Chapter 1

Particulate Matter Overview and Summary of Planning Requirements

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1 PARTICULATE MATTER OVERVIEW AND SUMMARY OF PLANNING REQUIREMENTS

1.1 INTRODUCTION

This chapter provides an overview of particulate matter as an air pollutant and a summary of planning activities to improve particulate matter (PM) and PM10 (particulate matter 10 microns or less in diameter) air quality in the San Joaquin Valley Air Basin (SJVAB). PM comes from a variety of sources. The Valley's sources of PM and PM precursor emissions, coupled with its geography and climate, support the formation and trapping of particulates in the atmosphere. The effects from the resulting PM10 levels in the atmosphere include health hazards to Valley residents (particularly sensitive groups), decreased visibility, and damaged vegetation.

Although PM10 levels have decreased substantially in the San Joaquin Valley in the past few years, levels of PM measured in the Valley's atmosphere at some locations still exceed federal standards set to protect public health and welfare. Consequently, the federal Clean Air Act (CAA) requires preparation of a plan to attain healthy PM air quality. The San Joaquin Valley Unified Air Pollution Control District's (District) *2006 PM10 Plan* is a continuation of the Valley's PM10 air quality planning activities and, as such, reflects the latest information on pollutant emissions, behavior, and control.

1.2 PARTICULATE MATTER BACKGROUND

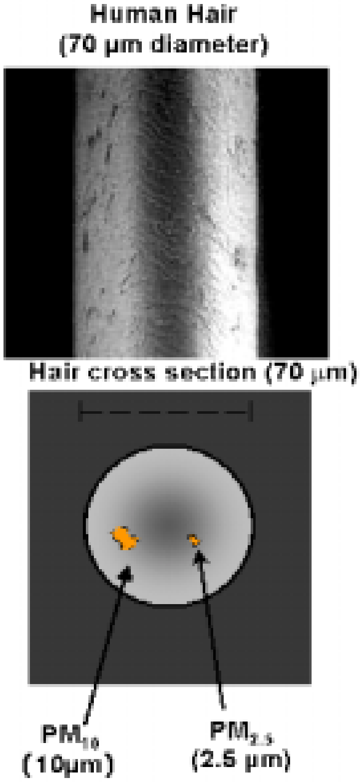
Particulate matter is a generic term for solid, liquid, or semi-volatile materials (except pure water) in the atmosphere varying in size and composition. The PM mixture of fine airborne solid particles and liquid droplets (aerosols) includes components of nitrates, sulfates, elemental carbons, organic carbon compounds, acid aerosols, trace metals, and geological materials. Some of the aerosols are formed in the atmosphere from gaseous combustion by-products such as volatile organic compounds (VOCs), oxides of sulfur (SOx), and nitrogen oxides (NOx). PM may eventually be removed from the atmosphere by gravitational settling, rainout (attaching to water droplets as they fall to the ground), and washout (being absorbed by water molecules in clouds and later falling to the ground with rain). However, particles can condense or re-enter the gas phase under different environmental conditions. All of these processes contribute to the complexity of predicting PM levels in the atmosphere using computer simulation models.

Primary PM sources, which emit PM directly into the atmosphere, include both human and natural activities and processes. Most primary PM emissions are generated from human (anthropogenic) activity. These types of activities include agricultural operations, industrial processes, combustion of wood and fossil fuels, construction and demolition activities, and entrainment of road dust into the air. Natural (nonanthropogenic or biogenic) sources also contribute to the overall PM10 problem. These include windblown dust and wildfires.

Secondary PM is formed in the atmosphere through chemical reactions among PM precursors that are emitted into the atmosphere as gases. SOx, NOx, VOCs, and ammonia are PM precursors. Control measures that reduce PM precursor emissions tend to have a beneficial impact on ambient secondary PM levels.

For air quality purposes, PM is measured and expressed as the mass of particles contained in a cubic meter of air (micrograms per cubic meter, or µg/m3). The United States has established two types of PM air quality standards: PM10 and PM2.5.[1] Air quality standards based on PM10 reflect the fraction of PM no greater than 10 microns in aerodynamic diameter (in comparison, human hair is about 60 to 75 microns in diameter, as shown in Figure 1-1). Air quality standards for PM2.5 reflect a subset of PM10 composed of particles no more than 2.5 microns in diameter[2]. Because of its size, PM10 can be inhaled through the upper respiratory airways and deposited in the lungs thereby causing serious health problems and the increased likelihood of death from other causes (see Section 1.5). Also in part because of its size, PM10 can degrade visibility through light scattering and damage vegetation by direct interaction with plant tissue (see Section 1.4).

Figure 1-1 Diameter Comparison: Human Hair, PM10, and PM2.5



1.3 SAN JOAQUIN VALLEY

1.3.1 Population and Land Use

The San Joaquin Valley Air Basin (SJVAB) is comprised of eight counties located in the southern portion of the Great Central Valley of California: Fresno, Kings, Madera, Merced, San Joaquin, Stanislaus, Tulare, and the Valley portion of Kern County. The SJVAB has major urban centers in Fresno, Stockton, and Bakersfield. Table 1-1 shows recently published population estimates for the SJVAB by county, including

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[1] On December 20, 2005, EPA announced its intent to revoke the PM10 NAAQS, revise the PM2.5 NAAQS, and establish a new 24-hour NAAQS for the PM2.5-10 fraction (urban areas only). These proposed changes are driven by new evidence on health effects from specific size fractions, federal CAA requirements, and case law affecting the PM10 and PM2.5 standards.

[2] The *2006 PM10 Plan* addresses only PM10. Federal law requires the District to prepare a separate PM2.5 Plan and submit it to EPA by April 5, 2008.

projections to 2010. The SJVAB currently has a population of approximately 3.6 million people, which represents about 9.8% of California's population in 2005 (California Department of Finance 2005), with growth projections of approximately 9% by 2010 (as compared to 2005). Increased population is a source of increased PM. New residents generate PM emissions directly and indirectly through such activities as new construction, increased vehicle miles traveled, fuel combustion, and residential wood burning.

