1998 CALIFORNIA PARTICULATE MATTER MONITORING NETWORK DESCRIPTION

PREPARED BY

Kasia Turkiewicz
Greg O'Brien
Air Quality Data Review Section
California Air Resources Board

CONTRIBUTORS

Ron Rothacker
Norma Montez
Nehzat Motallebi, Ph.D

June 30, 1998

TABLE OF CONTENTS

Attachments

Appendices

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The California Air Resources Board (ARB) in partnership with the local air quality management districts within California has developed a PM2.5 monitoring network to implement the new PM2.5 National Ambient Air Quality Standards (NAAQS). The term PM2.5 applies to airborne particles with aerodynamic diameters less than 2.5 microns. The PM2.5 network is designed to enable the air quality management community in California to collect ambient PM2.5 data as required by Title 40 of the Code of Federal Regulations (40 CFR), Parts 50, 53, and 58, published in the Federal Register on July 18, 1997. The ambient data from this network will be used for designating areas as attainment or non-attainment for the PM2.5 air quality health standards, developing control programs, and tracking the progress of these control programs.

During the early stages of the PM2.5 network design process, the ARB and the local air quality management districts established Monitoring Planning Areas (MPAs) for the State. There are 18 MPAs that have been used for locating PM2.5 monitoring sites throughout California. They are determined to be the best geographical divisions for the PM2.5 monitoring network planning. They are not intended for designating areas as attainment or non-attainment or for determining specific PM2.5 control measures. The boundaries to be used for these purposes will not be established until adequate PM2.5 data are available. The ARB and the local air quality management districts will recommend appropriate nonattainment boundaries to the U.S. EPA.

This document, the *1998 California Particulate Matter Monitoring Network Description*, consists of a statewide summary and 17 appendices. Each appendix includes a detailed description of the proposed network for each designated MPA in the State, except that the network description for the Coachella Valley MPA is included with the network description for the South Coast MPA. The objective of this document is to summarize the particulate matter monitoring strategy for California.

1.1 Population Characteristics of California

California is one of the largest and most diverse states in the nation. With more than 32 million people, California is home to 12.2 percent of the U.S. population, more than any other state. The population of California has grown enormously in the years following the Second World War. In 1946, 9.6 million people lived in California. The population in 1997 was 32.6 million, an increase of 240%. The California Department of Finance projects that by the year 2040, 63 million people will be living in California.

1.2 Emission Sources

The PM2.5 in California's air is the result of primary and secondary particulates. Primary particulate emissions are directly emitted from sources such as residential fireplaces, diesel trucks, forest burning, dust sources, and industrial processes. Secondary particulates form when gaseous or non-particulate substances react in the atmosphere with other substances to produce particulate matter.

The predominant sources of directly emitted PM2.5 vary regionally in California. In Southern California, inventory estimates show that approximately 25% of PM2.5 is from mobile sources. In the San Joaquin Valley, the mobile contribution is only 9% but geologic dust sources are more substantial PM2.5 contributors. In the San Francisco region, fireplaces are a major source of PM2.5. In the Southeast Desert region, dust sources are dominant. Each region in the state has its own unique mix of PM2.5 source contributors.

Precursors to secondary PM2.5 formation in California include oxides of nitrogen (NOx) from motor vehicles and other combustion sources, ammonia emissions, certain organic substances which form particulate matter, and additional emission sources. Secondary particulate levels are highly variable and are dependent on atmospheric conditions and precursor levels for formation. For example, in some regions at certain times of the year the secondary particles can comprise 50% or more of the total ambient measured PM2.5 concentrations. At other times, the secondary particulates are nearly negligible. Because secondary particles form through complex and variable atmospheric processes, it is not currently possible to produce accurate secondary particulate emission estimates as can now be done for the primary, directly emitted PM2.5.

1.3 Monitoring Planning Areas

The ARB and the local air quality management districts established 18 MPAs as the administrative framework for planning a PM2.5 monitoring network. Figure 1.3.1 shows MPAs for California. With few exceptions, the boundaries of MPAs correspond to the boundaries of the various air basins in the State. California is divided geographically into air basins for the purpose of managing the air quality resources on a regional basis. Areas within each air basin are considered to share the same air masses and are therefore expected to have similar ambient air quality. The State is currently divided into 15 air basins.

The State is also divided into Air Pollution Control Districts and Air Quality Management Districts (together they are referred to in this document as the *districts*), which are county or regional governing authorities that have primary responsibility for controlling air pollution from stationary sources. In the South Central Coast Air Basin and the Salton Sea Air Basin, the MPAs correspond to the local district boundaries of the agencies having jurisdictions over these areas. The splitting of these air basins facilitates the development of the PM2.5 network plans within these MPAs. The South Central Coast Air Basin has been divided into three MPAs, one for each of the districts in the air basin. The Salton Sea Air Basin has been divided into two MPAs, Coachella Valley MPA, which is under the jurisdiction of the South Coast AQMD, and the Imperial County MPA, which is under the jurisdiction of the Imperial County APCD. Table 1.3.1 lists the air basins and MPAs in California, along with the districts

Figure 1.3.1

having some jurisdiction in those areas.

The development of this *1998 California Particulate Matter Monitoring Network Description* was a cooperative effort among the air quality management agencies in California. The ARB was responsible for assembling the statewide network plan. The following eight districts drafted PM plans for their MPAs: Bay Area AQMD, Great Basin Unified APCD, Monterey Bay Unified APCD, San Diego County APCD, San Luis Obispo APCD, San Joaquin Valley Unified APCD, South Coast AQMD, and Ventura County APCD. The ARB drafted an additional nine MPA plans for the remainder of the State with the assistance and cooperation of the local districts in these areas. One of the roles of the ARB has been to ensure the coordination of the plan for each district along with the plans developed in adjoining districts.

The ARB and the local air quality districts have not established Community Monitoring Zones. The consensus among the air quality agencies is that it would be premature to do so at this time. Community Monitoring Zones within an MPA are intended for spatial averaging of PM2.5 data for comparison with the PM2.5 standards. The decision in California is to defer consideration of Community Monitoring Zones (CMZs) until there are adequate monitoring data from the PM2.5 monitors included in this network plan.

