

VOLUME IX: CHAPTER 1

GETTING STARTED: EMISSIONS INVENTORY METHODS FOR PM-2.5

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CONTENTS

Section	Page
1	INTRODUCTION 1.1-1
1.1	PURPOSE 1.1-1
1.2	BACKGROUND 1.1-2
1.2.1	Origins of PM-2.5 1.1-2
1.2.2	Relationship of PM-2.5 to PM-10 1.1-3
1.2.3	Relationship of PM-2.5 to Visibility Impairment 1.1-4
1.2.4	Organization of the Report 1.1-5
2	SOURCE CONTRIBUTIONS TO PM-2.5 IN AMBIENT AIR 1.2-1
2.1	Precursors to Sulfate 1.2-1
2.2	Precursors to Nitrate 1.2-2
2.3	Carbonaceous Particles 1.2-3
2.4	Geological (Crustal) Particles 1.2-4
2.5	Relationship Between Source Magnitude and Ambient Concentration 1.2-5
3	OVERVIEW OF EMISSION FACTORS AND INVENTORY METHODS 1.3-1
3.1	Inventory Development Procedures 1.3-1
3.1.1	Direct Measurements and Indirect Estimation Approaches 1.3-1
3.1.2	CEM Data versus Application of Emission Factors 1.3-3
3.1.3	Area and Mobile Source Estimation Methods 1.3-4
3.2	Types of Inventories and Inventory Applications 1.3-5
3.3	Level of Detail in Activity Data, Emissions Factors, and Projection Factors 1.3-7
3.4	Inventory Development Tools 1.3-8
3.4.1	Summary of the NET Inventory 1.3-9
3.4.2	Development of the Area Source Model 1.3-12

CONTENTS- (continued)

Section	Page
4	GETTING STARTED: PLANNING FOR THE DEVELOPMENT OF A PM-2.5 INVENTORY 1.4-1
4.1	Assessing Priorities 1.4-3
4.1.1	Use of Ambient Data to Establish Priorities 1.4-4
4.1.2	Use of Emissions Data to Identify Potential Key Sources 1.4-5
4.2	Determining Appropriate Spatial Scales for Inventories 1.4-6
4.3	Determining Appropriate Temporal Scales for Inventories 1.4-8
4.4	Preparing to Collect Activity Data 1.4-9
4.5	Summary 1.4-11
5	TECHNIQUES FOR INVENTORY VALIDATION 1.5-1
5.1	Uncertainty Issues 1.5-1
5.2	Speciated Linear Rollback and Simple Regression Models 1.5-2
5.3	Data Attribute Rating System (DARS) 1.5-3
5.4	Use of CMB and Dispersion Modeling 1.5-4
5.5	Development of Source Profiles for CMB Modeling 1.5-5
6	SUMMARY AND RECOMMENDATIONS 1.6-1
6.1	On-going National-Level Activities 1.6-1
6.2	Recommendations for State Activities 1.6-2
	REFERENCES 1.6-4
	APPENDIX A. PIE CHARTS OF SPECIATED AMBIENT PM-2.5 1.A-1
	APPENDIX B. STATUS OF PM-2.5 EMISSIONS ESTIMATION TOOLS 1.B-1

FIGURES AND TABLES

Figure		Page
A-1	PM-2.5 Composition in the Eastern United States	1.A-2
A-2	PM-2.5 Composition in the Western United States	1.A-3
Table		Page
3.1	1996 NET INVENTORY DEVELOPMENT METHODOLOGY	1.3-11
4.1	SPATIAL INFLUENCES IN PM-2.5 PLANNING	1.4-7
4.2	TEMPORAL INFLUENCES ON PM-2.5 SIP INVENTORY DEVELOPMENT	1.4-10
B-1	FACTORS AND ACTIVITY DATA FOR PM-2.5 PLANNING	1.B-6

LIST OF ACRONYMS

ASEM	Area Source Emissions Model
CAA	Clean Air Act
CEM	Continuous Emission Monitor
CMB	Chemical Mass Balance Model
DOI	U.S. Department of Interior
EIIP	Emissions Inventory Improvement Program
FIRE	Factor Information Retrieval system
FRM	Federal Reference Method
g	grams
GCVTC	Grand Canyon Visibility Transport Commission
IMPROVE	Interagency Monitoring of Protected Visibility Environments
µm	Micro meters (10 ⁻⁶ meters)
NAAQS	National Ambient Air Quality Standard
NESCAUM	Northeast States Consortium of Air Use Managers
NET	National Emissions Trends Inventory
NH ₃	ammonia
NO ₂	nitrogen dioxide
NO _x	oxides of nitrogen
OAQPS	Office of Air Quality Planning and Standards
OTAG	Ozone Transport Assessment Group
OMS	Office of Mobile Sources
PART5	Mobile Source particulate matter emission factor model
PM-2.5	particulate matter with mass median diameter less than 2.5 µm
PM-10	particulate matter with mass median diameter less than 10 µm
SAMI	Southern Appalachian Management Initiative
SMP	Smoke Management Plan
SO ₂	sulfur dioxide
SOA	secondary organic aerosol
SPECIATE	source-level species profile database maintained by EPA
TCM	Transportation Control Measures
TTN	Technology Transfer Network
USDA	United States Department of Agriculture
U.S. EPA	United States Environmental Protection Agency
VMT	vehicle miles travelled
VOC	volatile organic compounds
WESTAR	Western States Air Resources

1

INTRODUCTION

1.1 PURPOSE

The purpose of this document is to provide a concise overview of the state-of-the-science related to future needs for the development of emission inventories to support planning to reduce high ambient concentrations of PM-2.5, particulate matter with mass median aerodynamic diameter less than 2.5 micrometers (μm). The primary objective is to address issues that are important in the development of emission inventories for PM-2.5 and its precursors. This paper addresses emission factor and activity data development, spatial and temporal variability of PM-2.5, and priorities for methodology and emission factor development on National, regional, and nonattainment area scales. This document is not intended to replace the emissions inventory guidance for PM-2.5 that has been developed by the U.S. EPA.

On May 14, 1999, the U.S. Circuit Court of Appeals for the District of Columbia issued a ruling that remanded the ozone and particulate matter standard, and also called into question what actions, if any, may be taken to implement the new standards. The development of Statewide emission inventories for ozone and particulate matter and their precursors is necessary to address regional issues, irrespective of the final determination on the actual National Ambient Air Quality Standards. Since these are criteria pollutants and are key components of regional haze, development of emission inventories is still deemed to be appropriate including the statewide periodic emission inventories for calendar year 1999. Thus, it is appropriate for the Regions and State/local agencies to:

- discuss plans for developing emission inventories for 1999;
- identify appropriate future actions, programs and associated milestones regarding emission inventories; and
- identify specific issues which need resolution prior to making progress on emission inventories.

1.2 BACKGROUND

1.2.1 *Origins of PM-2.5*

There are three primary origins of PM-2.5: primary solid particulate matter that is emitted directly in the solid phase, primary condensable particulate that can be emitted at high temperature in the gas phase but which condenses into the solid phase upon dilution and cooling in the plume, and secondary particulate that is formed through atmospheric reactions of gaseous SO₂ and NO_x precursor emissions. The secondary components involve complex chemical and physical interactions among the precursor emissions in the atmosphere. Control of the secondary components will require appropriate controls on the sources of the various precursors. The atmospheric reactions and transport processes that result in secondary particulate formation extend over large distances from the sources of the emissions. Both directly emitted and secondary PM-2.5 can be transported over large distances.

Primary PM-2.5 particulate results largely from combustion of fossil fuels or biomass, although selected industrial processes can also be significant in some areas. The sources of PM-2.5 include, but are not limited to, gasoline and diesel exhaust, wood stoves and fireplaces, land clearing, wildland prescribed burning, and wild fires. Sources of primary particulate including fugitive emissions from paved and unpaved roads, dust from ore processing and refining, and to a lesser extent, crustal material from construction activities, agricultural tilling, wind erosion and other crustal source are less important based on their relatively small contribution to ambient PM-2.5 concentrations. The condensable components are largely made up of semi-volatile organic compounds that condense at ambient temperature to form aerosol. The condensable component represents a significant fraction of the PM-2.5 emitted from some sources. Testing for condensables, by means of Method 202, is necessary to characterize PM-2.5 emissions from many sources. EPA is currently exploring other options for source testing methods to characterize the condensable fraction more completely and with greater accuracy .

Secondary PM-2.5 forms through heterogeneous (gas to particle) chemical reactions that convert some common gaseous pollutants into very small particles. The observed secondary PM-2.5 is dominated by sulfur and nitrogen species in most locations, however, there can also be significant contributions from secondary organic aerosol in some locations.

Sulfate aerosol chemistry can involve either gas-phase or liquid-phase oxidation processes. Gas-phase conversion involves the oxidation of sulfur dioxide (SO₂) by hydroxyl radicals (OH), which are formed through the photodecomposition of ozone. The reaction results in sulfuric acid aerosol as an airborne particle with a typical diameter of less than 0.3 μm. The sulfuric acid particles are then neutralized by ammonia and molecular oxygen to form ammonium bisulfate and ammonium sulfate. Liquid-phase reactions involve SO₂ and

oxidants (H_2O_2 , O_3 and O) along with catalysts, such as manganese and iron, that are dissolved in cloud or fog droplets to form sulfuric acid aerosols with diameters in the 0.5 to 1.0 μm size range.

Nitrate aerosols can be produced by several pathways. The most important pathway is the gas-phase reaction of NO_2 with hydroxyl radicals to produce nitric acid, which is then neutralized by gaseous ammonia. When the levels of ammonia and nitric acid are sufficiently high, ammonium nitrate can be formed within the PM-2.5 size range.

Secondary organic aerosols (SOA) are formed by more complex mechanisms involving organic gas-phase particle precursors in the presence of ozone and hydroxyl radicals. The precursors of SOA arise from both anthropogenic and natural sources. Studies have shown that a significant fraction of the α - and β -pinenes, which react with ozone and hydroxyl radicals in the atmosphere, can lead to organic particle formation which then becomes a component of the organic carbon fraction. For example, in poorly ventilated urban areas such as Los Angeles, which has extensive brush covered hills, natural emissions of gaseous hydrocarbons may contribute up to 50% of the secondary organic particles. (NRC, 1993)

Currently, the details of SOA formation are not well known and the implications for needs related to the development of emission factors and other emissions estimation tools to characterize the precursor emissions are uncertain. Large carbon number organic compounds that have an affinity to stick together may contribute significantly to these processes. These processes may also be catalyzed by metals or other trace components. Future development efforts may need to be directed to expand VOC speciation profiles to include compounds that have not been of interest in ozone chemistry and to improve the methods for characterizing sources of trace metals.

These conversion mechanisms from gas to particle forms are thought to be one of the primary atmospheric removal mechanisms for gaseous pollutants. Once in the particle phase, those pollutants are efficiently removed, under the right conditions, by acting as cloud nuclei or through wet and dry deposition to the surface.

1.2.2 Relationship of PM-2.5 to PM-10

PM-10 primary emission inventories are typically dominated by fugitive dust sources. These sources were estimated to contribute approximately 89% of the national total PM-10 emissions in the 1996 National Emissions Trends (NET) inventory. Within the fugitive dust category, the main sources were unpaved roads (33%), wind erosion of natural soils (20%), agricultural crops (17%), construction (14%), paved roads (9%), and all other sources of fugitive PM-10 (2%). (EPA, 1997) However, about 80% of these fugitive dust emissions are larger than 2.5 μm . In all cases, these sources contribute primary particle emissions. In general, the contribution of combustion, condensable and secondary particle origins to PM-10

are an important but usually smaller fraction of the mass, although areas influenced by emissions from woodstoves or other forms of biomass burning and some urban areas can be exceptions.

The available ambient measurements of PM-2.5, however, suggest that anthropogenic combustion sources, fires, and other emitters of condensable and secondary origins contribute a large percentage of the overall PM-2.5 mass in most areas. Data will be needed to evaluate the extent to which existing control programs for PM-10 will benefit PM-2.5. While the effect of existing PM-10 controls on reducing PM-2.5 should be evaluated, planning for PM-2.5 programs may extend to different sources and source categories than those previously targeted for PM-10 programs. In some cases, PM-2.5 planning programs may also benefit from improving the rule effectiveness and compliance with existing pollution control rules for sources of particulates, ozone precursors, and acid rain precursors.

1.2.3 Relationship of PM-2.5 to Visibility Impairment

Visibility impairment is caused primarily by the scattering and absorption of light by fine particles in the atmosphere. Fine particles less than 2.5 μm in diameter scatter and absorb light more efficiently than larger particles. Regional haze is visibility impairment that is produced by a multitude of sources and activities emitting fine particles and their precursors which are located across a broad geographic area. The fine particulate matter (e.g., sulfates, nitrates, organic and elemental carbon, and soil dust) that impairs visibility is among the same particles related to serious health effects and mortality in humans, as well as to environmental effects such as acid deposition and eutrophication.

Data from the Interagency Monitoring of Protected Visual Environments (IMPROVE) network show that visibility impairment in the eastern U.S. is dominated by sulfate, up to 90% for the worst visibility days in some class I areas. In the west, sulfate accounts for about a third of the visibility impairment in many areas, but other components of PM-2.5 such as organic carbon and nitrates contribute more significantly as a percentage of overall visibility impairment levels than in the east. There appears to be a larger contribution from primary emissions from wood smoke and other combustion sources in the west.

The Clean Air Act sets a National goal of remedying existing impairment and preventing future impairment in the 156 Class I National Parks and Wilderness Areas across the country. State implementation plans are to ensure "reasonable progress" toward that goal. Because common pollutants, sources, and transport processes contribute to both health and visibility problems, EPA encourages States to coordinate their planning and assessment activities for PM-2.5 and regional haze programs. The development of statewide PM-2.5 emission inventories will be needed as a foundation for regional planning activities for both PM-2.5 and regional haze.

