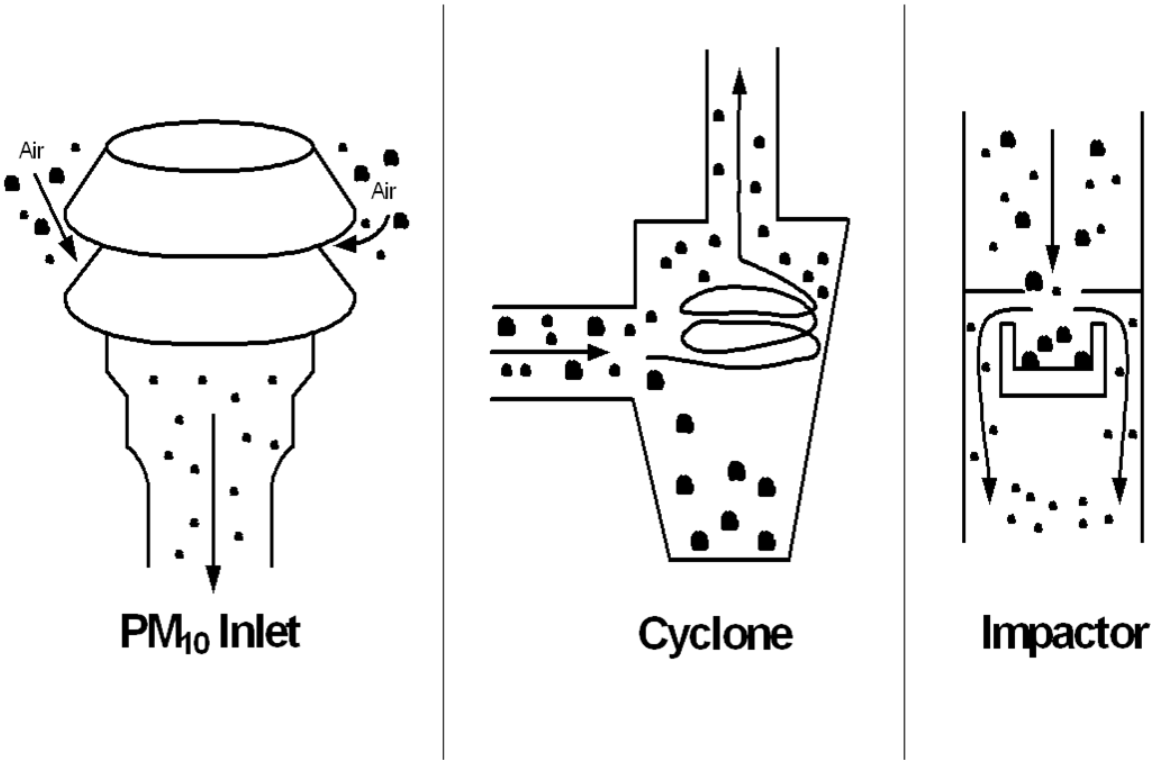


Figure 1. Separators in the most common $PM_{2.5}$ FRMs and Speciation Samplers; Courtesy of Edward Rickman, RTI International, 2006.

Figure 1 is a simplified cross-sectional sketch of the separators that are used in the most common $PM_{2.5}$ FRMs and speciation samplers. The first separation of particulate occurs as ambient air enters the sampler inlet, which allows particles with an aerodynamic diameter of 10 microns or less to enter the sample train. Air is then directed to a subsequent separator that further separates the particles that have a larger diameter than 2.5 microns. Particles that are 2.5 microns and below are the size range that the speciation sampler attempts to collect for quantification. Each sampler has been designed to collect a quantitative percentage of $PM_{2.5}$ in air that is drawn through a particulate separator at a specific flow rate (which actually translates into a velocity inside the separator of a specified design cross-sectional area). The critical flow rate is called the “cut point.”

The ability of a sampler to maintain the flow rate, for which the $PM_{2.5}$ cut-point was designed, is one of the most important attributes to control. Manufacturers have over-designed their air pumps to compensate for fluctuating ambient conditions, and electriCal and mechanical phenomena that affect pump effectiveness and efficiencies.

Consequently, sampler flow rates have to be regulated or controlled to the design value that achieves the desired cut point. Two types of devices have been invented to control flow. One is a critical orifice that is installed in the sample line; the other is mass/volumetric flow controllers. Mass/volumetric flow controllers are dependent on temperature and pressure sensors in the air stream. Mass/volumetric flow controllers are the principle device used in the CSN. It is therefore necessary to perform calibration of the mass/volume flow, temperature and pressure readings to assure that desired cut point for $PM_{2.5}$ is achieved and maintained. The calibration can be affected by degradation of the sensors and pumps with extended use or more traumatic events like power surges or extreme weather conditions. The IMPROVE network uses a critical orifice which may also be deleteriously affected (most often) by deteriorating pump capacity. Heavy deposition can also decrease flow but this is rare in the IMPROVE network, the exceptions being smoke from fires or dust storms.

The stability of calibration and ability to maintain the design flow rate are two of the most critical measurement quality objectives for all chemical speciation samplers. Periodic servicing of these samplers helps prevent deterioration in performance!

1.2.2 The IMPROVE Quality System

The IMPROVE quality system is documented in a series of documents including a Quality Management Plan (QMP), a QAPP, and SOPs, that can be accessed at http://vista.cira.colostate.edu/improve/Publications/publications.htm. It is a federally run monitoring network that is overseen by an Interagency Steering Committee. This steering committee approves all substantive changes to the hardware, software, operating procedures including quality control and data validation. The Quality system is administered primarily through the support contractors and partners-UC Davis, Colorado State University. A strong oversight role as well as final data validation is provided by the National Park Service. The analytical service laboratories operate under their respective QMPs, QAPPs and SOPs in addition to the IMPROVE program requirements.

(1) The history of flow rates for each sampler is examined at least once a month to monitor for changes in performance. This is accomplished by reviewing sampling results and data stored on a portable data storage device that is shipped back with routine filter samples every three weeks. Data is downloaded by the service lab, reviewed and stored in a data base, and the data card is returned with a subsequent shipment of filters to the monitoring site. This process occurs for all IMPROVE and IMPROVE protocol sites.

(2) The comparison of measurements of certain related species by different modules is performed once a quarter to verify that the flow rates of various modules agree. The most precise test is the comparison of sulfur from Module A with sulfate from Module B. A less precise comparison is by comparing organic matter by hydrogen-carbon bond analysis from Module A with the organic carbon analysis provided by Module C. A rough comparison may be made between $PM_{2.5}$ mass from Module A and PM_{10} mass from Module D.

(3) The IMPROVE QAPP specifies that "field flow calibrations are conducted at least every six months, and when there is a potential problem with flow measurements. An IMPROVE field technician performs a field calibration annually during annual maintenance." *IMPROVE does not adhere to this provision of their QAPP*. Historically a field team has performed only one routine annual calibration. The frequency of these service trips was cut in half due to budget shortfalls in 2013. The service laboratory performs data analyses to verify that flow rates meet acceptance criteria. If the service laboratory detects an aberration in the flow parameters the problem, they send out a mailable audit device. The site operator performs a flow verification and if it is out of specification he or she performs a field calibration.

