California Environmental Protection Agency

Air Resources Board

PUBLIC MEETING AGENDA

MEETING LOCATION (In-Person)

San Joaquin Valley Unified Air Pollution Control District
1990 East Gettysburg Avenue, Fresno, California 93726

or VIA VIDEO CONFERENCE (2 Locations)

District Northern Region Office
4230 Kiernan Avenue, Suite 130
Modesto, California 95356

District Southern Region Office
2700 M Street, Suite 275
Bakersfield, California 93301

This facility is accessible by public transit. For transit information, call: (559) 621-1393, website http://faxtransit@fresno.gov/
(This facility is accessible to persons with disabilities.)

TO SUBMIT WRITTEN COMMENTS ON AN AGENDA ITEM IN ADVANCE OF THE MEETING GO TO:
http://www.arb.ca.gov/lispub/comm/bclist.php

June 14, 2007
9:00 a.m.

Item #

07-6-1: Public Meeting to Discuss a Procedure for Considering Concurrence with Agricultural Burning Rules in the San Joaquin Valley

Staff will present for Board discussion a procedure for determining concurrence with San Joaquin Valley Air Pollution Control District Rule 4103 addressing prohibitions on agricultural burning pursuant to Senate bill 705 (Chapter 481, Statutes of 2003).

07-6-2: Public Meeting to Consider Approval of the San Joaquin Valley 2007 Ozone Plan

Public meeting to consider approval of the Proposed 2007 State Implementation Plan (SIP) for 8-hour ozone in the San Joaquin Valley. This new plan identifies the clean air strategies needed to bring the Valley into attainment with the federal 8-hour ozone standard by 2023.

07-6-3: Public Hearing to Consider 2007 Amendments to the Phase 3 California reformulated Gasoline Regulations

The Board will consider amendments to the California Phase 3 Reformulated Gasoline (CaRFG3) regulations to update the CaRFG3 Predictive Model to preserve benefits, add provisions to increase flexibility for refiners and producers to certify alternative formulation, modify limits to increase enforceability, and make other miscellaneous changes to increase consistency.

CLOSED SESSION – PERSONNEL MATTER

The Board will hold a closed session as authorized by Government Code section 11126(a) to consider a public employee performance evaluation.

OPPORTUNITY FOR MEMBERS OF THE BOARD TO COMMENT ON MATTERS OF INTEREST.

Board members may identify matters they would like to have noticed for consideration at future meetings and comment on topics of interest; no formal action on these topics will be taken without further notice.

OPEN SESSION TO PROVIDE AN OPPORTUNITY FOR MEMBERS OF THE PUBLIC TO ADDRESS THE BOARD ON SUBJECT MATTERS WITHIN THE JURISDICTION OF THE BOARD.

Although no formal Board action may be taken, the Board is allowing an opportunity to interested members of the public to address the Board on items of interest that are within the Board's jurisdiction, but that do not specifically appear on the agenda. Each person will be allowed a maximum of three minutes to ensure that everyone has a chance to speak.

TO SUBMIT WRITTEN COMMENTS ON AN AGENDA ITEM IN ADVANCE OF THE MEETING GO TO:
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IF YOU HAVE ANY QUESTIONS,
PLEASE CONTACT THE CLERK OF THE BOARD
1001 I Street, 23rd Floor, Sacramento, CA 95814

(916) 322-5594
FAX: (916) 322-3928
ARB Homepage: www.arb.ca.gov

To request special accommodation or language needs, please contact the following:

- **For individuals with sensory disabilities, this document is available in Braille, large print, audiocassette or computer disk. Please contact ARB's Disability Coordinator at 916-323-4916 by voice or through the California Relay Services at 711, to place your request for disability services.**

- **If you are a person with limited English and would like to request interpreter services to be available at the Board meeting, please contact ARB's Bilingual Manager at 916-323-7053.**

THE AGENDA ITEMS LISTED ABOVE MAY BE CONSIDERED IN A DIFFERENT ORDER AT THE BOARD MEETING.

SMOKING IS NOT PERMITTED AT MEETINGS OF THE CALIFORNIA AIR RESOURCES BOARD

California Environmental Protection Agency

Air Resources Board

PUBLIC MEETING AGENDA

INDEX

MEETING LOCATION (In-Person)
San Joaquin Valley Unified Air Pollution Control District
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June 14, 2007
9:00 a.m.

		Pages
07-6-1:	**Public Meeting to Discuss a Procedure for Considering Concurrence with Agricultural Burning Rules in the San Joaquin Valley**	---
07-6-2:	**Public Meeting to Consider Approval of the San Joaquin Valley 2007 Ozone Plan**	**1 - 214**
07-6-3:	**Public Hearing to Consider 2007 Amendments to the Phase 3 California reformulated Gasoline Regulations**	**215 - 352**

CALIFORNIA AIR RESOURCES BOARD

NOTICE OF PUBLIC MEETING TO CONSIDER THE APPROVAL OF THE SAN JOAQUIN VALLEY 2007 OZONE PLAN

The Air Resources Board (the Board or ARB) will conduct a public meeting at the time and place noted below to consider the approval of the San Joaquin Valley 2007 Ozone Plan and to consider updates to the transportation conformity budgets, the reasonable further progress demonstration, and the emissions inventories contained in the 2007 Ozone Plan.

DATE: June 14, 2007

TIME: 9:00 a.m.

PLACE: San Joaquin Valley Air Pollution Control District
1990 East Gettysburg Avenue
Fresno, California 93726

or Via Videoconference (2 Locations)

District Northern Region Office
4230 Kiernan Avenue, Suite 130
Modesto, California 95356

District Southern Office
2700 M Street, Suite 275
Bakersfield, California 93301

This item will be considered at a one-day meeting of the Board, which will commence at 9:00 a.m., Thursday, June 14, 2007. Please consult the agenda for the meeting, which will be available at least 10 days before June 14, 2007, to determine the schedule on which this item will be considered.

For individuals with sensory disabilities, this document is available in Braille, large print, audiocassette or computer disk. Please contact ARB's Disability Coordinator at 916-323-4916 by voice or through the California Relay Services at 711, to place your request for disability services. If you are a person with limited English and would like to request interpreter services, please contact ARB's Bilingual Manager at 916-323-7053.

Background

The federal Clean Air Act (CAA or the Act) establishes planning requirements for those areas that routinely exceed the health-based National Ambient Air Quality Standards (NAAQS). These nonattainment areas must develop and implement a State

Implementation Plan (SIP) that demonstrates how they will attain the standards by specified dates. Federal law holds each state responsible for implementing the provisions of the Act.

In July 1997, the U.S. Environmental Protection Agency (U.S. EPA) promulgated a new 8-hour NAAQS for ozone. U.S. EPA classified the San Joaquin Valley Air Basin as a "serious" nonattainment area with an attainment date of June 2013. The San Joaquin Valley Air Pollution Control District (District) developed an attainment plan with input from interested parties. In the 2007 Ozone Plan, the District's analysis showed that the local, State, and federal controls already in place will be insufficient to allow the San Joaquin Valley to attain the ozone standard by the 2013 deadline.

Consequently, the District adopted the 2007 Ozone Plan targeting a June 15, 2024 "extreme" attainment date. The 2007 Ozone Plan includes new local emission control measures, as well as the emission reductions benefits of the proposed 2007 State Strategy which the Board will consider at its meeting scheduled for June 21-22, 2007. The 2007 Ozone Plan also relies on the use of new technology, as allowed under section 182(e)(5) the federal Clean Air Act, to provide the final increment of nitrogen oxide emission reductions. The District adopted the 2007 Ozone Plan on April 30, 2007. At that time, the District also requested a reclassification to "extreme" nonattainment of the federal ozone standard.

The 2007 Ozone Plan establishes county-level on-road motor vehicle emission transportation conformity budgets for each milestone year, as well as for the attainment year. The emissions budgets in the 2007 Ozone Plan reflect the latest planning assumptions and were developed using EMFAC2007. ARB staff has updated the transportation conformity budgets to reflect revised Madera County vehicle activity data for all budget years, which were not available in time for publication in the 2007 Ozone Plan. In addition, the San Joaquin County 2008 transportation conformity budgets were updated to correct a data input error. Documentation on the proposed update is available on-line at http://www.arb.ca.gov/planning/sip/2007sip/2007sip.htm.

In addition, ARB staff is proposing to update the emissions inventory to reflect a change in the calculation of pesticide emissions provided by the California Department of Pesticide Regulation (DPR) which was not available in time for the District's plan publication and adoption. DPR staff has published a memorandum outlining revisions to the emission estimation calculations for ROG emissions from agricultural pesticide usage. These revised inventories reflect changes to the emission estimating methodology to include updated emission factors and the inclusion of an application use factor.

The Clean Air Act requires that areas such as the San Joaquin Valley demonstrate "reasonable further progress" (RFP) toward attainment of the federal ozone standard and provide for contingency measures in the event that the required level of progress is not achieved. The 2007 Ozone plan demonstrates that these requirements will be met as a result of rules and regulations already in place. ARB staff concurs. However, the

RFP demonstration included in the 2007 Ozone Plan does not include the impacts of the revised pesticide emissions, discussed previously. ARB staff has updated the RFP demonstration to include the revised pesticide emissions. ARB staff is proposing to submit this updated RFP demonstration to U.S. EPA for inclusion in California's SIP for the San Joaquin Valley.

Proposed Action

ARB staff has reviewed the 2007 Ozone Plan for the San Joaquin Valley and concluded that it meets applicable federal requirements. ARB staff has also concluded that the implementation of the 2007 Ozone Plan would reduce ozone levels throughout the San Joaquin Valley and result in attainment of the 8-hour ozone standard by June 2024. ARB staff is recommending that the Board approve the San Joaquin Valley 2007 Ozone Plan, as well as the updated transportation conformity budgets, emissions inventory, and progress demonstration, as a revision to the California SIP.

The 2007 Ozone Plan relies on emission reductions to be achieved from the proposed State Strategy for California's 2007 SIP (State Strategy). ARB is scheduled to consider the State Strategy at its June 21-22, 2007 meeting, and thus at the June 14, 2007 hearing ARB will be considering the 2007 Ozone Plan before the State Strategy has been approved. Therefore, final ARB approval of the 2007 Ozone Plan would be contingent upon ARB's subsequent adoption of commitments, as part of the State Strategy, to achieve the emission reductions from State measures that are relied on in the 2007 Ozone Plan.

ARB staff will present its recommendations to the Board at the meeting. Copies of a written Staff Report, which is expected to be available by May 24, 2007, may be obtained from the Board's Public Information Office, 1001 "I" Street, 1st Floor, Environmental Services Center, Sacramento, CA 95814, (916) 322-2990. The report may also be obtained from ARB's internet site at http://www.arb.ca.gov/planning/sip/2007sip/2007sip.htm.

Interested members of the public may also present comments orally or in writing at the meeting, and in writing or by email before the meeting. To be considered by the Board, written comments submissions not physically submitted at the meeting must be received **no later than 12:00 noon, Wednesday, June 13, 2007,** and addressed to the following:

Postal mail: Clerk of the Board, Air Resources Board
1001 I Street, Sacramento, California 95814

Electronic submittal: http://www.arb.ca.gov/lispub/comm/bclist.php

Facsimile submittal: (916) 322-3928

The Board requests, but does not require 30 copies of any written submission. Also, the ARB requests that written and email statements be filed at least 10 days prior to the meeting so that ARB staff and Board members have time to fully consider each comment. Further inquiries regarding this matter should be directed Mr. Jeff Lindberg, Air Pollution Specialist, (916) 322-2832, 1001 "I" Street, P.O. Box 2815, Sacramento, California 95812.

CALIFORNIA AIR RESOURCES BOARD

by W. Thomas Jennings

Catherine Witherspoon
Executive Officer

Date: May 15, 2007

The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, see our Website at www.arb.ca.gov.

State of California
AIR RESOURCES BOARD

Final Draft

STAFF REPORT

ANALYSIS OF THE SAN JOAQUIN VALLEY 2007 OZONE PLAN

Date of Release: 5/30/2007
Scheduled for Consideration: 6/14/2007

This report has been reviewed by the staff of the California Air Resources Board and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Air Resources Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

California Environmental Protection Agency
Air Resources Board

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ACKNOWLEDGMENT

ARB staff thanks the staff of the San Joaquin Valley Unified Air Pollution Control District for the high level of coordination between the agencies in the development of the technical elements of this plan.

Table of Contents

EXECUTIVE SUMMARY.....iii

I. BACKGROUND.....1
- A. Profile of the San Joaquin Valley
- B. Ozone Health Effects
- C. Historical Air Quality
- D. Central California Air Quality Studies

II. AIR QUALITY PLANNING.....7
- A. Air Quality Planning Background
- B. Recent Air Quality Planning Activities
- C. General Planning Requirements
- D. California Clean Air Act Plans

III. PLAN EVALUATION.....11
- A. Overview of the San Joaquin Valley 2007 Ozone Plan
- B. Emissions Inventory
- C. Air Quality Modeling
- D. Reclassification to Extreme Nonattainment
- E. Control Strategy
- F. Attainment Demonstration
- G. Reasonable Further Progress and Contingency Measures
- H. Transportation Conformity Budgets
- I. Additional Requirements for Extreme Nonattainment Areas

IV. ENVIRONMENTAL IMPACTS.....44

V. LEGAL AUTHORITY.....44

VI. STAFF RECOMMENDATIONS.....45

APPENDICES

Appendix A Emissions Inventory Output Tables

Appendix B Weight-of-Evidence Analysis – San Joaquin Valley Air Basin: Ozone

Appendix C Photochemical Modeling Protocol for Developing Strategies to Attain the Federal 8-hour Ozone Air Quality Standard in Central California

Appendix D Proposed Updates to the Transportation Conformity Budgets Identified in the San Joaquin Valley 2007 Ozone Plan

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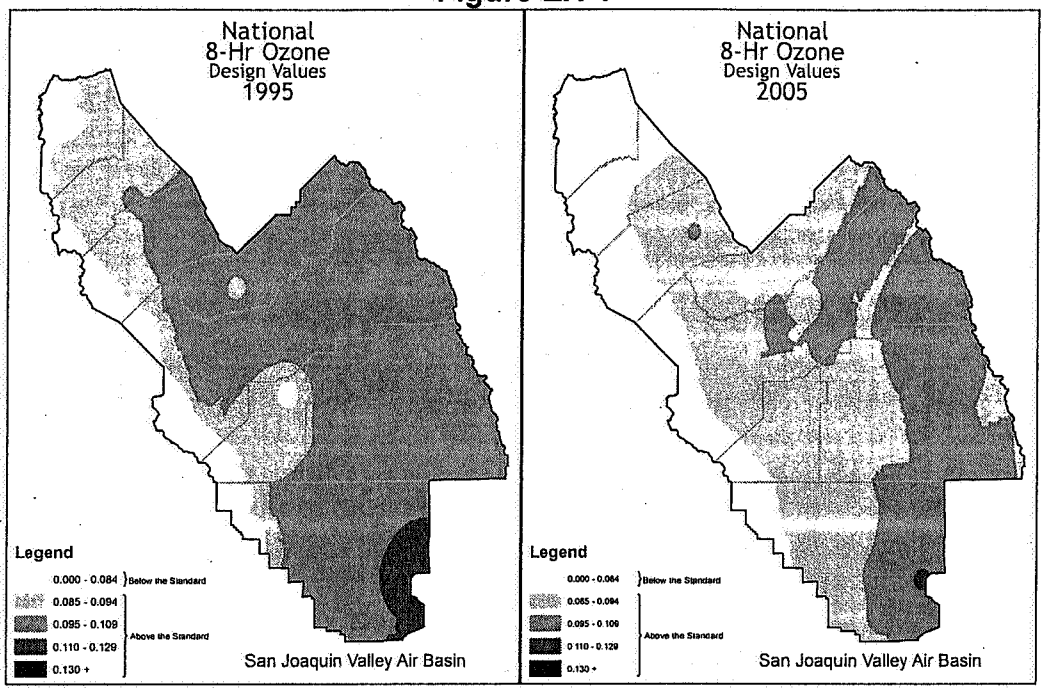
EXECUTIVE SUMMARY

On April 30, 2007, the San Joaquin Valley Unified Air Pollution Control District (District) adopted the 2007 Ozone Plan. The 2007 Ozone Plan charts the course to attainment of the federal 8-hour ozone air quality standard in the Valley. The staff of the Air Resources Board (ARB or Board) has reviewed the 2007 Ozone Plan and is recommending that the Board approve the 2007 Ozone Plan and submit it to the U.S. Environmental Protection Agency (U.S. EPA) as a State Implementation Plan (SIP) revision.

The topography of the San Joaquin Valley, combined with hot, dry summers, creates an environment very conducive to ozone formation, especially in the southern end of the Valley which most frequently experiences the highest ozone levels. This, combined with the physical environment and the emissions from cars, trucks, tractors, and industrial sources, results in some of the highest ozone levels in the nation. In 2006, Valley air quality monitors recorded 86 days over the federal 8-hour ozone standard, one day more than the South Coast Air Basin. The federal ozone standard is exceeded by 30 percent, based on the 2006 design value.

California has led the nation in reducing public exposure to harmful air pollution through the development of emission control regulations on both mobile and stationary sources. The rules and regulations in place today are already providing air quality improvement, measured by the 8-hour standard. However, progress indicators present a mixed picture. The average number of days exceeding the federal 8-hour ozone standard has declined nearly 20 percent between 1996 and 2006, yet maximum levels have been strikingly flat over the last 10 years, with the average federal 8-hour design value declining by only 3 percent. Still, although the 8-hour design value has come down slowly, the areas – and populations – experiencing the highest ozone levels have decreased in size dramatically (Figure EX-1), and Valley residents experience those elevated levels on fewer days.

Figure EX-1



Air quality modeling indicates that attainment of the ozone standard in the Valley is heavily dependent on control of nitrogen oxides (NOx) emissions, and that NOx emissions must be reduced by 75 percent from today's levels in order for the region to reach attainment of the standard. Reducing reactive organic gas (ROG) emissions will also help to reduce ozone, especially in the near-term, and will help bring many areas of the Valley into attainment of the 8-hour ozone standard more quickly. However, air quality modeling indicates that while important, ROG emission reductions do not have the same relative benefit as NOx emission reductions, especially in the areas with the worst air quality.

The U.S. EPA classifies the San Joaquin Valley as serious nonattainment for ozone, with an attainment date of June 15, 2013. To attain the standard by the 2013 deadline, the Valley would need to have all of the necessary NOx reductions in place by 2012. The majority of the emission reductions needed to bring the Valley into attainment will come from the implementation of the State's existing mobile source control program, as newer and cleaner equipment and vehicles are put in place. This will provide a 28 percent reduction in NOx and a 10 percent reduction in ROG emissions between now and 2012 in the Valley. Even with this marked improvement, the Valley will still be short of the NOx goal by 66 percent and will be 15 percent short of the ROG goal in 2012.

A "serious" classification does not reflect the true magnitude of the ozone problem in the Valley or the increased stringency of the 8-hour standard. Demonstrating attainment of the federal ozone standard by June 2013 as a

serious nonattainment area is not practical, given the scope of the problem and the need to rely on new technologies that will phase in between 2011 and 2017. The federal Clean Air Act (Act) allows, and U.S. EPA recommends, that in these cases the area be reclassified to an appropriate higher classification such as severe-15, severe-17, or extreme, with attainment dates in 2019, 2021, and 2024, respectively.

ARB and District staffs have identified additional opportunities to garner further reductions. ARB staff developed the proposed 2007 State Strategy [1] to provide significant new mobile source emission reductions in the Valley, beyond the existing control program, on a very aggressive timeline. On April 30, 2007, the District Governing Board adopted a plan which requires additional controls on stationary and area-wide sources.

Both the proposed State Strategy and adopted District plan include commitments to develop new emission control regulations and expand incentive programs as a mechanism to accelerate the conversion to newer, cleaner technologies. The local strategy includes a suite of near-term regulatory measure commitments for significant early ROG reductions which will result in near-term air quality improvement throughout the Valley.

The Valley faces a fundamental technology constraint in its effort to attain the federal ozone standard. As discussed later in this document, even if every car, truck, and piece of construction and farm equipment met the cleanest adopted emission standards, the Valley would still need more reductions. Therefore, the ARB and District staffs will need to continue to develop longer-term concepts and new technologies to provide the final increment of reductions needed for the Valley to attain the standard. Under the Act, the Valley's real-world need to rely on future technology is only allowable in SIPs for areas classified as extreme.

On April 30, 2007, the District adopted the San Joaquin Valley's 2007 Ozone Plan and voted to request that U.S. EPA reclassify the Valley to an extreme nonattainment classification. While the ultimate attainment date would be extended to 2024, full implementation of the 2007 Ozone Plan would result in most regions in the Valley attaining the standard before then. Table EX-1 demonstrates that the emission reduction commitments included in the San Joaquin Valley's 2007 Ozone Plan will result in attainment of the federal ozone standard throughout the Valley by the final attainment date. The near-term emission reduction measures approved by the District, combined with those proposed by ARB staff, will result in dramatic air quality improvement in the San Joaquin Valley. By 2023, only four sites in the Valley will need emission reductions, beyond the proposed state measures, in order to attain the federal ozone standard – and all sites will have seen marked improvement to that point.

[1] Available online at: http://www.arb.ca.gov/planning/sip/2007sip/2007sip.htm

Table EX-1
Setting and Meeting the Emission Reduction Target for Ozone Attainment
(Summer Planning tons per day)

San Joaquin Valley (2023)		
	NOx	**ROG**
2006 Emissions Inventory	650	454
Carrying Capacity	160	342
Emission Reduction Target	490	112
Emission Reductions from Existing Program	355	43
Emission Reductions from New Local Measures	9	47
Emission Reductions from New State Measures	46	25
Long-Term Concepts	80	--
Total Reductions Identified	490	115

The 2007 Ozone Plan includes long-term commitments to achieve this last increment of emission reductions necessary to meet attainment goals in the San Joaquin Valley. As the State agency charged with ensuring California's SIP compliance, ARB is ultimately responsible for ensuring the necessary measures are identified no later than 2020 (three years prior to the attainment year), and the emission reductions are achieved by 2023.

As part of the State Strategy under development, ARB staff is proposing to initiate a coordinated government, private, and public effort to establish emission goals for critical mobile and stationary emission source categories. Following the setting of emission goals, ARB would start an ongoing public process to assess technology advancement opportunities for the critical categories. ARB staff will periodically brief the Board at public meetings on emerging emission reduction opportunities, promising technologies, and the progress made in developing long-term emission reduction measures. As ARB staff identifies feasible technology-forcing emission reduction measures, staff will propose those measures to the Board for inclusion into the SIP.

The 2007 Ozone Plan, and the request for reclassification, is controversial. Many members of the environmental community believe that a reclassification to extreme represents an unacceptable delay in attainment of the federal 8-hour ozone standard. Based on the air quality modeling conducted for the San Joaquin Valley, combined with known emission control technologies which will be available, the District believes, and ARB staff concurs, that an extreme area attainment plan is the only one that realistically charts the course to clean air – which makes it the only federally approvable course of action.

While a reclassification to extreme is, in the District's and ARB staff's view, a practical and legal necessity, the District Board approved a dual path strategy for attainment. One path includes the commitments and timelines needed in a federally approvable SIP, and recognizes the constraints placed on the District by

State and federal law, policy, and guidance. The second path, which will parallel SIP implementation, includes important policy initiatives such as the use of increased, but as yet unsecured, incentive funding. Via the second path, the District is attempting to meet the standard before the 2024 extreme deadline.

ARB staff recognizes the significance of having the dual path approach in the 2007 Ozone Plan. However, only some of the included actions reflect federally enforceable commitments and quantifiable emission reductions. In this document, where the district has made an enforceable and quantifiable commitment, ARB staff has indicated such. Where the District has committed to broader-reaching, yet equally important dual-path strategies, ARB staff has indicated this as well. However, only the federally approvable elements will be transmitted to U.S. EPA for inclusion in the Valley's SIP.

While the focus of the current planning effort for the San Joaquin Valley is ozone, it is important to remember that the Valley is also classified as nonattainment for the federal PM2.5 standard. The Valley now has a nominal attainment date for the PM2.5 standard of April 2010. This attainment date may be extended from one to five years. The PM2.5 attainment plan must be submitted to U.S. EPA by April 5, 2008. Many of the control strategies needed to bring the Valley into attainment of the federal ozone standard will also provide progress towards attainment of the PM2.5 standard. Like the 8-hour ozone standard, U.S. EPA guidance requires all of the emission reductions needed to attain the PM2.5 standard to be in place by the beginning of the year prior to the attainment year, in this case 2014 if the extension is granted. The District will adopt a PM2.5 attainment plan in the first half of 2008. As part of this effort, ARB staff is working with the District to both identify emission reduction targets for attainment and to ensure the Valley comes into attainment with the fine particulate standard as expeditiously as practicable.

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I. BACKGROUND

A. Profile of the San Joaquin Valley

Covering nearly 25,000 square miles, the San Joaquin Valley (Valley) is one of the dominant features in California's landscape. The Valley is one of the fastest growing regions in California and is home to more than 3.6 million people. The Valley has four large cities, Stockton, Modesto, Fresno, and Bakersfield, with populations of greater than 200,000 people. Outside of these cities, the Valley has numerous smaller cities and towns, separated by large expanses of agricultural lands. While the Valley has large tracts of agricultural land, the Valley is very urbanized, and as more and more land is converted from agricultural to non-agricultural land uses, this urbanization will continue.

Open to the Sacramento-San Joaquin River Delta in the north, the San Joaquin Valley is surrounded by the Sierra Nevada Mountains to the east, the Pacific Coast Range to the west, and the Tehachapi Mountains to the south. Airflow patterns in the San Joaquin Valley tend to move from north to south and are dammed by the surrounding mountain ranges.

The climate and geography of the San Joaquin Valley create the optimal conditions for creating and trapping air pollution. The Valley is characterized by hot, dry summers, with normal temperatures in the nineties, and heat waves periodically exceeding 100 degrees Fahrenheit. Winters in the San Joaquin Valley are cool and damp, with frequent periods of dense fog. In both summer and winter, the major airflow patterns tend to result in long mixing times for emitted pollutants, especially in the central and southern portions of the Valley.

These stagnant weather patterns make the Valley vulnerable to forming ozone and fine particulate matter air pollution and impede the region's ability to disperse it. The ozone season in the San Joaquin Valley spans a six-month period—May through October. The Valley has ozone levels more than 30 percent above the federal standard, which make it among the most heavily impacted regions in the nation. Approximately two out of every three days in this period has an exceedance of the national ozone standard at one or more sites within the Basin—reflecting the challenge of attaining the standard throughout the Valley.

B. Ozone Health Effects

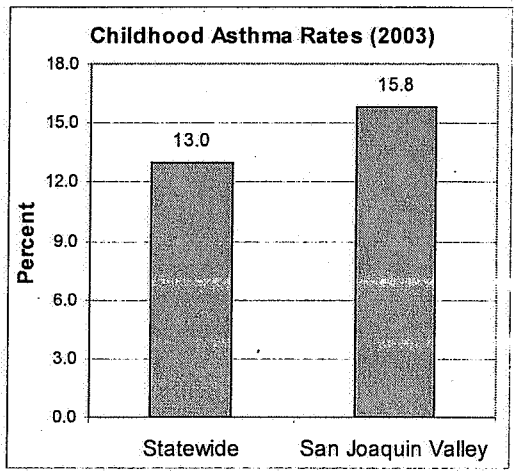
Ozone is a highly reactive gas that forms in the atmosphere through complex reactions between chemicals directly emitted from motor vehicles, industrial plants, consumer products and many other sources. It forms in greater quantities on hot, sunny, calm days, making the summer season the key exposure period.

Considerable research over the past 35 years has investigated how people respond to inhaling ozone. These studies have consistently shown that ozone can lead to inflammation and irritation of the tissues lining the human airways. This causes the muscle cells in the airways to spasm and contract, thus reducing the amount of air that can be inhaled. Symptoms and responses to ozone exposure vary widely, even when the amount inhaled and length of exposure is the same. Typical symptoms include cough, chest tightness, and increased asthma symptoms. Ozone in sufficient doses can also increase the permeability ("leakiness") of lung cells, making them more susceptible to damage from environmental toxins and infection.

Medical studies of large populations have found that ozone exposure is associated with an increase in hospital admissions and emergency room visits, particularly for persons with lung problems such as asthma and chronic obstructive pulmonary disease. Several studies have also associated ozone exposure with increased premature mortality. ARB analysis indicates that hospitalizations for respiratory related illnesses, not including premature mortality, resulting from ozone levels over the federal standard costs Valley residents on average 18 million dollars per year.

The following charts are examples of our reason for concern over the health effects of air pollution in the San Joaquin Valley (Figure 1). The rates for asthma in children and the rates for deaths from cardiovascular causes are listed for the San Joaquin Valley and compared to the State as a whole. Childhood asthma rates are from the California Health Interview Survey, 2003 data.

Figure 1



C. Historical Air Quality

The Valley is currently classified as serious nonattainment for the federal 8-hour ozone standard, and is designated as nonattainment for the federal PM2.5 standard. Unlike many other ozone nonattainment areas of the State, the ozone problem in the San Joaquin Valley is not dominated by one large urban area. Instead, it is the result of a number of moderately sized population centers, located along the main, northwest-southeast axis of the Valley.

The rules and regulations in place today were largely developed to reduce exposures to 1-hour ozone levels. The average number of days exceeding the now-revoked federal 1-hour standard dropped more than 75 percent over the past decade. Even with this progress, the 1-hour ozone design value in the San Joaquin Valley has declined by only 11 percent over that same time period (Figures 2 and 3).

Trends for 8-hour ozone levels for the San Joaquin Valley as a whole have also been strikingly flat over the last 10 years. While the average number of days exceeding the federal 8-hour ozone standard has declined nearly 20 percent between 1996 and 2006, the average federal 8-hour design value has dropped by only 3 percent.

Figure 2

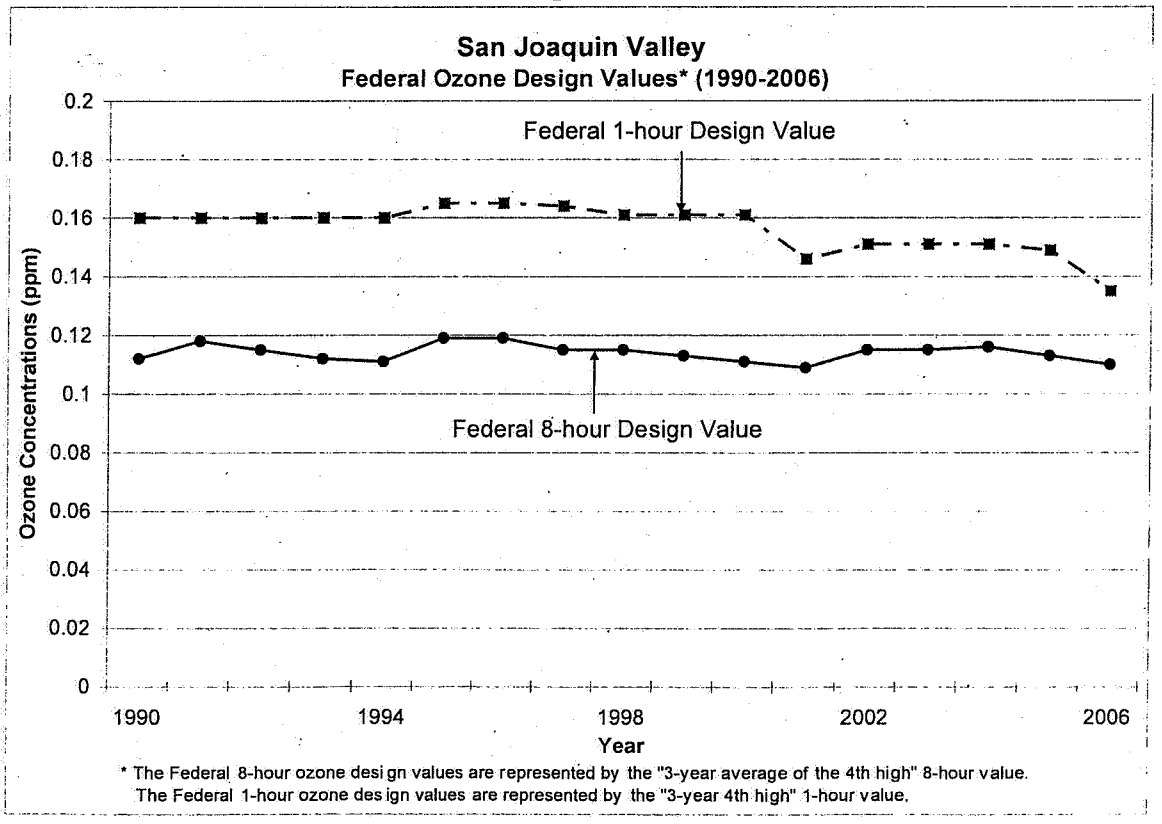
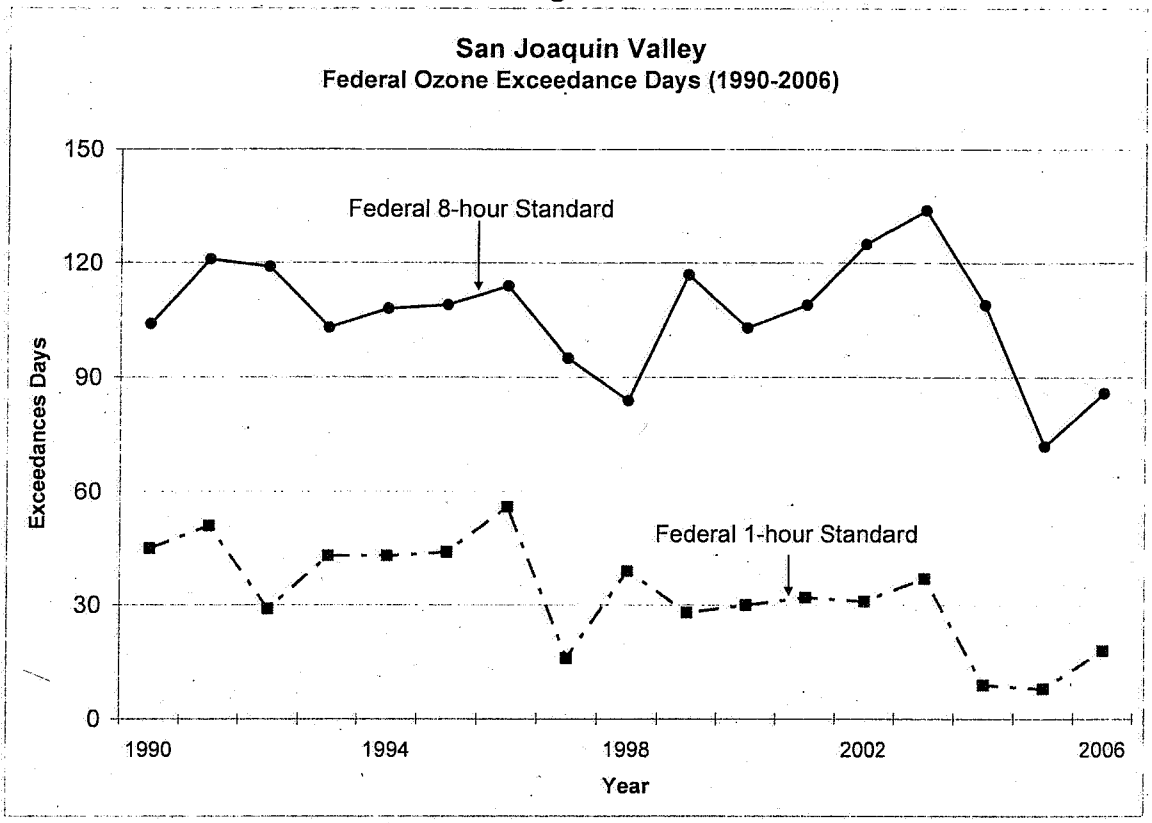


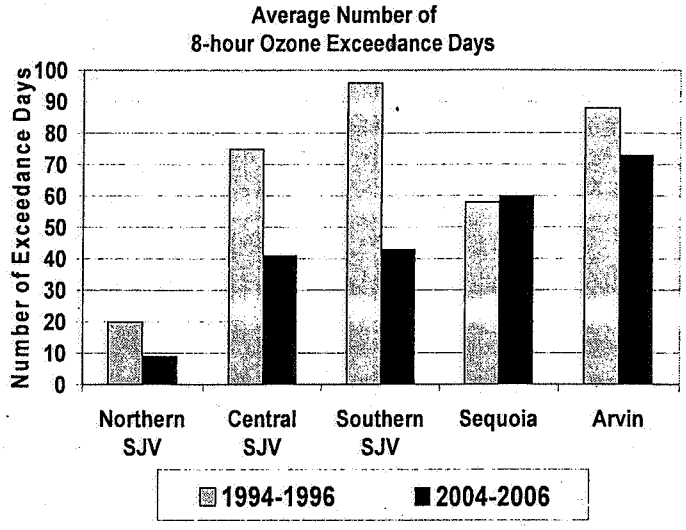
Figure 3



Because the Valley encompasses a very large geographic area, looking at sub-regions with similar geography and weather conditions helps provide a better understanding of air quality improvements and challenges. Generally, the number of days exceeding the level of the 8-hour standard is low in the northern region, but dramatically increases from the central to the southern region of the Valley. High ozone concentrations are widespread and commonly occur in the urbanized Merced, Fresno, and Bakersfield regions, and as well as in the downwind areas of Parlier, Sequoia National Park, and Arvin.

Over the past 10 years, air quality has improved throughout the Valley. On average, there were fewer days over the standard between 2004 and 2006 than between 1994 and 1996 (Figure 4), with the exception of the monitor at Sequoia and Kings Canyon National Park which shows slightly more days over the standard, on average. So, while the fourth highest ozone levels have remained relatively consistent, the number of days on which elevated levels occur has decreased.

Figure 4



Ozone exceedances in downwind areas such as Arvin and Sequoia National Park are a special concern. Arvin is a community of 15,000 people located southeast of Bakersfield at the foot of the Tehachapi Mountains. The air quality monitor located near Arvin is the site recording the San Joaquin Valley's highest 8-hour ozone levels. The 2006 design value[2], as monitored at the Arvin site, is 0.110 parts per million (ppm), over 30 percent above the level of the standard of 0.084 ppm. This compares to 17 percent above the standard in Fresno and 18 percent in Bakersfield. Generally, the number of exceedance days at Arvin surpasses any other site in the Valley with the possible exception of sites located in Sequoia National Park, downwind of the Fresno area. The air quality monitor in Arvin records an exceedance 85 percent of the time when there is an exceedance anywhere in the San Joaquin Valley.

