Chapter 5

Future Air Quality

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5 Future Air Quality

5.1 INTRODUCTION

Modeling analysis is used to evaluate air quality measurements that violate the air quality standards by utilizing statistical methods and computer modeling to understand the effects of meteorology and emissions sources on observed PM10 events. The measurements that violate the standard must also be evaluated to determine their relationship to the average of all measurements collected during a year (annual average) at each site. Based on the results of this analysis, a baseline connection between emissions and air quality is established for each site that violates one of the air quality standards. The baseline relationship is used with projection of the emissions for future years to show whether existing and proposed emissions reductions are sufficient to achieve PM10 NAAQS at the earliest practical date. The proposed control measures can then be evaluated to determine if they are sufficient to provide enough additional emission reduction to achieve compliance with NAAQS in future years.

The *2006 PM10 Plan* provides an update to the *2003 PM10 Plan* modeling analysis. The modeling protocol submitted and accepted as a part of the *2003 PM10 Plan* remains effective for this update. The only revision in approach is the use of an additional, newer model for analysis of the nitrate chemistry from CRPAQS (see Appendix C).

Procedures for modeling analysis for the *2003 PM10 Plan* and the *2006 PM10 Plan* have been selected to use the best available data to establish objective and reliable conclusions with the highest confidence. The modeling analysis establishes an attainment demonstration by successfully addressing all identifiable exceedances in the nonattainment area.

Analysis of PM10 concentrations uses emissions inventories, ambient data, meteorological analysis, chemical mass balance (CMB, which is used to identify and apportion sources of PM), and aerosol modeling. This plan also uses rollback (proportional reduction) methods to estimate the expected reduction in pollutant concentration in proportion to emissions reductions. The rollback approach has been strengthened by the incorporation of results of aerosol modeling and spatial analysis of emissions.

The *2006 PM10 Plan* uses recent air monitoring data to determine updated design values to use in the rollback. However, the rollback suggests less improvement in air quality than has actually been observed to date. EPA guidance allows use of alternative demonstration of attainment, but this guidance assumes an area dominated by a single source, or several large sources, of well quantified directly emitted particulates. However, the complex contributions of secondary PM10 in SJVAB episodes and annual averages make this alternative demonstration impractical at this time.

Utilizing the methodology described in this chapter, projections of the effect of control programs and emissions trends have been prepared for the annual and 24-hour design values at all required sites.

5.2 FEDERAL MODELING REQUIREMENTS

As required by federal guidance, air quality modeling analyses are performed to demonstrate that a proposed control strategy provides for attainment and maintenance of the PM10 NAAQS. SIP submittals must include a description of how the modeling analysis was conducted by providing information on what models are used and why they were selected; model version and configuration information; assumptions involved in model application; discussion of model input data including meteorological data and ambient monitoring data; and description of model output data. The Protocol contains the required elements and can be found in Appendix K to the *2003 PM10 Plan*, identified as the "San Joaquin Valley Air Pollution Control District State Implementation Plan PM10 Modeling Protocol." In accordance with federal guidance, the Protocol was submitted to EPA for review during development of the modeling analysis.

5.3 CHARACTERIZATION OF PM10 FOR MODELING

Characterizing PM10 for modeling requires scientific understanding of the physical and chemical properties, sources, and behavior of PM10. PM10 particle size, formation, composition, and chemistry provide a basis for addressing issues such as local contribution, regional contribution, and background. Developing an understanding of the principle factors and influences of PM10 concentrations provides a greater degree of certainty that proposed control strategy reductions will have the desired and expected results and that a projection of attainment has the highest degree of reliability achievable with current information.

5.3.1 Variation of PM10 formation

Meteorological conditions and sources affect particle formation. Secondary PM10 species, such as ammonium nitrate, ammonium sulfate, and organic particles, are formed through chemical interactions from directly emitted SOx, NOx, VOC and ammonia. Ammonium nitrate forms during colder conditions that occur in winter. Particulate sulfate and nitrate can form via both gas and aqueous phase pathways. In the aqueous phase, which is the main pathway during winter fog and cloud conditions, secondary ammonium nitrate and ammonium sulfate form when nitric acid and sulfur dioxide (SO2) dissolve in water droplets and then react with dissolved ammonia. Since the sulfate and nitrate ions compete with each other for the available ammonia, SOx, NOx, and ammonia must be treated as a coupled system in order to adequately understand the interactions and subsequent formation of nitrate and sulfate particles.

5.3.2 Fate of Airborne Particles

As described in Chapter 1, fine and coarse particles exhibit different behavior in the atmosphere, including how they are transported. PM10 originating from or going to other air basins, referred to as pollutant transport, has not been definitively quantified. Monitoring and speciation techniques currently available are not able to identify the origin of PM10 sources with sufficient detail to indicate the extent that the SJVAB is experiencing transport from outside the air basin or contributing transport of PM10 to other air basins. PM10 readings in the SJVAB are most severe during the fall and winter periods when wind speed and direction are not conducive to interregional transport. Transport of PM10 precursors that are also ozone precursors (such as NOx) has been studied as part of ozone transport evaluation. However, the transport of ozone was documented during the summer, when the highest ozone readings are more likely to occur. The amount of fall and winter PM10 that could be generated in the SJVAB or other air basins from such transport has not been quantified.

5.4 DESIGN VALUES

The cities expected to experience the highest fall and winter PM10 levels are monitored as specified by federal requirements. For each ambient air monitoring site, design values are established for each air quality standard. A design value is the representative value at an ambient air monitoring site for an air quality standard. When the design value is not in compliance with the standard for a pollutant (non-attainment), the design value is used to establish the amount of air quality improvement that is needed to achieve compliance with (attainment of) the standard. The design value is used as the baseline ambient concentration in modeling efforts to determine whether projected emissions reductions will be sufficient to reduce PM10 concentrations to levels that meet the federal standards.