Table 1.3.1
California Air Basins, Air Quality Districts, and PM2.5 Monitoring Planning Areas

Air Basin	Air Quality District with Jurisdiction in Area	PM2.5 Monitoring Planning Area
Great Basin Valleys	Great Basin Unified APCD	Great Basin Valleys
Lake County	Lake County AQMD	Lake County
Lake Tahoe	Placer County APCD El Dorado County APCD	Lake Tahoe
Mojave Desert	Antelope Valley APCD Kern County APCD Mojave Desert AQMD	Mojave Desert
Mountain Counties	Amador County APCD Calaveras County APCD El Dorado County APCD Mariposa County APCD Northern Sierra AQMD Placer County APCD Tuolumne County APCD	Mountain Counties
North Central Coast	Monterey Bay Unified APCD	Monterey Bay
North Coast	North Coast Unified AQMD Northern Sonoma County APCD Mendocino County AQMD	North Coast
Northeast Plateau	Siskiyou County APCD Modoc County APCD Lassen County APCD	Northeast Plateau
Sacramento Valley	Butte County AQMD Colusa County APCD Feather River AQMD Glenn County APCD Placer County APCD Sacramento Metropolitan AQMD Shasta County AQMD Tehama County APCD Yolo/Solano AQMD	Sacramento Valley
Salton Sea	South Coast AQMD	Coachella Valley
	Imperial County APCD	Imperial County
San Diego Air Basin	San Diego County APCD	San Diego County
San Francisco Bay Area	Bay Area AQMD	Bay Area
San Joaquin Valley	San Joaquin Valley Unified APCD	San Joaquin Valley
South Central Coast	San Luis Obispo County APCD	San Luis Obispo County
	Santa Barbara County APCD	Santa Barbara County
	Ventura County APCD	Ventura County
South Coast	South Coast AQMD	South Coast

1.4 PM2.5 Monitoring Requirements

The Metropolitan Statistical Areas (MSAs) and Primary Metropolitan Statistical Areas (PMSAs) were used by the U.S. EPA for identifying which parts of a state have sufficient population to justify the installation of a PM2.5 monitoring network. The MSAs and PMSAs are defined by the U.S. Office of Management and Budget. The MSAs and PMSAs are named after the most populated cities or counties and are intended to include the economic influence of a population center. Their boundaries may correspond to county or municipal boundaries. Figure 1.4.1 shows these statistical areas for California.

According to the U.S. EPA PM2.5 regulations, all MSAs and PMSAs with population greater than 200,000 are required to have one or more core PM2.5 monitoring sites (core sites). Core sites are located where people live, work, and play which may not necessarily be at the expected maximum impact point for specific source emissions. By the regulations, core sites are the only sites eligible for comparison to both the annual and 24-hour PM2.5 NAAQS. They are the most important sites in the PM2.5 network. Core sites should have a population-oriented location and neighborhood or greater zone of representation. This means that PM2.5 concentrations within an area whose diameter is between 0.5 and 4 km (with the monitor in the center) should vary by no more than ±10 percent. The required number of core monitors and sampling frequency are determined by the population statistics for each MSA based on the 1990 census. In general, the greater the population of an MSA, the more monitoring sites required in that area. Table 1.4.1 shows the minimum number of core monitors for a given MSA population.

Table 1.4.1 Number of Required Core PM2.5 Sites per MSA

MSA Population	Number of Core PM2.5 monitoring sites per MSA
200,000 to 500,000	1
500,000 to 1 million	2
1 million to 2 million	3
2 million to 4 million	4
4 million to 6 million	6
6 million to 8 million	8
> 8 million	10

One additional core monitoring site is required in every Photochemical Assessment Monitoring Station (PAMS) area. This monitor should be located at a PAMS site. The PAMS areas in California are Bakersfield, Fresno, Sacramento, San Diego, Santa Barbara, South Coast, and Ventura.

Figure 1.4.1

The regulations also require a PM2.5 monitor for every 200,000 people living either outside of an MSA or in MSAs with fewer than 200,000 people. The total population in California for the base year 1990 was 29,758,213. There were 1,732,597 people living outside of MSAs or in MSAs with fewer than 200,000 people. Supplemental PM2.5 monitors are required in some of these less populated areas. Each of the additional monitors are to collect a 24-hour PM2.5 sample once every three days. Therefore, at a minimum, eight additional sites are needed to satisfy this requirement for supplemental PM2.5 monitoring. It is planned that more sites will be deployed than the minimum number required in an effort to provide better overall coverage.

The U.S. EPA determined the number of required core PM2.5 monitoring sites assuming that each of the core site categories below needs to be represented by a separate monitoring site:

- A population-oriented site with the highest expected PM2.5 concentrations.
- A site in an area of high population density with poor air quality (maximum population impact).
- A site collocated at a PAMS site, for each PAMS area included in the MPA.

The ARB and the local air quality agencies determined that in some areas of California the optimal monitoring coverage can be accomplished with fewer monitors than required by the U.S. EPA PM2.5 regulations. The following regulatory exemptions apply to these areas:

- One or more required core sites may be exempted in an area where the highest concentrations are expected to occur in an area of maximum population impact (one site may satisfy both the maximum concentration and the maximum population impact siting criteria).
- One or more required core sites may be exempted in an area with low concentrations (e.g., highest concentrations are less than 80 percent of the NAAQS).

Table 1.3.2 summarizes the PM2.5 monitoring sites required in MSAs and in PAMS areas in California. Refer to the particulate matter monitoring network description for each individual MPA in the appendices for a more detailed discussion of the proposed sites.