Air quality planning in the San Joaquin Valley is further complicated because the Valley is also designated nonattainment for the federal PM2.5 standard. PM2.5 tends to be high during the wintertime. While the Valley does meet the current 24-hour PM2.5 standard of 65 ug/m3, the design value for the annual PM2.5 standard is approximately 25 percent above the standard of 15 ug/m3. Attainment of the annual standard is the most significant near-term challenge in the San Joaquin Valley. The San Joaquin Valley Unified Air Pollution Control District (District) is currently developing a PM2.5 attainment plan, which will be brought to the District Governing Board in early 2008. In addition, the Valley has a significant number of days above the new 24-hour standard of 35 ug/m3, which became effective at the end of 2006 and will be the subject of a future planning cycle.

[2] The Federal ozone design values are represented by the "3 year average of the 4th high" monitored 8-hour ozone level.

D. Central California Air Quality Studies

The Central California Air Quality Studies are comprised of two programs, the California Regional Particulate Air Quality Study (CRPAQS) and the Central California Ozone Study (CCOS). These studies are a collaborative effort between the public and private sector designed to: 1) develop an improved understanding of ozone and particulate matter in central California; and, 2) provide decision-makers with the tools needed to identify equitable and efficient control methods.

The studies are a comprehensive multi-year effort of meteorological and air quality monitoring, emission inventory development, data analysis, and air quality simulation modeling. Combined, the two studies reflect an investment of nearly 50 million dollars, coupled with extensive in-kind support from study sponsors, extending over a 15-year period. The resulting data and analytical tools are providing the most advanced scientific understanding available for State Implementation Plan development.

CCOS consists of a field program, data analysis, emission inventory development, and modeling. The CCOS field program was conducted during the summer of 2000. Emission inventory development, data analysis, and modeling are on-going projects. The entire effort is expected to be completed by 2011. ARB and the central California air pollution control districts are using the results of CCOS to prepare the ozone SIPs for nonattainment areas in central California. CCOS provides the most important scientific building blocks for the Valley's current ozone planning effort.

CRPAQS is intended to evaluate the Valley's particulate matter challenges with respect both to the national and State air quality standards for particulate matter smaller than 10 micrometers in diameter (PM10) and for particulate matter smaller than 2.5 micrometers (PM2.5). The San Joaquin Valley routinely experiences high levels of particulate matter, and currently exceeds the federal annual PM2.5 standard. CRPAQS was designed to address annual particulate levels as well as fall and winter episodic conditions. Data was collected for 14 months (December 1999 through February 2001) throughout the Valley and surrounding regions. CRPAQS will provide the scientific foundation upon which PM2.5 SIP planning efforts will be built.

II. AIR QUALITY PLANNING

A. Air Quality Planning Background

The federal Clean Air Act Amendments of 1990 (CAA or Act) establish the planning requirements for those areas that routinely exceed the health-based National Ambient Air Quality Standards (NAAQS). These nonattainment areas must adopt and implement a SIP that demonstrates how they will attain the standards by specified dates. Federal law holds each state responsible for implementing the provisions of the Act.

In the air quality management process, many regulatory authorities in California work together to reduce air pollution levels. Each of these agencies is responsible for achieving emission reductions from a part of the inventory. The State has primary regulatory authority over on-road vehicles sold and operated in California, consumer products, pesticide emissions, and certain off-road vehicles and equipment sold or operated in the State. The U.S. EPA has regulatory authority over on-road vehicles sold outside of California, large new farm and construction equipment, locomotives, ocean-going vessels, and aircraft. The regional air pollution control districts have primary authority over stationary emission sources, including industrial and commercial equipment. The regional air districts also develop locally approved air quality plans which, upon approval by the ARB and submission to U.S. EPA, become the region's SIP.

Ultimately, State law[3] designates the ARB as the State's air pollution control agency for all purposes set forth in federal law, including the preparation of the SIP. State law further specifies that the ARB must adopt the nonattainment area plan approved by a local district, unless the ARB finds, after a public hearing, that the locally adopted plan will not meet the requirements of the CAA.[4] The provisions and commitments in a U.S. EPA-approved SIP are federally enforceable. The CAA also allows interested parties to sue U.S. EPA, the State, or local agencies to compel implementation of an approved SIP and other provisions of the Act.

B. Recent Air Quality Planning Activities

Over the past decade, the San Joaquin Valley Unified Air Pollution Control District, ARB, and other State and local agencies have adopted a series of regulations and measures to improve air quality in the Valley. New mobile source standards, reformulated gasoline, and multiple consumer products regulations have been adopted and are being implemented today. And, while California continues to face serious air quality challenges, it is important to recognize the progress made as a result of California's landmark air pollution control programs.

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[3] California Health and Safety Code (HSC) section 39602.
[4] HSC Section 41650(a).

1. 2004 Extreme Ozone Plan

In October 2004, the San Joaquin Valley Unified Air Pollution Control District adopted the 2004 Extreme Ozone Attainment Plan (2004 Plan). The 2004 Plan addressed the now-revoked federal 1-hour standard. U.S. EPA never took action on the 2004 Plan. Still, the emission reduction measures identified in the 2004 Plan are being implemented and will provide significant progress towards reducing emissions of NOx and ROG, the two primary precursors to ozone formation.

2. 2006 PM10 Plan

The District has implemented a successful PM10 attainment plan which has resulted in the Valley coming into attainment of the federal PM10 standard. The San Joaquin Valley recently attained the federal PM10 standard, based upon three years of complete, quality-assured monitored air quality data for 2003-2005. The U.S. EPA concurred, and on October 30, 2006, published a finding of attainment[5] of the PM10 standard for the Valley. The 2006 data continues to support this finding.

C. General Planning Requirements

1. 8-hour Ozone Planning

In July 1997, U.S. EPA promulgated a new air quality standard for ozone that provides additional protection from the harmful health effects of this pollutant. The ozone standard was revised to protect against longer pollutant exposure periods by requiring that ozone concentrations not exceed specified levels over an 8-hour period instead of a 1-hour period. In April 2004, U.S. EPA finalized Phase 1 of the ozone implementation rule.[6] This rule set forth the classification scheme for nonattainment areas and continued obligations with respect to the existing 1-hour ozone requirements. As described by the Phase 1 rule, the San Joaquin Valley Air Basin is classified as a serious nonattainment area with an attainment date of June 15, 2013.

Ozone Standard

0.08 parts per million for 8 hours, not to be exceeded, based on the annual fourth highest concentration averaged over three years.

On December 22, 2006, after hearing arguments for and against limited aspects of the Phase 1 rule, the U.S. Court of Appeals for the District of Columbia Circuit vacated the rule, and sent it back to U.S. EPA for further proceedings. On

[5] Federal Register: October 30, 2006 (Volume 71, Number 209, pages 63641-63664)
[6] Federal Register: April 30, 2004 (Volume 69, Number 84, pages 23951-2400)

March 22, 2007, the U.S. Department of Justice petitioned the Court for a rehearing by the entire Court. While the ultimate outcome of this rule may have impacts on areas with lesser air quality problems, ARB staff expects the impacts on the San Joaquin valley will be minimal.

On November 9, 2005, U.S. EPA supplemented its Phase 1 implementation rule with a Phase 2 rule.[7] The Phase 2 rule outlines the emission controls and planning elements that nonattainment areas must address in their implementation plans, including:

- air quality modeling that demonstrates attainment of the 8-hour ozone standard;
- adopted control strategies capable of meeting attainment, and contingency measures in the event the controls fall short of achieving needed reductions;
- reasonable further progress plans;
- demonstration that all reasonably available control technology (RACT) has been applied to existing sources;
- transportation conformity emission budgets to ensure transportation plans and projects are consistent with, and will not hinder attainment;
- a weight-of-evidence analysis;

In order to demonstrate attainment of the 8-hour ozone standard by the Valley's formal attainment date, all of the emission reductions needed for attainment must be in place by the beginning of the full ozone season prior to 2024. For example, with a June 15, 2024 attainment date, the necessary emission reduction strategies must be in place by the beginning of the 2023 ozone season.

2. PM2.5 Planning

The San Joaquin Valley is also designated nonattainment for the federal fine particulate matter (PM2.5) standard. PM2.5 plans are due to U.S. EPA in April 2008. Recent air quality monitoring data shows that the San Joaquin Valley Air Basin attains the 1997 24-hour PM2.5 standard of 65 micrograms per cubic meter (ug/m3) of air. The Valley exceeds the annual standard of 15 ug/m3. However, U.S. EPA recently strengthened the 24-hour standard, lowering the acceptable levels to 35 ug/m3 over a 24-hour period.

NOx is one of the primary contributors to PM2.5 formation in the Valley. As such, the NOx reductions identified in the 2007 Ozone Plan will provide substantial progress towards attainment of the PM2.5 standard. The District and ARB staffs have begun to identify the magnitude of emission reductions needed to bring the Valley into attainment of the PM2.5 standard by 2015. To the extent that the NOx emission reductions identified in the 2007 Ozone Plan need to be supplemented, the District and ARB will explore opportunities to achieve direct PM2.5 emission reductions, particulate precursor reductions from sources such

[7] Federal Register: November 29, 2005 (Volume 70, Number 288, pages 71612-71705)

as mobile agricultural equipment, as well as additional precursor reductions through increased use of financial incentives.

D. California Clean Air Act Plans

The California Clean Air Act requires all areas that violate the State 8-hour ozone standard to achieve a 5 percent annual reduction in ozone precursors, but allows the option of adopting all feasible measures where this is not possible. Areas must demonstrate every three years that they are making steady progress towards attainment. Thus far, all districts, including the San Joaquin Valley APCD, have relied on the all feasible measures options to show progress.

Appendix E of the Valley's 2007 Ozone Plan addresses California Clean Air Act planning requirements. Appendix E will not be submitted to U.S. EPA as part of the 8-hour ozone SIP.

III. PLAN EVALUATION

A. Overview of the San Joaquin Valley 2007 Ozone Plan

The San Joaquin Valley Unified Air Pollution Control District adopted its 2007 Ozone Plan on April 30, 2007. This plan charts the course towards attainment of the federal 8-hour ozone standard in the San Joaquin Valley no later than the deadline for an extreme nonattainment area. The 2007 Ozone Plan contains a dual path strategy, one path constrained by the requirements contained in federal law and regulation on an extreme timeline, the other charting actions to beat that timeline. ARB staff supports this "beat-the-SIP" approach; however, as did the District, we recognize that California must submit a federally approvable plan, meeting all of the requirements of the Clean Air Act. The discussion below focuses on the federally approvable SIP elements, which ARB staff are proposing the Air Resources Board approve and forward to U.S. EPA.

Attaining the ozone standard in the San Joaquin Valley will require continued efforts at all levels of government. ARB staff will continue to track promising new emission reduction technologies. This will include technologies to ensure that new sources are as clean as possible and will leverage technology development to keep existing equipment operating at its intended levels. U.S. EPA will need to continue to reduce emissions from sources under its authority. In the San Joaquin Valley, this will require additional reductions from the on-road trucks registered outside of California and locomotives moving goods up and down the Valley, plus continued progress to clean up the off-road equipment under its control.

Substantial emission reductions will be achieved in the near-term through the use of programs which speed up the transition to cleaner mobile sources. However, as the adopted mobile source controls reach full implementation by 2020, new technologies will be needed to further reduce both mobile and stationary source emissions. Further, as mobile sources continue to get cleaner, stationary and area-wide sources will own a greater share of ozone forming emissions. The District has experience implementing first-of-their-kind emission control regulations. This will need to continue as cleaner industrial and commercial technology becomes available.

B. Emissions Inventory

An emissions inventory is a critical tool used to evaluate, control, and mitigate air pollution. At its core, an emission inventory is a systematic listing of the sources of air pollutants along with the amount of pollutants emitted from each source or category over a given time period. Emission inventories are *estimates* of the air pollutant emissions that are released into the environment – they are not direct ambient concentration measurements. The following are examples of key sources of air emissions:

- Stationary Sources – power plants and oil refineries;
- Area-wide Sources – consumer products and residential fuel combustion for heating homes;
- On-Road Sources – passenger vehicles and heavy-duty trucks;
- Off-Road Mobile Sources – aircraft, trains, ships, recreational boats, construction equipment and farm equipment;
- Non-anthropogenic (Natural) Sources – biogenic (or vegetation), geogenic (petroleum seeps) and wildfires

This section summarizes emissions in the San Joaquin Valley during 2006 and projects emissions for 2014, 2020, and 2023. More detailed emissions data are presented in Appendix B of the San Joaquin Valley 2007 Ozone Plan. The 2006 inventory reflects adopted District and ARB regulations through December 2006. Forecast (future year) emissions are based on adopted air regulations with both current and future compliance dates.

The San Joaquin Valley 2007 Ozone Plan uses two types of inventories: a modeling inventory used as an input to the air quality model and a summer-season planning inventory used to guide policy-makers in their efforts to identify solutions to the ozone challenge. These inventories use the same baseline assumptions and data sources. The primary difference is in how the inventories are aggregated for use. A modeling inventory reflects where and when the emissions are occurring in the region being examined. The planning inventory is aggregated by source type and industry sector, and reflects the emissions on a typical summertime day. The following discussion focuses on the planning inventory used in the San Joaquin Valley 2007 Ozone Plan.

The planning emissions inventory is divided into four major categories: stationary, area-wide, off-road mobile, and on-road mobile sources. These are the sources over which air quality regulators have influence. The summer season inventory is used for ozone because it reflects the activity levels and conditions that occur when higher ozone levels occur in the Valley.

In addition to the four major source categories, the modeling inventory includes non-anthropogenic emissions. In the San Joaquin Valley, these generally include wildfire emissions (if a fire occurred on an episode day) and emissions from vegetation. It is critical to include these emissions in the air quality modeling exercise, as they play an important role in understanding ozone formation in the Valley.

1. Summary of Emission Sources

Emission sources in the San Joaquin Valley are diverse. The San Joaquin Valley is an important transportation corridor for moving goods and people inside the State and beyond. In addition, it is one of the most productive agricultural regions in the world, as well as home to industrial and commercial activities. All

of these sources contribute to the concentrations of pollutants in the Valley. Table 1 shows the San Joaquin Valley's ozone precursor emissions split by source category.

Table 1
San Joaquin Valley Air Basin
Baseline Emission Trends
(Summer Planning tons per day)

Source Category	ROG			NOx		
	2006	2023	Change (%)	2006	2023	Change (%)
Stationary & Area-wide [a]	277	308	11%	128	113	-12%
On-Road Mobile Vehicles [b]	99	42	-58%	361	102	-72%
Off-Road Vehicles and Equipment [b]	74	59	-21%	161	80	-50%
Total [c]	450	409	-9%	650	295	-55%

a – Baseline emissions with SJV Controls Measures adopted through 2006.
b – State Measures adopted through 2006.
c – Numbers may not add up exactly due to rounding.

Mobile sources, including commercial trucks, passenger vehicles, tractors and construction equipment currently account for nearly 80 percent of the NOx emissions in the San Joaquin Valley. By 2023, the existing control program drops this to 62 percent. Of this, heavy-duty commercial trucks are the leading source, accounting for 44 percent of the total NOx emissions Valley-wide. Mobile agricultural equipment and passenger vehicles, the number two and three sources, account for about 9 percent of the total NOx emissions in the Valley. The future year emission inventory projections show reductions are expected to occur due to the on-going mobile source emission control program. Table 2 shows the top 10 sources of NOx emissions in the San Joaquin Valley.

Table 2
San Joaquin Valley Air Basin
Top 10 NOx Emission Sources*
(Summer Planning tons per day)

Source Category	2006	2015	2023
HEAVY DUTY DIESEL TRUCKS	285	141	75
FARM EQUIPMENT (COMBINES AND TRACTORS)	60	34	17
PASSENGER VEHICLES	58	28	16
Light Trucks, Minivans and SUVs	*27*	*13*	*8*
Passenger Cars	*20*	*9*	*5*
Medium Duty Trucks	*12*	*7*	*4*
MANUFACTURING AND INDUSTRIAL (BOILERS, IC ENGINES)	39	44	48
OFF-ROAD EQUIPMENT (CONSTRUCTION AND MINING)	35	20	12
OFF-ROAD EQUIPMENT (OTHER)	34	21	15
Oil Drilling and Workover Rigs	*21*	*13*	*8*
Industrial Equipment	*4*	*2*	*1*
Transport Refrigeration Units	*3*	*4*	*4*
Commercial	*3*	*2*	*1*
Cargo Handling Equipment	*1*	*1*	*1*
Airport Ground Support Equipment	*1*	*1*	*1*
Other	*3*	*2*	*1*
LOCOMOTIVES	22	21	22
AGRICULTURAL IRRIGATION PUMPS	16	5	5
OIL AND GAS PRODUCTION (COMBUSTION)	11	10	10
COGENERATION (ELECTRICITY GENERATION AND HEAT RECOVERY)	9	8	8
TOTAL OF TOP 10	**569**	**333**	**227**
TOTAL OF SJV	**650**	**398**	**295**
TOP 10 PERCENT OF TOTAL	**88%**	**84%**	**77%**

* Numbers may not add up exactly due to rounding.

Emission sources of ROG are more diverse. Of the top 10 ROG sources in the San Joaquin Valley (Table 3), only two individual categories are larger than 10 percent of the total inventory – passenger vehicles and composting currently account for 14 percent and 13 percent, respectively. All other ROG sources, including dairy cattle waste, prescribed burning, oil and gas production, and recreational boats make up less than 10 percent each when viewed individually.

When viewed at the larger level, stationary and area-wide emission sources account for more than 60 percent of the total ROG emissions. On-road mobile sources make up one-quarter of the ROG emissions. The balance is made up of off-road mobile sources such as construction and farming equipment. In the future, mobile source ROG emissions are expected to decline, as more of the vehicles and equipment in operation meet the most stringent emission standards required. ROG emissions from stationary and area-wide sources are expected to grow in the future, as economic growth outpaces the benefits of the current generation of emission control equipment. ROG emissions from waste disposal

and composting alone are expected to increase by more than 20 tons per day between now and 2023. The 2007 Ozone Plan sets out commitments to reduce composting emissions.[8]

Table 3
San Joaquin Valley Air Basin
Top 10 ROG Emission Sources*
(Summer Planning tons per day)

Source Category	2006	2015	2023
PASSENGER VEHICLES	62	35	24
Passenger Cars	*29*	*13*	*8*
Light Trucks, Minivans and SUVs	*26*	*16*	*11*
Medium Duty Trucks	*8*	*6*	*5*
OTHER (WASTE DISPOSAL/COMPOSTING)	57	71	80
LIVESTOCK WASTE (DAIRY CATTLE)	40	33	41
OIL AND GAS PRODUCTION (EVAPORATIVE LOSSES/FLARING)	28	25	23
CONSUMER PRODUCTS	24	26	30
HEAVY DUTY DIESEL TRUCKS	20	12	8
RECREATIONAL BOATS	20	17	17
Pleasure Boats	*16*	*14*	*14*
Personal Water Craft	*4*	*3*	*3*
PESTICIDES	18	18	18
FOOD AND AGRICULTURE (CROP PROCESSING AND WINERIES)	13	12	13
ARCHITECTURAL COATINGS (PAINTS AND THINNERS)	11	12	13
TOTAL OF TOP 10	**294**	**262**	**268**
TOTAL OF SJV	**450**	**402**	**409**
TOP 10 PERCENT OF TOTAL	**65%**	**65%**	**66%**

* Numbers may not add up exactly due to rounding.

2. Estimating Emissions

As mentioned previously, emission inventories are estimates of the pollutant emissions that are actually released into the environment. California uses computer models to estimate the emissions from on- and off-road mobile sources. Stationary source emissions data is derived directly from District permitting activities. Area-wide emissions are estimated based on emission factors and information on expected activity from these diverse sources and undergo routine reevaluation to ensure that they remain up to date and accurate.

All emission estimates take into account expected growth in activity, state-of-the-science emission data, and currently adopted emission control rules and regulations. The growth assumptions used to estimate future emissions are

[8] On March 15, 2007, the San Joaquin Valley Unified Air Pollution Control District adopted Rule 4565 - Biosolids, Animal Manure, And Poultry Litter Operations, satisfying the commitment to address emissions from this source (see New Local Measures Discussion, below).

critical elements in any attainment demonstration plan -- they directly impact the amount of emission reductions needed to reach the emissions target.

Stationary source emissions are derived from District permit data. Area-wide and off-road source emissions are estimated jointly by ARB, the District, and in the case of pesticide usage, by the California Department of Pesticide Regulation (DPR). Emission reductions from both ARB and District regulations adopted by December 2006 are included in the emission forecasts.

The mobile source emission inventories used in the 2007 Ozone Plan represent many improvements in the models that are used to estimate emissions from both on-road and off-road sources. Using the new models, our estimates of the emissions generated by mobile sources have increased relative to those used in earlier SIPs. These higher estimates do not indicate that actual in-the-air emissions are increasing – on the contrary, actual emissions from cars and trucks have declined and will continue to decline rapidly over time. This progress comes because of State and federal requirements for cleaner engines and fuels, and despite significant growth in population and vehicle usage.

Ozone-related emissions in the Valley are generally consistent with the overall downward trend statewide. Although motor vehicle miles traveled in the basin continue to increase, on-road vehicle emissions are dropping because of more stringent vehicle emission standards and fleet turnover. This trend will be strengthened between 2000 and 2020 as newer, lower-emitting vehicles become a larger percentage of the fleet. Likewise, as new engines and equipment replace older, more polluting models, emissions will decline more steeply. The issue before us is not whether, but how quickly emissions from the mobile source fleet can be reduced.

(a) EMFAC2007

EMFAC2007, California's updated on-road motor vehicle emission factor model, was used to generate the on-road mobile source emission inventory for the 2007 Ozone Plan. EMFAC2007 represents a comprehensive review and revision of the on-road inventory when compared to EMFAC2002, which was used in previous San Joaquin Valley plans. The major changes reflected in EMFAC2007 include updated information on emissions from heavy-duty diesel in-use engines, smog check testing, corrections to estimated fuel emissions, and more accurate vehicle population numbers. Transportation activity data was provided by the eight Valley Councils of Government (COGs) from their Regional Transportation Plans.

(b) OFFROAD2007

The 2007 Ozone Plan reflects improved estimates of engines and equipment population, usage, emission rates, and equipment deterioration for most

categories of off-road mobile sources. The inventory also includes revised estimates of evaporative emissions. The extensively revised ship and train emission inventories that were developed for ARB's Goods Movement Emission Reduction Plan have also been incorporated into the OFFROAD2007 model.

(c) Updated Pesticide Emission Estimates

The DPR has provided updated emission estimates for pesticide use in the San Joaquin Valley. On April 4, 2007, DPR staff published a memorandum [9] outlining revisions to the emission estimation calculations for ROG emissions from agricultural pesticide usage. These revised inventories reflect changes to the emission estimating methodology to include updated emission factors and the inclusion of an application use factor.

The proposed pesticide emission reduction measures under development by DPR staff are calculated using the updated emission estimates. Table 4 summarizes the estimated pesticide emissions calculated with the revised estimation methodology.

Table 4
Revised Pesticide Emissions

Source Category	2005	2006	2008	2011	2014	2017	2020	2023
Agricultural and Commercial Structural Pesticides Emissions [a]	~~22.9~~	–	~~22.2~~	~~21.7~~	~~21.4~~	~~21.2~~	~~21.0~~	~~20.9~~
Agricultural and Commercial Structural Pesticides Emissions [b]	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9

a. – As identified in Appendix B to the San Joaquin Valley 2007 Ozone Plan.
b. – As updated by the California Department of Pesticide Regulation and included in Appendix A to this report.

(d) Emission Reduction Credits

New Source Review (NSR) rules require new and modified major stationary sources that increase emissions in amounts exceeding specified thresholds to provide emission reduction offsets to mitigate the emissions growths. Emission reduction offsets represent either on-site emission reductions or the use of banked emission reduction credits (ERCs). ERCs are voluntary, surplus emission reductions, which are registered, or banked, with the District for future use as offsets.

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[9] California Department of Pesticide Regulation Memorandum. Date: April 6, 2007. Subject: Pesticide Volatile Organic Compound Emission Adjustments for Field Conditions and Estimated Volatile Organic Compound Reductions–Initial Estimates. Available online at: http://www.cdpr.ca.gov/docs/dprdocs/methbrom/comp_modeling.htm

According to U.S. EPA policy, ERCs banked before a plan's emission inventory baseyear (2002 for this plan) must be explicitly treated as emissions in the air. This plan does this by including projected ERC use in the emission inventory growth factors for stationary sources. This plan's projection for ERC use and total growth in stationary source emissions, between 2002 and 2023, is shown in Table 5.

Table 5
San Joaquin Valley
Projected ERC Use and Total Stationary Source Growth 2002-2023
(Summer Planning tons per day)

Pollutant	Expected ERC Use	Expected Growth
NOx	20.5	20.8
ROG	36.1	37.6

Projected ERC use is roughly equal to total growth expected for each pollutant. The District does take a conservative approach in estimating ERC usage, by assuming that all ERCs used will be from pre-baseyear ERCs. The District will need to very closely monitor pre-baseyear ERC usage and stationary source growth, especially in non-permitted source growth and permitted sources for which growth offsets are not required, to ensure that the sum of the two does not exceed total permitted and non-permitted growth. If all of the ERCs used are pre-baseyear ERCs, there will be extremely little margin (0.3 tpd NOx between 2002 and 2023) for non-permitted stationary source growth or growth at permitted sources which do not require offsets.

ARB staff recommends that the District consider setting the pre-baseyear ERC usage caps, as discussed in Appendix D of the 2007 Ozone Plan, at not more than 75 percent of expected stationary source growth, in order to ensure that there is adequate room for growth in non-permitted sources. This is consistent with the caps on pre-baseyear ERC usage in the 2004 1-hour Ozone SIP for the San Joaquin Valley.

3. Future Improvements to the Emissions Inventory

(a) Off-road Mobile Agricultural Equipment

As illustrated later in this document, ARB staff has not quantified the benefits of an off-road mobile agricultural equipment emission reduction measure. ARB staff plans to develop this emission reduction measure as part of the proposed State Strategy. Off-road mobile agricultural equipment currently accounts for 60 tons per day of NOx emissions in the Valley. As older equipment turns over, these emissions are expected to decline to 34 tpd by 2015. Part of the measure development effort will involve ARB staff acquiring a better understanding of the activity and population profile of off-road mobile agricultural equipment use in the

Valley, including where, when, and how this equipment operates. This understanding will improve the emissions inventory estimates and serve as the basis for a new emission reductions measure to be developed.

(b) Non-point Source Industrial Natural Gas Combustion

ARB staff recommends that the District explore opportunities to refine the emissions inventory for non-point source industrial natural gas combustion. In November 2006, District staff revised the emission estimation methodology [10] for this category. District staff estimates that combustion of natural gas in non-point source industrial heaters, boilers, and burners resulted in NOx emissions of more than 32 tpd in 2006, based on the California Energy Commission estimation of industrial natural gas usage in the Valley. Emissions from this category are expected to increase to more than 40 tpd NOx by 2023. Some of this equipment may be subject to existing district rules. If so, the benefits of these rules might not be reflected in the current emissions inventory estimation.

4. Model Emission Inventory

Modeling emission inputs are commonly known as "gridded inventories" or "modeling inventories." Even though the basic source of emissions data for planning and modeling purposes are the same, there are a variety of things that cause differences between emission estimates used for planning and modeling.

Where air quality planning strategies are generally developed using seasonal emission estimates for air quality planning or political boundary regions, air quality models require hourly estimates of emissions for each grid cell in a modeling domain. In addition, because base year model simulations are required to meet specific performance criteria in the base year, the base year modeling inventory estimates must also be most representative of the actual emissions that occurred during the days and hours that are being simulated. The need for greater spatial and temporal resolution involves taking into consideration, for example, temperature effects on evaporative or biogenic emissions and emission upsets that might have occurred at large sources.

During the July 30-August 2, 2000 base case, a large wildfire produced ozone precursors that affected air quality in the San Joaquin Valley. Wildfire emissions were only included in the modeling of the base case. Because there is no method to predict where, when and how large future wildfires will occur, wildfire emissions were not included in the base year (2002) and future year model projections.

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[10] See Emissions Inventory Methodology – 050 – Industrial Natural Gas Combustion, available online at:
http://www.valleyair.org/Air_Quality_Plans/EmissionsMethods/MethodForms/Mthd_IndustrialNGCombustion_SJV_2005.pdf

C. Air Quality Modeling

The Act requires the use of air quality modeling to relate ozone levels to emissions and meteorology in a region, and to simulate future air quality based on changes in emissions. Air quality modeling uses day-specific emission inventories, combined with meteorological and air quality measurements, to establish this relationship. The air quality modeling conducted for the Valley, as approved in the 2007 Ozone Plan, provides ROG to NOx carrying capacity diagrams which can be used to determine the relative efficacy of both ROG and NOx reductions. Rather than using air quality model predicted ozone concentrations results directly, U.S. EPA Guidance calls for using models to develop relative reduction factors (RRF). The RRF is calculated as the ratio of future-year to reference-year model-simulated concentrations at a specific location (i.e. based on estimates of forecasted, future year emissions and base-year emissions). The reference year for RRF calculations is 2002. The impact that future-year emission changes might have on reference-year pollutant design values is assumed to be proportional to the effect that the associated emission inputs used for modeling have on model-simulated concentrations. This is one of the reasons why multiple days are used in the calculation of RRFs, since the reference year design value is not day-specific. Thus, to estimate a future-year design value at a site, the 2002 reference-year, site-specific design value is multiplied by the RRF that is derived from modeling.

ARB staff conducted the modeling used in support of the San Joaquin Valley 2007 Ozone Plan with input from the Valley Air District, other northern California air districts, and the academic community. In particular, ARB staff drew heavily on the input and involvement of the CCOS Technical Committee, the Bay Area Modeling Advisory Committee, and the SIP Gridded Inventory Coordination Group. More information on the air quality modeling conducted by ARB staff can be found in Appendix C to this report, in Appendix F of the San Joaquin Valley 2007 Ozone Plan, and on-line at:

http://www.arb.ca.gov/eos/SIP_Modeling/

1. Ozone Episode

A key air quality modeling decision is the selection of a modeling episode. The modeling episode is an actual time period(s), or base-case, where extensive information on emissions, meteorological conditions, and air quality data have been studied and which are representative of exceedance conditions.

Two modeling episodes were selected for use in the San Joaquin Valley 2007 Ozone Plan: July 29-August 2, 2000 and July 9-13, 1999. Another episode in September 2000 was considered, but to date, model performance has been poor and consequently this episode has not been used. Episodes in 2000 were partially chosen because they fall within the intensive CCOS monitoring period

where a comprehensive data set to use in modeling is available. The 1999 episode was chosen because the Bay Area and Sacramento Metropolitan Air Quality Management Districts believed ozone levels during that episode were representative of their concentrations. In addition to selecting the model, the CCOS Technical Committee and Northern California SIP/Transport working group considered and approved these episodes.

For both the 1999 and 2000 episodes, the model-simulated ozone levels were near design values at key air monitoring sites. In general, modeling of these episodes met performance standards, but some concentrations were under-predicted at sites in the Valley. During the July – August 2000 episode, meteorology was generally representative of ozone exceedance days. A comparison of this episode to historical cases indicates that some days of the episode were extreme meteorological and pollutant events. For July 1999, statistical analyses also showed that meteorology was especially conducive to forming ozone. According to U.S. EPA guidance, these pollutant and meteorological characteristics make them good candidates for modeling. For these episodes, typical meteorological features that have been seen in the past, such as, slope, eddy, and marine flows were evident. The episodes did represent the transport and dispersion that have been observed historically in Central California. Additional detail on the episode selection can be found in Chapter three of the Valley's 2007 Ozone Plan.

2. Air Quality Model

The U.S. EPA-accepted "Comprehensive Air Quality Model with Extensions" (CAMx) modeling system was chosen to estimate the amount of emissions reductions needed to achieve the 8-hour ozone standard. A meteorological model, the Mesoscale Model version 5 (MM5), was used to generate the meteorological fields for the CAMx model. Modelers chose the [California] Statewide Air Pollution Research Center (SAPRC) chemical mechanism for the final run, which is slower computationally than other mechanisms but treats the chemical production of ozone in more detail. The choice of the modeling system was a consensus among the modelers and stakeholders in Central California. Discussion of these choices in models occurred through the Central California Ozone Study.

3. Model Performance

Appendix F of the 2007 Ozone Plan describes the modeling conducted by ARB staff and includes a detailed model performance analysis. The model performance analysis documentation provided to the District by ARB staff summarizes model performance procedures and results for meteorological modeling, as well as air quality modeling for the July 1999 and July-August, 2000, episodes. The model performance evaluations are based on U.S. EPA guidance, as well as recommendations from published academic

literature. The model performance documentation also provides a summary of the performance analysis and provides a tabular listing of complete graphical and statistical results, which can downloaded via file transfer protocol at:

ftp://eos.arb.ca.gov/pub/outgoing/model_protocol2

4. Weight-of-Evidence

ARB staff conducted the weight-of-evidence (WOE) analysis the District staff relied upon. Appendix F of the San Joaquin Valley 2007 Ozone Plan includes ARB staff's initial draft of the WOE analysis. Appendix B of this staff report updates this analysis and summarizes the analyses that comprise the WOE assessment for the San Joaquin Valley nonattainment area.

5. Attainment Emissions Target

Air quality modeling helps to establish the attainment emission target, a key piece of information that policy-makers need in order to assess the magnitude of the challenge and to develop appropriate solutions. The Valley's 2007 Ozone Plan uses modeling for future year 2020 to establish the carrying capacity. The 2020 modeling indicates that ozone levels in the San Joaquin Valley are much more constrained by the availability of NOx, especially in the southern region. The air quality modeling indicates that NOx emissions must be reduced by 75 percent from current levels. Similarly, ROG emissions must be reduced nearly 25 percent. Greater ROG reductions would not substantially change the NOx reductions needed. For example, increasing the ROG reductions by an additional 50 percent would only decrease the NOx reductions needed by 5 percent. While not the critical ozone precursor in the most heavily impacted downwind sites, early ROG reductions will result in significant improvement in air quality throughout the Valley. ARB modelers took background ozone levels into consideration when establishing the attainment target. Table 6 shows the current emission levels, the attainment emission target used in the 2007 Ozone Plan, and the emission reductions which need to be achieved in order to attain the federal ozone standard.

Carrying capacities for ozone reflect absolute ROG and NOx emissions in a given area and are largely independent of the year in which they occur, with two notable exceptions: ROG reactivity and spatial changes in emissions. The reactivity profiles for ROG species (i.e. the relative contribution of high vs. low reactivity ROG species) varies as new controls are implemented and older emission sources, primarily motor vehicles, are removed from service. However, reactivity and spatial changes tend to occur over a long time periods, so when the modeled years are close together chronologically, the impact of these changes is minimal. With that exception, carrying capacities can generally be viewed as independent of the year in which the absolute emission levels are achieved.

Table 6
Setting the Ozone Emission Reduction Target
(Summer Planning tons per day)

	San Joaquin Valley (2023)	
	NOx	**ROG**
2006 Emissions Inventory	650	450
Carrying Capacity	160	342
Emission Reduction Target	490	108

(2006 Emissions Inventory) – (Carrying Capacity) = (Emission Reduction Target)

2006 Emissions Inventory = Amount of ozone-forming emissions.
Carrying Capacity = Pollutant emissions limit that ensures air quality standards are met.
Emission Reduction Target = Amount of emissions that must be reduced to meet the standard.

D. Reclassification to Extreme Nonattainment

The control strategy discussed below reflects an extreme non-attainment area SIP. Because the magnitude of the air quality challenge in the San Joaquin Valley, and the limits on existing emission control technologies, the San Joaquin Valley Unified Air Pollution Control District is left with only one federally approvable option: to request reclassification to extreme nonattainment. The ARB is the primary regulatory authority for the majority of the NOx emissions in the Valley. As such, a reclassification to extreme is largely driven by the timing and magnitude of mobile source emission reductions which can be achieved.

While ARB staff's proposed State Strategy is very aggressive, it does not provide all the NOx emission reductions needed for attainment in the Valley. ARB staff therefore performed a broad brush analysis to see whether the shortfall could be covered by assuming complete replacement of mobile source fleets with the cleanest new technology standards phasing in from 2007-2017. Cost was not a constraining factor in this analysis. ARB staff considered the constraints of legal authority, since SIP measures addressing sources not under our authority to control cannot be approved.

In our analysis, shown in Table 7, we made the following assumptions: in 2020 the Valley would have no passenger vehicles older than 10 years; all diesel trucks would meet the extremely stringent 2010 standards; and all diesel construction and farm equipment would meet the most stringent Tier 4 standards.

Table 7
All New Fleets Analysis Unconstrained by Cost
(Summer Planning tons per day)

Source	Remaining NOx 2020 Emissions (tpd) [a]
Passenger vehicles	*5*
Diesel trucks	*43*
Construction and other equipment	*5*
Farm equipment	*7*
Locomotive	*5*
Ships and harbor craft	1
Aircraft	5
Stationary/area-wide sources	103
Subtotal of remaining emissions from above categories	173
All other NOx sources	22
Total of all remaining emissions	195
Carrying capacity	160

a. – Includes the emission reduction benefits of the 2007 Ozone Plan, as approved by the San Joaquin Valley Unified Air Pollution Control District on April 30, 2007.

In the above table, the top four rows are italicized to indicate the categories for which we assume that all vehicles and equipment meets the cleanest adopted emission standards. Because the ARB does not have emission standard setting authority for aircraft, stationary sources or area-wide NOx sources, the emissions reported above for those categories come directly from the standard emission inventory for 2020. Included in the category "all other NOx sources" are commercial gas trucks, motorcycles, buses, motor homes, ships and commercial boats, off-road recreational vehicles and gas powered off-road equipment.

The result of the all-new-fleet scenario was a NOx emission level of 195 tons per day compared, to a carrying capacity of 160 tons per day. Close to half of the remaining emissions, 103 tons per day, are from stationary and area-wide sources. Based on these types of analyses, long-term concepts that include new technologies for both mobile and stationary sources will be needed. This makes reclassification to extreme necessary in ARB staff's view.

