

Objectives of the PM “Supersites” Monitoring Program

Executive Summary

This document describes EPA’s rationale and underlying objectives for implementing a Supersites monitoring program, and provides background information prior to the July 22-23, workshop to be held in Chapel Hill, NC in 1998.

This program is being designed to conduct special, detailed chemical and physical characterization studies in geographic areas with a range of characteristic PM_{2.5} source-receptor and health risk situations. The scope and specific details of this program, termed “Supersites,” are being developed through substantial input from the scientific community, including the July 22-23rd workshop. The scope of this program includes the sampling and analysis of ambient aerosols and gases used to supplement particulate matter measurement, modeling, exposure and health risk assessment programs.

The EPA has not preselected geographic study areas, nor have we determined overall project design, the scope of measurements or sampling systems to be used. Development of the Supersites program is consistent with EPA’s desire to engage the scientific community in the design and operation of ambient air monitoring programs, and is responsive to recommendations in the National Academy of Sciences Report, *Research Priorities for Airborne Particulate Matter: I. Immediate Priorities and a Long-Range Research Portfolio*. As a focus for workshop discussions, several examples of research needs and associated measurements intended for coverage by this program are discussed below. These examples are meant to provide a common understanding of EPA’s objectives by a very diverse community of air quality professionals.

The geographic areas of the Supersites program (e.g., 4-7) ought to include regional variations in air pollution across the United States and include areas with unique characteristics (e.g., climatology, source distributions, air quality, population/demographics). For example, we know that differences exist in the composition and seasonality of aerosols in Southeastern, Northeastern, and Western U.S. cities. The number of Supersites will depend on the availability of sufficient resources to conduct high-quality, intensive and advanced measurement studies for ambient aerosols at each site commenced.

A single site viewed in isolation cannot address air quality issues that have strong regional components. Accordingly, these Supersites must be viewed as a complementary and intersecting activity to the regulatory monitoring network being deployed by the state and local agencies (Appendix C). Ideally, Supersites will be located where other major field studies (including exposure and health effects studies) either are in progress or being planned.

A major motivation for assembling the workshop is to bring together researchers from the atmospheric/physical science, health effects/exposure science, and regulatory communities to ensure that multiple objectives for studies in different disciplines can be addressed and coordinated across relevant programs. While the technical and scientific perspectives and objectives of these communities may differ, we suspect that major areas of common information needs exist. For example, epidemiological studies need to address co-pollutant interactions, which lead to the collection of the major components of particulate matter, as well as other gaseous species such as peroxides and ozone. Analogously, atmospheric processes underlying the formation of secondary aerosols are chemically coupled to oxidative species, including ozone and peroxides as examples. Ideally, this Supersites program will foster an environment across disciplines resulting in optimum use of environmental sampling resources. Accordingly, we acknowledge that the Supersites program is just one piece within an array of measurement and related studies.

There are three major Agency objectives common to all of the “Supersite” study areas:

- 1) support development of State Implementation Plans (SIP's) through improved understanding of source-receptor relationships leading to improved design, implementation, and tracking of control strategy effectiveness in the overall PM program;***
- 2) development of monitoring data and samples to support health and exposure studies to reduce uncertainty in National Ambient Air Quality Standards setting and to enable improved health risk assessments; and***
- 3) comparison and evaluation of emerging sampling methods with routine techniques to enable a smooth transition to advanced methods.***

The first two objectives should provide an opportunity to increase temporal, chemical, phase, and size fraction resolution of PM related measurements relative to “routine” monitoring programs that typically are limited, for example, to intermediate averaging times (e.g., 24 hours) and single size ranges. These knowledge gains will improve the scientific basis for setting standards and their implementation. The last objective recognizes the physical/chemical complexities of aerosols and associated sampling/analysis methodologies and the desire to accommodate and promote the use of emerging techniques.

Examples of the types of scientific and programmatic questions that will be supported through the Supersites program in coordination with other efforts are provided in Appendix A.

Program Objectives

Program objectives include three broad categories: 1) support for State Implementation Plans (SIP), 2) development of improved data for health and exposure studies and health risk assessments and 3) sampling method development and inter-comparisons. Since the Supersites program is an interdisciplinary effort bridging physical/chemical science and health assessment communities, a discussion of these objectives is provided to foster improved communications across these disciplines.