1.2.4 Organization of the Report

The remaining sections of this report provide a preliminary assessment of some of the important issues that need to be addressed and understood before starting activities to develop an inventory for PM-2.5. The next section discusses the primary sources of PM-2.5 based on available air quality data. This assessment is based primarily on data collected to support analyses of visibility in National Parks and Recreation Areas, and details on specific urban areas are not well represented. A review of the approaches used to develop emission factors and emissions inventories is provided along with a summary of some specific inventory development tools that are available for PM-2.5 programs. The following section summarizes some of the important considerations that might affect PM-2.5 inventory development activities and is meant to be a summary to help States get started on future planning activities. Some selected techniques that can be applied to evaluate the quality or validity of inventory data are presented. The report concludes with some general recommendations that are meant to provide some insights to help in planning and prioritizing efforts in the future. Pie charts showing measured ambient concentrations are shown in Appendix A. Appendix B presents a concise summary of data and tools that are available and remaining needs related to the primary components of PM-2.5. This report is not meant to be a comprehensive guide on inventory development or to identify all of the specific issues that might affect planning in any given area.

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SOURCE CONTRIBUTIONS TO PM-2.5 IN AMBIENT AIR

PM-2.5 is a new air quality indicator and, consequently, there is a relative paucity of information on the sources of PM-2.5 and emission factors for estimating PM-2.5 emissions. There is, however, a fairly robust ambient monitoring database that includes information on the composition of ambient PM-2.5. That database provides important insights on the source contributions to ambient PM-2.5, even though none of the data were collected according to the PM-2.5 monitoring reference method. These data are taken largely from the Interagency Monitoring of Protected Visual Environments (IMPROVE) project. IMPROVE was designed to explore the current status and potential causes of visibility impairment in National Parks and other Class I areas; therefore, that database is most useful to explore the regional distribution of PM-2.5. A limited set of data that is more representative of urban conditions is also available and those data are useful to infer information about the differences between rural concentrations and urban area concentrations. Since the urban data represent only a select few urban locations, it is not possible to present a comprehensive assessment of urban PM-2.5 distributions. These data have been discussed in detail elsewhere. (Pace and Kuykendal, 1998) Summary pie charts showing the composition of measured ambient PM-2.5 are included in Appendix A to this report. Similar trends in sulfate concentrations between east and west, and relative magnitudes of sulfate and nitrate between urban and rural locations have also been observed in monitoring data collected across Canada. (Brook et al., 1997)

2.1 PRECURSORS TO SULFATE

Review of the figures in Appendix A reveals that sulfate is a significant component of PM-2.5 in the east and is less prevalent in the west. This is not unexpected since the east is strongly influenced by major sources of SO₂ from coal burning utilities in the Ohio Valley, Tennessee Valley, and along the east coast. Other industrial sources of SO₂ are also common in the east. There are also large sources of ammonia arising from major livestock production and fertilizer application throughout the Midwest, gulf coast, mid-Atlantic, and southeastern States, in addition to the sources of ammonia associated with human activities. Ammonia is usually involved in the formation of sulfate, but SO₂ can form sulfuric acid aerosols in the absence of ammonia. In addition, water vapor and radicals from photochemical systems are frequently found in the east. These conditions

combine to produce the observed large contributions of sulfate, on a percentage basis, at the eastern monitoring locations. In general, the sulfate fraction measured at eastern monitors ranges between 30% to 60% of the total PM-2.5 mass. For comparison purposes, the sulfate fraction measured at western monitors that are affected by fewer SO₂ sources rarely exceeds 20% of the total PM-2.5 mass. Sulfate, nitrate and some organics are hygroscopic and, therefore, contribute more to light scattering than some other PM-2.5 components. Sulfates are responsible for most of the visibility impairment in the Eastern United States. The contribution of sulfates to visibility impairment is less in the west as a result of lower relative humidity and the lower sulfate fraction of total PM-2.5 mass. On a mass concentration basis the relatively constant concentrations of sulfate in both urban and non-urban locations in the east, supports the conclusion that sulfate is regional in the east. In the west, however, some urban locations appear to have higher concentrations than either other urban locations or the non-urban locations.

2.2 PRECURSORS TO NITRATE

Many of the measurements used to produce the average patterns of nitrate mass that are discussed here may be influenced by a sampling artifact. Some of the nitrate mass initially collected on Teflon® or glass fiber filter media (as is done in the Federal Monitoring Reference Method) can volatilize during the sampling period. This artifact contributes to an artificially low nitrate mass in some samples. This problem will be corrected in the U.S. EPA's Speciation network by use of nylon filters that absorb the volatilized gaseous nitrate. The observed nitrate concentrations in the following discussion were collected using a variety of sampling protocols and thus some of the nitrate concentrations may be higher than would be expected had the FRM been used.

The principal sources of NO_x, motor vehicles and all fossil fuel combustion, are much more ubiquitous across the country and, as a result, there is no recognizable gradient in the percentage of ammonium nitrate concentrations from east to west. The nitrate fraction, as a percentage of observed PM-2.5 mass, is also generally lower than or approximately the same as the sulfate component, although in some areas in the west, the nitrate fraction can be greater than the sulfate fraction. One exception, illustrated in Appendix A, is for data collected in the San Joaquin Valley where agricultural sources of ammonia might combine with NO_x from normal combustion sources to increase the amount of ammonium nitrate. Based on the data summarized in Appendix A, the fraction of nitrate rarely exceeds 20% of the total PM-2.5 mass at any location. Urban locations generally have concentrations of nitrate that are higher than in non-urban locations, indicating that urban sources of nitrate precursors are important. Some areas in the west appear to have larger nitrate concentrations than are found in the east. This is due in part to a lower concentration for the sulfate precursor SO₂ in much of the west.

2.3 CARBONACEOUS PARTICLES

Carbonaceous particulate matter represents a significant fraction of the observed PM-2.5 in many locations. The data summarized in Appendix A show that in the east approximately 25% to 40% of the PM-2.5 is carbonaceous, and in the west carbonaceous particulate contributes between 50% and 75% of the mass of PM-2.5. There is a consistent trend of higher absolute concentrations or carbonaceous mass in urban areas relative to nonurban areas. These results imply that a significant amount of the carbonaceous particulate is related to urban sources. A distinction has been made between elemental carbon and organic carbon to refine the identification of the sources of total ambient PM-2.5 carbon. These two forms of carbon can arise from fundamentally different types of processes. Organic carbon emissions are associated primarily with low temperature combustion processes such as biomass burning, while elemental carbon emissions result mainly from high temperature combustion, such as diesel engines. Tracking the two forms of carbon particles separately enhances the resolving power of source apportionment techniques relative to those based solely on the total carbon fraction.

The distinction between elemental and organic carbon is based on the laboratory measurement methods commonly used to analyze PM-2.5 ambient air particulate filters for carbon. Although a variety of analytical schemes have been developed to distinguish between organic and elemental carbon (soot), all of the methods expose a portion of the filter to a carrier gas stream within a heated oven where the particulate carbon on the filter is converted to a gas (carbon dioxide or methane), which is then measured by a detector. Since organic carbon is released at a lower oven temperature than elemental carbon, the temperature dependence can be used to distinguish between the two classes of carbon.¹

Nearly one hundred percent of the elemental carbon observed in ambient samples results from primary particulate emissions from fossil fuel and some biomass combustion processes that achieve high temperatures. These particles are produced primarily in the size range of less than one μm in diameter. Recent source apportionment studies indicate that motor vehicle sources dominate the elemental carbon observed on ambient samples taken in urban settings, with emissions from diesel exhaust contributing between 50% and 70% of the elemental carbon mass concentration. (Watson et al., 1998) Gasoline

¹ Definition of elemental and organic carbon is included in the draft of the Speciation Guidance Document (found under "Speciation" section of the AMTIC Internet Homepage). The analytical method (NIOSH Method 5040) can be found in Birch, M.E., 1998. *Analyst*. 123:851-857.

powered vehicles contribute around 25% of the total and much of that results from automobiles that may not be maintained at optimum performance. Small contributions associated with road dust may include resuspended tire wear particles.

Organic carbon represents the remainder of carbon containing particulate matter. This fraction includes contributions from primary particle emissions, condensed particulate, and secondary particulate. Motor vehicle sources contribute up to 80% of the organic carbon mass in urban areas, although commercial cooking and wood burning can also represent significant contributions in many locations.

Total carbonaceous material appears to be a consistently high contribution to PM-2.5 ambient concentrations in all urban areas, although the total concentrations might be slightly elevated in western urban areas relative to eastern urban areas. In general, non-urban locations are characterized by similar concentrations everywhere.

A significant fraction of these organic carbon particle mass may also be HAPs. More work is needed to evaluate the HAP fraction of PM-2.5. Likewise, some portion of these carbonaceous particles are secondary - formed in the atmosphere from VOCs and semivolatile gaseous precursors. Current thinking is that this secondary organic component of fine carbonaceous particles is low compared to primary organic particles, but more research is needed.

2.4 GEOLOGICAL (CRUSTAL) PARTICLES

Geological particles become airborne when crustal materials are mechanically disturbed. While sources of crustal material contribute up to 85% - 90% of observed PM-10 concentrations, analyses of ambient samples reveals only small contributions (10% to 15%) of crustal material to the total PM-2.5 in most locations. That trend toward small contributions from crustal materials is also seen in the data collected in Canada. (Brook et al., 1997) The primary sources of crustal material are agricultural tilling, construction activities, road dust from both unpaved and paved roads, and windblown dust. Crustal material contains common metals including Al, Si, K, Fe, Ca, and other trace metals. It is not expected that sources of crustal material will be significant in terms of control strategies for PM-2.5 in most areas. Although concentrations of crustal materials are low everywhere, there is a slight increase in urban locations relative to non-urban locations, implying that road dust and construction sources may be important.

2.5 RELATIONSHIP BETWEEN SOURCE MAGNITUDE AND AMBIENT CONCENTRATION

Estimates of the emissions magnitude for some sources of PM-2.5 are sometimes inconsistent with the resulting ambient concentrations measured at nearby monitoring sites. This effect is observed most clearly with respect to surface fugitive dust sources of primary emissions. The causes for these discrepancies are being investigated at this time. One cause appears to be related to the source measurement methods that have been applied in some recent monitoring programs of area and line sources (e.g., agricultural tilling, unpaved roads, etc.). Frequently, the source emissions rate is estimated using a procedure that measures the horizontal flux of emissions through a vertical plane in the downwind direction very near to the source activity. That measurement is then compared to a similar estimate immediately upwind of the activity and the difference is used to calculate the emission rate.

While this technique is thought to provide an accurate estimate of the mass emissions rate from the source, the approach may not accurately account for other influences that can serve to remove a portion of that mass before it is entrained into the transport layer. For example, nearby vegetation or other physical structures may retain some of the mass. Additional mass could be removed by adhering to larger particles that are deposited close to the source through gravitational settling. One hypothesis is that the portion of the emissions mass that can be transported to monitor sites is limited to the mass that rises above surface features and becomes entrained into the local and/or regional wind flow pattern. This problem seems to be confined primarily to near surface sources of fugitive dust. Emissions from most point sources released from stacks, and other surface combustion sources may be affected by heat induced buoyancy that serves to elevate these emissions into the transport layer.

EPA is currently coordinating with the United States Department of Agriculture (USDA), the Forest Service, and other experts with experience in these processes to refine the emissions estimation methods for these sources. Currently, the mechanisms that produce fugitive emissions and affect the transport of those emissions to potential receptor sites are not well represented in the emissions estimation methods. Therefore, the confidence in PM-2.5 emissions estimates from fugitive dust sources is low. A similar removal mechanism may also affect near surface releases of NH₃ and other noncombustion related emissions of the gaseous precursors to secondary PM-2.5. (Duyzer, 1994)

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3

OVERVIEW OF EMISSION FACTORS AND INVENTORY METHODS

3.1 INVENTORY DEVELOPMENT PROCEDURES

Emission inventories are the basis of essentially all air quality management activities. Inventory data can be applied to a variety of analyses and for several different purposes. Similarly, inventory data can be prepared using different methodologies, with specificity and detail consistent with that required for the particular application.

Emission factors are often applied to common activity data to develop emission estimates. Emission factors can also be estimated using a variety of techniques, each with its own specificity and accuracy for different applications. In other cases, emission rates depend on some other variable(s) (e.g., temperature, wind speed, soil moisture, or process parameters). In those cases, an algorithm is applied to estimate emissions for the particular set of conditions. Under certain circumstances, emission factors and emissions estimation techniques are applied to sources and/or for analyses other than those for which they were developed. This situation arises most frequently in analyses of emerging air quality issues that are based on an incomplete foundation. Currently, this situation can affect some sources important in PM-2.5 planning activities. The following discussion will serve as a brief introduction to the various approaches used to develop emission factors and other inventory estimation methods. The discussion is provided to assist readers in understanding the strengths and weaknesses of these various approaches, and to prioritize those activities that could improve the understanding of PM-2.5 issues in specific situations and locations.

3.1.1 Direct Measurements and Indirect Estimation Approaches

Generally, direct measurements of emissions from specific sources provide the most accurate emission factors and emissions estimates. For this reason, EPA encourages sources to conduct direct emission factor tests. Unfortunately, the source testing required to obtain these direct measurements is expensive and even direct measurements can produce misleading results for sources that have variable operating characteristics. In

addition, EPA allows the use of emissions reference methods for testing to facilitate consistency among different sources and to increase the reliability of emission factors when they are applied to other untested sources with the same operating characteristics. These EPA methods should be used to the maximum extent possible in conducting both direct and indirect emission factor tests. There is no established EPA test method for PM-2.5 at this time. In some cases the emissions reference method itself can produce, either by design or inadvertently, a biased or incomplete result. For example, the Method 201 sampling train for particulate matter, adapted for PM-10, specifies that the sample line be heated to ensure the collection of only the filterable fraction. This particular situation does not present a significant problem for PM-10 analyses, since in most cases, the contribution of the condensable fraction, mostly less than one μm in diameter, is often minimal in terms of the total PM-10 mass.