Table 1-1 SJVAB Population by County

County	2000	2005 Projection	2008 Projection	2010 Projection	% Change, 2000-2010
Fresno	804,333	889,029	925,588	949,961	18.1%
Kern [a]	552,255	626,711	653,471	671,311	21.6%
Kings	130,087	145,952	152,181	156,334	20.2%
Madera	124,542	141,218	146,654	150,278	20.7%
Merced	211,245	243,915	264,195	277,715	31.5%
San Joaquin	569,064	662,864	713,435	747,149	31.3%
Stanislaus	451,025	509,985	539,425	559,051	24.0%
Tulare	369,700	412,418	433,356	447,315	21.0%
TOTAL	3,212,251	3,632,092	3,828,305	3,959,114	23.3%

[a] Valley portion; Kern County has portions located outside of the San Joaquin Valley Air Basin. Populations are adjusted based upon a 17% total population reduction to account for the portion of Kern County outside the basin.
Source: Developed using Population Trends Reports, California Department of Finance (2005)

The Valley is the home of the nation's most productive agriculture industry. Agriculture and agriculture-related businesses have thrived as a result of the Valley's climate, excellent soil, extensive irrigation network, and its location between the San Francisco Bay Area and Southern California markets. According to the California Department of Food and Agriculture (CDFA), eight of the top ten agricultural counties based on income in the United States are located in California, and six of California's top 10 counties are located in the SJVAB (CDFA 2002). Although the amount of farmland is being reduced by urbanization, agriculture is expected to remain the region's economic engine for many years to come.

1.3.2 Air Basin Topography

Comprising nearly 25,000 square miles, the SJVAB represents approximately 16 percent of the geographic area of California (District 2003), making it the second largest air basin in California in terms of land area[3]. It is a continuous inter-mountain valley. On the western edge is the Coast Mountain range, with peaks reaching 5,020 feet, and on the east side of the Valley is the Sierra Nevada range with some peaks exceeding 14,000 feet. The Tehachapi Mountains form the southern boundary of the Valley. This mountain range includes peaks over 6,000 feet and contains mountain passes to the Los Angeles basin and the Mojave Desert.

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[3] The SJVAB is the largest air basin in California under the control of a single District.

1.3.3 Meteorology and Climate

Weather conditions can have a profound influence on ambient PM10 concentrations. Low precipitation levels, high temperatures and light winds are conditions found within the SJVAB that are conducive to elevated PM10 levels. Other meteorological influences such as inversion layers and vertical mixing can influence the ambient PM10 air quality. During the winter months, the Valley experiences variable winds of less than 10 mph. Low wind speeds combined with low-lying inversion layers in the winter create a climate conducive to the formation of high PM10 concentrations.

General Weather Types and Seasons

According to air quality monitoring data, exceedances of the federal 24-hour PM10 standard are generally seasonal, occurring usually during fall and winter months. The SJVAB has an "inland Mediterranean" climate, which is characterized by hot, dry summers and cool, rainy winters (refer to section 2.4.2 for additional information on seasonal variation of PM10 levels in the atmosphere). The most significant single control of the weather pattern is the semi-permanent subtropical high-pressure belt, often referred to as the “Pacific High.” It is located off the west coast of North America and is a cell in which air descends almost continuously. The descending air is compressed, thereby raising temperatures and lowering the relative humidity. Major storms and region-wide precipitation are not typical when this pressure cell is dominant. This belt of high pressure migrates north and south seasonally. The SJVAB is under its influence almost continuously during summer months. In winter, the influence of the Pacific High is intermittent, giving rise to alternate periods of stormy, unsettled weather and periods of stable, rainless conditions. The SJVAB averages over 260 sunny days per year (District 2003). Air pollutants are generally transported from the north to the south in the summer and in a reverse flow in the winter due to these influences. Strong temperature inversions occur throughout the SJVAB in the summer, fall, and winter.

Precipitation

Precipitation in the SJVAB is confined primarily to the winter months, with some occurring in late fall and early spring. Nearly 90 percent of the annual precipitation in the SJVAB falls between the months of November through April. Average annual rainfall for the entire SJVAB is about 10 inches on the valley floor. Annual rainfall totals vary from north to south, with northern counties experiencing as much as 11 inches of rainfall and southern counties experiencing as little as four inches per year (District 2003). North-south and east-west regional differences exist, with higher rainfall occurring in the northern and eastern parts of the SJVAB. Historical evaluations have correlated increased annual rainfall to decreased PM10 concentrations.

Temperature

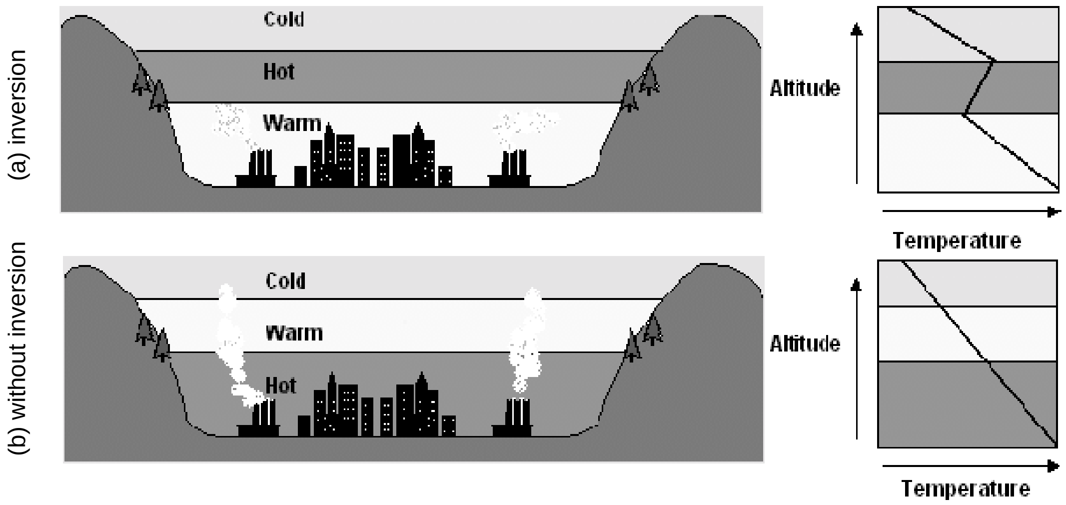
The valley floor is characterized by warm to hot, dry summers and cooler winters. The average temperature for Fresno from 1948 to 2004 was 63.3°F. Daily high temperature readings in July averaged 98°F. Also, over 1948-2004, Fresno averaged 106.3 days per year with temperatures over 90°F. Fresno averages 36 days per year with temperatures 100°F or hotter (Western Regional Climate Center 2005).

Winter temperatures in the SJVAB are generally mild, though temperatures will drop below freezing occasionally. Between 1948-2004, the average daytime high for the month of January was 54.4°F, and the average low was 37.5°F. Despite the latitudinal extent of the valley, the variation of temperature in winter is small. Surface temperatures are dependent on elevation, with colder temperatures on the mountain ridges both east and west of the valley floor.

