Chapter 3

What is Needed to Demonstrate Attainment?

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Chapter 3: What is Needed to Demonstrate Attainment?

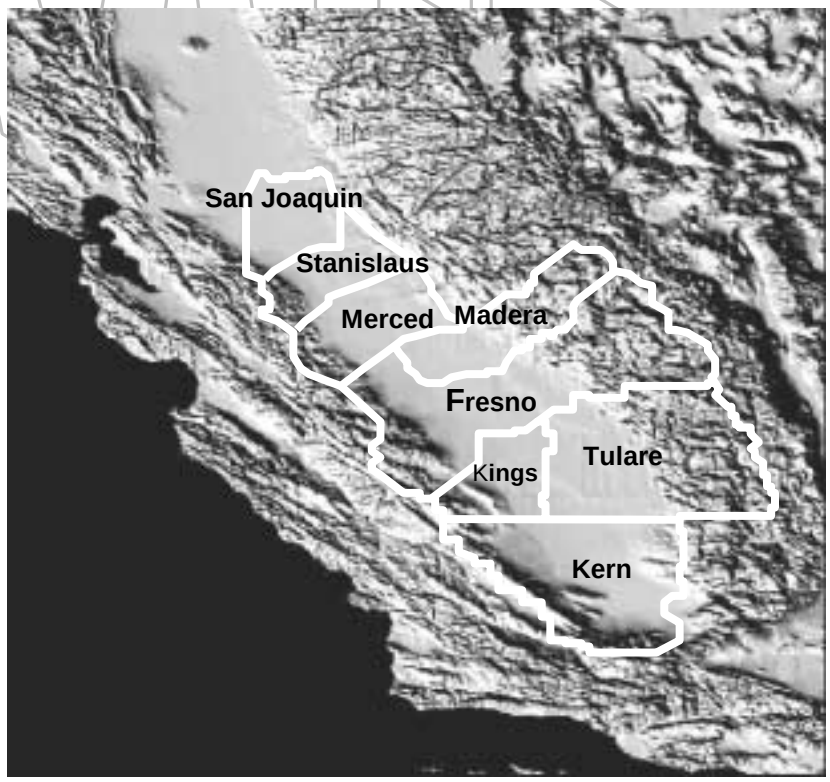
3.1 INTRODUCTION

This chapter describes what is needed to demonstrate that the San Joaquin Valley will attain the federal air quality standards for PM2.5 in accordance with federally mandated timelines. As required by EPA Guidance, computer modeling and supplemental analysis are used to determine the quantity of emissions reductions needed from sources within the District to demonstrate attainment of the standards. The scope of the effort faced by the District to establish a plan sufficient to attain the standards is defined by the local challenges and jurisdictional limitations.

3.2 CHALLENGES

The District must overcome difficult physical environment and regulatory challenges to attain the PM2.5 air quality standards. Natural conditions including climate, weather (meteorology), chemical reactions and physical processes create an atmospheric environment that forms and retains particulates in the Valley. Improving air quality is made more difficult by population growth that comes with inherent emission increases and jurisdictional limits that restrict the comprehensiveness of District efforts.

Figure 3-1 San Joaquin Valley Topography



3.2.1 Natural Conditions

The topography and climate in the San Joaquin Valley create ideal conditions for trapping and holding directly emitted PM2.5 within the Valley and generating additional PM2.5 from precursor emissions. PM2.5 emissions and precursors may be retained within the Valley for several days, recirculating within the Valley and accumulating to unhealthy levels.

The San Joaquin Valley Air Basin (SJVAB) (Figure 3-1) is a continuous inter-mountain valley encompassing nearly 25,000 square miles. On the western edge of the Valley is the Coast Mountain range with peaks reaching 5,020 feet. On the east side of the Valley is the Sierra Nevada range with some peaks exceeding 14,000 feet. The Tehachapi Mountains that form the southern boundary of the Valley include peaks over 6,000 feet and contain mountain passes to the Los Angeles basin and the Mojave Desert. The surrounding mountain ranges hinder the movement of air and block removal (dispersion) to other areas by minimizing wind flows into and out of the air basin, causing pollutants and precursors to be retained within the Valley.

The local climate produces extensive seasonal variations in particulate levels through differences in atmospheric conditions that affect the types of emissions, emission rates, and atmospheric formation of particles from precursor emissions. Long periods with little or no rainfall during summer months result in desiccation (extreme dryness) of soils along roadways, increasing emissions from traffic movement. Limited rainfall during the summer reduces the frequency of events that clear emissions from the local area. Winter brings rainfall, but also creates an atmospheric environment that forms more ammonium nitrate particulates. During winter, some types of cold winter fog events are linked to atmospheric chemistry that forms additional secondary particulates. The cold weather also induces the public to increase residential wood combustion use that adds further emissions to the atmosphere (though Rule 4901, Wood Burning Fireplaces and Wood Burning Heaters, prohibits fireplace use when the PM2.5 air quality is forecast to be unhealthy).

The SJVAB has an "inland Mediterranean" climate, which is characterized by hot, dry summers and cool, rainy winters. The SJVAB averages over 260 sunny days per year (District 2003). During summer months, the SJVAB is influenced almost continuously from a weather pattern referred to as the “Pacific High” which is a semi-permanent subtropical high-pressure belt often located off the west coast of North America. Major storms and region-wide precipitation are not typical when this pressure cell is dominant. The descending air in this cell compresses, raising temperatures and lowering the relative humidity. This belt of high pressure migrates north and south seasonally. 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. Due to the influence of these air movement patterns, air pollutants are generally transported from the north to the south in the summer and in a reverse flow in the winter. Analysis of wind flow shows that during the winter months, the mean flow is through the Valley from the southeast. By mid-spring, coastal breezes enter the Valley from the northwest,

which reverses the airflow pattern. In summer the northwest to southeast airflow is at its strongest. In the fall and winter, average wind speeds range from five to nine miles per hour; however, very light winds occur from twenty to forty percent of the time.

Precipitation in the SJVAB is confined primarily to the winter months with nearly ninety percent of the annual precipitation in the SJVAB falling between the months of November through April. Average annual rainfall for the entire SJVAB is about ten inches on the valley floor. Annual rainfall totals vary from north to south, with northern counties experiencing as much as eleven 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.

3.2.2 Meteorology

Meteorology plays an important role in determining the levels of air pollution in the Valley and is a key parameter to understanding and predicting PM2.5 concentrations. Meteorological data are used to assess the potential for air pollution to accumulate in certain locations. Pertinent meteorological parameters include wind speed and direction, ambient atmospheric temperature at different elevations above the ground, precipitation and mixing height (the elevation in the atmosphere into which the emissions will freely mix and disperse).

Meteorological patterns affect PM2.5 by directly affecting emissions (e.g. temperature linked evaporation rates), influencing secondary particle formation (aerosol chemistry) and controlling the rate at which pollution dissipates (wind induced dispersion or inversion restricted flow). The valley floor is characterized by warm to hot, dry summers and cooler winters. Winter temperatures in the SJVAB are generally mild, though temperatures will drop below freezing occasionally. Surface temperatures are dependent on elevation, with colder temperatures on the mountain ridges both east and west of the valley floor. Fall and winter meteorological conditions contribute to increased PM2.5 formation shifting from dominance by primary particles to secondary particles. Secondary particles formed from gases by atmospheric processes are a major portion of the PM2.5 during colder, wetter periods from mid November through early February. Colder, frequently stagnant conditions occurring in December and January favor formation of ammonium nitrate, and these months usually experience the highest levels of PM2.5. During the winter months, the Valley frequently experiences variable winds of less than 10 mph. Low wind speeds, combined with low-lying inversion layers in the winter and increased secondary particle formation, establish a situation conducive to the formation and accumulation of PM2.5.

Meteorological factors that restrict horizontal and vertical air movement of air masses are important factors in air quality. Horizontal movement spreads the pollutants over a wider geographic area. Winds carry emissions away from the area of emissions,

dispersing the emissions and keeping concentrations low. Emissions accumulate if wind speed is zero or stagnates and recirculates over a small area. Vertical mixing height is reduced when an inversion layer is present. An inversion layer is a layer of air warmer than the layer below it. Cooler air below the inversion layer cannot rise through the warmer layer. The warmer layer aloft prevents the usual rising airflow that disperses emissions from the ground. Air contaminants accumulate near the ground as emissions continue to be released into this cooler layer near the surface.

3.2.3 Horizontal Mixing (Transport)

Horizontal mixing, or transport, is also important in the dispersal of air pollutants. The greater the velocity of wind in the mixing layer, the greater the amount of mixing (dispersion) and transport of pollutants. Winds (at ground level or at higher altitudes) transport pollutants from other basins into the Valley, within the Valley to areas downwind, and from the Valley into other regions. Studying transport increases understanding of how pollution from other areas may impact the Valley as well as how pollution originating in Valley areas may impact other places within and beyond the Valley. Evaluation with improved emissions inventories, improved databases on meteorological behavior and atmospheric chemistry, and improved grid-based photochemical models all contribute to ongoing studies that enhance our understanding of pollutant transport. Future District plans will incorporate any significant advances in knowledge regarding transport as it becomes available from ARB and other agencies.

The amount of pollution transported from other areas into the Valley varies. PM2.5 originating from other air basins has not been quantified. During winter, the low wind speeds associated with high particulate levels generally reflect concentrations formed from local emissions. However, wildfires, Santa Ana winds, and offshore flow introduce particulates and precursors into the Valley at different times during the year. PM2.5 readings in the SJVAB are most severe during the fall and winter periods when wind speed and direction are not conducive to interregional transport. Monitoring and speciation techniques currently available are not able to identify the origin of PM2.5 sources with sufficient detail to indicate if the SJVAB is experiencing transport from outside the air basin. Transport of some PM2.5 precursors has been studied as part of ozone transport evaluation, identifying transport of ozone and ozone precursors from and to other air basins surrounding the SJVAB. The transport of ozone was documented during the summer when the highest ozone readings are more likely to occur. This transport includes precursors of ozone and PM2.5; however, the amount of PM2.5 that could be generated in the SJVAB from such transport has not been quantified. Pollution from areas outside of the Valley may or may not contribute to high PM2.5 levels within the Valley.