The application of the Method 201 sampling train, with modifications to produce a size cutoff for PM-2.5 (to be termed Method 201B), is useful for measuring the filterable component of PM-2.5 emissions. Alternatively, conventional particle sizing techniques, such as cascade impactors, can be used to obtain filterable PM-2.5 emission factor data. Method 201B, however, would not represent accurately the mass of the condensable fraction of PM-2.5. For PM-2.5, this approach can create a considerable bias, particularly for some combustion sources. For example, the emission factor for the condensable fraction of PM-2.5 from natural gas combustion is three times the factor for the filterable fraction. (EPA, 1998b)

EPA encourages sources to include condensable particulate matter testing for sources that generate significant quantities of vapor phase material that would pass through a conventional filterable particulate sampling train. Currently, the EPA test method for condensable material is Method 202. Method 202 yields only the mass in a solvent extraction and the mass in an aqueous extraction after the sample is drawn through a water impinger. Therefore, this method precludes any further speciation to assist in understanding the nature of the condensable material. Resolution of the component species in the condensable mass may be required for use in receptor modeling studies. Direct measurements will still provide the most reliable estimates of emission rates for PM-2.5, but different methods will be needed to accurately capture the total (filterable plus condensable) PM-2.5 mass. EPA is working on the evaluation of methods for this purpose, but it will be some time before an EPA method is published for PM-2.5.

Indirect measurements are also often used in inventory development for sources and source categories that do not lend themselves to direct source sampling. Indirect measurement methods can be most effective for source categories that consist of a large number of individual sources that are highly consistent in their emissions characteristics or for sources that are spread out over large areas. Emission factors based on a representative sample of the total population of sources can then be applied with a high

degree of reliability to the activity associated with the collection of all individual sources. An example is emissions from residential natural gas combustion sources. These units all operate similarly and an emission factor based on a representative sample provides a very reliable estimate of the emissions from all residential natural gas combustion. Therefore, indirect monitoring of the amount of natural gas consumed, allowing for theft and leakage, can be used to prepare the emissions estimates for these sources. Typically, emission factors based on indirect testing reflect the results of a few to more than 30 emission factor tests at different plants. The confidence level in the representativeness of an indirect emission factor increases as the number of individual sources that were tested increases and as the inherent process variability decreases.

Similarly, emissions for either agricultural burning or prescribed burning can be estimated from an equation that relates the emissions to parameters that describe the site, including the type and quantity of fuel burned, moisture content, etc. Indirect monitoring of the controlling parameters at the site to be burned can often be used to calculate a reasonable estimate that will represent the total emissions from a burn in that area. This type of estimate, which can also be applied to other source types, is considered indirect monitoring.

For sources with fugitive emissions, the emission factor test program should use well established fugitive capture techniques such as quasi-stack enclosures, ‘roof’ traversing, and upwind-downwind vertical emissions profiling. These techniques are among a number of fugitive emission capture techniques described in emission factor tests cited in AP-42. If innovative fugitive emission capture and testing techniques are required due to the specific characteristics of the source being tested, these techniques should be fully described and their limitations should be discussed in the test report. The release of tracer compounds within the plume of a fugitive emission source may improve the confidence in the test results. Test methods that rely in part on “back calculating” emissions from downwind ambient measurements using dispersion modeling are less desirable than capture techniques or vertical emissions profiling because of the additional assumptions required in the dispersion modeling.

3.1.2 CEM Data versus Application of Emission Factors

For some specific applications continuous emission monitors (CEMs) can be used. CEMs are monitoring techniques that measure emissions in a stack and record the concentration data to electronic storage media on a continuous basis. The best example of the use of CEMs for inventory purposes is found in the acid rain program (Title IV of the CAA). As part of the acid rain program, all affected utility and industrial combustion sources are required to install and operate CEMs to track total emissions of SO₂ and NO_x on a continuous basis. CEM type monitoring has the advantage of reflecting actual in-use emissions, including upsets and other unusual events. An obvious drawback of CEMs is

the significant cost associated with the purchase, installation, operation, and maintenance of these systems. Another drawback of using CEMs for inventory development purposes is that large amounts of data are generated and converting all of these data into useable formats takes some effort and time with obvious cost implications. CEMs for application to PM-2.5 source testing will not be available until there is a FRM.

An emission factor is usually developed from a set of direct source emission tests. Frequently, the test series is designed to represent the typical range of size and operating conditions for that source type. If the average mass emission rate, expressed as a function of some readily available process related parameter, is constant, the average factor can be applied to all sources that fit the conditions of the test series. Often different factors are required for different size ranges or categories of operating conditions, but the average factors developed in this way are always applied universally to all other sources in the category, whether or not they were tested directly. These factors can then be applied to estimate emissions based on more easily measured activity data. For example, emissions of SO₂ from coal combustion can be estimated reliably based on measurements of the amount of coal burned and the average sulfur content of the coal. Emission factors provide emissions estimates with a high degree of confidence as long as the source matches the operating conditions of the sources that were tested to develop the emission factor. The reliability of emission factors decreases when only a few source tests are used to develop the factor. Emission factors based on a small number of tests may not reflect operational variability and application of these factors could introduce bias in emissions estimates when the operating conditions vary. The user can consult the background document for a particular emission factor in AP-42 to determine the number and type of tests used to develop the factor.

3.1.3 Area and Mobile Source Estimation Methods

Not only is it difficult to measure emissions directly from most area and mobile sources, but is it often difficult to measure spatially and temporally resolved activity data as well. Often, measures of the relevant activity can be estimated at the State-level or National-level through economic or other indicators that represent a particular activity. For some applications, acceptable estimates of emissions can be developed by applying an assumption to represent the distribution of that total to smaller spatial scales. In other cases, this approach can introduce unknown bias. For example, PM-2.5 emission estimates for construction activities in the National Emissions Trends (NET) inventory are based on activity estimates that are derived from total annual dollars spent on construction activity at the EPA region-level. These estimates are then allocated to counties using a procedure that depends on construction costs and estimates of acres under construction in each county. Obviously, this technique will result in approximations that will match actual county-level construction related emissions at varying degrees of accuracy. This is an example of a category for which locally obtained

activity data can substantially improve an emission estimate. Other area source emissions estimates are based on State-level activity data that is then allocated through population, land use, or some other surrogate distribution factor.

Fires are important sources of PM-2.5 emissions in many locations. Prescribed burning (planned burning of natural areas), slash burning (land clearing), wildfires and to a lesser extent agricultural field burning can all contribute to ambient PM-2.5 loadings. While it is possible to measure the acres burned or biomass burned in the case of slash burning during these activities, other estimates about the fuel loading, moisture content of the fuel, and estimates of the specific wood types burned need to be estimated. This can be done by applying measurements that have been made in other nearby or similar land use types. The uncertainty associated with this kind of indirect emission estimation procedure is related to how well the assumptions on fuel type and fuel loading match the conditions of the area burned.

Similar issues arise when estimating emissions from mobile sources. Most mobile source emissions are calculated by applying an average emission factor expressed in terms of grams per vehicle mile traveled (g/VMT). Those factors are developed from a subset of actual in-use vehicles and are frequently based on controlled tests using a dynamometer. Those factors are then applied to an estimate of the total VMT at county resolution. Differences in the mix of vehicles, especially for heavy-duty diesel vehicles, or temporal activity patterns in any given area can introduce unwanted bias into the emissions estimate.

3.2 TYPES OF INVENTORIES AND INVENTORY APPLICATIONS

Planning for the development of an emission inventory depends on the type of air quality planning analysis it is intended to support. For example, approaches based on National-level or State-level activity data, and subsequent allocation to county or nonattainment area scales, can be useful for tracking trends or for evaluating air quality management programs over time. Those approaches are often referred to as top-down methodologies. In some cases, top-down methods provide reasonable estimates and improvement using local information is impractical if not impossible. In many instances, however, inventories at that level of detail are often inadequate for other more rigorous air quality management activities. For example, inventory improvements are usually needed to support an attainment demonstration and the development of a control strategy. That inventory needs to be source specific, spatially allocated to the correct scale, and representative of temporal variability that can affect the outcome of modeling exercises.

A discussion of the various types of inventories that can be developed and the types of analyses they support can be found in another document prepared by the Emission

Inventory Improvement Program (EIIP). (EIIP, 1997a) The level of detail needed in the emissions data to support the activities indicated decreases from Level 1 to Level 4. The categories of inventories discussed in that report are listed below:

- Level 1 - Source specific, used for permit and compliance programs;
- Level 2 - Urban scale, used for State Implementation Plan (SIP) and other large scale planning activities;
- Level 3 - Industry wide, applications that do not drive regulatory issues; and
- Level 4 - National and international Greenhouse Gas (GHG) issues.

Inventory issues in PM-2.5 planning will include: developing a baseline understanding of local and regional influences, reasonable further progress (RFP) planning and demonstration, modeling attainment demonstration, periodic inventories, emission statements, VMT reduction and transportation control measures (TCM) planning, regulatory development and cost analyses, etc. These examples are not inclusive of all of the applications of inventories in air quality management. Many of these analyses can build off of different levels of specificity and detail in terms of both specific emissions estimates and temporal or spatial resolution. The specific types of inventories required will be dependent on the types of analyses that need to be completed and the specifics of the particular areas. Some selected examples of specific types of analyses and the inventory needs to support those analyses are listed below:

- Emission control development and attainment modeling activities need source specific inventories with process level resolution. PM-2.5 programs need these data for the entire nation for both base-year and future-year controlled cases. These programs need estimates of primary, condensable and secondary contributions, representative temporal distributions, spatial allocation of nonpoint sources, and speciation profiles.
- Inventories with similar detail are needed for related air quality management activities, including source identification and prioritization, rule development, cost/benefit analyses, and compliance monitoring.
- RFP analyses can be based on inventories at lower resolution to track overall emission reductions or specific reductions from sources that have been controlled, combined with other broader growth estimates for the remaining parts of inventories.
- Emission statements can be prepared at industry level resolution, but may not need the species and temporal resolution required for air quality modeling to validate adoption and effects of emissions control rules.

The definition of a base-year has significant implications in PM-2.5 planning. First it will be necessary to define one base-year for all parts of the country to promote consistency in regional modeling analyses. The base-year needs to have a sufficient amount of appropriate

monitoring data available to ensure that the specific problems that need to be addressed are identified. Specific areas will have to evaluate the occurrence of natural events, unusual meteorological conditions, and any other external factors that could be affecting that base-year. Guidance on the development of PM-2.5 inventories has been posted through the EPA TTN Internet page. A cover memorandum explaining the implementation issues can also be found at the same TTN location. These documents can be found at the following Internet address:

<http://www.epa.gov/ttn/oarpg/t1p1gm.html>

3.3 LEVEL OF DETAIL IN ACTIVITY DATA, EMISSIONS FACTORS, AND PROJECTION FACTORS

As mentioned earlier, many emission estimation methodologies for area and mobile sources depend on activity data that is itself hard to monitor directly. VMT for highway mobile sources, hours in operation for many off-highway mobile sources, and fuel use in residential wood heating are examples. This poses particular problems for PM-2.5 planning efforts since area and mobile sources represent such a large percentage of the overall emissions totals. This situation is similar to the problems encountered in developing inventories for VOC and NO_x to support ozone planning. Estimating emissions from both highway and off-highway diesel vehicles is a good example of this problem. Diesel vehicles will contribute a significant portion of elemental carbon found in most locations. A small number of dirty vehicles can contribute a large percentage of the overall emissions from mobile sources. The available methodologies for estimating VMT for highway sources and hours in operation for heavy diesel off-highway sources do not consider specific types of vehicles and assume that all vehicles are operated at conditions that are near optimum efficiency. Concerning highway vehicles, this problem is compounded by the fact that the VMT estimation method is targeted primarily to count gasoline-powered vehicles (passenger cars) and may introduce bias when applied to area wide estimates of the number of heavy-duty diesel vehicles.

Emission factors and speciation profiles are often developed for specific sources but are then applied as is or with minor modifications based on engineering assumptions to other related sources. It is possible that surrogate factors and/or size and speciation profiles will be used in early PM-2.5 planning activities, simply because factors and profiles will not be available for all sources. Many of those factors and distribution profiles that are available were developed several years ago, and may not be representative of current operating and production conditions.

Projection factors are frequently based on broad economic forecasts of industry sector growth. This technique does not consider changes in technology, productivity, and other

issues that can influence the emissions relative to the projected growth assumptions. Growth factors are important because they are used to determine the emissions inventory in the attainment year for the purposes of developing the control strategy and attainment demonstration. Although the industry average growth assumptions can serve as a good starting point, the assumptions and factors should be modified to reflect local conditions. Per employee factors, per capita factors, and per unit area factors are particularly difficult to apply in this context. An updated version of the Economic Growth Analysis System (EGAS Version 4.0) is expected to be available in the spring of 1999. EGAS uses econometric principles to develop growth forecasts for industry sectors that are specific for urban areas. The forecasts of sector growth can be modified based on the overall mix of major industries and service activities in each area. The new system will include several upgrades related to projecting future activity in the utility and mobile source sectors specifically. EGAS was developed primarily for application to ozone precursors and therefore may not be useful for some of the important PM-2.5 sources. Information on EGAS can be found at the following Internet site:

http://www.epa.gov/ttn/chief/ei_data.html#EGAS

3.4 INVENTORY DEVELOPMENT TOOLS

EPA is developing a set of tools to assist the States in the preliminary evaluation and planning for PM-2.5 to support future air quality management activities. Currently, EPA has compiled an inventory of PM-2.5 emissions for all counties based on the current understanding of emissions processes and availability of emission factors. That inventory is included as part of the 1996 NET inventory database and is intended to support the States in preliminary assessments of important issues, and to help prioritize future planning and development efforts. The 1996 NET inventory and updates to the NET inventory that will be developed over the next two years will serve as the preliminary basis for future planning purposes. These planning activities will also support the development of improved national inventories that are needed to support regional modeling efforts. EPA is also supporting efforts to bring all of the various methods for estimating area source emissions together into a single shell program to assist in the development and improvement of PM-2.5 emissions data. It is anticipated that the computer program, referred to as the Area Source Emissions Model (ASEM), will be available for State use sometime in the Fall of 1999. Some of the features of the 1996 NET inventory and the ASEM are discussed in this section.

3.4.1 Summary of the NET Inventory

The National Emissions Trends (NET) inventory for 1997 represents EPA's most recent and most complete National-level air emissions inventory. (EPA, 1997, EPA 1998c) The NET inventory has evolved from the 1990 Interim Emissions Inventory, although the database does include several more detailed and specific estimates. The NET inventory includes estimates of annual and summer day emissions for VOC, NO_x, CO, SO₂, PM-10, PM-2.5, and NH₃. Emissions are estimated for all States and the District of Columbia. Point source emissions are reported at the AIRS segment/SCC-level, and area and mobile sources are reported at the county/SCC-level.