Table 1.4.2 Required and Proposed PM2.5 Monitoring Sites

MSA/PMSA	Population in 1990	Required PM2.5 Monitoring Sites			Proposed PM2.5 Sites
		Everyday Sampling	1 in 3 day Sampling	Total	
Los Angeles-Long Beach, PMSA	8,863,164	2-3*	8	10-11*	9
Riverside-San Bernardino, PMSA	2,588,793	2-3*	2	4-5*	10
San Diego, MSA	2,498,016	3	2	5	5
Orange County, PMSA	2,410,556	2	2	4	2
Oakland, PMSA	2,082,914	2	2	4	3
San Francisco, PMSA	1,603,678	2	1	3	2
San Jose, PMSA	1,497,577	2	1	3	2
Sacramento, PMSA	1,340,010	3	1	4	4
Fresno, MSA	755, 580	3	0	3	3
Ventura, PMSA	669,016	3	0	3	4
Bakersfield, PMSA	543,477	3	0	3	5
Stockton-Lodi, MSA	480,628	0	1	1	1
Vallejo-Fairfield-Napa, PMSA	451,186	0	1	1	1
Santa Rosa, PMSA	388,222	0	1	1	1
Modesto, MSA	370,522	0	1	1	1
Santa Barbara-Santa Maria-Lompoc, MSA	369,608	0	1	1	2
Salinas, MSA	355,660	0	1	1	1
Visalia-Tulare-Porterville, MSA	311,921	0	1	1	1
Santa Cruz-Watsonville, PMSA	229,734	0	1	1	1
San Luis Obispo-Atascadero-Paso Robles, MSA	217,162	0	1	1	2
Subtotal	**28,025,616**	**28**	**28**	**56**	**60**
Chico-Paradise, MSA	182,120	0	8	8	29
Merced, MSA	178,403				
Redding, MSA	147,036				
Yolo, PMSA	141,092				
Yuba City, MSA	122,643				
Outside of MSAs	961,303				
Subtotal	**1,732,597**	**0**	**8**	**8**	**29**
Background and Transport		0	2	2	3**
Total	**29,758,213**	**28**	**38**	**66**	**92**

* The number of monitors depends on the location of the core monitor required in the South Coast PAMS area. This monitor may be located in the Los Angeles-Long Beach, PMSA or in the Riverside-San Bernardino, PMSA.

** This number includes two background sites and one special purpose transport site. In addition, many of the monitoring sites will satisfy multiple monitoring objectives, including transport assessment.

2.0 EXISTING PARTICULATE MATTER MONITORING NETWORK IN CALIFORNIA

California has extensive network of existing particulate matter monitors. A brief overview of the network is given in Section 2.1. The three existing long-term PM2.5 monitoring programs are described in more detail in Section 2.2 through 2.4.

2.0 Overview of Existing Network

California has almost 10 years of PM2.5 data from dichotomous samplers at about 20 sites. In comparison, there are approximately 160 PM10 sites currently in operation. The existing dichot data have assisted in the design of the PM2.5 network by providing information on the trends and the magnitude of PM2.5 concentrations. By reviewing dichot data, it is apparent that PM2.5 concentrations are generally highest in the late fall and early winter throughout much of California. It is also known that nitrates are a much bigger component of PM2.5 than sulfates. There is a great deal of variation in particulate matter concentrations from region to region and within regions in the State as well.

The number of currently operating PM10 monitoring sites will not be reduced as a result of the new PM2.5 standards. California has State PM10 standards more health-protective than the PM10 NAAQS. Most areas of California have PM10 concentrations above the State PM10 standards and need to continue monitoring. Other areas with concentrations below the PM10 standards must maintain a minimum number of sites needed to determine long-term trends.

Although the dichotomous samplers collect PM2.5 data, they are not considered an equivalent monitoring method to the new PM2.5 Federal Reference Monitor (FRM). Thus, the dichot data cannot be used for designating areas as attainment or nonattainment for the PM2.5 NAAQS.

The current particulate matter monitoring network in California consists of the following approximate numbers of instruments:

- 160 High Volume Size Selective Inlet (SSI) samplers collecting 24-hour average PM10 concentrations.
- 20 dichotomous samplers collecting 24-hour average fine fraction ($\leq$2.5 microns in diameter) and coarse fraction (>2.5 and $\leq$ 10 microns in diameter) samples.
- 30 continuous mass samplers collecting PM10 measurements hourly, using either a Tapered Element Oscillating Microbalance (TEOM) sampler or Beta Attenuation Monitor (BAM) sampler.
- 39 coefficient of haze instruments.
- 17 nephelometers.
- 23 Total Suspended Particulate (TSP) Matter samplers without the size selective inlet.

The particulate matter data currently being collected are used for the following purposes:

- Compare the measured concentrations to the State and National PM10 standards.
- Track changes in the particulate matter concentrations over time.
- Evaluate the population exposure.
- Assess impact of transported particulate matter.
- Perform source reconciliation modeling.
- Assist in health studies and other research activities.
- Manage the agricultural burning program.
- Assess the need to increase or decrease the number of samplers.

The complete summary of particulate matter monitoring resources in California can be found in Attachment 1.

The following describes three long-term monitoring programs: California's routine monitoring with the dichotomous (dichot) sampler, the California Acid Deposition Monitoring Program (CADMP), and the Interagency Monitoring of PROtected Visual Environments (IMPROVE) measurement program. In these programs, particulate matter samples are collected over 24-hour periods, usually from midnight to midnight every sixth day. In addition, there have been dozens of special fine particle monitoring programs of limited (i.e., one year or less) duration in many areas of the State.

2.2 Dichotomous (Dichot) Sampler

The dichotomous sampler network has been in operation since 1983, and currently consists of almost 20 sites collecting 24-hour samples (midnight to midnight) every sixth day. The dichotomous sampler, or virtual impactor, uses a low-volume PM10 inlet followed by a virtual impactor which splits the air stream in two, separating particles into two fractions: fine particles (PM2.5, i.e., particles with aerodynamic diameters of less than 2.5 μm) and coarse particles (i.e., those having diameters of 2.5 to 10 μm). The sum of the fine and coarse fractions provides a measure of total PM10. Both fractions collected by the dichot sampler are analyzed by X-ray fluorescence (XRF) spectroscopy for 30 elemental species. Particles are collected on 37 mm diameter filters with a total specified flowrate of 16.7 liters per minute (lpm). Ten percent of the total flow is directed to the coarse particle filter, while the remainder goes to the fine particle filter. Thus, the coarse particles are collected at a low velocity, and may not adhere well to the filter. This may be one reason why PM10 concentrations measured by dichot samplers average 15 percent lower than PM10 concentrations measured by SSI samplers at a majority of sites in California on days when the state standard is exceeded (above 50 $\mu g/m^3$), based on 1990 to 1997 data. At some sites, the difference is more than 25 percent.