The calibration device is an orifice meter that measures the pressure drop across the orifice. All calibrations consist of comparison of the system transducer readings with the flow rates of the calibration device at four different flow rates covering the normal range encountered. If the correlation between the calibration and system flow rates has an R^2 value less than 0.99, then the calibration is repeated. If the nominal flow rate (flow rate with a normal clean filter) is **not** within 5% of the desired nominal values, the site operator may be asked to adjust the nominal flow rate and perform a new calibration. If the calibration results are not within 5% of the previous calibration results, the past data are reviewed to determine when the change occurred. This is determined by examining the comparisons between similar concentrations measured by separate modules (sulfur sulfate, organic mass by hydrogen and carbon). The new calibration is applied to all samples collected after that change. If no change date can be identified, the samples collected between the two calibrations will be flagged as QD (questionable data).

Sampler airflow accuracy is maintained by referencing all field calibration devices to a DryCal Nexus DC-2 Flow Calibrator that is certified NIST traceable. The results are verified using a dry gas meter. The field maintenance manager maintains a set of calibration orifice meters for routine service and incidental calibrations. All calibration devices are calibrated at UC-Davis using the same reference flow calibrator. The calibration of each calibration device is verified before and after each time the calibration device is used.

1.2.3 Quality Assessments of the Monitoring Networks

There are many ways to assess the quality of a monitoring network. This course focuses on one way commonly referred to as an audit. The audits described in this course consist of two parts. One is a technical systems audit (TSA) that involves interviewing personnel and reviewing record keeping, quality control procedures, and site conditions. The second part involves comparing sampling and analytical equipment performance with independent NIST traceable reference standards used by an independent technician or scientist—the auditor.

1.2.3.1 Assessment of Monitoring Agencies' Quality Programs

For the purposes of this course the field auditor should be familiar with the concept of a QAPP (Quality Assurance Project Plan). Every monitoring organization is responsible to develop and have an approved QAPP before the network begins

producing data that will be used in environmental decision-making. What is a QAPP? The QAPP is a document that the monitoring agency develops to provide a plan of how a monitoring program will acquire environmental data, optimize the quality of the data and assess the resulting quality of the data for the purpose of decision-making. The QAPP provides an overview of the project, describes the need for the measurements, and defines QA/QC activities to be applied to the project that will ensure the data quality is of the level needed for its stated purpose. The QAPP should be detailed enough to provide a clear description of every aspect of the project and include information for every member of the staff and data reviewers. The QAPP facilitates communication among clients, data users, project staff, management, and external reviewers. This is one of the most critical documents in an SLT's chemical speciation monitoring program. The auditor should ensure that a QAPP exists for the program that is sponsoring the site and sampler(s) being audited. If it does not, he or she should report this through a supervisor to the monitoring program manager and to the EPA Regional Contact for chemical speciation. Beyond the existence of the QAPP, the EPA Regional Office under whose oversight the monitoring agency operates, will conduct periodic reviews of SLT monitoring programs about every 3 years.

1.2.3.2 Assessments of Field Operations

Because of the numerous people, organizations and procedural steps involved, the field operations of the CSN have the largest potential for introducing variability and uncertainty in the resulting data. It is therefore necessary that a field auditing program be conducted to assess the level of proficiency with which the SLT agencies are managing these network influences, i.e., meeting the measurement quality objectives devised for $PM_{2.5}$ speciation monitoring. These assessments are called-for in the national $PM_{2.5}$ Chemical Speciation Network Model QAPP and in EPA's guidance on quality assurance. See http://www.epa.gov/ttn/amtic/specguid.html.

Based on the implementing regulations at 40 CFR Part 58 and the QAPP, there are three required levels of field operation assessments:

1. The site operators should be conducting monthly check-ups on their samplers with respect to clock, flow, temperature and pressure. The EPA has developed a utility to report the results to service contract laboratory. The contract laboratory will compile it into a database from which reports can be extracted. Flow rate check data may be voluntarily reported to AQS.

2. State, Local, and Tribal agencies that perform speciation monitoring must conduct annual, independent, full technical systems audits of all CSN sites. These audits usually focus on field-related activities plus data validation. (In the future, if continuous speciation sampling methods evolve and become more widely used, they will also be challenged by independent blind samples developed by EPA). Semi-annual audits of the samplers are required, but more frequent audits are recommended of newly deployed sites or samplers.

3. TSAs of the STL CSN programs should be conducted in concert with the MSRs that occur every three years. A full audit of at least one CSN site should be part of this assessment.

Note that Number 3 is a target that is difficult to reach given the current level of funding available to EPA for QA of the speciation network. Therefore EPA is attempting to create an auditing program that utilizes uniform auditing procedures, electronic field worksheets and reporting formats (for Number 2 above). EPA is encouraging SLT agencies to have all their auditors attend the Federal Auditors Certification course. This training and certification is required if SLT auditors desire to audit IMPROVE and IMPROVE protocol sites.

This course focuses on an assessment of the entire CSN field sampling operation, which in layman's terms, includes answering following questions:

(1) Is the site safe to audit?
(2) Is the sampler sited correctly?
(3) Is the sampler performing at its optimum operating design with respect to the parameters that affect the quantity of the species to be identified?
(4) Do network personnel operate the samplers proficiently and handle filters with due care and responsibility.
(5) Do personnel fill out data sheets and chain of custody forms properly?
(6) Do operators properly document unusual influencing environmental factors in a logbook and on field data forms?
(7) Are filter samples packaged properly for shipping to the contract service lab and do personnel understand the significance of shipping at prescribed temperatures and on the prescribed shipping schedule?
(8) Do the site operators know how to identify filter modules that may have been damaged during shipping and handling?
(9) Is adequate maintenance being performed on the monitoring site and the speciation sampler?
(10) Are audits conducted on the proper schedule and are adverse findings resolved expeditiously.

These activities and the criteria by which they may be evaluated are laid out in the TSA forms (in some detail) and in the sampler performance audit worksheets, which are covered in detail in the auditor training class. These tools are provided in total to all auditor training course alumni on a CD and are available to all CSN operators and auditors on the Air QA Website currently maintained by RTI International. See http://airqa.rti.org. IMPROVE audit worksheets and report forms are available only to graduates of the IMPROVE Auditor Certification Training Module.

1.2.3.3 Assessment of Laboratory Activities

While this course will focus on field operations, the auditor should be familiar with the servicing laboratories' procedures and analyses to appreciate how procedural or instrument errors in either place may adversely affect data quality. Several laboratories serve the speciation monitoring networks. These laboratories provide the following:

- Filter preparation,
- Initial records set-up and initiation of the chain of custody form,
- Shipment of filters to the field operators for exposure,
- Receipt of filters and field data sheets from the field,
- Coordination of all the requisite analyses
- Level 0 and 1 data validation, and,
- Posting of the resulting data into the appropriate data base.

Detailed SOPs and QAPPs are available for each laboratory. Each laboratory uses an elaborate and thorough QA/QC program to ensure that data quality is not compromised by their activities and procedures.

EPA has implemented a separate QA program for the analytical laboratories that serve the CSN. EPA's Office of Radiation and Indoor Air, National Analytical Radiation Environmental Laboratory (NAREL) Montgomery, Alabama, currently conducts this QA program. NAREL has developed a program that provides:

1. Performance evaluations using single-blind and double-blind samples for gravimetric analyses and XRF.
2. Prepared solution standards for challenging the speciation ion and carbon analyses, and
3. On-site technical systems audits of the speciation network analytical support laboratories on a bi-annual schedule.