State Implementation Plan (SIP) Support

SIP support covers a very wide spectrum of activities that can be viewed as the atmospheric sciences component of this Supersites program. Activities that support both the development of effective emission control strategies and the continuous assessment of such strategies constitute SIP support. These activities range from developing qualitative insights regarding the nature and cause of a particular air pollution problem (e.g., regionally dispersed sulfate and carbon constitute the majority of PM_{2.5} aerosols), to a comprehensive application of complex three-dimensional gridded air quality simulation models. Included in the mix of SIP support tools are various source attribution/apportionment tools, air quality simulation models and observational approaches, and methods to characterize trends in air quality to track progress. These tools support planning of emissions control strategies and enable mid-course adjustments. A more detailed discussion of each of the following SIP activities, their role in SIP development, and their corresponding measurement needs is provided in Appendix B:

- Air Quality Characterization (beyond the routine chemical speciation program)
- Evaluation of Emission Estimates
- Air Quality Simulation Model Evaluation and Application
- Receptor and Observation-Based Models: Evaluation and Application of Advanced Methods
- Air Quality Trends and Tracking Progress of Control Programs

SIP activities use ambient measurements to drive and/or to evaluate the basic air quality management tools used to characterize and predict air quality in terms of temporal, spatial, size delineation and chemical composition coordinates. Each has a common objective of developing and tracking success of effective emissions strategies. The underlying SIP support tools include regional/urban scale air quality simulation models (e.g., MODELS 3) and a suite of more empirically-based observational methods. Air quality simulation models require emissions and meteorological input; whereas observational methods rely on ambient measurements to infer source to receptor relationships or preferred control strategy approaches. These latter methods include source apportionment techniques (e.g., CMB8, SAFER), and a group of methods that infer a generalized preferred precursor reduction approach without specifying source categories

(e.g., nitrogen oxides limit ozone formation more than volatile organic compounds at a particular location and time).

Supersites provide an important diagnostic complement to the routine monitoring program needed for air quality modeling and emissions inventory efforts. Supersites in a SIP context provide highly resolved measurements to diagnose the effectiveness of existing tools by uncovering their strengths and weaknesses. Supersites do not independently support SIP development as they clearly provide only a small fraction of the data needed for state implementation planning. The Supersites do provide operational support, e.g., direct input into source receptor models, and can be distinguished by recognizing their diagnostic support. Perhaps the largest area of technical criticism confronting the regulatory community over the last decade has been the lack of diagnostic measurements and techniques to support operational tools.

Exposure and Health Risk Assessments

Improved characterization of ambient particles and associated “toxic” constituents or co-pollutants are needed to address critical exposure and health effect issues. These issues include:

- Characterizing human exposure and the relationship of exposure to specific PM characteristics and related measurements collected at ambient monitoring sites,
- Identifying the causal agents and mechanisms for the acute and chronic health effects that are associated with PM_{2.5}.

Hypotheses regarding the potential causative agents, toxic mechanisms and potential for human exposures would be given consideration in selecting the chemical and physical methods to be deployed at the Supersites. For example, to evaluate the hypotheses that ultra fine particles, soluble metals, or electrophilic organic compounds are the causative agents, these species or properties would need to be measured. In addition, spatial and temporal factors will be considered to ensure that both acute and chronic effects and related exposures can be related to the ambient measurements at these sites and that sufficient temporal resolution and frequency of measurements will allow these hypotheses to be tested. Geographic considerations that require further study are the past observations suggesting that the health risks of PM_{2.5} are similar across diverse air sheds with different sources and background aerosols. To further explore this observation, it will be important to include a full range of geographic and source variations. Supersites, for example, may be augmented by additional neighborhood sites to assess the relationship among different exposure microenvironments of concern. Ideally, emerging information identifying and characterizing the nature of the “toxic” components of PM will be incorporated into the Supersite measurement program.

The Supersites, in addition to advancing the understanding of the chemical and physical

nature of PM and directly supplying ambient measures for exposure, epidemiologic, and clinical field studies, will potentially be an important resource for toxicology studies. For example, various types of samples of ambient particles could be collected for in-vitro and in-vivo toxicology studies addressing mechanistic questions.

Specific human exposure, dosimetry, toxicology, and epidemiology studies will be supported through resources available outside the Supersites program by EPA and other funding sources.