2.3 California Acid Deposition Monitoring Program (CADMP)

The California Acid Deposition Monitoring Program was established in early 1988 to determine the spatial and temporal patterns of acidic pollutant concentrations in the state. The CADMP dry-deposition network initially consisted of ten samplers located in Azusa, Bakersfield, Fremont, Gasquet, Long Beach, Los Angeles, Sacramento, Santa Barbara, Sequoia National Park, and Yosemite National Park. A collocated sampler was situated at the Sacramento site until July 1993, when it was moved to Azusa. Originally, the CADMP sampler had two units designed for collection of particulate species in two size fractions and for collection of acidic gases. The PM10 unit collected particles less than 10 µm aerodynamic diameter on a Teflon filter, and had impregnated back filters for collection of ammonia and sulfur dioxide. The Teflon filter was analyzed for sulfate, nitrate, chloride, ammonium, sodium, magnesium, calcium, and potassium ions. The PM2.5 unit collected two samples of particles less than 2.5 µm aerodynamic diameter, one on a Teflon-nylon filter pack without a nitric acid denuder, and the other on a nylon filter after a denuder (consisting of anodized aluminum tubes). The Teflon filter is analyzed for the same species as the PM10 Teflon filter while the nylon back filter is analyzed for nitrate ions. The difference between the total nitrate measured by the filter pack and that by the nylon filter below the denuder is a measure of gaseous nitric acid by the "denuder difference" approach. Concentrations of dry-deposition particles and gases were measured by collecting consecutive 12-hour daytime (0600 to 1800 PST) and nighttime (1800 to 0600 PST) samples, once every sixth day.

Over the years, as the data were reviewed and the limited extent of the acid deposition problem in California became known, the number of pollutants sampled and the number of sites declined. In September 1995, the CADMP network was reduced to five monitoring sites primarily in urban areas (i.e., Azusa, Bakersfield, Long Beach, Los Angeles, and Sacramento). The sample collection was changed from two 12-hour samples to one 24-hour sample commencing at midnight like the routine particulate matter monitoring network, and the sampling was reduced to PM2.5 monitoring only. The CADMP sampler uses a 20 lpm flowrate for collecting the PM2.5 sample, similar to the 16.7 lpm flowrate proposed by the U.S. EPA for the PM2.5 FRM.

2.4 Interagency Monitoring of Protected Visual Environments (IMPROVE)

The Interagency Monitoring of Protected Visual Environments (IMPROVE) measurement program is a cooperative visibility monitoring effort between the U.S. EPA, federal land management agencies, and state air agencies. The objectives of IMPROVE are: to establish current background visibility in Class I areas, to identify chemical species and emission sources responsible for existing man-made visibility impairment, and to document long-term trends. The design of the IMPROVE monitoring network was resource- and funding-limited so that it was not practical to place monitoring stations at all 156 mandatory Class I areas where visibility is an important attribute. Instead, the IMPROVE Steering Committee selected a set of sites that were representative of the Class I areas. For the first IMPROVE report, published in the spring of 1993, data for 36 sites was summarized. In the intervening time, the IMPROVE network has

evolved; two sites were dropped, some sites were downgraded to the measurement of a subset of the variables measured at a fully complemented site, and other sites have been added. There are currently a total of 58 IMPROVE sites nationwide with various configurations of optical and aerosol monitoring equipment.

Aerosol monitoring in the IMPROVE network is accomplished by a combination of particle sampling and sample analysis. The sampler was designed specifically for IMPROVE. It collects four simultaneous samples: one PM10 sample on a Teflon filter and three PM2.5 samples on Teflon, nylon, and quartz filters. The IMPROVE sampler is programmed to collect two 24-hour duration samples per week (i.e., 26 per season, 104 per year). The PM10 filter is used to determine total PM10 mass. The PM2.5 Teflon filter is used to measure total fine aerosol mass, individual chemical species using Proton Induced X-ray Emission (PIXE) and Proton Elastic Scattering Analysis (PESA), and light-absorption coefficient using the Laser Integrating Plate Method (LIPM). The nylon filter is used to measure nitrate and sulfate aerosol concentrations with Ion Chromatography (IC). Finally, the quartz filters are analyzed for organic and elemental carbon using the Thermal Optical Reflectance (TOR) method.

Transmissometers are employed to measure the light-extinction coefficient at 15 of the IMPROVE sites, and 11 sites have integrating nephelometers, which measure the scattering coefficient. Transmissometers measure the light transmitted through the atmosphere over a distance of one to fifteen kilometers. The light transmitted between the light source (transmitter) and the light monitoring component (receiver) is converted to the path-averaged light extinction coefficient (b_{ext}), which is the sum of scattering (b_{ext}) and absorption (b_{abs}). Integrating nephelometers measure the scattering of light over a defined band of visible wavelengths from an enclosed volume of air and represents a point measurement of scattering. By combining the absorption coefficient from the particle sampler with the scattering coefficient from the nephelometer, the extinction coefficient can be reconstructed at the 11 nephelometer sites. Relative humidity is measured continuously at the transmissometer and nephelometer sites.

3.0 PM2.5 MONITORING NETWORK ELEMENTS

The newly planned PM2.5 monitoring network will collect data for multiple objectives, including:

- PM2.5 attainment/nonattainment designations.
- Development and tracking of implementation plans.
- Assistance in health studies and other research activities.

In order to understand the nature of the PM2.5 problem in California and develop control strategies, multiple types of PM2.5 monitoring instruments will be needed. The Federal Reference Method (FRM) sampler is a gravimetric filter-based sampler that produces a 24-hour average concentration of PM2.5. This is the only sampler currently approved that can provide data for determining the attainment status of an area. Nevertheless, the FRM alone cannot support the multiple information needs of the PM2.5 network. The sampler has a Teflon filter that can experience loss of volatile constituents. The volatile components of PM2.5 can be more completely captured using a speciation sampler. The FRM also does not provide temporally resolved data or full chemical characterization of ambient aerosols.

