Chapter 5 – FUTURE OZONE AIR QUALITY

5 FUTURE OZONE AIR QUALITY

5.1 INTRODUCTION AND SUMMARY

Air quality models are used to predict ozone concentrations in future years. These models simulate the formation, transport, and removal of ozone from the lower atmosphere. The models are computer programs that estimate the contribution of ozone from emissions, winds, temperature, dispersion, removal, and chemical changes.

Modelers used state of the art procedures to perform modeling for this plan. These procedures included: implementing a comprehensive measurement program, formulating and formatting model ready data inputs, running the model, comparing the model prediction to the base case, developing future year emissions scenarios, and running those with the model to predict future ozone levels. The goal of these modeling exercises is to formulate a controlled emissions scenario where ozone levels will achieve the federal 1-hour ozone standards. Appendix D provides more information on the modeling conducted for this *Extreme OADP*.

5.2 PARTICIPANTS

The use of ozone models for developing air quality plans requires both scientific and organizational procedures. For this plan, most of the development and initial implementation of the modeling was done under the direction of the San Joaquin Valley Study Agency. The Technical Committee of the San Joaquin Valley Study Agency, which consists of governmental and industry representatives from Central California (including the District, the Bay Area Air Quality Management District [BAAQMD], and the Sacramento Metropolitan Air Quality Management District [SMAQMD]), formulated and reviewed procedures for conducting the modeling for this plan. This body of expertise was supplemented by experienced and specialized consultants hired through the Study Agency to address specific questions related to SIP development. ARB developed modeling procedures for the future years and conducted the modeling.

5.3 MODEL CHOICE

Several photochemical models are available to assess the emissions reductions needed to achieve the one hour ozone NAAQS. These include the Community Multiscale Air Quality (CMAQ), SARMAP Air Quality Model (SAQM), and the Comprehensive Air quality Model with Extensions (CAMx) model. EPA has approved each of these models for use in SIPs. During the course of the SIP modeling effort, modelers ran each one of these models and then compared the output to observations. The CAMx model was judged to perform slightly better than the others, and this model has the capability of diagnosing internal operations that give the final pollutant results. CAMx has computer coding that can evaluate, within each grid cell at a given time for each physical and chemical process, the amount of ozone produced. This algorithm, called process analysis (PA), can diagnose problems in the model. For meteorological inputs to the air quality model, weather models called MM5 (Meso-scale Model 5) and Calmet were used. These models are discussed below. Other meteorological models were run, but this model resulted in the best overall performance for winds and temperatures.

5.4 MODEL BASE CASE

In order to estimate the amount of emissions reductions needed to achieve ambient air quality standards, modelers first establish a modeling base case. This is a historical episode that represents near worst-case weather conditions. Modelers select the episode by analyzing ozone and other pollutant concentrations, pollutant transport, dispersion, and day-specific emissions. The goal of this analysis is to determine the representativeness of the episode for testing emission reduction strategies.

Modelers considered five episodes for representing ozone episodes in the San Joaquin Valley. These episodes occurred during 1999, 2000, and 2002. The episodes in 2000 are part of the Central California Ozone Study (CCOS). During CCOS, scientists made extensive measurements of ozone, hydrocarbons, oxides of nitrogen, and other chemical species from ground-based sites and from aircraft. Additionally, lower air profilers measured continuous winds and temperatures aloft. Episodes outside of CCOS had much less meteorological and pollutant data to initialize and verify models. Consequently, members of the Technical Committee were highly interested in using CCOS episodes for SIP development. Candidate episodes for SIP analysis included:

- July 11-12, 1999
- June 17,18, 2000
- July 29-August 2, 2000
- September 17-21, 2000
- August 9-16, 2002

State and local agencies and their consultants working for CCOS simulated all of these episodes using one or more of the computer models described above. The focus of these modeling efforts was for the San Joaquin, Bay Area, and Sacramento SIPs. In addition to the ARB, contractors from private firms, NOAA, and academia worked on various aspects of modeling these episodes.

Of the CCOS episodes, where extensive air quality and meteorological data was available, the July/August 2000, episode was determined to be the most representative of the transport and formation of ozone in the Central California

Region. During CCOS, numerous air quality and meteorological measurements were taken that would produce more confidence in photochemical modeling results. For example, aircraft and ground based hydrocarbon measurements were taken that could be used to start the models. Lower air profilers that measured the winds and temperatures in the lower atmosphere achieved better coverage of the SJVAB and collected data more frequently than routine measurements. Technical Committee members identified some issues with this episode (notably the presence of wildfires), but the consensus was that shifting resources to other episodes had no demonstrable benefits.