Monitoring Methods Development Platforms

Multiple and constantly changing demands are placed on the ambient air sampling and analysis community. There is a demand for information that provides greater resolution in chemistry, size distributions, and time which closely parallel new instrumentation developments. However, a transition (or collaboration with the expert community) is necessary before advanced methods can be used routinely by state and local agencies. As an example, increased time resolution of speciated aerosol measurements is often desired. State-of-the-science, continuous, in-situ, speciation samplers have now been developed. However, many of these methods require testing and comparison with standard methods to characterize the differences between techniques and to develop standard operating procedures. New methods must be evaluated before they are used at routine monitoring sites. The Supersites program represents an excellent opportunity to test new methods side-by-side with existing techniques and to allow for a smooth transition for the routine use of more advanced methods. Ideally, method comparisons should be performed in several different air sheds of varying characteristics to identify the weaknesses and strengths of various approaches. Clearly, these intercomparisons will identify several regional differences in performance between the Federal Reference Methods and techniques designed to capture all mass components. More exciting is the opportunity to accelerate deployment of continuous methods, improve organic carbon sampling and analysis techniques, and other methods providing particle-specific information. These sites should provide a vehicle for collaborations between the expert community (including universities, private R&D groups, industry, states & local agencies, and EPA) and State/local air monitoring organizations responsible for implementing "routine" monitoring platforms.

Relationships between Supersites and other components of the PM_{2.5} Monitoring Network

The Supersites complement the monitoring network in two very important ways: 1) as test platforms for application of advanced methods in routine networks, and 2) supply high resolution temporal, chemical, and size distribution data to enhance the less resolved data from routine sites. In turn, the routine networks complement the Supersites by providing strong spatial complements to the intensive Supersites. Appendix C provides an "Overview of the National

PM_{2.5} Monitoring Networks” including the routine chemical speciation program that will be enhanced by the Supersites.

Supersites will provide inter-comparison platforms for “routine” speciation samplers and Federal/Equivalent Reference Method mass samplers. Several issues related to the comparability of data from routine and advanced methods call for inter- and intra-method comparison. Supersites and routine sites need to be established and maintained to ensure progress in applying advanced methods routinely, and to reduce uncertainty in data trends interpretations brought about by changing methodologies.

The more resolved data from Supersites supports a wider spectrum of SIP and health risk assessment activities than provided by routine measurements alone. These include; air quality model evaluation, emissions evaluation, application of source-receptor methods, and support of health risk assessments.

Air quality is strongly influenced by multiple interacting spatial scales calling for characterization across super-regional, regional, urban, and local scales and various land use categories. A single site in an air shed is not capable of characterizing spatial gradients, background concentrations or transport phenomena that collectively interact to affect air quality at a specific location. Similarly, one site generally cannot reflect exposure everywhere in a large urban area with heterogeneous mix of sources. Consequently, a network of sites reflecting spatially disparate conditions is needed for most air quality assessments. Supersites should address both spacial and temporal characterization and may be complemented by the routine chemical speciation sites (e.g., which may serve as satellites). The Supersites could also provide vertical scale resolution (through optical techniques, elevated platforms, periodic aircraft flights) not expected to be part of routine networks.

In addition to routine monitoring programs, the Supersites design should take into account both existing and planned field studies conducted as by universities, industry and public-private organizations such as NARSTO. For example, the Supersites will likely focus on populated areas where health studies may also be conducted through other programs. Ideally, these “urban” sites should be coupled with intensive regional/background sites to delineate differences across different spatial regimes.

Appendix A: Questions Addressed Through Support of the Supersites Program

Examples of scientific and programmatic questions that will be supported through the Supersites program in coordination with other efforts are provided below:

Air Quality Management/Atmospheric Processes

What fraction of PM is locally, versus regionally, versus naturally (e.g., biogenic emissions) generated?

What are the various source categories contributing to PM and how much does each source category contribute to each of the above fractions?

What limiting conditions for the formation of PM_{2.5} exist now and over time with respect to coupled PM precursors (e.g., ammonia, nitrogen oxides, sulfur oxides, volatile organic compounds)?

How is the total PM, and the contributions of the various source categories, changing over time?

Are these changes in agreement with the expected changes based on increases or decreases in known, measured or estimated emission rates?

How well can regional scale and/or urban scale air quality models simulate the observed hourly, horizontal and vertical distribution of PM parameters and components?