The NET inventory is the result of one of EPA's standing commitments to distribute an assessment of air quality and emissions trends over time. These trends inventories have historically been useful for tracking progress of air quality management programs and in demonstrating a relationship between control programs and improvements in air quality. The NET inventory was developed with significantly more process-level detail than many previous National-level inventories. One reason for improving the detail is simply to take advantage of other programs that have developed more complete and specific inventory data. Another reason is to provide a National-level inventory with sufficient detail and coverage so that it can be used by States as the basis for their preparation of the 1996 Periodic Emissions Inventory (PEI).

A version of the NET inventory for 1998 is currently in development. Updated CEM and VMT data will be applied to the 1997 database, which will yield final utility and onroad emissions. Thus, once the 1998 NET inventory is complete, the 1997 data will also be updated.

State-specific data developed to support the Ozone Transport Assessment Group (OTAG) analyses in the eastern United States and similar data developed by the Grand Canyon Visibility Transport Commission (GCVTC) in the west were used to overwrite emissions developed by EPA. These data were compiled in State supported collaborative efforts and are believed to be more representative and detailed than any data that can be prepared at the National-level. The exceptions are on-road mobile categories for which State-specific data were not used (other than VMT), and utilities. Data for utilities were taken directly from continuous emission monitors (CEMs) from the acid rain program, and Department of Energy Survey Forms (DOE Form 767).

The methodologies applied to prepare the NET inventory for emissions for States in other regions and for source categories that were not of interest in OTAG and/or GCVTC are summarized in Table 3.1. A more detailed discussion of the inventory preparation methodologies applied to the NET inventory can be found in a document titled "National Air Pollutant Emissions Trends Procedures Document 1900 - 1996," (EPA, 1998c) which can be

found at the Internet address provided below. Data summaries for PM-2.5 emissions can also be found in the trends update section at the Internet address below. More detailed estimates of PM-2.5 for States and counties will be available through this Internet page in the future.

<http://www.epa.gov/ttn/chief/trends97/emtrnd.html>

The nature of the PM-2.5 problem requires both regional and local analyses for solid forms of directly emitted fine particles, condensable fine particles, and those formed as secondary particles through chemical reaction in the atmosphere. Emissions data are required for NO_x, SO₂, and NH₃ to serve as input to models that will simulate the regional formation of sulfate and nitrate secondary particles, VOC to evaluate the formation of secondary organic aerosol, as well as PM-2.5 that is directly emitted in both solid form and condensable form. States will need to estimate the emissions of these precursor gases. Models will be used to estimate how much PM-2.5 is formed by them in the atmosphere. As a result, the effort that will be required to develop the emission estimates to support this complex air quality planning effort may be, in many ways, more demanding than those completed in the past for other criteria pollutants. The 1996 NET inventory provides an excellent starting point for this effort. States are encouraged to review the data and the description of the methodologies used to develop the data, and use that process to help assess the apparent strengths and weaknesses of the inventory and to prioritize future inventory development efforts. As States develop improved estimates for specific source categories, they will be encouraged to share those data with EPA for application to an improved base-line National inventory of PM-2.5 for the 1999 base-year.

General data quality assessments of the emissions of PM-2.5 and its precursors in the draft NET inventory are provided below. States are encouraged to make their own data quality assessments based on the nature of the PM-2.5 that affects the State (e.g., transport, locally generated, secondary) and the source mix that is suspected of contributing to high PM-2.5 concentrations in any given area.

NO_x In general, the quality of the NO_x data is good. Data from large utilities are available from CEMs through the acid rain program. Data from other nonutility point sources have been supplied through OTAG and GCVTC. States are encouraged to review the data and make any additional adjustments based on local conditions and data sources.

VOC Nonutility point source data were supplied through OTAG and GCVTC. Other solvent use data are not as reliable. Some of the estimates are based on old studies and grown to represent 1996 activity levels, and others are based on national mass balance and are allocated to county-level by surrogate distribution factors. States can significantly improve these estimates based on more detailed and specific information.

TABLE 3.1 1996 NET INVENTORY DEVELOPMENT METHODOLOGY

Source Category/Sector	Methodology
<u>Utilities</u> SO ₂ and NO _x VOC, CO, PM, NH ₃	The data is CEM data from acid rain program where available with DOE 767 Survey/AP-42 used to replace data gaps. DOE 767 Survey data (throughput, controls, and fuel characteristics) with AP-42 emission factors.
<u>On-Road Mobile</u> CO, VOC, NO _x PM and SO ₂ NH ₃	MOBILE5b; HPMS VMT data; State provided MOBILE inputs including 1990 registration distributions, I/M programs, and summer RVP data, supplemented with national 1996 registration distribution, OMS I/M program data, AAMA survey RVP data; OMS control program data for RFG and oxyfuels; State-level/monthly temperature data; national vehicle/road type speed data. PART5; same VMT and registration data as used for CO, VOC and NO _x . Emission factors based on Volkswagen data applied to the pre-1996 fleet; same VMT as for other pollutants. NH ₃ emissions for subsequent on-road mobile categories will be based on factors derived by OMS.
<u>NH₃ Agricultural Sources</u>	1990 emissions grown to 1996 using BEA earnings data. Further adjustments will be forthcoming from Census of Agriculture data.
<u>PM Fugitive Dust Sources</u> Paved and Unpaved Roads Agricultural Tilling Construction Wind Erosion	Same as the on-road emissions. A correction factor to account for precipitation was added to the unpaved road estimates. Controls were applied. AP-42 EF's, 1996 CTIC tilling data and tilling practices. New Emission Factors with default EPA correction parameters projected with 1996 Bureau of Census data. Controls are applied. Modified/simplified 1985 NAPAP methodology.
<u>Open Burning</u> Wildfires Prescribed Burning Agricultural Burning	AP-42 emission factors applied to acres burned and fuel loading data from DOI and the Forest Service. Based on 1989 Forest Service inventory for prescribed burning with specific emissions based on the ratio to 1985 NAPAP base. 1985 NAPAP inventory grown with BEA growth assumptions.
<u>Other Sources</u> Non-utility point sources and all other area sources Non-road Mobile Sources	1990 to 1995 emissions grown with BEA growth factors and 1990 CAA controls applied. For selected States data were grown from 1995 AIRS/AFS submittals. NONROAD national emissions model developed by OMS.

Source: National Emissions Inventory Documentation Attachment A (<http://www.epa.gov/tn/chief>)

- SO₂, CO Emissions estimates for utilities and on-road mobile sources are considered to be representative and accurate. Estimates for other sources are primarily based on the older databases with growth factors applied. State review and replacement will improve these estimates considerably.
- PM-2.5/-10 Many of the estimates of directly emitted PM-2.5 emissions are based on the application of a scaling factor that is derived from size distribution functions that were available from analyses that supported PM-10 planning efforts. For most sources, these emissions estimates are thought to be representative of the source strengths. Those source strengths, however, are inconsistent with ambient air quality speciation data, which implies that a portion of PM-2.5 emissions that emanate from the Earth's surface ultimately are removed by some mechanical or chemical deposition process. Differences between the spatial and temporal nature of the inventories and air quality data are also likely to contribute to discrepancies. Therefore, emission estimates for PM-2.5 from fugitive sources are suspect and in need of improvement. While EPA is working to improve the understanding of these processes, States are encouraged to review these data and provide any additional data or supporting databases that could be used to improve these estimates.
- NH₃ NH₃ is the least understood of all of the precursor species for secondary PM-2.5 formation. States are encouraged to review the data in the NET inventory to evaluate the relative importance of NH₃ in each State and to begin to collect and assemble any data that would be useful to develop improved and more specific emissions estimates. Specifically, States can begin to collect activity data representative of suspected major NH₃ source categories.

3.4.2 Development of the Area Source Model

EPA is currently conducting an effort to assemble the principal computer-based numerical tools that are used to develop and/or estimate area source emissions and link them together under an umbrella shell. This collection of tools is referred to as the Area Source Emissions Model (ASEM) and when finished, it will be made available to States to assist in the development, evaluation, and quality assurance of PM-2.5 area source emissions estimates. The ASEM can also be used by the States to prioritize, plan and eventually to improve both the basic activity data for area source categories of emissions of PM-2.5 and the precursors to PM-2.5, and the emission factors, size distribution functions, or assumptions related to emission rates for various sources.

The ASEM and the users manuals will be developed to be consistent with the methodologies used to prepare the draft 1996 NET inventory, other inventory development guidance, and inventory requirements documents that are being developed by EPA. The ASEM will include area source emissions estimation procedures for PM-2.5, SO₂, NO_x, and NH₃. To the

extent possible, the ASEM will use input activity data that is already collected for other inventory applications. For some particular source categories, additional types of activity data will be necessary as well. With the exception of source categories handled by other EPA models such as PART5, and NONROAD developed by EPA and the Wind Erosion Prediction System (WEPS) developed by USDA, the program will contain default activity data for most, if not all, source categories. Emissions of PM-2.5 could be generated using these default data. States will also have the opportunity to substitute more detailed and complete locally generated activity data and/or emission factors for nearly all categories. In many cases, the default activity data included in ASEM can be improved by substituting local data that is more representative.

A review of the nature of the source magnitudes, the quality of default emission factors and other considerations associated with PM-2.5 planning efforts will help States to prioritize and plan their inventory improvement needs. States should focus limited resources on efforts to improve emissions estimates for the most important sources and source categories affecting the planning area. Once the improved activity data are developed, the ASEM will apply emission factors and calculation procedures to develop a county-level emissions inventory for PM-2.5 for whichever counties are selected. The ASEM is expected to be available for testing in the fall of 1999.

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GETTING STARTED: PLANNING FOR THE DEVELOPMENT OF A PM-2.5 INVENTORY

Air quality management requires a detailed understanding of the local and regional processes that result in high ambient concentrations of the target pollutants. That understanding serves as the foundation for a comprehensive plan to reduce the relevant emissions magnitudes to levels that will result in acceptable ambient air quality. In nearly all cases, that planning effort is based on modeling analyses. While there are many technical considerations that affect the design of modeling scenarios and the interpretation of modeling results, emissions data are one very important input to those models. An accurate and comprehensive baseline emissions data set, resolved to be consistent with the controlling meteorological scenarios, is needed to evaluate model results against current and historical ambient air quality measurements. Meteorological data representative of the appropriate conditions that give rise to high ambient concentrations are also critical for these analyses. Future-year inventories are required to test the net effects of population growth, industrial growth, and source-specific control measures.

In most locations, ambient measurements of PM-2.5 include a significant mass fraction of secondary particulate. In the east, ammonium sulfate is the primary component of secondary particulate. The SO₂ precursor for sulfate formation comes primarily from power plants and other coal-fired and oil-fired boilers, and the ammonia precursor is emitted largely from agricultural activities. The sulfate precursors interact under typical large scale meteorological conditions found in the east to produce a relatively uniform regional contribution to PM-2.5. The nitrate aerosol precursor NO₂ arises primarily from transportation and energy generation sources. The nitrate components represent a somewhat larger fraction of the ambient PM-2.5 in the west, than in the east, but the distribution is fairly uniform within the regional areas. Primary emissions of carbonaceous particles from motor vehicles, biomass burning, and industrial sources are likely to make up the bulk of the controllable PM-2.5 in many areas. Although primary particle emissions can contribute to regional PM-2.5 distributions, the effect of primary emissions on air quality are more likely to be dependent on local influences of source mix, meteorology, and terrain features than are the major secondary components.

Source apportionment models and dispersion models can be used to identify and prioritize the most important sources affecting an area and to determine the relative contributions of those sources to the ambient mass loadings. Once the major source contributions are known, an effective control strategy can be developed. Source apportionment and dispersion modeling studies will be most useful to evaluate contributions and to identify control options for local sources.

It is likely that regional modeling analyses will also be necessary to track the large-scale transport processes and chemical transformations that result in secondary aerosol. Regional modeling is also necessary to provide boundary conditions for modeling local sources in subregional-level planning. The regional modeling studies will provide an understanding of the interrelationships among different primary sources and sources of precursors to secondary particle formation. That level of understanding is necessary to develop effective control strategies for PM-2.5 in most areas. Emissions data need to be spatially resolved into a grid cell system, temporally allocated to hourly values, and chemically allocated into the individual species that interact in the controlling chemistry before they can be used as input for these air quality models.

One approach that has been used to evaluate large scale regional air quality issues involves nested modeling. In this approach, the modeling spatial resolution begins with a relatively coarse grid size of up to 80 km on a side. The spatial resolution is increased in steps for subregions that surround the planning area. The most detailed level of resolution is frequently a grid system as small as 2 km on a side to describe the urban area. Each level of resolution is used to provide boundary conditions for the smaller scales and to account for the main large scale emissions and meteorological influences that effect the local area. The region included in the most coarse grid system can extend over an area with dimensions of 1,000 km on a side and can include several States.

These analyses will be similar in nature to investigations of the large scale influences of small particles on regional haze on the Colorado Plateau that were completed by the Grand Canyon Visibility Transport Commission (GCVTC). For States east of the Mississippi River, the efforts to evaluate the effect of regional NO_x emissions on ozone concentrations that were completed for the Ozone Transport Assessment Group (OTAG) is an example of this kind of analysis. Discussions of these programs that describe the planning that went into them and the conclusions that were developed can be found at the following Internet sites:

<http://www.epa.gov/ttn/otag/>

<http://www.nmia.com/gcvtc/>

Air quality management plans are composed of many different parts. While each of these parts is linked to emissions data, inventories that differ in detail in terms of source specificity, pollutant specificity, spatial coverage, and timing can be applied to different planning activities. This section discusses some of these issues from the perspective of assessing

priorities for inventory development and gives some ideas of the principal issues that might influence inventory preparation. Whenever possible regional or geographical influences will be discussed to assist in identifying specific planning issues that will effect spatial and temporal scales for inventories in different parts of the country. The following discussion addresses influences that effect spatial and temporal scales separately. This organization is used only to simplify the presentation of the important issues, and the reader should understand that these two influences act together to control the emissions characteristics in myriad ways. This is particularly true in PM-2.5 planning since certain spatial influences operate within specific temporal regimes. The combined effects of the spatial and temporal influences can have quite different results when planning in response to high 24-hour concentrations or for high annual concentrations.