Transport can also move Valley pollution into other air basins. PM2.5 going to other air basins from the SJVAB has not been quantified. During the daytime, heated air rises into the mountains and transports ozone and other pollutants up the Sierra Nevada, Tehachapi, and Coastal Mountains. According to the ARB, the Valley's pollution can

affect ozone air quality in the broader Sacramento area, the Great Basin valleys, the mountain counties, the Mojave Desert, and the north central and south central coasts, depending on meteorological conditions (ARB 2001). ARB assesses transport corridors for ozone but is not required to perform a similar assessment for particulates. Transport of particulates and precursors was evaluated as part of the California Regional Particulate Air Quality Study (CRPAQS) research program. A specific findings document has not been prepared to quantify the magnitude of transport between the major air districts; however, preliminary findings did identify that there may be occasions of some transport of particles and/or precursors from the SJVAB to the Bay Area in winter. A more detailed accounting of inter-basin transport between Bay Area, SJVAB and Sacramento Air Basin may be developed as part of final synthesis documents at the completion of the CRPAQS project.

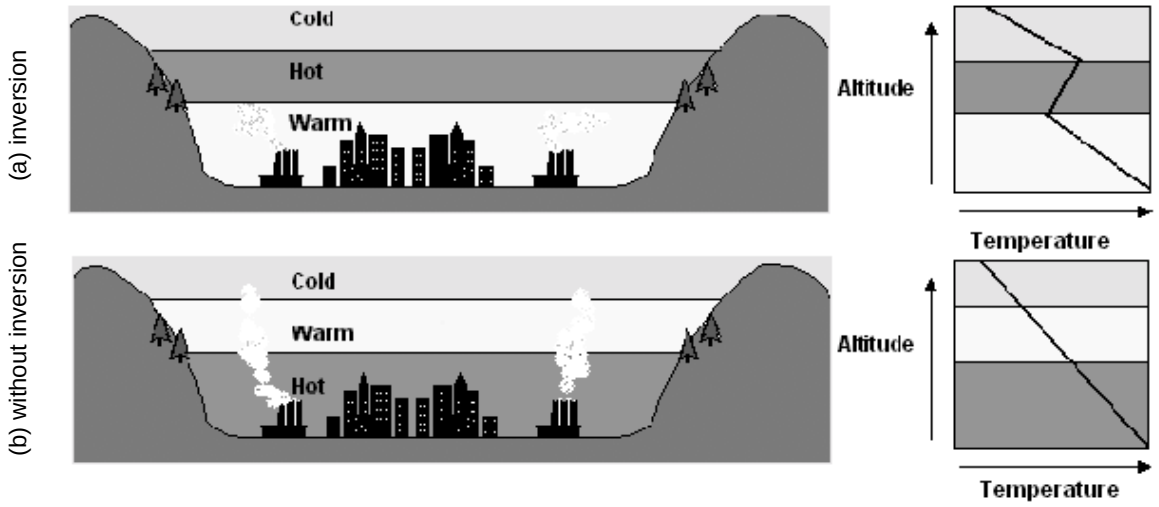
Precursors and directly emitted particulates originating in the SJVAB are also transported within the Valley. Local emissions are thought to be more responsible for the Valley's worst ozone and particulate air quality. Some SJVAB pollution is not transported into other basins, but remains and recirculates into other parts of the Valley. At night during the summer, cooler drainage winds from the surrounding mountains prevent exit of the air at the southern end of the SJVAB causing a recirculation airflow pattern known as the Fresno eddy. The eddy circulates pollutants in a counterclockwise pattern and returns polluted air to urban areas where more precursors are added the next day. Throughout the Valley, some of the pollutants transported to higher altitudes from daytime heating return to the Valley floor at night because of drainage winds from the mountains. During the winter, flow patterns at the Valley floor may become completely stagnant, keeping emissions within a few miles (or tens of miles) of the originating sources for several days.

3.2.4 Vertical Mixing and Inversion Layers

In general, the air at ground level is warmed by sunlight and activity, causing it to rise and carry emissions aloft. This rising air pattern mixes the fresh emissions with air at higher elevations, dispersing the emissions and reducing the concentration of directly emitted PM2.5 and precursors. However, in the San Joaquin Valley a temperature inversion layer frequently blocks the normal rising air dispersion pattern. Temperature inversions are a reversal of the "normal" decrease in atmosphere temperature with increasing height above the Earth's surface. Inversions reflect conditions in which temperature increases with height (Figure 3-2).

Vertical mixing decreases at the base of the inversion, also known as the mixing height. PM2.5 is trapped below the mixing height, remaining more concentrated than when it is allowed to mix more freely into higher elevation air. This contributes to higher PM2.5 concentrations in the SJVAB.

Figure 3-2 Vertical Dispersion, With and Without Temperature Inversion



Strong temperature inversions occur throughout the SJVAB in the summer, fall, and winter. 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. The challenge this creates for the Valley is that in the absence of an inversion layer, emissions will not accumulate to levels that are harmful to health. However, if an inversion layer forms the same level of emissions may create localized areas with high PM2.5 concentrations. Predicting the strength, elevation and duration of the inversion is based on regional meteorological models supplemented by a few vertical air profiler sites providing local data. The District uses this information to prepare daily forecasts of air quality and advises the public when conditions are projected to cause poor air quality. Additionally, the district manages agricultural and prescribed burning and residential wood combustion curtailments to avoid adding smoke emissions. when conditions are unfavorable.

3.2.5 Fog Effects on PM2.5

Particles that become fog droplets by absorbing water vapor are subsequently removed by gravitational settling. Fog episodes cause a net removal of PM by wet deposition. However, fog also provides an aqueous medium for formation of sulfate particulate. The net effect of a fog episode depends on the pre-fog concentrations of particulate precursors and availability of oxidants that are involved in the chemistry of particle formation, and the duration of the fog event.

+/- Sulfate is both produced and removed by fog. The end result of a fog event may be either increase or decrease in the monitored levels of PM2.5 sulfate. Sulfate

particulate is removed by wet deposition during fog; however, fog droplets provide the aqueous medium for the production of sulfates and the production of additional sulfate particulate by chemical reactions. The fog may over-balance the wet removal and actually increase the amount of sulfate PM2.5 in the atmosphere. Whether sulfate formation in fog exceeds sulfate removal by fog settling will vary from site to site, depending on the duration of event and concentrations of available reactants to form additional sulfate particulate matter.

- Nitrate and ammonium are partially removed by fog. Nitrate and ammonia gases in the atmosphere may be reduced by half through fog wet deposition.

- Secondary Organic Aerosol (SOA) formation (formation of organic carbon particulate from photochemical oxidation reactions of precursor gases) is reduced by decreased photochemical activity in circumstances where sunlight is reduced by fog or cloud cover. Clouds and fog reduce the photochemical production of secondary organic aerosols by a factor of two or three from the maximum clear sky conditions because of reduced availability of photons. The thermodynamic interactions between fog droplets and SOA are unknown.

3.2.6 Urban and Rural Comparison and Atmospheric Chemistry for PM2.5

The major effects of urban emissions are observed in the winter where primary emissions typically contribute more to PM2.5 at the urban sites than at the rural sites. In urban areas, directly emitted PM2.5 levels are dominated by motor vehicle and tire and brake wear emissions, entrained particulate from roadways, and carbon from residential wood combustion in winter. Precursors to secondary PM2.5 formed from atmospheric processes are dominated by urban emissions of nitrogen oxides (NOx), sulfur dioxide SO_2 and VOC; however the reactions of these precursors to form particles are dominated by concentrations of nitric acid (HNO_3), a secondary compound formed from atmospheric reactions. Ammonia (NH_3) emissions are largest in rural areas.

Total oxidized nitrogen is higher in the urban areas. NOx in urban areas is ten times more abundant than in rural areas. Ammonia is more abundant in Bakersfield than at the other core sites. SO_2 was also more abundant in the cities than rural areas. Gas-phase organic concentrations exhibited strong diurnal fluctuations in the urban areas.

District monitoring sites are not dominated by emissions from a single large facility or group of facilities. No direct link has been found between a specific locally observed source of emission activity and high PM2.5 at a single monitoring site on a consistent basis. The observed PM2.5 levels represent aggregated urban emissions with regional contributions. In winter, the urban residential and traffic monitor sites show higher concentrations than sites near industrial areas.

Ammonium nitrate is the main component of PM2.5 during the winter in the San Joaquin Valley. As supported by modeling evaluation, ammonium nitrate formation is limited by the availability of nitric acid, formed from urban NOx and hydrocarbon reactions. The

formation of ammonium nitrate is limited by the availability of atmospheric concentrations of nitric acid (HNO_3), a secondary compound that forms from emission of NOx interacting with hydrocarbons and OH radicals released from the hydrocarbons by photochemical reactions. Ammonia (NH_3) is abundant throughout the Valley and does not act as a limiting precursor. A large fraction of nitrates were associated with the particulate phase; only 18-25% of nitrate existed in the gas phase as nitric acid.

Independent corroboration of key aspects of ammonia contribution to particulate in the San Joaquin Valley is provided through scientific analysis conducted by other researchers. For example: an article by Battye, et al[1] identifies ammonia from motor vehicle exhaust as a major contributor to particulates during winter months with a reduced role for agricultural sources during this time period. This article has important implications for determining which sources of precursors contribute the most to ammonium nitrate particulate concentrations in the winter.

Secondary organic aerosols (SOA) contribute to a significant fraction of PM2.5. SOA is organic carbon particulate formed in the photochemical oxidation of anthropogenic and biogenic VOC precursor gases. Aromatic compounds are believed to be efficient SOA producers contributing to this secondary particulate.

Annual PM2.5 is dominated by winter concentrations, and urban sites have more carbon. According to the Desert Research Institute (DRI):

> "For most of the sites within the SJV, 50 – 75% of the annual average PM2.5 concentration could be attributed to a high PM2.5 period occurring from November to January. At non-urban sites, the elevated PM2.5 was driven by secondary NH4NO3. The temperature, RH [relative humidity], and stability of the valley boundary layer in winter are all favorable for the formation of NH4NO3 from its NH_3 and NOx, and VOC precursors. Elevated OM (organic matter, organic carbon compounds) exacerbates air quality mostly at urban sites. This is consistent with the winter use of wood fuel for home heating, as well as with traffic. This distinct spatial distribution also reflects the difference between primary and secondary aerosols. …The urban sites experienced much higher BC *(black carbon)* concentration than non-urban sites. This suggested that BC particles were closely related to urban sources such as traffic, RWC [residential wood combustion], and cooking. Multiple spikes of hourly BC were frequently observed especially at urban sites, suggesting that those BC originated from nearby urban sources. At all urban sites, the morning BC peak was found around 0600 to 0800 PST and the large evening peak around 2000 PST prolonged through the midnight and early morning next day. Non-urban sites did not exhibit any distinct diurnal patterns."[2]

[1] Source: "Evaluation and improvement of ammonia emissions inventories" William Battye, etal, Atmospheric Environment 37 (2003) 3873-3883

[2] Source: Initial Data Analysis of Field Program Measurements, DRI Document No. 2497, July 29, 2005 Judith C. Chow, L..W. Antony Chen, Douglas H. Lowenthal, Prakash Doraiswamy, Kihong Park, Steven D. Kohl, Dana L. Trimble, John G. Watson, DESERT RESEARCH INSTITUTE, Division of Atmospheric Sciences, 2215 Raggio Parkway, Reno, NV 89512.

