PLAN OVERVIEW AND INTRODUCTION

PLAN PURPOSE AND APPROACH

The San Joaquin Valley Air Pollution Control District (District) PM10 Plan (Plan) is designed to meet the requirements of the federal Clean Air Act (CAA) for areas classified as serious nonattainment of the national ambient air quality standards (NAAQS) for PM10, which is measured and expressed as the amount of particles 10 microns (µm) in diameter or less contained in a cubic meter of air (µg/m^3). 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 are provided as appendices or as reference documents. The following table provides a brief description of the information contained in each of the PM10 Plan chapters and key appendices.

Table 1-1
Contents of PM10 Plan

PM10 Plan Chapter or Appendix	Chapter Features
Chapter 1	This chapter provides background information on the regulatory requirements for serious PM10 nonattainment areas and regulatory responsibilities of all agencies involved in reducing PM10. This chapter also introduces PM as a pollutant and addresses the health effects to PM exposure. It also discusses the PM10 and PM2.5 NAAQS, and cities supporting documentation for the standards. In addition, demographic statistics are presented. The focus of this chapter is the District's Plan development chronology, and the reason for preparing this Plan.
Chapter 2	This chapter provides background information regarding the geographical and meteorological features of the District. It discusses the District's monitoring network and the type of pollutant readings taken at the various monitoring sites, including annual and daily exceedances of the federal air quality standards. It concludes with 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 emission inventory work, modeling analysis, and BACM studies.
Chapter 5	Modeling protocols and methodology is presented here. Information from chapters 3, 4 and 5 are used in the presentation of information in this chapter.
Chapter 6	This chapter presents attainment projections for the annual and the 24-hour PM10 standards.
Chapter 7	The chapter satisfies the Reasonable Further Progress requirement. There is brief discussion on the District's position regarding the CAA requirement of a five percent annual emission reduction.
Chapter 8	The final chapter presents on-going District activities and special research projects that intend to improve the PM10 emissions inventory and future modeling efforts.
Appendices	Information too lengthy or detailed to be included in the plan text is provided as an appendix. They include a SIP completeness checklist, inventory tables, growth factor tables, an emission reduction credit list, the Best Available Control Measure/Technology Demonstration, and others. Consult the list of appendices in the table of contents for the complete listing.

MULTI-LAYERED REGULATORY RESPONSIBILITY

The reduction of PM10 and PM10 precursor emissions in the District requires the cooperation of local and/or regional, state, and federal governments.

Federal

At the federal level, the United States Environmental Protection Agency (EPA) is responsible for setting the 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 air quality plans. 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. Appendix A is a checklist of criteria used by the EPA to make a completeness determination for plan submittals.

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.

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 emission. They also cooperate with Regional Transportation Planning Agencies (TPAs) to develop transportation control measures (TCMs) that are included in a SIP. In turn, the TPAs coordinate control measure commitments of the cities and counties that will be included in the local or regional air quality plan.

The San Joaquin Valley Unified Air Pollution Control District is an eight county unified district formed under the provisions of the California Health and Safety Code section 40151.

SERIOUS AREA CLASSIFICATION AND FEDERAL PLANNING REQUIREMENTS

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 1-2 outlines these requirements.

TABLE 1-2
Requirements for Serious PM10 Nonattainment Areas[1]

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.

[1] CAA Section 189

Federal Clean Air Act Sanctions

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, 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.

The first sanction[2] 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 highway sanction (the second sanction available to the EPA), 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: (1) programs for public transit, (2) bus and high-occupancy lanes, (3) employer trip reduction programs, (4) ramp metering and signalization, (5) parking facilities for multiple occupancy vehicles, (6) road use charges, (7) programs for breakdown and accident scene management, and (8) other programs improving air quality.

Conformity

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.

Transportation plans, commonly referred to as Regional Transportation Plans (RTPs), are prepared and adopted by Transportation Planning Agencies. 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 (TIP), 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, which requires federal funding or

[2] Title I, Part D, Section 173(a)

action, or is regionally significant, and is submitted to the TPAs for project review and fund application approval.