4.1 ASSESSING PRIORITIES

This report has pointed out some of the interrelated issues that will affect planning activities for developing PM-2.5 inventories. The variable origins of PM-2.5 will present challenges for effective planning to address the range of sources that influence PM-2.5 concentrations. While some of the sources of PM-2.5 can be treated with refinements to the approaches historically used in PM-10 planning, there are additional area sources of PM-2.5 and the precursors to PM-2.5 that have not been important in any planning activities completed previously. For example, PM-2.5 planning will require comprehensive estimates of emissions of NH_3 to understand the processes leading to secondary particle formation. It will also be useful to differentiate between elemental and organic carbon from primary PM sources to support regional haze programs, as well as for use in receptor modeling analyses. Initially, States will have to prioritize efforts and focus on the causes of high PM-2.5 concentrations in their State and other affected nearby States, and the sources that can be controlled.

EPA anticipates that the majority of planning activities will focus on the causes of and control of sources that result in high annual concentrations of PM-2.5. Emissions estimates may need to be developed with monthly resolution to address the strong temporal influences that affect sources of PM-2.5 and precursors to PM-2.5. In local areas, additional processes that vary over shorter time scales might also be important; therefore, additional temporal resolution may be required in some areas.

While it is expected that there will be common contributions to the PM-2.5 problems in all areas, it is almost certain that different States will identify different basic scenarios that result in the high measured concentrations of PM-2.5. Planning to address these problems will be facilitated by continuing a partnership between EPA and the States and among the States. EPA will be providing tools to assist in the analyses of sources and emissions that are ubiquitous. Each State will have to develop its own tools to address the specific local influences. States should explore opportunities to share the results of their work with each other so that each State will not have to expend limited resources on all of the possible

problems. To that end, each State should focus on developing tools and improving the activity data, emission factors, and/or emissions estimation methodologies for the important sources in their local planning areas that can be controlled to help reduce ambient concentrations. The application of the National-level tools being developed by EPA, other methodologies and emission estimation tools developed by other States, and any specific tools developed within each State will provide resources to begin the planning process. It is recognized that as the program develops and the collective experience in PM-2.5 inventories matures, additional refinements and improvements in the inventory development will be available.

4.1.1 Use of Ambient Data to Establish Priorities

A review of all available ambient monitoring data can often provide insights that can help establish planning priorities while emissions inventories are being prepared and adjusted during the initial planning efforts. Initially, ambient data can be applied intuitively to evaluate conditions that affect a given area. Preliminary applications of ambient data are discussed briefly here, while more formal applications involving source apportionment modeling are discussed later in this report.

Currently, ambient PM-2.5 and composition data are limited. The monitoring network using the reference method for ambient PM-2.5 is being established and results from those monitors will become available in the near future. These data can be useful to develop an overview of the spatial and temporal patterns of PM-2.5 in particular areas. Comparison of these patterns with the distribution and operating schedules of the known sources of PM-2.5 can help establish high priority emissions categories that are important on both the local and regional scales. As a simple example, high PM-2.5 concentrations in the winter might indicate that residential wood combustion is an important source, while high concentrations in the summer might lead to the conclusion that other open burning sources, like field burning or prescribed burning, are important.

Some of the samples from the ambient PM-2.5 monitoring network will be analyzed for components. As these speciated data become available, patterns associated with ambient samples and the likely sources that contribute to the ambient concentrations can be refined. It will be possible to draw conclusions about the relative contributions of mobile, industrial, and combustion sources. When a sufficient amount of high quality data are available, these types of analyses will lead to the identification of the principal sources that should be used in more rigorous source apportionment type modeling. As the monitoring record gets larger it will represent more of the conditions that control PM-2.5 formation, and the preliminary analyses can be refined to reflect that improved understanding of the nature and causes of high PM-2.5 concentrations.

It is not necessary to wait until there are several years of monitoring data available to begin this process. There are significant opportunities to begin these evaluations to help set

priorities early in the monitoring program. Even the appearance of the filter can help understand some of the gross features of the primary sources. A very black appearance would indicate that elemental carbon is dominant while a grey appearance would suggest that other origins of PM-2.5 are present in significant quantities. More information on planned activities related to the collection, analysis, and applications of ambient data on PM-2.5 and its precursors can be found at the following Internet page. This page also includes an extensive list of researchers interested in PM-2.5 issues with an emphasis on ambient monitoring and source apportionment.

<http://capita.wustl.edu/PMFine/>

4.1.2 Use of Emissions Data to Identify Potential Key Sources

Ambient PM-2.5 concentrations in many areas could result from ubiquitous sources that are found throughout the country (e.g., automobiles and stationary fuel combustion) and certain specific local industrial or commercial sources that are unique in a particular area. In many cases, it will be possible for planning agencies to identify possible missing or poorly represented sources by assessing the existing draft emissions inventory of PM-2.5 and its precursors available through the 1996 NET inventory and in periodic updates that are planned for that database.

The NET inventory is focussed necessarily on sources that are known to be of importance nation-wide. That inventory is also based largely on source categorizations and activity data estimates that have been applied for planning activities associated with other criteria pollutants. The NET and other databases that have developed for regional programs, such as the Grand Canyon Visibility Transport Commission (GCVTC), Southern Appalachian Mountain Initiative (SAMI), and the Ozone Transport Assessment Group (OTAG), can be reviewed to determine the completeness of source activities represented in those databases and the applicability of the activity data and emissions estimates to future PM-2.5 planning exercises. States are encouraged to review these databases to determine if there are significant local and unique source categories that are poorly represented in those databases.

This type of information will help States prioritize their efforts on collecting information that they can use to supplement those National-level or regional-level data. States should consider programs to develop source speciation profiles, spatial and temporal allocation factors, and activity data, in addition to, emission factors and other process characteristics that affect emissions.

4.2 DETERMINING APPROPRIATE SPATIAL SCALES FOR INVENTORIES

Assessment of the limited PM-2.5 ambient monitoring data leads to the observation that PM-2.5 air quality in different regions often results from different combinations of influences. There are certainly contributions to PM-2.5 air quality that are ubiquitous (e.g., carbonaceous components from diesel engines), but there are also significant contributions to PM-2.5 that vary on local and regional scales. An obvious example of a local influence is residential wood burning. For example, wood burning for residential heating will affect ambient PM-2.5 in many suburban and rural areas. An example of a regional influence is the observed contribution of ammonium sulfate that contributes roughly 50% of the ambient PM-2.5 in most samples in the east, but only 20% or less throughout the west. States should review all of the data that is available to understand the origins of PM-2.5 in their areas during periods of high ambient concentrations. Then States can begin a preliminary assessment of the sources of both primary PM-2.5, including the condensable components, and the precursors to secondary PM-2.5 that are important in those areas. Some of the spatial influences that need to be considered when preparing a plan to develop emissions data for PM-2.5 are summarized in Table 4.1.

A critical concern relative to spatial influences is to prepare emissions estimates with spatial resolution that is consistent with the air quality problem(s) affecting the area. For example, some areas may experience high 24-hour concentrations that are affected by residential wood burning. This type of problem can often be confined to limited spatial scales within a mountain valley. The inventory to support analyses of such a problem needs to be resolved within the valley. An emissions inventory technique that calculates a county-wide emissions estimate will not provide the information necessary to evaluate the conditions within the valley. This is particularly true in the west where counties often cover very large areas. In this example, the regional contributions to the problems can be handled with coarse resolution, but local influences will have to be characterized at finer spatial detail.

In some cases, emissions data may need to be prepared at varying spatial resolution to develop a complete understanding of the relative contributions of the different causes of PM-2.5. The analyses to understand these complex issues may rely on more than one modeling approach. Inventories with fine spatial resolution can often be aggregated to represent coarser spatial resolution for input into larger scale modeling exercises without introducing significant bias. The reverse process will almost always introduce bias and uncertainty when inventories with coarse spatial resolution are used to derive a more spatially resolved inventory using surrogate distribution factors such as population or land use factors.

Some of the activity data associated with PM-2.5 sources are related to land use or other geographic features that are unrelated to county or other geopolitical boundaries. Examples include acreage in various types of agricultural use, forested areas, and animal husbandry

TABLE 4.1 SPATIAL INFLUENCES IN PM-2.5 PLANNING

Source Category	Type of Emissions	Spatial Concerns		
		Modeling	Terrain	Transport
Fossil Fuel Combustion - Stationary Sources	Primary and condensable emissions, and precursors to secondary PM-2.5	Regional modeling applications; Primary PM-2.5 may be used in local modeling	Terrain not important in regional applications, may be important in local applications	Secondary precursors can be transported over considerable distances, emissions mainly released from tall stacks
Industrial Sources	Primary and condensable emissions	Regional modeling applications; Primary PM-2.5 may be used in local modeling	Terrain not important in regional applications, may be important in local applications	Not generally as important for long range transport as are utility sources; Emissions are sometimes transported down valleys with typical diurnal valley flow regimes
Agricultural Sources	Ammonia is involved in the formation of secondary PM-2.5	Important for Source apportionment modeling	Terrain and surface features can prevent emissions release to transport layers, local feature concentrate pollutants	Fire, dust and other emissions likely to be local influence; deposition is important issue that needs additional study
Mobile Sources	Primary and condensable emissions and precursors to secondary PM-2.5	Important on both regional and local scales	Urban canyon effects and inversions concentrate soot	Important in regional modeling and secondary aerosol formation, local sources can be concentrated in urban areas
Fugitive Dust	Primary emissions	Mainly of concern for local modeling	Terrain and surface features can prevent emissions release to transport layers, local feature concentrate pollutants	Mostly of concern in local transport; deposition is important issue that needs additional study
Other Combustion	Primary and condensable emissions and precursors to secondary PM-2.5	Important on both regional and local scales	Terrain effects can be significant	Emissions from open fires can transport over very large distances, but can also be very significant on local scales; deposition is important issue that needs additional study

activities. Often it is convenient to organize and manipulate this type of activity data using geographic information systems (GIS). When such data are already available in GIS format, States should consider ways to use those data in their planning efforts. It is usually relatively simple to aggregate such data to be consistent with more standard geopolitical features to facilitate other analyses associated with air quality management programs.

Several of the sources listed in Table 4.1 are identified as significant local sources of primary and condensable components of PM-2.5. Most of these local sources result in emissions that are released close to the surface. In all cases, when these types of sources are located in river valleys or in basins surrounded by mountains, those primary PM-2.5 emissions and surface emissions of secondary precursors will concentrate under conditions with limited mixing volumes caused by temperature inversions. Once the inversions break and the area is ventilated, those trapped emissions can be transported downwind to contribute to regional problems. In any given area, any measured high concentration of PM-2.5 will likely be the result of the combined contributions from local sources and regional processes. The important issues for each specific area must be determined from analyses of all available information. The types of information that will be useful to begin this assessment include the preliminary inventory of primary emissions of PM-2.5 for each county that was developed as part of the periodic emissions inventory process (NET 1996), available ambient monitoring data, and characterizations of visibility reducing conditions that affect any given area.

4.3 DETERMINING APPROPRIATE TEMPORAL SCALES FOR INVENTORIES

Temporal factors can influence planning efforts in several ways. Perhaps the most important temporal consideration is whether analyses are completed to address 24-hour concentrations, annual concentrations, or both. In most urban locations, it is almost certain that multiple emissions scenarios will be responsible for high annual concentrations. For example, there could be different causes of high PM-2.5 concentrations in summer and winter months, and both seasons contribute to annual average concentrations. It is also possible for high 24-hour concentrations to occur at different times of the year and be related to quite different origins of PM-2.5. In these cases, the inventory development effort will have to address each of the potential sources contributing to high concentrations.

Planning efforts to address high 24-hour concentrations will require inventory data that are resolved to hourly levels for those conditions that result in the high concentrations. The hourly inventory might need to also reflect a particular seasonal condition or a specific set of meteorological conditions (e.g., hot, dry, and stagnant meteorology). Planning for high annual concentrations will likely require inventory resolution that reflects seasonal variability. Monthly resolution is recommended for these applications. Frequently, strong persistent low-level temperature inversions are accompanied by low surface winds and minimal advection. These conditions, which trap pollutants near the surface, are generally

more common during the winter months than at other times of the year. On the other hand, sources of secondary particle precursors may have a greater effect during the summer months when meteorological conditions favor deep mixing and photochemical activity. In addition, there are conditions that vary seasonally and diurnally that simply favor higher than normal emission rates of PM-2.5 and important precursors to PM-2.5. For example, emissions from unpaved roads and construction activities will increase during periods that are both dry and windy relative to emissions under wet and calm conditions. All of these considerations must be included in the preliminary planning for inventory development.

Some of the temporal influences that might affect inventory development are listed in Table 4.2. Most of the issues that influence 24-hour concentrations are related to local sources, while planning analyses of annual average concentrations must also consider the regional influences of secondary particle formation.