3.2.7 Other Key Findings from Scientific Studies and SJV Evaluations

The CRPAQS research program has provided a wealth of scientific analysis specifically targeted to answer key questions that inform decision-making for effective reduction of particulate concentrations in the San Joaquin Valley. The findings cover a wide range of technical topics. An extensive list of CRPAQS results documents was included in the 2006 PM10 Plan, Appendix D (CRPAQS Bibliography), available on the District's website at: http://www.valleyair.org/Air_Quality_Plans/docs/Appendix_D.pdf

The information developed by CRPAQS may have value to other areas of the country, but in some cases the information discloses how California circumstances are different. For example, EPA methods assume a strong relationship between sulfate decrease causing a potential and nitrate formation increase. That issue was studied for the SJV and found not to be a concern.

3.2.7.1 Ammonium Nitrate Sensitivity to Sulfate Levels

According to Kumar and Lurmann:

> "Ammonium nitrate levels are sensitive to changes in sulfate under ammonia limited conditions. Sulfate and nitrate compete for ammonia when its supply is limited, and the thermodynamics indicates that ammonium preferentially associates with sulfate (forming ammonium sulfate or ammonium bisulfate) rather than nitrate under ambient conditions. Under ammonia limited conditions, reductions in sulfate may not be an effective means to reduce PM mass because ammonium sulfate removed from the aerosol is replaced with ammonium nitrate, thereby inhibiting significant reduction in PM mass.
>
> The effects of changes in sulfate levels on ammonium nitrate in the SJV were investigated using the eight cases for which isopleth diagrams were constructed. These were cases with relative high sulfate levels for the SJV (3 to 4 mg/m3). The effects of 50 and 100 percent reduction in sulfates on ammonium nitrate concentrations are listed in Table 3-10. The results indicate ammonium nitrate concentrations are not sensitive to large changes in sulfate levels. The lack of ammonium nitrate sensitivity to sulfate in the SJV is due to the ammonia-rich conditions and the low amounts of sulfate compared to nitrate." [3]

3.2.7.2 Precursor Relationships and Control Sensitivity

The issue of limiting precursors and secondary formation products has been extensively evaluated for the CRPAQS research program.

[3] Source: ANALYSIS OF ATMOSPHERIC CHEMISTRY DURING 1995 INTEGRATED MONITORING STUDY, STI-997214-1791-FR , Authors: Naresh Kumar, Frederick W. Lurmann, Sonoma Technology, Inc., Petaluma, CA; Spyros Pandis, Asif Ansari, Carnegie Mellon University, Pittsburgh, PA, July 1998.

- Particulate NH_4NO_3 concentrations are limited by the rate of HNO3 formation, rather than by the availability of NH_3.
- HNO_3 is formed via both daytime photochemistry and aloft nighttime chemistry.
- Secondary organic aerosol formation from VOC emissions may account for 15% to 25% of the total OC
- Relatively low non-methane organic compounds (NMOC)/NOx ratios indicate the daytime photochemistry is VOC, sunlight, and background-ozone limited in winter. This is a nonlinear regime for the gas-phase chemistry.[4]

According to Lurmann et al.:

> "Comparisons of ammonia and nitric acid concentrations indicate that ammonium nitrate formation is limited by the availability of nitric acid, rather than ammonia. Time-resolved aerosol nitrate data at the surface and on a 90-m tower suggest both the daytime and nighttime nitric acid formation pathways are active, and that entrainment of aerosol nitrate formed aloft at night may explain the spatial homogeneity of nitrate in the San Joaquin Valley. …This study's analyses suggest that reductions in NOx emissions will be more effective in reducing secondary ammonium nitrate aerosol concentrations than reductions in ammonia emissions. Reductions in VOC emissions will reduce secondary organic aerosol concentrations and may reduce ammonium nitrate. …Comparisons of ammonia and nitric acid concentrations show that ammonia is far more abundant than nitric acid, which indicates that ammonium nitrate formation is limited by the availability of nitric acid, rather than ammonia….The results indicate ammonium nitrate formation is ultimately controlled by NOx emission rates and the other species, including VOCs and background ozone, which control the rate of NOx oxidation in winter, rather than by ammonia emissions."[5]

The contributing PM2.5 sources have a variety of properties. This makes analysis of reductions more difficult consequently complicates the development of effective control programs. Nitrates and carbon are the two largest components, and their atmospheric behavior is entirely different. According to McCarthy et al.:

> "High concentrations of PM organic carbon (OC) were spatially limited to core urban sites while high concentrations of PM ammonium nitrate were regionally distributed throughout the SJV. Concentrations of PM and its precursors were typically lower at the elevated sites surrounding the SJV than at monitoring sites located on the SJV floor….At distances more than 50 km from the urban areas, OM [organic matter] concentrations typically declined by a factor of three or

[4] Source: Presented to: CRPAQS Data Analysis Workshop, Sacramento, CA, March 9-10, 2004, Tasks 6.1 and 6.2: Phase Distributions Tasks 6.1 and 6.2: Phase Distributions and Secondary Formation During Winter and Secondary Formation During Winter in the San Joaquin Valley in the San Joaquin Valley, Presented by: Fred Lurmann, Siana Alcorn, Manidipa Ghosh, Sonoma Technology, Inc., Petaluma, CA

[5] Source: *Processes Influencing Secondary Aerosol Formation in the San Joaquin Valley During Winter,* Frederick W. Lurmann, Steven G. Brown, Michael C. McCarthy, and Paul T. Roberts, Sonoma Technology, Inc., 1360 Redwood Way, Suite C., Petaluma, CA 94954

more. Emissions of OM at the urban core are either not rapidly transported to the rural sites or are diluted too much to substantially impact rural sites. Concentrations of OM at elevated sites were comparable to concentrations at rural sites on the Valley floor….Overall, these spatial patterns of OM suggest that the impact of emissions was largely confined to the local area and OM concentrations were unevenly distributed over the duration of the episode.

The contrast in spatial variability between the ammonium nitrate and OM components of PM2.5 in the SJV winter episodes provides information on the spatial extent of the production of ammonium nitrate. PM2.5 OM and ammonium nitrate are both subject to the same meteorological transport conditions, yet ammonium nitrate concentrations are relatively homogeneous and OM concentrations are much higher in the urban source areas. In addition, OM and ammonium nitrate components are expected to have the majority of their mass in a similar size fraction (PM0.1 to PM1) (Lighty et al., 2000; Hughes et al., 1999; Bench et al., 2002) and, therefore, the rates of removal should be approximately the same. In summary, the likely explanation for the difference in spatial variability is the spatial distribution of the emissions or precursors. Primary OM emissions occur predominantly from mobile sources and wood smoke located in urban areas. The formation of ammonium nitrate from NOx precursors (Lurmann et al., 2004) must occur throughout the SJV to account for its spatial homogeneity.

High concentrations of PM organic carbon were spatially limited to core urban sites while high concentrations of PM ammonium nitrate were regionally distributed throughout the SJV. The regional homogeneity of ammonium nitrate concentrations coupled with the stagnant wind conditions provides evidence that production of ammonium nitrate occurs at similar rates throughout the valley. In contrast, the OC component of PM indicates that production rates were much higher in the urban areas than at rural sites."[6]

3.2.8 Population Growth

Increased population, which results in increased vehicle activity and more consumer product use, leads to increased pollutant emissions, undermining the progress made by regulations. Table 3-1 shows population estimates for the eight counties of the SJVAB by county, including projections to 2014. In 2006, 9.9% of California's population resided in the SJVAB (California Department of Finance 2005). Population projections suggest that 11% of California's total population will reside in the San Joaquin Valley in 2020. Between 2005 (the base year for this plan) and 2014, the population of the San Joaquin Valley will grow by 43%. In contrast, the total population for the State of California will grow 24% over the same time period.

[6] Source: *Background and Boundary Conditions for Particulate Matter and Precursors in the San Joaquin Valley in Winter* (Technical Memorandum STI-902325-2779-TM), Michael C. McCarthy, Hilary R. Hafner, Steven G. Brown, Fredrick W. Lurmann, Paul T. Roberts, Sonoma Technology, Inc., 1360 Redwood Way, Suite C, Petaluma, CA 94954-1169, July 29, 2005.

Table 3-1 SJVAB Population by County

County	2005	2014 Projection	% Change, 2005-2014
Fresno	837,459	1,015,838	33
Kern [a]	580,794	718,656	36
Kings	135,218	167,701	37
Madera	129,728	163,753	42
Merced	224,488	310,961	61
San Joaquin	608,594	844,074	63
Stanislaus	479,203	596,967	36
Tulare	384,650	485,889	41
TOTAL	3,380,134	4,303,839	43

[a] Valley portion; Kern County has portions located outside of the San Joaquin Valley Air Basin.
Source: Developed using Population Trends Reports, California Department of Finance (2005).