2.0 GENERAL PROCEDURES FOR CONDUCTING AN AUDIT

A successful audit cannot be achieved without planning, preparation, implementation, and follow-up. Accurate and timely communication transcends the entire process. These elements will be addressed in some detail below.

The five Ps:
Planning & Preparation
Prevent
Poor
Performance
And

If We Fail to Plan, We ……

Enough Said!!!!

2.1 PLANNING YOUR ANNUAL AUDIT AGENDA

The auditor's objectives in terms of the number and type of monitoring sites to be audited should be thought out well in advance of the upcoming year's audit activities. There are a number of factors to consider in formulating a list of sites and a corresponding schedule to audit them. The rules governing audits of SLT sites are different depending on the agency that the auditor represents. For example EPA auditors or contractors performing audits for EPA will not have the same physical access to the site, or the ability to show-up unannounced. Some state auditors have autonomy and can show-up unannounced. A few additional factors are listed below, but the list is probably not exhaustive.

- For SLT auditors, the number or percentage of sites to be audited may be dictated by their Agency's speciation monitoring program QAPP or Quality Management Plan, or agency policy
- The SLT agency may have an interest in auditing an IMPROVE site that has some relation to the SLT's ambient monitoring data or visibility program. (This will require proficiency certification through this course and the follow-on recertifications.
- Climatic conditions during certain seasons may threaten the schedule and the auditor, especially at remote sites.
- Sites that have experienced performance issues--either equipment or attending staff-- may need more frequent visits
- Network Sampling Schedules—EPA does not endorse auditing on a day the CSN sampler is collecting routine samples.

IMPROVE sites always conduct weekly exposed filter cartridge recovery and new cartridge installation on Tuesdays. Every third week a run day occurs on a Tuesday. IMPROVE sites may be audited on these days, but the procedure is slightly different from and audit on a non sampling day

- Federal Auditors and Contract auditors must have a monitoring program representative on hand to provide access to the sampler, to run the sampler and to make any mechanical adjustments and/or calibrations,
- Policies on who can service samplers, if serious issues are identified, vary by agency. Some agencies have routine sampling operators that perform duties of operation, calibration, and auditing, while other agencies have the roles clearly and independently separated.
- Funding for travel seems to be getting tighter and tighter. It is not good to waste a trip due to poor planning, scheduling or communication! If a site or sampler "fails" an audit, immediate remediation, if possible, is a real time and money saver. Some site operators do not have this authority which dictates a second trip or some type of follow-up.
- Personal schedules-- multiple trips or repeat audits take up lots of time. Extended overnight trips can greatly influence family time. Vacations are most often taken during prime auditing seasons.
- The auditor may have the opportunity or mandate to audit other monitoring equipment while at speciation sites. This will be especially true for NCore sites.

Prior to the beginning of the year, the auditor should:

- **Develop an Annual Audit Plan or a tentative plan for the upcoming year**.
- Submit the list of sites and proposed dates (day or month) to each SLT agency (a SLT auditor will comply with his/her program's notification policies).
- Federal contract auditors will coordinate their annual audit plan with the EPA Region in which the target sampling sites are located.
- Auditors of the IMPROVE and IMPROVE Protocol network, should send the annual audit plan to Mr. Chuck Mc Dade at UC-Davis, also by January 31. mcdade@crocker.ucdavis.edu.

Be sure to confirm receipt of your annual audit plan by each SLT monitoring agency or IMPROVE-UC Davis prior to scheduling your annual audits.

2.2 STEPS FOR SCHEDULING AN AUDIT

2.2.1 Find Initial Site Information

Most SLT agencies keep a database of sorts on their websites. It should contain the following site information at a minimum:

- Street address
- Types of monitoring in addition to $PM_{2.5}$ speciation that is performed there,
- Classification of the site—urban, community or rural,
- Near-by pollution sources,
- Human activities in the area such as a school or shopping center,
- Safety issues such as unfriendly neighborhood, unleashed dogs or other vermin, platform in disrepair;
- Local medical treatment facilities,
- Cell phone reception or telephone access
- Past audit reports including both resolved and unresolved adverse findings,
- Photographs and sketches or drawings.

The new audit TSA forms and sampler worksheets were designed to record much of this information for digital storage and easier updating. In fact they can be expanded to contain anything an agency might deem important and stored locally for repeated use. The initial site information can be obtained by two methods depending on the network (CSN or IMPROVE).

2.2.2 Contact the site operator or manager

a. For Chemical Speciation (CSN) sites:

This information is located on the course CD distributed during the Chemical Speciation Auditor's Training Course, or on the website. If you are unable to reach the site operator or site manager, contact one of the three Delivery Order Project Officers

(DOPOs) given in Table 4 below. The three DOPOs have been assigned to handle site contact information based on their geographical locations (by US EPA Regional Offices). When talking to the DOPOs, obtain the site operator and field operator manager information (Name, phone number, direction to site).

TABLE 4. DOPO INFORMATION FOR THE CHEMICAL SPECIATION NETWORK

Geographical Region	US EPA Regional Office	DOPO Contact Information
Eastern	1,2, 3, and 4	Ms Loretta Hyden USEPA REGION 3 1650 Arch Street Mail Code: 3AP40 Philadelphia, PA 19103-2029 Phone: 215-814-2113 Email: hyden.loretta@epa.gov
Central	5, 6, and 7	Patricia Schraufnagel USEPA REGION 5 77 West Jackson Boulevard ***Mail Code:*** AT-18J Chicago, IL 60604-3507 Phone: 312-886-5955 E-mail: Schraufnagel.Patricia@epamail.epa.gov
Western	8, 9, and 10	Joseph Delwiche, Joshua Rickard USEPA REGION 8 999 18th Street Suite 300 ***Mail Code:*** 8P-AR Denver, CO 80202-2466 Phone: 303-312-6448 E-mail: delwiche.joseph@epa.gov; rickard.joshua@epa.gov

b. Contacting the IMPROVE Network

For tentative scheduling purposes you might be able to contact the site operator directly by calling the central office of the National Park, Wildlife Refuge, or Class I Wilderness area associated with the IMPROVE site of interest. You can usually get the office number from the particular sponsoring agency's unit website. They will usually be able to put you in contact with the operator, **but not always**. Contact IMPROVE Protocol sites as you would any State operated site. However, you will still need to get specific site information for completing the audit from UC Davis.

UC Davis is the primary resource for IMPROVE contact information. In addition to basic site contact information (operator and manager's name, phone number, direction to site) UC Davis will supply a spread sheet with information similar to the following example. It will provide the site Elevation factor and magnehelic and vacuum

coefficients for the “Site Information Section” on the IMPROVE Audit Worksheet”. **(Do**

MODULE	TYPE	ELEV (f)	CALIB DATE	MAG COEFFICIENTS A	MAG COEFFICIENTS B	NOM (mV)	VAC COEFFICIENTS C	VAC COEFFICIENTS D	NOM (mV)
A	PM2.5 T	1.012	6/14/2005	0.516	0.709	15.3	31.079	-0.650	12.8
B	PM2.5 N	1.012	6/14/2005	0.457	0.768	14.8	34.147	-0.711	16.1
C	PM2.5 Q	1.012	6/14/2005	0.472	0.731	16.2	33.695	-0.704	15.6
D	PM10 T	1.012	6/14/2005				22.996	-0.503	12.5
X (A-B-C)									
X (D)									

not alter these worksheets when you receive them!!!!)