The speciation sampler will provide chemical characterization of ambient aerosols for developing emission mitigation strategies and for tracking the success of implemented control programs. Continuous PM2.5 monitors will collect data for public reporting of short-term concentrations, for understanding diurnal and episodic behavior of fine particles, and for use by health scientists investigating exposure patterns.

3.1 Siting PM2.5 Monitors

The site selection process in California had many iterations and many opportunities for input. The process was coordinated by the ARB and involved air quality agencies from within California, U.S. EPA Region 9, and other stakeholders. Many competing needs and interests had to be considered when selecting sites for PM2.5 monitoring. Not all of the needs could be satisfied with the allocation of 78 sites in 1998 and 15 sites in 1999 . The following is the list of network design objectives that were given the highest priority during the PM2.5 network design:

- Satisfy the EPA core monitoring requirements.
- Represent California air basins and provide geographical representation.
- Represent high concentrations in populated areas.
- Characterize emission sources in high concentration areas.
- Consider the needs of ongoing special health studies for particle measurements.

The ARB and the local air quality districts analyzed all available information to develop a list of sites that would best satisfy these objectives. Preference was given to adapting existing sites to PM2.5 monitoring. During the site selection process, the ARB and the local air quality districts considered the following factors:

- Population statistics.
- Land use characteristics.
- Climate.
- Suspected area emission sources (e.g., wood smoke, agricultural burning, etc.).
- Existing monitoring network.
- Existing particulate matter data, including dichot data and PM10 data.
- Potential transport corridors.
- Ongoing special health studies.

The PM2.5 monitoring network planned for California will consist of the following sites:

- Eighty nine core PM2.5 State and Local Air Monitoring Stations (SLAMS). All core sites will collect data to determine attainment status with regard to both of the new PM2.5 standards. In addition, many of these sites will satisfy other monitoring objectives, including transport assessment and assistance in health studies.
- Two background sites to measure the lowest ambient PM2.5 concentrations representative of California.
- One special purpose transport assessment site primarily operated to determine the impact of transported PM2.5 on ambient concentrations in the receptor area.
- Thirteen IMPROVE sites to assess visibility impairment in Class I areas. Not all of the existing IMPROVE sites will be integrated with the PM2.5 program and some new sites will be established over the next two years in an effort to integrate visibility assessment with the PM2.5 monitoring. The IMPROVE protocol at these sites will be changed to make it more compatible with the national PM2.5 program.

Table 3.1.1 summarizes monitoring sites planned in California along with the monitoring equipment proposed at these sites. Attachment 2 lists all the monitoring sites and the type of instruments planned at these sites. The locations and number of FRM sites, as well as the locations and number of speciation samplers, listed in this report for deployment in 1999 are tentative and based on the availability of full funding from the U.S. EPA.

Table 3.1.1 Summary of PM2.5 Monitoring Sites

Site Type	Number of Sites	Monitoring Instruments		Monitoring Objective	Deployment Year
		Type	Number*		
Core SLAMS	89	FRM	89	Determine attainment status for the annual and 24-hour standards, assess transport, support health studies	78 sites in 1998 and 11 sites in 1999
		Speciation sampler	37	Analyze source attribution, evaluate emission inventories and air quality models, support health-related research studies.	1999
		Continuous sampler	8	Public reporting of short-term concentrations, understanding diurnal and episodic behavior of fine particles, investigating exposure patterns.	1999
Background	2	FRM	2	Measure lowest ambient PM2.5 concentrations	1999
Transport**	1	Continuous PM2.5	5	Assess transport	1999
		Meteorology	5		1999
IMPROVE	13	IMPROVE	13	Assess visibility impairment	1998 and 1999

* The number of instruments includes only primary samplers. The collocated samplers needed for Quality Assurance and Quality Control evaluation are not included in this table.

** This is the Special Purpose transport site that will be set up to assess transport. Many core sites will also collect data for transport assessment.

3.2 Core PM2.5 State and Local Air Monitoring Stations

The proposed PM2.5 monitoring network includes 89 PM2.5 monitoring sites to collect data for comparison to the NAAQS. Figure 3.2.1 shows the locations of the proposed sites. These sites are situated to meet the requirements for core PM2.5 monitoring sites (core sites). Based on the U.S. EPA regulations, core sites should include:

- A population-oriented site with the highest expected PM2.5 concentrations.
- A site in an area of high population density with poor air quality (not necessarily located in an area of expected maximum concentrations).
- A site collocated at a PAMS site, for each PAMS area included in the MPA.

Figure 3.2.1

The core sites are the most important sites in the PM2.5 network. Each core site will operate FRM samplers purchased through the National PM2.5 Procurement Contract established by the U.S. EPA. Only data from core sites are eligible for comparison to both the annual and 24-hour PM2.5 NAAQS. All of the sites proposed for 1998 have a population-oriented location and neighborhood zone of representation. The *neighborhood zone of representation* means that the 24-hour concentrations should vary by no more than ±10 percent over an area whose diameter is between 0.5 and 4 km.

All core sites selected to operate PM2.5 FRM samplers are located in populated areas with expected high PM2.5 concentrations for the broader area they represent. Some core sites will provide useful information about PM2.5 transport and emission sources. Each of the California Air Basins will have at least one PM2.5 monitoring site. Air basins with high population and expected high PM2.5 concentrations will have additional monitoring sites to provide better geographical representation.

A list of all PM2.5 sites proposed in California for 1998 and 1999, except the IMPROVE sites, is included in Attachment 2. Attachment 5 includes MPA maps with the proposed PM2.5 sites shown on the maps. Attachment 3 lists site characteristics for each site that will be established in 1998. The 14 sites planned for deployment in 1999 are not included in Attachment 3. Their selection is more tentative and contingent upon availability of grant funds from the U.S. EPA. The list of sites proposed for 1999 deployment will be finalized in the 1999 monitoring network plan.