4.4 PREPARING TO COLLECT DATA

Once the priorities have been established, States can plan to obtain assistance from the affected sources or trade associations that represent the affected sources. New or refined approaches for developing emissions estimates should take advantage of all readily available data related to specific processes and activity levels. Surveys are a preferred method to develop activity data for several of the area source categories that are important in PM-2.5 planning. For example, sources such as residential wood burning could rely on surveys of households, while sources such as fertilizer application or prescribed burning can rely on surveys of fertilizer distributors, or public and private land managers, respectively. Another example of source categories that would benefit from locally generated survey data are leaf and trash burning activities. Survey procedures for these types of source categories are complicated by the need to estimate the effectiveness and compliance with local burning bans where such bans exist. While preparing for data collection through surveys, it is important to define the spatial and temporal scales that are of interest in specific planning programs, and to conduct the survey to collect data that is resolved to the appropriate levels. Details on conducting surveys will vary on a case-by-case basis. Recent EIIP documents and other EIIP documents that are available for review at the Internet site below, provide useful information on how to conduct surveys and the type of information that can be collected through surveys. (EIIP, 1997b)

<http://www.epa.gov/ttn/chief/eiip/techrep.htm>

TABLE 4.2 TEMPORAL INFLUENCES ON PM-2.5 SIP INVENTORY DEVELOPMENT

Source Category	NAAQS	Temporal Scale	Temporal Issues
Fossil Fuel Combustion- Stationary Source	Primarily annual, some 24-hour	Seasonal to Annual	<ul style="list-style-type: none"> - Hot, humid conditions with deep and active mixing layers, related to ozone season - Potential for emission rates to vary with seasonal electric demand
Local Industrial Sources	Primarily 24-hour	Diurnal	<ul style="list-style-type: none"> - Local sources of primary and condensable PM-2.5 dependent on actual wind speed, and direction - Some local sources could be dependent on temperature - Potential to concentrate under tight surface temperature inversions.
Agricultural Sources of NH ₃	Both annual and 24-hour	Primarily Seasonal	<ul style="list-style-type: none"> - NH₃ resulting from fertilizer application dependent on season and soil moisture content - NH₃ emissions from livestock production increase with temperature - NH₃ emissions may be deposited near the source onto nearby vegetation when in full leaf
Mobile Sources	Both annual and 24-hour	Primarily Diurnal	<ul style="list-style-type: none"> - Primary emissions follow traffic density patterns - There are differences between daily emissions (week day, weekend day, etc.)
Fugitive Dust (Emissions appear to be overstated for these sources using current methodologies.)	Both annual and 24-hour	Seasonal	<ul style="list-style-type: none"> - Some paved road dust dependent on road sanding practices - Road dust dependent on soil moisture content - Construction and other soil disturbance activities dependent on seasonal weather conditions
Other Combustion	Primarily annual	Seasonal	<ul style="list-style-type: none"> - Residential wood burning is confined to winter months - Biomass combustion dependent on growing cycles and other seasonal considerations

High priority local sources could be treated as either point or area sources depending on the nature of those sources, the perceived importance of the source categories, and the resources that are available to address those sources. In some cases, it may be possible to develop a representative emissions estimate by using an existing activity indicator, while in other cases, it may be necessary to acquire new data to represent the activity rates for some unique sources. States should review all possible information and recognize that appropriate data to represent the source activity may be available through other regulatory or economic programs that are not related directly to the air quality management agency.

4.5 SUMMARY

For sources that rank low on the priority scale, initial emission estimates based on National-level methods and activity data available through the ASEM will suffice. Similarly, for low priority point sources simple size distribution functions included in *AP-42* (Compilation of Emission Factors) can be used to relate PM-2.5 emissions to PM-10 emissions. Other estimation methods for low priority sources could include the application of per capita or per employee factors, or land use factors that are based on National-level activity data. Estimates based on that level of detail may be sufficient to treat the sources that are not large emitters and can not be controlled to levels that would be of use in the control strategy. Therefore, resources should be concentrated on developing reliable activity data, and in improving the emission factors and estimation methods for those sources that contribute significant emissions and can be controlled with identifiable technology at acceptable costs. Some of the steps that can be taken to develop priorities are discussed below.

- Review all available ambient monitoring data including speciated samples to get an understanding of the principal causes of PM-2.5 that affect the expected planning areas. For example, rank likely local sources resulting from transportation, open burning, residential wood burning, fugitive dust, industrial sources, etc., relative to the contribution from regional secondary aerosol. The inventory development plan may require coordination with nearby States in addition to collection of activity data and the development of emission factors for the local sources.
- Review the draft inventory data for counties in the expected planning area and establish a ranked list of the main contributions of primary PM-2.5.
- Rank the sources of the main precursors of PM-2.5 represented in the draft inventory in a similar way. Identify important sources that affect the area that need new or improved emission factors, size distribution factors, new or improved sources of activity data, etc., to support the planning effort.
- In the near term, States can begin to identify contacts, locate pertinent sources of activity data, and start developing an inventory preparation plan with schedules.

- Develop a plan and the instruments necessary to conduct surveys of the activity data for relevant priority sources (e.g., surveys of wood use for residential heating, typical agricultural or prescribed burning activities, or construction activities).
- Review available data on the size distributions and source speciation for the major contributors to PM-2.5 in the expected planning area (size distribution and source composition profiles in SPECIATE, previous chemical mass balance (CMB) or other receptor modeling analyses, and in published research papers). SPECIATE is a collection of source profile data and CMB is a source receptor modeling approach. Both of these tools can be found on the EPA Internet site.
- Apply receptor modeling to any available speciated PM-2.5 measurements .
- Evaluate the potential amount of emissions control possible (known control technologies or pollution prevention methods and estimated control cost).

There are several other activities ongoing within EPA and EIIP that are developing tools and information resources for application to PM-2.5 emissions inventory planning. EPA is developing preliminary guidance for PM-2.5 emissions inventories, which will be posted on the CHIEF Internet page in the near future. EPA is also working on the Area Source Emission Model (ASEM) that will collect the area source methodologies into a consistent system. EPA is also working on updating, expanding and improving the SPECIATE database and system. As source profiles for PM-2.5 are identified, they will be added to the SPECIATE system. EPA and EIIP are also developing a webpage to serve as a central PM-2.5 Inventory Resource Center. This webpage will provide important summary information and will direct users to other useful Internet sites that contain detailed information related to various aspects of PM-2.5 inventory development. The webpage will eventually be accessible through links from the PM-2.5 EIIP webpage and various other pertinent Internet locations.

5

TECHNIQUES FOR INVENTORY VALIDATION

5.1 UNCERTAINTY ISSUES

Much of the discussion in this report addresses the current status and remaining weaknesses associated with the tools and procedures available for estimating emissions of PM-2.5 and its precursors. In applications to PM-2.5 planning, as well as for all other air quality planning programs, the emissions inventory development techniques rely primarily on estimation methods. Emissions data based on actual source measurements for PM-2.5 planning will be limited. In most cases, average emission factors are applied to all sources in a particular process or source category, and, in many cases, default values or procedures are used to estimate the activity data to which the emission factor is applied. In practice, the process characteristics and operating rates of individual sources can vary considerably within any particular source category. In addition, uncertainties arise through the use of surrogate spatial, temporal, and speciation allocation files. Therefore, emission inventory developers and the team responsible for air quality planning efforts must be aware of the inherent uncertainty of the underlying emissions estimates. Those uncertainties must be considered while establishing priorities, identifying causes of observed air quality, and ultimately in deriving control programs to achieve air quality goals.

The concept of uncertainty as applied to emissions inventory development is fundamentally different than the quantitative uncertainty and error bounds that are applied to measurements in experimental programs. The process to estimate and interpret uncertainty in emissions inventory applications is more intuitive than the approach that is commonly applied in experimental research. Therefore, the developers of PM-2.5 emissions inventories and the planners that depend on those inventories must be cautious when interpreting results based on these emissions estimates. Programs must maintain the flexibility to adjust to shortfalls and weaknesses of programs that are based on these inherently uncertain emissions estimates.

Because PM-2.5 planning is just getting started, the uncertainties associated with PM-2.5 emissions estimates can have more serious effects than in the case of other more mature planning programs. The techniques and tools used to estimate emissions inventories for PM-2.5 programs and to interpret analyses based on those inventories will improve as

experience is gained. Specifically, EPA and other organizations like the EIIP are working to improve emission factors, procedures to collect activity data, chemical species allocation profiles, and spatial and temporal allocation factors. Additional improvements in methodologies and tools for use in preparing emission inventories for PM-2.5 will also be developed by State planning agencies. During the initial planning efforts, it will be necessary to review the emissions estimates and to evaluate how well those estimates represent the overall air quality problems that are being addressed. The remainder of this section provides some suggestions for activities that can be used to validate emissions data and to identify components of the inventory that do not support other observations.

The following discussion presents a selection of techniques that States might find useful to complete this type of evaluation. The techniques discussed here are not the only methods that can be used to validate emissions inventories, but are discussed as examples of the kind of analyses that can be applied. States are encouraged to develop additional methods and techniques to assist in the evaluation of inventory data quality.

5.2 SPECIATED LINEAR ROLLBACK AND SIMPLE REGRESSION MODELS

The concept of linear rollback was first applied in early efforts by EPA to understand and prioritize the relative effects of various emissions sources on ambient air quality problems. This technique is based on the assumption that reductions in the amount of emissions from sources and/or source categories that affect a particular air quality problem will result in proportional reductions in the air quality measurement. This assumption does have some validity, although most air quality problems, including PM-2.5, do not exhibit a one-to-one relationship between emissions and air quality.

The speciated linear rollback model is based on the assumption that the mass of each type of particle (e.g., sulfate, nitrate, elemental carbon, etc.) is related to the spatially averaged emissions of the relevant pollutants. The requirements for the application of this approach are a speciated inventory covering the major contributors within the region, and a speciated ambient data set that represents the temporal averaging of the primary sources. The model will identify the contributing sources or source categories based on the resulting ambient air quality. The model can be used to complete preliminary tests of the adequacy of the regional inventory and to help prioritize efforts to find sources that may not be adequately represented or those that may not be represented at all. In this regard, it is a simplified receptor model.

Regression models use empirical relationships derived from the source and ambient data to apportion ambient particulate data among the distribution of sources in the region. The technique requires that data are available over a range of conditions and over a reasonable expanse of time. If sufficient information is available, these models can attribute source

contributions for the precursors to secondary particulate, as well as, the direct emissions of primary particulate.

Both of these techniques can be applied with limited information in a screening mode to identify serious weaknesses in the underlying emissions data. Take as an example a case in which these techniques indicate that there must be a major source or collection of sources that contribute organic carbon. Upon review of the inventory, no sources of organic carbon with a sufficient magnitude are found. This result would lead to an investigation of the possible sources of the missing organic carbon. Details of the application of the speciated linear rollback model and regression models can be found elsewhere. (NRC, 1993)

5.3 DATA ATTRIBUTE RATING SYSTEM (DARS)

The Data Attribute Rating System (DARS) was developed to assist in evaluating data associated with emission inventories. DARS provides a numerical confidence rating for emissions inventories. The numerical result is called the DARS score and in most cases it is less subjective than the usual qualitative letter grade rating procedures (i.e., A through E) that have historically been used to characterize emissions data quality. DARS was originally developed as a research tool for rating national and global greenhouse gas inventories. State agency personnel have used DARS to rate their base-year State Implementation Plan (SIP) ozone precursor inventories. In addition, particulate matter (PM-10) inventories (State- and National-levels) were evaluated by inventory developers trained in the use of DARS. More detail on the development and application of DARS can be found in EIIP documents available on the EIIP Internet site shown previously. (EIIP, 1996)

The DARS score is based on the perceived quality of both the emission factor and activity data. Numerical scores are assigned to four data attributes: measurement/method, source specificity, spatial congruity, and temporal congruity. These scores, which range from 1 to 10, reflect the confidence that the user associates with each of the attributes. DARS scores can be applied to groups of sources rather than to individual sources or to emissions estimates aggregated at different spatial and temporal scales. Results of these types of analyses are often useful to help assess priorities by defining large emissions sources that have low confidence levels. One advantage of DARS is to provide a quick evaluation of the effect of National-level or surrogate factors and activity data relative to local source specific factors. The relative improvement in the total score will be indicative of how sensitive the emissions are to local influences.

The proposed applications of DARS include:

- to validate emissions estimates to identify the weakest areas of an existing inventory for further research and improvement,
- to quickly compare and rank different inventories,
- to rank alternative emission estimation methods, and
- to set Data Quality Objective (DQO) targets during inventory planning and for future inventories.

5.4 USE OF CMB AND DISPERSION MODELING

Dispersion and receptor modeling are powerful tools for identifying and assessing various sources of primary emissions. The utility of these tools increases for applications to chemically inert species, but under some conditions, these tools can be used to evaluate sources of reactive components as well. One receptor modeling approach based on the Chemical Mass Balance Model (CMB), has been used effectively in many PM-10 planning efforts. The results of CMB modeling often can point to the major sources of the primary particulate and even to give estimates of relative source magnitudes. Similarly, dispersion modeling of chemically inert components can provide important information on the relative accuracy of emissions estimates. In both of these applications ambient concentration data are required.

While total mass concentration can be applied to some analyses, the power of these tools increases dramatically when applied to data that represent a full range of chemical speciation in the ambient data set. Currently, there are no ambient data for PM-2.5 collected using the FRM. Monitors consistent with the FRM are being deployed, and initial data from the first of these monitors will be available in 1999. The current monitoring plan requires that a subset of these monitors will collect samples for analyses of the chemical composition. These data will provide a wealth of information to use in CMB and dispersion modeling analyses to verify important sources, evaluate emissions estimates, and to prioritize emissions inventory improvement efforts.

Of course, the use of these approaches also requires detailed source composition data. Currently, the bulk of PM-2.5 source speciation data available through the SPECIATE system are dated, and in many cases, are not source specific. The only source-specific chemically speciated source data for PM-2.5 have been developed in research field studies. Some of these data in both SPECIATE and through the research programs include the condensable fraction and others do not. Many of the studies were completed prior to the promulgation of the NAAQS with the specification of the 2.5 μm size cutoff; therefore, some available profiles may be based on other size cutoff limits. Even with the difficulties presented with the existing data, it may still be possible to apply either CMB or dispersion

modeling to help States evaluate emissions estimates for the specific sources and source combinations that are important in particular areas.

This type of analysis will be most useful when applied across seasons, emissions scenarios, and other temporally variable scales that can affect the emissions from specific sources or the mix of emissions from the collection of sources in any given area. In the majority of cases, emissions data are expected to be applied to analyses of annual ambient concentrations. The causes of high ambient concentrations might change, however, with season or other temporally cyclical conditions. Repeated comparisons of the composition of the ambient samples to source components can be extremely informative in terms of improving the emissions inventory, identifying the principal causes of high measured concentration, and ultimately, in developing effective control plans.

5.5 DEVELOPMENT OF SOURCE PROFILES FOR CMB MODELING

Most local sources of primary PM-2.5 will be combustion sources, and the emissions will include a significant fraction of carbon. Direct sampling data and/or estimates of emissions from sources that are similar to other measured sources will benefit significantly if the elemental and organic carbon fractions are differentiated. This is such a critical requirement that States are cautioned that sampling of sources is not expected to be cost effective if results are not available for both elemental and organic carbon. Speciation of other components of the source mix that can serve as unique markers for specific sources will also improve source apportionment analyses. Developing the source profiles can be an expensive part of any source apportionment project, and the testing phase should be planned carefully to develop all of the data necessary.