You will also need to know the last annual field maintenance visit. (This date should be on a decal on the inside cover of the control module; if not, UC Davis should be contacted to verify the date, and it should be reported in the audit findings). It may take several days for UC Davis to pull the coefficients and elevation data. This is why advanced notice is so critical. **It is recommended that UC Davis be informed approximately 60 days prior to your proposed audit date**. It is good to have some alternate dates on the list as well.

Important Note: You will be asked to provide information that indicates you have attended a recent certification course or recent recertification course. This certification is the only means by which UC Davis is sure that you have critical information about recent changes to their network and site operations that if ignored, could jeopardize the integrity of routine samples.

The primary contact at UC Davis is:

Mr. Chuck McDade
Crocker Nuclear Laboratory
University of California, Davis
One Shields Avenue
Davis, CA

Phone: 530-752-7119
E-mail: mcdade@crocker.ucdavis.edu

2.2.4 Contact IMPROVE site operator and set audit date(s)

a) Initiate communication with site operator at least 30 days prior to visit.

   i) Discuss the site location, the best place to stay in area, schedule time for conducting audit and where to meet, and if there are any current problems with sampler.
   ii) Based on the network (Chemical Speciation or IMPROVE), send the site operator, by mail or e-mail, a list of items/documents (see Table 5) that you will be discussing with them during the site audit. Ask the site operator if he/she could have these items accessible for the audit.

iii) Always set a "rain" date especially for IMPROVE sites
iv) Make sure someone will be at the site when you arrive,

If you are auditing your own agency's site(s) you probably have a policy that supersedes the instructions given here. It will set your level of access and the accompaniment requirements for that site.

b) Two weeks prior to the visit, contact the site operator and verify arrangements.

c) One week prior to event, confirm the audit visit with site operator. With IMPROVE sites, pay attention to natural events. For example, a wildfire in a National Forest may detain the site operator for several days.

A phone call may save the cost of an airline ticket; a day's lodging and per diem. New airline ticket policies complicate planning. You might consider buying "cancellation" or "schedule change" insurance.

TABLE 5. LIST OF ITEMS THE SITE OPERATOR SHOULD HAVE AVAILABLE FOR AN AUDIT

For Chemical Speciation (STN) sites:

1. Current Quality Assurance Project Plan (QAPP) being used
2. Standard Operating Procedures (SOPs) being used
3. Record of completing any Chemical Speciation Field Operation Training
4. Current site sketch
5. Written waiver(s) for siting violation issues
6. List of nearby sources that may contribute to ambient particulate measured at this site
7. Site logbook (must have present during the audit)
8. Past field data forms
9. Current Chain-of-custody forms
10. Last date that Measurement Quality Objectives (MQOs) were checked against acceptance criteria (all should be documented in logbook)
    a. **Monthly checks** (clock checks, leak checks, flow rate checks, filter temperature and ambient temperature checks, barometric pressure checks, and inspect cyclones)
    b. **Quarterly or Semi-annual checks** (denuder swap out, clock checks, leak checks, flow rate audits, and filter temperature and ambient temperature audits, barometric pressure audits, and clean cyclones)
    c. **Semiannual checks** (clean inside of housing and clean air screens)
    d. **Annual checks** (flow rate calibration device, temperature calibration device, and pressure calibration device, flow rate audit device, temperature audit device, and barometric pressure audit device)
11. Field and trip blank data for the past 6 months, should be available from

For IMPROVE sites:

1. Last date the UC Davis field service technician visited
2. Current Standard Operating Procedures (SOPs) being used
3. Date of formal training to operate IMPROVE site These are rare.
4. Date of last mailable flow audit and the reason it was necessary; these are rare.
5. Current sketch of site
6. Written waiver for siting violation issues
7. List of nearby sources that may contribute to ambient particulate measured at this site
8. Site logbooks are recommended by EPA, but the IMPROVE QAPP does not require them. (IMPROVE Protocol sites should have one, since they are part of the SLT supplemental networks). If kept, operator should have the logbook present at the audit
9. Past field data forms (if copies were made before shipping to UC Davis)
10. Location of Handling facility for shipping boxes (visit is likely during a TSA)

2.3 PREPARATION FOR AN AUDIT

Three sets of activity are essential to "prepare" for a successful audit. The first is collection of personal, mechanical, digital and paper items needed to safely and efficiently conduct audit. The second is to practice using the equipment and digital tools needed during the audit to minimize mistakes and time taken at the site. The third is to make the appropriate travel arrangements.

2.3.1 The Checklist

A Checklist is standard operating equipment and one of the "paper" items on the Checklist!

Just a word on the "physical" aspect of "personal" preparations--Auditing can be physically demanding. Stairs (and mountainsides for IMPROVE), and high heat and humidity are common companions. Please get a physical periodically and obey doctors' instructions regarding personal health. If you have conditions that warrant concern, make sure your supervisor, manager, and site operators know of them. More will be said in a following section on safety.

Table 6 is list that EPA prepared based on the experience of several auditors. You are encouraged to take this list and modify to fit you own needs and auditing program. But by all means, make and use a ***checklist!!***

TABLE 6. MODEL CHECK LIST TO PREPARE FOR A SPECIATION AUDIT

Packed	Item	Comments
***Personal care and safety*:**		
	Identification and medical alert tags	
	Seasonal clothing with jacket and appropriate contingencies based on site location	

	Extra change of clothes	
	Sunglasses	
	Head covering as appropriate	
	Rain coat, umbrella	
	Medications if prescribed with directions	
	Over-the-counter drugs for minor ailments	
	Special climate and location items, e.g. high-top boots, snow shoes, gloves	
	bug repellant	
	Wasp spray	
	Suntan lotion	
	Water and snacks for personal needs (safety)	
	Hand towel for perspiration	
	Toilet paper, hand cleaner and other hygiene articles	
***Equipment*:**		
	Tarp or large umbrella	
	Cord and stakes for Tarp	
	Metone audit filter modules (Teflon #1, nylon #2, and quartz #3) and three sharp-cut cyclones	
	Audit Cartridge for URG 3000N	
	NIST-traceable Standard(s); e.g. TriCal, TetraCal, etc.	
	Primary	
	and a Back-up	
	Other certified NIST Traceable standards are acceptable but must accommodate the operating parameter range for flow, temperature and pressure of the sampler	
	URG 3000 flow adapter, inline shutoff valve (if needed) , and reducer--borrowed from site operator or acquired separately	
	IMPROVE adapters (must be purchased separately)	
	Tubing	
	Batteries: An extra set for every day in the field	
	Cardinal Direction signs for taking pictures	
	Metric tape measure or laser measuring device	
	Small torpedo and annular bubble level	
	Compass	
	Inclinometer or protractor	
	GPS unit and directional chart or map of the immediate area	
	Cell phone or Atomic watch	
	Tool kit (basic tools, Allen wrenches (5/32”), strap wrench,	
	First aid and basic survival kit	
	Hand-held hot air gun or hair dryer	
	Snow chains if appropriate	
	Shovel	
	Broom	
	Stool or small step ladder if you are under 5’10”, or otherwise height challenged	
	Towel or shop cloth for wiping equipment	

	Small portable table to rest laptop and clipboard	
	A backpack for transporting essential equipment to hike-in sites	
Digital and paper supplies		
	Laptop computer with backup file storage (floppy disk/flash stick)	
	Extra battery for Laptop fully charged or maybe an inverter for a vehicle 12-volt outlet	
	Training course CD	
	TSA and sampler audit worksheet files loaded on computer hard drive and storage device	
	Multiple paper copies of TSA and sampler audit worksheets	
	Copies of SOPs or operating manuals for each type of sampler to be audited	
	Clipboard and pad for sketching and notes	
	A **good** road map of the state or region	
	Your completed Checklist!!	