3.3 Transport and Background Monitoring

An individual monitoring site can have multiple types of monitoring instruments. Many of the proposed monitoring sites in California will collect data for multiple monitoring objectives. Some core sites will collect data that could be used for assessing transport of PM2.5 between different areas within and outside of the State, as well as for other monitoring objectives. The 24-hour average data collected using FRMs will be of limited value for transport assessment. The FRM data will indicate the magnitude of PM2.5 concentrations at a site located in a transport corridor. To actually track the plume of transported PM2.5, hourly data are needed along with meteorological data. Deploying multiple instruments to provide this is expensive. Before significant resources are dedicated to transport assessment, the ARB and the local air quality agencies are proposing to do a pilot study in one transport corridors. This study would be designed to answer the following questions:

- To what extent does the transported PM2.5 contribute to high concentrations at downwind areas?
- How effective are the transport assessment tools?

Initially, we propose to evaluate the one corridor listed in Table 3.3.1 below. This is the most likely locations at which potential PM2.5 transport between air basins is expected to occur. This is a tentative proposal and will be further evaluated next year, after we collect more PM2.5

data. At the transport site, we are considering deploying continuous monitors and surface meteorological instruments (wind speed, wind direction, temperature, relative humidity, and solar radiation). The most appropriate type of continuous particulate matter monitor for transport assessment will be determined at a future time.

If we find that transport of PM2.5 contributes to high concentrations at the receptor areas and that available tools are effective in the assessments, we would consider monitoring at other corridors in the future.

Table 3.3.1 PM2.5 Transport Corridor Selected for the Initial Evaluation

Source Area	Transport Corridor	Receptor Area
San Francisco Bay Area	Altamont Pass (Tracy)	San Joaquin Valley

In addition to this special transport assessment corridor, a number of the core sites operating an FRM include transport assessment as one of the monitoring objectives. The PM2.5 data from these sites will be of little use in assessing transport unless meteorological data are collected at the sites as well. All of these core sites, except the monitoring sites in Redding and Ridgecrest, currently collect meteorological data. In 1999, the ARB and the local air quality district propose to add surface meteorological monitoring instruments at the PM2.5 sites in Redding and Ridgecrest.

Background sites are intended to quantify regionally representative PM2.5 concentrations for sites located away from populated areas and other significant emission sources. Background sites should measure PM2.5 typical of the lowest ambient concentrations in California. Because of the size and geographical diversity of the State the current proposal is to have two background sites. The feasibility of locating PM2.5 background monitors at Point Reyes National Park and at Santa Rosa Island is currently being evaluated. Both of these sites would measure PM2.5 background concentrations using FRM monitors or continuous PM monitors.

3.4 PM2.5 Chemical Speciation Sampling

The basic objective of the chemical speciation sampling is to develop seasonal and annual chemical characterizations of ambient aerosols across the nation. These chemically resolved data will be used to perform source attribution analyses, evaluate emission inventories and air quality models, and support health-related research studies.

The U.S. EPA is expected to support a network of 37 PM2.5 speciation sites in California with Federal funds. At least six of these sites are required by the regulation. One PM2.5 speciation sampler is required for each PAMS area. This sampler is required to be located at a PAMS Type 2 site in each PAMS area. These six sites will be part of the National Air Monitoring Stations (NAMS) network. In most of California, the ozone season runs from late spring through the early fall when PM concentrations are lowest. The PAMS Type 2 sites were selected to

capture the maximum ozone precursor concentrations during summer conditions. In most of California, the PM2.5 sites are most appropriately selected based on the fall and winter conditions associated with the high PM2.5 concentrations. Because PAMS Type 2 sites and PM2.5 sites have a population-oriented location, in some areas they coincide. However, not all of the PAMS areas will have the speciation sampler at a Type 2 PAMS site.

Overall, the U.S. EPA recognizes that sampling for speciation is a developing science. At the remaining 31 sites, the collection method can be tailored to the needs of individual areas. The ARB and the local air quality districts will select the speciation sampler best-suited for each of the monitoring sites in California. All chemical speciation samplers should collect samples for the currently targeted analytes, including the following:

- Cations: particulate ammonium, ionic sodium, calcium, and magnesium.
- Anions: particulate sulfate, nitrate, and chloride.
- Carbon: total, organic, and elemental.
- Trace elements: sodium, magnesium, etc., through lead.
- Semi-volatile organic particles.

Core PM2.5 sites that best meet the following criteria, listed in order of importance, were selected for collecting speciated data:

- High PM2.5 concentrations, or expected significant contribution of PM2.5 to high PM10 concentrations.
- Located in a area of significant population density.
- Supports the agricultural burning program in the Central Valley.
- Located in PAMS areas where there is a maximum precursor site for PM2.5 (this may also be a high concentration site).
- Significant for atmospheric transport determinations.
- Geographical representation of a monitored area.

We have selected 36 monitoring sites to operate speciation sampler. These sites are listed in Attachment 2 and shown in Figure 3.4.1. We are holding an additional speciation sampler in reserve, for a total of 37 speciation samplers. Holding one sampler in reserve will give us flexibility in responding to high priority needs for PM2.5 speciation monitoring that may arise later during the network design process. The list of all sites proposed to operate speciation samplers is tentative. A further evaluation of where to deploy speciation samplers will be part of the revisions to the plan next year.

Figure 3.4.1

3.5 Continuous PM2.5 Monitoring

The 40 CFR 58, Appendix D, 2.8.2.3 regulation requires that continuous samplers be placed in metropolitan areas with population greater than 1 million. Table 3.5.1 summarizes the MSAs or PMSAs in California that are required by the regulation to operate continuous PM2.5 monitors. Continuous PM2.5 data will provide useful data for public reporting of short-term concentrations, for understanding diurnal and episodic behavior of fine particles, and for use by health scientists investigating exposure patterns. However, currently available instruments for continuous measurements of suspended particulate mass have many shortcomings. The Tapered Element Oscillating Microbalance (TEOM) sampler uses a heated inlet causing evaporation of the volatile components of the air sample. The Beta Attenuation Monitor (BAM) which samples at ambient temperatures and relative humidities may overestimate particle concentrations by allowing liquid water to be collected along with particles. The ARB and the local air quality management districts will select the type of continuous instrument best suited for the monitoring conditions in various parts of California.