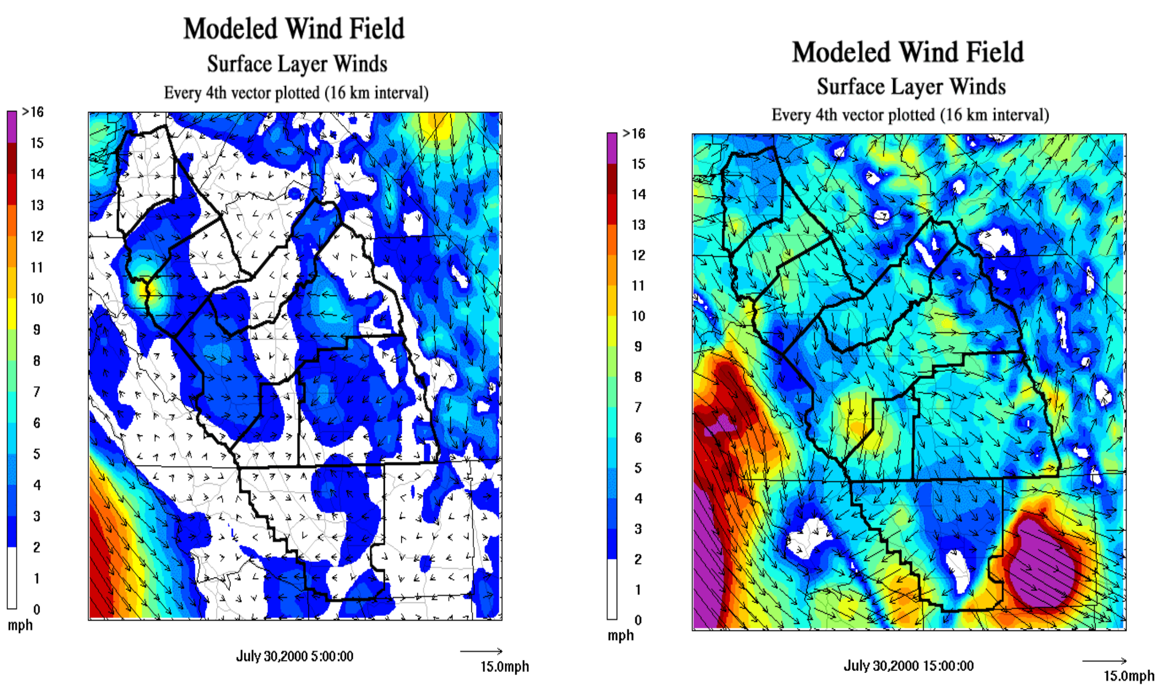
Because of the issues identified for the July/August 2000 episode, the District was also interested in the September 17-21, 2000 episode for potential use in the SIP. Consequently, the District contracted modeling of this episode through the Study Agency. After considerable study, the performance of this episode was found to not meet performance criteria for use in the SIP, so it was not pursued.

Weather causing poor dispersion and light transport of pollutants during the July-August 2000 episode was typical of high ozone events in Central California. High pressure dominated the region and the magnitude of that pressure was typical of high ozone events. This weather pattern caused light winds, strong inversions, and poor dispersion throughout the episode. Study Agency and outside contractors along with staff concluded that the July-August 2000 episode meteorology was typical of ozone episodes in the SJV. Therefore, the episode was deemed useful for evaluation of emission reductions.

The July-August 2000, episode exhibited weather features that were similar to high ozone events analyzed historically. Observed winds showed morning upslope, nighttime downslope, local eddies, and marine wind flows. Figure 5-1 shows winds in the morning and afternoon of July 30, 2000. Morning down-slope and afternoon up-valley flow are evident in this simulation. Marine flow is also evident in the afternoon in the northern SJV. A prominent feature of the afternoon simulation is the up valley wind flow into the SJV from the Bay Area, which brings marine air into the Northern SJV; however, the air becomes quite modified and hot by the time it reaches Fresno. High velocity downslope winds are evident in the morning simulation near Fresno. The Fresno eddy (Section 2) is not obvious in the morning simulation, but there is some hint of it in the data because the winds are easterly in east Fresno County and westerly in west Fresno County. Modelers produced meteorological simulations using a hybrid of the Meso-scale Model 5 (MM5) and the Calmet model. NOAA developed the MM5 simulation under contract to the study agency. ARB and consultants working for the districts in Central California also conducted MM5 runs. Technical Committee members evaluated the MM5 runs, and found differences between observed vs. predicted meteorology that could not be resolved by additional MM5 runs. For this reason, the Technical Committee explored a hybrid approach in which results from another model (Calmet) are used to modify the MM5 results to see if predictions of meteorological parameters more closely match observed values for these parameters. Calmet is an observational based model where surface and aloft meteorology are interpolated. For the modeling exercise in this Plan, modelers used Calmet as the basis for the wind simulation, and adjusted the results using MM5 results in areas where no observations were available.