Can a data base of hourly, horizontal, and vertical PM parameters and related components be used to improve air quality models? What are the spatial three-dimensional and temporal distributions of PM and oxidant precursors, PM components, PM and oxidant sinks and how are each transported at the surface, aloft, and in between?

How does the partitioning across gaseous and solid/liquid phases affect the fate of aerosol compounds?

What precursors (ammonia, nitrogen, and sulfur oxides, semi-volatile and volatile organic compounds) are most important to regional and local formation of secondary aerosols, and how is their relative importance expected to change over time?

How well can regional scale and/or urban scale air quality models simulate the observed

hourly, horizontal, and vertical distribution of PM parameters and components?

Can a data base of hourly, horizontal, and vertical PM parameters and components be used to improve air quality models?

What are the important chemical and physical coupling processes between oxidants and aerosols that affect the development of strategies targeted at both ozone and particulate matter? What regions of the country and over what seasons are coupling processes quantitatively important in developing co-pollutant emission strategies? How are these processes further coupled to deposition and toxics assessments?

What particle parameters, over and beyond those ordinarily measured, are useful in understanding sources? Examples include: particle number, particle surface area, particle size distribution, particle composition by size, light scattering, nonvolatile mass, nonvolatile plus semi-volatile mass, etc.

Exposure Assessment

Which parameters and components of PM are sufficiently evenly distributed across an urban area to provide a valid average community concentration (for use as a surrogate for the community average personal exposure)?

What exposure measure and time resolutions better predict the acute health effects than the 24-hr average? For example, is the maximum hourly concentrations or the 8-hour maximum concentration an independent exposure parameter or is it highly correlated with the 24-hour average?

What is the relationship between the ambient site measurements and human exposure?

Health Effects (Epidemiology/Toxicology)

What constituents of PM or associated pollutants are most highly associated with toxicity or adverse health effects?

What time resolution of ambient pollutant measures are the best predictors of adverse health effects (considering that this will vary with the type of health effect being studied and will be different between acute and chronic effects)?

To what extent does the presence of co-pollutants modify the effects of PM exposure?

Monitoring Methods

What is the difference in $PM_{2.5}$ that is characterized by Federal Reference Method techniques and techniques that capture a more comprehensive range of aerosol components?

How do such differences vary seasonally and geographically?

What is the difference in $PM_{2.5}$ that is characterized by Federal Reference Method techniques and techniques that capture a more comprehensive range of aerosol components?

How do such differences vary seasonally and geographically?

What operational and technical obstacles exist in applying emerging in-situ continuous methods for total $PM_{2.5}$ mass and spectate components, PM precursors, and oxidants/intermediates (peroxides, nitrogen dioxide, peroxy radicals, OH radical, nitrate radical)?

What steps must be deployed to move emerging methods into routine application?

Appendix B: SIP Support Activities and Data Needs

Examples of SIP support activities are provided here to illustrate how the Supersites program will support SIP's. The discussion is not intended to completely explain the technical approaches underlying the SIP process. Additional materials (Demerjian et al, 1995; EPA, 1996) provides a more thorough explanation of how the complementary uses of SIP support tools provide a solid underpinning of control programs. Throughout the discussion an emphasis is placed on how more detailed chemical, temporal and size distribution information from a Supersites will complement the routine chemical speciation program (Appendix C) which provides 24 hours averaged samples of major components (e.g., total organic carbon, not individual compounds) at less than daily sampling periods for one size cut (2.5 microns).

- **General Air Quality Characterizations.** Characterizing air quality through reconstructing component mass balances that identify the relative fractions of major components [e.g., major ions (sulfate, ammonium, nitrate), carbon (total elemental and organic), and elements (particularly crustal elements)] is an initial step leading to qualitative assumptions regarding principal impact sources and further refined analyses. This effort largely will be achieved through the routine chemical speciation program, which typically provides these measurements on 24-hour filter based samples. Since the routine program often will collect measurements on a 1/6 or 1/3 day sampling schedule, the Supersites program will enhance these general characterizations by providing daily (and probably continuous) measurements of the same components. This will allow for site-specific testing of the statistical adequacy of routine sampling schedules and allow for recommended adjustments to the routine program.
- **Evaluation of Emission Estimates.** Emissions are the major input into air quality simulation models and generally a source of considerable uncertainty. Emissions estimates include direct primary emissions, such as fugitives and soil/agricultural dust, incomplete combustion products, and condensible organic compounds; and precursors to secondarily formed aerosols, such as ammonia, nitrogen and sulfur oxides, and volatile organic compounds. While some of the precursor gases such as nitrogen and sulfur oxides are believed to be reasonably well characterized for major point sources, there remains large uncertainties in fugitives, ammonia and condensible organic compound sources. Many emission categories (and their near field concentration profiles) exhibit strong diurnal and seasonal patterns (e.g., mobile sources, biogenics), and emit specific organic compounds that are not analyzed routinely with standard chemical speciation protocols that sample over a 24-hour period. Similarly, assumptions regarding particle growth and related emissions size distributions (or particle number) incorporated in emissions models have large uncertainties that demand testing with observed data. Clearly, the