3.2.9 Jurisdictional Limits and Regulatory Authority

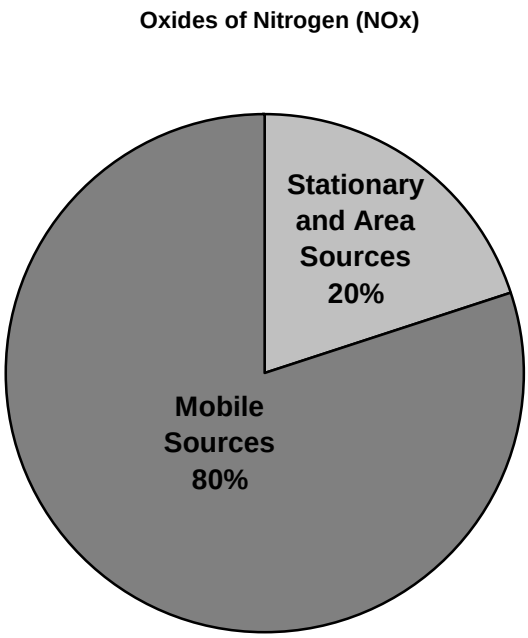
Attainment of air quality standards and the reduction of precursor emissions in the SJVAB require the cooperation of local and/or regional, state, and federal governments. At the federal level, the EPA is responsible for establishing federal motor vehicle emission standards. The EPA is also responsible 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 ARB 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. Other state agencies such as the Department of Pesticide Regulation (DPR), California Department of Transportation (CalTrans), and the Bureau of Automotive Repair (BAR) also have responsibility for certain emissions sources.

Districts like the San Joaquin Valley Unified Air Pollution Control District have authority to regulate stationary sources and some area sources of emissions. Districts cooperate with Regional Metropolitan Planning Organization (MPOs) to develop measures affecting local transportation activity that are included in a SIP. In turn, the MPOs 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 primary jurisdiction of the District is therefore limited to just part of the total emissions inventory (Figure 3-3). Based on 2005 inventories developed for this plan, 20% of the total NOx inventory for the SJVAB is under the primary regulatory jurisdiction of the District.

Figure 3-3 NOx Precursor by Source Type [7]
(Based on Annual Emissions Inventories)



Although the responsibility for establishing the tailpipe emissions standards for the mobile sources belongs to state and federal governments, additional reductions are needed to reach attainment. Therefore, the District is also proposing measures, such as trip reduction, green contracting, and enhanced indirect source review, to provide additional mobile source emissions reductions for this plan and will continue to use incentive programs to accelerate mobile source emissions reductions.

3.3 MODELING

The *SJVAPCD PM2.5 SIP Modeling Protocol* describes the selection of the general modeling approach, methods of analysis, and identification of data pertinent to

[7] Please note that Mobile Sources includes on-road and off-road sources. For NOx, 67% of the total mobile source emissions in 2005 come from on-road sources, and 33% of the total mobile source emissions come from other mobile sources.

supporting modeling analysis. The protocol proposes comprehensive analysis combining the results of evaluations, correlated and reconciled to establish by preponderance of results (weight of evidence) that all nonattainment areas will be adequately addressed. EPA guidance recommends that models be used in a relative sense due to their uncertainties and the differences that exist between model input data and design values applicable to determine attainment. EPA directs that model results and other analysis be combined to establish a confirmed finding of attainment in a "weight of evidence" determination, particularly if the predicted future values are close to the standard. New approaches recommended by EPA guidance also require special processing of speciated data and a Speciated Modeled Attainment Test (SMAT).

3.3.1 Model Choice

Annual meteorology has seasonal components, reflected in EPA guidance recommending at least quarterly evaluation and analysis. Regional modeling is being performed for an entire year on a daily basis that can be processed to monthly or quarterly analysis as needed. Receptor modeling, with a speciated rollback approach used for the PM10 SIP with monthly meteorological analyses and source identification combined into an annual composite, is being updated for the PM2.5 analysis. Prior analysis determined that fall and winter seasons are most important for PM10 in the San Joaquin Valley and the winter remains the most important for PM2.5 due to increased carbon and nitrate particulates.

- **Receptor Modeling** Receptor modeling is performed by the District to establish a link between observed particulates and contributing emission sources using the combined outputs and techniques of several models. Receptor analysis of observed events and annual average particulate levels was performed by ARB in consultation with the District using the chemical mass balance (CMB) model. The output of this model is used in a receptor modeling speciated rollback model developed by the District to calculate the effect of predicted emission trends and adopted and proposed control measure reductions. The District developed receptor speciated rollback as one of its earliest improvements to standard rollback modeling, with documented assumptions for the isolation of natural emissions and transport of emissions that would not be affected by the control program. The effort to remove sampling artifact and non-reactive species has been incorporated into EPA SMAT methods to correct similar issues for the regional modeling. The District added a spatial area-of-influence element to more accurately reflect the effect of controls on contributing sources. Receptor modeling methods used for the PM10 SIP have been revised to evaluate PM2.5 by modifying assumptions to address fine particle mechanisms and with methodology revisions to reduce uncertainties for the PM2.5 annual standard. Further revision may occur to incorporate new findings of current regional modeling of secondary particle formation.

  This receptor modeling method works well for analysis of directly emitted particles, but is less certain in predicting the effect of reductions of secondary precursors (gases that form particles in the air that may not produce particles in amounts

directly proportional to the amount of emissions). The formation of secondary particulates has been examined with regional modeling to determine appropriate adjustments to predictions of secondary particulates. The receptor modeling approach uses direct (linear) assumptions for the connection of emissions changes to projected future contributions. This is adjusted to reflect the nonlinear chemistry associated with nitrate formation as determined by the regional model. Sulfate formation approaches linear relationship and is not adjusted for nonlinear chemistry in the receptor modeling. The expected result of linear projection is an over-prediction of future concentration. The method anticipates uncertainty in the inputs and uses the over-prediction as a safety margin for attainment modeling. The PM10 receptor modeling resulted in a sizable margin of safety, projecting attainment several years after actual compliance was achieved. Comparing the results of PM2.5 receptor modeling with regional modeling results and other pertinent information is important to develop a weight of evidence approach to determining when attainment will be achieved.

- **Regional Modeling** EPA guidance expects regional modeling to play a larger role in the PM2.5 modeled attainment test. The primary purpose of the regional modeling for the PM2.5 SIP is to provide an independent analysis of the reductions needed to achieve attainment. Regional photochemical modeling has limitations for depicting the dispersion and removal processes that occur in scales finer than the grid resolution but provide equilibrium modeling for the most significant contributions to observed mass. Regional modeling uses the known emissions inventory in a bottom-up analysis that calculates the amount of mass that should be present due to the emissions. Using the model to predict mass from a future emissions inventory produces the best assessment of nitrate and sulfate levels that can be provided. The use of the model results in relationship to the design value provides a reasonable estimate of future PM2.5 nitrate and sulfate mass components.

  Regional modeling of secondary particulates has been conducted by ARB using several different data sets and models. Results of regional modeling improve understanding of particle formation rates and ratios of precursors to particle formation, particularly for nitrate particulates. These results have been used in conjunction with receptor modeling to enhance the accuracy and reliability of predicted effects of emission trends and adopted and proposed control measure reductions of secondary precursors. The first regional assessment used the Urban Airshed Model, modified to address aerosol chemistry (UAM-AERO). This assessment used the IMS-95 dataset (an early component of CRPAQS) to evaluate a monitored event of nitrate particulate formation. Regional modeling was also conducted for the later 2000-2001 CRPAQS data, providing an update to the PM10 receptor modeling projections in 2006. A third round of regional modeling with the Community Multiscale Air Quality (CMAQ) model has been completed by ARB, has been used to develop SMAT projections for the SJV and is undergoing performance evaluation. If this provides a different regional photochemistry analysis for nitrate formation, the receptor modeling estimates for nitrates will be reviewed.

3.3.2 Model Application

ARB is conducting regional modeling, positive matrix factorization (PMF) evaluation for 2004 to 2006, and chemical mass balance (CMB) modeling for 2005 annual speciation data for Fresno and Bakersfield. The District is reevaluating prior receptor modeling (CMB and speciated rollback) for the prior PM10 plans (2000 annual evaluations), establishing PM2.5 speciation for these analyses and projecting the concentrations from 2000 to 2005. The District has performed an analysis and receptor projection from 2005 to 2014 for the PM2.5 speciated versions of the 2000 annual evaluations the new 2005 PM2.5 CMB speciation for Fresno and Bakersfield and the PMF evaluation. The receptor evaluations are relatively consistent for all of these events providing a strong weight of evidence comparison. The regional modeling results are not yet available.

Technical issues are being examined, and revised calculations may be produced for the new CMB evaluations to improve profile selection for improved model performance in the summer and for PMF regarding the handling and analysis of carbon artifact. Prior CMB profile selection was conducted to match the winter dominant sources. Improved profile selection is recommended to meet EPA recommendation for at least a quarterly evaluation of profile accuracy. Carbon artifact handling in the PMF analysis should use the most current and accurate CRPAQS findings. Furthermore, artifact adjustments should follow EPA guidance and be included in relative mass comparison rather than be excluded from calculations.

3.3.2.1 PM2.5 Speciation for Annual Rollback Modeling

The speciation data and CMB modeling results for PM10 contain a combination of coarse and fine particles. The relationship between PM10 and PM2.5 is not proportional; therefore special evaluation is required to develop an appropriate speciation set for PM2.5 rollback analysis from the CMB modeling performed for PM10. To convert the PM10 annual CMB modeling and rollback analysis to PM2.5, the mass distribution must be replaced by PM2.5 speciation data or be calculated by other methods from the mass determined by PM10 CMB modeling. The methodology includes the following components and considerations:

- Fresno, Kern, Kings and Tulare counties have 2005 PM2.5 design values that exceed the 15 microgram annual standard. Analysis is required for each of these counties to determine emission reductions required to achieve compliance. PM2.5 speciation measurements are collected at Bakersfield, Fresno, Modesto and Visalia. Fresno speciation data for PM2.5 covers the period used for the rollback foundation annual PM10 CMB analysis (2000-2001). Complete data for Bakersfield and Visalia is available for 2002 and thereafter, but is not available for 2000-2001. No PM2.5 speciation data was collected for Kings County; however, prior PM10 speciation analysis and CMB modeling determined that Tulare and Kings County conditions are quite similar, allowing use of Tulare County speciation data with minor adjustments. The speciation data provides total mass for annual evaluation, nitrates, sulfates, geologic material and metals.

- Natural and regional background for PM2.5 cannot be directly measured and is easily identifiable or separable from other measured local contributions. Background concentrations have been established in the same manner used to establish background values for the PM10 rollback analysis. The significance of background levels is that such material will not be affected by the District's control efforts. Since rollback provides a linear projection of effect for reducing emissions, failure to exclude background will over-predict the effect of control efforts. All assumptions for background are now expressed as percentages of material. The background values for geologic material, nitrate and sulfate particulates have been set at 10% of the observed concentration instead of a fixed concentration. Dynamic background contributions of 10% were too high for use with PM10 due to high deposition rate and short average distance of travel; however, PM2.5 has greater travel distance and persistence in the atmosphere.