Other issues of concern in developing source profiles are listed below:

- Ensure that plans are made to collect data with sufficient chemical speciation to allow CMB to distinguish specific source contributions.
- Develop profiles for all of the important sources affecting the receptor. Keep in mind that profiles that are specific for the actual sources of interest improve the confidence in the results relative to analyses that use source average or surrogate profiles.
- Complete screening tests to determine if two important sources have characteristics that are so similar that CMB cannot distinguish between them. If that appears to be the case, consider adding a chemical marker to one or both of the sources to make each source unique.
- Test the sources under the typical operating conditions that are believed to result in the air quality effect.

- Be sure to collect data that is representative of the spatial scale and the temporal scenario under which the air quality effect is observed.

6

SUMMARY AND RECOMMENDATIONS

Although the development of PM-2.5 emissions inventories will represent a new planning activity for States, there is a considerable amount of information available to begin gathering basic information on the sources of PM-2.5. EPA is currently working to bring the available information and inventory development tools together to make them more accessible to States. Some of these tools and data sources are currently national in scope and may not represent sufficient detail for all local planning applications. These information sources do, however, provide a firm basis upon which future National and State planning efforts will build. The future activities associated with PM-2.5 emissions inventories will expand the current base of information and tools to regional and local levels. The task ahead is challenging, and will be facilitated by coordinated efforts involving the EPA and States. Many of these sources of information and information that is readily available from Internet sites will be included on the PM-2.5 Inventory Resource Center that can be accessed from the PM-2.5 EIIP Internet webpage or at the Internet address provided below.

<http://www.epa.gov/ttn/chief/eiip/pm25inventory/>

The regional nature of PM-2.5 will require the development of regional approaches, combined with appropriate local control measures. It is recognized that mandated National-level planning and control activities will not always provide the most efficient solutions for all States. States are encouraged to form regional planning organizations and to use existing organizations like Western States Air Resources (WESTAR) and North East States Consortium for Air Use Management (NESCAUM) to collectively address some of these regionally specific problems. In the meantime, EPA will continue to work with the States to provide guidance on significant issues that are important on the National-level and to help States coordinate efforts and to share information.

6.1 ON-GOING NATIONAL-LEVEL ACTIVITIES

1. EPA will continue to develop guidance documents for PM-2.5 inventory development. The guidance documents will provide information on what is expected of the States, including schedules, and will direct States to data

- sources and other relevant information on how to collect and assemble activity data and to apply emission factors.
2. EPA will review the information that is already available and prioritize PM-2.5 source categories that are important on the National-scale. The prioritization will be based on expected emissions magnitude, potential for emissions control, and assessments of the credibility and reliability of existing activity data and emission factors.
 3. Based on the results of that review, EPA will begin to address those issues that are of high priority on a National-scale (e.g., evaluate and improve outdated or low quality emission factors, and address area source methods for sources of national importance).
 4. EPA will continue to coordinate with the USDA, DOI, and other organizations to refine methods for calculating emissions from fugitive dust and open burning sources.
 5. EPA will continue to support the development of National-level emissions estimates in the form of updates to the draft 1996 NET PM-2.5 inventory.
 6. EPA will continue to develop estimation tools like the ASEM, Factor Information Retrieval (FIRE) database, and SPECIATE.
 7. EPA Emissions Measurement Center will continue to assess candidate methods for a reliable source test to distinguish between filterable and condensable PM-2.5.
 8. EPA will continue to oversee and support the deployment of the PM-2.5 ambient monitoring network and to assist States in the collection and evaluation of ambient mass and speciated PM-2.5 data.

6.2 RECOMMENDATIONS FOR STATE ACTIVITIES

1. States should develop a preliminary inventory preparation plan. This should include an initial assessment of the priority issues and which of those can benefit from National-level activities and which will be more appropriately handled at the State- and regional-level. The plan should include a strategy and a schedule for collecting the appropriate information and merging that information with existing data. The plan should address all relevant spatial scale issues and temporal considerations.
2. States should become actively involved in coordinating with EPA and with one another to ensure that the results of all development efforts are applied in a timely way and that efforts are not duplicated among States. One effective opportunity is to participate in EIIP activities and use that forum to address key issues of concern.
3. States should review all available EIIP documentation on methods and approaches for estimating PM-2.5 emissions from area sources. These documents will provide useful information on preferred methods for obtaining

and managing activity data for important area sources of PM-2.5, open burning sources, residential wood combustion, etc. The document on residential wood is available and others are near completion.

4. States should review the existing inventory data, emission factors in AP-42 and supplements to AP-42, and all ambient monitoring data as they become available, to develop an understanding of the type and scope of the problems that affect them.
5. States should begin to identify local sources of activity data for area source and point source categories that can be used to replace National-level default values that will be provided in the ASEM. This activity should include plans for conducting surveys to specify local activity rates, timing of significant fire events, and other significant features related to source strength for appropriate categories. Guidance on conducting surveys for several biomass burning categories is included in EIIP documents.
6. States should begin coordinating with other nearby States to develop cooperative agreements for sharing the burden of data collection and in developing regional plans to address PM-2.5 issues. States should contact representatives from GCVTC States and other existing multi-State cooperative organizations to get advice on and to facilitate that type of cooperation.
7. States are encouraged to become active in the EIIP process to make contacts, identify joint projects, and to share information.
8. States will need to develop a list of priorities that are of importance in their local areas and complete decision making processes on how best to address those priorities and how to commit resources to maximize their understanding of the processes that result in high PM-2.5 concentrations. The list of priorities for any particular area should consider the EPA list of national priorities and focus on those issues that will not be covered by the national effort.
9. States should begin to review existing approaches for source apportionment and other models that are useful to discriminate the relative contributions of various sources to observed PM-2.5 concentrations.
10. States should review policy guidance on prescribed burning and the application of smoke management plans and the relationship of those activities to PM-2.5 planning. States should begin a dialog with Federal Land Managers (FLM) who have familiarity with the policy and information on how fires are managed in terms of acres burned and timing of fires in each local area.

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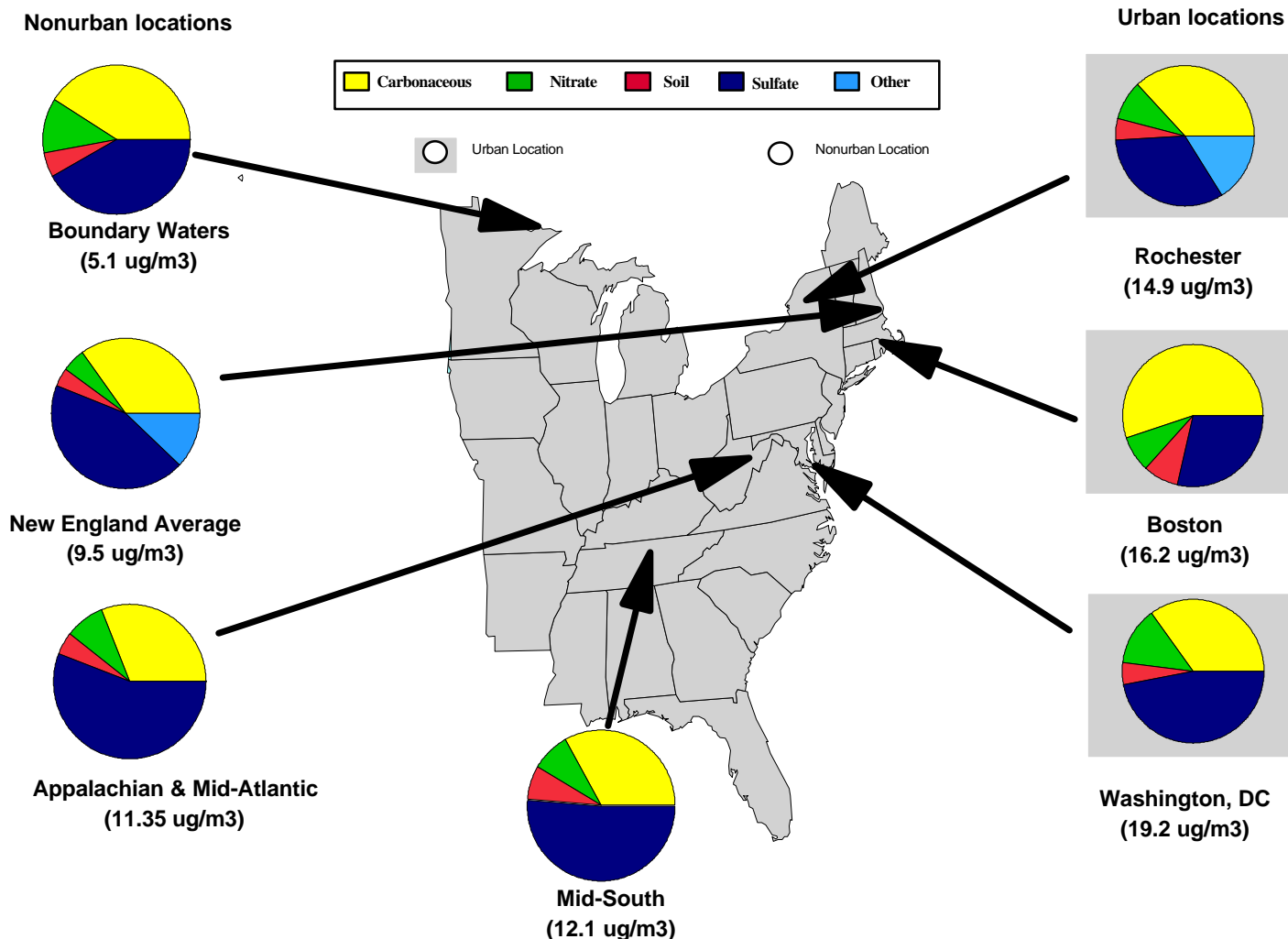
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APPENDIX A PIE CHARTS OF SPECIATED AMBIENT PM-2.5

NOTE: The pie charts are best viewed on the screen in color or after printing to a color printer. Printing these pie charts on a black and white printer may result in gray scale gradations that will be difficult to distinguish.

1.A-2

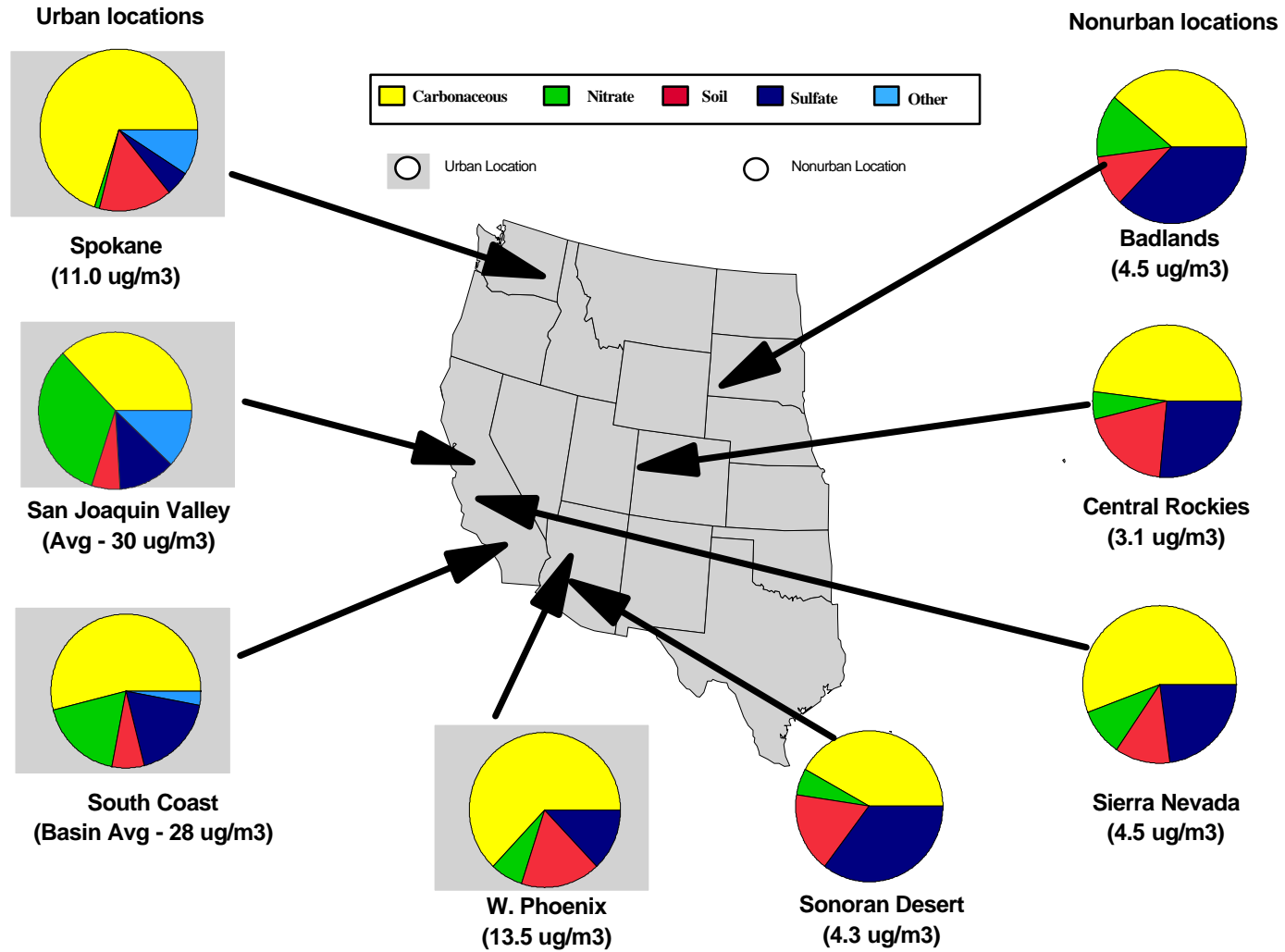
Figure A-1. PM-2.5 Composition in the Eastern United States



Note: PM-2.5 mass concentrations are determined on at least 1 year of monitoring at each location using a variety of non-Federal reference methods. They should not be used to determine compliance with the PM-2.5 NAAQS.