Supersites program will provide ambient data, which under certain conditions, will allow for evaluation (i.e., reality check) of modeled emissions estimates for certain species. Thus, the Supersites complements the routine networks by providing continuous (or at least higher time resolution) measurements and detailed species specific chemical information over various size fractions.

- **Application and Evaluation of Air Quality Simulation Models.** Emissions driven Air Quality Simulation Models (AQSM's) are valuable spatial, temporal, and chemical interpolators that require considerable validation with surface and aloft ambient measurements of both predicted values and process formulations. These modeling systems operate over multiple spatial scales (domains of over 1000 km and grid resolution down to 2-4 km, with capability for subgrid scale specific plume characterization), in near continuous time (effectively 1 hour increments) and considerable chemical definition. Given the enormous time, space, and chemical detail of modern AQSM's, there is no limit on the variety of ambient data that can provide useful testing information. While data from the routine programs (e.g., chemical speciation, PAMS) provide valuable evaluation data, those data fall short in either temporal (24 hours when hourly data are needed), chemical, or vertical resolution. Especially important is the availability of measurements that allow for true diagnostic¹ evaluation of the robustness of a model's ability to generate realistic emissions strategies by testing whether the model truly is capable of integrating transport and chemical process dynamics. In addition to common products (e.g., sulfate, nitrate, ozone) and precursor observations (nitrogen and sulfur oxides, volatile organic compounds); additional chemical data (that Supersites can provide) on precursors, such as ammonia; sinks (or removal species), such as peroxides and nitric acid (which also behaves as a precursor for aerosols), and important short lived and photochemical dynamic species, such as peroxy radicals and nitrogen dioxide allow for such testing. Due to the atmospheric chemical coupling between oxidants and aerosols, any evaluation of modern AQSM's supported by the Supersites benefits both ozone and aerosol implementation programs. An array of meteorological measurements

¹ Diagnostic activities attempt to determine whether the assessment tools truly recreate physical and chemical processes in the atmosphere. For example, an air quality model often is evaluated with data that are available. Historically, ozone model applications relied on available ground level ozone data. The resulting model evaluation provides some limited confidence that the model works as it should; however, so many coupled chemical and physical pathways potentially create circumstances where accurate ozone predictions result from compensating errors in process characterizations (e.g., underestimated mixing and emissions fields). These errors compromise the model's future predictive ability when applied to various emission scenarios. A diagnostic approach to evaluation would provide measurements of key chemical components in near continuous time to test whether the model is capturing important processes, to ensure confidence in reproducing various emission scenarios. In addition, measurements extending vertically clearly are needed given large spatial gradients that often exist in the atmosphere. The problem is magnified with aerosols, where routine measurements typically are aggregated over 24 hours, whereas significant transient changes in atmospheric mixing and emissions occur over much smaller time periods. Moreover, aerosol model evaluations are challenged by additional complexities of multiple phases and size distributions of varied chemistry.

which capture three-dimensional characteristics of wind velocity, temperature, pressure, relative humidity, and other parameters useful for defining structural features for mixing purposes is especially critical for model evaluation.