- Mobile exhaust and tire and brake wear were determined by CMB annual analysis for PM10. From the emissions inventory we are able to establish that slightly over 90% of the mobile exhaust emissions are PM2.5 and approximately half of the tire and brake wear material is PM2.5. The mass determined for PM10 rollback has been adjusted accordingly to establish a reasonable mass attribution for these sources.

- Fresno annual rollback uses a design value derived from the annual speciation data set for the years 2000 and 2001. Fresno annual rollback uses limited elements of the annual PM10 CMB analysis, performed for the year 2000 with additional data from the first quarter of 2001, to provide mass estimates for motor vehicles and tire and brake wear. The modeled contribution for motor vehicles and tire and brake wear has been adjusted by factors determined from the emissions inventory to be representative of PM2.5 material. The average of 2000 and 2001 PM2.5 speciation data is used to provide PM2.5 species for nitrates, sulfates, geologic material and unassigned (elements). Organic carbon and vegetative burning is composed organic and elemental carbon similar to the motor vehicle emissions but contains both large and small particles. The mass for organic carbon and vegetative burning has been calculated as the remainder of the annual PM2.5 speciated mass not assigned to the other categories.

- Bakersfield uses the same elements from the annual PM10 analysis but is required to use 2002 PM2.5 speciation data as the earliest complete speciation available for this purpose. Modeling may be revised or adjusted in other ways if improvements to the methodology are identified by technical evaluation.

- Visalia uses the same elements from the annual PM10 analysis but is required to use 2002 PM2.5 speciation data as the earliest complete speciation available for this purpose. Modeling may be revised or adjusted in other ways if improvements to the methodology are identified by technical evaluation.

- Kings County uses Visalia speciation data for the year 2002 to establish PM2.5 mass with adjustment to motor vehicle and tire and brake wear. The PM10 speciation data was very similar for Kings and Tulare counties in previous years, with the exception of fugitive PM10 emissions that are large particles. Motor vehicle contributions were similar to Visalia in Hanford but much less in Corcoran. Corcoran is the site that sets the design value for Kings County. Prior CMB modeling of the same event at both Visalia and Corcoran establishes an approximate ratio of the motor vehicle and tire and brake wear contributions at the two sites. Based on this evaluation, motor vehicle emissions and tire and brake wear are adjusted to 55% of the Visalia concentration to reflect the smaller urban contribution found in Corcoran.

- CMB results for Fresno and Kern provided by ARB were adjusted by 0.6 micrograms reassigned from organic carbon (OC) to unassigned mass as found with earlier CMB modeling. Inert material is common in SJV samples and the method of assigning all unaccounted mass to OC overestimates that profile.

3.3.2.2 PM2.5 Methodology Revisions for Annual Receptor Modeling

- Cooking emissions, previously grouped with vegetative burning, are included in organic carbon associated with industrial and commercial emissions.

- The speciated rollback analysis developed by the District provides spatial projection of the area of influence of contributions. The PM10 methodology utilized different assumptions for contributions dominated by large particles and contributions dominated by fine particles, PM2.5 and smaller. The PM10 travel distance assumptions for geologic and construction, tire and brake wear and unassigned mass utilized large particle assumptions which are modified for the PM2.5 analysis to be consistent with travel distance assumptions for other contributions dominated by fine particles. Methodology for the defined apportionment of mass to local and regional intrabasin transport has been adjusted from a fixed ratio to a mass weighted calculation to improve accuracy and correlation to the conceptual model.

- For categories that are comprised of directly emitted particulates and secondary organic aerosol (SOA) formation of organic carbon compounds a default split was used for earlier receptor modeling assuming an even split for the two pathways. CRPAQS results indicate a maximum of secondary aerosol formation of fifteen percent of the observed carbon. The rollback analysis has been revised for this updated information. The emissions linkage to SOA is ROG instead of TOG.

- Nitrate mass will be reevaluated to determine if any adjustments to linear projection are required. The 2003 analysis included nonlinearity adjustments obtained from analysis of UAM-AERO regional modeling of CRPAQS IMS-95 data. The variation of nitrate chemistry is represented by the monthly variations of CMB modeling for the annual, which inherently incorporates the variation in nitrate chemistry throughout the year. Regional modeling nitrate nonlinearity adjustments are appropriate for episode evaluation but potentially introduce a redundant penalty in the annual

speciated rollback modeling. The linear projection of annualized rollback already includes assessment of the variation of nitrate formation; therefore further adjustment with modeling response may constitute a redundant adjustment. The comparison of linear model estimation to the projections with regional modeling penalties for nonlinear nitrate response will be preserved until technical discussions on this matter are complete.

- Receptor modeling will use the alternate linear estimation assumptions for trapped water. Water bonded to ammonium nitrate is approximated as equivalent to twelve percent of the mass and water bonded to ammonium sulfate is approximated as 26 percent of that mass. This method allows the water to remain incorporated in the proportional rollback because the trapped water is assumed to be proportional to the ammonium nitrate and ammonium sulfate mass. The linear assumption avoids the need to handle trapped water as a separate calculation.

3.3.3 Weight of Evidence

A weight of evidence approach compares conceptual descriptions, episode categorization techniques, adjusted air quality trends, and other analysis to modeling results. The purpose of these additional analyses is to provide additional insights into the projection of expected future air quality. The Speciated Modeled Attainment Test is the primary benchmark for quantifying reduction targets to achieve attainment; however, supplemental evaluations may be appropriate if air quality trends or other information indicate that the targets will be met with less reduction than indicated or will require additional efforts to achieve compliance with the standards. The District has determined that the 15 microgram annual standard is more stringent for our air basin than the 1997 65 microgram daily standard. The new 35 microgram daily standard appears to be more stringent than the annual standard but is on a different timeline for planning and implementation and has not been used to determine reduction goals for this plan.

PM2.5 monitoring is a relatively new program; therefore, the historical record of data does not provide a sufficient history to evaluate long-term trends and patterns. The District and ARB will continue evaluation of data using a variety of statistical methods to identify potential key factors. Results of evaluations will be used to improve the District's conceptual understanding of events and may be considered to provide substantive data in the process of establishing a weight of evidence finding for attainment.

The PM2.5 receptor modeling examines the 15 microgram per cubic meter annual federal standard. When evaluating the 50-microgram annual standard for PM10, an uncertainty of one-microgram represented only a two percent variation; however, a one-microgram uncertainty in the PM2.5 analysis represents a variation that is almost seven percent of the total allowed. This sets a very difficult benchmark for accuracy. Furthermore, PM2.5 is not a single material but a host of different materials with both separate behaviors and dependent interactions. Although there is a solid foundation of

conceptual understanding, there are many technical issues that remain open questions for continued study. The PM2.5 SIP will utilize all completed analyses available at this time; however, the District expects emerging technical information to enhance understanding of observed events to improve our ability to predict future PM2.5 concentrations.

3.3.4 Speciated Modeled Attainment Test

EPA guidance acknowledges the difficulty in obtaining a data set for modeling that exactly matches the current design values and has developed a methodology to break down the modeling into the component constituents and use the model response in a relative sense to predict the reductions needed to achieve attainment. This Speciated Modeled Attainment Test (SMAT) methodology is necessary because the different types of materials come from different types of sources and the emissions inventories of these sources vary at different rates and have different relationships for the contribution of PM2.5 mass. Therefore, the constituent materials that contribute to PM2.5 are not directly additive and must be calculated separately and be added together as a final step to determine the total PM2.5 mass. ARB will perform SMAT for the regional model and the District has developed an implementation of SMAT for the receptor modeling.

The Speciated Modeled Attainment Test (SMAT) methodology calculates remaining mass other than the nitrates and water as organic carbon. This approach is too coarse for use for the District. The basis for this method is that most areas of the country do not have extensive control programs for geologic material (fugitive dust) or extensive emissions from carbon sources subject to direct control (residential wood combustion and agricultural burning). Carbon particle size growth and trapped carbon particles within nitrate and sulfate particulates that are not measured in the analysis methods are further losses not addressed by SMAT. CRPAQS modeling for particle size growth is under development but not available at this time. Metals are also not isolated by SMAT methods. For any elements not well-supported by the regional model results, receptor modeling or other substantive data will be reviewed to establish a weight of evidence finding for attainment.

Model response is used in a relative sense to predict the reductions needed to achieve attainment. Speciated Modeled Attainment Test (SMAT) calculations determine the amount of reductions needed from the major source categories to achieve compliance with federal PM2.5 standards at all monitoring sites. The results of this process predict future PM2.5 concentrations that would result from trends and current and proposed control programs. EPA guidance identifies how these calculations should be performed for a regional model. The District has determined applicability to the receptor analysis.

The Speciated Modeled Attainment Test (SMAT) methodology is generally applicable throughout the country but conflicts with certain important considerations critical to San Joaquin Valley Air Basin (SJVAB) assessment. Specific adjustments have been made to address technical issues specific to the SJVAB and to provide the most accurate means to reflect the effects of emission reductions.

- The receptor analysis exceeds SMAT requirements by providing extensive separation of contributing direct and secondary carbon sources. Secondary formation rate information developed by the CRPAQS program is used to quantify the secondary aerosol partition. By means of CMB model evaluation, carbon mass, along with associated trace metals and other contributions to the source signature, is divided between:
    - Motor vehicle emissions,
    - Tire and brake wear,
    - Stationary and area sources carbon mass, and
    - Vegetative burning.
- The receptor analysis exceeds SMAT requirements that recommend quarterly evaluation by performing monthly evaluation and determining that CMB performance meets standards on a monthly basis. The annual CMB modeling adjusts speciation selections for wood burning to reflect seasonal changes but otherwise uses a consistent set of speciation signatures. Performance verification demonstrates that the selected profiles are acceptable for identifying and representing the contributing sources throughout the year. A further evaluation of CMB performance with quarterly optimized profiles will be performed as a corroborative test.
- The receptor analysis exceeds SMAT requirements by separating the contributions of geologic material from other sampling artifacts and unknowns. This is of particular importance to the SJV due to the District regulations for control of fugitive dust. The benefit of the District programs must be modeled separately from artifacts to quantify reductions appropriately.
- Receptor modeling addresses the SMAT requirement regarding trapped water in ammonium nitrates and sulfates using approved alternate linear assumptions. The linear assumption avoids the need to consider trapped water as a separate calculation. According to the linear assumption, water bonded to ammonium nitrate is approximated as equivalent to twelve percent of the ammonium nitrate mass and is proportional to the amount of ammonium nitrate particulate mass present. Water bonded to ammonium sulfate is approximated as 26 percent of that mass and is proportional to the amount of ammonium sulfate particulate mass present. Because the amount of trapped water is established by the linear assumption method as proportional to the amount of the ammonium related mass contributions, the speciated rollback analysis processes the trapped water as an incorporated linear component of the ammonium nitrate and ammonium sulfate particulate masses and does not establish a separate calculation column.