Inversion Layers

Temperature inversions are a reversal of the "normal" decrease in atmosphere temperature with increasing height above the Earth's surface; as a result, they reflect conditions in which temperature increases with height (Figure 1-2). Vertical mixing ceases at the base of the inversion, also known as the mixing height. PM10 is trapped below the mixing height, and this contributes to higher PM10 concentrations in the SJVAB. Inversions are more persistent (stable) in the SJVAB during the winter months, when inversions occur from 50 to 1,000 feet above the SJVAB floor.

Figure 1-2 Vertical Dispersion, With and Without Temperature Inversion



Horizontal Mixing and Dispersion

Horizontal mixing, or transport, is also important in the dispersal of air pollutants. The greater the velocity of the wind in the mixing layer, the greater the amount of mixing (dispersion) and transport of pollutants. In the SJVAB, meteorological data indicate that during the summer the light and variable winds usually form an influx of air from the Pacific Ocean through the Bay Area delta region entering the north end of the valley

(District 2003). The wind generally flows towards the south-southeast through the valley, through the Tehachapi Pass and into the Southeast Desert Air Basin portion of Kern County. Figure 1-3 shows the wind flow entries and exits during the Valley's summer months.

Figure 1-3 SJV Summer Wind Patterns

During the winter, wind occasionally varies from the south-southeasterly direction and originates from the south end of the Valley, flowing in a north-northwesterly direction (District 2003). Figure 1-4 shows winter wind patterns. Both summer and winter SJV wind patterns illustrate the potential for transport of PM10 and PM10 precursors.

PM10 geologic dust emissions in the SJVAB do not follow the conventional assumption that wind erosion is the dominant factor. The average wind velocity in the SJVAB is the lowest in the nation for an area this large (District 2003). Only on 30 to 50 days per year do winds normally exceed velocities necessary for erosion to occur. Erosive winds are defined as having a velocity of 13 mph at a height of one foot above the ground or eighteen miles per hour at a height of approximately 33 feet above the ground; these two wind speeds are considered equivalent. Erosive wind speeds can be much lower for some soil conditions.

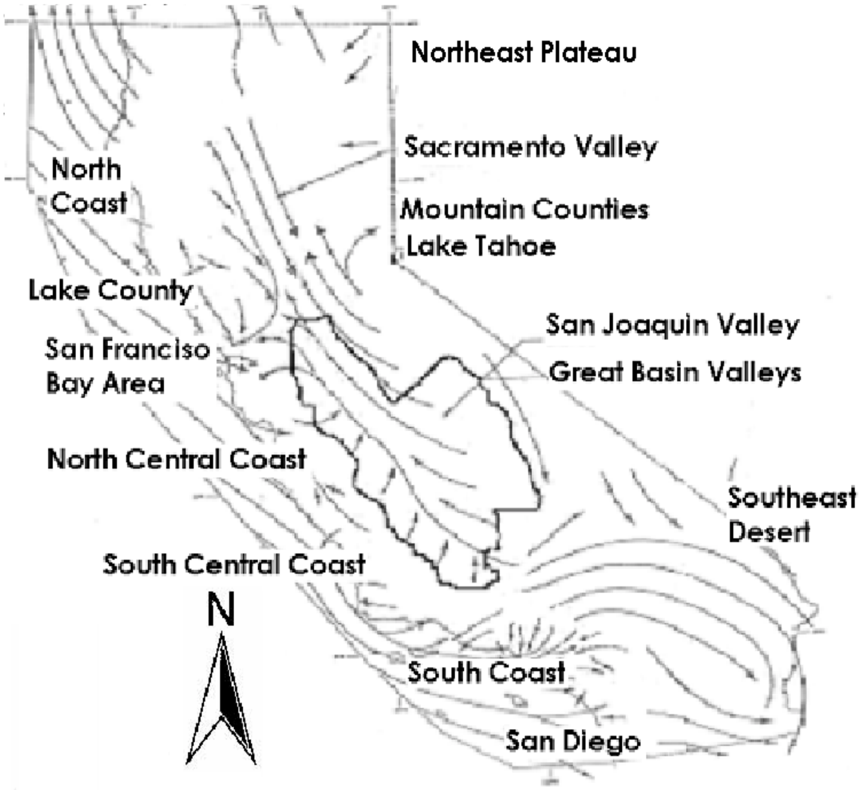


Figure 1-4 SJV Winter Wind Patterns

Sites along the southeastern edge of the SJVAB have a significantly lower number of erosive wind days than the western edge due to the mountain ranges, which act as wind barriers adjacent to these areas. Over 75 percent of the winds with enough velocity to cause erosion occur in the spring and summer seasons in the SJVAB, when PM10 concentrations are among the lowest. This suggests that these winds are effective in dispersing or transporting PM10 out of the SJVAB. Also, factors such as soil type and soil moisture content prevent these winds from entraining a large amount of PM10 during this period.

The amount of PM10 originating from or going to other air basins, referred to as pollutant transport, has not been definitively quantified. Monitoring and speciation techniques currently available are not able to identify the origin of PM10 sources with sufficient detail to indicate whether the SJVAB is experiencing transport from outside the air basin or contributing transport of PM10 to other air basins.

1.4 ENVIRONMENTAL EFFECTS OF PM

Sources hundreds or even thousands of miles away can contribute to visibility problems at remote locations, such as the Sierra Nevada Mountain Range or many of the United States' (U.S.) national parks. Regional haze, haze that impairs visibility in all directions over a large area, consists of sufficient smoke, dust, moisture, and vapor suspended in air to impair visibility. These particles often grow in size as humidity increases, further impairing visibility. In national parks in the eastern U.S., average visual range has decreased from 90 miles to 15-25 miles. In the West, visual range has decreased from 140 miles to 35-90 miles (EPA July, 2005).

The CAA amendments of 1977 and 1990, the Transportation Equity Act for the 21st Century (TEA-21), the Environmental Protection Agency's (EPA) Regional Haze Rule (1999), and the proposed amendments to the Regional Haze Rule (2005) are federal regulatory approaches to regional haze. Federal agencies that address haze include the National Park Service, the U.S. Forest Service, and the U.S. Fish and Wildlife Service. The Western Regional Air Partnership (WRAP), one of five regional planning organizations, addresses haze in California and other western states in cooperation with Western States Air Resources Council (WESTAR). By reducing local emissions of PM and its precursors, District regulations, incentives and voluntary programs also help to reduce regional haze.