DISTRICT PM10 PLAN CHRONOLOGY

When the 1990 amendments to the CAA were initially promulgated, the District was designated nonattainment for PM10 and was classified as a “moderate” area for PM10. The District was required to adopt a PM10 SIP by November 15, 1991. The District submitted a plan that contained reasonably available control measures (RACM) required for moderate areas, but was unable to demonstrate attainment by the moderate area deadline of December 31, 1994. This resulted in reclassification to “serious” nonattainment effective February 8, 1993.

The serious classification required the District to implement more stringent regulatory requirements as part of the SIP within 18 months after the re-classification and to demonstrate attainment of NAAQS by December 31, 2001. The District submitted a 1994 Serious Area Plan containing BACM commitments on September 13, 1994. On May 15, 1997 the District submitted a PM10 Attainment Demonstration Plan (ADP). Late in 2001, the EPA indicated that it intended to disapprove the 1997 PM10 ADP because it failed to provide an adequate BACM demonstration and a most stringent measures (MSM) demonstration. The MSM demonstration was required for an approval of a one-time, five-year extension to the attainment date. In addition, the ADP predicted attainment of the annual PM10 NAAQS by the December 31, 2001 and several monitoring sites had exceeded this standard in the previous three years.

Prior to the EPA’s final disapproval, the District withdrew its 1997 ADP in order to avoid an immediate freeze on local transportation funding that would have resulted from the disapproval of a Plan. This action led the EPA to file a “Notice of Failure to Submit the 1997 PM10 Plan” and started a CAA sanction clock. If the District fails to correct this deficiency, the EPA will implement the first sanction regarding offsets on August 28, 2003. The second sanction, which is the withholding of federal transportation funds, would go into effect on February 28, 2004.

The EPA made a final finding of failure to attain the PM10 standard on July 23, 2002 (effective August 22, 2002). This finding indicated that the District was required to submit an attainment plan update by December 31, 2002 that included a five percent per year reduction of PM10 or PM10 precursors. On March 21, 2003, EPA made a finding of failure to submit the “five-percent plan” by December 31, 2003 starting a second sanction clock. This finding resulted in no additional consequences because the earlier sanction clock for failure to submit the PM10 Plan would go into effect first and the same corrective action would stop both sanction clocks. The EPA must find a Plan complete within 60 days, but no later than six months after receipt. The EPA must approve, disapprove, partially approve, or conditionally approve the plan within one year of finding the Plan complete.

Table 1-3 presents an abbreviated historical chronology of the District's plan submittals and actions taken.

TABLE 1-3
District Plan Chronology

Date	Event
November 7, 1991	District Board approves the Moderate Area PM10 Attainment Plan
January 8, 1993	District reclassified as a Serious Nonattainment Area
September 14, 1994	District Board approves the Serious Area PM10 Plan
May 15, 1997	District approves the PM10 Attainment Demonstration Plan
February 21, 2002	District initiates request to withdraw the PM10 Attainment Demonstration Plan
March 15, 2002	EPA makes proposed finding of failure to attain federal PM10 standards
March 18, 2002	EPA finds that the District did not submit a PM10 Attainment Demonstration Plan; started sanction clock effective February 28, 2002 with first sanction imposed August 28, 2003
July 23, 2002	EPA finds that the SJVAB did not attain the 24-hour and annual PM10 standards by December 31, 2001
March 21, 2003	EPA finds that the SJVAB failed to submit a 5% PM10 Attainment Plan by December 31, 2002 starting 18-month and 24-month sanction clock

DEMOGRAPHICS

The San Joaquin Valley Air Basin (SJVAB) is comprised of eight counties located in the southern portion of the Great Central Valley (Valley) of California. The Valley is a major geographic, population, and agricultural sub-region of California. 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.

The SJVAB represents approximately 16 percent of the geographic area of California. It extends from the northern boundary of SJVAB south through the Valley to the SJVAB portion of Kern County (not including Eastern Kern County). From east to west, the SJVAB extends from the crest of the Sierra Nevada Mountains including the entire San Joaquin River watershed, down across the valley floor and up to the crest of the Coast Range Mountains.