    Technical note: The SMAT methodology separates out trapped water and ammonium, sulfate and nitrate ions. This is necessary in portions of the country that are dominated by sulfate emissions. Decreases in sulfate emissions can actually cause increase in nitrate formation in areas dominated by sulfates. The associated water content of sulfates is much different than for nitrates and can require mass recalculation for areas with high sulfates. The SJVAB is dominated by ammonium nitrate particulates with low sulfate particulate concentrations; therefore this process is of minimal effect on the Valley PM2.5 mass calculation.

3.4 MODELING RESULTS

The modeling was conducted with an annual emission inventory ***PM 2.5 SIP Planning Projections - v1.00 RF#994.***

Although ambient PM2.5 levels all sites in the Valley must be within the standard for the Valley to be redesignated into attainment, some sites already comply with the PM2.5 standards in force for this plan (annual standard 15, daily standard 65). The revised daily standard of 35 has a separate timeline for planning and compliance.

A speciated modeled attainment test (SMAT) has been completed with receptor analysis modeling. The receptor modeling evaluation uses speciated rollback for its base calculations and is used in the prescribed relative reduction method fro the Speciated Modeled Attainment Test. Variations from EPA methodology that use additional information available for the SJVAPCD and to adjust for assumptions documented by EPA and others as not appropriate for California are identified in the PM2.5 Modeling Protocol.

Table 3-2 San Joaquin Valley Air Pollution Control District PM2.5 Receptor Speciated Modeled Attainment Test

County	2005 Design Value (DV) (µg / m^3)	Receptor Modeled SMAT RRF 2005-2014	Projected Value 2014 (DV * RRF) (µg / m^3)	Predicted Compliance Year
San Joaquin	12.9	Meets Standard		**Meets Standard**
Stanislaus	14.1	Meets Standard		**Meets Standard**
Merced	14.7	Meets Standard		**Meets Standard**
Madera	-	No data, unclassified		**No data, unclassified**
Fresno M1	**17.2**	**.721**	**12.40**	**2010**
Fresno M2	**17.2**	**.753**	**12.94**	**2011**
Fresno PMF	**17.2**	**.707**	**12.17**	**2011**
Kings M1	**17.2**	**.770**	**13.25**	**2011**
Tulare M1	**18.2**	**.730**	**13.29**	**2013**
Kern M1	**18.9**	**.728**	**13.76**	**2014**
Kern M2	**18.9**	**.742**	**14.02**	**2014**
Kern PMF	**18.9**	**.746**	**14.09**	**2014**

Method 1: 2000 baseline species were projected to 2005 and then the 2005 projected species were used for projection to 2014. Due to limited speciation data, Method1 will be used for Tulare and Kings.

Method 2: 2004-2006 species were projected to 2014. This second test is available for Fresno and Kern.

PMF: A receptor projection was also prepared from output of the PMF model for Bakersfield and Fresno speciated data.

A regional model evaluation has been prepared by ARB. Observations from 2000-2001 were used to prepare the model for performance evaluation. Relative response is established for emission inventory years 2005 and 2014. Findings from a SMAT evaluation of the regional model shown in table 3-3 compare very closely to the results of the receptor SMAT analysis shown in Table 3-2. To maintain public records and archives for the PM2.5 SIP, the District has requested a copy of the SMAT calculation files developed by ARB for analysis of the regional model output. However, due to the size (the previous version received by the District was 54 megabytes) and technical nature of these files, the District does not intend to print or distribute these modeling analysis files.

Table 3-3 San Joaquin Valley Air Pollution Control District PM2.5 Regional Speciated Modeled Attainment Test

Reference and future year annual design values for SJV FRM sites determined from the regional model using EPA SMAT procedure

Site	Code	Speciation	2006 DV	2014 "Controlled" DV
Bakersfield - 5558 California	BAC	BAC	18.51	14.28
Bakersfield - 410 E Planz Road	BEP	BAC	18.86	14.70
Bakersfield - Golden State	BGS	BAC	18.64	14.39
Clovis - N Villa Avenue	CLO	FSF	16.39	12.72
Corcoran - Patterson Avenue	COP	VCS	17.24	13.27
Fresno - 1st Street	FSF	FSF	16.68	13.01
Fresno - Hamilton and Winery	FSH	FSF	17.16	13.47
Merced - 2334 M Street	MRM	M14	14.69	11.76
Modesto - 14th Street	M14	M14	14.10	11.44
Stockton – Hazelton Street	SOH	M14	12.93	10.87
Visalia - N. Church Street	VCS	VCS	18.20	14.47

3.4.1 Discussion of Results

- The four northern SJV counties, San Joaquin, Stanislaus, Merced and Madera, need no additional reductions and already meet attainment requirements for the annual standard. Table 3-2 lists projected values for 2014 because all counties must meet the standard to demonstrate attainment and analysis of Bakersfield does not support projection of attainment prior to 2014.

- Kings County – attainment is projected by 2011 with existing emission reduction commitments (Method 1 projection of 2000 PM2.5 species data to 2005 and projection from 2005 to 2011 for SMAT). The projected value in 2014 is 13.25 $\mu g/m^3$. Linear projection methods are conservative and, when used for the PM10 SIP, projected a later attainment date than was actually achieved.

- Fresno County attainment is projected by 2011 with existing emission reduction commitments. Linear projection methods are conservative and, when used for the PM10 SIP, projected a later attainment date than was actually achieved.
    - Method 1 projects attainment by 2010 with no margin for error. Method 1 uses 2000 PM2.5 species data to 2005 and projection from 2005 to 2010 for SMAT projected a concentration of exactly fifteen micrograms. The projected value in 2014 is 12.40 $\mu g/m^3$.
    - Method 2 projects attainment by 2011 for Fresno. Method 2 analysis of 2004-2006 speciation data, using essentially the same methodology as Method 1 with modification of secondary aerosol evaluation due to use of a more restrictive motor vehicle emission profile. The projected value in 2014 is 12.94 $\mu g/m^3$.
    - PMF evaluation projects attainment by 2011. Corroboration is available for Fresno County by PMF evaluation. The PMF results were used to prepare a SMAT evaluation. The PMF evaluation uses data from 2003 to 2006 for evaluation but excludes many samples that fail specified screening criteria. Therefore, the PMF data has gaps during the year and may not precisely match an annual evaluation due to variations during the year that are not well represented. Despite the differences in assumptions and approach, the PMF results correlate to Method 1 and Method 2 with a projected value in 2014 of 12.17 $\mu g/m^3$. The PMF results confirm and update evaluation of regional transport by determining the contribution of aged aerosol. This information has been used to update the assumptions for regional transport of nitrate and sulfate for Method 1 and Method 2.

- Tulare County – attainment is projected by 2013 with existing emission reduction commitments (Method 1 projection of 2000 PM2.5 species data to 2005 and projection from 2005 to 2013 for SMAT). The projected value in 2014 is 13.29 $\mu g/m^3$. Linear projection methods are conservative and, when used for the PM10 SIP, projected a later attainment date than was actually achieved.

- Kern County attainment is projected by 2014 with emission reduction commitments. Linear projection methods are conservative and, when used for the PM10 SIP, projected a later attainment date than was actually achieved.
    - Method 1 projects attainment by 2014. Method 1 uses 2000 PM2.5 species data to 2005 and projection from 2005 to 2014 for SMAT projected a concentration of 13.76 $\mu g/m^3$.
    - Method 2 projects attainment by 2014. Method 2 analysis of 2004-2006 speciation data, using essentially the same methodology as Method 1 with

modification of secondary aerosol evaluation due to use of a more restrictive motor vehicle emission profile. The projected value in 2014 is 14.02 µg/m^3.

- PMF evaluation projects attainment by 2014. Corroboration is available for Kern County by PMF evaluation. The PMF results were used to prepare a SMAT evaluation. The PMF evaluation uses data from 2003 to 2006 for evaluation but excludes many samples that fail specified screening criteria. Therefore, the PMF data has gaps during the year and may not precisely match an annual evaluation due to variations during the year that are not well represented. Despite the differences in assumptions and approach, the PMF results correlate to Method 1 and Method 2 with a projected value in 2014 of 14.09 µg/m^3. The PMF results confirm and update evaluation of regional transport by determining the contribution of aged aerosol. This information has been used to update the assumptions for regional transport of nitrate and sulfate for Method 1 and Method 2.

Regional photochemical and particle modeling has also been completed by ARB. ARB confirms a finding of attainment for all monitoring sites in the District by 2014. Table 3.3 provides projections for the 2014 design value at all District sites that collect federal reference method (FRM) PM2.5 monitoring data. The use of this data is required for the implementation of the SMAT process that uses the design value established by this data with the relative change projected by the model to project the future design value. Extensive discussion of the regional modeling approach and documentation of results is in Appendix G to this plan.

It is important to note that both the receptor methods and regional modeling include all directly emitted and precursor reductions. All of these reductions have some effect on future particulate levels. Directly emitted PM2.5 reductions provide a direct benefit, while particulate precursors do not have the same one-to-one relationship. SOx has a strong PM2.5 forming potential throughout the year. NOx has a strong particulate forming potential during winter months. ROG emissions have a very limited particulate contribution by formation of secondary organic aerosol. The technical issues regarding precursors have been extensively evaluated and are discussed in the modeling protocol (Appendix F) with sensitivity evaluations documented in the receptor analysis modeling files.