The process to develop and validate an air quality model generally is very complex and resource intensive, and the development of the July/August CCOS episode was no exception. Technical Committee members and consultants spent a great deal of time and effort in the development and review of the modeling inputs, and in the application and validation of the air quality model. Many stakeholders participated in this process, including representatives of local air districts and transportation planning agencies in the region, and members of the CCOS Technical Advisory Committee. The modeling for this episode is an ongoing effort, since it will eventually support many uses in addition to one-hour ozone SIP planning, and since it will continue to reflect new information and improvements in the science. However, the modeling results presented in this document satisfy accepted model performance criteria and are acceptable and appropriate for use in SIP planning.

Figure 5-1
Wind Field for July 30, 2000 at 5:00am and 3:00pm PST



The Technical Committee has raised several issues regarding the use of the July-August 2000 episode in this Plan. Although the Southern Region near Bakersfield observed 1-hour ozone levels near design values (see Chapter 2), the Central Region near Fresno did not. The model predicts 1-hour ozone levels near design values in the Fresno area, but these have not been verified by observations. Earlier versions of the modeling showed lower predicted ozone levels; later model runs with the hybrid meteorology described above produced higher predicted 1-hour ozone levels near Fresno. Although some members of the Technical Committee raised issues regarding the merging of modeled and observational data[1], no better solution was found. The better agreement of the simulated regional 1-hour ozone peaks and the measured design value near Fresno, using the hybrid approach, is a principal advantage of the hybrid.

Figure 5-2 shows the maximum ozone simulated in the base case (July/August 2000). Concentrations in the San Joaquin Valley are approximately 140 ppb near Bakersfield and Fresno. Typical design values (see Section 2) for the period from 2001-2003 are 150 ppb near Bakersfield at Arvin and 151 ppb near Fresno at Parlier. The large ozone plume east of Tulare was due to a large wildfire called the Manter fire. Although the model showed fire effects in the SJVAB on the last day of the simulation (August 2), on July 30 the fire effects were minimal on the floor of the valley. Figure 5-3 shows the effects of the fires on simulated ozone concentrations.

5.5 FUTURE YEAR PROJECTIONS

Once the model has been validated by comparing predicted and observed concentrations, the model can be used to predict future air quality. Future year emissions projected in a process described in Chapter 3 are processed to provide input to the model. The first step in estimating reductions to achieve the federal 1-hour ozone standards is to forecast emissions for the attainment year, which for this plan is 2010. The 2010 emissions estimate was run through the model. The model showed that the projected 2010 emissions did not attain the federal 1-hour ozone standards. Because of fire emissions impacts in the model on the days later in the episode, July 30 at the beginning of the episode was chosen to do future year analyses. The model forecast that the highest concentrations in the San Joaquin Valley would be 128 ppb near Fresno and 136 ppb near Bakersfield. Figure 5-4 shows the model response to 2010 emissions estimates using meteorology from July 30, 2000.

[1] For example, the air quality model is resolved to 4km X 4km grids. Some believe that the meteorology and air quality model resolution should match, and that only meteorological model physics should drive the analysis.