The SJVAB is California's largest air basin in land area. It has a population of approximately 3.3 million persons with expected growth projections of nearly 30 percent in a period of twenty years. As a result of this population growth, activities associated with an increased population base, particularly the major population centers within the SJVAB represent a significant contributor to the high levels of pollutants in the area.

Increased population growth, in itself, is a source of PM. New residents generate PM emissions directly and indirectly through such activities as new construction of housing and businesses, increased vehicle miles traveled, fuel combustion, and increased residential wood combustion. The most recent published estimates of population levels and projections within the SJVAB are shown in Table 1-4.

The Valley is the home of the nation's most productive agriculture industry. According to the California Department of Food and Agriculture (CDFA)[3], eight of the top ten agricultural producing counties in the United States are located in California and six of California's top ten counties are located in the SJVAB. The top two counties, Tulare and Fresno, produced over $6.7 billion in commodities in 2001. Over 27,000 farms are located in the region. Harvested acreage exceeds 5.1 million acres per year. Another 5.4 million acres is used as rangeland and irrigated pasture. Although farmland is being reduced by urbanization, agriculture will remain the region's economic engine for many years to come.

Table 1-4
SJVAB Population and Land Area

County	2000[1]	July 2005 Projection[1]	% Change[2]	July 2010 Projection[1]	% Change[2]	Land Area[3]
Fresno	816,400	893,300	9.4%	970,900	18.9%	5,968
Kern[4]	563,155	640,179	13.7%	723,428	28.5%	5,584
Kings	134,500	149,600	11.2%	165,300	22.9%	1,396
Madera	127,700	152,600	19.5%	178,900	40.1%	2,145
Merced	214,400	239,900	11.9%	266,700	24.4%	1,981
San Joaquin	573,600	645,600	12.6%	727,800	26.9%	1,414
Stanislaus	454,600	522,700	15.0%	587,600	29.3%	1,511
Tulare	375,100	422,000	12.5%	469,800	25.2%	4,844
Total	3,259,455	3,665,879	12.5%	4,090,428	25.5%	24,843

[1] As of June 2001. State of California, Department of Finance, Demographic Research Unit, Interim County Population Projections, Estimated July 1, 2000 and Projections for 2005, 2010, 2015, and 2020.
[2] Percent change from the 2000 population figure.
[3] Area in square miles.
[4] 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 of the air basin.

[3] California Department of Food and Agriculture, *Agricultural Statistical Review, California Department of Food and Agriculture Resource Directory 2002*, page 31.

PARTICULATE MATTER

Background

Particulate matter (PM) is a generic term used to describe a complex group of air pollutants that vary in size and composition, depending upon the location and time of its source. It is any material, except pure water, that exists in the solid, liquid or semi-volatile state in the atmosphere. The PM mixture of fine airborne solid particles and liquid droplets (aerosols) include components of nitrates, sulfates, elemental carbon, organic carbon compounds, acid aerosols, trace metals, and geological material. 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).

The size of PM can vary from coarse wind blown dust particles to fine particles directly emitted or formed from chemical reactions occurring in the atmosphere. PM10 comprises particles with an aerodynamic diameter less than or equal to a nominal 10 microns. Particulate matter represents a broad class of chemically and physically diverse substances.

In addition to characterizations by size, particles can be described by their formation mechanism or origin, chemical composition, physical properties, and in terms of what is measured by a particular sampling technique. The EPA document, "Air Quality Criteria for Particulate Matter," contains an extensive analysis of PM10 scientific information.