Air monitoring data recorded at each site, which is presented in chapter 2, is used to determine the design value for the annual average and 24-hour PM10 standards. The annual design value is intended to represent the average value of the last three years of complete, quality assured data. Each quarter of a year is averaged as a group so that extra or missing measurements do not unduly influence the design value average. All of the valid 24-hour samples collected at each site over the same period are used to establish the 24-hour PM10 design value. This value represents the peak, valid value observed at each site.

The PM10 annual and 24-hour NAAQS require a separate design concentrations for each standard. The sources, amounts, and varieties of PM10 in the SJVAB vary by site. Use of a single design value for the entire SJVAB is not appropriate, so a design value is calculated for each site.

The annual design concentration is the expected annual arithmetic mean. The uncertainty in the design concentration estimate is reduced to the extent that sufficient, representative meteorological and monitoring data are available. At least three years of representative air quality measurements are considered in determining 24-hour design concentrations. The current design values are shown in Tables 5-1 and 5-2. Bold values indicate that the sites exceed the NAAQS.

Table 5-1 Federal 24-Hour PM10 Design Values

Site Name	Design Value for the *2003 PM10 Plan*	Current Design Value for the *2006 PM10 Plan*
Bakersfield - California Ave.	**190**	110
Bakersfield - Golden #2	**205**	**189**
Clovis	**155**	92
Corcoran – Patterson Ave.	**174**	**168**
Fresno – Drummond	**186**	106
Fresno – First	**193**	96
Hanford - Irwin St	**185**	**161**
Modesto - 14th Street	**158**	83
Oildale - 3311 Manor St	**158**	106
Turlock - 900 Minaret Street	**157**	93

Bold indicates value exceeds standard

Table 5-2 Federal Annual Average PM10 Design Values

Site Name	Design Value for the *2003 PM10 Plan*	Current Design Value for the *2006 PM10 Plan*
Bakersfield - Golden #2	**57**	**51**
Fresno - Drummond	50	35
Hanford - Irwin St	**53**	48
Visalia - Church Street	**54**	45

Bold indicates value exceeds standard

The *2003 PM10 Plan* analyzed each of the sites indicated. Though the Fresno Drummond site did not exceed the standard, it was included in 2003 as a precautionary evaluation to review whether future projections would show continued compliance.

Only sites with bold values in the 2006 columns require analysis for the *2006 PM10 Plan*. Bakersfield at Golden exceeds both the annual and 24-hour federal PM10 standards. Hanford exceeds the 24-hour standard. Corcoran, despite having achieved an estimated frequency of occurrences that complies with the standard, will be included in the analysis due to its extensive history of fall particulate episodes. For each of these sites, the rollback modeling must be updated to reflect revised emissions projections and determine whether current control measure commitments are sufficient to achieve attainment. Only Bakersfield requires reevaluation of CMB modeling for the annual standard. All other sites evaluated for the *2003 PM10 Plan* do not require reevaluation because the air quality at those sites is now in compliance. However, the emissions from those areas contribute to exceedances at other locations, and the emissions

reductions proposed for all areas of the SJVAB are included in the evaluation of reductions required to achieve attainment at the sites that continue to exceed the standards.

5.5 MODELING METHODOLOGY

Analysis of PM10 concentrations, chemical composition, and meteorology has provided information on the temporal and spatial behavior of PM10 in the SJVAB. Results reveal three different situations that must be addressed:

- Sites with annual average concentrations above the 50 µg/m³ standard
- Sites with 24-hour levels above 150 µg/m³ in the fall (October to mid-December, sometimes transitioning as early as mid November) with the largest contribution from geologic sources
- Sites with 24-hour levels above 150 µg/m³ in the winter (mid-November to mid December through February) with the largest contribution from secondary formation and fine particulate matter sources

Evaluation is not required at sites with annual design values at or below 50 µg/m³ (rounded to the nearest microgram) and sites with 24-hour design values at or below 150 µg/m³ (rounded to the nearest ten microgram level). However, areas with design values in compliance with the standards do have emissions that contribute to the concentrations observed in locations that do not comply with the standards. Therefore, the contribution of emissions to regional levels from sites in compliance were considered for current and projected future years when evaluating the sites with concentrations above the standards.

Sites with annual average concentrations above the 50 µg/m³ level and events with levels above 150 µg/m³ are required to be evaluated to determine the amount of reductions needed to achieve attainment. Most of the sites evaluated for the *2003 PM10 Plan* are now in compliance with the standards and therefore do not need to be evaluated to determine additional reductions needed to achieve attainment.

Since a linear rollback method is being used, and emissions reductions continue to show decline for future years, only the sites with design values that exceed the standard would produce a result of value in a calculation to determine additional required reductions. If long-term emissions projections showed an increase, then sites at or near the standard would be evaluated for continued compliance. Current air quality data require analysis of Bakersfield and Hanford, with Corcoran added due to its conditional status and prior history.

5.5.1 Emissions Inventory Preparation for Modeling

The District and ARB maintain annual emission inventories of permitted emissions and estimations of mobile source, area source and naturally occurring emissions. For

modeling analysis, adjustments were made to prepare seasonal modeling inventories consistent with the conditions applicable at the time of year that a high PM10 concentration was observed. The emission inventories for modeling were also prepared to address the appropriate spatial scale with an understanding of the appropriate area identified as influencing the ambient concentration at the monitor. Emissions were grouped for CMB analysis and rollback projection as required by the technical constraints of these techniques.

The emissions inventories prepared to correlate with observed design values are called modeling base year inventories. Since these are intended to reflect emissions connected to the design value concentrations, the inventories are not the same as baseline inventories used to establish current District emissions. Projections of future year seasonal emissions without additional controls establish future year projected modeling projections. Projections of future year seasonal emissions inventories with controls to achieve attainment are referred to as attainment inventories.