Lacking all of the emission reductions needed by 2020 to close the gap for attainment in 2021, the San Joaquin Valley is left with only one realistic option: to request that U.S. EPA reclassify the San Joaquin Valley nonattainment area to an extreme classification. While an extreme classification has impacts on industrial growth, it also allows the San Joaquin Valley to take advantage of the full suite of tools allowed by the Act, including the use of new emission control techniques which are expected to develop in the future. The impacts of reclassification are borne locally, so the decision to be reclassified is one which

should properly be made by the local air quality agency. The District Governing Board resolution adopting the 2007 Ozone Plan includes a request for U.S. EPA to reclassify the Valley to extreme nonattainment.

E. Control Strategy

Many actions already taken by the District, ARB, and U.S. EPA have reduced emissions in the San Joaquin Valley. These actions include the adoption of controls on stationary sources as well as reductions in tailpipe emissions from motor vehicles and off-road equipment.

California's on-going mobile source control program will provide the majority of the NOx emission reductions needed to bring the Valley into attainment of the federal ozone standard. By 2023, ozone precursor emissions from on-road motor vehicles are expected to decline by nearly 70 percent, while off-road vehicles and equipment emissions will decline by more than 40 percent. Emissions from stationary and area sources are projected to increase slightly, 5 and 3 percent, respectively.

The existing mobile source emission control program does not provide all of the necessary emission reductions needed to meet the deadlines established by U.S. EPA. ARB and District staffs have identified aggressive new emission control strategies which will result in marked improvement of air quality. These strategies focus on cleaning up the existing mobile source fleet, through regulatory actions and financial mechanisms. While the majority of the NOx emission reductions will come from mobile sources, the 2007 Ozone Plan also includes an aggressive suite of near-term ROG reduction measures. Combined, the near-term strategies would provide significant additional emission reductions benefits. Table 8 illustrates the emission reductions which would be achieved through implementation of the 2007 Ozone Plan.

Table 8
NOx Emission Inventory with the Benefits of the San Joaquin Valley 2007 Ozone Plan
(Summer Planning tons per day)

	2006	2023 (with Proposed Near-term Measures)	Percent Reduction
On-road Mobile	361	79	78%
Off-road Mobile	161	58	64%
Stationary and Area-wide	128	104	19%
TOTAL	650	240	63%

ARB staff believes that the combined control strategy provides enforceable measures and commitments that meet the applicable requirements for approval.

1. New Local Measures

(a) Rule Development Commitment

The San Joaquin Valley Unified Air Pollution Control District's approved 2007 Ozone Plan contains a suite of commitments to develop rules to control ROG and NOx emissions for implementation by 2012. The six NOx control rules will reduce emissions by six tons per day in the 2012 ozone season and 8.2 tons per day by 2023. The 14 ROG emissions control rules will achieve reductions of 26.5 tons per day and 46 tons per day by 2023.

Table 9 lists the District's emission reduction measure commitments, the emission benefits of these measures at each milestone year, and the rule adoption timelines as identified in Chapter Six of the District's Plan.

Table 9
Summary of the Near-term Rule Development Commitments* in the 2007 Ozone Plan
(Summer Planning tons per day)

CM#	Measure Name	Product	Completion Date	Compliance Date	Reduction Start	Projected NOx Reductions by 20__ Year							Projected VOC Reductions by 20__ Year						
						08	11	12	14	17	20	23	08	11	12	14	17	20	23
S-GOV-1	Composting Biosolids	Rule	2007 1Q	2008	2008								2	3.4	3.4	3.9	4.0	4.1	4.1
S-AGR-1	Open Burn	Rule	2007 2Q 2010 2Q	2007 2010	2007 2010	1.1	2.4	2.4	2.4	3.5	3.5	3.4	1.3	2.8	2.8	2.8	2.8	2.8	2.7
S-SOL-11	Solvents	Rule	2007 3Q	2010	2010								0.0	1.3	1.32	1.39	1.46	1.53	1.62
S-COM-5	Gas Turbines	Rule	2007 3Q	2010	2010	0.0	0.6	0.6	0.61	0.64	0.66	0.68							
S-IND-24	Soil Decontamination	Rule	2007 3Q	2008	NA								0.0	0.0	0.0	0.0	0.0	0.0	0.0
S-IND-6	Polystyrene Foam	Rule	2007 3Q	2010	2011								0.0	0.0	0.10	0.10	0.11	0.12	0.35
S-PET-1&2	Gasoline Storage & Transfer	Rule	2007 4Q	2009	2009								0.0	0.9	0.92	0.99	1.03	1.07	1.08
S-PET-3	Aviation Fuel Storage	Rule	2007 4Q	2010	2010								0.0	0.05	0.05	0.05	0.05	0.05	0.05
S-COM-1	Large Boilers	Rule	2008 3Q	2011	2011	0.0	0.0	0.69	0.72	0.75	0.77	0.8							
S-COM-2	Medium Boilers	Incentives Rule Backstop	2008 3Q	2020	2012 from incentives	0.0	0.0	0.51	0.51	0.51	0.51	0.51							
S-COM-7	Glass Melting	Rule	2008 3Q	Varies	2008	1.2	1.2	1.6	1.7	1.8	1.9	2.0							
S-SOL-20	Graphic Arts	Rule	2008 4Q	2011	2011								0.0	0.0	0.07	0.07	0.08	0.08	0.08
S-COM-9	Residential Water Heaters	Rule	2009 1Q	Attrition	2011	0.0	0.2	0.25	0.40	0.55	0.70	0.85							
S-GOV-5	Composting Green Waste	Rule	2009 1Q	2012	2012								0.0	0.0	9	10	10	11	11
S-IND-21	Flares	Rule	2009 2Q	NA	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S-IND-14	Brandy & Wine Aging	Rule	2009 3Q	NA	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S-SOL-1	Architectural Coatings	Rule	2009 4Q	2012	2012								0.0	0.0	2	2.1	2.1	2.2	2.3
S-AGR-2	CAFO	Rule	2010 2Q	2011	2011								0.0	6.8	6.7	18.9	20.4	21.5	22.9
S-SOL-6	Adhesives	Rule	2010 3Q	2012	2012								0.0	0.0	0.11	0.17	0.12	0.13	0.15
					Total Projected NOx Reductions by 20__ Year								Total Projected VOC Reductions by 20__ Year						
						08	11	12	14	17	20	23	08	11	12	14	17	20	23
						2.3	4.4	6.0	6.3	7.8	8.0	8.2	3.3	15.3	26.5	40.5	42.2	44.5	46.3

NA (Not Available)

* For the purposes of implementing the 2007 Ozone Plan, the District is committed to adopt and implement control measures that will achieve, in aggregate, the emission reductions specified in Table 9.

47

(b) Innovative Strategies

In addition to traditional rules, the Valley Plan includes several strategies which could result in additional NOx and ROG reductions. These strategies include development of programs which will promote air quality friendly behavioral changes, including commitments to develop a green contracting "model ordinance," to expand the Spare-the-Air efforts, to develop a heat-island mitigation model ordinance, and to promote alternative energy and energy efficiency within the Valley. The District will also explore ways to achieve even greater emission reductions from land development activities.

The Valley Plan includes a commitment to explore the expanded use of episodic emission control programs as a mechanism to reduce ozone levels on days when air quality is expected to be poor. Episodic controls utilize real-time meteorological and air quality data to forecast air quality on the following day. An example of an episodic control program is the District's Rule 4901 "Wood Burning Fireplaces and Wood Burning Heaters." This "check before you burn" program moves a step beyond informational "don't light tonight" programs by prohibiting the use of wood-burning residential fireplaces when particulate matter levels are expected to be elevated. Episodic and regionally-focused controls will be considered as a part of each rule rulemaking exercise. The Valley Plan does not include quantified emission reduction commitment for these types of controls at this time.

The Valley Plan also includes a commitment to consider amending other prohibitory rules to require facilities which are already subject to controls to achieve even greater emission reductions through the Advanced Emission Reduction Options (AERO) program. The AERO program would set emission reduction goals for stationary sources which are based on advanced technologies.

The AERO program will be implemented through individual rulemaking efforts, at which time the appropriate level of advanced control goal would be determined. The AERO program is primarily a compliance flexibility tool, which will provide stationary source operators with flexibility to achieve additional emission reductions in a manner that fits into their individual business plan. The 2007 Ozone Plan does not take credit for the benefits of AERO provisions as part of the attainment demonstration.

The emission reduction goals would be met through several possible options: application of the advanced controls upon which the regulation is based, achieving on- or off-site emission reductions by controlling other emission sources (such as replacing on-site forklifts), or through the payment of a fee to the District's Community Clean Air Fund (CCAF). Funds placed into the CCAF

would support emission reductions achieved through the District's incentive programs.

Finally, the 2007 Ozone Plan includes a commitment to achieve emission reductions through the adoption of a mandatory employer-based trip reduction program. This program will require employers with 100 or more employees to establish a ride sharing program which will reduce NOx and ROG emissions. The rule would discourage single occupant vehicle commutes, by making ridesharing or other mass transit options more appealing. Table 10 lists the emission benefits the District is committing to achieve from the employer based trip reduction program.

Table 10
Mandatory Employer-based Trip Reduction Program
Estimated Emission Reductions (tpd)

	2008	2011	2012	2014	2017	2020	2023
NOx	0.0	0.23	0.24	0.25	0.26	0.27	0.28
ROG	0.0	0.61	0.62	0.64	0.65	0.66	0.68

(c) Incentive Programs – Secured Funding

The District proposal differentiates incentive-based emission reductions into two types: those for which the funding has been secured, and those which could be achieved if new sources of funding are identified. In the attainment demonstration, the 2007 Ozone Plan only includes the benefits of incentive programs for which funding has been secured. Table 11 lists the incentive based emission reductions the District commits to achieve as part of the 2007 Ozone Plan. These emission reductions are funded through a combination of Indirect Source Review fees, Developer Mitigation Contract fees, and Department of Motor Vehicle Surcharge fees. Carl Moyer Program reductions are not credited here, as they are included in the ARB baseline adjustments identified in Appendix B, Table B-2, of the 2007 Ozone Plan.

Table 11
NOx Reductions Achieved by District Incentive Measures with Assured Funding [a]

Year	NOx Reductions (tpd)
2012	1.4
2020	0.7
2023	0.6

a. – The Reductions achieved with through the Carl Moyer Program are not included in the reductions listed here since ARB includes these reductions in the baseline emission projections.

ARB staff believes that the emission reductions achieved through the Carl Moyer Program represent the "Gold Standard" for an incentive-based emission reduction program. When the District follows the Carl Moyer Program Guidelines, no additional effort should be needed to ensure that the emission reductions achieved are SIP creditable. The District staff is required to use the Carl Moyer Program Guidelines when expending funds from the Carl Moyer program. However, as the District addresses non-Carl Moyer Program funding, additional documentation may be necessary. The 2007 Ozone Plan includes a commitment to strengthen the District's incentives program in order to ensure that the incentive program is SIP creditable.

The District will strengthen their program through the development of additional emission reduction calculation protocols where needed, the enhancement of auditing and enforcement of contracted emission reductions, and the tracking and periodic reporting of the benefits of the projects funded through the District's incentive program.

The District has the discretion to use the Carl Moyer Program Guidelines when expending funds from other sources. ARB staff encourages the District staff to use the protocols developed under the Carl Moyer Program Guidelines where applicable. However, recognizing that special circumstances may arise where the Carl Moyer Program may not provide guidance or the District needs additional flexibility to address specific sources, the District can develop and implement specific protocols which allow non-Carl Moyer Program funds to address specific District needs. ARB staff will provide technical assistance in the development of these additional protocols, as needed.

2. Proposed New State Measures

Cleaning up the mobile NOx sources in the San Joaquin Valley is the most critical component of the emission control effort to reduce both ozone and PM2.5 concentrations in the Valley. Vehicles and equipment operating in California are subject to the most stringent tailpipe emission standards in the world. ARB has a long history of adopting successful programs to reduce emission from mobile sources. These regulations will result in fewer emissions as vehicles and equipment units meeting the cleanest emission standards enter into service. However, the benefits of these cleanest engines are only realized as new engines enter service and older engines are retired, and diesel engines have very long useful lives. In order to expedite the use of engines meeting the cleanest emission control standards, ARB staff is proposing a comprehensive list of emission control measures to reduce both NOx and ROG emissions throughout the State.

Table 12 summarizes the estimated benefits of ARB staff's proposed measures in the San Joaquin Valley. ARB staff is proposing to commit to the total emission reductions benefits of the proposal in 2020 and 2023 in the San Joaquin Valley.

The potential emission reduction benefits of individual measures are provided for informational purposes only. The emission reduction benefits of the proposed State Strategy in 2014 will be considered, and recommended as a State commitment, in the context of the Valley's PM2.5 attainment plan. Additional details on the individual measures being proposed by ARB staff, and on the estimated benefits of those measures, are available in the proposed 2007 State Strategy, which is available on-line at:

http://www.arb.ca.gov/planning/sip/2007sip/2007sip.htm

Table 12
Expected Emission Reductions from Proposed New SIP Measures
San Joaquin Valley
(Summer Season, tons per day)

Proposed New SIP Measures	2020		2023	
	NOx	ROG	NOx	ROG
Passenger Vehicles	**2.7**	**4.1**	**2.1**	**3.3**
Smog Check Improvements (BAR)	2.4	2.2	2.1	1.9
Expanded Vehicle Retirement	0.3	0.3	0.04	0.1
Modifications to Reformulated Gasoline Program	--	1.6	--	1.3
Heavy-Duty Trucks	**30.2**	**3.3**	**21.2**	**2.3**
Cleaner In-Use Heavy-Duty Trucks	30.2	3.3	21.2	2.3
Goods Movement Sources	**15.6**	**1.2**	**16.4**	**1.3**
Auxiliary Ship Engine Cold Ironing & Clean Technology	--	--	--	--
Cleaner Main Ship Engines and Fuel	--	--	--	--
Port Truck Modernization	--	--	--	--
Accelerated Intro. of Cleaner Line-Haul Locomotives	15.6	1.2	16.4	1.3
Clean Up Existing Harbor Craft	--	NYQ	--	NYQ
Off-Road Equipment	**7.0**	**1.0**	**5.4**	**0.6**
Cleaner In-Use Off-Road Equipment (over 25hp)	7.0	1.0	5.4	0.6
Cleaner In-Use Agricultural Equipment	NYQ	NYQ	NYQ	NYQ
Other Off-Road Sources	**0.4**	**8.7**	**0.6**	**11.4**
New Emission Standards for Recreational Boats	0.4	3.8	0.6	5.3
Expanded Off-Road Rec. Vehicle Emission Standards	--	4.9	--	6.1
Additional Evaporative Emission Standards	--	NYQ	--	NYQ
Vapor Recovery for Above Ground Storage Tanks	--	NYQ	--	NYQ
Area-wide Sources	**--**	**6.1**	**--**	**6.3**
Consumer Products Program	--	3.6	--	3.8
Pesticides: DPR 2008 Pesticide Plan	--	2.5	--	2.5
Emission Reductions from Proposed New Measures	**56**	**24**	**46**	**25**

NYQ = Not Yet Quantified. BAR = Bureau of Automotive Repair. DPR = Dept. of Pesticide Regulation
Locomotives measure relies on U.S. EPA rulemaking and industry agreement to accelerate fleet turnover.
Note: Emission reductions reflect the combined impact of regulations and supportive incentive programs. Emission reduction estimates for each proposed measure are shown for informational purposes only. Actual emission reductions from any particular measure may be greater than or less than the amounts shown.

3. Proposed New Federal Measures

The San Joaquin Valley 2007 Ozone Plan does not include federal commitments for new emission reductions. However, the proposed State Strategy takes advantage of new emission standards for on- and off-road engines and equipment which will be in place in the near future. The proposed State Strategy also takes advantage of Tier 4 locomotive emission standards that U.S. EPA has

proposed to implement by 2017.[11] The ARB staff has proposed developing a suite of measures and agreements with the railroads to ensure that the cleanest locomotives in the industry's fleets are operated in California on an expedited timeline. U.S. EPA must work to develop these standards in a timeframe which will allow the benefits to be achieved in the Valley as expeditiously as possible.

4. Long-term Measures

In order to attain the federal 8-hour ozone standard, the Valley needs to achieve a 75 percent reduction in NOx emissions and a 25 percent reduction in ROG emissions, valleywide. The near-term measure commitments in the 2007 Ozone Plan, as a whole, will reduce NOx emissions by 63 percent and ROG emissions by 25 percent.

Combined, the near-term NOx emission reduction commitments adopted by the District and under consideration by ARB staff will not provide all of the NOx emission reductions necessary for the Valley to attain the federal ozone standard. Federal law [12] allows areas classified as extreme nonattainment of the federal ozone standard to take advantage of improvements in emission control technologies and techniques which are expected to develop in the future. This provision allows areas with the most extreme air quality challenges to develop approvable SIPs, even where 100 percent of the necessary reductions cannot be achieved cost effectively with today's technologies. In order to demonstrate attainment, the 2007 Ozone Plan relies on the use of advanced technologies to achieve the last increment of emission reductions.

More than 80 tons per day of the necessary NOx emission reductions remain to be achieved, beyond what known technologies will reliably achieve. It is impractical to presumptively apportion those reductions by primary regulatory authority. Both the ARB and District staffs must work diligently to identify and take advantage of all effective emission control technologies as those technologies as quickly as they become available.

The District's 2007 Ozone Plan has two components, future study measures and long-term concepts, which will help identify and promote the technologies and programs needed to achieve additional emission reductions on both mobile and stationary sources. ARB staff has also identified long-term measures which may result in additional emission reductions.

(a) Future Study Measures

The District has identified a suite of future study measures which, upon completion, could result in opportunities for additional emission reductions. These study measures seek to explore where and how additional emission

[11] Federal Register: April 3, 2007 (Volume 72, Number 63, pages 15937-16151)
[12] Clean Air Act Amendments Section 182(e)(5)

reductions may be achieved through another round of prohibitory rules. The District is committing to release a study report by the dates listed in Table 13, which may recommend a future amendment to the regulatory implementation schedule to include those additional measures identified as fruitful.

Such study measures include the internal combustion engine study and the two boiler studies. In all cases, the District should strive to adopt new rules within one year of completion of study measures, where the studies indicate that emission reductions could be achieved. For study measures where additional emission reductions are not available, the District should periodically revise those studies, to take advantage of technology as quickly as it becomes available.

Table 13
District Stationary Source Feasibility/Future Study Implementation Schedule

CM#	Measure Name	Product	Completion Date
S-COM-6	ICE Electrification\Pump Efficiency Incentives	FS	2008
S-GOV-6	Prescribed Burning	FS	2008
Program Review	Open Burning Biomass Incentive	FS	2008
S-PET-13	Oil Production Sumps	FS	2009
S-PET-16	Heavy Crude Oil Components	FS	2009
S-COM-4	Solid Fuel Fired Boilers	FS	2009
S-COM-3	Small Boilers	FS	2010
S-IND-12	Wine Fermentation & Storage	FS	2010
S-IND-5	Asphalt Roofing	FS	2010
S-PET-18	HOTS & Gauge Tanks	FS	2010
S-AGR-4	Pesticide Fumigation Chambers	FS	2011
S-COM-11	Dryers	FS	2011
S-GOV-4	Asphalt Paving	FS	2011
S-IND-13	Bakeries	FS	2011
S-COM-6	IC Engines – Standards Review	FS	2012
S-GOV-2	POTW Water Treatment	FS	2012
S-IND-23	Reduction of Animal Matter	FS	2012
S-PET-22	Refinery Turnaround Units	FS	2012
S-PET-23	Refinery Vacuum Devices	FS	2012
S-PET-24	Refinery Wastewater Separators	FS	2012

FS – Feasibility/Future Study: Not currently quantifiable. FS reports will be released by the completion date, which may recommend an amendment to the Plan Regulatory Implementation Schedule to include additional regulatory measures identified as fruitful and have the potential of achieving reductions committed to in the Black Box.

(b) Incentive Programs – Unsecured Funding

The primary driver of emission reductions in the "beat-the-SIP" strategy is through the use of additional incentive monies. ARB staff supports use of incentives to accelerate the air quality progress. However, the federal regulation and policy constrains what can be included in a federally approvable SIP. Despite these constraints, ARB staff believes that securing funding and getting cleaner vehicles and equipment into service quickly will improve air quality throughout the Valley.

Chapter 7 of the 2007 Ozone Plan outlines the District staff's incentive-based emission reduction "action plan" which would be employed as funding becomes available. Using economic incentives to facilitate fleet clean-up has the potential to achieve greater emission reductions, well before they would occur with natural turnover. The District staff has experience implementing several emission reduction incentive programs, including the State funded Carl Moyer Program.

ARB staff believes that, where possible, District incentive funding should not be limited to mobile equipment. Where possible and cost effective, the District should explore funding ultra-clean stationary source technology. Funding the use of cutting-edge stationary source emission control technologies would help demonstrate that these technologies are effective in real-world applications. Development of these newer and more advanced technologies could support another round of regulatory development, needed to achieve the final increment of emission reductions in the Valley.

U.S. EPA does not allow regions to use emission reduction estimates from unsecured incentive money as part of an approvable attainment demonstration. In addition to having secure funding, EPA requires that emission reductions achieved through an incentive program must be quantifiable, surplus to regulatory requirements and inventory estimation assumptions, permanent over the life of the project, and enforceable by the District. Emission reductions meeting these requirements are considered to be "SIP creditable." Identifying new funding streams, and implementing the requirement that emission reductions must be surplus to regulatory requirements, will help drive the development and implementation of new advanced technologies.

Since prospective funding does not meet U.S. EPA SIP accountability criteria, the District plan does not take credit, in the attainment demonstration, for emission reductions achieved through prospective funding. However, once funding has been secured, the incentive measures identified will provide additional near-term emission reductions. Long-term, these will help achieve the last increment of emission reductions needed for attainment. As this money is secured, the District staff will work with the public, U.S. EPA, and ARB to ensure that the emission reductions are SIP creditable.

Sections 7.6 and 7.7 of the 2007 Ozone Plan outline the District's strategy to strengthen their current and future incentive programs. These sections were approved by the District and recognize the need to ensure that implementation of the publicly funded incentive programs is transparent. These sections will serve as the guiding principles and strategies the District staff will follow in developing new funding sources to support their beat-the-SIP approach. The District is not submitting sections 7.6 and 7.7 for inclusion in the San Joaquin Valley SIP.

(c) Long-term Concepts

Chapter 11 of the 2007 Ozone Plan outlines three long-term strategy components: alternative energy sources, advanced retrofit/replacement technologies, and smart growth/land use. Developments in these three arenas could lead to increased emission reductions, reduced vehicle travel, and a further clean-up of the remaining vehicles and equipment.

(d) Proposed Long-term State Measures

A discussion of the ARB staff's proposed long-term measures can be found in Chapter 3 of the proposed 2007 State Strategy.

(e) Contingencies for New Technologies

Additional provisions apply to extreme areas that include new technologies in their attainment plans. These attainment demonstration plans can rely on future advances in emission reduction technologies (referred to as new technologies) if the State, among other things:

- submits enforceable commitments to develop and adopt contingency measures if the anticipated technologies do not achieve the planned reductions;

- demonstrates that the contingency measures shall be adequate to produce emission reductions sufficient to achieve attainment and reasonable further progress.

These contingency measures to back-up the new technology provisions are not due until three years before implementation of these new technology provisions.

After adoption of the State Strategy, ARB staff proposes to initiate a coordinated government, private, and public effort to establish emission goals for critical mobile and stationary emission source categories. Following the setting of emission goals, ARB will start an ongoing public process to assess technology advancement opportunities for the critical categories. ARB staff will periodically brief the Board at public meetings on emerging emission reduction opportunities, promising technologies, and the progress made in developing long-term emission reduction measures. As ARB staff identifies feasible technology-forcing emission reduction measures, staff will propose those measures to the Board for inclusion into the SIP.

No later than 2020, ARB and the District will prepare a revision to the 8-hour Ozone SIP that (1) reflects any modifications to the 2023 emission reduction target based on updated science, and (2) identifies any additional strategies,

including the implementing agencies, needed to achieve the necessary emissions reductions by 2023. If the specific measures developed to satisfy the long-term obligation affect on-road motor vehicle emissions, we will work with the air districts and transportation planning agencies to revise the transportation conformity budgets accordingly.

F. Attainment Demonstration

The emission reduction measures identified previously, including long-term measures, will provide the necessary emission reductions to demonstrate attainment of the federal standard by 2023. Table 14 demonstrates that the required emission reductions will be achieved by implementing the commitments for new and long-term measures proposed in the State Strategy and approved in the San Joaquin Valley's 2007 Ozone Plan.

From today's emission levels, reaching the emission targets for attainment will necessitate NOx emission reductions of 490 tons per day (see table 5, above). The existing emission control program will yield 355 tons per day of NOx reductions between today and 2023. The San Joaquin Valley 2007 Ozone Plan, including ARB staff's proposed new measures, would generate another 55 tons per day of NOx reductions by 2023. This leaves an additional 80 tons per day of NOx emissions to be addressed by long-term, new technology measures. The existing and proposed new measures will achieve all of the ROG reductions needed, without the reliance on new technologies.

Table 14
Meeting the Ozone Emission Reduction Target
(Summer Planning tons per day)

	San Joaquin Valley (2023)	
	NOx	ROG
Emission Reduction Target	490	108
Emission Reductions from Adopted SIP Measures	355	41
Emission Reductions from New Local Measures	9	47
Emission Reductions from New State Measures	46	25
Long-Term Measures	80	--
Total Reductions	490	113

Emission Reductions from Adopted SIP Measures = Emissions reduced from measures adopted through 2006.
Emission Reductions from New Measures = Emissions reduced from measures in the State Strategy or new local measures adopted after 2006.
Long-Term Measures = Emissions reduced from measures adopted after 2020 that rely on new or evolving technology, as allowed in section 182(e)(5) of the Clean Air Act.

1. Requirements for Failure to Attain by the Applicable Deadline

The Act requires that, should the Valley not attain the federal 8-hour zone standard by 2024, the SIP include contingency measures which take effect without further action by the State.[13] The State's mobile source emission reduction program will achieve additional emission reduction benefits as older dirtier mobile sources are removed from service after the Valley's attainment deadline. Those additional benefits achieved are available to meet the attainment-year contingency requirements. ARB staff is proposing to commit the benefit of the State's mobile source emission reduction program in 2024 for attainment-year contingency measures.

The Act also requires that areas classified as severe or extreme nonattainment of the federal ozone standard include In the SIP procedures to levy a fee for failure to attain.[14] The District has an adopted a rule[15] implementing these

[13] Section 172(c)(9) of the 1990 Clean Air Act Amendments.
[14] Section 185 of the 1990 Clean Air Act Amendments.
[15] San Joaquin Valley Unified Air Pollution Control District Rule 3170 – "Federally Mandated Ozone Nonattainment Fee."

requirements, which goes into effect automatically if the Valley does not attain the ozone standard by the 2024 deadline.

G. Reasonable Further Progress and Contingency Measures

The Clean Air Act requires that areas classified moderate or greater, demonstrate that progress towards attaining the federal standard will not be delayed. This Reasonable Further Progress (RFP) requirement ensures that areas do not delay implementation of emission control programs until immediately before the attainment date. RFP requirements vary by nonattainment classification. Nonattainment areas classified serious and above, including the San Joaquin Valley, must demonstrate an 18 percent reduction in ROG and/or NOx emissions from the 2002 baseline ROG inventory by 2008. In the years that follow, they must demonstrate, on average, an additional 3 percent per year reduction in ROG and/or NOx emissions until their attainment year.

The Act also requires that nonattainment areas provide for contingency measures which take effect without further action if an area fails to achieve the reductions required to demonstrate RFP. U.S. EPA has interpreted this to mean that the contingency measures must be from measures that have already been adopted.

The District staff analysis of RFP and contingency measures, set out in Chapter 10 of the Valley's 2007 Ozone Plan, demonstrates that all of the emission reductions needed to meet the RFP and progress related contingency measure requirements will come from the existing emission control program.

ARB staff concurs that RFP and contingency measures requirements are met through currently adopted rules and regulations. Table 15 sets out the RFP and contingency measure demonstration conducted by ARB staff. This demonstration includes the impacts of the revised pesticide emissions, which were not available in time for inclusion in the publication and adoption of the 2007 Ozone Plan by the District. As such, ARB staff is proposing to submit this RFP demonstration to U.S. EPA for inclusion in California's SIP for the San Joaquin Valley. Details on the calculation procedures can be found in Appendix D to the proposed State Strategy, and is available on-line at:

http://www.arb.ca.gov/planning/sip/2007sip/apr07draft/revdrftappd.pdf

Table 15
San Joaquin Valley
RFP and Contingency Measure Summary

	Milestone year					
	2008	**2011**	**2014**	**2017**	**2020**	**2023** (for 2024 attainment)
ROG or NOx percent reduction required from 2002 levels	18%	27%	36%	45%	54%	63%
ROG percent reduction projected from existing program 2002 levels used to meet RFP	8.9%	13.3%	13.7%	14.5%	14.0%	12.7%
NOx percent reduction projected from existing program from 2002 levels used to meet RFP	9.1%	13.7%	22.3%	30.5%	40.0%	50.3%
Total ROG and/or NOx percent reductions from existing program used to meet RFP	18%	27%	36%	45%	54%	63%
RFP percent reduction requirements met?	Yes	Yes	Yes	Yes	Yes	Yes
Total NOx or ROG percent reductions used to meet contingency requirements	2.5%	3%	3%	3%	3%	3%
Contingency measure requirements met?	Yes	Yes	Yes	Yes	Yes	Yes

H. Transportation Conformity Budgets

The District's 2007 Ozone Plan establishes county-level on-road motor vehicle emission transportation conformity budgets for each milestone year, as well as for the attainment year. The emissions budgets reflect the latest planning assumptions and were developed using EMFAC2007. These new conformity budgets are listed in Table 16. Detailed calculations used to derive the transportation conformity budgets can be found in Chapter 9 and Appendix C of the San Joaquin Valley 2007 Ozone Plan.

Two updates to the San Joaquin Valley on-road transportation conformity budgets are being proposed by ARB staff: new on-road mobile source activity estimates for Madera County which was not available in time for inclusion in the 2007 Ozone SIP; and a technical correction to the San Joaquin County transportation conformity budgets for 2008 to fix a data input error discovered subsequent to District Governing Board action. Table 16 includes the impact of these updates. Appendix D to this report discusses these updates in greater detail.

With the proposed updates identified above, the emission budgets established in the Valley's 2007 Ozone Plan fulfill the requirements of the Act and U.S. EPA regulations to ensure that transportation projects will not interfere with progress, and attainment of, the federal 8-hour ozone standard.

Table 16
Transportation Conformity Budgets [a]
(Summer planning tons per day)

County sub-area	2008		2011		2014		2017		2020		2023	
	ROG	NOx	ROG	NOx	ROG	NOx	ROG	NOx	ROG	NOx	ROG	NOx
Fresno	18.6	58.5	15.5	47.9	12.9	37.2	11.1	29.1	8.0	16.9	7.8	15.7
Kern (SJV)	18.1	93.9	15.7	79.4	13.5	64.1	11.6	49.5	8.5	18.4	8.1	24.8
Kings	3.9	18.3	3.4	15.9	2.8	12.3	2.3	9.4	1.7	5.3	1.6	4.7
Madera [b]	4.4	14.6	3.7	12.2	3.1	9.7	2.6	7.7	1.9	4.8	1.9	4.5
Merced	7.4	35.5	6.2	28.8	5.1	22.3	4.2	17.1	2.9	9.9	2.8	9.0
San Joaquin	13.9 [b]	40.0 [b]	12.1	34.7	10.1	27.8	8.6	21.3	6.3	12.7	6.3	11.9
Stanislaus	10.5	26.7	9.0	22.3	7.5	17.2	6.5	13.4	4.9	8.0	4.6	7.1
Tulare	10.5	23.4	9.2	20.9	7.7	16.6	6.7	13.1	5.2	8.4	4.8	7.4

a. – The budgets were derived using EMFAC2007 with updated vehicle population and vehicle miles traveled data where available. The budget was established by taking the EMFAC results, subtracting by County, emission reductions from District and ARB control measures and rounding up to the nearest tenth if the hundredths place was "1" or higher.

b. – Revised per discussion above. Please see Appendix D for additional details.

I. Additional Requirements for Extreme Nonattainment Areas

1. Major Source Permitting Requirements

The Act requires that areas classified as extreme nonattainment revise their permitting requirements to be applicable to sources with the potential to emit 10 tons per year of ozone forming emissions. The 2007 Ozone Plan includes a commitment to submit to U.S. EPA a revised New Source Review rule which meets the requirements for an extreme area, within one year of District Board approval of the plan. See Chapter 2 of the 2007 Ozone Plan for more detail.

2. Clean Fuels Requirements

The Act also has requirements for the use of clean fuels or advanced technology in all electric utilities and industrial or commercial boilers which emit more than 25 tons per year of NOx. Existing District rules[16] meet implement this requirement. More information is available in Chapter 2 of the Valley's 2007 Ozone Plan.

[16] San Joaquin Valley Unified Air Pollution Control District Rules 4305, 4306, and 4352.

IV. ENVIRONMENTAL IMPACTS

The California Environmental Quality Act (CEQA) requires that State and local agency projects be assessed for potential significant environmental impacts. Air quality plans are "projects" that are potentially subject to CEQA requirements. The District staff found that the plan would not have a significant effect on the environment and prepared an Initial Study/Negative Declaration. The District Governing Board approved this Initial Study/Negative Declaration on April 30, 2007.[17]

V. LEGAL AUTHORITY

The federal Clean Air Act Amendments (the Act) require states to provide for the attainment of national ambient air quality standards. The primary tool to be used in the effort to attain national ambient air quality standards is a plan that any state with one or more nonattainment areas must develop, which provides for implementation, maintenance and enforcement of the standards—the State Implementation Plan (section 110(a)(1)). Section 110(a)(2)(A) of the Act broadly authorizes and directs states to include in their SIPs:

> "...enforceable emission limitations and other control measures, means, or techniques (including economic incentives such as fees, marketable permits, and auctions of emissions rights), as well as schedules and timetables for compliance, as may be necessary or appropriate to meet the applicable requirements of the Act."

State law charges the ARB with coordinating State, regional, and local efforts to attain and maintain both State and national ambient air quality standards. The direct statutory link between ARB and the mandates of the Clean Air Act is found in section 39602 of the Health and Safety Code (HSC). This provision states:

> "The state board is designated the air pollution control agency for all purposes set forth in federal law.
>
> The state board is designated as the state agency responsible for the preparation of the state implementation plan required by the Clean Air Act (42 U.S.C., Sec. 7401, et seq.) and, to this end, shall coordinate the activities of all districts necessary to comply with that act."

State law also limits what the ARB may submit as a SIP revision. HSC section 39602 goes on to state,

> "Notwithstanding any other provision of this division, the state implementation plan shall only include those provisions necessary to meet the requirements of the Clean Air Act."

[17] San Joaquin Valley Unified Air Pollution Control District resolution number 07-04-11a.

ARB will exclude from the SIP submittal any provisions of the San Joaquin Valley 2007 Ozone Plan that relate solely to the California Clean Air Act requirements.

VI. STAFF RECOMMENDATIONS

As described in this report, ARB staff has reviewed San Joaquin Valley's 8-Hour Ozone Attainment Plan 2007 and consulted extensively with District staff during this review.

ARB staff finds that the San Joaquin Valley's 2007 Ozone Plan meets all applicable requirements. We believe that implementation of this plan would clearly reduce ozone levels throughout San Joaquin Valley and benefit public health and result in attainment of the 8-hour ozone standard by June 2024. Therefore, we recommend that the Board take the following actions:

(1) Adopt the local elements of the 2007 San Joaquin Valley 2007 Ozone Plan as a revision to the California SIP, including the local control strategy, the updated emission inventories, the updated attainment demonstration, and the updated motor vehicle emission budgets.

(2) Direct the Executive Officer to submit the local plan elements to U.S. EPA as a revision to the California SIP.

The San Joaquin Valley 2007 Ozone Plan relies on emission reductions to be achieved from the proposed State Strategy for California's 2007 SIP. The State Strategy is scheduled to be considered by ARB on June 21, 2007, and thus at the June 14, 2007 hearing ARB will be considering the 2007 Ozone Plan before the State Strategy has been approved. Therefore, final ARB action on the San Joaquin Valley's 2007 Ozone Plan would be contingent upon ARB's subsequent adoption of commitments, as part of the State Strategy, to achieve the emission reductions from State measures.

Appendix A

Emissions Inventory Output Tables

Emissions Inventory Output Tables

Appendix A includes the emissions inventory output tables for all nonattainment areas for the 2007 SIP. The inventories shown are the baseline summer season planning inventories on which the State Strategy is based.

For each precursor pollutant, the inventory tables provide emissions for stationary, areawide, and mobile sources broken down by source subcategory.

The summer planning inventories reflect adjustments for regulations adopted through 2006 and minor technical improvements not yet included in the California Emissions Forecasting System (CEFS) inventories on the ARB web site (and described in Appendix F). These adjustments are specified in a separate table for each precursor pollutant in each nonattainment area. The adjustment categories are summarized below. ARB web site addresses are also listed for further information on related rulemakings.

Baseline Adjustments – Category Descriptions

Public Fleet:
Rule to reduce diesel truck emissions in government and private utility fleets (adopted December 2005).
For more information:
http://www.arb.ca.gov/msprog/publicfleets/publicfleets.htm.

Idling:
Rule to limit general truck idling to five minutes (adopted July 2004) and rule to limit sleeper cab trucks to five minutes of idling or use of an auxiliary power unit (adopted October 2005).
For more information:
http://www.arb.ca.gov/toxics/idling/idling.htm
http://www.arb.ca.gov/msprog/truck-idling/truck-idling.htm.

AB 1493:
Criteria pollutant benefits from greenhouse gas limits for motor vehicles (adopted September 2004).
For more information: http://www.arb.ca.gov/cc/ccms/ccms.htm

Moyer:
Emission reductions from the Carl Moyer Memorial Air Quality Standards Attainment Program ($81 million in incentive funds from 2007 through 2015). The Carl Moyer Program provides incentive grants for cleaner-than-required

Further Baseline Adjustment Explanations

HHDD Trucks. Adjustment for 2005 Heavy-Duty Truck VMT

ARB's on-road motor vehicle emissions model (EMFAC2007) estimates for heavy heavy-duty truck vehicle miles traveled (VMT) for year 2005 were adjusted to match transportation agency VMT estimates.