Particle size determines the deposition points along the respiratory system. Particles larger than 10 microns in aerodynamic diameter are deposited almost entirely in the nose and throat area, whereas fine and ultrafine particles are able to reach the alveoli (air spaces) deep in the lungs. Generally, the smaller the particle, the greater the likelihood that it will penetrate deeply into the airways.[4]

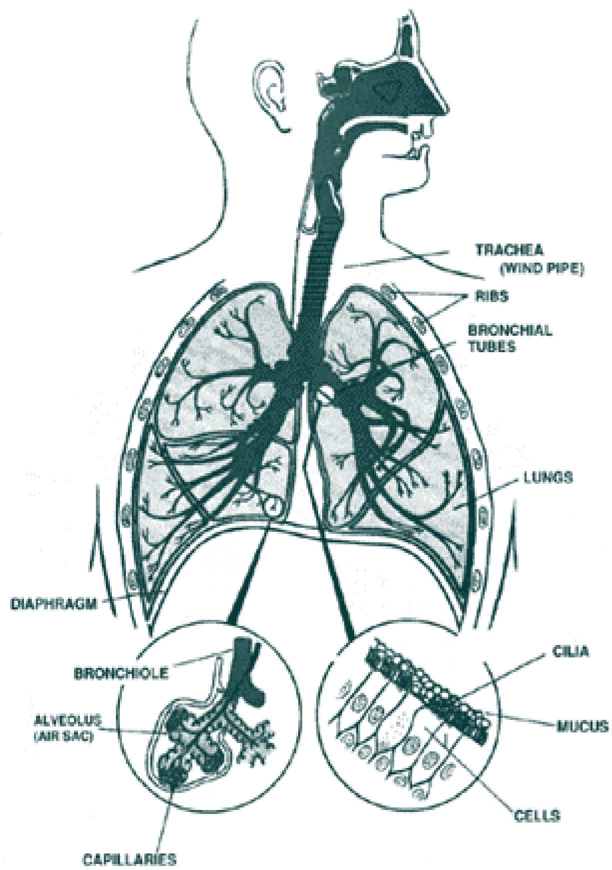
Air quality standards are based on the fraction of PM that measures at less than 10 microns in aerodynamic diameter (in comparison, human hair is about 60 to 75 microns in diameter). This fraction of particulate matter is commonly referred to as PM10. PM10 can be inhaled through the upper respiratory airways, and deposited in the lungs causing serious health problems and the increased likelihood of death from other causes. Some of the particles that measure less than 10 microns can penetrate and deposit deeply in the lungs without an ability to be exhaled. This smaller fraction, commonly referred to as PM2.5, is of special concern to health. These particles are based on the fraction of PM10 that measures at less than 2.5 microns in diameter. These finer particles are easily inhaled deeply into the lungs where they can be absorbed into the bloodstream or remain embedded for long periods of time.[5] Finer particles may be aerosol carriers of toxic and biological

[4] Health Effects Institute, *HEI Perspectives, Insights from HEI's Research Programs*, April 2002, HEI, Boston , MA, p.4, www.healtheffects.org.
[5] American Lung Association State of the Air 2002, ALA Fact Sheet Particulate Matter Air Pollution, http://www.lungusa.org/air/pm_factsheet99.html.

materials, which can be absorbed by the blood in the gas exchange tissues of the lungs and carried to other parts of the body. See Figure 1-1 for the major components of the human respiratory system.

Components of PM10 include finely divided solids or liquids such as dust, fly ash, soot, smoke, aerosols, fumes, mists and condensing vapors that can be suspended in the air for extended periods of time. Particles originate from a variety of stationary and mobile sources and may be directly emitted (primary emissions) or formed in the atmosphere (secondary emissions) by transformation of gaseous emissions such as sulfur oxides (SOx), nitrogen oxides (NOx), ammonia, and volatile organic compounds (VOC). These pollutants are known as precursors to secondary PM10 formation.

Figure 1-1: Respiratory System[6]



The complex chemical and physical properties of PM10 complicate our ability to understand and control PM10, since they vary greatly with time, region, meteorology, and source category. Primary and secondary fine particles can remain in the atmosphere for up to several days before being removed by gravitational settling, rainout (attached to water droplets as they fall to the ground), and washout

[6] www.on.lung.ca/yourlungs/yourlungs.html

(absorbed by water molecules in clouds and later falls to the ground with rain). Particles can condense or re-enter the gas phase under different environmental conditions.