5.5.2 Modeling Protocol

The "San Joaquin Valley Air Pollution Control District State Implementation Plan PM10 Modeling Protocol" (Protocol) outlines the procedures and technical considerations involved in the modeling analysis for the *2003 and 2006 PM10 Plans*. The ARB, District, and Valley Transportation Planning Agencies (TPAs) jointly prepared data analyses and emissions inventories for modeling for the *PM10 Plans*. Modeling has been conducted with jointly developed input files and mutually accepted modeling assumptions.

The goal of the Protocol is to determine an effective program of emission control, establishing the necessary amount and types of emission reduction that must be implemented to achieve compliance with the federal PM10 ambient air quality standards.

The Protocol contains evaluation elements including analysis of meteorological factors affecting PM10 concentrations using a variety of accepted statistical methods to determine the factors related to known and observed episodes. Modeling of the observed episodes and predicted changes are conducted using receptor modeling using the chemical mass balance model (version CMB 8) for annual and episode conditions at sites that currently do not comply with the federal PM10 NAAQS; regional modeling of secondary particulates by ARB using regional scale models and a photochemical model evaluation to address aerosol chemistry. Episodes evaluated include observations that are required to be analyzed for the SIP and episodes observed by additional monitoring during the December 1999 to January 2001 field study monitoring period for the California Regional PM10/PM2.5 Air Quality Study (CRPAQS).

5.5.3 Utilization of Application Assumptions

Establishing modeling assumptions and background values requires understanding baseline and projected inventories; air monitoring data; and the properties, sources and behavior of PM10. In addition, the spatial influence of emissions sources and an estimation of background levels must be considered. When assessing secondary PM10, atmospheric reaction processes and rates must also be considered. Factors essential for modeling analysis include: origin and properties of particles, chemistry and physics of atmospheric particles, atmospheric behavior, transport and fate of airborne particles, and background concentrations to support modeling.

The analysis of background contributions must identify the portion of the observed particulate that should be attributed to local sources. Background and regional contribution estimates must consider particle dynamics, physics, atmospheric behavior and processes that remove particles from the air. The assumptions for background and regional components must be considered in rollback calculations to ensure that control effectiveness is not overstated or understated. If background estimates are too high, effectiveness would be underestimated and require implementation of excessive control measures. If background estimates are too low, effectiveness would be overstated and provide an insufficient target for the amount of reductions required to achieve attainment. For modeling purposes, background includes particulate matter from natural sources as well as anthropogenic emissions of particulate matter and precursor emissions of VOCs, NOx, and SOx from areas outside of the SJVAB.

Background concentrations are an input for the specified rollback modeling to identify particulate matter that is not part of the emissions inventory and would not be reduced by local control measures. For modeling purposes, background particulate matter includes particulate matter from natural sources including local, regional and offshore emissions and transport of anthropogenic emissions of particulate matter and precursor emissions of VOCs, NOx, and SOx into the SJVAB from adjacent air basins and the surrounding region. To prevent over estimation of control effects, emissions from outside of the SJVAB must be treated as background in the modeling process to discriminate the portion of the measured PM10 affected by control strategies. The modeling definition of background is different than would be used for health assessment studies, where background is limited to natural sources and all anthropogenic emissions are evaluated for their cumulative health impact.

The natural component of the background contributes to both fine and coarse particles in the atmosphere and arises from physical processes of the atmosphere that entrain particles of crustal material (PM10 contained in soil, classified as geologic material) as well as emissions of organic particles and gases from vegetation and natural combustion sources such as wildfires that form secondary particulates. Background natural particulate and particulate precursor emissions sources include: wind blown dust from erosion; sea salt; particles formed from the sulfur compounds emitted from oceans and wetlands; nitrogen oxides (NOx) from natural forest fires and lightning and hydrocarbons emitted by vegetation. Living organic matter including fungal spores,

pollen, bacteria, viruses, endotoxins, and animal and plant debris also contribute to PM10 mass. Bacteria, viruses, and endotoxins are mainly found attached to aerosol particles and their mass will be attributed to those aerosols. Fungal spores, pollen, and animal and plant debris are found as separate particles. Levels of fungi and bacteria vary seasonally, are generally higher in urban than in rural areas and are highest near compost and agricultural activities.

The exact magnitude of the natural portion of particulate matter for a given geographic location cannot be precisely determined because the natural emissions are indistinguishable from the long range transport of anthropogenic particles or precursors. Regional annual average natural background levels are estimated as 4 - 8 $\mu g/m^3$ PM10 and 1-4 $\mu g/m^3$ PM2.5 for the western US. Annual average PM10 concentrations in national parks, wilderness areas, and national monuments in the western United States range from 5 to 10 $\mu g/m^3$ based on data from Interagency Monitoring of Protected Visual Environments (IMPROVE).

5.5.4 Determination of Appropriate Modeling Approach

While there are several techniques available to model the direct emission of particulates, secondary formation of particles and dispersion, it is important to select a methodology that is appropriate for the San Joaquin Valley and considers and compensates for the strengths and weaknesses of available approaches. Based upon availability of emission estimates, meteorology, and air quality data in the SJVAB, the use of receptor CMB modeling is proposed with the support and enhancement of regional aerosol modeling to evaluate secondary formation ratios, with profile selection for CMB modeling enhanced by assessment of local temporal and spatial emission distribution.

Supporting analyses provided in the *2003 PM10 Plan* included the examination of historical monitoring data, evaluation of source zones of influence, assessment of spatial representativeness of monitored episodes, and meteorological and statistical analysis. Examining historical data provides the context for design value observations and an assessment of whether the design values are consistent with previous experience.

5.6 MODELING ANALYSIS COMPONENTS

Meteorological data are used to assess the potential for air pollution to accumulate in certain locations. Weather factors that may 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 while vertical movement of air disperses pollutants upwards, thinning the concentration found at ground level. Low velocity air movement (light winds or stagnation) result in accumulation of pollutants, while higher

velocity winds increase the amount of mixing (dispersion) and reduce concentrations of pollutants, but may transport the pollution to other locations.