Figure 5-2

Maximum Ozone Concentration for CCOS Episode, July 30—August 2, 2000

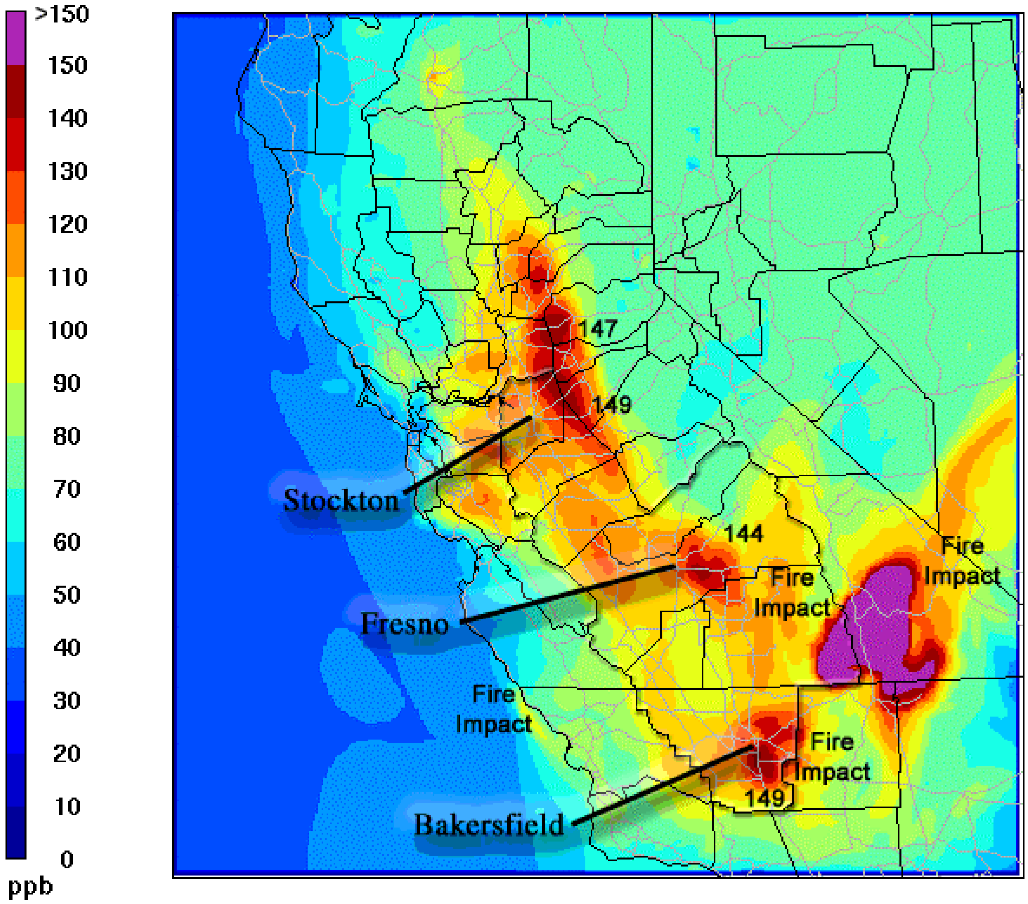