In addition, the differences in the composition and sources of PM10 may have varying implications for health effects. Particles larger than 2.5 microns are often referred to as the coarse fraction, while those particles at 2.5 microns and smaller are referred to as the fine fraction. The fine particles are so small that several thousand of them could fit on the "period" at the end of a sentence. Coarse particles (larger than 2.5 microns) come from a variety of sources, including geological and general mechanical operations (e.g., automobile tire wear), industrial processes (e.g., cutting and grinding), and the re-suspension of particles from the ground or road surfaces by wind and human activities.

In contrast, particles smaller than 2.5 microns are mostly derived from fuel combustion sources, such as automobiles, trucks, and other vehicle exhaust, as well as from stationary combustion sources, such as power plants. These fine particulates are either directly emitted or they are formed in the atmosphere from gases that are emitted. Some geologic components, such as sea salt may also be present in amounts varying by geographic location.[7] More detailed information on the origins, sources, and particle properties can be found in Chapter 5

Effects on the Environment

The fine particles that are linked to serious health effects are also a major cause of visibility impairment (regional haze) in many national parks. The term regional haze means haze that impairs visibility in all directions over a large area. Regional haze consists of sufficient smoke, dust, moisture, and vapor suspended in air to impair visibility. Particulate matter that is formed when gaseous pollutants react in the atmosphere also causes regional haze. These particles often grow in size as humidity increases, further impairing visibility. Sources hundreds or even thousands of miles away can contribute to visibility problems at remote locations, such as the Sierra. In many parts of the United States, the range of visibility has been reduced 70 percent from natural conditions. In the west, the visual range has been reduced to over 60 percent. Haze currently reduces natural visibility from approximately 140 miles to between 33 and 90 miles.[8]

Significant Primary and Secondary PM10 Sources

Primary PM10 sources are derived from both human and natural activities. A significant portion of PM10 sources is generated from a variety of 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.

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[7] SJVUAPCD 1997 PM10 Plan; SCAQMD Proposed 2003 AQMP for South Coast Air Basin
[8] www.epa.gov/oar/oaqps/regusmog/infhaze.html; Last updated on Thursday, June 6th, 2002.

Secondary PM10 sources directly emit air contaminants into the atmosphere that form or help form PM10. Hence, these pollutants are considered precursors to PM10 formation. These secondary pollutants include SOx, NOx, VOCs, and ammonia. Control measures that reduce PM10 precursor emissions tend to have a beneficial impact on ambient PM10 levels.

HEALTH STANDARDS AND CONCERNS

Introduction

Since 1996, there have been more than 800 new scientific studies published that associate the effects of airborne particulates on human health. Overall, the studies validate earlier research and confirm the relationship between particulate air pollution, illness, hospitalization, and premature death. Recent research supports the results of previous major long-term studies and confirms mortality effects found in short-term national and international studies. New analyses also show that lives may be shortened by months or years, rather than days, and they affirm that infants and children, particularly asthmatic children, are especially sensitive to the effects of fine particle pollution.[9]

In short, the inhalation of particulate matter, especially fine particles, is associated with a series of significant health problems, including premature death; respiratory-related hospital admissions and emergency room visits; aggravated asthma; acute respiratory symptoms, including aggravated coughing and difficulty in breathing; chronic bronchitis; decreased lung function (shortness of breath); and work and school absenteeism. 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.

Past studies estimate that tens of thousands of elderly people die prematurely each year from exposure to ambient levels of fine particles. Breathing fine particles can also adversely affect individuals 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.[10]

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[9] American Lung Association, *Selected Key Studies on Particulate Matter and Health: 1997-2001, New Studies Confirm that Current Levels of Particulate Air Pollution are Harmful to Human Health*, Updated March 5, 2001
[10] www.epa.gov/ebtpages/airairpolparticulatematterpm.html

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.[11] 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.[12]

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.[13] 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.[14] 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.[15]

Overall, the most susceptible population segment at risk at low-level exposures consists of elderly individuals with pre-existing 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.[16]

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.[17]