The sites selected to operate continuous monitors will be determined during next year's annual network review and included in the 1999 monitoring network plan. The monitors will be installed in late 1999.

Table 3.5.1 Continuous PM2.5 Monitors Required in California

MSA/PMSA by Monitoring Planning Area	Population in 1990	Required Number of Continuous Monitors
Bay Area MPA		
Oakland, PMSA	2,082,914	1
San Francisco, PMSA	1,603,678	1
San Jose, PMSA	1,497,577	1
Sacramento Valley MPA		
Sacramento, PMSA	1,340,010	1
San Diego MPA		
San Diego, MSA	2,498,016	1
South Coast MPA		
Los Angeles-Long Beach, PMSA	8,863,164	1
Riverside-San Bernardino, PMSA	2,588,793	1
Orange County, PMSA	2,410,556	1

3.6 PM2.5 Monitoring in Class I Areas

The U.S. EPA plans to locate an additional 13 IMPROVE monitors in California in the Class I Areas (national parks and wilderness areas) listed in Table 3.6.1. These IMPROVE sites will be used for visibility assessment. They will also be considered part of the PM2.5 network, although the data from the samplers for these sites will not be comparable to the standards for regulatory purposes. The IMPROVE protocol at these sites will be changed to make it more compatible with the national PM2.5 program. Not all of the existing IMPROVE sites will be integrated with the PM2.5 program, and some new sites will be established over the next two years in an effort to integrate visibility assessment with the PM2.5 monitoring. The IMPROVE Network is operated by federal land managers. Figure 3.6.1 shows a map of Class I areas in California. Those Class 1 areas that will include IMPROVE monitors and be considered part of the PM2.5 network are underlined. The U.S. EPA is proposing that the federal land managers operate these sites.

Table 3.6.1 PM2.5 Monitoring Planned in Class I Areas

Aqua Tibia Wilderness
Joshua Tree National Monument
Lava Beds National Monument
Marble Mountain Wilderness
Minarets Wilderness
Mokelumne Wilderness
San Gabriel Wilderness
San Gorgonio Wilderness
South Warner Wilderness
Ventana Wilderness
San Rafael Wilderness
Yolla Bolly Middle Eel Wilderness
Yosemite National Park

3.7 PM2.5 Quality Assurance and Laboratory Analyses

The ARB, in coordination with U.S. EPA Region IX, will be implementing new quality assurance (QA) procedures for the PM2.5 Air Monitoring Program. The new QA procedures will be developed and included in the ARB Air Monitoring Quality Assurance manuals. These PM2.5 QA procedures will incorporate the requirements, as found in 40 CFR Part 58, Appendix A, and in *EPA Requirements For Quality Assurance Project Plans For Environmental Data Operations* (EPA QA/R-5), and the guidance, as found in the U.S. EPA Quality Assurance Handbook, Volume II. The ARB will include Quality Assurance/Quality Control (QA/QC) procedures specific for the PM2.5 Air Monitoring Program equipment which will be used to implement the program.

Figure 3.6.1

The schedule for implementation will be as follows:

Submittal of the ARB PM2.5 Quality Assurance Project Plan (QAPP) outline	07/01/98
Submittal of the draft ARB PM2.5 QAPP	09/01/98
Submittal of the final draft ARB PM2.5 QAPP	11/12/98
Approval by U.S. EPA Region IX of the ARB PM2.5 QAPP	12/01/98
Implementation of the QA/QC activities as defined in the ARB PM2.5 QAPP	01/01/99

The QA/QC activities to be implemented will include, but not be limited to the following: participation in the National FRM Performance Audit Program, routine performance and system audits, data quality assessments, precision and accuracy reporting, site surveys, and a laboratory pre-certification review. The PM2.5 QAPP developed by the ARB will be utilized statewide as an integral part of the PM2.5 Air Monitoring Program.

The U.S. EPA regulations require 25 percent of PM2.5 monitoring sites to operate collocated samplers for collecting precision data. Figure 3.7.1 shows monitoring sites proposed to operate collocated PM2.5 samplers in 1998.

The U.S. EPA is supporting the development of the following five laboratories in California to perform filter weighing for mass determination:

- Bay Area AQMD.
- California Air Resources Board.
- San Diego County APCD.
- South Coast AQMD.
- Ventura County APCD.

The laboratories listed above are being upgraded to include the appropriate environmental controls and micro-balance. Because of the capital investment required to set up a proper filter weighing facility, each lab facility is expected to provide support not only within its district but also for surrounding districts. Table 3.7.1 includes the proposed division of responsibility.

Each PM2.5 mass weigh room facility (laboratory) submitting data as part of California's PM2.5 monitoring program needs to be precertified by the ARB. The requirements established in 40 CFR, Part 50, Appendix L, for mass analysis of PM2.5 filters are extremely stringent, more so than the requirements for mass analysis of PM10 filters. The U.S. EPA anticipates that the PM2.5 data collected by states will be subject to intense scrutiny by air agencies, Congress, industry, the public, and others. It is vital that these data be thoroughly supportable and of the highest quality.

Figure 3.7.1

The ARB expects to precertify the above five laboratories in 1998 for their ability to perform PM2.5 mass determinations. While additional labs may request and be included in the precertification process, priority will be given to the five funded laboratories.

The U.S. EPA will only allow California PM2.5 mass data from precertified laboratories to be entered in the Aerometric Information Retrieval System (AIRS). Information on this is being distributed to all California districts in letters from the ARB and U.S. EPA Region 9.

Samples collected from the speciation monitors will be analyzed through a nationwide network of one to three central contract laboratories. The contract laboratories are yet to be determined.