The District and ARB conducted analysis of meteorology data for the *2003 PM10 Plan* to identify relevant factors for SIP development. The analysis examined the representativeness of historical and recent episodes, determined seasonal differences in the influence of meteorological variables and categorized the meteorological regimes of pollution episodes analyzed by CMB analysis. Large and medium scale weather patterns were analyzed to determine key weather features that produced poor dispersion or transport during PM episodes. Various statistical models were applied to determine key predictive and common factors. The analysis identified how much the local, regional, and larger scale (mesoscale) meteorology influenced pollutant concentrations.

Receptor modeling using the chemical mass balance model (version CMB 8) was conducted for the *2003 PM10 Plan* for annual and episode conditions at sites that did not comply with the federal PM10 air quality standards. This method uses chemical analysis of collected air monitoring samples and information about the chemical composition of contributing sources to evaluate the link between observed conditions and emission sources. Analysis of samples is used to establish the typical components found in the emissions of a source. This source signature is referred to as a speciation profile. Many sources have components in common. For example, the PM10 emitted by the tires of a vehicle on a road is almost identical to windblown emissions from the adjacent land. The various signatures are used in modeling to identify the contributing sources to observed events, to the extent which the signatures can support reliable identification. To improve the accuracy of the receptor analysis, airflow back trajectories and analysis of the physical location of emissions (gridded inventory) were used to identify appropriate source signatures for analysis of contributing sources.

To establish attainment at sites noncompliant with the NAAQS, CMB receptor model analysis results were used with a modified linear rollback approach to calculate the cumulative effect of predicted emission trends and control measure reductions. In the rollback projection, ambient pollutant concentrations are linked to CMB receptor analysis of source contributions utilizing the most accurate source identifications available.

The quality of the rollback projection was enhanced to incorporate additional available information. Analysis of airflow back trajectories was combined with analysis of the physical location of emissions (gridded inventory) to quantify the contributing sources and influence of reductions as accurately as is possible with current information. The nonlinear secondary particle formation atmospheric processes are not accounted for in standard rollback methods; therefore, the method was improved by incorporating an adjustment for the secondary nitrate formation rates determined by regional modeling of a SJVAB particulate episode.

Regional modeling of secondary particulates was conducted by ARB. Results improve understanding and provide useful secondary particle formation rates and precursor ratios, particularly for nitrate particulates. Results are used in conjunction with receptor modeling to predict effects on secondary precursors due to emission trends and adopted and proposed control measure reductions.

A modified version of the Urban Airshed Model was used address aerosol chemistry (UAM-Aero) for the *2003 PM10 Plan*. This model was used to evaluate the IMS-95 dataset (an early component of CRPAQS) by modeling a monitored event of nitrate particulate formation. Additional analysis of the dataset with modeling techniques under development for CRPAQS was used for comparison to the UAM-Aero results.

ARB has performed additional evaluation with a new aerosol model for review of nitrate particle formation for the *2006 PM10 Plan*. The Mesoscale Model, version 5, (MM5) was used to model atmospheric physics and the Community Multiscale Air Quality (CMAQ) Model (version 4.4), with California specific modifications to correct model code and utilize California specific data rather than defaults, was used to model the portion of PM10 formed in the atmosphere (secondary PM10) for the CRPAQS winter 2000-2001 episode, and to evaluate the response of particle formation to emission reductions.

5.7 MODELING RESULTS

Combining the results of the meteorological and statistical analysis allows evaluation of whether the monitoring data and design value represent the likely worst case value, which would be a more stringent design value than is required, or whether the monitoring data may represent something less than the fourth highest likely value, which may not be sufficiently protective. Receptor and regional modeling allow evaluation of future NAAQS compliance by rollback analysis.

CMB receptor modeling is an analysis method used to link observed levels of particulates to the sources of emissions grouped into source categories. The CMB model links the speciated chemical composition of the filter sample at the site to emissions inventories that represent the emissions at the time of the 24-hour observation, or represent seasonal or annual average values as appropriate. Where emission information is lacking for a particular component (e.g., seasonally resolved mineral dust emissions) rollback can still be applied to other components.

Annual: Evaluation of annual concentrations by receptor modeling to determine probable source contributions must include appropriate consideration of, and adjustments for, seasonal differences in sources and seasonal differences in atmospheric conditions that affect particle origin, formation and atmospheric residence time. In addition to CMB modeling of episode days, monthly averages for required sites have been modeled to develop annual average contribution estimates. For the *2006 PM10 Plan*, the monthly analysis of the variations expected during a year does not need

to be updated, but the emissions estimates for future years have been updated for the future year projections.

24-Hour Episodes: Exceedances were characterized and grouped by chemical speciation and source attribution based on conceptual models, data evaluation and modeling analyses. This information has been used to help identify the contributing sources. For 24-hour exceedances where ammonium and nitrate ions are a significant fraction of the total particulate mass, particle speciation, gaseous concentration, meteorological, and emissions data have been analyzed to attempt to determine the limiting precursor. Only Bakersfield and Hanford are required to be reevaluated for the *2006 PM10 Plan*; however, Corcoran will be included because of its long history of fall exceedances.

5.8 ATTAINMENT DEMONSTRATION METHODOLOGY AND PROCEDURE

Observed exceedances are evaluated by mass balance analysis and related to the emissions inventory for the year when the exceedance occurred. Portions of PM10 samples may originate from emissions sources that are not included in the District's emission inventories, such as emissions transported from areas outside the SJVAB. However, these emissions are indistinguishable from local emissions, so portions must be estimated based on evaluations of current technical literature. Because local control programs do not reduce natural emissions and emissions from outside the local region, these emissions are excluded from emission reduction calculations and added back to the resulting future year projection unchanged.

The future year predicted concentration is the sum of the projected, regulated local contribution plus the estimate of emissions that are not under the District's regulatory authority. Attainment is demonstrated if the concentrations predicted by rollback modeling achieve attainment of both the 24-hour and annual average PM10 standards.