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

[11] Anderson, B. “Funds for Child Asthma Study Renewed,” The Fresno Bee, Tuesday, December 17, 2002, www.fresnobee.com/local/story/5621985p-6598174c.html
[12] www.epa.gov/ebtpages/airairpolparticulatematterpm.html
[13] Dockery, D.W., “Air Pollution in Typical U.S. Cities Increases Death Risk,” a press release, Environmental Epidemiology Program, Harvard School of Public Health, Boston, May 13, 1991, p.1.
[14] Controlling Fine Particulate Matter Under the Clean Air Act: A Menu of Options; State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials, DRAFT, February 1996, p. 2-12.
[15] Ibid, p.2-12.
[16] Ibid, p.2-12.
[17] Ibid, p.2-12.

response to sulfuric acid at exposure levels only slightly above peak ambient levels.[18]

Health-Based Federal and State Standards

Based on health considerations, both the state and the federal government set ambient air quality standards for PM10, and more recently, these standards have been revisited to address the health-related concerns regarding PM2.5. In general, the air quality standards developed were determined by level of exposure to an airborne pollutant without experiencing adverse health effects.

The health- and welfare-based standards for particulate matter were last revised in 1987. The NAAQS for PM10 replaces older particulate standards based on total suspended particulates (TSP) in the atmosphere. In 1987, the EPA replaced the TSP standards because particulate matter of less than 10 microns diameter contained in a cubic meter of air ($\mu g/m^3$) that can be inhaled deeply into the lungs has greater health effects than larger particles. Under certain circumstances some particles less than 10 microns may never be removed from the lungs by exhaling, and such particles may be carriers of other toxic materials which can be absorbed by the blood and carried to other parts of the body.[19] The federal health standard for PM10 is set at 150 $\mu g/m^3$ averaged over a 24-hour period, and 50 $\mu g/m^3$ for an annual average.

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 in 2002, pursuant to the Children's Environmental Health Protection Act. The 24-hour PM10 standard is 50 $\mu g/m^3$ (however, ARB is currently reviewing the standard) and the revised annual standard is 20 $\mu g/m^3$ (changed from 30 $\mu g/m^3$). In addition, the ARB adopted a standard for PM2.5, set at 12 $\mu g/m^3$ for an annual average.

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 national 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.

[18] Ibid, p. 2-12
[19] Health Effects Institute, *HEI Perspectives, Insights from HEI's Research Programs*, April 2002, HEI, Boston, MA, p.4, www.healtheffects.org.

New Health-Based Ambient Air Quality 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 effects, such as premature mortality, hospital admissions, and respiratory illnesses, 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 established annual and 24-hour standards for the fine fraction of particulates. It revised the primary (health-based) PM standards by adding a new annual PM2.5 standard set at 15 μg/m^3 and a new 24-hour PM2.5 standard set at 65 μg/m^3. Based on health studies conducted, PM2.5 is considered to be more adverse to human health than any other pollutant.

The EPA will retain the current annual PM10 standard of 50 μg/m^3 and adjust the PM10 24-hour standard of 150 μg/m^3 by changing the form of the standard. The EPA has yet to promulgate the air quality designations of the various regions for the new PM2.5 standard.[20]

The EPA also revised the secondary (welfare-based) standards by making them identical to the primary standards. The purpose of the secondary standards in combination with the federal regional haze program is intended to provide protection against the major PM related welfare effects, such as visibility impairment, soiling and materials damage. Other recent changes made by the EPA include rules to address the monitoring network design for the new PM2.5 standards and to improve visibility by requiring states to develop programs to help reduce regional haze.[21]

The State of California also recently reviewed its PM standards. On June 20, 2002, the ARB passed new, stricter standards for particulate matter that include the following changes:

- Updated PM10 annual average standard of 20 μg/m^3, reduced from the previous standard of 30μg/m^3
- New PM2.5 annual average standard of 12μg/m^3
- Retention of the 24-hour PM10 standard of 50μg/m^3; and
- Retention of the sulfates 24-hour average standard of 25μg/m^3

The Federal Air Quality Standard Development Process

When EPA reviews national ambient air quality standards 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 information available. The EPA develops a "staff paper," which is compiled by technical staff that interprets the most relevant information in the "criteria document" to be used in making policy

[20] SCAQMD, Proposed 2003 AQMP for the South Coast Air Basin
[21] www.epa.gov/ebtpages/airairpolparticulatematterpm.html

decisions. It 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.