PM also affects vegetation, both directly and indirectly. Particulate pollution primarily affects plants and soil by deposition of nitrates and sulfates. Particulates can degrade the outer protective layer (wax cuticle) of vegetation, cause direct foliar damage, disrupt chemical processes within the plant, or coat the plant, reducing light absorption and, in turn, hindering photosynthesis. The response varies by plant species, the type of PM, and the amount of available light.

1.5 HEALTH CONCERNS

This section is based on the science of the human health effects of PM10 as defined before December 20, 2005, when EPA proposed its intent to revoke the PM10 NAAQS, revise the PM2.5 NAAQS, and establish a new 24-hour PM2.5-10 NAAQS for urban areas. In its December 20, 2005 announcement, EPA noted that their survey of scientific evidence did not show significant public health risks associated with exposure to coarse particles typically found in rural areas or with exposure to long-term exposure to any coarse particles.

1.5.1 PM in the Respiratory System

Particles must come into contact with organ tissue to have a biological effect. The target organs in humans for PM are in the respiratory tract, which is commonly divided into three sections: the extrathoracic (from the mouth and nose to the larynx), the tracheo-broncial (from the larynx through the conducting airways), and the alveolar (the gas exchange zone deep in the lungs). Figure 1-5 shows the major components of the human respiratory system.

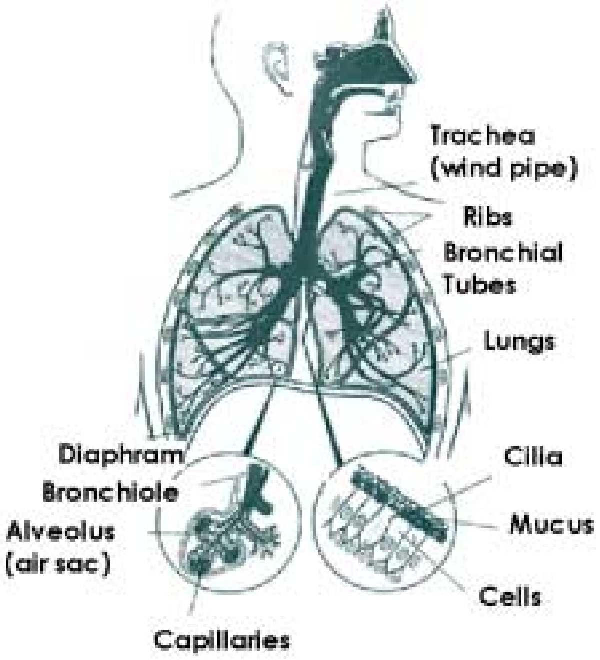


Figure 1-5 Respiratory System

Source: www.on.lung.ca/yourlungs/yourlungs.html

Any particles 10 microns or less are considered respirable. Generally, the smaller the particle, the greater the likelihood that it will penetrate deeply into the airways (HEI 2002). Larger particles are typically deposited in the extrathoracic and upper tracheo-broncial areas and smaller (fine and ultrafine) particles usually arrive deeper in the lungs in the lower tracheo-bronchial and alveolar areas. PM2.5 is of special concern to health because it is easily inhaled deeply into the lungs, where it can be absorbed into the bloodstream or remain embedded for long periods of time without an ability to be exhaled (ALA 2002). Finer particles may be aerosol carriers of toxic and biological materials, which can be absorbed by the blood in the gas exchange tissues of the lungs and carried to other parts of the body.

Particles can deposit in these areas by several mechanisms: gravitational settling, impaction on the wall of a bronchus or bronchiole, diffusion, and electrostatic attraction (which is considered less important than the other three). The respiratory responses produced by PM may be due in part to inflammation of nervous tissue. Within the conducting airways, sensory neurons in contact with particulate matter can be stimulated to release neuropeptides , which can create airway inflammatory events.

The initial target organ affected by exposure to particles is the lung, though small particles have been reported to penetrate into the blood and be detected in the systemic circulation within minutes of inhalation (Nemmar et al., 2001a, b). The basic models of the functional changes that accompany PM-related health impacts begin with deposition of PM in the airways and the alveoli, producing an inflammatory response, and potentially affecting pulmonary defenses against infection. A variety of cell types in the lung may respond to the presence of particles by secreting chemical messengers, which in turn can attract inflammatory cells to the lungs from the circulation. Exposure to respiratory irritants can stimulate airway cells to release cytokines and other chemical messengers, and can result in local inflammation, altered epithelial permeability, increased mucus secretion, and bronchoconstriction.

Chronic lung diseases, including asthma, emphysema, and chronic bronchitis, all involve ongoing, unresolved inflammation in the lung. Localized airway inflammation and absorption of particles into the lung as well as circulation may result in systemic impacts, including effects on factors influencing blood coagulation, altered cardiac autonomic control, and mobilization of inflammatory cells from the bone marrow. Interestingly, most if not all of these events have been reported to occur acutely, within a day or less of exposure (ARB 2002).

Some PM may be removed from the body. Soluble particles are cleared from the respiratory tract by absorption into mucus or other fluids, then to epithelial cells, from which they can clear the lungs (Foster 1999). In general, insoluble particles have been considered to be cleared in two phases: (1) a faster tracheo-bronchial phase considered to be more or less complete within 24-36 hours; and (2) a more prolonged phase, which can continue for days to months. (Foster 1999).

1.5.2 Health Effects Studies

The health outcomes associated with PM include hospitalization for cardiovascular or respiratory disease, emergency room and urgent care visits, asthma exacerbation, acute and chronic bronchitis, activity restrictions, work loss, school absenteeism, respiratory symptoms, and decrements in lung functions. Hundreds of published scientific studies associate airborne particulates with human health (Bell et al. 2004). Some studies of PM health effects use a time-series analysis of daily count data, in which daily counts of a particular health outcome are examined in response to PM concentrations averaged over single- and multi-day time periods, while controlling for potential confounders, such as season, meteorology, day of the week, and time trends. Another approach is to compare the daily health outcomes of a sample of individuals selected and followed over time with daily air pollution measures while controlling for differences in body mass, occupational exposures, smoking, alcohol use, age, and gender.

Time-series studies examine daily changes in air pollution, typically based on 24-hour average concentrations, in relation to daily counts of mortality. Recent, higher-quality studies are characterized by improved regression modeling, three or more years of daily data in a given city or metropolitan area, examination of the effect of day-of-the-week and daily changes in the weather, and use of locally weighted smoothing to account for time trends and seasonal patterns.