- **Application of Receptor² and Observation-Based³ Models.** A suite of source apportionment techniques that relate chemically-spectate ambient data to chemical features specific to particular source emissions will be applied to attempt to delineate the principal source categories and their quantitative impacts at a specific location. Examples of these techniques include the Chemical Mass Balance Model version 8 (CMB8) and various multivariate approaches, such as multiple linear regression, constrained factor analyses (e.g., SAFER/UNMIX), and Principal Component Analysis. The multivariate approaches require the simultaneous use of many ambient samples, but have the potential of avoiding the need for externally-supplied source profiles, as in the case of CMB8. An additional promising but relatively unexplored source apportionment technique is the use of the chemical and morphological features of the individual particles composing an ambient PM sample, as determined from scanning electron microscopy (SEM) analysis. All of these techniques are limited by the richness of available data. Thus, while routine 24-hour averaged samples of chemical constituents can be used to drive these techniques, it is often preferable to use data aggregated over smaller time periods that reflect diurnal emissions release patterns (e.g., mobile sources) and/or meteorologically stable periods. Also, specific chemical markers that associate closely with known sources enhance source apportionment analyses. The Supersites are expected to provide specific organic compound data not routinely collected that should enable apportionment, for example, between sources such as (1) diesel- vs. gasoline-powered vehicles, (2) nominally similar vehicles but with very different emissions characteristics (hot-stabilized vehicle emissions vs. “smokers”), and (3) food processing/cooking vs. biomass-derived emissions.
- **Air Quality Trends and Tracking Progress of Control Programs. A**

² Source apportionment is a very broad term that can extend to the more deterministic Eulerian models which develop source-receptor relationships. Depending on perspectives, there may or may not be much delineation between the terms source apportionment and source-receptor. For clarification, we will use source apportionment to refer to the more observation driven approaches such as chemical mass balance receptor models.

³ Observational Models require ambient data as explicit inputs to drive model calculations; more deterministic air quality simulation models are driven principally through emissions and meteorological input fields. A class of observational methods infer “preferred” general control strategy approaches based on atmospheric chemistry conditions. For example, the smog production algorithms (Blanchard et al., 1992) and the Georgia Tech OBM (Cardelino and Chameides, 1995) indicate whether ozone is preferentially reduced through reductions in Nitrogen oxides or volatile organic compounds, rather than identifying a particular source category such as a coatings operation or specific combustion source. Techniques for identifying the relative importance of ammonia and nitrogen dioxide for nitrate aerosols recently have been developed (Blanchard..., 1997).

continuous tracking of air quality is required as a basic accountability measure of ensuring that 1) planned emission strategies are implemented as designed, and 2) such programs achieve acceptable results. Such accountability is absolutely required given so many predictive uncertainties in atmospheric processes and related technical tools as well as unknowns associated with forecasting economic and demographic change. The atmosphere includes complex nonlinearities⁴ as well as negative and positive feedbacks⁵ that demand constant assessment of the effectiveness of emissions strategies. [These same concerns demand that AQSM's undergo diagnostic level testing.] The routine chemical speciation program will provide the basic information to test programmatic effectiveness. While the routine program should provide a measured signal indicating program effectiveness, it is unlikely that routine programs will be capable to explain the "why" or "how" behind unfulfilled program objectives, given the complexity of aerosol and oxidant systems. Clearly, the long term availability of detailed chemical, size and time-resolved data enhances our ability to diagnose the successes and failures of implemented programs, and ensure needed adjustments to optimize air quality management. Similarly, the uncertainties associated with relating specific PM mass components to adverse health impacts demand that a long term tracking system exist to retrospectively review associations as research provides more insight into the relationship between specific PM components and health effects.

4 A proportionate reduction in a pollutant precursor does not result in a proportionate reduction in the targeted pollutant

5 A reduction in a precursor can lead to an increase or decrease in targeted pollutant level

Appendix C: Overview of National PM_{2.5} Monitoring Networks

The current planned scope of the national PM_{2.5} network consists of three major components: mass monitoring, routine chemical speciation, and special study areas termed "Supersites." In very broad terms, the network, as a whole, supports three principal regulatory objectives: 1) determining nationwide compliance with the NAAQS; 2) State Implementation Plan (SIP) development (e.g., source attribution analysis and air quality model evaluation; and 3) tracking trends and progress of emissions reduction strategies. The EPA recognizes that, with care in design and execution, components of this program can also provide significant support for priority research needs. The following brief description is intended to provide background for understanding the context and relationship between these components and between them and EPA's research program. The attached table outlines for each category below a synopsis of the budgeted number, major purposes, and potential flexibility for integration with PM research programs.