5.8.1 Methodology for Simulation of Attainment Particulate Concentration

The Chemical Mass Balance Model (CMB version 8) was used to estimate source contributions for each site's design value. Annual and 24-hour chemistry was established by this method for the *2003 PM10 Plan.* This information was used for reevaluation of Bakersfield annual and Hanford and Corcoran 24-hour design values for the *2006 PM10 Plan*. Speciation was not available for the Hanford 2002 design value episode that occurred at a transition time of year and could be either a nitrate or geologic dominated episode. Therefore, the Hanford episode was modeled with two different speciation patterns representing a nitrate increase and a geologic increase to predict the effect of reductions in either possible case. A new evaluation was added for Bakersfield episode in 2002 that was dominated by geologic material.

In any modeling approach, inherent uncertainties affect the accuracy of predictions. The rollback procedure is a conservative estimate, which means that attainment is likely to be achieved even if the actual future emissions are slightly more than the calculated future rollback inventory.

The *2003 PM10 Plan* recommended caution in considering the outcome of the rollback projections as conservative due to uncertainties in the modeling and projection process. The distance and position of sources relative to the monitoring site is not considered by CMB modeling; therefore, the effect of emissions changes for a source or source category may be greater or less than projected by the linear rollback method. The accuracy of the projection is dependent on the selection of speciation profiles that are appropriate to identify emissions sources in the area being modeled, the accuracy of CMB modeling, and the completeness, precision and representativeness of monitoring data and emissions inventories for the locations modeled. Accuracy will be affected if the monitoring data or emissions inventories are not typical and representative of the community.

Rollback modeling is intended to be conservative, using linear projections for processes that are more complex; however, the amount of observed improvement that has been experienced in the SJVAB is much greater than this simplified approach projects.

Recent air quality data indicate that the rollback projections were very conservative and may well have been affected by uncertainties that underestimated the effects of emissions reductions. Air quality has continued to improve year by year since 2001, with no winter exceedances since 2001 and no fall exceedances since 2002. No technical adjustment to the rollback modeling method has been identified that would correct for the underestimation of the benefits of reductions. Therefore, the updated rollback projections for the *2006 PM10* Plan should also be expected to be more conservative than required to achieve attainment. Attainment may occur before the projected target year of 2010. Three years of compliance with the NAAQS are required to establish attainment. The District has experienced two consecutive years without a 24 hour exceedance and the annual standard has been met at all but one site; however, meteorological variation could cause events that might delay qualification for attainment even with the current generally improving trend of reduced particulate concentrations.

5.8.2 CMB Source Profiles

The modeling evaluations for the *2003 PM10 Plan* included monitored exceedances of winter episodes dominated by secondary particulate formation in urban areas and fall episodes dominated by emissions composed of geologic material found in San Joaquin Valley (SJV) soil. The *2006 PM10 Plan* uses these analyses and updates the emissions inventory projections to establish revised determinations of the amount of additional reductions required to achieve attainment.

Fall events are usually dominated by material found in SJV soil that becomes entrained in the atmosphere due to a variety of urban and rural activities. It is also possible to

have similar events related to high winds or unusual activities. Winter 24-hour exceedances are dominated by urban combustion and evaporative emissions. Nitrate particulates are formed from reaction of combustion related nitrogen oxides with ammonia in the atmosphere. Carbon compounds are directly emitted or formed from combustion and evaporative gases. The largest urban communities experience the highest winter PM10 levels.

The CMB model analyzes ambient particulate samples to estimate the relative contributions of different source categories to the measured particulate concentration by using the known chemical composition (profile) of likely contributing sources. CMB source profiles were derived from the EPA source profile library, local geological and burning profiles and chemical profiles representing California motor vehicle fuel, type, age, and emission factor data (EMFAC).

Specific source profiles representative of the sources in the area during the season in which the design day occurred were identified for the 24-hour design day at each site. Performance evaluation of each analysis estimates the quality of the statistical fit of the source profiles to the observed event. Profiles were selected based on review of sources appropriate for the time of year, related emissions activities, and meteorological analysis to determine the probable area of contributing sources influencing the observation. CMB modeling has difficulty assessing source contributions from sources with very similar chemical composition. Contributions from paved and unpaved roads, agricultural harvesting, off-road activities and other source signatures described as fugitive dust emissions are essentially indistinguishable to the model. To address this limitation of CMB modeling without excluding important contributing sources, composite profiles were developed by combining the signatures of the various sources so that the affect of the group of emissions could be assessed by CMB modeling.

5.8.3 CMB Contributions

The results of CMB modeling can be used directly to project future concentrations from forecast future inventories that include estimated emissions reductions. The CMB method identifies the contributing sources and the proportional rollback method is used to predict future concentrations based on forecast emissions reductions.

CMB modeling assumes a direct relationship (linear) that predicts that emissions changes will be directly proportional to emission reductions. CMB modeling therefore has inherent difficulties predicting changes in particulates affected by non-linear factors. Non-linear relationships between emissions and particle formation occur due to complex chemical reactions in the processes of atmospheric chemistry.

PM10 episodes that are heavily dominated by primary emitted particles from sources that emit carbon and soil based emissions from roads, agriculture, construction and related activities are suitable for direct CMB analysis and rollback. However, SJVAB episodes and annual concentrations include contributions from nitrate and sulfate particulates produced from complex non-linear atmospheric chemistry reactions.

Evaluating the complexity of the relationships involved in particle formation provides information to determine how to adjust the CMB assumption of linear response to modify modeling methods for improved prediction of secondary particle formation.

5.8.4 Secondary Particle Formation Rates

Regional modeling is used to evaluate the relationship of gaseous precursors to fine particle formation to address the inherent limitation of CMB modeling to consider atmospheric chemistry. All modeling approaches have advantages that recommend their use and limitations that call for supporting analysis. CMB receptor modeling provides the most comprehensive positive features for analysis but is not designed to evaluate nonlinear chemistry as is possible with a regional photochemical model. The regional grid based photochemical models do not handle the dynamics of large particle deposition and air stagnation events as well as receptor analysis.