Acute Health Effects Considerations

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. Mortality refers to death, while morbidity refers to occurrence of disease. 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 US and Europe. These studies either include PM among the mix of pollutants or focus specifically on the health effects PM. As a group they provide clear evidence that exposure to PM increases the risk of respiratory illness in children, particularly asthmatics.

For example, a 1982 study in Steubenville, Ohio[22] examined the response of school children to episodes of elevated particulate matter. It found a possible risk of small, reversible changes in lung function, which persisted on average for 2 or 3 weeks, at levels of PM10 ranging from 140-250 $\mu g/m^3$. A similar study of school children in the Netherlands[23] found comparable results. An update of the data, published in 1994, found PM10, as well as other measures of PM, to be strongly associated with incidence of lower respiratory symptoms, such as coughing, wheezing, and phlegm, in elementary school children, even though daily PM10 levels remained below the current federal standard of 150 $\mu g/m^3$.

A 1991 study in Provo, Utah, found similar results. Statistically significant associations between elevated PM10 levels and reductions in lung function, increases in symptoms of respiratory disease, and increased medication use among asthmatics were seen even after the only pollution episode that violated daily

[22] Dockery, D.W., J.H. Ware. B.G. Ferris, Jr., F.E. Speizer, N.R. Cook, S.M. Herman. 1982. "Change in pulmonary function in children associated with air pollution episodes, " Journal of Air Pollution Control Associations. 32: 937-942.

[23] Dassen, W., B. Brunekreef, G. Hoek, P. Hofschreuder, B. Staatsen, H. De Groot, E. Schouten, K. Biersteker. 1986. "Decline in Children's Pulmonary Function During an Air Pollution Episode," Journal of Air Pollution Control Associations. 36: 1223-1227.

standards was excluded from the data and the highest recorded daily PM10 concentration was 114 $\mu g/m^3$. A study of hospital admissions in Provo found increases in admissions of children and adults for asthma and bronchitis in central Utah during months of high PM10 levels. These results were also significant because no other significant air pollutants, such as SO_2 and acid aerosols, were present. In another study conducted in Utah Valley in 1989 and 1991, it was observed that hospital admissions of children for respiratory disease dropped by over 50 percent during the winter of 1986-87 compared to adjacent years. During this winter, a strike at the local steel mill led to much lower PM-10 concentrations (a mean of 51 $\mu g/m^3$ and maximum of 113 $\mu g/m^3$ compared to a mean of 90 $\mu g/m^3$ and a maximum of 365 $\mu g/m^3$ in the previous year). A 1992 follow-up study in the Utah Valley showed an increased risk of non-asthmatic children for both upper and lower respiratory symptoms of 1.30 and 1.39, respectively, for an increase of 50 $\mu g/m^3$ in PM10.

A 1995 study of African-American asthmatic children in central Los Angeles[24] found that both PM10 and ozone were associated with increased shortness of breath, although the authors could not separate the effect of the two pollutants. Studies in the Netherlands and Switzerland have also demonstrated increased risks of cough and upper respiratory symptoms for incremental increases in PM10 of 50 to 100 $\mu g/m^3$.

Chronic Health Effects Considerations

The annual standards are based upon studies of long-term particulate exposure. Several studies have noted a correlation between mortality rates and long-term particulate pollution levels. Such long-term exposure mortality studies include (1) population-based cross-sectional mortality studies and (2) prospective mortality studies. The former 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 in this case, 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. Results of these studies were considered during margin-of-safety evaluations of the annual PM10 standard.

The data relating to morbidity that were most influential in the development of the federal annual average PM10 standard were published by Ware et al (1986) and involved approximately 10,000 six-to-nine-year-old children in six U.S. cities. The study concluded that an association existed between particulate pollutant levels and coughing, bronchitis, and respiratory illness.