EIIP Volume IX

Figure A-2. PM-2.5 Composition in the Western United States



Note: PM-2.5 mass concentrations are determined on at least 1 year of monitoring at each location using a variety of non-Federal reference methods. They should not be used to determine compliance with the PM-2.5 NAAQS.

APPENDIX B.

STATUS OF PM-2.5 EMISSIONS ESTIMATION TOOLS

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STATUS OF PM-2.5 EMISSIONS ESTIMATION TOOLS

This Appendix provides a summary of the status of available emission factors, emissions estimation algorithms, and activity data that could support the preparation of future PM-2.5 emissions inventories. The Appendix is not meant to be a comprehensive list of all factors and approaches, but rather a guide concerning the perceived strengths and weaknesses of the methods and tools that are available at this time. The specific information that is available can be obtained through readily accessible sources. Those information sources are identified in this Appendix. A summary of the available data and further needs is provided in tabular form in Table B-1.

Stationary Combustion Sources

Emission factors are available for PM-2.5 and its precursors for most stationary combustion sources. Many of the factors are based on size distribution functions. Most, if not all, of those size distribution functions were obtained through source testing using some form of size separation sampling device (e.g., cascade impactor, multi-cyclone separator). In some summaries, the factors for PM-2.5 may be presented as a percentage of PM-10 or total particulate. The reader is advised that in most cases these percentage factors are based on sampling data and are not simply an assumed fraction. These factors apply to SO₂, NO_x, VOC, and PM-2.5 for most stationary combustion sources. Many of the factors that are applied to area sources may have been developed specifically for point sources. These combustion sources should not differ widely, however, in terms of emissions per unit of fuel consumed. The PM-2.5 factors are largely representative of the filterable fraction, although in some cases, a condensable fraction or total PM-2.5 is represented. These factors can be found in *AP-42* - Fifth Edition, the supplements to the fifth edition, and in the procedures document for the 1996 NET inventory. The Factor Information Retrieval (FIRE) system lists PM-2.5 emission factors and will be continually updated as new factors are developed.

There are three remaining weaknesses related to PM-2.5 from stationary combustion sources. As indicated above the condensable component of PM-2.5 is not well characterized for many of these sources. Work is now underway to add these factors. Recent updates to *AP-42*, including Supplement D to the Fifth Edition, do include some specific factors for condensable PM-2.5 from selected source categories. The processes that result in the formation of condensable PM-2.5 are not well understood at this time. Although VOC emissions from most stationary combustion sources are typically minimal, there is the potential for some of these emissions from low temperature firing applications to participate in the formation of SOA. Currently, there is an incomplete understanding of the contribution and role of VOCs from combustion sources in the formation of SOA.

There is also a considerable lack of understanding of NH₃ emissions from point sources. The tools to adequately represent NH₃ emissions from stationary combustion sources are limited. Stationary combustion sources are not thought to be a significant source of NH₃ and, therefore, this weakness is not expected to have serious consequences in terms of National-level planning in the short term. Improvements in these factors will be needed to promote higher accuracy predictions of secondary particle formation in future studies. There are likely specific processes that will be important sources of NH₃ in some local areas. Further efforts will be necessary to address these local sources. The NH₃ factors that are available are discussed in the procedures document for the 1996 NET inventory.

Activity data for stationary combustion sources are the same as those used for these sources in the preparation of other more traditional inventories. There is adequate guidance available to assist States in the collection and organization of these data. There are no significant weaknesses related to the development of activity data for sources that are of national importance. Some weaknesses may exist in the tools and data sources for developing activity data for selected sources that are important in a limited number of local applications.

Open Burning Sources

The data sources available for estimating PM-2.5 from open burning sources arise largely from size distribution functions applied to data that had been developed to support PM-10 planning. There is a significant amount of information related to filterable PM-2.5 emissions, but less is available for the condensable fraction from all of the origins of PM-2.5 from open burning. Emissions of NO_x and VOC are also released from these sources. These sources tend to burn their fuel at lower temperatures than do boilers and other combustion related point sources. One result is an increased potential for emissions of organic carbon whether emitted directly in the solid phase or in the condensed phase. Characteristics related to NO_x and VOC emissions can also be quite different relative to high-temperature fuel combustion in boilers. The information that is available is summarized in the procedures document for the 1996 NET inventory, and additional information can be found in recently published and soon to be published EIIP documents (Open Burning Sources Chapter V, Volume 16). This guidance does not yet include information related to the agricultural or forest related sources of open burning. EPA is continuing to coordinate with organizations through the USDA and the U.S. Forest Service to develop information and resources to assist in calculating emissions from these sources. Reports will be prepared in the near future to provide information useful for application to these kinds of sources.

Activity data to support emissions estimates for these sources vary considerably. Details on available information and how to improve that information from local perspectives is provided in the EIIP documents. Additional efforts are needed to prepare adequate estimates of activity data for these sources.

Mobile Sources

Emissions of VOC and NO_x from mobile sources are routinely estimated using well established approaches and data collection techniques. Guidance from EPA's Office of Mobile Sources (OMS) and the Office of Air Quality Planning and Standards (OAQPS) is available to assist in the collection and application of both emission factors and activity data.

The data available for PM-2.5 emitted both as solid particles and as condensable material is less established. OMS has developed an emissions estimation model for PM called PART5. The current version of PART5 operates with input similar in nature to the input files used to support other mobile source emission factor models prepared by OMS. The model uses measurement data to calculate an aggregate emission factor for PM-2.5. Some issues remain concerning the application of the model. First, in its current form, the model produces a fleet average emission factor and can not separate output factors by vehicle class. This condition makes it difficult to separate out the competing influences from various types of on-road or off-road heavy-duty diesel vehicles. Overall emission factors will also include emissions from tire wear and brake wear. OMS has also recently completed an assessment of NH₃ emissions from various types of mobile source activities. These data will be reflected in subsequent national inventories (e.g., 1997 NET inventory).

All emission factors are presented in terms of VMT for on-road vehicles and in terms of hours-in-operation for off-road vehicles. Additional work is needed to improve the understanding of and data to support the development of emissions of PM-2.5 from mobile sources.

Fugitive Dust Sources

While it is generally recognized that most fugitive dust generated by construction, paved and unpaved roads, agricultural tilling, many minerals processing activities, and other crustal origins is in the coarse range (2.5 μm to 10 μm), there is still the potential for a contribution of PM-2.5 from fugitive sources in selected areas. Data on source strengths based on size distribution functions suggest that there is indeed a large amount of mass included in the emissions of particles under 2.5 μm. Speciated ambient data collected at various locations across the U.S. suggest that the amount of mass that is entrained into the prevailing transport regime, and ultimately to be collected at ambient samplers, is much lower than that emitted. One reason for this is that most (about 70%) of the emissions are within 2 meters of the ground. There are several potential physical processes that could remove or alter the fine particulate before it can reach the transport layer. Some candidate mechanisms, include impaction on nearby vegetation and structures, and rapid deposition of the particles owing to their low release height and lack of thermal buoyancy. Once investigations of these processes are completed, additional information will be made available to assist in the development of fugitive dust emissions of PM-2.5. In the meantime, estimates based on current factors and

estimation methods that have been made available at the National-level are believed to be overestimated. Obtaining activity data for many of these sources will require significant State involvement.

Agricultural Sources

Agricultural activities do contribute significantly to the burden of NH_3 in many areas. Both animal husbandry and the application of nitrogen-based fertilizers can result in NH_3 emissions. These sources are not well understood and continued research is required to develop more reliable estimates of emissions of NH_3 . The results of a significant amount of research on NH_3 sources from agricultural activities completed in Europe are available. These studies represent most of the basic understanding used in estimates prepared at the National-level. These studies are well conceived and conducted, and the information is reliable and applicable. Further understanding of the specifics of animal management (conditions in feedlots, dairies, etc.) and waste management activities (lagoons, land application, confinement and treatment, etc.) is necessary to ensure that these studies are representative of actual conditions in the U.S.

Other Sources

Emissions from noncombustion industrial sources can potentially be significant in some areas. Emissions from wood products industries, and metallurgical industries can contribute to PM-2.5 loadings. It is possible that there are also other specific types of sources that might contribute to PM-2.5 emissions. States will be encouraged to explore these types of sources and develop methods and tools to estimate emissions.

TABLE B-1. FACTORS AND ACTIVITY DATA FOR PM-2.5 PLANNING

Source Contribution to Ambient PM-2.5 ¹	Emission Factors		Activity Data	
	Available Information	Remaining Needs	Available Information	Remaining Needs
Primary Emissions of PM-2.5				
Area Sources (1,800k tpy) (nonfugitive dust)	Emission factors for combustion and fugitive dust sources are available for most significant source categories, but improvements are needed.	Many factors do not distinguish between filterable and condensable fraction. For fugitive dust, issues remain concerning the relationship between source strength and ambient data.	Existing activity data for fugitive dust sources can be applied for PM-2.5.	In most cases, local surveys are needed for residential wood burning, wildland, and other open burning sources. Improved data are also needed for construction, unpaved roads, and silt loading on paved roads, and spatial and temporal resolution factors.
Point Sources (900k tpy)	Emission factors are available for filterable PM-2.5 for most stationary combustion sources.	Many factors do not distinguish between filterable and condensable fraction. Factors are needed for some key sources.	Standard point source fuel use and throughput data can be applied.	Some key sources that are not important in other inventory efforts may need activity data development.
Mobile Sources (600k tpy)	Emission factors can be generated using the OMS model PART5.	PART5 currently provides a fleet average factor. Revision needed to increase the level of detail available.	PART5 operates with the same VMT data that is used in other mobile inventories.	In some cases, local data on diesel/gasoline split could be useful.

TABLE B-1. FACTORS AND ACTIVITY DATA FOR PM-2.5 PLANNING (continued)

Source Contribution to Ambient PM-2.5 ¹	Emission Factors		Activity Data	
	Available Information	Remaining Needs	Available Information	Remaining Needs
Sulfur Precursors to Secondary Aerosol Formation				
Point Sources (16,600k tpy)	High quality emission factors are available for nearly all major combustion sources. CEM data available for many utility sources. Emission factors for smelters are reliable. Data source AP-42.	National-level analyses for industrial combustion sources based on average industry factors. Updates to reflect changes in technology could improve inventories.	Fuel use and sulfur content is routinely and reliably monitored for utilities and large industrial boilers.	Specific data for fuel use and spatial/temporal allocation of fuel use for smaller industrial boilers could improve estimates relative to national analyses.
Area (1,800 k tpy)	Point source factors applied to area source emissions for wide spread small combustion sources (e.g., small diesel generators, etc.) Data source AP-42.	Improved emission factors for open burning sources with specific studies. Relative contributions from industrial sources are small.	Fuel use and allocation are primarily dependent on growth and earlier inventory assumptions in national analyses.	Emissions at local levels based on specific activity data will be much improved over national methods.
Mobile Sources (1,300k tpy)	Emission factors for sulfur and PM from mobile sources is from PART5 and is linked to VMT estimates for fleet average. Off-road estimates based on national analyses.	Improved methods for allocation among heavy diesel on-road and off-road categories are needed. Relative contributions are small.	On-road estimates related to VMT. Off-road estimates related to national analyses of heavy diesel equipment, and other non-transportation activities.	Emissions estimates could benefit from area specific surveys of construction and other heavy diesel equipment.

TABLE B-1. FACTORS AND ACTIVITY DATA FOR PM-2.5 PLANNING (continued)

Source Contribution to Ambient PM-2.5 ¹	Emission Factors		Activity Data	
	Available Information	Remaining Needs	Available Information	Remaining Needs
Nitrogen Precursors to Secondary Aerosol Formation				
Mobile Sources (11,600k tpy)	Emission factors for on-road sources are from MOBILE models developed by OMS. Off-road sources are based on similar on-road engines.	Emission factors for off-road vehicles might be improved through specific testing.	VMT collected as part of normal ozone inventory development. National-level estimates are available. Significant guidance exists.	State data needs to be filled in for all counties that have not been subject to specific planning requirements in the past.
Point Sources (9,300k tpy)	Emission factors available for most large combustion sources; CEM data available from utilities. Data Source AP-42.	Updates to reflect changes in technology could improve inventories for industrial sources.	Fuel use and firing type is reliable for most major combustion sources.	Specific data for fuel use and spatial/temporal allocation for industrial boilers could improve emissions estimates.
Area Source (2,500k tpy)	Emission factors for industrial combustion sources are reliable. Data based on AP-42 point source factors. Factors under development for many open burning sources.	Factor for small ubiquitous units could be improved with better understanding of operating conditions. Need better understanding of wild fires and prescribed fires.	Fuel use data is routinely and reliably monitored for industrial boilers.	Fuel loading for wild and other open fires needs local development and updates.

TABLE B-1. FACTORS AND ACTIVITY DATA FOR PM-2.5 PLANNING (continued)

Source Contribution to Ambient PM-2.5 ¹	Emission Factors		Activity Data	
	Available Information	Remaining Needs	Available Information	Remaining Needs
Organic Precursors to Secondary Aerosol Formation				
Area Sources (8,900k tpy)	For many sources of solvent use, assumption of 100% air emissions can be made. Factors are dependent more on capture and control efficiency.	Improved factors for organic emissions including condensable from combustion and open burning (low temp. combustion) are needed.	Activity data from typical industrial sources is readily available as applied in other inventory efforts. Guidance is readily available.	Methods are needed to develop activity data for open burning and some other unique area sources. Solvent use data needs improved spatial and temporal resolution.
Mobile Sources (7,700k tpy)	Emission factors from MOBILE models by OMS and Off-Road model for non road vehicles. Factors are reliable for ozone precursor type species.	Improved factors and/or speciation profiles to represent higher carbon number compounds and semi-volatile compounds.	Activity from VMT estimates and estimates of hours in use for off road sources. National defaults are available.	Improvements can be achieved with locally derived data particularly for off-road sources. Could require surveys.
Point Sources (2,500k tpy)	Typically, point sources contribute a minimal mass of VOC emissions. Emission factors are available for most point sources in AP-42.	Speciation factors need to be reviewed to determine if low or semi volatile VOC compounds are adequate.	Activity data to support point sources emissions are well developed and guidance to develop these data is readily available.	Needs related to development of activity data for point sources generally is a low priority issue relative to PM-2.5 emissions development.

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