CMB receptor modeling analyzes the contents of observed filter samples that inherently reflect the end result of all atmospheric and dispersion processes. CMB modeling evaluates contributing sources by the physical and chemical components of the emissions and does not need to know the distances that particles traveled to produce an analysis of contributing sources, but accordingly the CMB analysis is limited in the information it provides concerning the area that influenced the observation. The District and ARB addressed limitations of CMB modeling by thorough analysis of meteorology associated with each event to determine the probable area of influence represented by the observed episode and by using regional modeling to evaluate nonlinear chemistry associated with nitrate particle formation.

Regional grid based modeling provides technically improved understanding of secondary particulate formation, but is not the best approach to model primary particulates. In addition to the lack of sufficient information to model the chemistry of each event with a regional photochemical model including aerosol chemistry, the regional model is burdened by limitations and uncertainties in available information for area source particulate emission rates and distributions and deposition rates for directly emitted large particles. Regional modeling requires estimation of these influences in its effort to predict what will occur in the atmosphere. Regional modeling also has difficulty representing the dispersion of coarse particle falloff distances that are less than the grid spacing, the minimum area for which the model provides a prediction. Using smaller grid spacing and/or using a coupled grid and dispersion approach would improve regional modeling of primary particulates, but available data sets lack sufficient data density to provide suitable input information for fine scale regional modeling.

Regional photochemical grid modeling is useful for evaluation of the secondary particulate portion of PM10, formed from gaseous precursors such as NOx, VOC, and NH3, for episodes involving large quantities of fine particulate matter. These episodes need to be evaluated with an understanding of the atmospheric processes and the best information available about atmospheric chemistry and formation rates. Particle formation rates may vary due to influences of meteorology and precursor ratios.

Temperature, relative humidity, photochemical energy flux, wind speed and atmospheric mixing affect the formation rates of secondary particulates. The balance of precursors and concentrations of ozone and carbon dioxide also influence particle formation.

Regional modeling was used to determine the particle formation relationships specific to the SJVAB using a version of the Urban Airshed Model modified to assess nitrate particle formation (UAM 8-Aero) for the *2003 PM10 Plan*. Evaluation and modeling of extensive data collected for a typical winter episode from the IMS 95 project, an early element of the CRPAQS research program, was used to establish precursor and particle formation ratios for secondary particulates. This analysis confirmed that the formation of nitrates associated with NOx emissions has a nonlinear response in the SJVAB.

The *2006 PM10 Plan* uses more recent projects of the CRPAQS research program and newer modeling methods to reevaluate the particle formation processes. Modeling with newer models and CRPAQS data is used to augment the determination of representative particle formation ratios. The Community Multiscale Air Quality (CMAQ) Model (version 4.4), with California specific modifications, was used to model the portion of PM10 formed in the atmosphere (secondary PM10), and to evaluate the response of particle formation to emission reductions. Using meteorology data from MM5 and the CCOS version 2.12 gridded emissions inventory, the photochemical model predicts expected secondary PM10 concentrations over the domain for the CRPAQS winter 2000-2001episode.

The photochemical modeling used CCOS emissions inventory version 2.12, which was prepared using California Emission Forecasting System (CEFS) and an emissions grid program named EMS-95. CEFS source-specific emissions information was used where available to spatially and temporally allocate emissions from point sources. For area sources, CEFS uses emission factors based on source category and activity data to estimate emissions. These estimates are then spatially allocated to the four kilometer-by-four kilometer grid covering the domain using EMS-95. EMS-95 uses spatial surrogates to estimate the sources categories influence on each grid cell. For on-road mobile sources, the Direct Travel Impact Model (DTIM) version 4 results are used as a surrogate to distribute the emission estimates from EMFAC2002. California's emissions inventory uses the best available source profiles as inputs into each of these projections. Reductions to the gridded emissions were used to evaluate response of nitrate particle formation to emissions reductions.

The CMAQ model was developed under US EPA sponsorship and is universally considered to be the best model available today to simulate particulate matter. The scientific foundation and the coding of this model has gone through several extensive peer-review processes. The California specific modifications included fixing errors in the code and using California specific information in place of model defaults. These modifications were presented to EPA at the 4th CMAS Models-3 Modeling Workshop in North Carolina on September 27-29, 2005 and a manuscript based on the these modifications will be submitted to a peer-reviewed technical journal in the near future.

Results of the regional modeling are used to modify the rollback projections by incorporating an adjustment in the calculation methods to account for nonlinear formation rates of secondary particulates. The rollback projection future year annual average and 24 hour episode response to emission precursor reductions uses results of the CMB modeling combined with conversion factors for precursor formation of secondary particulate matter developed from the regional modeling.

5.8.5 CMB Rollback Calculations

Combining CMB modeling results with grid-based photochemical aerosol chemistry modeling analysis, performed by ARB, provides the best available methodology to establish a reliable rollback analysis. In this approach, CMB modeling provides source apportionment for primary particles and the grid-based photochemical model provides conversion factors of precursors into secondary particles that were used to adjust the proportional rollback analysis of secondary particulates for modeled atmospheric reaction rates. The area of influence affecting the episode was determined by separate meteorological analysis of the days before and during the observed episode.

The CMB modeling analysis used chemical profiles to divide the observed episode concentration into contributions associated with a limited number of categories. The CMB categories are very broad, including contributions from many different types of sources. Emissions inventories prepared by the District and ARB contain a much finer division of sources in smaller categories. To predict the effect on future PM10 concentrations from control programs, the CMB categories were linked proportionally to the sum of comparable emissions inventory categories. The 24-hour and annual connections between CMB and emissions inventories are different due to seasonal differences and other factors.