MASS MONITORING (1100)

1. **Core mass monitoring (850).** Approximately 850 NAMS/SLAMS sites, required according to EPA guidance to the States, will be dedicated to mass monitoring. A breakdown of these 850⁶ sites includes 750 required for NAAQS compliance and 100 sites for characterizing background and transport. The regulation requires a continuous sampler to be collocated with an FRM/FEM at the 52 largest cities (greater than 1,000,000 population).
2. **Mass samplers for spatial averaging and special purpose monitoring (SPM)(200).** Roughly 200 additional sites to accommodate spatial averaging⁷ and special purpose monitoring needs are expected to be deployed. The SPM sites are those established to identify unique source location or communities, and are not required to be compared to the NAAQS if operating less than 2 years (or a sampler without FRM/FEM designation).
3. **Continuous monitoring (50).** In addition to the required collocated 52 continuous monitors, plans include deployment of an additional 50 continuous samplers. Collectively,

⁶ EPA network guidance (40CFR58) requires 850 NAMS/SLAMS sites; however, 100 of those sites are to be designated as background or transport sites (2 per State) which can use the IMPROVE sampler, which is not designated as an FRM/FEM and therefore would not be used for NAAQS comparisons.

⁷The annual PM_{2.5} standard is specified as reflecting an area-wide distribution or spatial average of a representative single monitor or the average of multiple monitors. States have requested additional monitors to provide for spatial averaging.

at least 100 continuous samplers will be deployed, and probably more, since the States can elect to purchase and operate continuous samplers for sites designated as special purpose monitoring.

Principal objectives for mass monitoring:

- (a) FRM/FEM samplers and NAMS/SLAMS. The primary objective for mass monitoring, especially the designated NAMS/SLAMS¹ sites are for comparison to the PM_{2.5} NAAQS. In addition, 100 NAMS/SLAMS will serve as background and transport sites, integrated with other efforts such as IMPROVE, to characterize regional transport and background concentrations.
- (b) Continuous samplers. Continuously operating samplers will provide a real time estimate of PM_{2.5} levels and allow for input into public information displays (similar to current ozone mapping efforts that reach local weather forecast venues) as well as the Pollutant Standards Index (PSI). Other objectives for continuous samplers include developing statistical relationships with FRM/FEM's to serve as potential surrogates for compliance indicators, and characterizing diurnal patterns of exposure and emissions.
- © Special Purpose Monitors (SPM's). The SPM's samplers are intended to provide flexibility for State and local agencies to investigate areas that may have exceedances without the repercussion of regulatory requirements associated with a NAAQS violations. The purpose of SPM's is to encourage monitoring where it might otherwise be discouraged due to fear of associated regulatory requirements. The SPM's are expected to be located in unique or rural communities subject to localized sources, or enhance the regional/background/transport network to better characterize multiple spatial scale interactions. Samplers for SPM's purposes can be FRM/FEM that operate less than 2 years, or non-FRM/FEM samplers. Many State and local agencies are expected to operate continuous samplers within the classification of SPM's sites.

ROUTINE CHEMICAL SPECIATION (300).

The routine chemical speciation program consists of two components: 50 required NAMS, and up to 250 additional sites (EPA's contribution to the IMPROVE program technically is similar to the routine speciation program but addressed separately due to budget considerations). The major purpose of these sites is to assess long-term trends in major PM_{2.5} components, as well as to provide useful information for source apportionment, evaluating current and future control programs, and health risk assessments.

1. **NAMS (50)**. The regulation requires 50 speciation sites across the country, located mostly in urban areas (e.g., all PAMS cities will have a speciation site). These 50 sites will be designated as NAMS and will follow sampling and analysis protocols similar to the

existing Interagency Monitoring of Protected Visual Environments (IMPROVE) program. Filter sampling techniques (Teflon, nylon and quartz media) for 24-hour periods will be analyzed for principal mass components: most elements through X Ray Fluorescence; major ions through Ion Chromatography/Colorimetry (nitrates, sulfates, chloride/ammonium); and organic and elemental fractions of carbon through Thermo analysis. The sampling methodology and frequency (1-in-6 day or greater) are being evaluated in light of peer review comments. Prescriptive protocols for sampler selection, analytes, and sampling frequency will be adhered to ensure national consistency across space and time.