To calculate VMT for years 2000 through 2005, ARB staff used population data from the Department of Motor Vehicles (DMV) together with mileage accrual rates from the Bureau of Automotive Repair. As result, default EMFAC2007 VMT for 2000 through 2005 can differ from transportation agency estimates, which are transportation model outputs. This was the case for the 2005 heavy heavy-duty VMT estimate. For SIP purposes, State law directs ARB to use transportation agency VMT data when it is available. Ozone and PM2.5 air quality modeling was done for 2005, making it a critical year for the SIP. Therefore, ARB staff applied an external factor to heavy heavy-duty truck emissions for 2005 that matched EMFAC2007 VMT to transportation planning agency VMT.

Reflash. Heavy-Duty Diesel engine Software Upgrade

ARB staff estimates that overall benefits of the software upgrade regulation plus related actions provided approximately 38 tons per day of NOx emission reductions statewide in 2007. This is within the range of the original staff estimate of 30 to 40 tons per day. Reductions included in the adjustment beyond those required by the now invalidated regulation come from voluntary upgrade programs, ongoing engine rebuilds, engines upgrades by manufacturers exempt from the regulation, and interstate trucks.

Pesticides/Fertilizers. Pesticide ROG Inventory Adjustments

The California Department of Pesticide Regulation (DPR) is the lead agency for tracking pesticide usage. DPR provided two sets of pesticide emissions inventory updates for ozone nonattainment areas. These data are in the attached tables.

- In October 2006, DPR provided pesticide emissions based on the latest pesticide use (2004 Pesticide Use Report) data.

- Subsequently, DPR provided updated pesticide emissions estimates for five areas based on a review of recently published literature, including monitoring studies demonstrating lower emissions when fumigant applications are tarped, irrigated after application, or applied through drip irrigation systems. The five areas are:
  - Sacramento
  - San Joaquin Valley

San Joaquin Valley

NOX - SJV - SUMMER PLANNING INVENTORY -- ADJUSTED FOR MEASURES AND CATEGORIES THROUGH 31 DEC 2006															
SUBCATEGORY	2002	2005	2006	2008	2009	2010	2011	2012	2013	2014	2015	2017	2018	2020	2023
Stationary															
ELECTRIC UTILITIES	3.13	3.32	3.27	3.00	3.07	3.15	3.17	3.18	3.19	3.21	3.22	3.32	3.37	3.47	3.57
COGENERATION	10.57	10.04	9.36	7.11	7.27	7.28	7.33	7.39	7.44	7.48	7.54	7.80	7.94	8.20	8.36
OIL AND GAS PRODUCTION (COMBUSTION)	15.52	11.19	11.06	10.20	10.09	9.99	9.94	9.88	9.83	9.77	9.72	9.70	9.69	9.67	9.73
PETROLEUM REFINING (COMBUSTION)	0.23	0.20	0.15	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
MANUFACTURING AND INDUSTRIAL	36.62	37.72	38.45	39.42	39.92	40.55	41.29	42.02	42.76	43.51	44.25	45.31	45.84	46.90	47.48
FOOD AND AGRICULTURAL PROCESSING	30.49	30.50	28.51	19.74	17.24	14.75	12.93	11.19	9.44	7.71	6.00	5.97	5.96	5.93	5.91
SERVICE AND COMMERCIAL	4.65	4.41	4.43	4.45	4.47	4.50	4.51	4.53	4.56	4.58	4.61	4.60	4.61	4.63	4.63
OTHER (FUEL COMBUSTION)	1.92	1.59	1.53	1.42	1.37	1.32	1.28	1.24	1.20	1.15	1.11	1.06	1.03	0.98	0.99
SEWAGE TREATMENT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LANDFILLS	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04
INCINERATORS	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
SOIL REMEDIATION	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER (WASTE DISPOSAL)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LAUNDERING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DEGREASING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COATINGS AND RELATED PROCESS SOLVENTS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PRINTING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ADHESIVES AND SEALANTS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER (CLEANING AND SURFACE COATINGS)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OIL AND GAS PRODUCTION	0.09	0.11	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.13
PETROLEUM REFINING	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
PETROLEUM MARKETING	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
OTHER (PETROLEUM PRODUCTION AND MARKETIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CHEMICAL	0.28	0.30	0.31	0.33	0.34	0.34	0.35	0.36	0.37	0.37	0.38	0.39	0.40	0.41	0.43
FOOD AND AGRICULTURE	9.28	9.15	9.10	9.06	9.02	8.98	8.93	8.91	8.88	8.86	8.85	8.82	8.81	8.81	8.74
MINERAL PROCESSES	2.28	2.36	2.37	2.47	2.54	2.58	2.64	2.68	2.74	2.81	2.84	2.92	2.98	3.08	3.23
METAL PROCESSES	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.13
WOOD AND PAPER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GLASS AND RELATED PRODUCTS	9.60	9.38	7.64	8.02	8.16	8.37	8.56	8.73	8.94	9.08	9.32	9.64	9.80	10.12	10.65
OTHER (INDUSTRIAL PROCESSES)	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Extra-inventory Reductions (District Rules)	0.00	0.00	0.00	-0.81	-1.01	-1.22	-1.43	-1.59	-1.72	-1.85	-1.96	-2.07	-2.22	-2.63	-2.63
Stationary Subtotal	125.21	120.80	116.86	105.21	103.27	101.39	100.30	99.33	98.43	97.51	96.70	98.29	99.07	100.42	101.94
Area-Wide															
CONSUMER PRODUCTS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ARCHITECTURAL COATINGS AND RELATED PROCES	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PESTICIDES/FERTILIZERS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ASPHALT PAVING / ROOFING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESIDENTIAL FUEL COMBUSTION	3.24	3.08	3.03	2.96	2.96	2.96	2.97	2.97	2.98	2.98	2.99	3.00	3.01	3.02	3.04
FARMING OPERATIONS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CONSTRUCTION AND DEMOLITION	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAVED ROAD DUST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UNPAVED ROAD DUST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FUGITIVE WINDBLOWN DUST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FIRES	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04
MANAGED BURNING AND DISPOSAL	8.28	8.16	8.14	8.10	8.08	8.06	8.04	8.02	8.00	7.98	7.96	7.91	7.89	7.85	7.81
COOKING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER (MISCELLANEOUS PROCESSES)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Area-Wide Subtotal	11.54	11.27	11.20	11.09	11.07	11.05	11.04	11.02	11.01	10.99	10.98	10.95	10.93	10.91	10.88
On-Road Mobile															
LIGHT DUTY PASSENGER (LDA)	31.07	21.58	19.78	16.51	15.33	14.13	12.79	11.57	10.45	9.42	8.54	7.10	6.52	5.66	4.69
LIGHT DUTY TRUCKS - 1 (LDT1)	13.15	9.70	8.88	7.44	6.95	6.47	5.93	5.45	5.00	4.57	4.17	3.45	3.14	2.66	2.12
LIGHT DUTY TRUCKS - 2 (LDT2)	24.37	19.23	17.70	15.06	14.22	13.41	12.45	11.53	10.66	9.85	9.11	7.83	7.28	6.37	5.38
MEDIUM DUTY TRUCKS (MDV)	14.71	13.08	12.07	10.27	9.74	9.20	8.64	8.10	7.58	7.09	6.63	5.77	5.39	4.69	3.84
LIGHT HEAVY DUTY GAS TRUCKS - 1 (LHDV1)	4.90	4.45	4.17	3.83	3.80	3.77	3.71	3.67	3.64	3.61	3.59	3.56	3.55	3.54	3.50
LIGHT HEAVY DUTY GAS TRUCKS - 2 (LHDV2)	1.01	0.97	0.95	0.92	0.92	0.92	0.90	0.89	0.88	0.87	0.85	0.83	0.82	0.81	0.79
MEDIUM HEAVY DUTY GAS TRUCKS (MHDV)	2.31	2.05	1.95	1.74	1.69	1.63	1.54	1.44	1.35	1.25	1.16	1.00	0.92	0.80	0.66
HEAVY HEAVY DUTY GAS TRUCKS (HHDV)	2.69	2.41	2.24	1.96	1.89	1.82	1.76	1.69	1.64	1.59	1.53	1.46	1.43	1.38	1.35
LIGHT HEAVY DUTY DIESEL TRUCKS - 1 (LHDV1)	0.36	5.43	4.87	3.87	3.71	3.45	3.19	2.98	2.82	2.68	2.55	2.28	2.16	1.94	1.63
LIGHT HEAVY DUTY DIESEL TRUCKS - 2 (LHDV2)	2.33	3.35	3.21	2.87	2.82	2.68	2.52	2.36	2.22	2.08	1.95	1.71	1.59	1.39	1.13
MEDIUM HEAVY DUTY DIESEL TRUCKS (MHDV)	19.84	21.33	20.48	18.24	17.72	16.81	15.61	14.42	13.24	12.11	11.03	9.15	8.35	7.03	5.62
HEAVY HEAVY DUTY DIESEL TRUCKS (HHDV)	198.24	213.30	256.26	215.35	205.92	192.43	178.47	164.60	150.90	137.81	125.60	104.20	95.15	80.42	66.28
MOTORCYCLES (MCY)	0.66	1.34	1.36	1.35	1.36	1.39	1.38	1.39	1.40	1.41	1.43	1.47	1.49	1.54	1.62
HEAVY DUTY DIESEL URBAN BUSES (UB)	2.11	2.24	2.22	2.18	2.26	2.33	2.36	2.38	2.41	2.38	2.40	2.45	2.46	2.47	2.51
HEAVY DUTY GAS URBAN BUSES (UB)	0.25	0.26	0.27	0.27	0.28	0.30	0.31	0.32	0.32	0.34	0.35	0.36	0.37	0.38	0.39
SCHOOL BUSES (SB)	2.22	2.39	2.38	2.25	2.20	2.25	2.14	2.12	2.00	1.88	1.75	1.09	1.07	1.05	1.02
OTHER BUSES (OB)	0.92	1.07	1.05	0.99	0.99	0.96	0.92	0.87	0.83	0.78	0.73	0.64	0.60	0.52	0.43
MOTOR HOMES (MH)	1.26	1.10	1.06	0.97	0.96	0.94	0.90	0.86	0.82	0.77	0.73	0.64	0.59	0.51	0.40
Extra-inventory Reductions (District Rules)	0.00	0.00	0.00	-3.80	-4.50	-5.20	-5.90	-6.30	-5.25	-4.20	-3.50	-2.10	-1.87	-1.40	-1.10
On-Road Subtotal	322.40	325.26	360.90	302.28	288.24	269.66	249.61	230.35	212.90	196.30	180.61	152.88	141.02	121.76	102.27
Other Mobile															
AIRCRAFT	2.94	3.05	3.16	4.07	4.16	4.34	4.53	4.61	4.68	4.76	4.84	4.99	5.07	5.24	5.27
TRAINS	28.46	23.64	22.24	21.10	20.87	20.04	20.36	20.50	20.58	20.67	20.78	21.02	21.16	21.46	21.98
SHIPS AND COMMERCIAL BOATS	1.06	1.02	1.06	1.11	1.08	1.05	1.02	1.03	1.04	1.05	1.09	1.21	1.30	1.50	1.72
RECREATIONAL BOATS	3.89	5.02	5.33	5.59	5.56	5.54	5.52	5.52	5.53	5.55	5.58	5.65	5.69	5.73	5.77
OFF-ROAD RECREATIONAL VEHICLES	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.18	0.19	0.20	0.20	0.22	0.23	0.24	0.27
OFF-ROAD EQUIPMENT	75.42	70.16	67.79	61.66	58.62	55.46	52.52	49.65	46.77	44.14	41.43	36.68	34.62	31.05	27.13
FARM EQUIPMENT	71.22	63.95	61.53	55.41	52.85	50.77	48.03	44.60	41.25	38.38	35.50	30.34	27.87	23.37	17.92
FUEL STORAGE AND HANDLING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Mobile Subtotal	183.15	166.99	161.26	149.09	143.30	137.36	132.16	126.09	120.04	114.75	109.42	100.12	95.93	88.60	80.05
Grand Total	642.30	624.32	650.23	567.67	545.88	519.46	493.11	466.79	442.38	419.55	397.70	362.24	346.95	321.68	295.14

ROG - SJV - SUMMER PLANNING INVENTORY -- ADJUSTED FOR MEASURES AND CATEGORIES THROUGH 31 DEC 2006															
SUBCATEGORY	2002	2005	2006	2008	2009	2010	2011	2012	2013	2014	2015	2017	2018	2020	2023
Stationary															
ELECTRIC UTILITIES	0.50	0.52	0.53	0.54	0.55	0.55	0.56	0.56	0.56	0.57	0.57	0.59	0.60	0.62	0.64
COGENERATION	0.39	0.43	0.45	0.45	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.45	0.45	0.46	0.46
OIL AND GAS PRODUCTION (COMBUSTION)	3.06	3.29	3.41	3.28	3.26	3.24	3.24	3.24	3.23	3.23	3.23	3.27	3.29	3.32	3.40
PETROLEUM REFINING (COMBUSTION)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
MANUFACTURING AND INDUSTRIAL	0.36	0.39	0.40	0.41	0.42	0.42	0.43	0.44	0.45	0.45	0.46	0.47	0.48	0.49	0.50
FOOD AND AGRICULTURAL PROCESSING	2.53	2.50	2.49	2.47	2.46	2.45	2.44	2.43	2.42	2.41	2.40	2.39	2.38	2.36	2.34
SERVICE AND COMMERCIAL	0.27	0.27	0.27	0.27	0.27	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.29	0.29	0.29
OTHER (FUEL COMBUSTION)	0.21	0.16	0.16	0.14	0.13	0.13	0.12	0.12	0.11	0.10	0.10	0.09	0.09	0.08	0.08
SEWAGE TREATMENT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LANDFILLS	1.49	1.59	1.62	1.68	1.71	1.74	1.76	1.79	1.82	1.85	1.88	1.93	1.96	2.01	2.09
INCINERATORS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SOIL REMEDIATION	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10
OTHER (WASTE DISPOSAL)	56.67	57.44	59.42	63.36	64.10	64.81	65.49	66.00	69.33	72.73	73.41	74.86	75.90	78.00	81.14
LAUNDERING	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08
DEGREASING	8.74	1.47	1.46	1.46	1.47	1.49	1.50	1.51	1.53	1.54	1.55	1.58	1.59	1.61	1.64
COATINGS AND RELATED PROCESS SOLVENTS	7.80	7.66	7.77	8.17	7.55	7.79	7.98	8.17	8.37	8.61	8.80	9.14	9.35	9.66	10.15
PRINTING	1.60	1.66	1.67	1.74	1.78	1.81	1.85	1.88	1.92	1.96	1.99	2.06	2.09	2.16	2.26
ADHESIVES AND SEALANTS	2.99	3.19	3.19	3.32	3.38	3.45	3.52	3.59	3.66	3.73	3.80	3.94	3.93	4.08	4.30
OTHER (CLEANING AND SURFACE COATINGS)	3.01	3.38	3.52	3.74	3.85	3.97	4.08	4.19	4.30	4.41	4.51	4.70	4.80	4.99	5.27
OIL AND GAS PRODUCTION	29.77	27.92	28.35	27.54	27.15	26.77	26.46	26.14	25.83	25.51	25.20	24.71	24.47	23.98	23.44
PETROLEUM REFINING	0.72	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.67	0.67	0.67	0.67	0.67	0.67	0.67
PETROLEUM MARKETING	7.19	7.55	7.68	7.91	8.06	8.20	8.33	8.45	8.58	8.71	8.83	9.11	9.23	9.49	9.93
OTHER (PETROLEUM PRODUCTION AND MARKET	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CHEMICAL	2.18	2.35	2.42	2.50	2.56	2.60	2.65	2.69	2.75	2.79	2.85	2.94	2.98	3.07	3.39
FOOD AND AGRICULTURE	12.78	12.72	12.80	11.77	11.86	11.95	12.05	12.16	12.26	12.36	12.46	12.68	12.79	13.01	13.36
MINERAL PROCESSES	0.38	0.39	0.41	0.42	0.43	0.44	0.45	0.45	0.47	0.48	0.48	0.50	0.51	0.52	0.55
METAL PROCESSES	0.43	0.43	0.43	0.44	0.45	0.45	0.46	0.47	0.48	0.49	0.50	0.52	0.52	0.53	0.55
WOOD AND PAPER	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
GLASS AND RELATED PRODUCTS	0.36	0.37	0.37	0.39	0.40	0.41	0.42	0.42	0.43	0.44	0.45	0.47	0.47	0.49	0.52
OTHER (INDUSTRIAL PROCESSES)	0.20	0.21	0.22	0.23	0.23	0.23	0.24	0.24	0.25	0.25	0.25	0.27	0.29	0.31	0.32
Extra-inventory Adjustment	0.00	0.00	0.00	-1.13	-1.11	-1.10	-1.08	-1.07	-1.06	-1.04	-1.03	-1.00	-0.99	-0.97	-0.95
Stationary Subtotal	143.78	136.75	139.87	141.95	142.25	143.39	144.51	145.46	149.26	153.18	154.31	156.82	158.33	161.44	166.57
Area-Wide															
CONSUMER PRODUCTS	25.13	23.48	23.58	23.00	23.32	23.61	24.09	24.56	25.04	25.52	25.99	26.95	27.43	28.38	29.89
ARCHITECTURAL COATINGS AND RELATED PROC	13.63	11.09	11.20	11.39	11.49	11.58	11.68	11.79	11.89	11.99	12.09	12.37	12.51	12.78	13.26
PESTICIDES/FERTILIZERS	15.58	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91
ASPHALT PAVING / ROOFING	2.93	2.97	2.99	3.01	3.02	3.03	3.04	3.04	3.05	3.06	3.06	3.08	3.09	3.10	3.13
RESIDENTIAL FUEL COMBUSTION	0.49	0.47	0.45	0.44	0.42	0.42	0.41	0.40	0.39	0.39	0.39	0.39	0.39	0.40	0.41
FARMING OPERATIONS	62.03	65.38	66.50	59.86	51.71	52.42	53.37	54.33	55.28	56.23	57.18	59.08	60.04	61.94	64.79
CONSTRUCTION AND DEMOLITION	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAVED ROAD DUST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UNPAVED ROAD DUST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FUGITIVE WINDBLOWN DUST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FIRES	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.12
MANAGED BURNING AND DISPOSAL	13.73	13.64	13.60	12.32	12.28	12.24	12.20	12.16	12.12	12.08	12.04	11.96	11.91	11.82	11.71
COOKING	0.45	0.44	0.45	0.46	0.47	0.48	0.48	0.49	0.50	0.51	0.51	0.53	0.53	0.55	0.57
OTHER (MISCELLANEOUS PROCESSES)	0.00	0.00	0.00	0.00	0.00	0.00	-1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Area-Wide Subtotal	134.06	135.47	136.77	128.47	120.70	121.78	122.20	124.79	126.28	127.78	129.29	132.37	133.91	136.99	141.78
On-Road Mobile															
LIGHT DUTY PASSENGER (LDA)	39.99	31.12	28.59	23.93	22.43	20.79	19.08	17.44	15.95	14.60	13.45	11.58	10.80	9.64	8.41
LIGHT DUTY TRUCKS - 1 (LDT1)	14.19	11.60	10.72	9.07	8.50	7.92	7.43	6.94	6.46	6.00	5.59	4.82	4.47	4.03	3.57
LIGHT DUTY TRUCKS - 2 (LDT2)	17.71	15.76	14.82	13.24	12.90	12.55	12.02	11.47	10.92	10.38	9.92	9.12	8.77	8.25	7.79
MEDIUM DUTY TRUCKS (MDV)	9.50	8.64	8.11	7.24	7.08	6.90	6.72	6.52	6.31	6.12	5.94	5.59	5.42	5.08	4.66
LIGHT HEAVY DUTY GAS TRUCKS - 1 (LHDV1)	6.05	5.12	4.42	3.43	3.19	3.01	2.84	2.71	2.59	2.51	2.44	2.33	2.28	2.17	1.99
LIGHT HEAVY DUTY GAS TRUCKS - 2 (LHDV2)	1.32	1.19	1.10	0.94	0.89	0.85	0.79	0.74	0.70	0.65	0.60	0.54	0.51	0.46	0.40
MEDIUM HEAVY DUTY GAS TRUCKS (MHDV)	3.63	2.91	2.66	2.18	2.03	1.88	1.69	1.50	1.34	1.18	1.03	0.80	0.68	0.53	0.41
HEAVY HEAVY DUTY GAS TRUCKS (HHDV)	1.48	1.25	1.13	0.90	0.84	0.78	0.73	0.67	0.62	0.57	0.51	0.43	0.40	0.32	0.27
LIGHT HEAVY DUTY DIESEL TRUCKS - 1 (LHDV1)	0.02	0.19	0.18	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.14	0.14	0.13	0.13	0.12
LIGHT HEAVY DUTY DIESEL TRUCKS - 2 (LHDV2)	0.10	0.15	0.15	0.14	0.14	0.14	0.14	0.13	0.13	0.13	0.12	0.11	0.11	0.10	0.09
MEDIUM HEAVY DUTY DIESEL TRUCKS (MHDV)	0.45	0.53	0.53	0.50	0.50	0.50	0.49	0.47	0.45	0.43	0.42	0.39	0.38	0.36	0.35
HEAVY HEAVY DUTY DIESEL TRUCKS (HHDV)	14.63	16.01	19.40	17.07	16.37	15.59	14.78	13.95	13.10	12.27	11.47	10.03	9.40	8.36	7.34
MOTORCYCLES (MCY)	3.59	6.13	5.92	5.50	5.44	5.43	5.30	5.27	5.26	5.28	5.31	5.40	5.46	5.62	5.89
HEAVY DUTY DIESEL URBAN BUSES (UB)	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.10
HEAVY DUTY GAS URBAN BUSES (UB)	0.12	0.15	0.14	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.19	0.19	0.20	0.20
SCHOOL BUSES (SB)	0.23	0.22	0.21	0.20	0.20	0.20	0.20	0.20	0.20	0.19	0.19	0.19	0.19	0.18	0.18
OTHER BUSES (OB)	0.29	0.23	0.22	0.20	0.20	0.19	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.11	0.09
MOTOR HOMES (MH)	0.49	0.36	0.33	0.28	0.26	0.24	0.22	0.20	0.18	0.16	0.15	0.11	0.10	0.07	0.05
On-Road Subtotal	113.88	101.65	98.71	85.21	81.37	77.38	73.03	68.80	64.80	61.05	57.70	52.00	49.52	45.72	41.90
Other Mobile															
AIRCRAFT	6.57	6.78	6.98	8.66	8.83	9.16	9.51	9.65	9.79	9.93	10.08	10.37	10.52	10.82	10.87
TRAINS	1.63	1.64	1.61	1.57	1.55	1.54	1.55	1.55	1.55	1.56	1.56	1.57	1.57	1.58	1.60
SHIPS AND COMMERCIAL BOATS	0.12	0.12	0.11	0.10	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.08	0.08	0.10	0.10
RECREATIONAL BOATS	20.27	20.45	20.08	19.18	18.66	18.22	17.86	17.57	17.33	17.14	16.99	16.77	16.69	16.60	16.79
OFF-ROAD RECREATIONAL VEHICLES	5.78	7.23	7.43	7.76	7.94	8.15	8.38	8.64	8.90	9.19	9.48	10.14	10.50	11.25	12.48
OFF-ROAD EQUIPMENT	22.12	22.05	20.80	18.84	17.97	17.07	16.23	15.45	14.72	14.04	13.44	12.41	12.03	11.45	11.24
FARM EQUIPMENT	14.60	13.28	12.60	11.19	10.61	10.14	9.52	8.70	7.89	7.20	6.58	5.51	5.01	4.22	3.46
FUEL STORAGE AND HANDLING	5.18	5.08	4.83	3.59	3.33	3.13	2.96	2.80	2.66	2.54	2.44	2.28	2.21	2.10	1.98
Other Mobile Subtotal	76.28	76.62	74.45	70.89	68.99	67.51	66.10	64.44	62.93	61.67	60.64	59.12	58.62	58.12	58.53
Grand Total	468.01	450.49	449.80	426.52	413.32	410.06	405.84	403.49	403.27	403.68	401.94	400.31	400.38	402.27	408.78

PM2.5 - SJV - SUMMER PLANNING INVENTORY – ADJUSTED FOR MEASURES AND CATEGORIES THROUGH 31 DEC 2006															
SUBCATEGORY	2002	2005	2006	2008	2009	2010	2011	2012	2013	2014	2015	2017	2018	2020	2023
Stationary															
ELECTRIC UTILITIES	0.56	0.60	0.61	0.60	0.61	0.62	0.62	0.62	0.62	0.62	0.62	0.63	0.63	0.64	0.65
COGENERATION	1.08	1.16	1.21	1.22	1.25	1.25	1.25	1.26	1.27	1.28	1.29	1.32	1.34	1.38	1.39
OIL AND GAS PRODUCTION (COMBUSTION)	0.96	1.05	1.09	1.05	1.05	1.04	1.04	1.05	1.05	1.05	1.05	1.07	1.08	1.10	1.14
PETROLEUM REFINING (COMBUSTION)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
MANUFACTURING AND INDUSTRIAL	0.74	0.79	0.81	0.83	0.84	0.86	0.87	0.89	0.91	0.92	0.94	0.96	0.97	0.99	1.01
FOOD AND AGRICULTURAL PROCESSING	1.85	1.79	1.74	1.65	1.61	1.57	1.52	1.48	1.44	1.40	1.36	1.28	1.24	1.16	1.04
SERVICE AND COMMERCIAL	0.41	0.42	0.42	0.42	0.42	0.43	0.43	0.43	0.43	0.44	0.44	0.44	0.44	0.44	0.44
OTHER (FUEL COMBUSTION)	0.08	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05
SEWAGE TREATMENT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LANDFILLS	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
INCINERATORS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SOIL REMEDIATION	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08
OTHER (WASTE DISPOSAL)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LAUNDERING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DEGREASING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COATINGS AND RELATED PROCESS SOLVENTS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PRINTING	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06
ADHESIVES AND SEALANTS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER (CLEANING AND SURFACE COATINGS)	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
OIL AND GAS PRODUCTION	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
PETROLEUM REFINING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PETROLEUM MARKETING	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04
OTHER (PETROLEUM PRODUCTION AND MARKETI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CHEMICAL	2.01	2.25	2.36	2.49	2.54	2.62	2.67	2.73	2.80	2.86	2.93	3.02	3.08	3.19	3.34
FOOD AND AGRICULTURE	4.80	4.78	4.76	4.75	4.71	4.70	4.71	4.71	4.72	4.72	4.71	4.72	4.72	4.73	4.75
MINERAL PROCESSES	1.92	1.98	2.01	2.07	2.12	2.15	2.17	2.20	2.23	2.26	2.32	2.38	2.42	2.47	2.56
METAL PROCESSES	0.13	0.14	0.14	0.14	0.15	0.16	0.16	0.16	0.16	0.17	0.18	0.19	0.19	0.19	0.21
WOOD AND PAPER	0.42	0.41	0.42	0.44	0.45	0.47	0.47	0.48	0.48	0.49	0.49	0.67	0.76	0.94	0.99
GLASS AND RELATED PRODUCTS	1.00	1.03	1.03	1.08	1.10	1.12	1.15	1.17	1.20	1.22	1.25	1.29	1.31	1.35	1.42
OTHER (INDUSTRIAL PROCESSES)	0.11	0.12	0.12	0.13	0.13	0.13	0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.16	0.17
Stationary Subtotal	16.28	16.83	17.02	17.18	17.29	17.41	17.52	17.63	17.76	17.89	18.04	18.45	18.68	19.09	19.47
Area-Wide															
CONSUMER PRODUCTS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ARCHITECTURAL COATINGS AND RELATED PROC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PESTICIDES/FERTILIZERS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ASPHALT PAVING / ROOFING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESIDENTIAL FUEL COMBUSTION	0.85	0.82	0.80	0.77	0.75	0.74	0.73	0.72	0.70	0.69	0.70	0.71	0.71	0.72	0.74
FARMING OPERATIONS	27.52	24.16	22.80	22.93	22.99	20.99	21.09	21.20	21.30	21.40	21.51	21.72	21.82	22.04	22.40
CONSTRUCTION AND DEMOLITION	2.73	2.45	2.68	2.44	2.67	2.69	2.47	2.49	2.51	2.53	2.55	2.60	2.62	2.66	2.47
PAVED ROAD DUST	7.85	7.95	8.13	7.82	8.09	8.35	8.56	8.76	8.97	9.17	9.38	9.80	10.00	10.42	11.11
UNPAVED ROAD DUST	11.37	10.82	10.69	10.41	10.44	10.24	10.28	10.32	10.35	10.39	10.42	10.53	10.58	10.69	10.89
FUGITIVE WINDBLOWN DUST	15.24	13.96	13.45	13.22	13.18	12.47	12.43	12.39	12.35	12.31	12.27	12.20	12.16	12.09	12.04
FIRES	0.15	0.16	0.16	0.17	0.17	0.17	0.17	0.18	0.18	0.18	0.18	0.19	0.19	0.20	0.21
MANAGED BURNING AND DISPOSAL	16.60	16.48	16.44	16.37	16.33	16.30	16.26	16.23	16.19	16.15	16.11	16.03	15.99	15.90	15.80
COOKING	1.22	1.24	1.25	1.29	1.31	1.33	1.35	1.37	1.39	1.41	1.43	1.47	1.49	1.53	1.60
OTHER (MISCELLANEOUS PROCESSES)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Area-Wide Subtotal	83.55	78.04	76.44	75.44	75.94	73.30	73.36	73.66	73.96	74.26	74.58	75.26	75.59	76.26	77.27
On-Road Mobile															
LIGHT DUTY PASSENGER (LDA)	0.77	0.77	0.78	0.80	0.83	0.86	0.89	0.90	0.92	0.93	0.95	0.99	1.00	1.05	1.15
LIGHT DUTY TRUCKS - 1 (LDT1)	0.27	0.27	0.27	0.27	0.28	0.28	0.29	0.29	0.30	0.30	0.31	0.31	0.32	0.33	0.36
LIGHT DUTY TRUCKS - 2 (LDT2)	0.54	0.65	0.66	0.68	0.71	0.74	0.77	0.79	0.81	0.82	0.84	0.88	0.89	0.93	1.04
MEDIUM DUTY TRUCKS (MDV)	0.24	0.35	0.35	0.37	0.39	0.41	0.43	0.44	0.46	0.47	0.48	0.50	0.51	0.54	0.60
LIGHT HEAVY DUTY GAS TRUCKS - 1 (LHDV1)	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.07
LIGHT HEAVY DUTY GAS TRUCKS - 2 (LHDV2)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
MEDIUM HEAVY DUTY GAS TRUCKS (MHDV)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
HEAVY HEAVY DUTY GAS TRUCKS (HHDV)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
LIGHT HEAVY DUTY DIESEL TRUCKS - 1 (LHDV1)	0.01	0.06	0.06	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03
LIGHT HEAVY DUTY DIESEL TRUCKS - 2 (LHDV2)	0.03	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02
MEDIUM HEAVY DUTY DIESEL TRUCKS (MHDV)	0.56	0.63	0.62	0.56	0.56	0.55	0.53	0.51	0.49	0.47	0.45	0.42	0.41	0.39	0.38
HEAVY HEAVY DUTY DIESEL TRUCKS (HHDV)	8.92	9.01	10.81	8.69	8.13	7.56	7.01	6.48	5.96	5.47	5.00	4.17	3.81	3.23	2.68
MOTORCYCLES (MCY)	0.02	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
HEAVY DUTY DIESEL URBAN BUSES (UB)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
HEAVY DUTY GAS URBAN BUSES (UB)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SCHOOL BUSES (SB)	0.08	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.11
OTHER BUSES (OB)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
MOTOR HOMES (MH)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
On-Road Subtotal	11.56	12.05	13.86	11.70	11.23	10.74	10.27	9.77	9.28	8.81	8.38	7.62	7.30	6.82	6.58
Other Mobile															
AIRCRAFT	1.33	1.36	1.43	2.02	2.08	2.19	2.31	2.35	2.39	2.44	2.48	2.57	2.62	2.72	2.72
TRAINS	0.60	0.60	0.59	0.54	0.54	0.54	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.54	0.54
SHIPS AND COMMERCIAL BOATS	0.07	0.06	0.07	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.05
RECREATIONAL BOATS	0.71	0.79	0.83	0.92	0.97	1.02	1.08	1.14	1.20	1.27	1.33	1.48	1.55	1.70	1.98
OFF-ROAD RECREATIONAL VEHICLES	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.09
OFF-ROAD EQUIPMENT	3.81	3.52	3.41	2.99	2.81	2.64	2.46	2.26	2.07	1.89	1.73	1.43	1.31	1.10	0.91
FARM EQUIPMENT	4.03	3.63	3.48	3.03	2.89	2.79	2.64	2.42	2.19	1.99	1.82	1.50	1.34	1.06	0.73
FUEL STORAGE AND HANDLING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Mobile Subtotal	10.60	10.02	9.85	9.60	9.38	9.27	9.11	8.79	8.47	8.21	7.99	7.61	7.47	7.24	7.02
Grand Total	121.98	116.94	117.17	113.92	113.84	110.72	110.26	109.85	109.48	109.17	108.99	108.94	109.04	109.41	110.34

SOX - SJV - SUMMER PLANNING INVENTORY -- ADJUSTED FOR MEASURES AND CATEGORIES THROUGH 31 DEC 2006															
SUBCATEGORY	2002	2005	2006	2008	2009	2010	2011	2012	2013	2014	2015	2017	2018	2020	2023
Stationary															
ELECTRIC UTILITIES	0.89	0.90	0.90	0.90	0.90	0.91	0.91	0.91	0.92	0.92	0.92	1.01	1.06	1.16	1.22
COGENERATION	0.71	0.75	0.78	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.78	0.78	0.77
OIL AND GAS PRODUCTION (COMBUSTION)	2.05	2.25	2.35	2.26	2.25	2.24	2.25	2.25	2.26	2.27	2.28	2.32	2.35	2.39	2.49
PETROLEUM REFINING (COMBUSTION)	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
MANUFACTURING AND INDUSTRIAL	6.27	6.82	6.89	7.06	7.14	7.29	7.44	7.58	7.73	7.88	8.02	8.14	8.20	8.32	8.52
FOOD AND AGRICULTURAL PROCESSING	2.55	2.53	2.52	2.50	2.49	2.48	2.47	2.47	2.46	2.45	2.44	2.43	2.42	2.41	2.40
SERVICE AND COMMERCIAL	0.87	0.90	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.92	0.92	0.91	0.90	0.90	0.89
OTHER (FUEL COMBUSTION)	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05
SEWAGE TREATMENT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LANDFILLS	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.08	0.08	0.08	0.08
INCINERATORS	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
SOIL REMEDIATION	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER (WASTE DISPOSAL)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LAUNDERING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DEGREASING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COATINGS AND RELATED PROCESS SOLVENTS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PRINTING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ADHESIVES AND SEALANTS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER (CLEANING AND SURFACE COATINGS)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OIL AND GAS PRODUCTION	0.19	0.22	0.24	0.24	0.24	0.24	0.24	0.24	0.25	0.25	0.25	0.25	0.25	0.26	0.26
PETROLEUM REFINING	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
PETROLEUM MARKETING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER (PETROLEUM PRODUCTION AND MARKETI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CHEMICAL	0.93	0.97	0.99	1.02	1.04	1.06	1.08	1.09	1.11	1.13	1.14	1.17	1.19	1.23	1.28
FOOD AND AGRICULTURE	0.79	0.79	0.79	0.79	0.80	0.80	0.80	0.80	0.80	0.81	0.81	0.81	0.81	0.82	0.82
MINERAL PROCESSES	1.47	1.53	1.55	1.61	1.64	1.67	1.70	1.74	1.77	1.80	1.83	1.89	1.92	1.98	2.07
METAL PROCESSES	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
WOOD AND PAPER	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
GLASS AND RELATED PRODUCTS	3.70	3.79	3.81	3.99	4.07	4.17	4.26	4.34	4.44	4.52	4.63	4.79	4.87	5.03	5.29
OTHER (INDUSTRIAL PROCESSES)	0.22	0.23	0.23	0.24	0.24	0.24	0.25	0.25	0.26	0.26	0.26	0.27	0.28	0.28	0.29
Stationary Subtotal	21.15	22.20	22.46	22.81	23.02	23.32	23.62	23.91	24.21	24.51	24.82	25.34	25.60	26.12	26.87
Area-Wide															
CONSUMER PRODUCTS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ARCHITECTURAL COATINGS AND RELATED PROC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PESTICIDES/FERTILIZERS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ASPHALT PAVING / ROOFING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESIDENTIAL FUEL COMBUSTION	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05
FARMING OPERATIONS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CONSTRUCTION AND DEMOLITION	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAVED ROAD DUST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UNPAVED ROAD DUST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FUGITIVE WINDBLOWN DUST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FIRES	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MANAGED BURNING AND DISPOSAL	1.15	1.15	1.15	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.13	1.13	1.13	1.13
COOKING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER (MISCELLANEOUS PROCESSES)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Area-Wide Subtotal	1.21	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.19	1.19	1.19	1.19	1.19	1.18	1.18
On-Road Mobile															
LIGHT DUTY PASSENGER (LDA)	0.26	0.18	0.18	0.17	0.18	0.18	0.19	0.19	0.20	0.20	0.21	0.22	0.22	0.23	0.25
LIGHT DUTY TRUCKS - 1 (LDT1)	0.12	0.09	0.09	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.09
LIGHT DUTY TRUCKS - 2 (LDT2)	0.13	0.11	0.11	0.10	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.13	0.13	0.14	0.15
MEDIUM DUTY TRUCKS (MDV)	0.09	0.09	0.09	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.11
LIGHT HEAVY DUTY GAS TRUCKS - 1 (LHDV1)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
LIGHT HEAVY DUTY GAS TRUCKS - 2 (LHDV2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
MEDIUM HEAVY DUTY GAS TRUCKS (MHDV)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HEAVY HEAVY DUTY GAS TRUCKS (HHDV)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LIGHT HEAVY DUTY DIESEL TRUCKS - 1 (LHDV1)	0.00	0.05	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LIGHT HEAVY DUTY DIESEL TRUCKS - 2 (LHDV2)	0.02	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MEDIUM HEAVY DUTY DIESEL TRUCKS (MHDV)	0.18	0.23	0.23	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04
HEAVY HEAVY DUTY DIESEL TRUCKS (HHDV)	1.47	1.76	2.20	0.22	0.23	0.23	0.24	0.24	0.25	0.26	0.27	0.28	0.29	0.31	0.33
MOTORCYCLES (MCY)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HEAVY DUTY DIESEL URBAN BUSES (UB)	0.02	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HEAVY DUTY GAS URBAN BUSES (UB)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SCHOOL BUSES (SB)	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER BUSES (OB)	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MOTOR HOMES (MH)	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
On-Road Subtotal	2.36	2.62	3.04	0.71	0.73	0.75	0.77	0.78	0.80	0.82	0.84	0.89	0.91	0.95	1.02
Other Mobile															
AIRCRAFT	0.42	0.45	0.45	0.50	0.51	0.52	0.54	0.54	0.55	0.56	0.57	0.58	0.59	0.60	0.61
TRAINS	0.68	0.71	0.73	0.07	0.07	0.07	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
SHIPS AND COMMERCIAL BOATS	0.25	0.31	0.33	0.12	0.13	0.08	0.08	0.09	0.09	0.10	0.10	0.12	0.12	0.14	0.16
RECREATIONAL BOATS	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
OFF-ROAD RECREATIONAL VEHICLES	0.08	0.06	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.09	0.10	0.10	0.11	0.11	0.13
OFF-ROAD EQUIPMENT	0.46	0.48	0.49	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06
FARM EQUIPMENT	0.51	0.51	0.51	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
FUEL STORAGE AND HANDLING	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Mobile Subtotal	2.41	2.53	2.58	0.87	0.89	0.86	0.83	0.84	0.86	0.88	0.90	0.93	0.95	0.99	1.05
Grand Total	27.14	28.55	29.29	25.60	25.85	26.13	26.41	26.73	27.07	27.40	27.75	28.34	28.65	29.24	30.12

Appendix B

Weight-of-Evidence Analysis
San Joaquin Valley Air Basin: Ozone

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Appendix B

Weight-of-Evidence Analysis
San Joaquin Valley Air Basin: Ozone

Introduction

Under federal law, the San Joaquin Valley Air Basin (San Joaquin Valley, SJV, Valley, or Basin) is currently classified as a Serious nonattainment area for the federal 8-hour ozone standard. This classification requires attainment by June 15, 2013. Given the magnitude of emissions reductions needed to reach attainment, including reductions relying on new or the improvement of existing control technologies, it is not likely the Valley will meet the 2013 attainment date. In such cases, the federal Clean Air Act allows, and U.S. EPA recommends, bumping-up to an appropriate higher classification with a later attainment date. Based on analyses, an Extreme classification, with an attainment date of June 15, 2024, is the Valley's most realistic option. The following sections describe the air quality, emissions, and supplemental analyses, as well as the photochemical modeling that support the overall conclusion that the San Joaquin Valley can attain the federal 8-hour ozone standard by the 2024 deadline.