2.3.2 Practice and Training

The goal is to conduct an accurate audit every time we visit a site.

That is what this course is all about. But the fact is that you will not learn it all in "one-sitting." That is why we conduct recertifications and updates. But even then, practice the procedures a couple of times!! Conduct an audit or two within a couple of weeks after training.

Don't be ashamed to ask someone how to operate some of the monitoring equipment and audit instruments if you are inexperienced or just forgot how! Don't be afraid to call EPA or another colleague even in another agency. If we do the training correctly we should all be using the same procedures. Then share your experiences with the auditing community; it will help the training get better!

2.3.3 Make Realistic Travel Arrangements

Set up audit dates that are realistic. Make the contacts with the program contact or site operator on time. Give yourself adequate time to get to the site a half-hour ahead of the scheduled time, even if you are familiar with the site and area. Plan for more lead-time if it is the first time you are visiting a site. Take into consideration special access issues such as monitoring sites that are located on locked buildings, which might require additional escorts. Some IMPROVE sites may literally require a hike with equipment in a back pack. Allow yourself time to get there without creating a medical emergency!

2.4 Conducting an Audit

2.4.1 Arrival at the site

As indicated above, arrive a few minutes ahead of schedule. It helps in addressing exigencies and it shows you respect the operator's time and value your own.

2.4.2 Safety first!!

The first item of business is to make sure the site is safe for an audit. Any number of issues can threaten the safety of you and others attending the audit. The following is a list of situations encountered and reported by auditors like you. See if you can recognize the safety issue in each situation.

- As you drive up to a speciation site, a severe thunderstorm is underway with numerous lightning strikes in the area
- The sampling platform is on top of a structure with a metal ladder on the side of the structure to reach the top of the platform. The first rung breaks off and you notice the next one is loose
- During an audit of a speciation sampler on a roof-top, and as you place your hand on the guard rail, the railing falls over
- A monitor on top of a roof is powered through an extension cord with the connecting socket and plug resting in a pool of water
- A brood of wasps have built a nest under a step on the stairs leading up to the sampling platform.
- In a fairly remote location, as you are setting up a small tray table to provide shade for the audit equipment, you hear the distinctive sound like beads in a small bottle
- 50 yards of tall grass separates the monitoring site from the parking spot for your van. It is late spring.
- You have to audit an IMPROVE site in northern Maine in May.
- You are at Tonto National Monument in Arizona in July, a Metone sampler has failed an audit and the operator has asked you to help recalibrate it. The temperature **is 45^{o} C.**
- You are planning to audit an IMPROVE sampler at Brigantine National Wildlife Refuge in New Jersey in August. It is in a savannah area infested with green-head flies and ticks.
- You're supposed to audit the site at Lake Tahoe in November; a freak blizzard hits the night you arrive. You have 4-wheel drive.
- An IMPROVE sampler is mounted on the side of a tall shed. Access is provided by a sampling platform from which two 18" strips of OSB are bridged to a cat-walk on the shed. There are no guard rails between the sampling platform and the shed. The local population is about 20 in the winter.
- You drive up to a site in Boston at 3:00 in the afternoon in late October, and see broken wine and whiskey bottles, beer cans and remnants of drug paraphernalia. The site speciation operator has left but an ozone monitor operator is just finishing up a daily zero and span check.

Please share your experiences with the auditing community.

2.4.3 "Ladies and gentlemen, start your engines;" and…. Equilibrate the Reference Standards!

The first on-site, audit-directed activity should be to switch on any digital flow rate reference standard, and temperature and barometric pressure standard, and place them in ambient air but not in direct sunlight, for a period specified in the manufacturer's start up instructions. All standards require some equilibration period. The BGI triCal (the older predecessor model of the tetraCal) will take up to an hour. There is plenty to do while the standard(s) equilibrate: conducting the TSA and making site sketches, taking photographs, etc. These will be covered in the following sections. Make sure all of the standards and instruments that you will need for the audit are accessible and organized for efficient use. Become familiar with each device's idiosyncrasies. ***Bring extra batteries!***

The BGI triCal: EPA is not allowed to endorse any particular commercial product over other products that can accomplish the same goal or service. The Federal auditors use the BGI triCal or the newer generation tetraCal, because it contains a flow, temperature and barometric reference standard in a single box that is the size of a small shoe box. As of this edition of this manual, it is the only NIST traceable, integrated set of reference standards in this configuration. There are a few important characteristics of the triCal that should be accommodated. The triCal calibrates itself upon switching "on" using the first temperature it reads from its internal temperature probe. If difference between the pre-equilibration storage temperature and ambient is ~20^{o}C or greater, the initial calibration is biased by a disparate ambient temperature reading. Conversely, the internal probe can also present a problem if the triCal is left in the sun, because the box acts like a solar collector and the thermal mass keeps the ambient probe at an elevated temperature for an extended period. The problem is resolved by turning on the triCal, allowing it to equilibrate for an hour in a shielded location, then switching it off and back-on. This allows the triCal to recalibrate at the correct ambient temperature read by the internal sensor. BGI has addressed this issue in its new generation tetraCal®, by placing the ambient temperature probe in a small gill screen solar shield that extends from the box. Usually equilibration occurs within 30 minutes. A good check is that the external "filter" probe temperature should be within 2 ^{o}C of the ambient sensor. Also, errant flow rate readings have be encountered when the battery capacity in the triCal is at 80%. Make sure the battery strength is at 90% of maximum voltage, especially in cold weather. If not, replace them.

The cost of an unsuccessful audit is clearly much more than the cost of a set of batteries! This might be a hint!

2.4.4 The Technical Systems Audit (TSA)

Provided with this course are Excel files that contain a TSA form and sampler audit worksheet for both the CSN and IMPROVE networks. The TSA form is a series of questions regarding the operation of the monitoring site and the SLT's monitoring QA procedures. It includes the following:

- Site contact information and the Monitoring agency's organizational structure and responsibilities
- Documentation of operational procedures and the monitoring program's QAPP
- Qualifications of personnel operating the monitors and training experience
- Safety issues at the site
- Sample handling, temporary storage and shipping procedures—these are observed during the audit
- Records kept regarding activities at the site, air pollution episodes or unique situations that might affect the data, performance verifications, audit history and maintenance records
- A section to evaluate whether the monitoring site complies with site location and configuration criteria surrogated from the $PM_{2.5}$ criteria in 40 CFR Part 50 Appendix L and Part 58 Appendices A, C, D, and E.

It is recommended that the auditor review these references in order to draw conclusions about evolving characteristics of the monitoring site. For example a community scale site over time may be surrounded by urban activities such as shopping malls, office parks and light industry. Or massive roadways may have been constructed outside the fence line of the monitoring compound.

The TSA form for each network is self explanatory, but each one will be discussed in detail during the initial, full-length auditor certification course and reviewed for updates during recertifications. As mentioned above, most of this form can be completed during the reference standard equilibration. The appropriate TSA form should be completed for each site that is audited and saved as a digital file and in hard copy.