Table 3-4 Regional Model Evaluation
2014 emissions without controls compared to 2014 emissions with controls

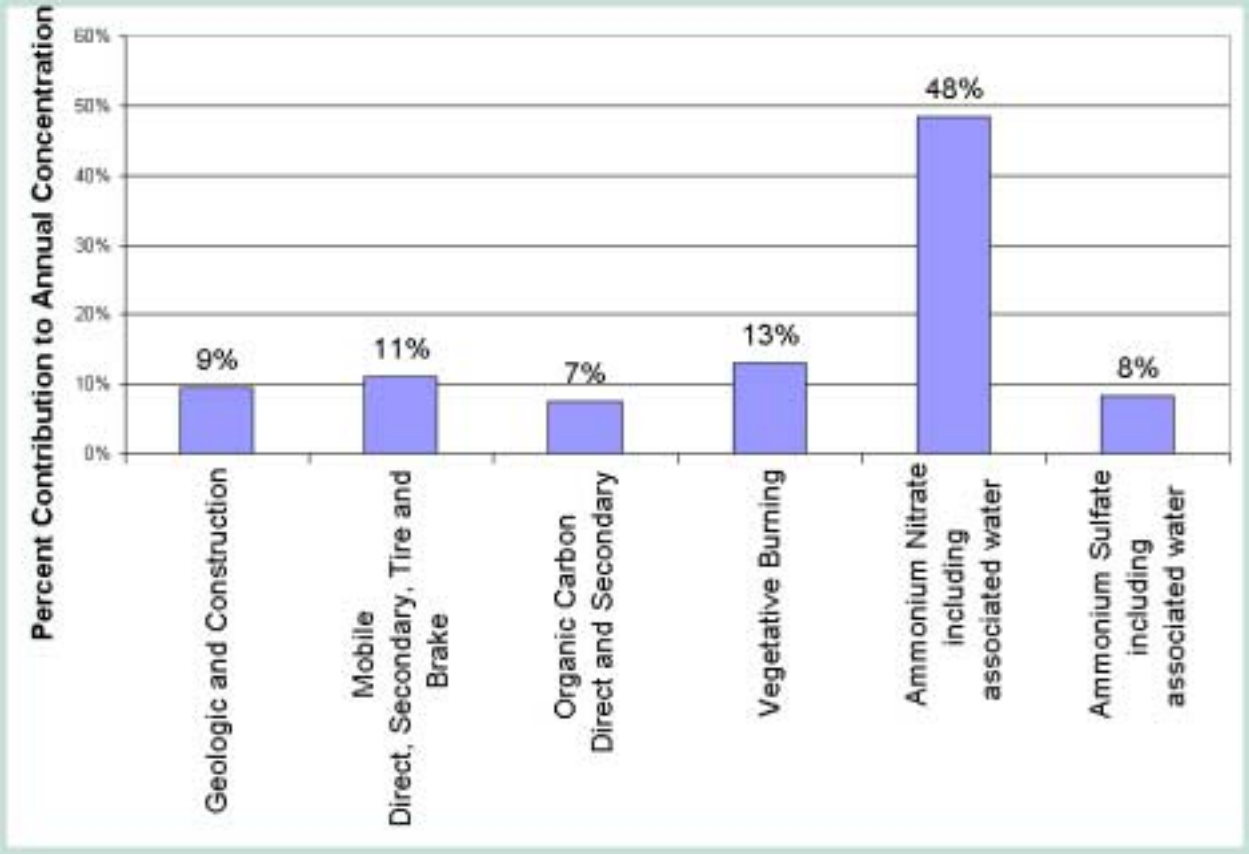
Percent of Reduction	NOx	PM2.5	SOx	ROG
Defined State Measures (Strategy 4/26/07)	**20**	**5**	**0**	**6**
District Rules (Dft Plan 12/11/07)	**4**	**8**	**4**	**0**
Total Reduction	**24**	**13**	**4**	**6**

Receptor modeling includes the reductions associated with all emission sources. The analysis provides separate correlation to PM2.5 contribution for geologic emissions,

motor vehicle direct and secondary emissions, tire and brake wear particulate, organic carbon that is directly emitted or formed as secondary organic aerosol, ammonium nitrate particulate that forms from NOx emissions, ammonium sulfate particulate that forms from SOx emissions, and vegetative burning emissions from residential wood burning, wildfires and agricultural burning.

An example of the relative contribution to the annual PM2.5 is shown in the following figure, which reveals that even after proposed reductions in 2014, all of the categories continue to provide measurable contributions to the annual PM2.5 concentration. The extensive contribution of ammonium nitrate from NOx remains dominant, but the other contributions are collectively half of the annual concentration.

Figure 3-4 Example annual PM2.5 source contributions, Kern 2014, including reductions



Receptor modeling results were evaluated by the District to determine the importance of reductions for particulates and precursors other than reductions of NOx (which reduce ammonium nitrate particulate). Each precursor has a different relationship to directly emitted or secondary formation of particulate, making it difficult to describe reductions in common terms. The easiest approach to identify the importance of other reductions (PM2.5 direct or SO_2) with the receptor model is to remove the reductions from the analysis and determine how much more NOx reduction would be required to offset

those reductions. The District analysis evaluated the highest concentration site analyzed by the receptor modeling (Kern County – Bakersfield California Street) for both the 2005 to 2014 and 2009 to 2014 reductions. The result of this analysis is that without the reductions of other PM2.5 and precursors, an additional 172 tons of NOx reduction would be needed by 2014 to achieve the same improvement in PM2.5 as provided by the other reductions. An additional 40 tons would be needed for the more limited time period of 2009 to 2014. This demonstrates that the majority of other reductions (77% of the direct and other secondary reductions) are being expeditiously implemented by 2009.

3.4.2 Weight of Evidence

A weight of evidence evaluation is required when the projected future year value is close to the standard. Projections of the receptor evaluation predict that Bakersfield will have a design value close to the standard in 2014 and projections of the regional model predict both Visalia and Bakersfield as having future design values close to the standard in 2014. A weight of evidence determination that attainment will be achieved by the Plan is established by comparing the evidence provided by air monitoring data, technical analysis and the results of various models. The following is a brief weight of evidence evaluation by the District that draws upon the extensive weight of evidence documentation provided by ARB as Appendix H to this plan.

- **Prior Accuracy of Receptor Evaluation Methodology for PM10:** Use of the speciated rollback receptor modeling for PM10 established the merits of the method and demonstrated a strong correlation to observed improvement. As expected for a linear projection, the projected future values are conservative and attainment was achieved prior to the projected date. Fourth quarter fine particulate matter dominates the annual PM10 evaluations; therefore, much of the PM10 annual standard is also a PM2.5 annual evaluation. This establishes a strong probability that the receptor evaluation will provide a reliable basis for PM2.5 modeling.

- **Consistency of Method 1 Projection Methodology:** The projection of 2000 to 2014 for the foundation data observations was essentially equal to the values predicted by projecting the 2000 data to 2005, resetting the species to the projected values for 2005, and projecting the change from 2005 to 2014. This indicates a stable relationship between the inventory and the concentration projections. An inconsistency in this result would have been unexpected and would have indicated greater uncertainty in the connection between the observations and the inventory.

- **Method1 and Method 2 Comparison:** Method 1 and Method 2 provide receptor analysis based on different years of observations. The species data for the different year groups is quite different for carbon sources; however, both evaluations reflect a similar response to emissions change for the period from 2005 to 2014, establishing a consistent relative response factor (RRF) for the speciated modeled attainment test (SMAT). The raw projected value for Fresno differs for the two evaluations,

reflecting local changes in vegetative burning and possibly reduction of motor vehicle emissions, although motor vehicle emission change is difficult to assess due to the use of a different motor vehicle emissions profile in the Method 2 evaluation. However, the relative reduction factor response for Fresno remains consistent for the two evaluations. Kern County evaluations project similar concentrations as well as a similar RRF value while reflecting differences in the attribution of carbon sources, at least in part due to the use of the different motor vehicle profile for the Method 2 analysis. The relative consistency of 2005 episodes to 2000 episodes through relationship to the emissions inventory indicates a strong proportional linkage between the receptor modeling PM2.5 concentration and the emissions inventory. The strong linkage between the inventory and the observations establishes a reliable foundation for using the receptor modeling to establish emission reduction targets to achieve attainment.

- **PMF Confirmation of Regional Component Estimates:** The PMF analysis provides an independent confirmation of regional contributions previously estimated for Method 1 and Method 2. The PMF analysis also provides sufficient information to establish a receptor evaluation for corroboration with Method 1 and Method 2.

    - The PMF results were used to revise estimation of nitrate and sulfate background contributions (particulate inflow from outside the District). The PMF evaluation determines the contribution of "aged aerosol" by determining the amount of nitrates, sulfates and organic carbon that have reacted with inflow of sea salt in the air. This reaction takes time to occur and establishes that the emissions are aged rather than fresh local emissions. The importance of identifying the amount of inflow contribution is that projected changes from District actions and trends in local emissions must be matched against the local source emissions and must not be reflected as affecting contributions from outside the District. The accuracy of this evaluation prevents over-prediction of benefit from local actions.

    - PMF results were used to prepare a receptor evaluation for corroborative comparison to the SMAT receptor evaluations for Method 1 and Method 2. The PMF analysis uses data from 2003 to 2006 for evaluation, similar to the 2004 to 2006 period of data used for Method 2, but is required to exclude many samples that fail specified screening criteria. Therefore, the PMF data has gaps during the year and may not precisely match an annual evaluation due to variations during the year, if the variations are not well represented by the remaining data. Despite the differences in assumptions, input data processing and approach, the SMAT receptor analysis prepared with the PMF results correlates closely to Method 1 and Method 2 receptor evaluations. The RRF for the PMF receptor evaluations vary from the other methods by two percent for Fresno County and less than half a percent for Kern County. However, the attribution of contributing sources is quite different, with more mass attributed to nitrate and sulfate particulate and less mass attributed to

vegetative burning particulate. The differences result in a dissimilar emissions response (9 percent difference for NOx reductions in Kern County).

- The processing of PMF for source identification conducted by ARB excluded a specified portion of the measured organic carbon mass due to collection with a non-federal reference method (FRM) sampler. Sampler comparison was conducted and the regression difference between samplers was considered to be a sampler artifact of VOC incorrectly quantified as particulate matter. This methodology has been previously accepted as a method for PMF to establish sources that correlate well to FRM samplers. The removed organic carbon mass was restored to the receptor analysis based on review of CRPAQS technical findings that establish a smaller estimate for the artifact and guidance for SANDWICH (measured Sulfate, Adjusted Nitrate, Derived Water, Inferred Carbonaceous mass Hybrid Material Balance Approach) and SMAT data evaluation. With the removed organic carbon mass included in the receptor evaluation, the PMF 2003-2006 results for organic carbon match well with the Method 2 analysis of 2004-2006 organic carbon. While some of the organic carbon is unquestionably sampler artifact from VOC, FRM samplers also collect a smaller amount of such artifact. Per EPA guidance for SMAT, artifacts are retained in the analysis and compared proportionally. The receptor analysis methodology used by the District includes the organic carbon artifact with secondary organic aerosol (SOA - also formed from VOC) and projects future concentration based on changes in the VOC inventory. The proportional change is used in the SMAT evaluation and will reflect the comparable effect on FRM sampler mass that is also attributable to secondary organic aerosol and retained VOC quantified as particulate matter.