2. **Other “Routine” Speciation Sites (250).** In addition to the NAMS, resources are expected to be available to support up to 250 additional sites. These sites will be less prescriptive than the NAMS and will be subject to a balance among competing needs for national consistency (50 sites are not adequate to characterize the U.S., suggestions for more frequent sampling), and flexibility to address local-specific issues such as winter time wood smoke, or the need to support related scientific studies, which might require more intensive seasonal sampling and analysis. This component of the program does provide true flexibility for State and local agencies. Certain States (e.g., California) have expressed an interest in establishing more advanced methods capable of in-situ, near continuous measurements of principal species. Given the flexibility of this component of the national program, substantial opportunity exists to interact with the health and atmospheric chemistry research communities. With the exception of the Supersites program, however, all of these components are funded by State Grants, which provide hardware and related capital costs, laboratory analyses, and salaries for State and local agencies to operate the network. Consequently, the dialogue must involve EPA, State and local agencies, and the research community.
3. **IMPROVE Sites (108).** In addition to 30 existing EPA supported sites, 78 new IMPROVE sites are being added, in or near Class I Federal areas (e.g. national parks and wilderness), to address the requirements of the forthcoming Regional Haze regulations. These sites conduct speciation sampling similar to the 50 NAMS, but on a 1/3 day sampling interval. These sites are considered as part of the entire PM_{2.5} National network, recognizing that the technical connections (e.g., sources/ambient characterizations, measurement techniques) between PM_{2.5} and visibility require integration. Although funded through State Grant funds, this program is managed by the IMPROVE Steering Committee, and most of the technical work conducted by Universities and the Federal Land Managers.

SUPERSITES (4-7). See main text.

Scientific Review of Network Components

The use of PM_{2.5} mass as an “indicator” for PM standards was recommended by the Clean Air Scientific Advisory Committee (CASAC) at the conclusion of their review of the scientific criteria and standards. Both the Federal Reference Method for measuring PM_{2.5} mass and EPA’s guidance for establishing the mass compliance network were peer reviewed by the Fine Particle Technical Monitoring Subcommittee of CASAC in 1996. The more recent plans for speciation measurements, continuous monitors, and Supersites are in partial response to the subcommittee’s recommendations for monitoring beyond 24-hour PM_{2.5} mass. The approach for the required speciation monitoring network was recently reviewed by an expert scientific panel in Seattle. The approach and objectives for the super site program will be the focus of a major 2-day workshop in July. A workshop planning group, including a number of recognized scientific experts in health, exposure, atmospheric sciences, and monitoring met in May and is continuing to develop materials for the program. In addition to providing periodic updates on this program to the NAS panel, EPA intends to present its approach for integrating the “routine” speciation network with the super site monitoring and research programs for review by the Fine Particle Monitoring Technical Subcommittee of CASAC in the Fall.

List of Acronyms

PM_{2.5} = Particles with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers

PM = Particulate Matter

EPA = Environmental Protection Agency

NAMS = National Air Monitoring Station

SLAMS = State/Local Air Monitoring Station

NAAQS = National Ambient Air Quality Standards

FRM = Federal Reference Methods

FEM = Federal Equivalency Methods

SPM = Special Purpose Monitoring

IMPROVE = Interagency Monitoring of Protected Visual Environments

PSI = Pollutant Standards Index

Overview of National PM_{2.5} Network

Site Category	Projected Number	Major Purpose	Potential Flexibility for Research
Core Sites	850 FRM/FEM measure PM _{2.5} mass. Also 50 collocated monitors measure continuous mass	Minimum required for designations. FRM and network design peer reviewed by CASAC. Continuous required for PSI reporting.	Limited. States follow EPA guidance on location according to population, other factors. Frequency of sampling could be adjusted at some.
Spatial Averaging/ Special Purpose	200 FRM/FEM, other	States requested additional monitors for spatial averaging for attainment designations. SPMs limited duration (<2 yr), e.g. source attribution study	Locations determined by States according to local circumstances. SPM might be adjusted to accommodate research
IMPROVE	100 additional IMPROVE monitors	Supports regional haze rules in class I areas and PM _{2.5} transport assessment. Chemical speciation.	Limited to class I areas.
Chemical Speciation	300 sites with "routine" chemical analyses	Trends, source attribution of major chemical species, for source apportionment, risk assessment. Regional variations encouraged.	Substantial flexibility to accommodate health and other research subject to resource limitations on frequency.
Continuous	50 additional continuous PM _{2.5} mass monitors	PSI reporting and further delineation of source/exposure patterns	Substantial flexibility to support exposure studies.
Total	1500 Sites		

In addition 4 to 7 Supersites not included in above with research grade instrumentation will be established for health risk and source assessment work integrated with research program. The design of this program is fully flexible for incorporation into other priority scientific research on PM.