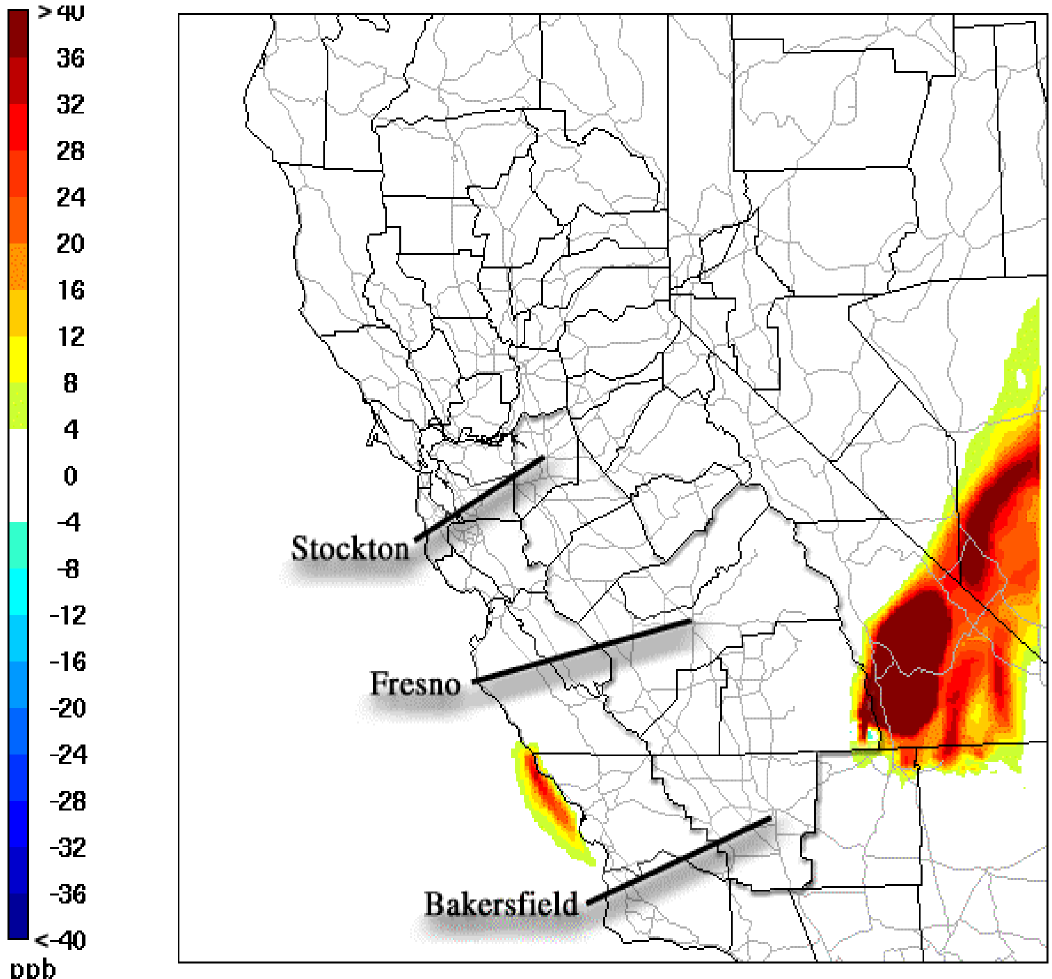
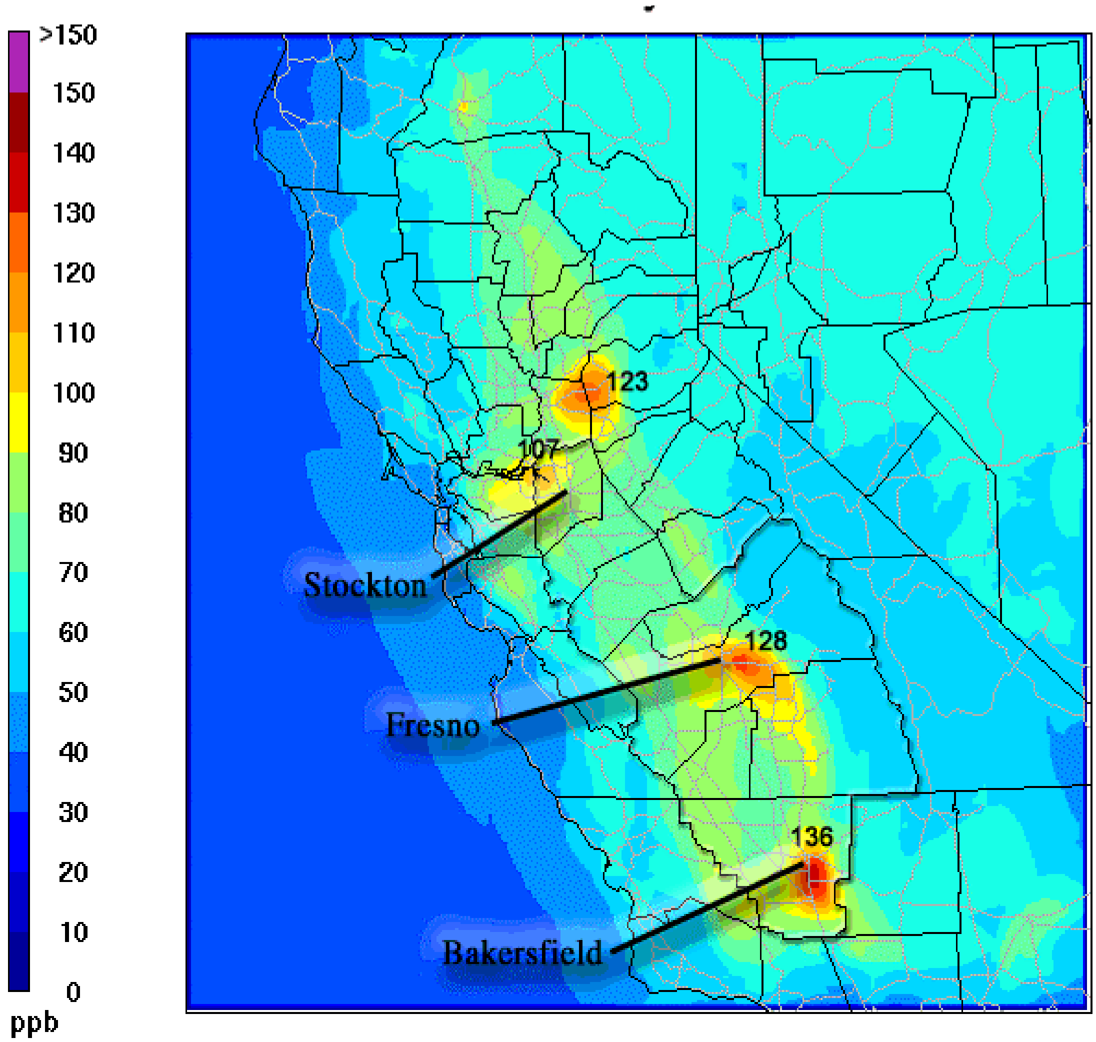