5.8.6 Attainment Projection Results

From the CMB receptor modeling identification of emissions source contributions by chemical species, future source contributions have been estimated from baseline and projected inventories with rollback techniques to evaluate the effects of trends and proposed emissions reductions in future years. The design value concentrations were modeled at each site where concentrations were measured that exceeded the federal PM10 NAAQS and where adequate data was available to support a valid analysis. In the following tables, values that exceed the standard are shown in bold.

Rollback calculations for each monitoring site determine future compliance with federal NAAQS for PM10 by calculating the effect of emission reductions predicted for the major source categories as defined in the CMB receptor modeling. The predicted PM10 concentration may also be achieved by different reductions of precursor and PM10 emissions as long as the total particulate reduction is equivalent. Attainment is

demonstrated for each site that is projected to have future concentrations at or below the federal NAAQS.

Attainment of the 24-hour standard is projected to occur by or before 2010 at all sites. The *2003 PM10 Plan* projected that four sites would achieve attainment without additional controls included in the plan. Since the adoption and implementation of the plan, seven of the ten sites have achieved compliance with the annual PM10 NAAQS prior to the year 2010. Winter exceedances have been completely eliminated following the year 2001. A recurrence of the severe meteorological conditions that occurred in 2001 might have the potential to cause exceedances in future years until the goals for emissions reductions by 2010 have been achieved. However, the rollback modeling has established a conservative relationship between emissions reductions and the projected air quality improvement; therefore, the reductions currently achieved may be sufficient to prevent or limit the severity of such an episode.

Table 5-3 Simulated Future Year 24-hour PM10 Values

Site Name	Design Value	2010 Projection for *2003 PM10 Plan* without additional reductions	2010 Projection for *2003 PM10 Plan* with additional reductions
Bakersfield, California Ave.	**190**	**182**	148
Bakersfield-Golden #2	**205**	**196**	154
Clovis	**155**	140	121
Corcoran, Patterson Ave.	**174** **174**	**154** **160**	136 134
Fresno-Drummond	**186**	**174**	143
Fresno-First	**193**	**175**	147
Hanford, Irwin St	**185**	**166**	143
Modesto, 14th Street	**158**	142	117
Oildale, 3311 Manor St	**158**	148	128
Turlock, 900 Minaret Street	**157**	140	117

Table 5-4 Simulated Future Year 24-hour PM10 Values

Site Name	Revised Design Value	2010 Projection for *2006 PM10 Plan* without additional reductions	2010 Projection for *2006 PM10 Plan* with additional reductions
Bakersfield-Golden #2	**189**	**163**	153
Corcoran, Patterson Ave.	168	146	
Hanford, Irwin St	**161**	132 or 134	

The Corcoran design value exceeds the federal standard, but the estimated frequency of events of no more than one per year complies with requirements. All other sites have design values that comply with the federal standard

Bakersfield-Golden, Corcoran, and Hanford each had a non-winter exceedance recorded in 2002 but have not violated the standard since that year. Bakersfield Golden State was the highest design value and the most resistant to emissions change. Continued implementation of commitments and adopted controls is required to achieve and maintain attainment at these sites. The regional contributions from other areas of the SJVAB do contribute to exceedances at these sites and the reductions projected for the entire District are considered as necessary to achieve compliance of the standard by 2010. While one additional year of air quality that complies with the standard would technically meet attainment criteria at all three sites, variations in meteorology and unusual or exceptional events may result in episodes in future years. The controls that have been implemented should reduce the severity and frequency of such events. Exceptional events may be discounted from the record after review of the applicability and implementation of a District exceptional events action plan for those events that can be clearly established as meeting required criteria.

Table 5-5 Simulated Future Year Annual PM10 Values

Site Name	Design Value	2010 Projection for *2003 PM10 Plan* without additional reductions	2010 Projection for *2003 PM10 Plan* with additional reductions
Bakersfield-Golden #2	**57**	**56**	50
Fresno-Drummond	50	47	44
Hanford-Irwin St	**53**	49	45
Visalia-Church Street	**54**	49	45

Table 5-6 Simulated Future Year Annual PM10 Values

Site Name	Design Value	2010 Projection for *2006 PM10 Plan* without additional reductions	2010 Projection for *2006 PM10 Plan* with additional reductions
Bakersfield-Golden #2	**51**	49	
All other sites have design values that comply with the federal standard			

As projected in the *2003 PM10 Plan*, Fresno, Hanford, and Visalia achieved compliance with the annual PM10 NAAQS prior to the year 2010. Bakersfield has recorded two years of annual averages that comply with the standard but may require implementation of the proposed commitments to achieve compliance by 2010. Attainment requires the continued implementation of adopted controls. Variations in meteorology may result in years with higher annual averages than recently experienced, but attainment of the annual standard is projected to occur by or before 2010.

Projections of the future PM10 concentrations in response to proposed and implemented reductions and emissions trends are contained in Appendix C.

5.9 COMPARISON OF PREDICTIONS TO OBSERVED AIR QUALITY

Comparison of rollback predictions to air quality observations and trends is a valuable additional evaluation due to the limitations inherent in rollback modeling. Rollback modeling for the annual average has the potential to establish an excessive requirement for reductions because it uses conservative linear projections that may understate the effect of reductions and because the method does not account for trends other than those expressed by the emissions inventory changes. The rollback projections for the 24-hour standard utilize the same linear methods for a design value episode, usually a worst-case event, for each site. The rollback method does not assess whether the design value episode represents a typical or unusual event to be used as the basis for determination of required reductions.

Observed air quality can be used to examine the accuracy of the rollback projections, but it cannot be used to provide an alternative attainment demonstration or target for emissions reductions. Guidance for alternative demonstration of attainment directly from observed air quality was written to address areas dominated by one or several large sources of emissions. The San Joaquin Valley is dominated by well-mixed sources and secondary particle formation that are not suited to evaluation by the method defined by guidance.