[24] "A Sensitivity Analysis of Mortality/PM-10 Associations in Los Angeles," 7: 59-69.

Because of the limited scope and number of longer-term quantitative studies, qualitative data from epidemiological and annual studies were also considered in the development of the standard. These studies justify concern for sensitive groups including asthmatics, bronchitic individuals and the elderly.

In 1997, the EPA announced the establishment of new NAAQS for fine particles (PM2.5). This endeavor required the EPA to complete a review of the standards by July 2002. To increase scientific understanding of PM and health effects, the EPA also increased funding for research studies on particulates. Since the EPA last issued its "Air Quality for Particulate Matter," in 1996, numerous scientific papers and research reports have been written. In March 2001, the American Lung Association provided a summary of selected key studies on PM and health as annotated bibliography that presents these post-1996 findings of some of the "most significant new research studies that advance understanding of the harmful health effects of particulate air pollution."[25]

Local Health Studies and Research

In January 2002, a local study conducted by the Kaiser Foundation Research Institute, under ARB sponsorship, completed its research entitled, *Particulate Air Pollution and Morbidity in the California Central Valley*. The final report was issued on July 12, 2002. The purpose of the study was to investigate the relationship between particulate and other air pollutants and acute cardiopulmonary morbidity. The primary objective was to conduct time-series studies to assess how daily ambient measures of PM10, PM2.5, and selected PM chemical components, NO_2, and ozone were correlated with daily hospital admissions and emergency room visits for cardiovascular, chronic respiratory and acute respiratory diseases. A multiple time-series approach was used to incorporate an exposure assignment protocol that assigned exposure to account for daily variation over time and space in the study area. The study population was the Kaiser Permanente, Northern California membership who resided in the San Joaquin Valley. The study period was from January 1, 1996 to December 31, 2000.

In summary, researchers of the Kaiser study found strong and consistent air pollution effects and acute and chronic respiratory hospitalizations and emergency room visits among its Kaiser Permanente members living in the Central Valley. These associations were consistent across type of analysis and type of admission (hospitalization or emergency room visit). Of the pollutants studies, researchers found consistent associations with PM10 and PM2.5. To a lesser extent CO and NO_2 were associated with adverse outcomes. In addition, their results for cardiovascular admissions were less impressive and they found inconsistent results with the pollutants studied.[26]

[25] American Lung Association, *Selected Key Studies on Particulate Matter and Health: 1997-2001, New Studies Confirm that Current Levels of Particulate Air Pollution are Harmful to Human Health*, Updated March 5, 2001
[26] Final Report (Contract 97-303), Particulate Air Pollution and Morbidity in the California Central Valley: A High Particulate Pollution Region. Kaiser Permanente, et al, 12 July 2002.

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. Over 250 asthmatic children who reside in the Fresno and Clovis areas will be studied to determine the effects of different components of PM, including PM10 and PM2.5, in combination with other ambient air pollutants, on the natural history of the asthma in young children. The study consists of a variety of measurements taken over the course of five years. Measurements taken include skin testing for allergies, lung function testing, and extensive questions about the child's health and home environment. Research staff will also visit the child's home to collect indoor air and dust samples. Children will keep a journal of activities and time spent in different locations throughout the day, as well as symptoms and medication use. Portable spirometers will be used to measure lung function at home. 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. Study results are expected in 2005.[27]

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 entitled, "Dollars and Cents: The Economic and Health Benefits of Particulate Matter Reductions in the United States." The study results suggested that the United States could save an estimated annual 10.9 billion or more dollars in health benefits from prevented negative PM10 health effects if the nationwide PM10 standards are reduced to the California PM10 standards.[28]

[27] F.A.C.E.S., ARB website, www.arb.ca.gov/research/faces/faces.htm, also see California Environmental Protection Agency News Release, September 27, 2001, http://www.arb.ca.gov/newsrel/nr092701.htm
[28] Dollars and Cents: The Economic and Health Benefits of Particulate Matter Reductions in the United States, American Lung Association, June 1995, p. S-4.