For short-term exposure to PM, two general methods are available to address the issue of the existence of a threshold, or an ambient PM level below which there would be no risk of a significant adverse health outcome. First, it can be examined indirectly, by considering data sets with very low mean ambient concentrations. Second, it can be examined directly by developing statistical tests that carefully model the shape of the concentration-response function. Studies of short-term exposure and daily mortality have detected correlations between increases in concentrations of PM pollution and mortality rate in Santa Clara (Fairley, 1999) and Coachella Valley (Ostro et al., 2000). Another study found that short term increases in air pollutant concentrations were associated with adverse health effects and missed school days among inner-city asthmatic children (O'Conner et al., 2004).

In a large, representative cross-sectional sample of the United States population, Schwartz (2001b) found that ambient PM10 was associated with elevated blood levels of several cardiovascular risk factors. Schwartz (2001b) examined local PM10 concentrations either the same day or the day before an extensive questionnaire and physical examination (including obtaining venous blood samples) while controlling for age, race, sex, body mass index, and cigarette smoking. PM10 concentrations were significantly associated with serum fibrinogen levels, platelet counts, and white blood cell counts.

Both the ACS (American Cancer Society) and Harvard Six-Cities (Boston, Knoxville, Portage, St. Louis, Steubenville, Topeka) studies report robust and statistically significant associations between several years of exposure to PM and various measures of mortality. Krewski et al. (2000) completed an independent validation and reanalysis of both the Six-Cities and the ACS studies.

Associations have been observed between daily concentrations of PM10 and daily hospital admissions for total cardiovascular disease and several of its specific components, such as congestive heart failure and ischemic heart disease. Among California cities, associations have been reported between PM10 and hospitalization for total cardiovascular disease and congestive heart failure among individuals above age 30 in Los Angeles (Linn et al., 2000 as cited in ARB 2002). In another study of Los Angeles' hospitals, Moolgavkar (2000b) reported associations between PM10 and total cardiovascular admissions among people ages 20 and older. Infant mortality and morbidity has also been associated with elevated PM10 levels in the South Coast Air Basin of Southern California (Ritz et al. 2004).

1.5.3 Who Is At Risk?

Airborne particulate matter causes an estimated 50,000 to 60,000 premature deaths nationwide each year, or three percent of the total deaths (Dockery 1991). Populations at a higher risk of experiencing adverse health effects from exposures to particulate matter include children, people of all ages with asthma, and the elderly with illnesses like bronchitis, emphysema and pneumonia (STAPPA/ALAPCO 1996). Patients with chronic obstructive pulmonary disease, such as emphysema and bronchitis, are also potentially susceptible to mortality because of their vulnerability to physical and chemical stimuli and the absence of an adequate ventilatory reserve (STAPPA/ALAPCO 1996).

Studies (such as Schiller-Scotland et al 1994 and Bennett and Zeman 1998) suggest that children may experience proportionately greater particle deposition than adults. Because of differences in anatomy, activity, and ventilation patterns, children are likely to inhale and retain larger quantities of pollutes per unit body weight than adults (Adams 1993). For infants, associations between PM and both low birth weight and premature delivery (occurring at less than 37 weeks of gestation) among a cohort of 98,000 neonates born in Southern California between 1989 and 1993. (Ritz et al. 2000).

Asthmatics and asthmatic children are at the greatest health risks from fine air particulates, and Fresno County leads the state in childhood asthma, with one in six children having lung disease (Anderson 2002). More and more people are being diagnosed with asthma every year. Nationally, fourteen Americans die every day from asthma, a rate three times greater than just 20 years ago. Children make up 25 percent of the population, but comprise 40 percent of all asthma cases. Breathing fine particles, alone or in combination with other pollutants, can aggravate asthma, causing greater use of medication and resulting in more medical treatment and hospital visits.

Breathing fine particles can also adversely affect individuals of all ages with heart disease, emphysema, and chronic bronchitis by causing additional medical treatment. Children are the most susceptible to such air pollutants because their respiratory systems are still developing and they breathe 50 percent more air per pound of body weight than adults. Exposure to fine particles is associated with increased frequency of childhood illnesses, which are of concern both in the short run and for the future development of healthy lungs in the affected children. Fine particles are associated with increased respiratory symptoms and reduced lung function in children, including symptoms such as aggravated coughing and difficulty or pain in breathing. These can result in school absences and limitations in normal childhood activities.

Studies of respiratory illness resulting from PM exposures have concluded that children, particularly asthmatics, are at greatest risk. Respiratory illness is particularly important in children because many studies have indicated that respiratory illness events in childhood (mostly viral) are important determinants for future risk of chronic respiratory symptoms in adult life.

Asthmatic individuals also appear to be more sensitive than healthy individuals to the effects of acid aerosols on lung function. Adolescent asthmatics may be more sensitive than adults, and may experience small decreases in lung function in response to sulfuric acid at exposure levels only slightly above peak ambient levels.

In general, PM has a disproportionate effect on the elderly. A large share of the acute-exposure mortality and hospitalization occurs within the elderly population. The most susceptible population segment at risk at low-level exposures consists of elderly individuals with preexisting cardiovascular and respiratory diseases, the majority of which are either current or former smokers. Smoking is an important risk factor, since it is the major cause of chronic obstructive pulmonary disease. Smoking may also be a key contributor to any low-level particulate matter exposure induced exacerbation of respiratory infections among other adults and children and to any increased cancer mortality attributable to chronic ambient particulate matter exposures.

In addition, certain subpopulations are at risk for increased exposure to particulates, and thus adverse health impacts. These populations include people living near transit corridors and people who spend a significant amount of time in-transit. The evidence to date (including Dockery et al., 1993; Krewski et al., 2000; McDonnell et al., 2000; Zanobetti and Schwartz, 2000; and Samet et Al., 2000) suggests that there may be a greater effect of PM among individuals from lower socioeconomic status groups, although the actual risk factors are unknown. Candidate risk factors include poor nutrition, lower access to and use of health care, and higher air pollution exposures due to location of residences near PM sources such as freeways and industrial facilities.

In short, the inhalation of PM10 (especially PM2.5) is associated with a series of significant health problems, including: premature death (including increased infant mortality); in-utero effects including low-birth weight and pre-term delivery; increased morbidity; mutagenic effects including cancer; respiratory-related hospital admissions and emergency room visits; cardiac-related hospital admissions and emergency room visits; aggravated asthma; acute respiratory symptoms, including aggravated coughing and difficulty in breathing; chronic bronchitis; chronic obstructive pulmonary disease (COPD); decreased lung size and function; heart disease; and work and school absenteeism. Mortality refers to death, while morbidity refers to occurrence of disease. Those who are most at risk from the exposure to fine particles include the elderly, sensitive individuals with pre-existing heart or lung disease, and children.