Table 3.7.1 PM2.5 Mass Analysis Laboratories and Proposed Areas of Responsibility

Laboratory	Areas of Responsibility by MPA	Number of Sites in 1998	Contact	Telephone Number
Bay Area AQMD	Bay Area Lake County North Coast	12	Rudy Zerrudo	(415) 749-4629
San Diego County APCD	San Diego Imperial Mojave	12	Mahmood Hossain	(619) 694-3358
South Coast AQMD	South Coast Coachella	17	Rudy Eden	(909) 396-2000
Ventura County APCD	Ventura Santa Barbara San Luis Obispo Portion of San Joaquin Valley Monterey Bay	13	Doug Tubbs	(805) 662-6950
Air Resources Board	Sacramento Mountain Counties Northeast Plateau Lake Tahoe Great Basin Portion of San Joaquin Valley	24	Charles Cowell	(916) 323-0223

4.0 SAMPLING FREQUENCY

The federal requirements call for everyday sampling for PM2.5 at certain core SLAMS and 1-in-3-day sampling at all other PM2.5 sites. All PM10 sites are required to sample on a 1-in-3-day schedule, unless certain waivers apply. In order to collect sufficient data and at the same time conserve monitoring resources, we are proposing alternative sampling frequencies for PM2.5 and PM10.

Data completeness is a very important consideration. For the purpose of making comparisons with the particulate matter standards, a minimum of 75 percent of the scheduled samples per quarter are required. Each sample must be collected in accordance with the requirements specified in 40 CFR, part 50, Appendix L. These requirements are also summarized in the Quality Assurance Guidance Document 2.12. The number of valid samples required to meet the data completeness criteria depends on the sampling frequency and is summarized in Table 4.0.1. Monitoring sites operating on a 1-in-6-day schedule can miss no more than three samples in a quarter to satisfy the requirement for 75 percent data completeness. Therefore, it is especially important that sites sampling on a 1-in-6-day schedule make up missing samples on a timely basis.

Table 4.0.1 Particulate Matter Sampling Frequency and the Required Number of Samples

Sampling Frequency	Number of Samples in a Quarter	
	Total Possible Samples	Minimum Required to Meet 75% Data Completeness
everyday	90	68
1-in-3 day	30	23
1-in-6 day	15	12

4.1 PM2.5 FRM Sampling Frequency

According to the new PM monitoring regulations (40 CFR section 58.13 and part 58, Appendix D), everyday sampling is required at 29 core PM2.5 sites in California (two sites per area over 500,000 population and one site per PAMS area). All other sites are required to sample once every three days. To facilitate the deployment of the PM2.5 network, the U.S. EPA issued two memorandums outlining the EPA guidance on sampling frequency during 1998 and 1999. Based on these memorandums, fewer sites will be required to sample everyday and some sites will be allowed to sample less than once in three days. One or more core SLAMS must sample everyday through 1999 in the following areas.

- In each large metropolitan area (population greater than 1 million).
- In each medium metropolitan area (population between 500,000 and 1 million) without a PM2.5 correlated acceptable continuous analyzer.
- In each PAMS area, collocated with a PAMS site during June-August.

In addition, daily sampling is encouraged at one or more SLAMS sites in monitoring areas where violations of a controlling 24-hour PM2.5 NAAQS are anticipated during seasons of the highest PM2.5 concentrations. A 1-in-6-day sampling schedule is allowed at any Special Purpose Monitoring (SPM) site.

The ARB and the local air quality districts propose a sampling frequency that will adequately support area designations, modeling, health studies, and other monitoring objectives during the first year covered by the plan (July 1, 1998 through June 30, 1999). The proposed sampling frequency varies to a limited degree from the EPA guidance. Overall, there will be more sites sampling everyday in California than required by the EPA guidance. However, the effort will be concentrated in the problem areas or areas with PM2.5 concentrations close to the standard (based on the dichotomous data and/or PM10 data). In areas where 24-hour PM2.5 concentrations are well above or below the 24-hour standard on a seasonal basis (based on the dichot data and/or PM10 data), the sampling frequency will be adjusted seasonally. In areas where 24-hour concentrations are below the 24-hour standard year round (based on the three or more years of PM2.5 and/or PM10 data), the sampling frequency will be 1-in-6-day. The following situations were considered for proposing less frequent sampling:

- A waiver from the everyday sampling schedule requirement for 1 year from the time a PM2.5 sequential sampler has been approved by the EPA.

- Exemptions from everyday or 1-in-3-day sampling during seasons or periods of low PM2.5. (A minimum frequency of 1-in-6-day sampling will be required.)

- Alternatives to everyday sampling schedules at sites with correlated acceptable continuous analyzers.

- Exemptions from 1-in-3-day sampling where existing information suggests that the maximum 24-hour-average measurements are less than the level of the standard.

The discussion of the proposed sampling frequencies is included in the MPA plans and summarized in Attachment 4. Some sites required to sample everyday will sample once every three days until the end of March, 1999, based on the 1-year waiver. After March 31, 1999 there will be 11 monitoring sites in California sampling everyday for PM2.5. An additional six sites will sample everyday during the period of expected high PM2.5 concentrations (October 1 through March 31). The remaining sites will sample on a 1-in-3-day or 1-in-6-day schedule, depending on the type of sampling equipment and estimated PM2.5 concentrations. Some sites with PM2.5 concentrations estimated to be below the standard will sample on a 1-in-6-day schedule.

We will re-evaluate the sampling schedule during the annual network review next year. Monitoring sites with PM2.5 concentrations above the 24-hour standard will be considered for more frequent sampling during the high PM2.5 season, which for most of the State is during the fall and winter.

4.2 PM2.5 Chemical Speciation Sampling Frequency

The required sampling frequency for PM2.5 chemical speciation is 1-in-12 days. This sampling frequency may not be sufficient in some cases to adequately support control plans. The appropriate sampling frequency will be determined in the future and it will depend on data needs and available resources.

4.3 PM10 Sampling Frequency

The new U.S. EPA minimum requirement for PM10 sampling frequency is once every three days. The Air Resources Board and the local air pollution control districts in California have requested in a letter dated February 18, 1998, that the U.S. EPA Region 9 grant a statewide waiver allowing sampling at the current schedule of 1-in-6 days, with certain exceptions to be determined on a case-by-case basis. To demonstrate changes in the attainment status for the national 24-hour PM10 standard, more frequent sampling may be needed. Monitoring sites with maximum 24-hour concentrations close to the 24-hour standard may be required to sample everyday or at least on a 1-in-3-day schedule. However, this should be decided on a case by case basis by the districts, the State, and the Regional U.S. EPA Office.