Figure 5-3
Change in Maximum Ozone Concentration Due to Wildfires, July 30, 2000



Positive values indicate increases in peak ozone concentration.
Negative values indicate decreases in peak ozone concentration.

Figure 5-4
Maximum Predicted Ozone Levels, 2010, Without Additional Controls



5.6 ATTAINMENT DEMONSTRATION

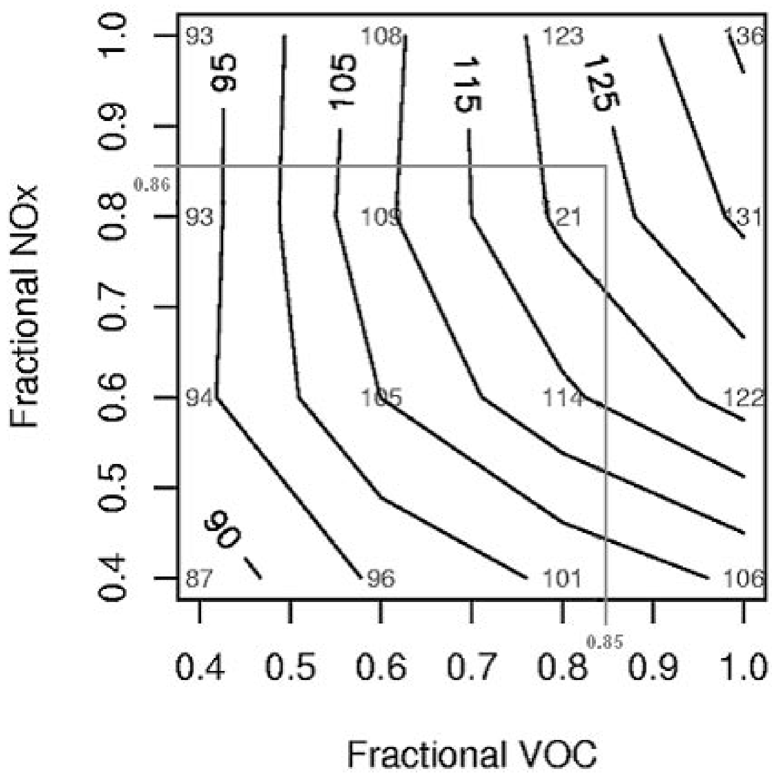
Attainment demonstration refers to estimating the amount of ozone precursor emission reductions needed for the model to project attainment of the federal 1-hour ozone standards. After validation of the model, and some emissions adjustments for inventory improvements, modelers calculate the amount of reductions needed to attain the federal 1-hour ozone standards.

Once a base 2010 emission scenario was established, modelers established reductions in emissions of ozone precursors across the modeling region from the 2010 emissions forecast. These cuts consist of reducing the amount of VOC and NOx emissions in the region by a percentage, running these emissions through the model, and recording and plotting the results. This process was repeated for many across-the-model-region emissions cuts for both VOC and NOx. Cuts were made to the NOx and VOC inventories at 10% intervals. The model responses to these emission cuts were then plotted, and combinations of VOC and NOx controls that achieve the standards were analyzed. These plots, called isopleths, revealed that both VOC and NOx emissions reductions were needed in the Fresno and Bakersfield area using the July 30 episode day. Plots for other days near the end of the simulation, especially August 2, showed that in the Bakersfield area ozone was limited by VOC and reductions in NOx did not change ozone much. Because the end of the episode was affected by fire emissions on August 2, that day was not used for attainment demonstration.

Figure 5-5 presents the isopleth for July 30, 2010 in Bakersfield. The axes represent fractions of NOx and VOC that produce various ozone levels in (represented by the numbers on the curves that are shown; units are in parts per billion). Since the federal 1-hour ozone standards are 0.12 ppm, any ozone value of 124 ppb or less on Figure 5-5 represents attainment of the federal 1-hour standards. Planners thus look at what combinations of fractions of the VOC and fractions of the NOx inventories support ozone levels that attain the standards. For example, a NOx inventory of 85% of the total used in the modeling[2], coupled with a VOC inventory also at 85% of the modeled inventory[2], would produce attainment because the intersection of lines drawn parallel to the respective axes from these points intersect to the left of (and hence are lower than) the curved line labeled “125”[3]. Thus the attainment demonstration exercise consists of using percentages of the VOC and NOx emissions inventories used to create the isopleths and seeing what combination of VOC and NOx reductions will demonstrate attainment.