1.5.4 Local Health Studies and Research

In 2002, Kaiser Foundation Research Institute, under ARB sponsorship, completed a research project entitled, Particulate Air Pollution and Morbidity in the California Central Valley. Researchers of the Kaiser study found strong and consistent correlation between air pollution effects and hospital visits for acute and chronic respiratory problems among Kaiser Permanente members living in the Central Valley (Kaiser et al 2002). These associations were consistent across type of analysis and type of admission (hospitalization or emergency room visit). Of the pollutants studied, researchers found the strongest associations with PM10 and PM2.5. To a lesser extent, carbon monoxide (CO) and NO_2 were associated with adverse outcomes. In addition, their results for cardiovascular admissions were less consistent.

The Fresno Asthmatic Children’s Environment Study (FACES), which began in the fall of 2000, is a large epidemiological study of the effects of air pollution on children with asthma. The FACES project is a five-year collaborative effort sponsored by the ARB. The research is being conducted by a number of researchers from various organizations lead by the University of California, Berkeley. Results were not available in 2005, so they were not included in this plan. Future SJVAB PM plans will introduce results from FACES if they are available.

1.5.5 Health-Based Costs Associated with PM10

Adverse health effects related to PM10 result in a number of economic and social consequences, including medical costs, work loss, increased burdens for caregivers, as well as other social and economic costs. In 1996, the American Lung Association completed a study that found that the U.S. could save an estimated annual 10.9 billion or more dollars in health benefits from preventing the negative PM10 health effects if the nationwide PM10 standards are reduced to the California PM10 standards.

1.5.6 Acute Health Effects and Short-Term Standards

In developing the short-term (24-Hour) health-based standards for PM10, the EPA considered health effects reported in the literature, including mortality and various morbidity indicators such as reduced lung function. Studies of short-term or acute respiratory disease examine the rates of upper respiratory illness, lower respiratory illness, and increased coughing. Respiratory illness is particularly important in children because many studies have indicated that respiratory illness events in childhood (mostly viral) are important determinants for future risk of chronic respiratory symptoms in adult life. A large number of studies have been conducted on the effects of pollution mixes on children in the U.S. and Europe. These studies either include PM among the mix of pollutants or focus specifically on the health effects of PM. As a group they provide clear evidence that short term exposure to PM increases the risk of respiratory illness in children, particularly asthmatics (Dockery et al 1982, Dassen et al 1986).

1.5.7 Chronic Health Effects and Long-Term Standards

The annual federal ambient air quality standards are based upon studies of long-term particulate exposure. Long-term exposure mortality studies include (1) population-based cross-sectional mortality studies and (2) prospective mortality studies. The former studies employ averages across various geopolitical units to examine the relationship between mortality and levels of particulate matter. Such community-based studies seek to define the average community characteristics that are associated with its overall average health status (i.e. annual mortality rate). Prospective mortality studies consider data on the relative survival rates of individuals, as affected by age, sex, race, smoking habits, and certain other individual risk factors. There is some advantage to the prospective studies, since the identification of the actual decedents allows classification according to important risk factors such as smoking. These studies have concluded possible premature mortality due to particulate pollution; however, study results have been given less weight due to methodological shortcomings (District 2003). Results of these studies were considered during margin-of-safety evaluations of the annual PM10 standard.

1.6 MULTI-LAYERED REGULATORY RESPONSIBILITY

Based on human health and other environmental considerations, both the state and the federal government set ambient air quality standards for PM10. On the federal side, “Primary standards” are set to protect public health and are set at levels that include a margin of safety. “Secondary standards” are established to protect public welfare in issues such as material degradation, haze, and environmental effects. California standards are set to protect public health. The current California and national ambient air quality standards are listed below in Table 1-2. The attainment of air quality standards for PM and the reduction of direct PM and PM precursor emissions in the District requires the cooperation of local and/or regional, state, and federal governments.

Table 1-2 National and State Ambient Air Quality Standards for PM

Averaging Time	PM10	PM2.5
Federal [a]		
Annual b	50 µg/m^3	15 µg/m^3
24 Hours	150 µg/m^3	65 µg/m^3
California		
Annual [b]	20 µg/m^3	12 µg/m^3
24 Hours	50 µg/m^3	NA [c]

[a] On December 20, 2005, EPA announced its intent to revoke the PM10 NAAQS, revise the PM2.5 NAAQS, and establish a new 24-hour NAAQS for the PM2.5-10 fraction (urban areas only). These proposed changes are driven by new evidence on health effects from specific size fractions, federal CAA requirements, and case law affecting the PM10 and PM2.5 standards.
[b] Annual arithmetic mean
[c] No 24-hour PM2.5 air quality standard exists in California

1.6.1 Federal

At the federal level, EPA is responsible for setting NAAQS and establishing federal motor vehicle emission standards. The EPA is also responsible for reducing emissions from locomotives, aircraft, heavy duty vehicles used in interstate commerce, and other sources such as off-road engines that are either preempted from state control or best regulated at the national level.

The EPA has the authority under the CAA to require states to prepare plans to attain the NAAQS by deadlines specified in the CAA. EPA is the final reviewing agency and may approve or disapprove state air quality plans. State implementation plans (SIPs) prescribe specific pollution control strategies for each federal nonattainment area in the state. The state compiles plans prepared by regional and county air pollution control districts and air quality management districts from all nonattainment areas for submittal as the SIP. SIPs demonstrate to the EPA that the state will achieve quantifiable emission reductions and meet the federal NAAQS throughout the state by a specific date.

When EPA reviews NAAQS for a pollutant such as PM, it develops a "criteria document" that represents a compilation and scientific assessment of all the health and environmental effects. EPA develops a "staff paper" on the information available that is compiled by technical staff who interpret the most relevant information in the "criteria document" to be used in making policy decisions. The staff paper also contains staff recommendations to the EPA Administrator regarding any revisions needed to the standards to protect public health and welfare.

Both the criteria document and staff paper are based on thousands of peer- reviewed scientific studies and are part of an extensive scientific assessment process that includes an extremely rigorous scientific peer review and public comment process. Before these documents become the basis for policy decisions, they undergo repeated, detailed reviews by the scientific community, industry, public interest groups, the general public, and the Clean Air Scientific Advisory Committee, which is a Congressionally mandated group of independent scientific and technical experts. As part of its mandate, the Clean Air Scientific Advisory Committee also makes recommendations to EPA on the adequacy of the standards.