A Excel template of the CSN TSA form and the sampler audit forms may be downloaded from http://airqa.rti.org whenever they are needed. The directions for accessing the website, registering, downloading the templates and posting the completed templates as audit reports is included in Appendix A to this handbook. Should this website cease operation or change the excel templates will be posted on AMTIC under $PM_{2.5}$ Chemically Speciation; Quality Assurance. *Retaining the digital file provides a form that can be expeditiously up-dated during future audits. If nothing changes the TSA stands!* IMPROVE audit forms may be acquired from the OAQPS IMPROVE QA lead.

The digital files become the draft and final reports that are submitted to the monitoring agencies and EPA, (and the draft if an IMPROVE site) accessThis data will

be stored on http://airqa.rti.org website for access by only auditors, monitoring program managers, and EPA data analysts and SLT analysts for their respective data.

2.4.5 The Sampler Performance Audit and Evaluation of Sample Handling and Shipping

The core of the field audit is challenging the sampler's calibration, its actual, operating flow rate and its ability to accurately detect and record ambient barometric pressure, and the ambient and filter temperatures. This is not intended to be a "gotcha" exercise. The sampler audit is intended to provide useful information about how the sampler is operating at that particular time. The audit of the flow rate is the primary measurement of the surrogate value for accuracy, which will be reported to AQS. If conducted properly and consistently over a period of time, it along with monthly flow checks, indicates sampler stability and reliability.

A detailed SOP and a video module for auditing each of the prominent samplers in the CSN and the IMRPOVE networks have been developed and provided as part of the training course material and the CSN materials are posted on AMTIC. Quick Reference Auditing Guides for each of the major speciation samplers have also been prepared and included with the training material. These guides are reviewed and used in the certification and recertification courses. Below are a few points to keep in mind as you conduct the audit of the sampler and the sample handling, storage and shipping procedures.

- Fill out as much as possible of the TSA form and audit worksheet in digital form prior to the audit. As audits at this site are repeated, this information should take only a few minutes to update
- If the audit is at an IMPROVE site make sure the imported spreadsheet with calibration coefficients provided by UC Davis is the one for this site. Otherwise you will not get immediate results.
- Most auditors find that it is actually easier to take a paper copy of the audit worksheet to the site and fill in the data that is taken from the samplers and reference standards. It is particularly useful to have a written version to fall back on if the subsequent spreadsheet results look suspect, but there are some drawbacks.
    - You will not get flow rate audit results for the sampler unless you plug the numbers into the computer spreadsheet or calculated them independently. This increases the opportunity for a translational error.
    - Being unable to identify a flow rate problem also precludes immediate remediation, thus continuing a situation that potentially invalidates more sampling events.
- Write neatly and clearly; make a single line through mistakes and then initial
- A tendency is to rush through the audit.

Brevity is not a substitute for poor or indecipherable results!

- Keep in mind that the value added is in providing an accurate assessment of performance regardless of whether it is below expectations or perfect.
- If it is an IMPROVE audit be sure you have double checked for the proper filter position to test flow rates. We do not want to invalidate a previous run by over exposure or damaging a filter.
- If if is an IMPROVE audit ***Remember!!! Release the vacuum after every leak check very slowly***. This step has the highest risk in the audit for damaging a filter and invalidating the subsequent sampling event data.
- Do not forget to document deviations from the proper procedures for handling, storage and shipping of recovered samples.

Watch for uncovered filter cassettes.

- Have the CSN operator perform all hands-on functions of the sampler during the audit, unless he or she specifically asks you to perform them.
- IMPROVE operators may be uncomfortable with performing the controller keystrokes and removing and replacing the down tubes, plugs and temperature probe. Secure their permission and ask that they watch carefully as you move, remove and reposition the parts necessary to perform the audit.
- Explain what you are doing to the operator; explain expected and actual results. If something is awry sometimes they will notice something that can be corrected or adjusted, which produces acceptable results.
- Allow, in fact, encourage operators or attending technicians to recalibrate or reset parameters that are outside of acceptance limits. It ultimately saves time and money for all concerned. The audit worksheet makes provision for a repeat audit. Just record the last audit results in the cells designated for post-corrected performance. Note interim corrections and results on a separate pad or the back of a hard copy. The number of attempted corrections should be documented in case the sampler must be factory serviced.
- It is inappropriate for Federal auditors to remediate problems at a site, (some SLT auditors are authorized to remediate). It is permissible and usually builds good relations to offer to help in troubleshooting a problem, or to coach the operator through the resolution of a problem if they ask, and if the auditor has a high degree of confidence that they know the resolution

Please remember the initial audit results must be reported to AQS as well as post – remediation audit results on the same day!

2.4.6 Close-out the Audit in a Professional Manner

- Put away all reference standards, tools and other equipment and supplies
- Make sure the sampler is ready to sample or in a stand-by or set-up mode depending on when the next sampling day is scheduled.
- Make sure the site and sampler is in the same or better operating condition than when you arrived
- Provide a debriefing of preliminary results for the operator and other attendants if they are interested. Explain the reporting and follow-up procedures if they are unfamiliar with them.

- Be sure to leave a business card or contact information if they need to reach you
- Thank them for their attendance and assistance
- Have them sign a copy of the Check-out list for their network and sampler provided in Appendix B. Keep this on file!!

3.0 AUDIT REPORTS AND FOLLOW-UP

The Job is not over 'til the paper work is done!!

A fundamental precept of a quality system is that audits and assessments produce findings that require documentation and remediation in cases of unacceptable performance. Each SLT monitoring agency may set their own time schedules for reporting and responding to CSN audits but these should follow 40 CFR Part 58.16(b), which specifies that all final reports are to be submitted for posting in AQS within 90 days after the end of the calendar quarter in which, the audit was conducted. The SLT agency should clearly describe the reporting, response and follow-up procedures in their QAPP, which is approved by their EPA Regional Office. Generally the speaking the CSN audits will be reported as a spreadsheets, that are uploaded to the web-based reporting utility developed and maintained by a contractor for OAQPS. Again the current address for the website is https:\\airqa.rti.org.

3.1 REPORT AND FOLLOW-UP PROCEDURES FOR FEDERAL CSN TECHNICAL SYSTEM AUDITS

Below is the step-by-step, ~90-day, process that is proposed for reporting and follow-up of a TSA of a **CSN** site by a Federal auditor, or contractor directed to conduct an audit in behalf of EPA.

An EPA contractor does not have the authority to make a judgment call that a site "fails", i.e., issue a categorical statement that the site produces invalid data in its reported condition. This responsibility resides with EPA or the authorized SLT personnel. A contractor may make observations and report them on the TSA form. The contractor will record the parametric results of the sampler audits on the report forms. It is the responsibility of the SLT agency that owns and operates the site and sampler to invalidate routine sampling data based on the audit results.

1) The auditor should prepare a completed Performance Audit Worksheet including any findings recorded during the TSA interview and inspection in the "Findings" text box. The findings should be divided into "Significant" and "General."
2) "Significant" to "Catastrophic" findings should be reported to the monitoring agency's site operator and supervisor as soon as possible. Within two weeks following a site audit, a draft audit report should be submitted to the site operator or person who attended the audit.
3) The site operator or attending person should be given two weeks to respond for the purpose of ensuring there are no erroneously recorded data that led to a false significant finding. Erroneous data entry should be corrected if there is a high level of

confidence that accurate audit data can be recovered from the written versions of the Performance Audit Worksheet and TSA form.