U.S. EPA Attainment Demonstration Requirements

The attainment demonstration portion of a State Implementation Plan or SIP consists of the analyses used to determine whether a proposed control strategy provides the reductions necessary to meet the federal standard by the attainment year. This attainment demonstration includes photochemical modeling which predicts that projected controls will result in a high site 8-hour design value for the SJV that is below the level of the federal standard by 2024. While reclassifying as Extreme extends the attainment date, the Valley should nevertheless realize substantial progress over the next decade. Air quality modeling predicts that all sites in the Basin will reach attainment prior to 2024, with the exception of several sites with the most severe air quality problems. However, with the implementation of proposed emissions control measures, ozone air quality in these areas is projected to meet the standard by the 2024 deadline.

Because of the uncertainties inherent in photochemical modeling, U.S. EPA allows states to supplement the modeling results with a "weight of evidence" (WOE) demonstration. The WOE assessment provides a set of analyses that complement the SIP-required modeling. These analyses can include consideration of measured air quality, emissions, and meteorological data, evaluation of other air quality indicators, as well as additional air quality modeling, if appropriate. Because all analysis methods have inherent strengths and weaknesses, examining an air quality problem in a variety of ways helps to offset the limitations and uncertainties inherent to air quality modeling. This

approach also provides a better understanding of the overall problem, as well as insight about the level and mix of emissions controls needed for attainment.

The scope of the WOE analysis is different for each nonattainment area, with the level of appropriate detail dependent upon the complexity of the air quality problem, how far into the future the attainment deadline is, and the amount of data and modeling available. This document summarizes the analyses that comprise the WOE assessment for the San Joaquin Valley nonattainment area.

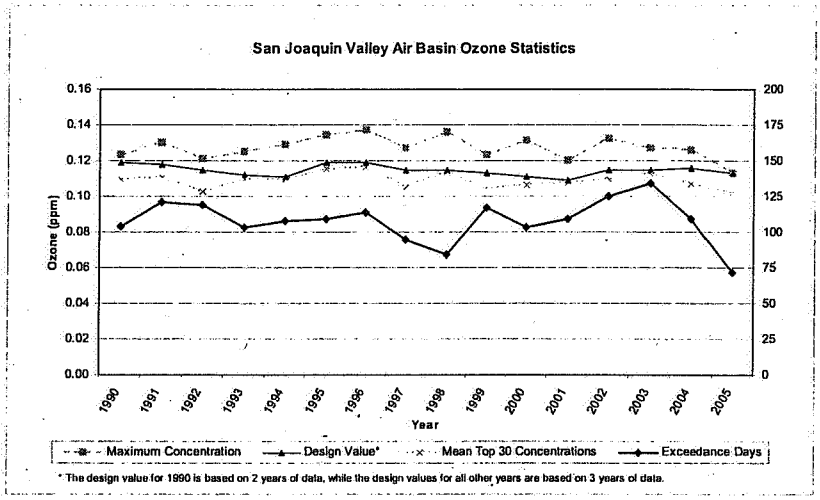
Historical Context

Over the years, ozone has posed a persistent problem in the San Joaquin Valley. Looking at ozone air quality from an historical perspective is challenging because of the lack of long-term sites in this area. Between 1975 and 1990, monitoring began at a number of sites, but was discontinued after several years. Furthermore, these transient monitors did not include sites in the worst areas of the central and southern portions of the Basin. For these reasons, 1990 was chosen as the start year for long-term trends in the SJV. 1990 is the first year for which Arvin, consistently one of the highest sites in the Valley, has complete data during the May through October ozone season. In addition, data are available for a number of other typically high concentration sites, including Clovis, Edison, Parlier, and several Fresno area sites.

Over the long-term, emissions control programs have improved ozone air quality in the SJV, but not to the same degree as seen in other areas of California. Both the climate and geography of the Valley present significant challenges to progress in the SJV. Figure B-1 shows the 1990 to 2005 basinwide trends for several air quality indicators. Because the trend lines for both federal 8-hour exceedance days and maximum concentrations reflect values for individual years, they show a fair amount of variability, with only a small amount of progress over the 15-year period. Overall, the decrease in the number of exceedance days was more substantial than the decrease in maximum concentrations. In contrast to these two indicators, the other two indicators shown on the graph, the design value and the mean of the maximum concentrations on the Top 30 days, are less variable because these indicators are more robust. While these two indicators show even less change over the 15-year period, the 2005 values are lower than the 1990 values.

Although not shown in Figure B-1, perhaps the greatest indicator of ozone air quality improvement in the SJV is the reduction in population-weighted exposure. This indicator shows a 50 percent reduction in exposure to concentrations above the level of the federal 8-hour standard between 1990 and 2005. Despite the gains in improving population-weighted exposure, the overall rate of progress for other indicators in the SJV has been slow, and this area will face tremendous challenges in reaching attainment.

Figure B-1: San Joaquin Valley Air Basin Ozone Statistics 1990 to 2005



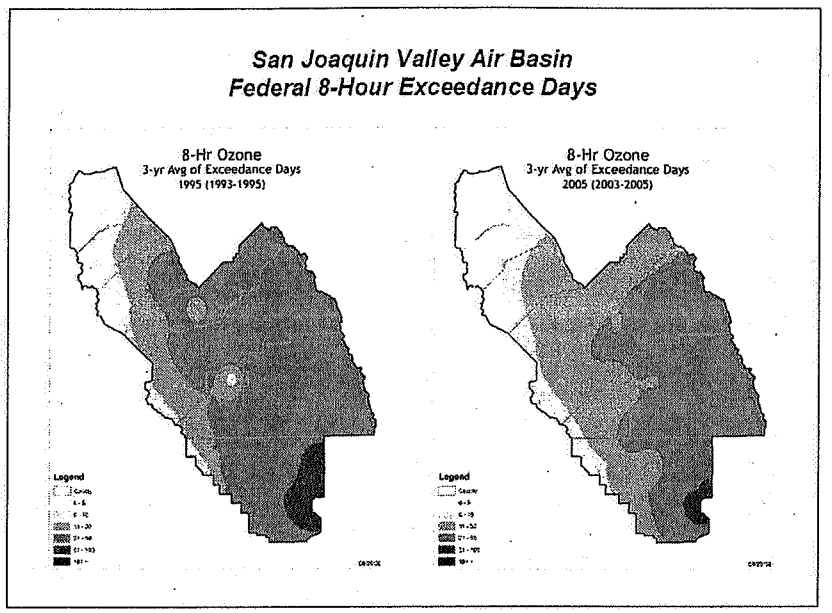
Assessment of Recent Air Quality Trends

General Basinwide Perspective

Over the years, ozone improvement in the SJV has lagged behind other areas of California, and the Valley ranks second only to the South Coast Air Basin with respect to the nation's worst ozone air quality. Modest levels of progress have occurred in the SJV over the last ten years, with a 15 percent drop in maximum concentration, a 5 percent drop in design value, and a 35 percent drop in exceedance days between 1995 and 2005 (refer to Figure B-1). However, most of this improvement has occurred since 2003. While values for 2006 were up slightly from 2005 (maximum concentration of 0.121 ppm and 86 exceedance days), they were still among the lowest values over the last 15 years. Ozone levels in the SJV are not as high as in the South Coast; however, maximum concentrations during 2006 were still more than 40 percent higher than the federal standard, with nearly three months of exceedance days each year.

While ozone levels are still unhealthy, modest improvements over the years have resulted in a reduction of the extent of the problem, especially in the northern portion of the Valley. The maps in Figure B-2 are based on monitoring data and estimate the reduction in days exceeding the national 8-hour standard over the last decade (1995 to 2005), throughout the San Joaquin Valley, thereby providing an estimate of the spatial extent of the ozone problem. Ten years ago (1993 to 1995 average map), more than half of the SJV experienced between 21 and 50 federal 8-hour exceedance days, with the worst site experiencing about 90 days. Areas in the northern SJV were cleaner than areas in the central and southern Valley. However, only a relatively small portion of the Basin averaged 10 or fewer exceedance days.

Figure B-2: San Joaquin Valley Air Basin Change in Federal 8-Hour Exceedance Days 1995 to 2005



Today (2003 to 2005 average map), we see a substantial expansion of areas with 10 or fewer exceedance days. Ambient concentrations in most of San Joaquin and Stanislaus counties are now below the level of the federal 8-hour ozone standard. Much of the rest of the Valley experiences an average of only 6 to 20 exceedance days per year. Areas with more than 20 exceedance days are now generally limited to the eastern portion of the central and southern SJV. While the extent of these areas is much smaller than during 1995, the areas of poor ozone air quality are also some of the most heavily populated (Fresno and Kern counties). Even though these areas still pose a substantial challenge, the worst sites show an average reduction in exceedance days of approximately 35 percent over the last ten years.

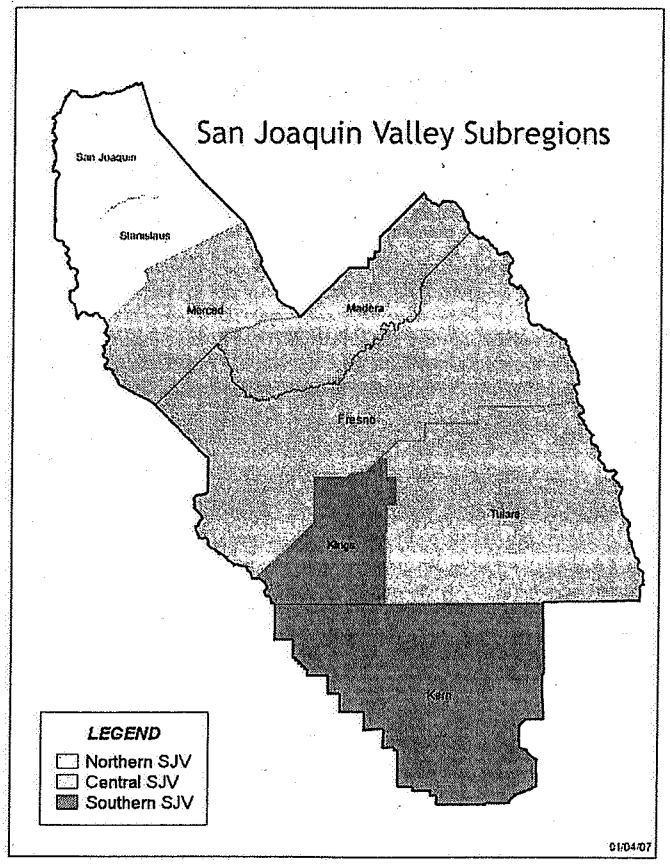
In summary, although there has been some progress in the SJV over the last ten years, the rate of progress has been slow in comparison to other areas of the State. Overall, the trend lines for various air quality indicators, including maximum concentration, exceedance days, design value, and mean of the Top 30 concentrations, are relatively flat, with some year-to-year variability caused by meteorology (refer to Figure B-1). Most of the progress seen over the last 15 years has occurred since 2003. While there has been only a 15 percent decrease in maximum concentration since 1995, the decrease in the number of exceedance days has been more substantial, at close to 35 percent. In spite of the slow rate of progress, the ozone problem is now confined mostly to the central and southern portions of the Valley, as continued emissions reductions have been successful in shrinking the spatial extent of the problem areas. At the

same time, the "clean" areas have expanded substantially, and nearly all of San Joaquin and Stanislaus counties now have air quality that meets the federal 8-hour standard. However, although these counties are generally clean with respect to ozone, emissions from these northern SJV areas can impact ozone air quality in other portions of the Valley.

Regional Analyses

The basinwide air quality indicators for the SJV show limited progress because they are dominated by the high sites, which pose the most severe problems. However, when the Basin is subdivided into different regions, different patterns of progress emerge. For the following discussion, the Valley is divided into three general areas, as shown in Figure B-3: the northern SJV, the central SJV, and the southern SJV. For convenience, these regions are divided along county boundaries. However, they generally represent three distinct areas with respect to geography, meteorology, and air quality. While ozone air quality within each of the three subregions tends to be similar, the level of air quality and rates of progress from one area to another can vary substantially.

Figure B-3: San Joaquin Valley Air Basin Subregions



A third of the Basin population lives in the northern SJV. This lowland area is bordered by the Sacramento Valley and Delta lowland to the north, the central portion of the SJV to the south, and on the other two sides by mountains. Because of the marine influence, which extends into this area through gaps in the coastal mountains to the west, the northern SJV experiences a more temperate climate than the rest of the Basin. These cooler temperatures and the predominant air flow patterns generally favor better ozone air quality.

In contrast to the northern SJV, most of the Valley population lives in the central and southern portions of the Basin, in and around the Fresno and Bakersfield urban areas. Sites in the central and southern areas exceed the federal standard by the greatest margin, and geography, emissions, and climate pose significant challenges to air quality progress. Similar to the northern SJV, the central and southern SJV are also low lying areas, flanked by mountains on their west and east sides. The southern SJV represents the terminus of the Valley and is flanked by mountains on the south, as well. The surrounding mountains in both areas act as barriers to air flow, and combined with recirculation patterns and stable air, trap emissions and pollutants. The higher temperatures and more stagnant conditions in these two regions lead to a build-up of ozone and overall poorer air quality. In addition to the urban air quality problems, emissions and pollutants from these areas are transported downwind, making for even poorer air quality in downwind areas such as Arvin and the Sequoia National Park.

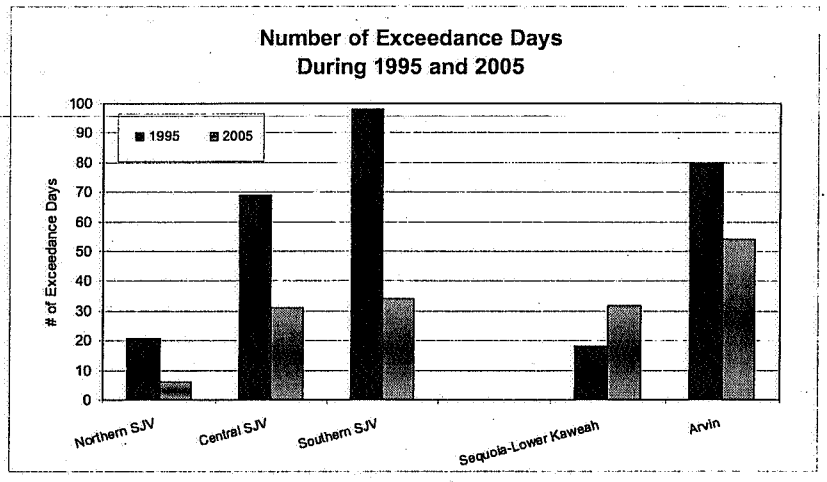
ARB staff completed an analysis of ozone episodes that occurred in both the central and southern SJV during 2004 and 2005. Based on these data, high ozone concentrations occurred as multi-day episodes more than 65 percent of the time, in both regions. Furthermore, episodes with higher federal 8-hour concentrations typically spanned a greater number of days, with the highest concentrations occurring in the middle of the episode period. During 2004 and 2005, more than 75 percent of the central SJV ozone episodes showed their highest 8-hour concentration at sites located within the Sequoia National Park. During more than 40 percent of the episodes, exceedances were limited only to sites located within the Sequoia National Park. While the downwind Sequoia sites tend to be the most problematic in the central SJV, is it interesting to note that very few central SJV episodes began prior to the start of an episode in the southern SJV. In fact, nearly 90 percent of the central SJV episodes started on the same day or during an ozone episode in the southern SJV. The most problematic site in the southern SJV is Arvin, and during 2004 and 2005, about 95 percent of the southern SJV ozone episodes showed their highest 8-hour concentration at Arvin:

Figure B-4 shows the average number of exceedance days during 1995 and 2005 for each of the subregions mapped in Figure B-3. Two sites, Sequoia National Park-Lower Kaweah and Arvin are plotted separately, and therefore, data for these two sites are not included in the totals for the central and southern SJV areas. The Sequoia National Park-Lower Kaweah and Arvin sites are

located downwind of the Fresno and Bakersfield urban areas, respectively, and tend to have poorer air quality.

The northern SJVAB continues to be far cleaner than the other areas of the SJV. Over the last decade, the number of exceedance days in this area has decreased about 70 percent. During 2005, about 80 percent of the days during the May through October ozone season were below the more stringent State 8-hour standard. However, while the number of days in this region has shown improvement, Modesto stands out as the high site in the northern SJV.

Figure B-4: San Joaquin Valley Air Basin Change in Number of Federal 8-Hour Exceedance Days by Subregion 1995 and 2005



From north to south, the severity of the ozone problem in the SJV generally increases. Between 1995 and 2005, the number of exceedance days at sites in the central SJV (excluding the Sequoia area) decreased 55 percent. Although the decrease is still relatively high, the number of days in the central SJV during 2005 was five times higher than in the northern SJV. The number of exceedance days in the southern SJV (excluding Arvin) decreased about 65 percent during the last decade, and the number of exceedance days during 2005 was just slightly higher than the number of days in the central SJV. With respect to days below the State 8-hour standard, about 40 percent of the days during the ozone season were below this level in both the central SJV and the southern SJV areas during 2005. Similar to the basinwide trends, most of the progress in the central and southern SJV subregions has occurred since 2003.

The sites downwind of the Fresno and Bakersfield urban areas continue to pose the most severe problems in the SJV, and improvements in these areas have been much slower than in other areas. Arvin has always been one of the high sites in the Basin. Between 1995 and 2005, federal exceedance days declined

about 30 percent, which is lower than the rate seen at other sites in the southern SJV region. In contrast, sites located at higher elevations in the Sequoia National Park have shown worsening ozone air quality over the last several years. Between 1995 and 2005, the number of federal exceedance days actually increased more than 75 percent at the Sequoia-Lower Kaweah site. This increase highlights the problem of transported emissions and pollutants from the upwind urban area. The Sequoia-Lower Kaweah site was used in this comparison because it is a long-term site with data for both 1995 and 2005. However, it should be noted that during 2005, the Sequoia-Kings Canyon site had even poorer air quality. In fact, during 2005, the Kings Canyon site had the same number of exceedance days as Arvin, as well as a similar maximum concentration.

Similar to exceedance days, concentrations have also been decreasing at a faster rate in the urban areas than at Arvin or Sequoia. Peak concentrations, as measured by the mean of the Top 4 daily concentrations, decreased only 3 percent over the last five years at Arvin and increased in the Sequoia area. However, the same indicator decreased at twice that rate in the Bakersfield and Fresno urban areas. Today, the 4th highest 8-hour ozone concentration averages 0.095 ppm for sites in both urban areas, compared with 0.105 ppm five years ago. Similarly, the mean of the Top 30 concentrations for both urban areas is declining and is now close to the level of the federal standard. The mean of the Top 30 concentrations is 0.084 ppm for the Fresno/Merced area and 0.089 ppm for the Bakersfield region. Five years ago, both of these urban areas had mean Top 30 concentrations greater than 0.100 ppm. Although the mean of the Top 30 concentrations is not directly comparable to the federal standard, it is a fairly stable statistic that is less influenced by year-to-year changes in meteorology. Therefore, it provides an indication of how concentrations on the worst days of the year are changing over time.

In summary, there have been changes in the patterns of exceedances on a subregional basis in the SJV over the last ten years. Today, the numbers of exceedance days in all areas except the Sequoia region are smaller than they were ten years ago. The most progress occurred in the northern SJV, and ozone concentrations in this area are now below the level of the more stringent State 8-hour standard 80 percent of the time during the ozone season. Trends in peak ozone concentrations reflect similar subregional differences. Based on current air quality and past trends, the areas downwind of Bakersfield and Fresno will likely pose the most difficulty for attainment.

Meteorology and Air Quality Trends

Ozone in the ambient air is the result of several factors, two of the most important being pollutant emissions and meteorology. The meteorological and photochemical processes leading to ozone formation are complex,

involving interactions both at the surface and in the upper air. However, they can be characterized in very general terms: strong sunlight and weak dispersion generate relatively high ozone levels, while weak sunlight and strong dispersion generate relatively low ozone levels. Meteorology, or weather conditions, can vary widely, and these day-to-day conditions strongly influence ambient ozone concentrations.

The previous trends discussion looked at air quality as measured at ambient monitoring sites, without any consideration of or adjustment for meteorological variability. The following discussions characterize the general meteorological conditions leading to high ozone concentrations, as well as several different methods of accounting for meteorological variability. These analyses are an effort to better understand the impact of meteorology on air quality and thereby track improvements attributable to emissions reductions. Another goal of these analyses is to determine the role meteorology has played in the SJV, where ozone improvement has lagged behind other areas of the State. Although ozone improvements have been slower to occur in the SJV, the following analyses show that modest progress has occurred.

Characterization and Frequency of Episodic Conditions

In evaluating the meteorological conditions associated with ozone episodes, ARB staff identified three well-defined patterns as being associated with the majority of episodes. Collectively, these three patterns are associated with nearly 90 percent of the 8-hour exceedances. Summertime meteorology in the Valley is dominated by a constant ebb and flow between high atmospheric pressure over the Southwest Desert and low pressure over the Gulf of Alaska. When a high pressure ridge moves over California, stagnant conditions can persist for several days, resulting in widespread violations of the federal 8-hour standard. When a low pressure trough pushes inland, the Valley floor may see considerable improvements in air quality. However, downwind transport-impacted areas may experience higher concentrations.

In order to categorize the air flow patterns prevalent in the San Joaquin Valley, ARB staff performed a cluster analysis involving all days during May through October, 1990 through 2005. Subsequently, staff considered the meteorological characteristics of a subset of the clusters (2000 through 2005) and the incidence of federal 8-hour ozone episodes found in each cluster. These assessments show that nearly 90 percent of the SJV federal 8-hour exceedances are associated with three meteorological patterns, each distinguishable by the relative dominance of a high pressure ridge versus a low pressure trough. These patterns are generally characterized by high pressure aloft, mostly clear skies, warm temperatures, and strong morning inversions. The differences between the patterns are seen through large-scale variations in atmospheric pressure along the coast.

Under the "high pressure ridge pattern," a ridge of high pressure covers all of the SJV, leaving the region with clear skies and very warm temperatures. Surface winds are terrain driven, with little or no sea breeze moving through the Carquinez Strait. Average afternoon wind speeds typically range between 3 and 7 miles per hour (mph), with only a few hours above 10 mph recorded in the northern part of the Basin. Maximum surface temperatures normally reach 100 degrees in most areas, with occurrences of 105 degrees or greater during the peak summer months. The resulting stagnant conditions promote the formation of high ozone levels throughout the Basin, with maximum concentrations found close to the major source areas. Areas typically dominated by transport, such as the higher elevations of Sequoia National Park, will exhibit lower concentrations in comparison, as light winds keep pollution movement to a minimum. This pattern has led to the highest ozone readings in the Basin, and was associated with about half of the 8-hour ozone exceedances recorded during May through October of 2000 to 2005.

The "approaching trough pattern" causes ozone and its precursors to move downwind from source locations. Under this pattern, the high pressure ridge over central California is weaker, and this increases the sea breeze flowing through the Carquinez Strait. Average afternoon wind speeds range between 6 and 12 mph, with a few hours above 14 mph recorded in the northern parts of the Basin. The maximum surface temperatures reach into the upper 90s in most southern areas, with northern areas in the upper 80s to lower 90s. High ozone levels are observed downwind of the major urban source areas (for example, downwind of Stockton, Fresno, and Bakersfield). High ozone levels are also observed in the foothill areas, such as the Sequoia National Park area. During this weather pattern, the extreme northern sections of the Valley experience lower ozone concentrations, as increased wind flow pushes pollutants further south and east. During May through October of 2000 to 2005, the approaching trough pattern was associated with about 20 percent of the measured 8-hour ozone exceedances.

Finally, the "trough pattern" results in peak ozone further downwind of the major emission sources, primarily affecting the eastern and southernmost portions of the SJV. Under this pattern, the ridge of high pressure is weakened more significantly. This increases wind flow through the Carquinez Strait, causing temperature and ozone levels to be much lower over the northern and central portions of the Valley. Surface winds are predominantly from the west-northwest in the northern portion of the Basin. As the surface winds move southward, channeled by the terrain, they veer and become a northwest flow. Average afternoon wind speeds range between 8 and 16 mph, with some stronger gusts at night. Maximum temperatures still reach near 90 degrees or slightly above in most low lying areas of Kern and Tulare counties, with the northern areas in the 80s. Under this weather pattern, ozone levels peak in the southern region of the Basin, downwind of major emission source areas. The highest ozone levels are

found at sites such as Parlier, Arvin, and Sequoia National Park, where transport is typically the dominant mechanism for ozone and precursor movement. The trough pattern was associated with about 20 percent of the 8-hour ozone exceedances recorded during May through October, 2000 to 2005.

High Ozone Forming Potential

As one approach to help understand the types of meteorological conditions leading to high ozone concentrations, ARB staff completed an analysis of ozone and meteorology using Classification and Regression Tree (CART) techniques. The CART analysis determined rules that separated days into 15 groups, based on the degree to which weather conditions favor ozone formation. The CART rules used daily data for surface air temperature, air temperature at 1500 meters[1], wind speed/direction, atmospheric stability, and other factors in relation to daily maximum 8-hour ozone concentrations. From the 15 groups, a subset with high average ozone levels and containing on average about one-third of the ozone season were considered to represent high ozone forming potential (OFP).

The analysis, presented in Figure B-5, shows the number of days with high OFP along with the number of days exceeding the federal 8-hour ozone standard each year (three-year moving means). The changes in exceedance days relative to the changes in high OFP days helps distinguish changes due to meteorology from changes due to emissions reductions. Progress is shown when the number of exceedance days decreases in relation to the number of high OFP days.

The two lines generally track together, indicating that year-to-year changes in exceedance days have been largely attributable to year-to-year changes in weather, rather than changes in emissions. Relative to the high OFP line, however, the number of exceedance days has decreased. During the 1990's, the trend for exceedance days averaged 14 days above the trend for high OFP days. Since 1999, however, the trend for exceedance days averaged 4 days below the trend for high OFP days, indicating a "real" decrease of about 18 days.

Furthermore, the unsmoothed trends in Figure B-6 show the 68 exceedance days measured in 2005 was a new low for the Basin (note that the 68 exceedance days reflects only those occurring during the May through October ozone season). Three years, 1990, 1997, and 1999, had OFP values similar to 2005, but exceedance days during these years averaged 13 days above the OFP trend. In contrast, the 68 exceedance days measured during 2005 were 13 fewer than the number of high OFP days. These results indicate that some real progress in reducing ozone is now taking place in the SJV, as increasingly adverse meteorological conditions are needed to create ozone levels exceeding the federal 8-hour standard.

[1] Above sea level

Figure B-5: San Joaquin Valley Air Basin Three-Year Means of Federal 8-Hour Exceedance Days and High OFP Days 1990 to 2005

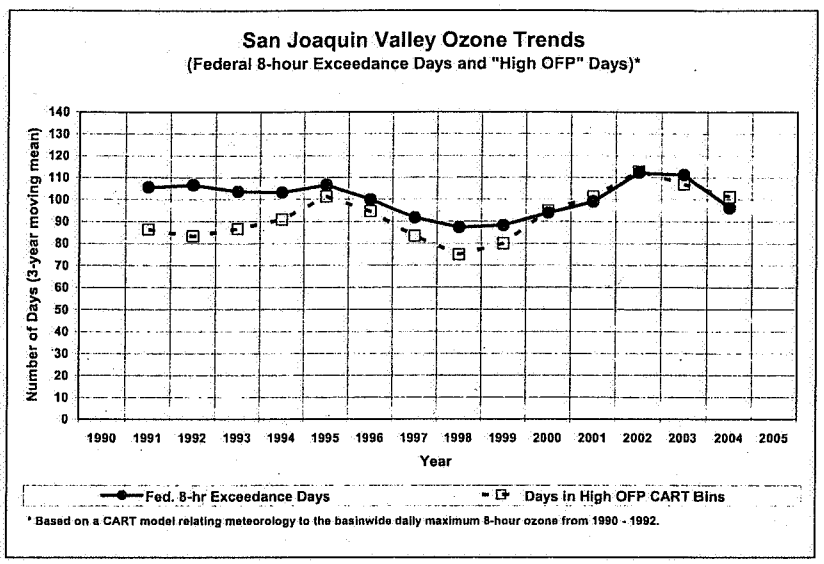
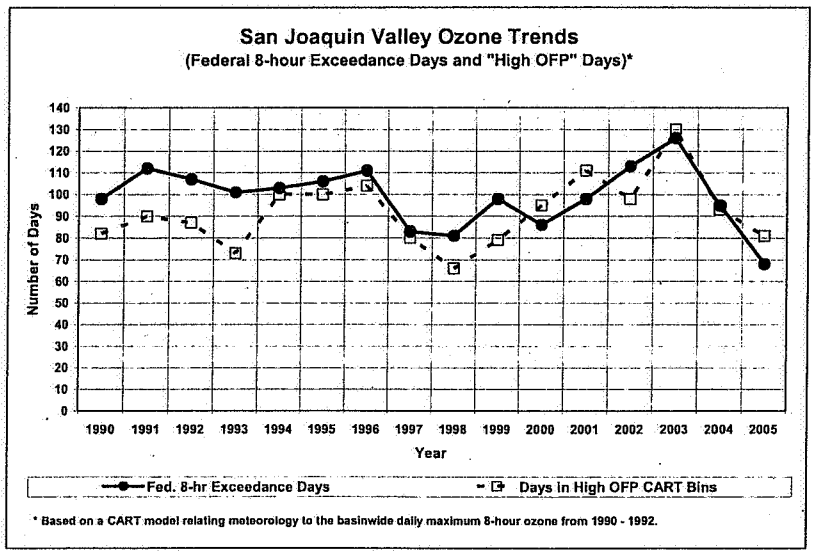


Figure B-6: San Joaquin Valley Air Basin Federal 8-Hour Exceedance Days and High OFP Days 1990 to 2005



Meteorologically Adjusted Trends

As discussed above, meteorological parameters such as temperature, pressure, and wind speed are systematically correlated with sunlight and dispersion, and can be used in formulas that predict daily ozone levels. As a second method to address the role of meteorology, a statistical model that predicts daily maximum ozone on the basis of daily meteorological data was used to adjust daily ozone observations.

First, days from the May through October ozone season for the years 1990 to 2005 were assigned to separate groups based on pressure and temperature gradients, along with selected wind speeds and directions. Together, three of the groups accounted for the vast majority of exceedance days during the ozone season in the San Joaquin Valley. For each of these groups, data from 1990 through 1993 were used to calibrate a within-group model to predict daily maximum 8-hour ozone from daily weather data. The limited span of years was used for calibration so that when it was applied for all the years (1990 through 2005), it would provide a level playing field for meteorological effects, apart from the influence of changes in emissions.

Met-adjusted trends are presented in the following three figures. The figures are based on data for basinwide daily maximum ozone concentrations after these have been reconciled to long-term meteorological norms regarding group frequencies and concentrations within each group. The three lines on each graph represent the mean of the Top 10, Top 20, and Top 30 met-adjusted concentrations. The trends in Figures B-8 and B-9 were smoothed using a three-year moving mean, because the process of met-adjustment does not remove all meteorological effects perfectly, and other factors also affect the year-to-year changes.

Figures B-7 and B-9 show that ozone declined approximately five percent from 1990 to 2005. An upswing in the trend from 2001 to 2004 may be attributable to meteorological effects for which the process of met-adjustment is incomplete. Following the upswing, the met-adjusted values for 2005 reached a new low for all three indicators, indicating that modest improvement (5 percent) in ozone occurred in the San Joaquin Valley in the 2000s, compared to the 1990s. It is also noteworthy that this progress has been similar for all three indicators: mean of the Top10, Top20, and Top30 ozone concentrations. This shows that the Top 30 (top 16 percent[2]) summer ozone concentrations have responded very similarly to emissions reductions in the SJV since 1990.

[2] The May – October ozone season has 184 days, of which 30 is 16%.

Figure B-7: San Joaquin Valley Air Basin Ozone Trends 1990 to 2005 Adjusted for Meteorology

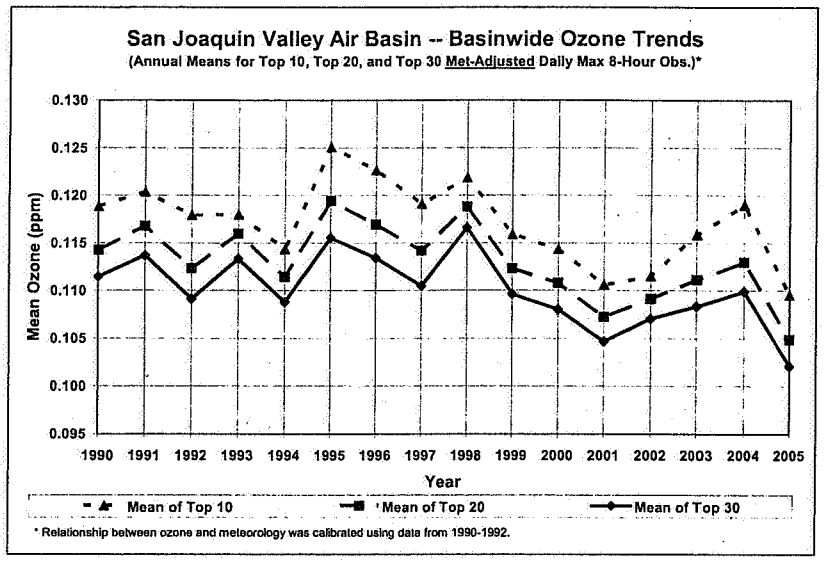


Figure B-8: San Joaquin Valley Air Basin Three-Year Mean Ozone Trends 1990 to 2005 Adjusted for Meteorology

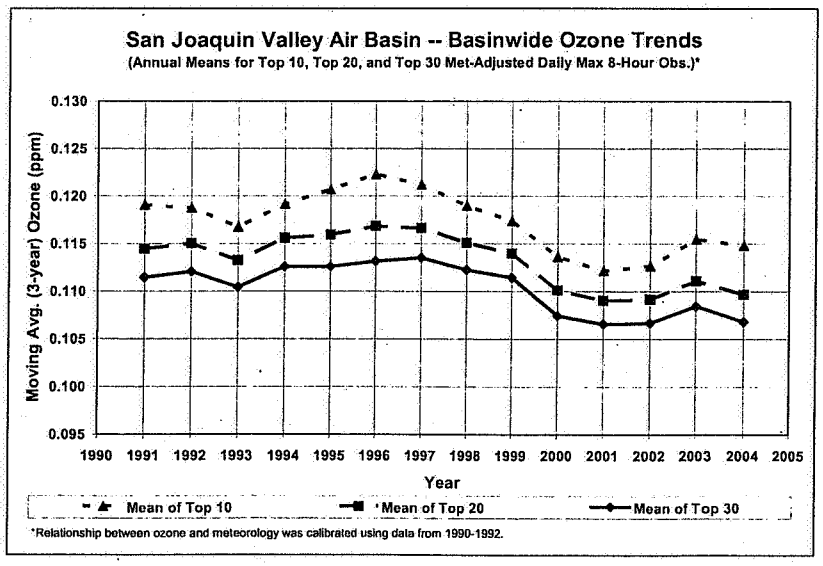
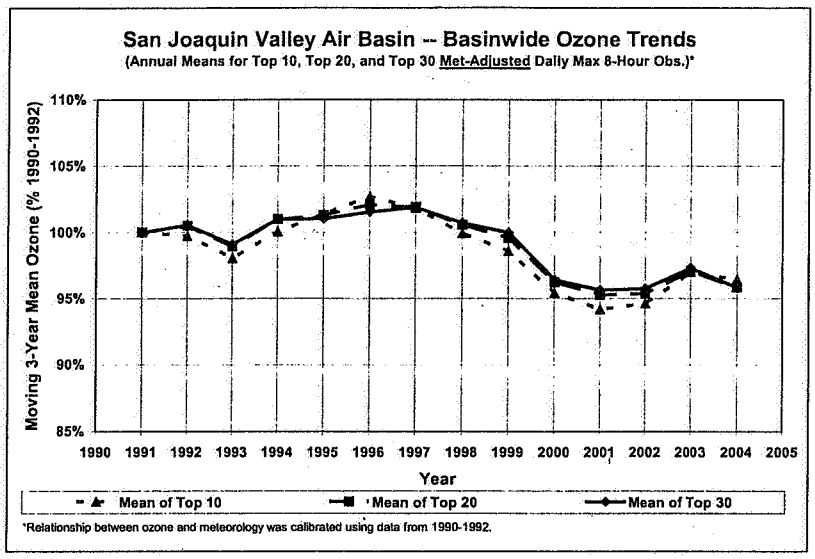


Figure B-9: San Joaquin Valley Air Basin Ozone Trends 1990 to 2005 Adjusted for Meteorology and Expressed as a Percentage of the Base Year



The above analyses use different methods to account for the variable impacts of meteorology on ozone air quality. Results of these analyses confirm that progress has occurred in the San Joaquin Valley Air Basin, especially during the last several years. Although adjusting ozone air quality for meteorology does not change the overall flatness of the trend in the SJV throughout most of the analysis period, it does show some measure of real progress during the most recent years.