Federal PM standards were initially based on total suspended particulates (TSP) in the atmosphere. In 1987, the EPA replaced the TSP standards with PM10 standards. Since the PM10 standards were established in 1987, a large number of important new studies have been published on the health effects of particulate matter. Many of these studies suggested that significant health effects occurred at concentrations below the 1987 standards. In July 1997, the EPA adopted new air quality standards for ozone and particulate matter. After reviewing hundreds of peer-reviewed scientific studies, the EPA determined that these changes were necessary to protect public health and the environment. The EPA revised the primary (health-based) PM standards by establishing annual and 24-hour standards for PM2.5. The EPA also revised the secondary standards by making them identical to the primary standards.

The EPA recently distributed a staff paper concerning a potential coarse PM NAAQS (EPA June, 2005). The proposed standard would address particles in the size range of 2.5 to 10 microns. EPA staff concluded that coarse particles in urban and industrial areas tend to be inherently more toxic than coarse particles in rural areas. Consequently the staff paper recommended an urban coarse particle indicator for UPM10-2.5. Recently the Clean Air Scientific Advisory Committee (CASAC) reviewed the EPA staff paper (CASAC 2005). CASAC concluded that a coarse particle standard was necessary and supported the evidence indicating a variation in the composition and potential health effects of urban and rural coarse particles. In its December 20, 2005 announcement of PM NAAQS revision, EPA noted that their survey of scientific evidence did not show significant public health risks associated with exposure to coarse particles typically found in rural areas or with exposure to long-term exposure to any coarse particles.

Based on health studies conducted, PM2.5 is considered to be more adverse to human health than any other pollutant. In 1997, EPA added an annual PM2.5 standard set at 15 µg/m3 and a new 24-hour PM2.5 standard set at 65 µg/m3. On January 5, 2005 the SJVAB was designated as non-attainment for the federal PM2.5 standard (40 FR 944).

The federal health standard for PM10 is set at 150 µg/m^3 averaged over a 24-hour period, and 50 µg/m^3 for an annual average. Attainment of the standards is determined by a calculation, called a form. For the form of the 24-hour PM10 standard, the standard is attained when the expected number of days per calendar year with a 24-hour average concentration above 150 µg/m^3 is equal or less than one. The annual

PM10 standard is attained when the 3-year average of the weighted annual mean PM10 concentration at each monitor within an area does not exceed 50 µg/m^3.[4]

The CAA contains several requirements applicable to the SIP for an air district classified as a serious nonattainment area for PM10, such as the District. Table 1-3 outlines these requirements.

Table 1-3 Federal Requirements for Serious PM10 Nonattainment Areas

General Requirements	Description
Major Stationary Source	Include any stationary source or group of sources located within a contiguous area and under common control that emits, or has the potential to emit, at least 70 tons per year of PM10 or PM10 precursors
Attainment and Reasonable Further Progress (RFP) Demonstrations	The State is required to submit a demonstration (including air quality modeling) that provides for attainment by the applicable date (December 31, 2001). Best Available Control Measures to control PM10 must be implemented no later than four years after the area is reclassified to serious. The attainment demonstration shall contain quantitative milestones, which are to be achieved every three years until an area is designated attainment and which demonstrates reasonable further progress (RFP). Demonstration needs to show volatile organic compound emissions reductions from the baseline emissions by at least 3 percent each year.
Precursor Control	The control requirements applicable to major stationary sources of PM10 shall also apply to major stationary sources of PM10 precursors, except where the Administrator determines that such sources do not contribute significantly to PM10 levels, which exceed the standard in the area.
Failure to Attain	Serious PM10 nonattainment areas in which the standard is not attained by the applicable date (December 31, 2001) shall submit plan revisions, which provide for attainment and from the date of submission until attainment, for an annual reduction in PM10 or PM10 precursors within the area of not less than five percent of the amount of such emissions as reported in the most recent inventory prepared for such area.

The EPA has the authority under the CAA to impose sanctions on any area that fails to comply with the requirements of the law. The two mandatory sanctions they may impose consist of the following: (1) increased emissions offsets for major stationary sources, and (2) a prohibition on the use of federal highway funds. The offset sanction applies to major stationary sources. In a serious nonattainment area for PM10, a major source is defined as any source that emits, or has the potential to emit, 70 tons per year or more of VOC or NOx.

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[4] On December 20, 2005, EPA announced its intent to revoke the PM10 NAAQS, revise the PM2.5 NAAQS, and establish a new 24-hour NAAQS for the PM2.5-10 fraction (urban areas only). These proposed changes are driven by new evidence on health effects from specific size fractions, federal CAA requirements, and case law affecting the PM10 and PM2.5 standards.

The first sanction is as follows: the owner/operator of a major source must obtain construction and operation permits from the District for constructing a new major source or for making a major modification to an existing source. To obtain these permits, the source must reduce emissions within the District by more than the emissions created by the new or modified source on a 1.3 to 1 ratio. If the mandatory offset sanction is imposed, the offset ratio will become 2 to 1, which means that for every one ton of emissions produced, two tons must be reduced from an applicable source in the District.

The second sanction available to the EPA, the highway sanction, prohibits the federal Secretary of Transportation from approving or awarding transportation projects or grants, except for projects designed to improve a demonstrated safety problem or intended to minimize air pollution. Air quality exceptions to this sanction include the following types of programs:

- Programs for public transit
- Bus and high-occupancy lanes
- Employer trip reduction programs
- Ramp metering and signalization
- Parking facilities for multiple occupancy vehicles
- Road use charges
- Programs for breakdown and accident scene management
- Other programs improving air quality

1.6.2 State

The California Air Resources Board (ARB) is the lead state agency for air quality. It is responsible for preparing and submitting a SIP to the EPA. In preparing a state plan, the ARB reviews and approves county and regional air quality plans and incorporates them into the SIP. Under state authority, ARB also establishes emission standards for on-road motor vehicles and some off-road sources. The ARB also establishes fuel specifications and develops consumer product standards for meeting air quality goals in California. ARB develops air quality models, conducts and funds air quality research, develops emission inventories, and provides other assistance to local air districts. Other state agencies such as the Department of Pesticides, California Department of Transportation (CalTrans), and the Bureau of Automotive Repair also have responsibility for certain emission sources within their jurisdiction.