4) Disputed findings of any parameter or condition that were not the result of erroneous data entry should be identified for the interim final report.
5) Within 2 weeks after an TSA has concluded and two weeks after the operators response period, an Final report of the initial audit will be prepared and forwarded to the Site operator, the SLT's monitoring program manager, the EPA Speciation audit reporting utility (website), and the appropriate Regional Monitoring Program contact and QA Contact. If correction or remediation occurred on the same day as the initial audit, and there are no other issues to be resolved, both sets of results should be recorded in the appropriate cells in the audit report spreadsheet. The spreadsheets that are associated with the audit are uploaded to the reporting utility, https:\\airqa.rti.org. The report utility will interpret the results as two audits on the same day and post the results sequentially in AQS as two separate audits.

Note that IMPROVE audits are reported to UC Davis and OAQPS; not to the Air QA website.

6) If the initial finding has not been resolved by the date the initial audit is posted, the EPA Regional QA contact will issue a corrective action notice to the Monitoring Agency. Monitoring site owners are expected to correct significant findings within 60 days following issuance of the corrective action notice.

EPA recommends that safety findings be corrected immediately, but we acknowledge we have no way to enforce immediate action.

Remedies for significant findings in procedures or program elements should be patterned after those stated in the National $PM_{2.5}$ Chemical Speciation Network guidance document and Field QAPP. (Note the current version of the QAPP document is posted on AMTIC)

7) A subsequent, follow-up audit should be conducted by the monitoring agency. The resulting audit report will be posted to the EPA Speciation audit reporting utility (website). In addition to the audit results the report will document corrective actions taken by the SLT.
8) Audit Reports for the Speciation Network will be summarized in a National QA Audit report at the end of the calendar year.

Table 7 shows a tabulated view of this proposed reporting process.

TABLE 7. TABULATED VIEW OF PROPOSED CSN TSA REPORTING PROCESS

Time Frame	Function	Submitted by	Submitted to
Within 24 hours of audit	Report significant findings	Auditor	Site Operator and supervisor, EPA Regional Monitoring QA Contact.
2 weeks from audit	Preliminary Site report submitted, include remedi-ation during audit	Auditor	Site operator
2 weeks after receiving preliminary audit report	Review Preliminary Site report for erroneously recorded data and send comments; report any remediation since the audit and post-remediation audit results.	Site Operator	Auditor. Regional EPA contact and OAQPS/ORIA may be copied if a dispute exists regarding findings that could result in invalid routine monitoring data
2 weeks after response from site operator	Initial Site audit report submitted	Auditor	Report uploaded to AQS Reporting utility; EPA Regional Office notified if significant adverse finding unresolved at time of upload.
2 weeks after final audit report from auditors	Submit Corrective Action Notice unless remediation was performed at time of audit, or prior to final initial audit report	EPA Region	Site Operator, SLT's monitoring program manager, EPA Speciation Network National Program Manager, EPA Regional Delivery Order Project Officer
8-9 weeks after corrective action notice	Remediation Report in response to Corrective action notice, including post remediation follow-up audit results	Site Managers	Audit report loaded to AQS Reporting Facility; copy to EPA Region

3.2 REPORT AND FOLLOWUP PROCEDURES FOR THE IMPROVE NETWORK

Because the IMPROVE network is essentially a Federal, Interagency monitoring network that is administered by an interagency Steering committee, the reporting and follow-up procedures are somewhat different than the SLT-owned-and-operated CSN. Table 8 below contains a working draft of the reporting and follow-up procedures The abilities of the auditor corps and the agencies involved with this monitoring network to work within this schedule may evoke further revisions.