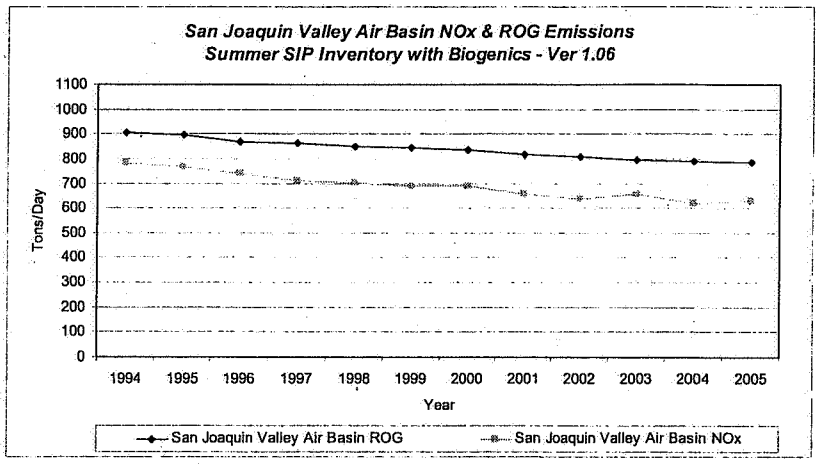
Emissions and Precursor Trends

Oxides of nitrogen (NOx) and reactive organic gases (ROG) are precursors to ozone. Emissions controls have reduced the amounts of these precursors throughout the Basin, resulting in the modest improvement in ozone air quality observed in the SJV. The following sections describe the NOx and ROG emissions trends in the SJV since 1994, as well as the amounts of these precursors measured in the ambient air.

Emissions Trends

Emissions controls have substantially reduced the amounts of both ROG and NOx emitted by various sources throughout the San Joaquin Valley. Figure B-10 shows the estimated basinwide trend in these precursor emissions from 1994 to 2005. The totals reflect estimates for the summer season in tons per day and include emissions from natural biogenic sources.

Figure B-10: San Joaquin Valley Air Basin Estimated NOx and ROG Emissions 1994 to 2005



Since 1994, there has been a fairly steady decrease, basinwide, in both ROG and NOx emissions. While the relative amounts of the two precursors have remained fairly constant over the 12-year period, the overall reduction in ROG emissions (about 15 percent) has been slightly smaller than the overall reduction in NOx emissions (about 20 percent). However, it is important to note that a substantial portion of the ROG emissions (from 45 and 50 percent of the total ROG between 1994 and 2005) comes from biogenic sources. Because the biogenic portion is constant over time, it masks the reductions attributable to emissions control programs. When looking only at the anthropogenic portion of the ROG inventory, ROG emissions impacted by control programs decreased nearly 25 percent between 1994 and 2005.

Figures B-11 and B-12 show the estimated emissions trends for the three SJV subregions. In all three areas, both ROG and NOx emissions are decreasing. Similar to the basinwide trend, NOx emissions are decreasing at a faster rate than ROG in both the central and southern areas, but not in the northern SJV. Another interesting observation is that similar to the basinwide trend, ROG emissions are at a higher level than NOx emissions only in the central SJV. In the other two areas, NOx emissions are higher. Overall, the greatest reductions in NOx emissions (with respect to both percentages and tons per day) occurred in the southern SJV. This area has also seen substantial reductions in the number of 8-hour exceedance days in both the upwind and downwind portions of the region.

Figure B-11: Northern and Central SJV ROG and NOx Emissions 1994 to 2005

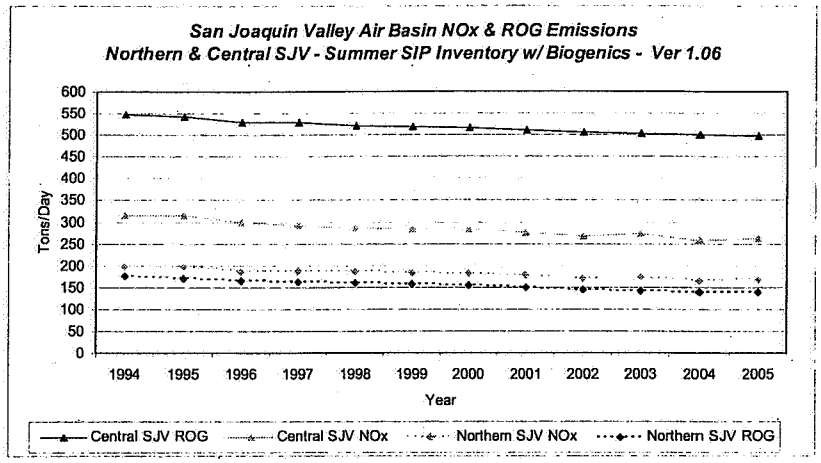
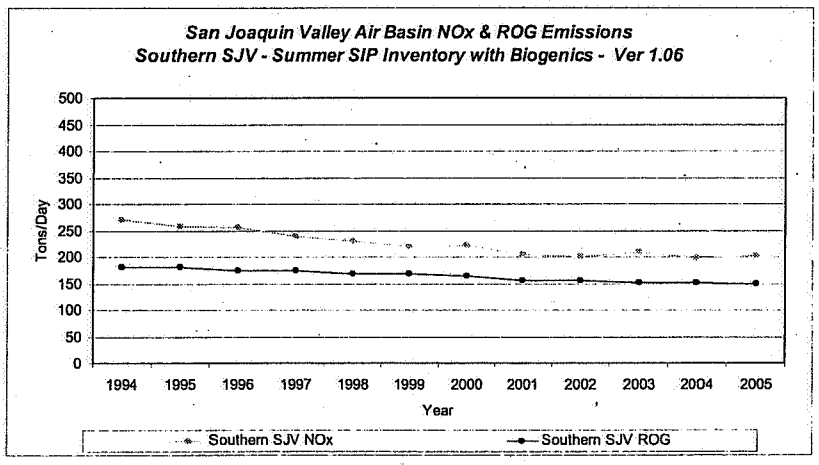


Figure B-12: Southern SJV ROG and NOx Emissions 1994 to 2005

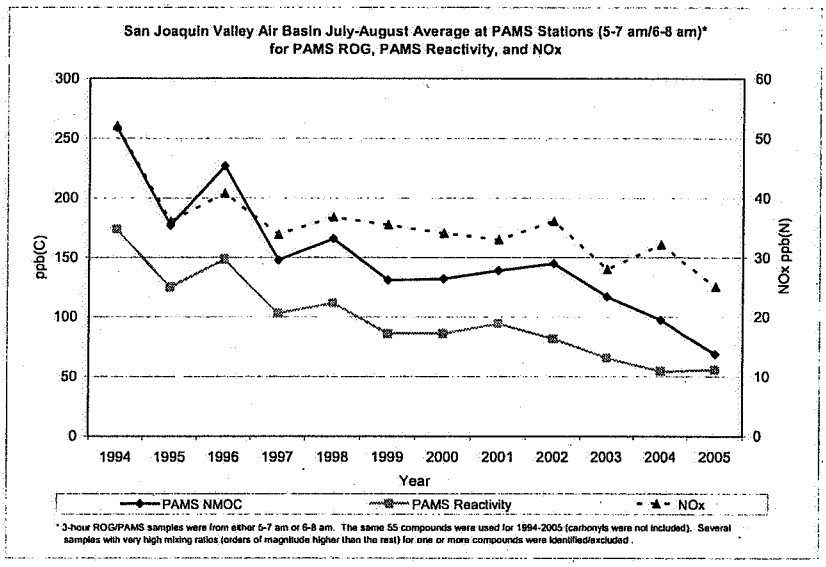


Precursor Trends

In addition to the reduction in overall emissions as estimated by the emissions inventory, measured data show a reduction in the amounts of ROG and NOx in the ambient air. Ambient monitoring data from the Photochemical Assessment Monitoring Stations (PAMS) network are plotted in Figure B-13 and show reductions in both precursors. Since 1994, ROG, as measured by the PAMS network in the SJV, shows an overall reduction of about 75 percent. Coupled with the reduction in ROG is a similar reduction in the reactivity of the hydrocarbon mix (about 70 percent between 1994 and 2005). During this same timeframe, ambient NOx concentrations decreased approximately 50 percent, with the greatest decrease occurring between 1994 and 1995. Between 1995 and 2005, ambient NOx concentrations were flatter, with only a modest overall

reduction. The overall trends from the ambient monitoring network are generally consistent with the trends in estimated emissions in that they both show both precursors decreasing.

Figure B-13: San Joaquin Valley Air Basin Summer Morning Average ROG, Reactivity, and NOx at PAMS Stations



Based on the PAMS ambient data, the reductions in precursor and reactivity levels in the Valley suggest there should have been improvements in peak ozone levels. However, SJV ozone levels have changed very little, except during the last three years. This implies that there are other factors at work that affect the production of ozone. Perhaps emissions in the SJV remain in the Valley for longer periods of time, providing additional opportunities for lower reactivity precursors to contribute to peak ozone levels. In addition, because ambient ROG levels have changed faster than NOx levels, the ratio of ROG to NOx has decreased from 5.0 in 1994 to 2.8 in 2005. This change in the precursor ratio has likely changed the responsiveness of the Valley to predominately ROG emissions reductions. As a result, NOx emissions reductions may become more important for future emission control strategies. The greater decrease in estimated NOx emissions, coupled with the substantial drop in exceedance days in the southern SJV, appear to support this conclusion. Finally, meteorology is an important factor. Changes in temperature and vertical mixing are known to impact ozone levels. Therefore, accounting for meteorology is one way to provide a better understanding of the available data (refer to previous section on Meteorology and Air Quality Trends).

Modeling Results

The ozone modeling domain for the SJV was based on the domain defined for the year 2000 Central California Ozone Study (CCOS) and includes not only the Central Valley, but the San Francisco Bay area, as well. The domain comprises a grid measuring 185 by 185 cells with a horizontal resolution of four kilometers. The required meteorological fields were generated using the MM5 prognostic meteorological model, and the required emissions inventories were developed by ARB staff. The ozone air quality modeling utilized the Comprehensive Air Quality Model with Extensions (CAMx) air quality model, with initial and boundary conditions based on estimates of clean-air concentrations.

ARB staff completed ozone modeling for two episode periods – one during July 1999 and the other during July/August 2000. During these episodes, 8-hour ozone concentrations exceeding the federal standard occurred throughout the region. Analysis of the model outputs included the estimation of 1-hour and 8-hour ozone concentrations for each ozone monitoring site within the domain, as well as statistical measures comparing observed and simulated ozone concentrations. These analyses were used to evaluate model performance by subregion within the domain.

As required by U.S. EPA, a relative reduction factor (RRF) approach was used in projecting future year design values. The RRF reflects the ratio between the future year model prediction (in this case the end of 2023) and the reference year model prediction. A reference year design value is then multiplied by the RRF to project a future year design value.

Results of the modeling analyses indicate that NOx reductions will be relatively more effective than ROG reductions in reducing ozone concentrations in the San Joaquin Valley. Therefore, the attainment strategy relies on a 75 percent reduction in NOx, in combination with a 25 percent reduction in ROG, to bring the worst-case sites into attainment.

Because ozone concentrations vary throughout the Valley, the modeling indicates different overall reductions are needed in different areas to reach attainment. However, as emissions controls are implemented, ozone concentrations will decrease in all areas of the Valley. San Joaquin Valley Unified Air Pollution Control District (District) staff estimate that by 2015, over 50 percent of the Valley's population will live in areas that meet the federal 8-hour ozone standard. By 2020, the portion of the population living in clean areas will increase to 90 percent. Although ozone concentrations will drop measurably throughout the entire Valley over time, downwind areas such as Arvin will require the greatest level of emissions reductions to meet the standard. Some of these reductions rely on technological advancements and are expected after 2020, but no later than 2023. These reductions are expected to bring the last remaining nonattainment areas into compliance with the federal 8-hour ozone standard.

Summary

The Weight of Evidence (WOE) package comprises a set of complementary analyses that supplement the SIP-required modeling, thereby providing additional support for the attainment demonstration. Currently, the San Joaquin Valley is classified as a Serious nonattainment area with an attainment date of June 15, 2013. Because of the magnitude of emissions reductions required, the District is requesting reclassification as Extreme, with a required attainment date of June 15, 2024. The Extreme classification allows the attainment demonstration to rely on emissions reductions from measures that anticipate the development of new technologies or improvement of existing technologies. These measures are often referred to as "black box" measures and go beyond the short-term measures that are based on known and demonstrated technologies.

U.S. EPA guidance allows the use of a Weight of Evidence (WOE) analysis to supplement photochemical modeling in demonstrating attainment. The ARB staff's modeling results indicate substantial NOx and ROG emissions reductions will be needed to bring the Valley into attainment. However, with reclassification as an Extreme nonattainment area, the SJV will be able to reach attainment by the 2024 deadline with a 75 percent reduction in NOx emissions, in combination with a 25 percent reduction in ROG emissions. Based on these reductions, even the worst-case sites will attain the federal 8-hour ozone standard. Based on modeling, as well as supporting analyses completed as part of this WOE evaluation, attainment by 2024 is anticipated because of the following factors:

- Over the last decade, the number of basinwide exceedance days decreased 35 percent. The maximum concentration and design value show more modest reductions, with decreases of 15 and 5 percent, respectively. Because these are basinwide numbers, they reflect the "worst case" sites. On a subregional basis, the amount of improvement during the last ten years is greater. While values for 2006 were up slightly from 2005, they are still among the lowest values over the last 15 years.

- During the mid-1990s, the ozone problem was widespread throughout the San Joaquin Valley. Today, the spatial extent of the relatively clean areas has expanded substantially. The greatest amounts of improvement have occurred in the northern SJV, and ambient concentrations in most of San Joaquin and Stanislaus counties now meet the federal standard. Over the last decade, the number of exceedance days in the northern SJV decreased 70 percent, and during 2005, about 80 percent of the days during the ozone season were below the more stringent State 8-hour ozone standard.

- The ozone problem is now confined primarily to the central and southern portions of the Valley. Sites located downwind of the Fresno and Bakersfield urban areas continue to pose the most severe problems. While the number of exceedance days has declined substantially at most sites in the central and southern SJV (55 to 65 percent between 1995 and 2005), exceedance days have declined more slowly at Arvin, while increasing at sites located at higher elevations in the Sequoia National Park.

- Estimated ROG and NOx emissions trends, as well as measured data from the PAMS monitoring network in the San Joaquin Valley indicate reductions in both precursors since 1994. These reductions have resulted in modest ozone improvements over the last decade.

- Analyses suggest that recent ozone improvements are linked to emissions reductions. The decline in the number of exceedance days relative to the number of days with a high potential for ozone formation indicates that the modest improvements in ozone over the last few years were related to emissions reductions rather than favorable meteorological conditions. Results of these analyses also indicate that increasingly adverse meteorological conditions are now needed to create ozone levels exceeding the federal 8-hour standard.

- Emissions estimates indicate a continuing decline in ROG and NOx emissions as the State and District pursue the aggressive dual pollutant strategy outlined in the SIP. Based on the magnitude of emissions reductions needed for ozone attainment, as well as the readiness of NOx control technologies, a NOx-heavy strategy is proposed and will provide the most efficient path to attainment (75 percent NOx reduction, coupled with 25 percent ROG reduction).

- Photochemical modeling shows all sites in the San Joaquin Valley Air Basin will attain the federal 8-hour ozone standard by the end of 2023, as required for Extreme nonattainment areas. Many areas will reach attainment before this date. The District estimates that by 2015, 50 percent of the Basin population will live in areas attaining the standard, and by 2020, the number will increase to 90 percent.

Taken together, all of these factors indicate that all sites in the San Joaquin Valley can expect to attain the federal 8-hour ozone standard by June 15, 2024, the required attainment date for an Extreme ozone nonattainment area.

Appendix C

Photochemical Modeling Protocol for Developing Strategies to Attain the Federal 8-Hour Ozone Air Quality Standard in Central California

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The Photochemical Modeling Protocol for Developing Strategies to Attain the Federal 8-Hour Ozone Air Quality Standard in Central California documentation includes the following appendices:

- Appendix A – *Gridded Inventory Coordination Group Minutes*
- Appendix B – *Development of Stack Parameters and Vertical Distributions for Modeling Large Wildfires in the CCOS Domain*
- Appendix C – *Proposed Method to Improve Temporal Distribution of Gridded On-road Motor Vehicle Emissions*
- Appendix D – *Development of Version Two of the California Integrated Transportation Network (ITN)*
- Appendix E – *Sample Letter from ARB to Transportation Planning Agencies (TPAs) Statewide Requesting Updated Activity Data for Base Years and Forecasted Years*
- Appendix F – *Draft EMFAC Modeling Change Technical Memo*
- Appendix G – *Development of a Biogenic Hydrocarbon Emission Inventory for the Central California Ozone Study Domain*
- Appendix H – *Surrogate Cross-Reference Tables*

These appendices are not included in this file, but are available for download at:

http://eos.arb.ca.gov/eos/SIP_Modeling/

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PHOTOCHEMICAL MODELING PROTOCOL

FOR DEVELOPING STRATEGIES

TO ATTAIN THE FEDERAL 8-HOUR OZONE AIR

QUALITY STANDARD IN CENTRAL CALIFORNIA

California Air Resources Board
Planning and Technical Support Division
Sacramento, California 95814

Draft (5/22/07)

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TABLE OF CONTENTS

1 INTRODUCTION 3
1.1 Purpose 3
1.2 Approach 3
1.3 Background 6
2 EPISODE SELECTION 11
2.1 July 7-13, 1999 (Routine Episode) 12
2.2 July 29-August 2, 2000 (CCOS Episode) 13
2.3 Available Observational Data 15
3 MODEL SELECTION 19
3.1 Meteorological Model 19
3.2 Photochemical Model 20
4 MODELING DOMAIN AND GRID STRUCTURE 22
4.1 Meteorological Modeling Domain 22
4.2 Photochemical Modeling Domain 26
5 MODEL INITIALIZATION AND BOUNDARY CONDITIONS 29
5.1 Initialization of the Meteorological Model 29
5.2 Air Quality Model Initial and Boundary Conditions 31
6 EMISSION INVENTORY DEVELOPMENT 40
6.1 Background 41
6.2 Point and Area Source Emissions 42
6.3 Forecasted Emissions 47
6.4 Day-Specific Emissions 48
6.5 Temporally and Spatially Resolved Emissions 50
6.6 Surface Temperature and Relative Humidity Fields 51
6.7 On-Road Mobile Source Emissions 52
6.8 Biogenic Emissions 69
6.9 Spatial Allocation 71
6.10 Speciation 78
7 MODEL PERFORMANCE EVALUATION 83
7.1 Meteorological Model Performance 83
7.2 Air Quality Model Performance 87
8 FUTURE-YEAR AIR QUALITY MODELING 92
8.1 Estimation of Future Design Value (DV_F) 93
9 REFERENCES 99

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1 INTRODUCTION

1.1 Purpose

This modeling protocol is intended to both guide and describe the technical aspects of air quality modeling that is to be conducted in support of developing an 8-hour ozone State Implementation Plan (SIP) for central California. It will describe the data, technical decisions, and the procedures associated with producing computer-based simulations of ozone concentrations. It will also describe how model results will be evaluated with field measurements and how future year air quality will be simulated. The approach taken follows U.S. EPA modeling guidance for 8-hour ozone SIPs (2005).

1.2 Approach

The intent of this protocol is to utilize the best available science, technical tools, and data to develop the modeling system. Once the modeling system has demonstrated adequate performance, it will be used as a technical resource to assist decision makers in selecting the most effective future-year emission control measures to include in the SIP. Some examples of the types of questions that will likely be considered are:

- In terms of ozone formation, what are the regional and sub-regional effects of hydrocarbon emissions and emissions of oxides of nitrogen?
- With regard to reducing 8-hour ozone concentrations, what are the carrying capacities for the on-attainment areas in the region?
- What are the likely years that the non-attainment areas in the region will achieve attainment?

The modeling approach draws heavily on the products of large-scale, scientific studies in the region, collaboration among technical staff of State and local regulatory agencies, as well as from participation in technical and policy groups within the region. In particular, the following three groups provided substantial input:

- The 2000 Central California Ozone Study (CCOS) – More information on CCOS, including the organizational structure, CCOS products, and the Technical Committee (CCOS-TC) can be found via the following two links:

http://www.arb.ca.gov/airways/crpaqs/organization.htm

http://www.arb.ca.gov/airways/ccos/ccos.htm

- The Bay Area Modeling Advisory Committee (BA-MAC) – This technical group was established by the Bay Area Air Quality Management District (BAAQMD) to guide modeling in support of the 2004 Bay Area SIP revision. More information and results from this group can be found at:

  http://www.baaqmd.gov/pln/plans/ozone/2003_modeling/index.htm

- The SIP Gridded Inventory Coordination Group (SIP-GICG) – This group of regulatory agency staff (and, in some cases, their consultants) was established by ARB to coordinate the development and review of the emissions inventory inputs to SIP air quality modeling in central California.

The regular participants for each of these three groups are listed in the following two tables. Table 1.1a lists non-government participants and Table 1.1b lists government agency participants. The suite of candidate episodes, models, model inputs to consider, and, ultimately, the selected episodes, modeling tools, and inputs for use in SIP modeling were discussed within and among these technical groups, including via projects or contracts that were sponsored by them individually or collectively.

Table 1.1a – Consultants and Public/Private Stakeholder Representatives

Group	Employer	Representative	BA-MAC	CCOS-TC	SIP-GICG
Acadamia/Consulting	Alpine Geophysics	James Wilkinson	X		X
	Dowling and Associates	Carrie Anderson			X
	Envair	Steve Reynolds		X	
	ENVIRON	Chris Emery	X		X
	Golden Gate University	Ken Kloc	X		
	UC Berkeley	Rob Harley	X		
Environmental	West County Toxics Coalition	Henry Clark	X		
	Sierra Club	John Holtzclaw	X		
	Clean Air Partnership	Jude Lamare	X		
Industry	Chevron-Texaco	Steve Ziman	X	X	
	PG&E	Sam Altshuler	X		
	Shell	Christopher Rabideau	X	X	

Table 1.1b. Government Agency Stakeholder Representatives

Group	Employer*	Representative	BA-MAC	CCOS-TC	SIP-GICG
Federal Government	US-EPA (Region 9)	Carol Bohnenkamp	X	X	
	NOAA	James Wilczak	X	X	
Local Government	ABAG	Eugene Leong	X		
	BAAQMD	Amir Fanai	X		X
	BAAQMD	Gary Kendall	X		
	BAAQMD	Jean Roggenkamp	X		
	BAAQMD	Peter Hess	X		
	BAAQMD	Phil Martien	X	X	X
	BAAQMD	Saffet Tanrikulu	X	X	
	BAAQMD	Toch Mangat			X
	Fresno COG	Mike Bitner			X
	Monterey Bay APCD	Bob Nunes	X		
	MTC	Harold Brazil	X		X
	Sacramento Area COG	Gordon Garry			X
	San Joaquin Valley APCD	David Nunes	X	X	
	San Joaquin Valley APCD	Evan Shipp	X	X	X
	San Joaquin Valley APCD	James Sweet	X	X	
	San Joaquin Valley APCD	Gary Arcemont			X
	San Joaquin Valley APCD	Leland Villalvazo			X
	San Joaquin Valley APCD	Steven Shaw			X
	Sacramento Metro AQMD	Brigette Tollstrup	X		
	Sacramento Metro AQMD	Bruce Katayama	X	X	X
	Sacramento Metro AQMD	Charles Anderson	X		X
	Sacramento Metro AQMD	Hao Quinn			X
	Sacramento Metro AQMD	Larry Greene	X		
	TRANSDEF	David Schonbrunn	X		
	Yolo-Solano AQMD	Rene Toledo			X
State Government	CalTrans	Leonard Seitz			X
	ARB	Ajith Kaduwela	X	X	
	ARB	Anne Lin			X
	ARB	Bruce Tuter	X		
	ARB	Daniel Chau		X	
	ARB	Cheryl Taylor	X	X	X
	ARB	Eugene Yang		X	X
	ARB	Jeff Lindberg			X
	ARB	Jinyou Liang	X		
	ARB	John DaMassa	X	X	
	ARB	Martin Johnson			X
	ARB	Kemal Gurer		X	
	ARB	Mimi Sogutlugil			X
	ARB	Paul Allen			X
	ARB	Vernon Hughes	X	X	X

*NOAA – National Oceanic and Atmospheric Administration; ABAG – Assoc. of Bay Area Governments; BAAQMD – Bay Area Air Quality Management District; COG – Council of Government; APCD – Air Pollution Control District; MTC – Metropolitan Transportation Commission; AQMD – Air Quality Management District; CalTrans – California Department of Transportation.

1.3 Background

The shaded relief maps provided at the end of this section illustrate the topography in California as well as the Air Basin and County political boundaries (Figure 1.1) and Air District and County boundaries (Figure 1.2).

Generally, the weather conditions that lead to high ozone levels in the San Joaquin Valley include large-scale high-pressure systems that develop over the Western United States, low wind speeds, and high temperatures. These conditions occur frequently in the San Joaquin Valley between May and September, and may persist for several days. The complex features of airflow within the region contribute to various types of ozone episodes in the San Joaquin Valley, the Sacramento Valley, the Mountain Counties, and the San Francisco Bay Area. Ozone and its precursors are distributed throughout the mixed layer by turbulent diffusion. When meteorological conditions are favorable, daytime sea breezes are funneled through the Carquinez Strait and nearby mountain passes, bringing ozone and precursors into the northern part of the San Joaquin Valley. Some inflow is also observed through the Pacheco Pass to the west side of the Valley.

Depending upon the nature of the airflow in the region, ozone episodes in the San Joaquin Valley or Sacramento can be generated predominantly from locally derived pollutants or by pollutants transported from upwind regions. In the San Francisco Bay Area (SFBA), ozone concentrations are elevated when airflow from the Bay Area to the Central Valley is limited. Elevated ozone concentrations are observed in the Mountain Counties due mostly to transported pollutants. The conditions that promote the formation of a nocturnal jet within the Valley may limit ventilation of the Valley. During the day, pollutants may be transported from the San Joaquin Valley to the Mojave Desert via the Tehachapi Pass. Outflow from the San Joaquin Valley to the coast in the vicinity of San Luis Obispo area has also been observed.

Except on the warmest days, an inversion is almost always present within the Central Valley throughout the year. This inversion tends to trap pollutants either emitted within the Valley or transported into the Valley from surrounding regions. In this regime, mesoscale flow patterns such as sea breeze intrusion, local eddies, bifurcation and convergence, and mountain/valley flows are especially important in determining the distribution of pollutants throughout the region. These mesoscale characteristics are described in more detail below, and provide a reference for features to consider during qualitatively assessing meteorological model performance, which is discussed further in Chapter 7:

Sea Breeze and Marine Air Intrusion: Differential heating between the land and ocean causes a pressure gradient between the cooler, denser air over the ocean and the warmer air over the land. The resulting pressure gradient draws marine air into the Valley during the day. Typically, with calm coastal winds during mornings, rush hour pollutants can accumulate in the coastal source region. As the sea breeze develops by

mid-day, ozone and its precursors can enter the Valley, encountering warmer temperatures and higher insolation.

Nocturnal jet and eddies: A low-level nocturnal wind maximum can develop during evening hours. As surface temperatures cool overnight, a strong stable layer within the Central Valley can result. As this stable layer forms, the wind aloft may be decoupled from the surface and accelerate. The result is an overnight wind flow that may carry pollutants from one end of the Valley to the other. While this nocturnal jet may be present in other seasons, it has been observed during the ozone season (Smith et al. 1981; Blumenthal 1985; Thuillier et al. 1994). It is believed to be a pollutant transport mechanism during the summer months. Depending on the temperature structure of the Valley, the jet may not be able to exit through the Tehachapi Pass (~1400 m); in which case the air is forced to turn north along the Sierra foothills at the southeastern edge of the Valley. Smith et al. (1981) mapped the northerly flow, sometimes called the Fresno eddy, with pibals and described an unusual case where it extended as far north as Modesto. During the Southern San Joaquin Ozone Study, Blumenthal et al. (1985) measured the Fresno eddy extending above 900 meters above ground level about 50% of the time. Neff et al. (1991) measured the eddy using radar wind profilers during the SJVAQS/AUSPEX study.

Bifurcation and Convergence Zones: Marine air entering the Sacramento River Delta region from the west may diverge. It may flow into the San Joaquin Valley to the south and Sacramento Valley to the north. The position of this bifurcation zone may shift and can determine the relative proportion of Bay Area pollutants transported to each downwind basin. The dynamics of this bifurcation zone are currently not well understood. However, this zone may also prevent transport between air basins by functioning as a block to air moving north to south within the Delta. For example, the effect of convergence zones on air quality is provided by Blumenthal et al. (1985), where it is hypothesized that the increase in mixing heights (~200 m higher than in the northern SJV) at the southern end of the San Joaquin Valley was due to damming of the northerly flow against the Tehachapi mountains at the southern end. Without this damming effect, the mixing levels over Bakersfield, Arvin, and Edison would be lower, with correspondingly higher ozone concentrations.

Up-slope and Down-slope Flows: The increased daytime heating in mountain canyons and valleys adjacent to the Central Valley causes significant upslope flows during the afternoons in the San Joaquin and Sacramento Valleys. This can act as a removal mechanism, and can lift mixing heights on the edges of the valleys, relative to the mixing heights at valley center. During the nighttime, mountain valleys and canyons may cool relative to the Valley floor, resulting in a reversal of the flow. Myrup et al. (1989) studied transport of aerosols from the San Joaquin Valley into Sequoia National Park. They found a net up-slope flow of most pollutant species. The return flow can bring pollutants back down. Smith et al. (1981) used tracer data to estimate pollutant budgets due to slope flow fluxes (and other ventilation mechanisms). Smith et al. suggested that polluted air at higher elevations is diluted, thus down-slope flows may result in lower pollution levels within the San Joaquin Valley.

Up-Valley and Down-Valley Flows: Up-valley and down-valley flows are similar to up-slope and down-slope flows, but take place along the valley on a larger scale. During the summer, the Sacramento River Delta tends to have cooler air temperatures during the day and warmer temperatures at night than at the extreme ends of the Central Valley due to higher humidity within the Delta. During the daylight hours, up-valley flow draws air south into the San Joaquin Valley and north into the Sacramento Valley. At night, down-valley drainage winds tend to ventilate both valleys. Hayes et al. (1984) described both regimes for the Central Valley.

Figure 1.1. California Air Basins and Counties.

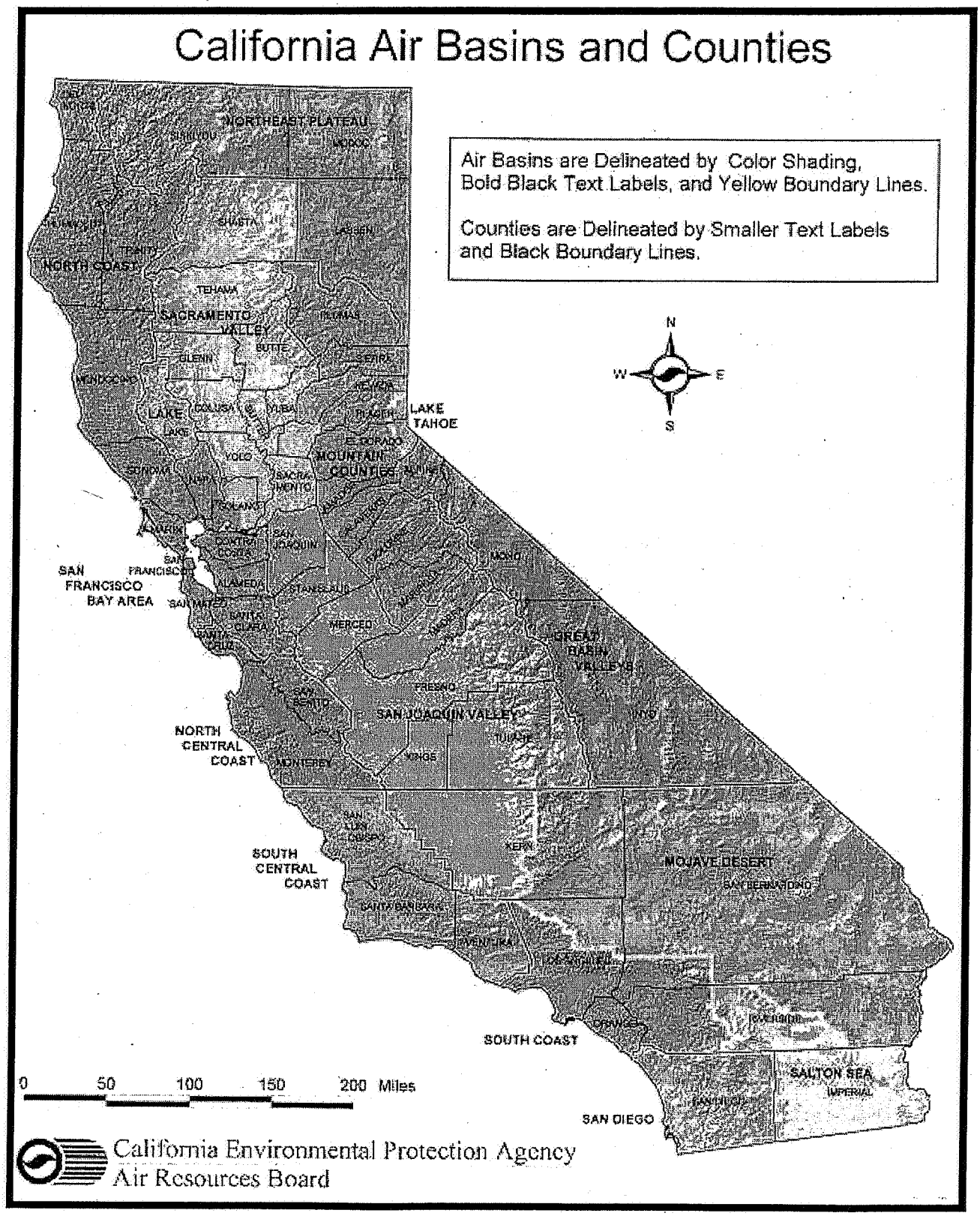
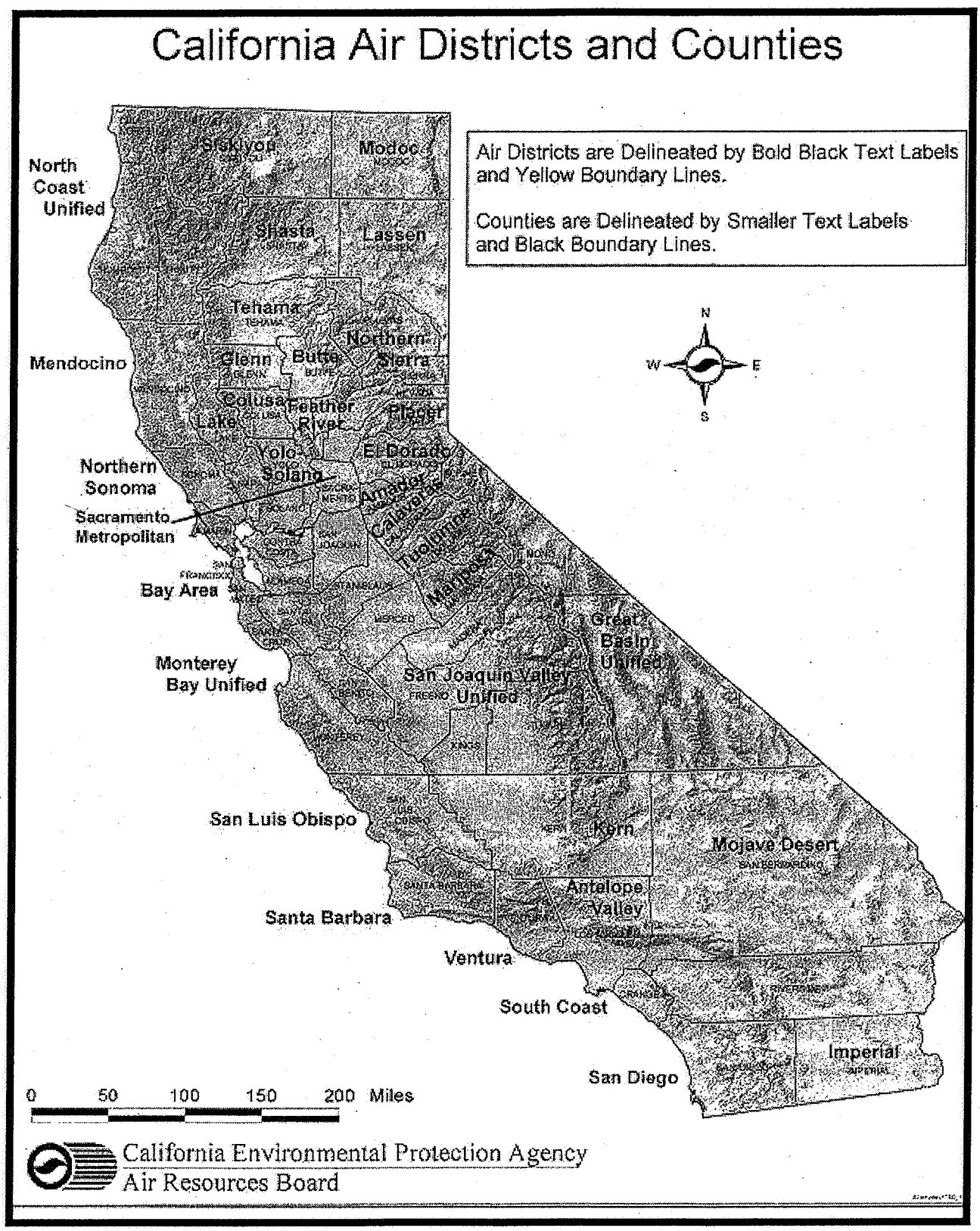


Figure 1.2. California Air Districts and Counties.