[2] An inventory that is 85% of the total used in the modeling reflects an overall emission reduction of 15% for that ozone precursor.
[3] A value of “125” or higher (to the upper right) represents nonattainment.

Figure 5-5. Isopleths for Bakersfield on July 30, 2010



Planners used Figure 5-5 for this *Extreme OADP* by first estimating emissions reductions that have been identified since completion of the emissions inventory used in the modeling for this *Extreme OADP* (the gridded photochemical modeling described above reflects emissions controls in place as of September 2002). Thus, for this *Extreme OADP*, any control measure commitments identified after September 2002 represent additional reductions that contribute to the overall total reductions needed for attainment. These measures include (1) District control measures and state and federal measures identified for the 2003 *PM10 Plan* approved by EPA effective June 25, 2004, (2) District measures adopted after the inventory cutoff but before the *PM10 Plan* and not reflected in the *PM10 Plan*, and (3) any additional District, state, and federal measure commitments developed for this *Extreme OADP*.[4] Planners added these emissions reductions for each of VOC and NOx and used the resulting totals to

[4] Note that Table 4-1 only supplies some of the emissions reductions needed for the attainment demonstration; others come from the 2003 *PM10 Plan*, incentives, and state emission control measures. For these reasons, the sum of reductions in Table 4-1 does not match the sum needed to demonstrate attainment in Table 5-1.

TABLE 5-1
SJVAB FEDERAL 1-HOUR OZONE ATTAINMENT CONCEPT

Category	2010 Summer Planning Inventory (tons/day)	
	VOC	**NOx**
2010 Baseline Inventory[a]	367.6	401.7
District Rules-- Post-Inventory and Pre-*PM10 Plan*[b]	**0**	**0.1**
New State Commitments in 2010 from *PM10 Plan*[c]	2.5	14.9
New District Commitments in 2010 from *PM10 Plan*[d]	11.6	23.9
Total New Commitments in 2010 from *PM10 Plan*	**14.1**	**38.8**
New ARB Commitments in 2010 from *Extreme OADP*[e]	15.0	10.0
New District Commitments in 2010 from *Extreme OADP*[f]	21.3	2.9
Total New Commitments in 2010 from *Extreme OADP*	**36.3**	**12.9**
Total Reductions through PM10 Plan and Extreme OADP	***50.4***	***51.8***
Reductions Needed from Long-Term Measures	***5***	***5***
Total Reductions	***55.4***	***56.8***
Total Reductions as % of 2010 Inventory	***15.1%***	***14.1%***

[a] See Table 3-1; CCOS Summer Inventory, Version 2.11, January 2004; reflects control measures through September 2002.
[b] Represents District Rule 4313 for Lime Kilns, which is estimated to provide 0.1 tpd of 2010 NOx reductions. This rule was not included in the emissions reductions used in the 2003 *PM10 Plan*; it was adopted in March 2003 after the September 2002 cutoff date for the inventory.
[c] Based on estimated annual emissions reductions in the 2003 *PM10 Plan*, Table 4-14 in 2003 *PM10 Plan* (all references to 2003 *PM10 Plan* refer to the Amended version, December 2003). Values have been adjusted to reflect summer emissions. State measures for VOC reflect 2.5 tpd from I/M enhancements (the *PM10 Plan* accounts for only NOx reductions from Smog Check II—it does not take credit for VOC reductions from Smog Check II, which are estimated at 2.5 tpd). State measure for NOx includes reductions from Smog Check II (10.0+4.9=14.9 tpd) [Table 4-17 in 2003 *PM10 Plan*].
[d] Based on estimated annual emissions reductions in the 2003 *PM10 Plan*, Tables 4-17 and 4-19 in the 2003 *PM10 Plan*, converted to summer totals thru the EIC codes affected by the control measure categories using summer and annual CCOS inventories. Residential wood combustion emissions excluded.
[e] New state measures above and beyond those in the 2003 *PM10 Plan*; see Table 4-3 in the *Extreme OADP.*
[f] New District measures above and beyond those in the 2003 *PM10 Plan*; emissions reductions from measures listed in Table 4-1 of the *Extreme OADP* that are already in the *PM10 Plan* were not included in this subtotal because they are already captured in the "District" line for the *PM10 Plan* and thus have already been subtracted.

compute the percentages by which the 2010 NOx and VOC emission inventories were reduced by the control measures. As shown in Table 5-1, adding the emission reductions from these three components gives a total VOC emission reduction of about 50.4 tons/day and a total NOx emission reduction of about 51.8 tons/day. These inventories represented about 86.3% of the VOC inventory used in the modeling and about 87.1% of the NOx inventory used in the modeling. Plotting these data on Figure 5-5 showed that the intersection of the two controls resulted in a predicted ozone level that is clearly on or to the right of the "125" nonattainment line, thereby indicating nonattainment.