Based on a review of measured PM10 concentrations, the San Joaquin Valley Air basin appears very close to attainment of both the federal 24-hour PM10 standard and the federal Annual Average standard. The rollback modeling indicates more resistance to air quality improvement than is reflected in current air quality data. The patterns in air quality data usually experience fluctuation due to meteorological variation from year to year. Even though current data indicates steady decline in observed values, years with higher and lower values should be expected due to meteorological variation.

5.9.1 Annual Standard Nonattainment Site Observations

All sites in the San Joaquin Valley except the Bakersfield site at Golden State already comply with the annual PM10 standard. The Bakersfield site annual design value was 57 micrograms for the *2003 PM10 Plan* and is 51 micrograms for the *2006 PM10 Plan.* The rollback prediction is 49 micrograms by 2010. This prediction reflects a slower rate of improvement than is reflected by the air quality change in the last few years. Many factors may be responsible for the more conservative prediction of the rollback model, including the inability of the model to account for trends in the data from factors other than changes in the SJV emissions inventory.

The aerosol modeling of IMS-95 by UAM-AERO and CRPAQS episode modeling by CMAQ are in relatively close agreement on the influence of NOx reductions. CMAQ modeling also provided evaluation of ammonia and VOC reductions. Ammonia was shown not to be effective, with a fifty percent reduction of ammonia producing only a minor reduction of particulates (a fraction of one microgram). A bibliography and summary of CRPAQS research supporting this conclusion is available in Appendix D.

VOC reduction was beneficial but less extensive than the NOx reduction, providing only about one fourth as much improvement for a fifty percent reduction.

The actual improvement in nitrates between 2000 and 2004 is 50% in Kern County. Specific measurements of nitrate concentrations are not collected at the Golden State site, but the observations at other sites establish the County trend. The peak PM10 nitrate reading in 2000 was approximately 40 micrograms and was 20 in 2004. The 2001 data that was used for establishing the nitrate chemistry for CMAQ had a peak Kern nitrate value of over 70 micrograms. The year 2001 appears to be atypical, with steady decline shown in 2002, 2003 and 2004 peak values for nitrate observed in Kern County. The IMS-95 episode had nitrate levels more consistent with recent years other than 2001; however both the CMAQ and IMS predictions of response for NOx reductions were consistent. The similarity of results by two different modeling approaches for two different air quality episodes provides an increased confidence in the estimation of response to emission reductions.

The rollback projection showed attainment using the average of the IMS-95 and CMAQ nitrate analysis. The observed air quality change indicates that modeling estimates may still be a conservative estimate of improvement, reflecting less improvement than will actually occur. The design of rollback modeling is intended to be conservative in the prediction of improvement; therefore the conclusion that more improvement will be experienced than is reflected by the model is an expected outcome. It is possible for conditions like 2001 to reoccur, but the severe January conditions produced concentrations over fifty micrograms greater than has been observed in winter in Kern County during any other year in the last ten years; therefore 2001 data does not provide the best foundation for prediction of future trends.

5.9.2 Observations for 24-hour Standard

Basin-wide attainment of the 24-hour standard requires three consecutive years of no violations at any station. Twelve of the fifteen SJV monitoring sites currently meet the 24-hr standard with zero measured concentrations greater than 154 $\mu g/m^3$ during the last three years. The Valley had only one measured exceedance during 2004, on September 3, at Corcoran. This exceedance was caused by a high wind event and has been removed from consideration after review and consultation with ARB and EPA. The event has been determined to be a natural event, is not considered a violation of the federal 24-hour standard, and is not used to determine attainment status. After removal of this event from consideration, the District monitoring network detected no other violations during the last two years. If there are no violations of the 24-hour standard in 2005, it will be the third and final year of no violations needed for the District to establish attainment of the 24-hour federal standard.

The Corcoran design value has dropped from 174 to 168 and rollback projection predicts improvement to 146 by 2010. The air quality data and rollback prediction are relatively consistent. Peak values at Corcoran were 168 in 2002, 150 in 2003 and 139 in 2004. The trend in values does appear to be improving in accordance with the

rollback prediction. This event is a fall event that is much less influenced by the nitrate evaluation for secondary particulate formation.

The Hanford design value episode is the only winter violation detected since 2001. The design value at Hanford has improved from 185 micrograms to 161 micrograms. Rollback modeling was conducted using a speciation pattern that assumed the event was dominated by an increase in nitrate particulates and an alternative assumption of a geologic particulate dominated event. The rollback model predicts improvement to 132 or 134 by 2010 depending on whether the event was dominated by geologic or nitrate particulates. In either case, attainment of the standard is predicted by or prior to the year 2010. Peak values at Hanford were 161 in 2002, 140 in 2003 and 123 in 2004. The trend in values does appear to be improving more than is predicted by the rollback prediction. As previously discussed, the nitrate modeling may be reflecting less improvement than will actually occur for the nitrate portion of winter episodes in Hanford.

The design value episode for Bakersfield at Golden State, a concentration of 189 micrograms on May 20, 2002, is the only exceedance of the standard in the last three years. This was an atypical event in May that would probably qualify for removal from consideration as an exceptional event. Although analysis of this event was conducted, the review of the episode was not definitive in determining cause of the high concentration. The atypical nature of this May event can be shown by review of historical data for Kern County. Review of all data from 1995 to 2004 indicates that the next four highest values in the period from March to June are all in the 80s, a full hundred micrograms less severe. The winter exceedance on which the *2003 PM10 Plan* rollback was based has not recurred, with winter peak values less than 116 micrograms since 2001. Air quality data indicate that attainment of the standard is highly likely prior to 2010 due to the infrequent occurrence of the atypical events that have established the design values.

5.9.3 Significance of the Results of Air Quality Trend Review

Observed air quality trends indicate that improvement in air quality, in response to emissions reductions and other factors, is occurring more rapidly than the rollback model projects. Attainment of the federal 24-hour and annual PM10 standards may occur earlier than the 2010 rollback prediction provided by the *2003 PM10 Plan* or the revised rollback predictions provided in this Plan.

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