The California 24-hour and annual average standards are considerably more stringent than the federal 24-hour and annual average standards. The ARB revised the standard for the annual average on June 20, 2002, pursuant to the Children’s Environmental Health Protection Act. The 24-hour PM10 standard is 50 µg/m^3 and the revised annual standard is 20 µg/m^3 (changed from 30 µg/m^3). In addition, the ARB adopted a standard for PM2.5 that is set at 12 µg/m^3 for an annual average. California has no mandated timelines for attaining state air quality standards.

The ARB and the State Department of Health Services adopted the more stringent standards because serious health effects were found to occur at PM10 levels well below the federal 24-hour standard. The standards were developed with the intention of preventing excess deaths from short-term exposures and exacerbation of symptoms in sensitive patients with respiratory disease. In addition, the state standards were developed with the intent to prevent excess seasonal declines in pulmonary function, especially in children.

In developing these standards, the ARB and the Department of Health Services reviewed many sources of health effects data, including epidemiological, biochemical, and clinical studies of controlled human exposures, animal toxicology, and short-term bioassay. The development of the final standards focused primarily on epidemiological studies.

1.6.3 Local

Air pollution control districts and/or air quality management districts are responsible for developing the overall attainment strategy in their respective geographic areas. Districts have authority to regulate stationary sources and some area sources of emissions. They also cooperate with Regional Transportation Planning Agencies (TPAs) to develop measures affecting local transportation activity that are included in a SIP. In turn, the TPAs coordinate the process to identify and evaluate potential control measures and compile local government commitments that will be included in the local or regional air quality plan.

The District is an eight county unified district formed under the provisions of the California Health and Safety Code section 40151. The TPAs for this region are: the San Joaquin Council of Governments, Stanislaus County Association of Governments, Merced County Association of Governments, Madera County Transportation Commission, Council of Fresno County Governments, Kings County Association of Governments, Tulare County Association of Governments, and Kern Council of Governments.

Conformity requirements date back to the 1977 amendments to the CAA, but the 1990 Amendments to the CAA substantially broadened their coverage and made them more specific. Under the conformity requirements, the Valley TPAs cannot approve any Regional Transportation Plan (RTP) or Transportation Improvement Program (TIP) unless it conforms to the SIP’s purpose of eliminating the severity and number of violations of the federal standards and achieving expeditious attainment of these standards.

A RTP is normally a 20-year master plan for each county that provides policies, actions, and financial projections to guide investment decisions. Transportation programs, commonly referred to as Transportation Improvement Programs, are financially constrained sets of highway and transit projects to be funded over a multi-year period. The TIP includes all projects requiring federal funding, permits, or other approvals as well as regionally significant, non-federally funded projects. A transportation project is any highway or transit project that is included in the RTP and TIP that requires federal funding or action, or is regionally significant, and is submitted to the TPAs for project review and fund application approval.

1.7 DISTRICT PM10 PLAN HISTORY

The Governing Board of the District adopted the *2003 PM10 Plan* on June 19, 2003 and adopted Amendments on December 18, 2003. EPA approved the *2003 PM10 Plan* as amended on May 26, 2004, effective June 25, 2004 (69 Federal Register 30006-30036).[5] As part of the plan approval, the EPA approved the District's commitment to submit a SIP revision based on a mid-course review to determine whether the level of emissions reductions in the *2003 PM10 Plan* is sufficient to attain the NAAQS for PM10. This SIP revision is to include an evaluation of the modeling from California Regional Particulate Air Quality Study (CRPAQS) and the latest technical information, including inventory and monitoring data. In early 2005, the District began developing this SIP revision. On May 19, 2005, the District Governing Board adopted the *2005 Amendments to the 2003 PM10 Plan*, primarily to update control measure schedules and reductions while aligning the *2003 PM10 Plan* with federal requirements for contingency measures. The *2006 PM10 Plan* is the SIP revision required by the Federal Register approval notice for the December 2003 Amendments. The District must submit the *2006 PM10 Plan* to EPA by March 31, 2006. Following receipt of a Plan, the EPA must find the Plan complete within six months of receipt. The EPA must approve, disapprove, partially approve, or conditionally approve the plan within one year of finding the Plan complete (CAA Section 110k).

1.8 PLAN PURPOSE AND APPROACH

The *2006 PM10 Plan* is designed to meet the requirements of the CAA for areas classified as serious nonattainment of the NAAQS for PM10. The *2006 PM10 Plan* is intended to address issues and uncertainties identified by the *Federal Register* approval notice for the *2003 PM10 Plan*. The Plan contains all required components and demonstrates attainment of the federal PM10 standards at the earliest possible date. The Plan is divided into eight chapters. Supporting documents to sections of these chapters will be provided as appendices or as reference documents. Table 1-4 provides a brief description of the information contained in each of the *2006 PM10 Plan* chapters and key appendices.

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[5] In this approval notice, EPA did not act on the contingency measure provision of the plan.

Table 1-4 Contents of *2006 PM10 Plan*

PM10 Plan Chapter or Appendix	Chapter Features
Chapter 1	This chapter introduces PM as a pollutant and addresses the health effects to PM exposure. It also discusses the PM10 and PM2.5 NAAQS and cites supporting documentation for the standards. In addition, demographic statistics are presented. This chapter provides background information on the regulatory requirements for serious PM10 nonattainment areas and regulatory responsibilities of all agencies involved in reducing PM10.
Chapter 2	This chapter discusses the District's monitoring network and the type of pollutant readings taken at the various monitoring sites. It includes an air quality analysis of these readings.
Chapter 3	The emissions inventory for PM10 is presented here.
Chapter 4	This key chapter of the *PM10 Plan* presents the types of controls the District is proposing to attain the PM10 NAAQS. The information in this chapter is the culmination of information from emissions inventory work, modeling analysis, and Best Available Control Measure (BACM) studies.
Chapter 5	Modeling protocols and methodology are presented here. This chapter also presents attainment projections for the annual and the 24-hour PM10 standards.
Chapter 6	The chapter satisfies the Reasonable Further Progress (RFP) requirement. There is brief discussion on the District's position regarding the CAA requirement of a five percent annual emission reduction.
Chapter 7	The final chapter presents on-going District activities and special research projects that improve the PM10 emissions inventory and future modeling efforts.
Appendices [a]	Information too lengthy or detailed to be included in the plan text is provided as an appendix. Consult the list of appendices in the table of contents for the complete listing.

[a] Some appendices from the *2003 PM10 Plan* are referenced in this plan. They are not repeated herein since they are already in the SIP and will not be changed by information in this Plan.

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