- **Regional Modeling:** Regional modeling performed by ARB also projects attainment by 2014. Regional model SMAT projections were compared by the District to findings provided by receptor modeling Methods 1, Method 2 and PMF. All sites were in very close agreement with the largest difference at Visalia. The peak value predicted by the regional model is 14.70 µg/m^3 at Bakersfield Planz, a site not suitable for receptor evaluation due to a lack of speciation data. The regional model prediction for Bakersfield California site is14.28 µg/m^3 which correlates well with the receptor Kern M2 prediction of 14.02 based on data from the same site. The widest variation is at Visalia with a difference of 1.18 micrograms. Although the models disagree on exact value for Visalia, both models predict a 2014 design value that complies with the annual standard.

Table 3-5 Regional and Receptor Model Comparison

Site	Code	2014 Regional	2014 Receptor	Difference
Bakersfield - 5558 California	BAC	14.28	14.02	0.26
Corcoran - Patterson Avenue	COP	13.27	13.25	0.02
Fresno - 1st Street	FSF	13.01	12.94	0.07

Visalia - N. Church Street	VCS	14.47	13.29	1.18

- **Model Reliability:** A receptor model must demonstrate a reliable connection between the emission inventory and the observed concentrations. This test has been met for both the PM10 and PM2.5 receptor evaluations. Furthermore, the District has been using this approach long enough to determine that the method is reliable and conservative when estimating reductions required to achieve attainment. The regional model is the third effort for regional photochemical modeling of the SJV performed by ARB. This approach uses state-of-the-science methods to model each day of a fourteen-month period. Performance analysis of the regional model for submission to EPA as model documentation is still in progress; however, the correlation to receptor modeling gives a strong indication that the model will meet the required accuracy requirements.

- **All Contributing Sources Considered:** A review of contributing sources indicates that both the receptor and regional modeling evaluations are comprehensive. The SMAT procedure of EPA guidance calls for evaluation of the major contributing sources. This procedure has been followed for the regional modeling and an equivalent process was established for the receptor evaluation. Both models use the current emissions inventory and common projections of reductions. Evaluation in the previous section identifies the importance of including all key sources and reductions. Emission Inventories undergo constant review and improvement and the California emission inventories are more comprehensive than other states due to inclusion of much smaller contributing sources.

- **Air Monitoring Data and Trends:** Analysis of recent air quality data and trends is included in Appendix H. Significant improvement has occurred from 2001 to 2006 in maximum concentration, frequency of higher concentration days and annual design value. Changes in chemical composition are strongly related to identified emission reductions in recent years providing confirmation and support for current modeling methods. Air monitoring data for 2007, which is not yet complete or certified, indicates that 2007 might reflect a one-year increase in comparison to the last three years. Year-to-year variation is to be expected and is why design values are established over a three-year period. The District performed a sensitivity test with an estimated design value based on available uncertified data for 2007 and determined that the 2014 daily design value would still be far below the required 65 microgram standard. Evaluation of the top 25% of days modeled by the regional model also indicate a projected future design value well below the daily standard while the annual projection is very close to the standard. The importance of these evaluations is the finding that attainment of the daily 65 microgram per cubic meter standard will be met by less reduction than is required to attain the annual standard. The annual standard is a more stringent requirement at this time and establishes the reduction goals for this PM2.5 Plan. However, the new 35-microgram standard is more restrictive than the fifteen microgram annual standard and is expected to establish attainment goals when plans are developed and submitted for that standard.

- **Technical analysis:** Technical issues are discussed in:
    - o Appendix F the SJV PM2.5 SIP Modeling Protocol,
    - o Appendix E District Additions to the Conceptual Model
    - o Appendix H: Weight of Evidence

  These issues are discussed extensively in the Appendices and briefly at the beginning of this Chapter. Evaluation of the technical issues does not contradict model projections, but provides insight into why the Valley has high particulate levels in comparison to other areas of the country. The modeling approaches followed by the District and ARB incorporate and are consistent with our understanding of these technical issues.

- **Weight of Evidence Conclusion:** Weight of Evidence evaluation concludes that the model projections are consistent and project attainment. The importance for the weight of evidence analysis of correlation between modeling results that use different approaches and data is the finding that all of the modeling approaches are in agreement and project attainment by 2014. Both receptor and regional chemical-photochemical evaluations arrive at the same conclusion and nearly identical values for the sites common to both models.

  Supplemental issues reviewed in the weight of evidence evaluation also provide support for the projection of attainment by 2014. A review of contributing sources indicates that both the receptor and regional modeling evaluations are comprehensive. Although there are fluctuations in the annual 24-hour data, it has been determined that the annual standard is more restrictive and that attainment of the daily 65 microgram per cubic meter standard for this planning process will be met with less reduction than is required to attain the annual standard. Technical analysis has examined the conceptual model and identified additional considerations applicable to the SJV. The technical issues do not contradict model projections; rather they provide additional insight into why the Valley has high particulate levels in comparison to other areas of the country.

3.4.3 Demonstration of Attainment

Attainment is demonstrated for each site that is projected to have future concentrations at or below the federal standards. The predicted PM2.5 concentration may also be achieved with different equivalent reductions in individual sources or source categories. When the future predicted design value is close to the standard, EPA recommends that a weight of evidence analysis be conducted to confirm the projection of attainment.

Required demonstrations:

- Attainment of the annual standard 15 $\mu g/m^3$
- Attainment of the prior 24-hour standard 65 $\mu g/m^3$

- Weight of evidence evaluation if either projection is near the standard
- Evaluation of unmonitored areas (areas without monitoring sites)

Attainment of the annual standard is projected by 2014 by the regional photochemical model and all receptor evaluations. The predicted value is within one microgram of the standard; therefore, a weight of evidence evaluation is appropriate. The predictions of these models are compared, along with air monitoring data, trends and other technical information, to establish a weight of evidence assurance that attainment will be achieved. The weight of evidence evaluation supports acceptance of the regional and receptor modeling predictions. Evaluation of the receptor modeling identifies that attainment will not occur by 2009 with the expected achievable reductions and will require the extensive NOx reductions proposed by ARB for 2014. Reductions achieved by the District and current ARB efforts for all directly emitted and secondary particulate sources are important to achieving attainment. The proposed NOx reductions for 2014 would not be sufficient to achieve attainment without these other reductions. The strategy for attainment includes reduction of directly emitted PM2.5 (geologic, mobile, organic carbon and vegetative burning) as well as reductions from SOx and NOx as precursors to ammonium sulfate and ammonium nitrate. Secondary organic aerosol particulate formation is also included in the modeling evaluation of motor vehicle and organic carbon contributions.

Attainment of the prior 24-hour 65 microgram standard is projected to occur prior to 2014 and with much less reductions required than are needed to attain the annual standard. This means that the annual standard identifies the amount of reductions needed to achieve attainment. ARB used the regional model to evaluate the top 25% of days modeled to provide the annual analysis. Based on design values for 2005, ARB projected a 2014 value of 45 micrograms or less at all sites. Due to concerns that the last two years have experienced slightly higher 24-hour values, the District also performed a screening assessment with estimated design values for 2007 (based on incomplete and uncertified data). Evaluation by the District projected a 2014 value of 53 micrograms. Both of these projections are well below the 65 microgram standard and do not require a weight of evidence evaluation.

Unmonitored area evaluation for the year 2014 was conducted by ARB and provides confirming evidence for the attainment demonstration. The unmonitored area evaluation requires examination of regional modeling results for the entire Valley. ARB has provided a screening assessment produced from the regional model results for the year 2014 to determine if any portion of the modeling domain predicts concentrations greater than the monitored locations. This initial analysis did not identify any grid squares that have higher values. ARB has committed to conduct further evaluation in accordance with EPA guidance should this be determined to be necessary; however, the screening assessment indicates that it is unlikely that any areas will be identified that require subsequent evaluation or temporary monitoring. The District and ARB will confer with EPA to ensure that the unmonitored area evaluation provides sufficient confirmation for the attainment demonstration.

3.5 PM2.5 CONSIDERATIONS IN THE OZONE PLAN

In preparing the *2007 Ozone Plan*, the control strategy was developed with utmost consideration to future needs for the PM2.5 attainment plan. Sophisticated regional PM2.5 modeling for the San Joaquin Valley Air Basin using state of the science tools developed with data gathered from the $30 million field programs studying air pollution in the San Joaquin Valley was still under development at the time the ozone plan was completed and was therefore not available as a tool to establish a combined PM2.5 and 8-hr ozone plan. The District wanted some indication (order of magnitude estimates) of the Valley's PM2.5 carrying capacity so that the District could gauge the effects of the Valley's 8-hr ozone emission control strategy on PM2.5 attainment. As a result, a simplified modeling exercise was conducted by ARB to help estimate the Valley's carrying capacity for PM2.5. Evaluation of the San Joaquin Valley ozone control strategy to attain the federal 8-hr ozone standard determined that the ozone plan include NOx emissions reductions that are close to what is needed for attainment of the 1997 PM2.5 standards by the maximum possible statutory attainment date of April 5, 2015. Based on simplified modeling exercises performed at the time the ozone plan was completed, the ozone control strategy was determined to have a design that would provide most – if not all - of the reductions needed to attain the PM2.5 annual standard.

3.6 PM2.5 EFFECT ON THE OZONE PLAN

Additional actions to achieve the PM2.5 standards by 2015 will accelerate compliance with the ozone standard. The reductions of NOx that are valuable for PM2.5 compliance will support early compliance for the eight-hour ozone standard. Some reductions for the PM2.5 plan, such as geologic/soil material reductions, will have no material benefit for the ozone plan; however, no actions in the PM2.5 attainment plan have been identified that would be detrimental to the ozone strategy. The smoke management programs enforced by the District throughout the year were initially developed to safeguard air quality during the ozone season and will continue to have that effect. The winter management of smoke and residential wood combustion has been enhanced to support the additional needs of the PM2.5 attainment strategy.

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