This predicted nonattainment led the District to identify additional emissions reductions, which when added to the totals reflected in Table 5-1, would be sufficient to demonstrate attainment. The District determined that 5 tons per day of VOC emissions reductions and 5 tons per day of NOx emissions reductions, when added to the totals already shown in Table 5-1 from specific District and State measures identified through this *Extreme OADP*, would be sufficient to demonstrate attainment. Addition of 5 tons per day to each of the VOC and NOx categories produced total reductions of 55.4 tons per day of VOC and 56.8 tons per day of NOx (Table 5-1). These reductions result in a VOC emissions inventory that is 84.9% of the VOC inventory used in the modeling and a NOx emissions inventory that is about 85.9% of the NOx inventory used in the modeling. Plotting these percentages (rounded to the nearest percent) on Figure 5-5 shows that the lines intersect to the left of the "125" nonattainment line, indicating a predicted 2010 ozone level that is in attainment with the federal 1-hour ozone standards. The resulting 2010 emissions inventory that demonstrates attainment of the federal 1-hour ozone standards in the SJVAB is about 312 tons per day of VOC and about 345 tons per day of NOx.

In accordance with the federal Clean Air Act and as described in Section 4.9, these additional emissions reductions needed to demonstrate attainment are placed into the category of "Long-Term Measures" that will be identified in 2007 (see Section 4.9). No specific control measures producing these reductions are identified at this time. As discussed in Section 4.9, the District needs to identify these measures no later than the spring of 2007. Because of other major SIP commitments that are scheduled to occur prior to this date (e.g., the 2006 *PM10 Plan* and the 2007 *8-hour Ozone Attainment Demonstration Plan*), specific control measures with reductions of this magnitude are expected to be identified.

Put another way, the emissions reductions achieved through the *Amended 2002 and 2005 Rate of Progress Plan for San Joaquin Valley Ozone*, when modeled out to 2010, are insufficient to attain the federal 1-hour ozone standards in the SJVAB. Additional reductions are needed for attainment. Adding together the additional reductions from District and state measures in the 2003 *PM10 Plan* and the *Extreme OADP* (including the "Long-Term Measures") produces a total emission reduction that is sufficient to demonstrate attainment of the federal 1-hr ozone standards in the SJVAB in 2010 for the types of weather conditions observed during this episode.

5.7 Modeling Caveats and Future Work

Three major caveats exist regarding the modeling that has been done for this plan. The first is that emissions from major wildfires are in the base case, but not in the future year attainment runs. This approach was used because no reliable and defensible technique exists for predicting the location, duration and intensity of future wildfires. Consequently, the predicted ozone levels for 2010 receive some “benefit” from lack of ozone precursor emissions from major wildfires. Studies done for this plan show that the magnitude of the fire effect is minimal for the day actually used for attainment demonstration (July 30, 2010). The second caveat is that the measured ozone values in Fresno were not near the highest concentrations that historically have occurred. The justification for using this episode was that the peak may have occurred away from a monitoring site, and the modeled peak may be more indicative of what actually occurred in the July-August 2000 episode. The third caveat is that the meteorological fields for this episode were developed by using a hybrid approach that combined observational and physics-driven meteorological models. This hybrid was used because it resulted in the best agreement between simulated and observed ozone. It is possible that the combination of these could have resulted in compensating errors where the meteorological field made up for underestimations in the inventory and other problems.

In spite of all of these caveats, the modeling used for this plan is based on the best available information and science as of Spring 2004. Future work under CCOS will improve our understanding of ozone production in the SJVAB. As noted in Section 3, other future tasks will address improvements in the emissions inventory. Together, these improved data and modeling tools will lead to stronger modeling exercises for future ozone attainment demonstration plans.

Toward this end, work is currently underway by ARB, SJVAPCD, SMAQMD, BAAQMD, and the consultants for these organizations to improve photochemical modeling in Central California. A systematic plan funded by the Study Agency has been formulated that describes the analyses of emissions, meteorology, chemistry, and model formulation to improve the model performance. Most of the funding for this overall CCOS modeling plan has been approved, and the analyses will be implemented over the next few years.