2 EPISODE SELECTION

As indicated in the first chapter, a large body of work already exists that has been produced by stakeholder groups towards the goal of determining representative, candidate episode periods for use in 8-hour ozone SIP modeling for the region. From this collective body of work, the following four episodes were identified as having the greatest potential for SIP modeling in the region:

- July 7-13, 1999 (captured with routine State and Local measurements)
- July 29-August 2, 2000 (CCOS-studied episode)
- September 17-21, 2000 (CCOS-studied episode)
- August 8-15, 2002 (captured with routine State and Local measurements)

Due to time constraints and based on model performance issues expressed by stakeholder efforts for the two later episodes, the first two episodes (July 7-13, 1999, and July 29-August 2, 2000) were determined to be the most adequate for the initial round of 8-hour ozone SIP attainment planning. Brief summaries of the two episodes selected for SIP modeling are contained in the following sections.

With regard to the two episodes being dropped from consideration, CCOS sponsored a project that was focused on developing the third (September, 2000) episode while the Sacramento Metropolitan Air Quality Management District (SMAQMD) sponsored a project to develop the fourth (August, 2002) episode. As indicated above, achieving adequate model performance for both of these periods was problematic. It should be noted, however, that a subsequent effort is now underway (via a pending 2007 CCOS Request for Proposals) to improve model performance for the September, 2000 episode. More information on efforts to initially develop or to improve these two dropped episodes can be found via the following links:

September 2000 (CCOS):

http://www.arb.ca.gov/airways/ccos/docs/03-01CCOS_Alpine_Final_Report_PDF.zip

http://www.arb.ca.gov/airways/ccos/RFPs/Sept_Modeling/RFP_septmodeling_FINAL.pdf

August 2002 (SMAQMD):

http://www.airquality.org/cleanairplan/modeling.shtml

2.1 July 7-13, 1999 (Routine Episode)

On July 8, 1999, high pressure began to build throughout the southern United States. Through July 10, the high pressure at 500mb increased and a relative high formed over the 4-Corners area. After July 10, the 500mb high began to regress westward and weaken after July 12. Winds aloft during this period were generally weak and variable.

During this episode period, the high-pressure ridges that formed were generally shallow. The maximum 500mb pressure-heights were in excess of 594 dm and are consistent with the high pressures and strong subsidence generally associated with the occurrence of high ozone concentrations within central California.

Ozone concentrations exceeded 125 ppb on July 8-13, 1999. On July 8, a concentration of 155 ppb was recorded at Parlier; however, this peak was isolated in time and space and was considered difficult to model. On July 10, high ozone concentrations were recorded throughout the Sacramento area, with a peak of 147 ppb. On July 11, high ozone concentrations were recorded from the San Francisco Bay Area into Sacramento, and continued into July 13 with a high ozone concentration of 156 ppb recorded at Concord. Concentrations declined thereafter and on July 13, the only concentration exceeding 125 ppb was the 132 ppb recorded at Merced.

The 8-hour ozone concentrations exceeding 85 ppb in this period were recorded on July 8, and occurred through July 13 (Table 2.1). In the San Joaquin Valley, ozone concentrations in excess of 85 ppb were recorded for at least 10 sites on each day of the episode period until July 13. The maximum 8-hour ozone concentration was recorded at the Fresno – First Street site on July 11. In the Sacramento Area, the peak 8-hour concentration was recorded at Folsom, also on July 11. In the San Francisco Bay Area, the maximum daily ozone concentrations did not exceed 85 ppb until July 10. However, the daily maximums and number of sites recording concentrations greater than 85 ppb increased on July 11 and 12. The maximum 8-hour ozone concentration in the San Francisco Bay Area during this episode period was 123 ppb recorded at Concord on July 12.

Table 2.1 The number of monitoring sites with measured 8-hour ozone concentrations exceeding 85 ppb and daily maximum measured concentrations.

	Total Sites	July 8		July 9		July 10		July 11	
		Sites	Max	Sites	Max	Sites	Max	Sites	Max
Bay Area	19	0	72	0	73	2	95	11	116
Sacramento Valley	17	4	96	8	116	13	129	14	124
San Joaquin Valley	20	13	110	13	102	15	108	19	123

	Total Sites	July 12		July 13	
		Sites	Max	Sites	Max
Bay Area	19	7	123	0	74
Sacramento Valley	17	13	107	4	91
San Joaquin Valley	20	11	116	8	117

2.2 July 29-August 2, 2000 (CCOS Episode)

During the 2000 CCOS field campaign, the duration of high pressure ridging, which fosters ozone production, was somewhat shorter than those recorded in previous summers. When compared to the 30-year climatology for June to September for Fresno and San Francisco, (Table 2.5-1, CCOS Field Study Plan, Fujita et al. 1999), the inland temperatures were statistically colder during CCOS, while the coastal temperatures were not. For example the study period daily temperature maximum at Fresno, 91.4±0.7 °F, was more than three standard deviations below the climatological value of 94.8 °F. The study period daily temperature maximum at San Francisco, 71.5±0.7 °F, was below the climatological value of 72.0 °F. This can be explained by the occurrence of fewer high pressure ridges and/or ridging of shorter duration passing over the western United States, where the inland sites are not as influenced by the mitigating effects of the Pacific Ocean (after Lehrman et. al., 2003). Statistical analyses indicate that this episode is in the upper range of poor air pollution dispersion meteorology that results in exceedances of the NAAQS in the San Joaquin Valley. Lehrman (2003) reported that all days during the July-August 2000 ozone episode fall into meteorological categories within one standard deviation of the mean for days greater than the NAAQS.

Inspection of 500-mb and surface daily weather maps shows that low-pressure troughs, cut-off lows, and zonal flow occurred during the first seven weeks of the study period, except for one brief incursion of an Eastern Pacific High, which brought some ridging over the West Coast. That occurred on June 14-15, which became the Practice Intensive Operating Period (IOP) on June 14 and 16. After this slow start to the study

period, ridging during IOP#1, July 23-24, brought a Four Corners High. Unfortunately, this 500-mb high positioning can also foster monsoonal flow. Too much positive vorticity (lifting) kept ozone concentrations low over much of the study area, in particular the southern San Joaquin Valley. This high persisted the next week and moved over the Great Basin during IOP#2, July 30-Aug 2. By August 6, the high had weakened and moved eastward leaving troughs or zonal flow over California for almost another week. IOP#3 was conducted on August 14 when the high had broadened to include southern California. But IOP#3 lasted only one day, as the high retreated from a trough moving down from the Gulf of Alaska. As the high retreated further east to Texas, Oklahoma, and Arkansas, a trough remained over the pacific Coast as far south as Northern California, but cut-off lows and zonal flow over southern California kept ozone concentrations relatively low. Because of the lack of suitable episodes during the originally scheduled end of the field study on September 3, the CCOS was extended to late September.

On September 11, zonal flow over the Pacific Northwest and a weak cut-off low off the California coast were adjacent to a new high expanding up from the south over Northern Mexico. Due to the slow start in the study period, IOP#4 was called for September 14. Unfortunately, a relatively strong cut-off low developed offshore of the US-Canadian border and kept the high to the east. As the cut-off low moved east over Idaho, a relatively strong high built in behind it over the eastern Pacific. IOP#5 was initiated on September 17, a ramp-up day, and continued through the 21st when the high had regressed back westward leaving strong northerly flow through a trough axis from Hudson Bay to San Francisco Bay. As the trough gave way to zonal flow over the next week, flights were conducted to monitor boundary conditions during zonal flow conditions during September 30 through October 2.

By July 25, the ridge had weakened slightly and dropped southeastward into eastern New Mexico, and a trough developed along the West Coast from Point Conception to British Columbia. This resulted in the lowering of 500 mb heights and 850 mb temperatures somewhat during July 25 and 26. However, on the 27th, the high-pressure ridge once again regressed towards the west and strengthened somewhat to become centered once again in the Four Corners area. With this regression of the ridge, the 850 mb temperature and 500 mb heights at Oakland (OAK) once again rose during that period and continued to rise through July 30, and the period of the next IOP. During the IOP of July 30 through August 2, the ridge remained strong and continued to slowly regress towards the west until it was centered near Reno, Nevada by July 31. The OAK 850 mb temperature during the IOP reached as high as 27°C and the 500 mb height topped at 5,970 m.

During the July-August 2000 CCOS episode, the highest ozone level was a recorded 151 ppb at Edison on August 2 in the southern portion of Central Valley. Peak ozone values on July 30 occurred in the San Joaquin Valley, where values near 130 ppb were recorded at Parlier and Edison; the Bay Area and Sacramento region experienced no federal 1-hour exceedances that day. On July 30, only the San Joaquin Valley exceeded the 1-hour NAAQS for ozone. Concentrations at Parlier and Edison were 129

and 128 ppb, respectively. The highest reading on July 31 occurred at Livermore in the Bay Area. The measured peak value was 126 ppb. This was the only exceedance of the federal standard on that day in the CCOS domain. The only federal 1-hour exceedances on August 1 occurred in the Sacramento region, which experienced its highest ozone readings of the episode. On that day a peak value of 133 ppb ozone was observed at the Sloughouse site. Similarly, the only exceedances on August 2 occurred in the San Joaquin Valley, which had peak readings of 131 ppb in the northern part of the valley (Turlock and Modesto) and the maximum concentration for the episode at Edison of 151 ppb.

Maximum daily 8-hour ozone concentrations exceeded 85 ppb beginning on July 30 (see Table 2.2). Most of these were located in the San Joaquin Valley with a maximum of 106 ppb at Parlier. On July 31, ozone concentrations exceeded 85 ppb in the San Francisco Bay Area, the Sacramento Area, and the San Joaquin Valley. The frequency of high 8-hour ozone concentrations within the Sacramento Area and the San Joaquin Valley increased on August 1 and 2, with the maximum of 113 ppb recorded at Edison on August 2.

During this episode period, there were a number of large wildfires in the southern part of the study domain. Model-based analyses suggested that these fires impacted ozone concentrations measured in Kern County.

Table 2.2 The number of monitoring sites with measured 8-hour ozone concentrations exceeding 85 ppb and daily maximum measured concentrations.

	Total	July 30		July 31		August 1		August 2	
	Sites	Sites	Max	Sites	Max	Sites	Max	Sites	Max
Bay Area	11	0	66	2	90	1	91	2	94
Sacramento Valley	16	4	93	2	89	11	109	9	107
San Joaquin Valley	25	14	106	11	104	18	110	19	113

2.3 Available Observational Data

Model performance for the computer simulations of the two episodes characterized above will be based on comparing model predictions with observational data collected from both routine field measurement efforts as well as from the Central California Ozone Study. The data networks for both of these sources are described below.

2.3.1 Routinely Collected Data (1999)

Routine meteorological and air quality data are collected regularly through different network systems, including (1) the State and Local Air Monitoring Stations (SLAMS) network, (2) the National Air Monitoring Station (NAMS) network, (3) the Photochemical Assessment Monitoring Station (PAMS) network and (4) Special Purpose Monitoring (SPM) that is performed at some sites. More detailed information on routinely available data can be obtained from the California Air Resources Board web site at:

http://www.arb.ca.gov/aqd/namslams/namslams.htm

2.3.2 Data Collected During CCOS (2000)

The Central California Ozone Study database is comprised of data collected during the summer of 2000 at a variety of special study stations, routine field stations, and supplemental sources. The CCOS monitoring network is illustrated in Figures 2.1 and 2.2. More specific information regarding the CCOS field study design and CCOS data collection efforts, including information on the supplemental data sources, can be found in the documents located under the following link:

http://www.arb.ca.gov/airways/CCOS/CCOS.htm

In addition, CCOS observational data collected during the summer, 2000, field study can be accessed via interactive web queries at:

http://www.arb.ca.gov/airways/Datamaintenance/default.asp

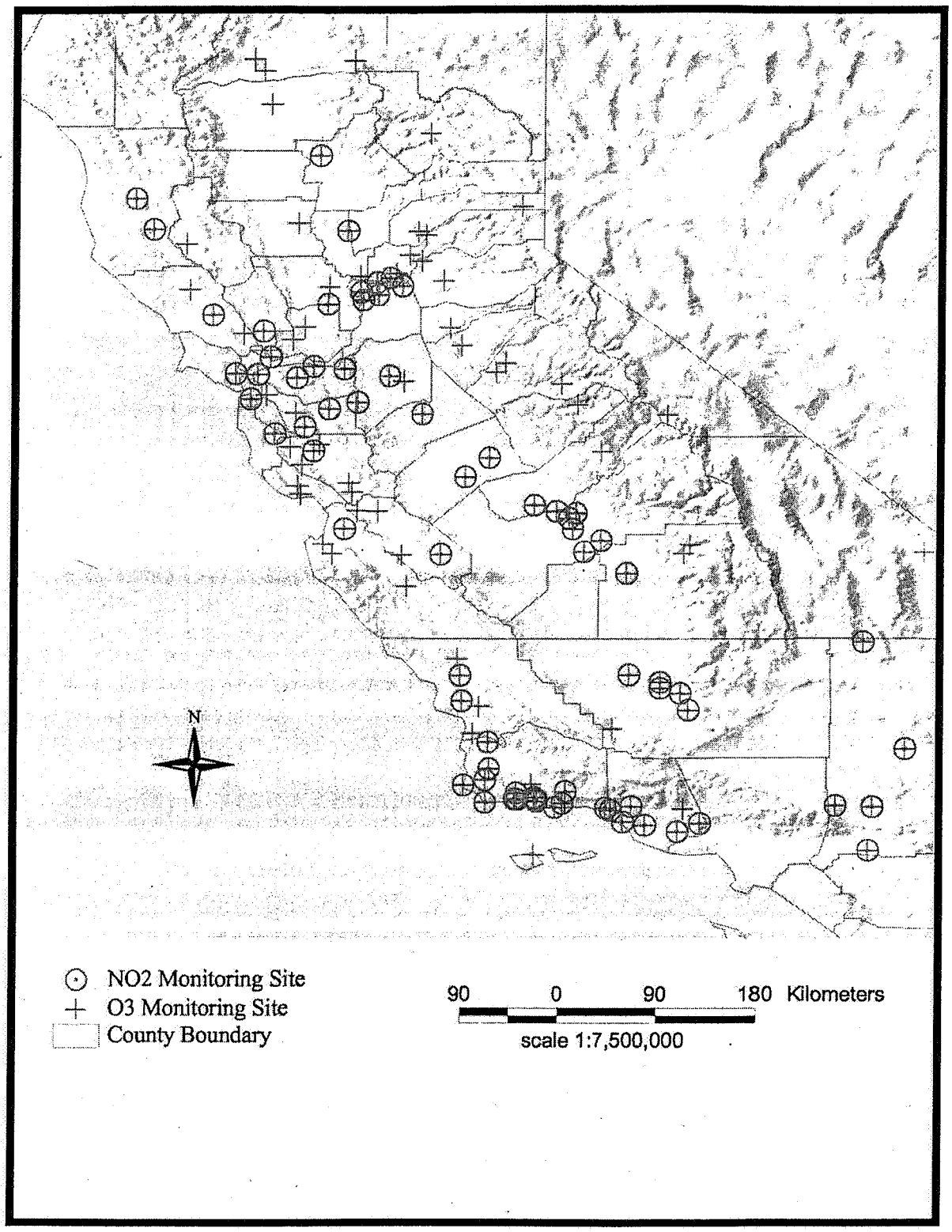


Figure 2.1 Existing routine ozone and nitrogen oxides monitoring sites.

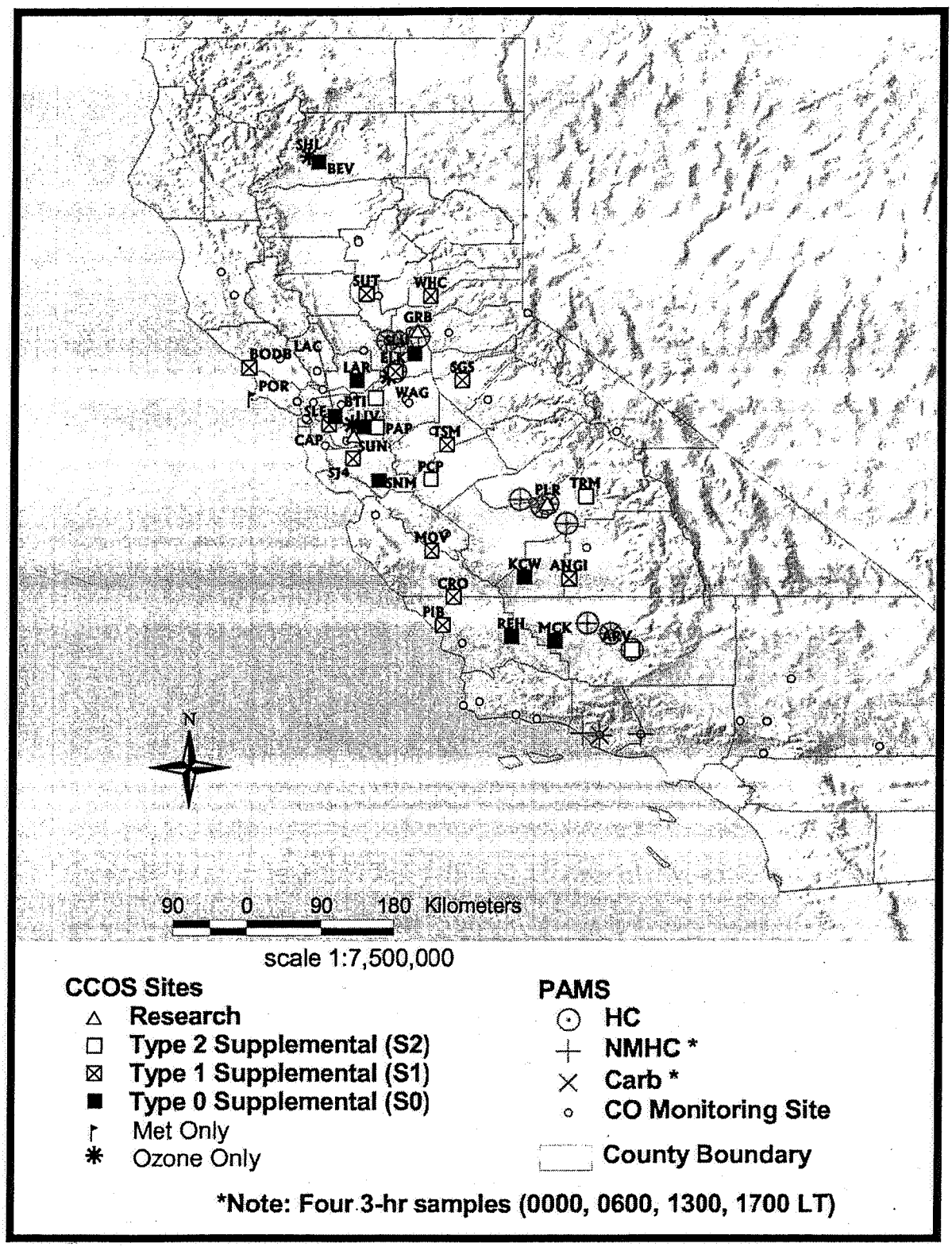


Figure 2.2 CCOS supplemental air quality and meteorological monitoring sites, and Photochemical Assessment Monitoring Stations.

3 MODEL SELECTION

This chapter describes the selection of the meteorological and air quality models to be used.

3.1 Meteorological Model

Meteorological model selection is based on a need to accurately simulate the synoptic and mesoscale meteorological features exhibited during the selected episodic periods. The main difficulties in accomplishing this are California's extremely complex terrain and its diverse climate. It is desirable that atmospheric modeling adequately represent essential meteorological fields, such as wind flows, ambient temperature variation, evolution of the boundary layer, etc. to properly characterize the meteorological component of photochemical modeling.

In the past, the ARB has applied prognostic, diagnostic, and objective models to prepare meteorological fields for photochemical modeling. There are various numerical models that are used by the scientific community to study the meteorological characteristics of an air pollution episode. The models under consideration for SIP modeling are:

- NCEP ETA model (Mesinger et al, 1988),
- Regional Atmospheric Modeling System (RAMS) (Pielke et al, 1992),
- Mesoscale Meteorological Model Version 5 (MM5) (Grell et al, 1994), and
- Weather and Research Forecasting Model (WRF) (Skaramock et al, 2005).

The NCEP ETA model is primarily used by the National Weather Service as a forecast model and has been used only in limited applications as a research tool. The RAMS model has been used extensively both as a research tool as well as a forecast model by various scientific communities.

The Bay Area Air Quality Management District (BAAQMD) has been using RAMS along with MM5 over the last decade. The application of RAMS conducted by BAAQMD showed consistent results or no better than MM5 simulations for selected episodes. The recent air quality results of the BAAQMD indicated some undesirable model performance characteristics of RAMS (Martien, BAAQMD, 2004, personal communication). Also, the intensive effort from BAQQMD on improving the RAMS model during the past years was curtailed due to limited technical resources.

MM5 is a mesoscale, limited area, non-hydrostatic numerical model developed by Penn State and the National Center for Atmospheric Research (NCAR). It uses a terrain-following, Lambert Conformal, sigma coordinate system. MM5 allows users to study the atmospheric motions at small scales by explicitly treating the effects of convective motions on atmospheric circulations. It has been improved on an ongoing basis over

the last two decades by contributions from a broad scientific community and has been maintained by NCAR along with necessary meteorological and geographical input data. Based on the complexity of terrain in northern and central California, the MM5 model represents an appropriate tool for resolving dynamics and thermodynamics using nesting capabilities. The ARB has also been using the MM5 model over the last two decades, since it has been widely used and tested for various meteorological regimes over the world and has been supported by the NCAR.

NCAR is currently developing the WRF model to eventually replace MM5. However, the model is still under development and has not been extensively tested or demonstrated for SIP use. In addition, the preliminary tests that have been conducted by NCAR to date have not reported any significant improvement over MM5.

Based on preliminary work by the stakeholder groups mentioned in Chapter 1 as well as the long history of utilizing MM5 for SIP modeling, the MM5 numerical model will be used to generate meteorological fields for SIP modeling.

3.2 Photochemical Model

ARB considered several photochemical air quality models to simulate the two episodes under consideration:

- SAQM (Chang et. al.,1997),
- CAMx (ENVIRON, 2004), and
- CMAQ (USEPA 1999).

The SAQM (SARMAP Air Quality Model) model was used for the 1994 ozone SIP modeling for the San Joaquin Valley (SJVUAPCD, 1994). This model was built upon the basis of the RADM (Regional Acid and Deposition Model) in 1993 for the SARMAP air quality study domain with non-optimal numerical calculation and coding. The program was not coded in a modular fashion to facilitate updates (like alternative modules), the documentation is incomplete, and the model has not been successfully applied to ozone modeling problems outside of the San Joaquin Valley since the SARMAP study. Embarking on updating and recoding this model for the present day would require an unwarranted level of resources to adopt the most recent transport numerical schemes and photochemical mechanisms (or any other major modification).

The CMAQ model is a widely recognized and highly regarded photochemical model supported by the US EPA. It has been widely used throughout most of the United States for ozone, PM, and visibility analysis; however, its successful application within California has been limited. It is a flexible model and allows the selection of alternative modules, such as a different chemical mechanism, advection scheme, or chemical solver. The CMAQ model has been shown to run slower than alternative models; however it has been linked to the MPI (Multiple Processor Integration) software library package to run in parallel through a distributed process mode, significantly reducing episodic run times.

The CAMx model is used throughout the United States. It is widely viewed as one of the better documented and supported air quality models. Periodic updates from the developers ensure that more recent technical developments are incorporated. The CAMx model has also been shown to be very flexible. Alternative chemical mechanisms (CB-IV and SAPRC99) and advection schemes can be selected and meteorological inputs may be developed from objective/diagnostic or prognostic meteorological models. It also has two built-in probing tools, DDM (Decoupled Direct Method) for formal sensitivity analysis and PA (Process Analysis) for model dynamic examination. A PM module for simultaneous simulations of ozone and aerosols has recently been updated.

Tonneson (2003a) prepared test case simulations for the July-August, 2000 episode using the CAMx, SAQM, and CMAQ models. Within the allotted time, the simulations using CAMx were the only ones completed. However, the study strongly suggested better model performance by CAMx over the other two (Tonneson, 2003b). At CARB (CARB, 2003), the CAMx air quality model was configured for the July-August, 2000 episode in approximately 1 day (excluding the development of the required meteorological fields). The preparation of the SAQM took approximately 2 weeks, and the CMAQ model took approximately 2 months (much of this time was spent investigating the installation of the CMAQ code and the code for the IOAPI and MPI libraries on an LINUX system and addressing file-size limitations). Given this relative ease of use, its acknowledge stature as a state-of-the-art photochemical air quality model, and its flexibility in accepting meteorological inputs, the CAMx model was selected as the primary air quality model for the CCOS ozone modeling. This decision was reinforced by the selection of CAMx for SIP modeling by the South Coast Air Quality Management District (SCAQMD, 2005) and the hope that one model can be used throughout the State of California.

While selecting CAMx as the primary model of choice for CCOS modeling, it was also acknowledged that CMAQ is an alternative model that is being widely used across the United States for ozone SIP modeling. Therefore, as resources allow, the CMAQ photochemical model may also be run for the episodes to compare the performance of the two models.

4 MODELING DOMAIN AND GRID STRUCTURE

As described in Chapter 1, stakeholders have already produced a significant body of work, including model simulations, for the two selected modeling episodes. Selection of the domain and grid structure described in this chapter and to be used for SIP modeling are based on this prior experience.

4.1 Meteorological Modeling Domain

The MM5 meteorological modeling domain is consistent for both episodes. It consists of three nested grids: 36 km, 12 km and 4 km uniform, horizontal grid spacing (illustrated in Figure 4.1). The purpose of the coarse, 36 km grid (D01) is to provide synoptic-scale conditions to all three grids; while the purpose of the 12 km grid (D02) is to provide input data to the 4 km grid (D03). The D01 grid is centered at 37 N x 120.5 W while the subsequent two inner grids, D02 and D03, are placed within the coarser grids such that they are not too close to the lateral boundaries. The innermost grid D03 consists of 189 x 189 grid cells having an origin at -384 km x -300 km (Lambert Conformal projection). Although a nested grid structure is configured, each modeling domain was run independently using the output of its coarser, parent grid as input. The D03 grid is intended to resolve the fine details of atmospheric motion and is used to feed the air quality model simulations.

4.1.1 July-August, 2000 Episode Application

The vertical structure of the modeling domain for this episode was developed under CCOS (Chapter 1) and consists of 50 vertical layers, for which the top layer extends to a height of approximately 15,000 magl (Table 4.1). 20 vertical layers were placed within the first 1000 magl of the whole depth of the modeling domain to resolve the small boundary layer atmospheric flow features such as large eddies and vertical advection of the fluxes of all meteorological quantities. Model integration was executed between July 29, 2000 at 12Z and August 3, 2000 at 12Z.

4.1.2 July, 1999 Episode Application

The vertical layer structure for the July 1999 episode was developed in collaboration with the Bay Area MAC (Chapter 1) and is configured in 30 layers, as shown in Table 4.2.

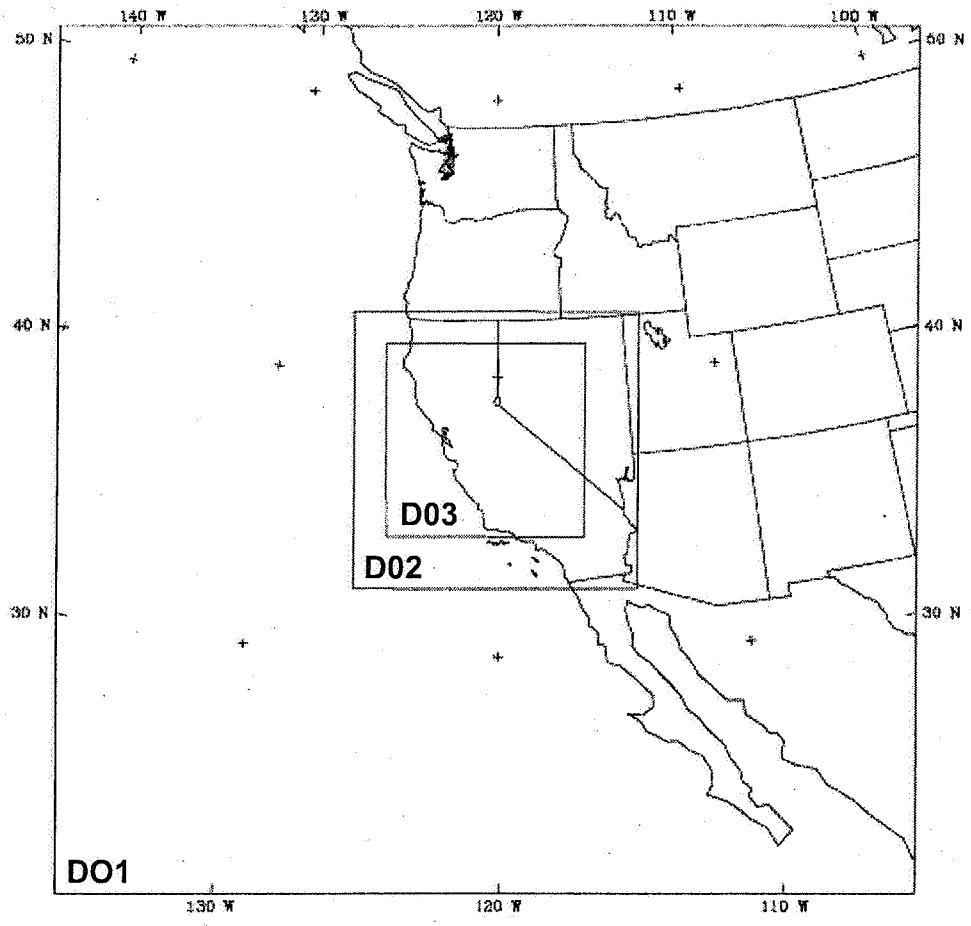


Figure 4.1: The structure of the three nested grids adopted for the numerical modeling for both SIP episodes using the MM5 model (D01 36km; D02 12km; and D03 4km).

Table 4.1 MM5 50 Vertical Layer Configuration for July-August 2000 Episode

Layer No.	Height (m)	Layer Thickness (m)
50	15674	1503
49	14171	1502
48	12669	1503
47	11166	1503
46	9663	1152
45	8511	993
44	7518	856
43	6662	738
42	5924	636
41	5288	547
40	4741	473
39	4268	408
38	3860	351
37	3509	303
36	3206	272
35	2934	246
34	2688	221
33	2467	199
32	2268	180
31	2088	162
30	1926	146
29	1780	131
28	1649	119
27	1530	106
26	1424	96
25	1328	87
24	1241	82
23	1159	81
22	1078	77
21	1001	74
20	927	71
19	856	69
18	787	65
17	722	63
16	659	61
15	598	59
14	539	56
13	483	54
12	429	50
11	379	48
10	331	44
9	287	41
8	246	39
7	207	36
6	171	34
5	137	31
4	106	29
3	77	27
2	50	26
1	24	24
0	0	0

Table 4.2 MM5 30 Vertical Layer Configuration for July 1999 Episode

Layer No.	Height (m)	Layer Thickness (m)
30	15674	998
29	14676	982
28	13694	976
27	12718	970
26	11748	972
25	10776	973
24	9803	979
23	8824	983
22	7841	994
21	6847	1002
20	5845	972
19	4873	818
18	4055	687
17	3368	577
16	2791	484
15	2307	407
14	1900	339
13	1561	285
12	1276	238
11	1038	199
10	839	166
9	673	139
8	534	115
7	419	97
6	322	81
5	241	67
4	174	56
3	118	47
2	71	39
1	32	32
0	0	0

4.2 Photochemical Modeling Domain

The objectives of the SIP require that the photochemical modeling domain include all of the Central Valley of California and upwind areas. The constraints of the CAMx air quality model require that the domain be rectangular to accept meteorological input fields from MM5. The resulting ozone modeling domain is mapped in a Lambert Conformal, Conic Projection with parallels at 30°N and 60°N latitude, with a central meridian at 120.5°W longitude. The domain origin is defined at 37°N x 120.5°W. The photochemical modeling domain is defined horizontally as 185x185, 4x4-km grid cells, shown in Figure 4.2. The domain lower, left-hand corner is at -376 x -292 km from the defined origin. The MM5 output for the 4-km modeling domain consists of a grid of 189 x 189 grid cells having an origin at -384 km x -300 km, and has been processed to match the air quality model domain. The emissions inventory domain that has 190x190 grid cells is also processed in order to match the air quality model domain. The vertical structure of the air quality modeling domain, depending on the meteorological model configurations, will be adjusted accordingly to generate the required inputs for two episodes.

The 4-km resolution domain included areas of ocean and land, and terrain elevations (cell-averaged) from sea level to 3712 magl. The San Joaquin Valley is part of the larger Central Valley of California than runs roughly north/south and is surrounded by mountains, except in the vicinity of the SFBA.

There are two scenarios being evaluated for the determination of the height of the ozone modeling domain. In the first view, referred to herein as the 'MM5' view (although not used for all MM5-based air quality simulations) the vertical reach of the ozone modeling domain extends to the height of the top of the prognostic modeling domain at 100 millibars (~15 km). To reflect this view, the vertical structure of the ozone modeling domain was defined as 20 layers using the sigma coordinate system. In the sigma coordinate system, vertical layer heights were defined in terms of normalized pressure levels, therefore, the exact thickness of each layer varies somewhat as air temperature and density change across the domain. An additional justification for a vertical domain to 15,000 magl is that the presence of deep vertical layers aloft would dampen adverse effects from spurious vertical velocities that may occur in the wind fields from some meteorological models (ENVIRON, 2005a).

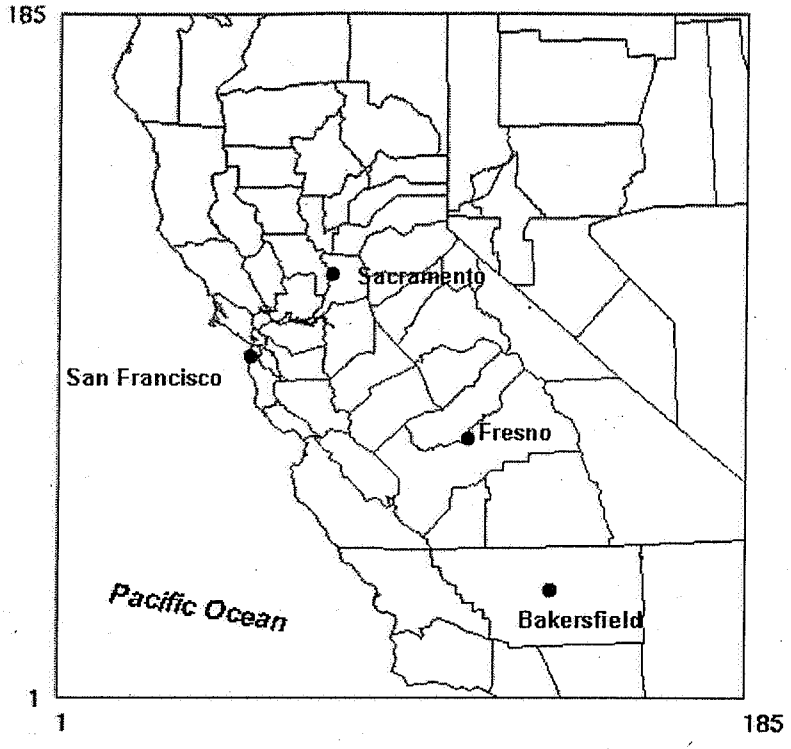


Figure 4.2 Photochemical Modeling Domain with185x185 Grid Cells at 4x4-km Horizontal Resolution

The number of vertical layers used in the ozone simulations will be tied closely to the meteorological model ultimately used. Configurations of 16-layer and 20-layer will be used for the July 1999 and July-August 2000 episodes, respectively, as shown in Table 4.3.

All photochemical model simulations will be run using a Pacific Daylight Time (PDT) time base.

Table 4.3 Vertical Layer Heights(m) of Photochemical Modeling for July-August 2000 and July 1999 Episodes.

Layer No.	July-August episode 50-Layer MM5 configuration Height(m)	July 1999 episode 30-Layer MM5 configuration Height(m)
20	15673	
19	12669	
18	9663	
17	7518	
16	5289	4873
15	3860	3368
14	2935	2306
13	2268	1560
12	1781	1275
11	1424	1037
10	1159	839
9	927	673
8	722	534
7	540	418
6	329	322
5	246	241
4	172	174
3	107	118
2	50	71
1	24	32

5 MODEL INITIALIZATION AND BOUNDARY CONDITIONS

Regional meteorological and air quality models must be initialized so that the chemical and physical conditions at the start of a model simulation approximate ambient conditions. This chapter is divided into two sub-sections that cover the initialization of the meteorological model (MM5) and the air quality model (CAMx) separately. Each section briefly covers the data upon which model initialization is based.

5.1 Initialization of the Meteorological Model

MM5 is a complex numerical model that requires setting a large number of input parameters and model options. Some of these requirements include: the specification of initial and boundary conditions (IC/BCs); gathering and processing representative data to be used for initial/boundary conditions as well as FDDA; and the selection of a variety of algorithms to calculate meteorological parameters, such as winds, temperature, humidity, pressure, soil temperature, the depth of the planetary boundary layer, cloud microphysics, and radiative transfer.

There is no apriori guidance on the specific data or options to be used in MM5. Rather, these decisions are determined based on optimizing model performance. Thus, during the preparation of preliminary meteorological fields for the July-August 2000 and July 1999 SIP episodes, vast amounts of data were processed and many combinations of model options were tested. Based on the best model performance for these preliminary tests, the most successful MM5 model options and input datasets were determined. These are described in the following sections.

5.1.1 MM5 Model Options

As indicated above, many sensitivity studies were conducted to choose a set of model options that result in scientifically reasonable meteorological fields that are representative of the specific conditions during each of the two selected ozone episodes.