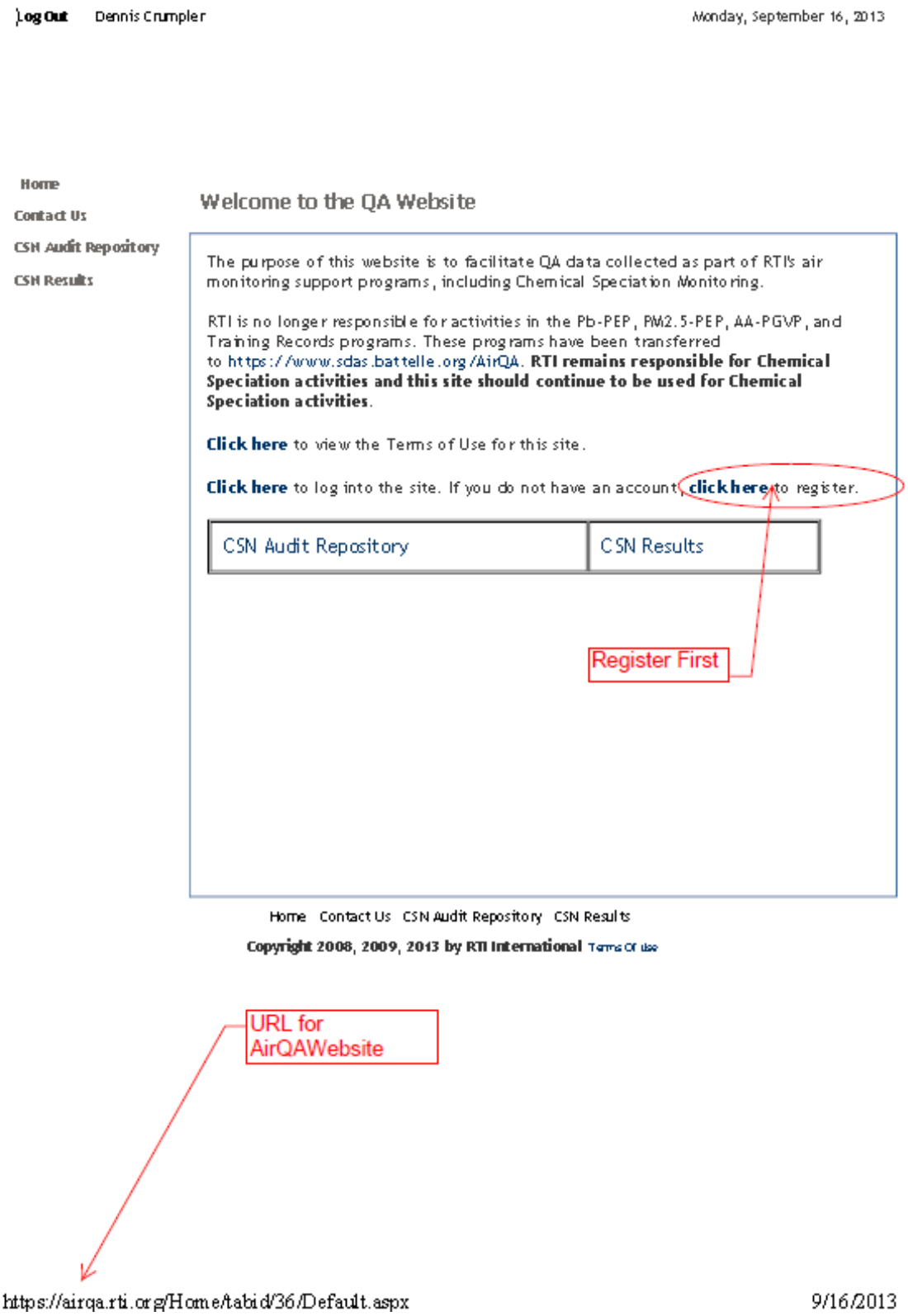
TABLE 8. TABULATED VIEW OF PROPOSED IMPROVE REPORTING PROCESS

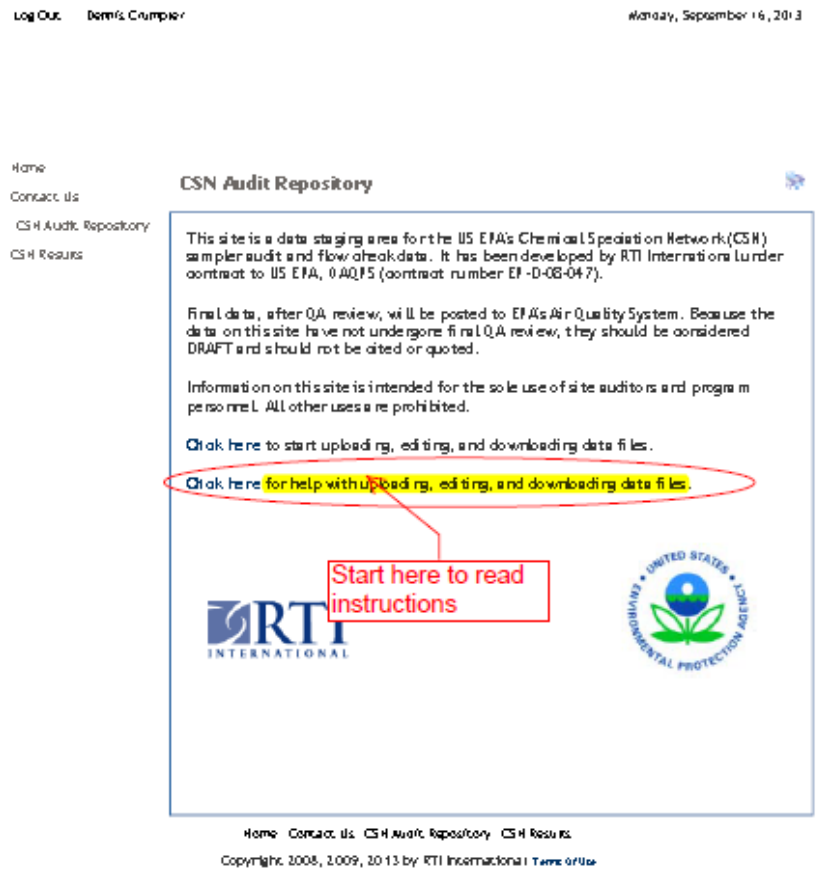
Time Frame	Function	Submitted by	Submitted to
Within 24 hours of audit	Report significant findings	Auditor	UC Davis, Site sponsor-SLT or FLM OAQPS/ORIA coordinators
2 weeks from audit	Preliminary Site report submitted, include remedi-ation during audit	Auditor	UC Davis,
2 weeks after receiving preliminary audit report	Review Preliminary Site report; send comments for inconsistent results; report any remediation since the audit and post-remediation audit results.	UC Davis	Auditor. Site sponsor-SLT or FLM, OAQPS/ORIA may be copied if a dispute exists regarding findings that could result in invalid routine monitoring data
2-3 weeks after response from site UC Davis	Final Site initial audit report submitted	Auditor	UC Davis; Report emailed to OAQPS/ORIA [1]; Site sponsor-SLT or FLM notified if significant adverse finding unresolved at time of email.
2 weeks after final audit report from auditors	Submit Corrective Action Notice unless remediation was performed at time of audit, or prior to final initial audit report	OAQPS/ORIA	UC Davis with copy to Site sponsor-SLT or FLM,
4-6 weeks after corrective action notice	Submit Remediation Report in response to Corrective action notice, including post remediation audit results if any.	UC Davis	Auditor; with copy to OAQPS/ORIA and Site sponsor-SLT or FLM,
1 week after remediation reports	Add final actions update to follow-up Audit report	Auditor	Follow-up Audit report emailed to OAQPS/ORIA[1]; copies to UC Davis and FLMs

[1]A reporting facility similar to the one developed for the CSN will ultimately be developed.

Appendix A

Directions for Accessing the AirQA Website


Log Out
Dennis Crumpler
Monday, September 16, 2013
Home
Contact Us
CSN Audit Repository
CSN Results
Welcome to the QA Website
The purpose of this website is to facilitate QA data collected as part of RTI's air monitoring support programs, including Chemical Speciation Monitoring.
RTI is no longer responsible for activities in the Pb-PEP, PM2.5-PEP, AA-PGVP, and Training Records programs. These programs have been transferred to https://www.sdas.battelle.org/AirQA. RTI remains responsible for Chemical Speciation activities and this site should continue to be used for Chemical Speciation activities.
Click here to view the Terms of Use for this site.
Click here to log into the site. If you do not have an account, click here to register.
CSN Audit Repository
CSN Results
Register First
Home Contact Us CSN Audit Repository CSN Results
Copyright 2008, 2009, 2013 by RTI International Terms Of Use
URL for AirQAWebsite
https://airqa.rti.org/Home/tabid/36/Default.aspx
9/16/2013


Log Out
Dennis Crumpler
Monday, September 16, 2013
Home
Contact Us
CSN Audit Repository
CSN Results
CSN Audit Repository
This site is a data staging area for the US EPA's Chemical Speciation Network (CSN) sampler audit and flow check data. It has been developed by RTI International under contract to US EPA, OAQPS (contract number EP-D-08-047).
Final data, after QA review, will be posted to EPA's Air Quality System. Because the data on this site have not undergone final QA review, they should be considered DRAFT and should not be cited or quoted.
Information on this site is intended for the sole use of site auditors and program personnel. All other uses are prohibited.
Click here to start uploading, editing, and downloading data files.
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URL for AirQAWebsite

Appendix B

Post-Audit Site Check-out Lists

Metone Site Check-out List

1) Site operator installs new sample canisters
2) Site operator installs plugs if the sample canisters are not going installed
3) Auditor observes installation of sample canisters and handling technique
4) Site operator installs solar shield
5) Site operator sets up next run

Site Operator's name (print): _____

Site Operator's signature: _____

Date: _____

Auditor's name (print): _____

Auditor's signature: _____

Date: _____

URG 3000N Site Check-out List

1) Site operator installs new sample cartridge
2) Site operator confirm inline shutoff valve, audit adapter, and reducer removed and vacuum lines reconnected correctly
3) Auditor observes installation of sample cartridge and handling technique
4) Auditor observes operator for setup of sampler for next sample run

Site Operator's name (print): _____

Site Operator's signature: _____

Date: _____

Auditor's name (print): _____

Auditor's signature: _____

Date: _____

IMPROVE Site Check-out List

1) Prior to audit, Auditor and Site operator verify that all plugs are in the bottom of the "T" fittings on the sampler inlet
2) Auditor puts all inlet tubes in sampling position
3) Auditor replaces temperature probe to sampling position
4) Auditor tightens all Allen bolts and confirms that the D-Module downtube is secure
5) Auditor replaces all black filler caps removed during the audit
6) Site operator verifies all inlet tubes are in sampling position
7) Site operator verifies all Allen bolts are secure
8) Site operator verifies that all plugs are in the bottom of the "T" fittings on the sampler inlet
9) Site operator verifies that all black filler caps have been replaced
10) Site operator verifies that sampler is ready for the next run
11) Site operator and auditor agree that site is fully operational

Site Operator's name (print): _____

Site Operator's signature: _____

Date: _____

Auditor's name (print): _____

Auditor's signature: _____

Date: _____