For the July-August 2000 episode, the Kain and Fritsch (1993) cumulus parameterization scheme was selected for coarse grids, while no cumulus parameterization was used for the 4 km grid. In addition, the ETA model for the parameterization of boundary layer flow (Janjic, 1994), Dudhia simple ice scheme for the treatment of cloud microphysics (Dudhia, 1989), the RRTM scheme for the calculation of radiation (Mlawer, 1997), and NOAH Land Surface Model for the calculation of surface energy balance (Chen and Dudhia, 2001) were used in all grids.

For the July 1999 episode, no cumulus parameterization scheme was used for any of the grids and a 5-layer slab model (Dudhia, 1996) was used for the calculation of surface energy balance for all grids. The cloud radiation scheme was used for the 4 km grid. All other model options were kept the same as those used for July-August 2000 episode.

5.1.2 MM5 Initial and Boundary Conditions (IC/BC)

The MM5 IC/BCs were prepared based on 3-D analyses of ETA model output that is archived at NCAR by the National Center for Environmental Prediction (NCEP). These data are archived for the continental United States and have a 40 km horizontal resolution. Initial conditions to MM5 were updated at 6-hour intervals for the 36 and 12 km grids. In addition, surface and upper air synoptic observations obtained by NCEP are also used to further refine the IC/BCs.

5.1.3 MM5 Four Dimensional Data Analysis (FDDA)

The MM5 model was forced to follow the meteorological conditions observed during the July-August 2000 and July 1999 episodes by using the analysis nudging option of the Four Dimensional Data Analysis (FDDA) for the 36 and 12 km grids only. Input conditions for the 4 km grid were obtained from the output of the 12 km grid, and observational nudging option of FDDA was used to enhance these input conditions for the two episodes. Only wind measurements were used for observational FDDA due to some inconsistent temperature measurements.

The extent of meteorological data available for developing FDDA input datasets is different for the July-August 2000 and July 1999 episodes. The July-August 2000 episode benefited from the extensive CCOS field campaign conducted during the summer of 2000. About 300 surface and 25 upper air meteorological stations were operated during CCOS field campaign (Section 2.3) and provided additional meteorological data in addition to the routine surface data that are available through the instruments operated by local air districts, ARB, and National Weather Service. Since a separate field campaign was not in place during the July 1999 episode, this episode had only six upper air meteorological stations plus the hourly surface data available from routine monitoring networks.

5.1.4 Meteorological Data Quality Assurance

In developing the IC/BCs and FDDA datasets, quality control is performed on all associated meteorological data (both inputs and outputs). Generally, all surface and upper air data are plotted in space and time to identify extreme values that are suspected to be "outliers". Data points are also compared to other, similar surrounding data points to determine whether there are any large relative discrepancies. If a scientifically plausible reason for the occurrence of suspected outliers is not known (e.g. after discussion with peers and stakeholders), the outlier data points are flagged as invalid and not used in the modeling analyses. Model-simulated meteorological

parameters such as 3-D winds, temperature, pressure, and humidity values are compared against surface and upper air observations to study the temporal and 3-D spatial structure of atmospheric motions as well as to evaluate the model performance. More details on the evaluation of model performance are provided in Chapter 7.

5.2 Air Quality Model Initial and Boundary Conditions

Air quality model initial conditions define the concentration distributions of chemical species within the modeling domain at the beginning of the model simulation. Boundary conditions define the chemical species concentration distributions for air entering or leaving the modeling domain. To some extent the initial and boundary conditions need to reflect the modeling domain dimensions, the episode, and the characteristics of the model being used.

This section discusses the initial and boundary conditions used by the Air Resources Board (ARB) in air quality modeling that will support developing the 8-hour ozone State Implementation Plan (SIP). The selected boundary conditions are summarized in Tables 5.2 and 5.3, while episode-specific initial conditions are provided in Table 5.4. These conditions were determined with stakeholder input at a March 10th, 2005, meeting of regulatory agency modeling staff.

5.2.1 *Photochemical Mechanism*

Historically, over the last several decades, air quality modeling for ozone SIPs throughout California have predominately been conducted using the Carbon Bond IV (CBIV) chemical mechanism. The CBIV mechanism uses 36 chemical species and 89 chemical reactions (may vary somewhat among different air quality models) to describe the relationship between ozone and ozone precursors in the atmosphere. Over the last decade, more complex chemical mechanisms, such as the 1999 State Air Pollution Research Center chemical mechanism (SAPRC99; Carter, 2000), have been developed; however, the use of SAPRC99 has historically been restricted by limited implementation in newer air quality models and the relatively large computational requirements.

Since SAPRC-99 is the most up-to-date chemical mechanism available (74 chemical species and 211 chemical reactions) and has been thoroughly peer-reviewed, ARB's Reactivity Scientific Advisory Committee recommended unanimously in October of 1999 that ARB use SAPRC-99 instead of CBIV for SIP modeling. Minutes of the October 8, 1999, Reactivity Scientific Advisory Committee (RRAC) can be found at:

http://www.arb.ca.gov/research/reactivity/rsac/oct99-min.html

In central and northern California, SAPRC has been the mechanism of choice for over a decade. Consistent with this and with the expectation of better representation of

atmospheric chemical behavior for ozone modeling, the SAPRC99 chemical mechanism was selected for all 8-hour ozone air quality modeling in California.

5.2.2 *Supporting Information*

This section discusses ambient concentrations available from measurements, related studies, as well as USEPA guidance on initial conditions, boundary conditions, and background concentrations of pollutants. Ideally, initial and boundary conditions used in modeling would be based upon measurements. Unfortunately, for a domain as large as that defined for CCOS, the boundaries are located in remote Pacific ocean areas (56km from northern coast line, 200km from S.F. coast line, and 360km from southern coast line) and there are few measurements that may be considered uncontaminated by anthropogenic sources.

The USEPA (1991) recommends default initial/boundary conditions based upon species for the Carbon Bond IV chemical mechanism. Table 5.1 shows USEPA's recommended initial concentrations for individual CBIV species, including 40 ppb ozone, 2 ppb NO_x, and approximately 22 ppbC ROG.

During the year 2000 CCOS field study, pollutant concentrations aloft were measured along several aircraft flight patterns and from ozonesondes at two locations (Granite Bay and Parlier). However, comparison of measurements taken along the coast of California versus historical data collected offshore suggest that the CCOS concentrations may not represent concentrations occurring over the Pacific Ocean. Thus, whether the CCOS samples are appropriate for the definition of top or lateral boundary concentrations is subject to interpretation.

Ozonesondes were launched four times per day from Parlier and Granite Bay during CCOS intensive measurement periods. However, these sites were located within the Sacramento and San Joaquin Valleys and are not necessarily well suited to represent ozone concentrations on the lateral domain boundaries, several hundreds of kilometers from the launch locations. During the July-August, 2000 episode, ozone concentrations at 5000 meters above ground level (magl) ranged between about 50 and 90 pbb. However, during other episode periods such as the September 18-20, 2000 episode, ozonesonde measurements showed ozone concentrations at 5000 magl of 40 ppb or less.

Unfortunately, the CCOS aircraft measurements were conducted at altitudes that rarely exceeded 1500 magl. Depending on the time of day and flight-path, ozone concentrations measured aloft from the aircraft ranged from 15 ppb to more than 100 ppb. Ozone concentrations during CCOS in the 70-80 ppb range were measured from aircraft as far as 160 km offshore (to the west); however, these flights were few and the evaluation of wind flow patterns during these flights casts doubt on the representativeness of these measurements for model boundary concentrations.

A study by Newchurch et. al. (2003) reported annual-average ozone concentrations aloft from ozonesondes at four sites in the U.S. Among them, the Trinidad Head site is located at the north coast of California as shown in Figure 5.2. Ozone measurements from two single day ozonesondes launched by the National Atmospheric and Oceanic Administration (NOAA) on July 21 and August 1, 2000, at Trinidad Head and two CCOS ozonesondes during a CCOS intensive measurement period (IOP #2) are plotted in Figure 5.3. NOAA's measurements at Trinidad Head show ozone concentrations at 15 km aloft of around 135 ppb. The CCOS measurements at Granite Bay and Parlier have higher ozone levels below 5000 magl than the ozonesonde at Trinidad Head. This is likely due to location – higher ozone levels in the Sacramento and San Joaquin Valleys are expected versus on the coastline. An analysis conducted by the Bay Area Air Quality Management District (BAAQMD) found a similar difference: that measured concentrations along the California coastline consistently have lower ozone levels in comparison with inland measurements.

Table 5.1 USEPA Default Background Concentrations for Carbon Bond-IV Species (1991).

Species	Species Names	Concentration (ppbC)
OLE	Olefins	0.60
PAR	Paraffins	14.94
TOL	Toluene	1.26
XYL	Xylene	0.78
FORM	Formaldehyde	2.10
ALD2	Higher Aldehydes	1.11
ETH	Ethene	1.02
CRES	Cresol, Higher Phenols	0.01
MGLY	Methyl Glyoxal	0.01
OPEN	Aromatic ring fragment Acid	0.01
PNA	Peroxynitric Acid	0.01
NXOY	Total Nitrogen Compunds	0.01
PAN	Peroxyacyl Nitrate	0.01
HONO	Nitrous Acid	0.01
H2O2	Hydrogen Peroxide	0.01
HNO3	Nitric Acid	0.01
MEOH	Methanol	0.10
ETOH	Ethanol	0.10
O3	Ozone	40.00 (ppb)
NO2	Nitrogen Dioxide	2.00 (ppb)
CO	Carbon Monoxide	350.00 (ppb)
ISOP	Isoprene	0.10 (ppb)

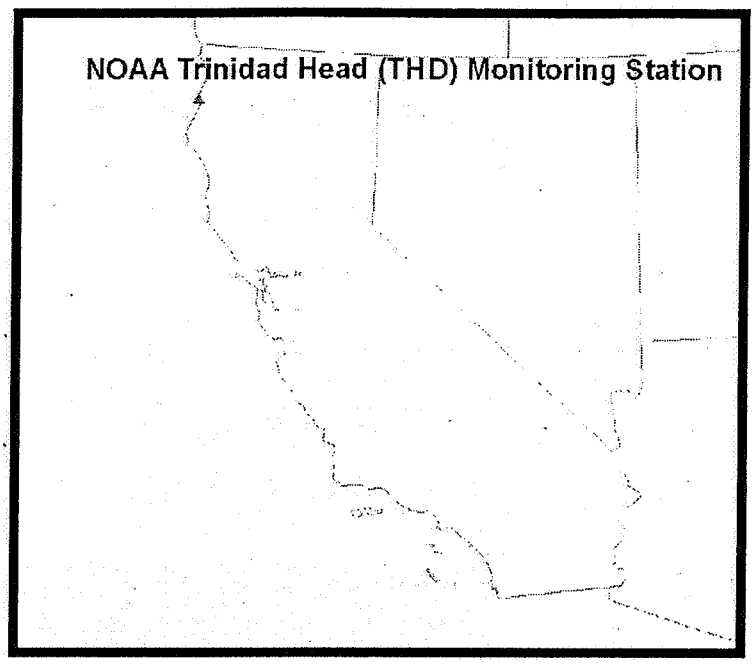


Figure 5.2. Trinidad Head ozonesonde site operated by NOAA.

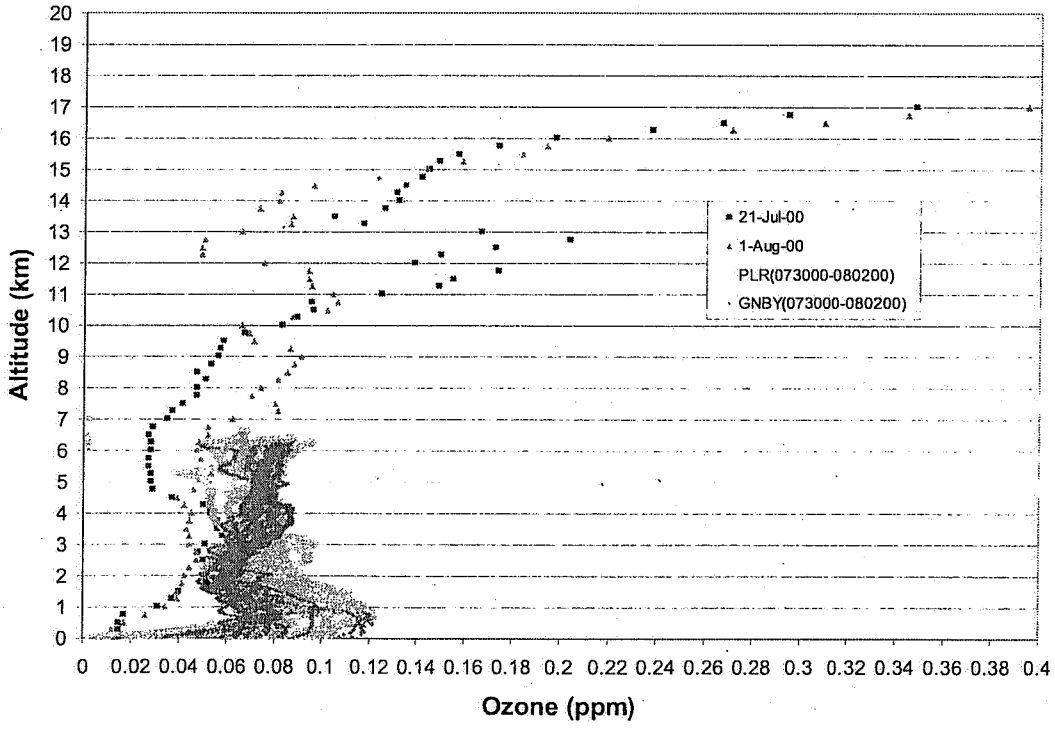


Figure 5.3. Ozone vertical profiles measured by ozonesonde at Trinidad Head (operated by the NOAA) as well as Granite Bay and Parlier (operated during CCOS).

The USEPA recommends a boundary condition for ozone of 40 ppb. However, analyses conducted by the BAAQMD (2005) suggested that lower concentrations are common at the surface near the Pacific coastline.

Reactive Organic Gases (ROGs) are the most difficult pollutant category to provide a measurement-based assessment of boundary concentrations, since there are only a limited number of measurements available. At the surface, all of the ROG samples collected during CCOS were made at sites located within the San Joaquin Valley, which are unlikely to represent boundary concentrations. A few dozen aircraft-based ROG samples were collected during the July-August, 2000, episode. However, the aircraft samples collected were of only short duration and an evaluation of the offshore flow patterns during these flights casts doubt on whether the measurements taken are representative of boundary concentrations.

For ROG boundary conditions, the U.S. EPA (1991) recommends default concentrations of 22 ppbC. However, ROG concentrations measured at the surface during CCOS were often higher than this. Aloft, concentrations of ROG measured during CCOS aircraft flights ranged from less than 10 to 100 ppbC. For most of the CCOS aircraft samples collected during the July-August, 2000 episode, ROG concentrations were between 20 and 40 ppbC. These data suggest that, while higher ROG concentrations occurred aloft, the concentrations aloft were not uniformly high. Analyses conducted by STI under a CCOS contract (2005) reported no significant correlation between high ROG concentrations aloft and high ozone concentrations observed throughout the episode. The data further suggested that the ROG concentration of 22 ppbC suggested by the USEPA was a reasonable estimate of clean air concentrations.

5.2.3 *Boundary Concentrations*

The recommended initial and boundary conditions are tabulated in Tables 5.2 and 5.3. More episode-specific details are provided in Attachment 1. The selected conditions were determined with BAAQMD, SJVAPCD, and SMAQMD stakeholder input at a March 10th, 2005, meeting of the SIP Modeling Working Group (Attachment 2).

Because of their relatively clean values, the boundary conditions for future years are kept the same as boundary conditions for the base years.

Table 5.2. Recommended air quality modeling domain boundary conditions.

	Region Top*	Over-Water Lateral	Over-Land Lateral
O_3 (ppb)	70	25-70	40-70
ROG (ppbC)	26	26	48
NO_2 (ppb)	1	1	1
CO (ppb)	200	200	200

* The July 1999 episode domain top is at approximately 5 km and the CCOS 2000 domain top is at approximately 15 km.

Table 5.3. Recommended SAPRC99 boundary conditions (ROG).

Over-Land			Over-Ocean	
Specie(s)	ppb*		Specie(s)	ppb*
HCHO	2.0		HCHO	2.0
RCHO	0.5		RCHO	0.5
ALK1	10.0		ALK1	6.0
ALK2	2.50		ALK2	1.0
OLE1	0.50		OLE1	0
OLE2	0.20		OLE2	0
ARO1	0.35		ARO1	0
ARO2	0.25		ARO2	0
ISOP	0.10		ISOP	0
ACET	1.0		ACET	1.0
PAN	0.005		PAN	0.005

* Based on USEPA (1991) and approximate 22 ppbC Carbon Bond IV ROG (chemical species not listed were set to concentrations of 0.00001).

Table 5.4. Summary of Episode-Specific Ozone & Precursor Boundary Conditions.

July 1999 (ppm)			
Layer	Elevation (m)	Over water	Over land
1	32	0.025000	0.040000
2	71	0.025000	0.040000
3	118	0.026000	0.042000
4	174	0.028000	0.043000
5	241	0.030000	0.045000
6	322	0.040000	0.050000
7	418	0.045000	0.052000
8	534	0.050000	0.055000
9	673	0.055000	0.058000
10	839	0.058000	0.060000
11	1,037	0.060000	0.062000
12	1,275	0.062000	0.064000
13	1,560	0.064000	0.065000
14	2,306	0.065000	0.066000
15	3,368	0.068000	0.068000
16	4,873	0.070000	0.070000

July-Aug. 2000 (ppm)			
Layer	Elevation (m)	Over water	Over land
1	24	0.025000	0.040000
2	50	0.025000	0.040000
3	107	0.026000	0.042000
4	172	0.027000	0.043000
5	246	0.028000	0.045000
6	379	0.030000	0.045000
7	540	0.030000	0.050000
8	722	0.040000	0.052000
9	927	0.045000	0.055000
10	1,159	0.050000	0.055000
11	1,424	0.055000	0.058000
12	1,781	0.058000	0.060000
13	2,268	0.060000	0.060000
14	2,935	0.062000	0.062000
15	3,860	0.063000	0.063000
16	5,289	0.064000	0.064000
17	7,518	0.065000	0.065000
18	9,663	0.066000	0.066000
19	12,669	0.068000	0.068000
20	15,673	0.070000	0.070000

Precursors (ppm)

	Over water	Over land
NO	0.000050	0.000050
NO2	0.001000	0.001000
CO	0.200000	0.200000
HCHO	0.002000	0.002000
RCHO	0.000500	0.000500
PAN	0.000005	0.000005
ALK1	0.006000	0.010000
ALK2	0.001000	0.002500
OLE1	0.000000	0.000500
OLE2	0.000000	0.000200
ARO1	0.000000	0.000350
ARO2	0.000000	0.000250
ISOP	0.000000	0.000100
ACET	0.001000	0.001000
ROG (ppbC)	26	48

5.2.4 *Initial Conditions and Spin-Up Period*

User-defined initial concentrations are often based on limited observational data and associated with a degree of uncertainty. To alleviate these uncertainties, the air quality model is started prior to the period of interest (i.e. a spin-up period) in an effort to allow the air quality model to generate appropriate initial conditions based on emissions and boundary conditions. Utilizing a spin-up period also reduces the affects of not specifying secondary reaction products or chemical radicals at start-up. That is, the spin-up period allows the model to use simulated meteorology and chemical transformation processes to generate more representative secondary and radical concentrations prior to beginning the simulation of air quality during the episode days of interest.

For both modeling episodes, a 2-day (48 hours) spin-up period will be utilized to minimize the impacts of the defined initial concentrations on the model predictions.

6 EMISSION INVENTORY DEVELOPMENT

One of the necessary inputs to air quality modeling is an emission inventory with temporally and spatially resolved emissions estimates. Emissions are broadly categorized into major stationary or point sources, area sources (which include off-road mobile sources), on-road mobile sources, and biogenic sources.

To support the body of work conducted by stakeholders, modeling inventories have been developed by ARB staff on an on-going basis for the July 1999 and July-August 2000 episodes. The following sections describe how emissions estimates required by the selected air quality models (commonly and interchangeably referred to as 'modeling inventories' or 'gridded inventories') are estimated and how they will be used to develop base case and future year emissions estimates for modeling used to prepare the State Implementation Plan (SIP). As modifications to basic inventory inputs are approved by the responsible regulatory agencies, including ARB, they will be incorporated into final SIP modeling. Once final SIP modeling is complete, the specific versions of the emission inputs used will be documented and summarized.

To help coordinate the development of gridded inventories for CCOS modeling, an Emission Inventory Coordination Group (CCOS EICG) was established in February 1999. Participating in the group were many local air districts, regional transportation planning agencies (RTPAs), the California Department of Transportation (Caltrans), the California Energy Commission, the U.S. Environmental Protection Agency, and the ARB. Local air districts that participated included San Joaquin Valley APCD, Bay Area AQMD, Sacramento Metropolitan AQMD, Mendocino County APCD, Northern Sierra AQMD, Yolo/Solano AQMD, Placer County APCD, San Luis Obispo County APCD, and Monterey Bay Unified APCD. All local air districts in the CCOS region were invited to participate. The CCOS-EICG coordinated six studies through CCOS to improve the emission inventory:

- Small district assistance with point source updates (Contract 00-22CCOS, UC Davis). Section 6.2.1.3 describes this project in more detail.

- Small district assistance with area source updates (Contract 00-24CCOS, Sonoma Technology, Inc). Section 6.2.1.3 describes this project in more detail.

- Collect day-specific traffic count data and develop hourly distributions (Contract 00-04PM, UC Davis). Section 6.7.6 provides more detail.

- Develop the Integrated Transportation Network (ITN) and run the Direct Travel Impact Model (DTIM) (Contract 93-2PM, Alpine Geophysics). Section 6.7.9 describes this project in more detail.

- Validate databases for modeling biogenic emissions (Contract 00-16CCOS, UC Cooperative Extension). Section 6.8 provides more detail.

- Develop spatial surrogates for gridding area and off-road sources (Contract 00-24CCOS, Sonoma Technology, Inc.). Section 6.9 describes this project in more detail.

The CCOS EICG met on a regular basis to discuss CCOS emission inventory development issues into 2002.

As indicated in Chapter 1, as modeling inventories became available for the 1-hour ozone SIPs, the Air Resources Board established a SIP Gridded Inventory Coordination Group (SIP-GICG) in February 2003. The GICG consists primarily of government agencies and their contractors that are responsible for the variety of data used to develop gridded emission inventories for SIP purposes. Many of the same participants in the CCOS-EICG participate in the SIP-GICG. The purpose of the SIP-GICG is to conduct quality assurance of the emissions, and to distribute and coordinate the development of emission inputs for SIP modeling. In February 2005, the focus was changed to inventory development for the 8-hour ozone SIPs. Minutes from the SIP-GICG meetings are provided in Appendix A.

6.1 Background

In order to understand how the modeling inventories are developed, it is necessary to understand the basics of how an annual average emission inventory is developed. California's emission inventory is an estimate of the amounts and types of pollutants emitted from thousands of industrial facilities, millions of motor vehicles, and of hundreds of millions of applications of other products such as paint and consumer products. The development and maintenance of the inventory is a multi-agency effort involving the ARB, 35 local air pollution control and air quality management districts (districts), regional transportation planning agencies (RTPAs), and the California Department of Transportation (Caltrans). The ARB is responsible for the compilation of the final, statewide emission inventory, and maintains this information in a complex electronic database. Each emission inventory reflected the best information available at the time.

To produce regulatory, countywide emissions estimates, the basic principle for estimating emissions is to multiply an estimated, per-unit emission factor by an estimate of typical usage or activity. For example, on-road motor vehicle emission factors are estimated for a specific vehicle type and model year based on dynamometer tests of a small sample of that vehicle type and applied to all applicable vehicles. The usage of those vehicles is based on an estimate of such activities as a typical driving pattern, number of vehicle starts, typical miles driven, and ambient temperature. It is assumed that all vehicles of this type in each region of the state are driven under similar conditions.

Developing emission estimates for stationary sources involves the use of per unit emission factors and activity levels. Under ideal conditions, facility-specific emission

factors are determined from emission tests for a particular process at a facility. More commonly, a generic emission factor is developed by averaging the results of emission tests from similar processes at several different facilities. This generic factor is then used to estimate emissions from similar types of processes when a facility-specific emission factor is not available. Activity levels from point sources are measured in such terms as the amount of product produced, solvent used, or fuel used.

ARB maintains an electronic database of emissions and other useful information. Annual average emissions are stored for each county, air basin, and district. The database is called the California Emission Inventory Development and Reporting System (CEIDARS). Emissions are stored in CEIDARS for criteria and toxic pollutants. The criteria pollutants are total organic gases (TOG), carbon monoxide (CO), oxides of nitrogen (NOx), oxides of sulfur (SOx), and total particulate matter (PM). Reactive organic gases (ROG) and particulate matter 10 microns in diameter and smaller (PM_{10}) are calculated from TOG and PM, respectively. Following are more details on how emissions are estimated for point and area sources, on-road motor vehicles, and biogenic sources. Additional information on emission inventories can be found at http://www.arb.ca.gov/ei/ei.htm

6.2 Point and Area Source Emissions

6.2.1 Development of Base-Year Emission Inventory

The stationary source component of the emission inventory is comprised of more than 17,000 individual facilities, called "point sources", and about 160 categories of "aggregated point sources". Aggregated point sources are groupings of many small point sources that are reported as a single source category (gas stations, dry cleaners, and print shops are some examples). These emission estimates are based mostly on area source methodologies or emission models. Thus, the aggregated point sources include emissions data for the entire category of point sources, not each specific facility. All districts report as point sources any facility with criteria pollutant emissions of 10 tons per year and greater. Some districts choose a cutoff smaller than 10 tons per year for reporting facilities as point sources. Any remaining sources not captured in the point source inventory are reported as aggregated point sources.

The area-wide source component includes several hundred source categories and is made up of sources of pollution mainly linked to the activity of people. Examples of these categories are emissions from consumer products, architectural coatings, pesticide applications, and wind-blown dust from agricultural lands. The emissions for these categories are located mostly within major population centers. Some of the emissions in these categories come from agricultural centers and construction sites.

The off-road mobile source inventory is based on the population, activity, and emissions estimates of the varied types of off-road equipment. The major categories of engines

and vehicles include agricultural, construction, lawn and garden, and off-road recreation, and include equipment from hedge trimmers to cranes. ARB's OFFROAD model estimates the relative contribution of gasoline, diesel, compressed natural gas, and liquefied petroleum gas powered vehicles to the overall emissions inventory of the state. In previous versions of the inventory, emissions from the OFFROAD model were aggregated into about 100 broad categories. Since April 2006, the inventory reports emissions in about 1800 detailed categories that match what is produced by the OFFROAD model. Carrying this level of detail allows for more accurate application of control measures as well as more specific assignments of speciation and spatial distribution. For more information, see http://www.arb.ca.gov/msei/offroad/offroad.htm.

Local air districts estimate emissions from point sources. The districts provide point source information to ARB to update the annual average CEIDARS database. Estimating emissions from area sources is a cooperative effort between ARB and air district staffs. Updating the emission inventory is a continual process, as new information becomes available.

6.2.1.1 Terminology

There can be confusion regarding the terms "point sources" and "area sources". Traditionally, these terms have had two different meanings to the developers of emissions inventories and the developers of modeling inventories. Table 6.2 summarizes the difference in the terms. Both sets of terms are used in this document. In modeling terminology, "point sources" refers to elevated emission sources that exit from a stack and have a potential plume rise. "Area sources" refers collectively to area-wide sources, stationary-aggregated sources, and other mobile sources (including aircraft, trains, ships, and all off-road vehicles and equipment). That is, "area sources" are low-level sources from a modeling perspective. In the development of the CCOS inventories, all point sources were treated as possible elevated sources. Processing of the inventory for the photochemical model (e.g. CAMx) will determine which vertical layer the emissions from a process will be placed into. So, for the CCOS modeling inventories, the use of the term "point sources" is the same whether using the modeling or emission inventory definition.

Table 6.2 Inventory Terms

Modeling Term	Emission Inventory Term	Examples
Point	Stationary – Point Facilities	Stacks at Individual Facilities
Area	Off-Road Mobile	Farm Equipment, Construction Equipment, Aircraft, Trains
Area	Area-wide	Consumer Products, Architectural Coatings, Pesticides
Area	Stationary - Aggregated	Industrial Fuel Use
On-Road Motor Vehicles	On-Road Mobile	Automobiles
Biogenic	Biogenic	Trees

6.2.1.2 Quality Assurance of Base Year Emissions

In order to prepare the best inventory possible for use in modeling, ARB and district staff devoted considerable time and effort to conduct quality assurance (QA) of the inventory. Staffs from many local districts, including the Bay Area AQMD, Monterey Bay Unified APCD, Sacramento Metro AQMD and San Joaquin Valley APCD conducted extensive quality assurance to provide an accurate and complete inventory. Districts in the southern part of California had recently completed a similar exercise to improve their inventories as part of the Southern California Ozone Study (SCOS).

In particular, facility location, stack data, and temporal data were closely checked. This information is critical whenever photochemical modeling is conducted, such as during SIP preparation or special studies such as CCOS. However these data are not always of sufficient quality in the inventory database since this information is not needed in the actual calculation of emissions and resources are limited. ARB ran several types of QA reports on the inventory to assist the districts in locating errors or incomplete information. This QA process began with the 1999 CEIDARS database that was used initially for CCOS and 1-hour ozone SIP inventory preparation. This QA process has continued with the 2002 CEIDARS database, which is the basis for the modeling inventories being developed for the 8-hour ozone SIP.

- Stack data – The report checks for missing or incorrect stack data. The report lists missing stack data and also checks the data for reasonable stack height, diameter, temperature, and stack velocity. Additionally, the report compares the reported stack flow rate with the computed theoretical flow rate (calculated using the diameter and stack velocity).

- Location data – The report checks for missing or wrong Universal Transverse Mercator) UTM coordinates. The report lists missing UTM coordinates for both facilities and stacks. UTM coordinates are also checked to ensure that they are

in the range for a given county. Another report is also run that shows the UTM coordinates for a facility grouped by the city in which the facility is located. This allows staff to look for outliers that may indicate facilities whose locations are in the county, but not in the correct location. Additionally, ARB staff reviewed location coordinates for accuracy and completeness. Comparisons were made using address or zip code mapping.

- Temporal data – The report checks for missing or invalid temporal information. Temporal codes used to describe the hours per day, days per week, and weeks per year are checked for completeness, accuracy, and validity. The relative monthly throughput, which assigns a relative amount of activity to each month of the year, is checked to ensure the sum is 100%.

- Code Assignments – Source Classification Codes (SCC) and Standard Industrial Classification Codes (SIC) were reviewed for accuracy. The SCC is used to determine the speciation profile assigned (speciation is discussed in Section 6.10). The SIC and SCC combined determine emission control rules that may apply for forecasting emissions (see Section 6.3) along with the categorization of emissions for reporting purposes.

6.2.1.3 Improvements to Base Year Emissions for CCOS

In addition to the extensive QA checks described above, the CCOS Emission Inventory Coordination Group agreed to assist the small districts in the CCOS domain. Many small districts in the CCOS region have limited staff and resources to provide updated emission inventories to the ARB. After discussion with staff from districts in the Sacramento Valley and Mountain Counties Air Basins, two studies were decided upon. One study would focus on point sources and the second on area sources.

District staff said that they did have emission estimates for their point source facilities, but that they did not have the resources to provide the data to ARB. The first study sent engineering students from UC Davis (Kleeman, 2000) to visit several districts to gather the emissions and related data for 1999. The students then put the information into ARB's CEIDARS database. Two teams containing three students and one ARB staff person each visited Amador County APCD, Butte County AQMD, Colusa County APCD, El Dorado County APCD, Feather River AQMD, Glenn County APCD, Northern Sierra AQMD, Placer County APCD, Shasta County AQMD, Tehama County APCD, Tuolumne County APCD, and Yolo/Solano AQMD. The results of this project have been incorporated into the 1999, 2000, and 2002 CEIDARS inventories.

For area sources, district staff said that the best way to provide assistance would be to have a contractor develop emission estimates for the area source categories for which the districts were responsible. The CCOS study contracted with Sonoma Technology, Inc. (STI) (Coe, 2003) to prepare revised emissions estimates. STI would format the emissions and related data for input into the CEIDARS database. District staffs have

included these updates in the 2002 database. STI developed protocol memoranda that contained the following elements:

- Description of emission source
- Emission factors
- Activity data
- Emissions calculations, including a sample calculation
- Temporal allocation
- References and contacts

The protocols were pulled together from a variety of resources, including local air districts' past methods documents, U.S. Environmental Protection Agency documents, ARB documents, and original ideas based on the discovery of new information sources through library research, Internet research, and telephone contacts. Generally, STI attempted to incorporate data and information resources into the protocols that are readily available to the general public at no or low cost. And, while these methods and information resources are useful, it is recognized that it is more ideal to use highly customized or bottom-up emissions estimates when the costs of these efforts are warranted.

Emissions were estimated for the following counties: Amador, Butte, Calaveras, Colusa, E. Solano, El Dorado, Glenn, Mariposa, Mendocino, Nevada, Placer, Plumas, Sacramento, Shasta, Sierra, Sutter, Tehama, Tuolumne, Yolo, and Yuba. Area source methodologies were developed for the following broad categories:

- Asphalt paving/roofing
- Chemical and related products manufacturing
- Cleaning and surface coatings and related process solvents
- Fuel combustion:
    - Commercial natural gas
    - Commercial liquid fuels
    - Industrial natural gas
    - Industrial liquid fuels
    - Unspecified
    - Resource recovery
    - Petroleum production
- Cooking
- Wastes (e.g. livestock waste and landfills)
- Food and agriculture
- Mineral and metal processes
- Miscellaneous processes (e.g. miscellaneous industrial processes)
- Petroleum marketing

The protocol memoranda can be found on a password-protected project web site (URL: www.sonomatech.com/ccosii/; user name: "ccosii"; password: "emissions").

6.3 Forecasted Emissions

Air pollution programs have always depended on predictive models for gaining a better understanding of what the emissions will be in the future—these predictions are based on expectations of future economic conditions, population growth, and emission controls.

ARB's model to forecast or backcast emissions is known as the California Emission Forecasting System (CEFS). The CEFS model is designed to generate year-specific emissions estimates for each county/air basin/district combination taking into account two factors: 1) the effects of growth and 2) the effects of adopted emission control rules. It does this by linking these growth and control factors directly to CEIDARS emission categories for a particular base year (2002 for this project). A key component of the model is the Rule Tracking Subsystem (RTS). The RTS was developed to link year-specific implementation of emission control rules to the emission process level. The emission process level is identified in one of two ways. For facilities, the Source Classification Code (SCC) and Standard Industrial Classification (SIC) are used. For all other sources, the Emission Inventory Code (EIC) is used. In total, the emission process level comprises more than 30,000 possible emission categories statewide.

Reports of year-specific emissions are available to district staff on-line. District staffs should contact their emission inventory liaisons for URL and password information. The reports can be generated for a variety of years, pollutants, source types, seasons, and geographical areas.

6.3.1 Growth Factors

Growth factors are derived from county-specific economic activity profiles, population forecasts, and other socio/demographic activity. These data are obtained from a number of sources, such as:

- districts and local regional transportation planning agencies (RTPAs) when they are available
- economic activity studies contracted by the ARB
- demographic data such as population survey data from the California Department of Finance (DOF) and Vehicle Miles Traveled (VMT) data from the California Department of Transportation (Caltrans)

Growth profiles are typically associated with the type of industry and secondarily to the type of emission process. For point sources, economic output profiles by industrial sector are linked to the emission sources via SIC. For area-wide and aggregated point sources, other growth parameters such as population, dwelling units, and fuel usage may be used.

6.3.2 Control Factors

Control factors are derived from adopted State and Federal regulations and local district rules that impose emission reductions or a technological change on a particular

emission process. These data are provided by the agencies responsible for overseeing the regulatory action for the particular emission categories affected. For example, the ARB staff develops the control factors for sectors regulated by the ARB, such as consumer products and clean fuels. The districts develop control factors for locally enforceable stationary source regulations that affect emissions from such equipment as internal combustion engines or power plant boilers. The Department of Pesticide Regulation (DPR) supplies control data for pesticides. In general, control factors account for three variables:

- *Control Efficiency* which estimates the technological efficiency of the abatement strategy
- *Rule Effectiveness* which estimates the "real-world" application of the strategy taking into account factors such as operational variations and upsets
- *Rule Penetration* which estimates the degree a control strategy will penetrate a certain regulated sector taking into account such things as equipment exemptions.

Control factors are closely linked to the type of emission process and secondarily to the type of industry. Control levels are assigned to emission categories, which are targeted by the rules via emission inventory codes (SCC/SIC, EIC etc.) that are used in CEIDARS.

6.4 Day-Specific Emissions

As part of CCOS, the Emission Inventory Coordination Group (EICG), made up of ARB and district staff to guide inventory development for CCOS, requested that districts within the CCOS domain collect day-specific data from facilities and other sources within their jurisdiction. The EICG gathered hourly/daily emission information for:

1) large point sources (> 100 tons per year of NOx or ROG)
2) sources with large variability in emissions (e.g. power plants)
3) unusual events (e.g. source shut down, variances, breakdowns)
4) agricultural or prescribed burning
5) shipping emissions for the Bay Area
6) wildfires

6.4.1 Point Sources

Eleven air districts provided daily or hourly emission estimates for 67 facilities. The districts which provided data were Amador County APCD, Bay Area AQMD, Colusa County APCD, Monterey Bay Unified APCD, Placer County APCD, Sacramento Metro AQMD, San Joaquin Valley APCD, San Luis Obispo County APCD, Shasta County AQMD, Tehama County APCD, and Yolo/Solano AQMD. Day-specific emissions replaced emissions estimated from CEFS. Additionally, the Bay Area AQMD provided emission estimates from unusual events, such as equipment breakdowns. These emissions were added to the modeling inventories on the day when the unusual event occurred.

6.4.2 Area Sources

Three districts provided day-specific data for agricultural burning. In most districts, no agricultural burning occurred because no-burn days were declared during the episode.

6.4.3 Shipping in the Bay Area

Professor Bob Bornstein, San Jose State University, developed day-specific shipping adjustments for the Bay Area Air Quality Management District. Professor Bornstein provided factors that were applied to the annual average emission estimates for ships in the ocean and San Francisco Bay as well as for tugboats. Professor Bornstein developed factors for July 4 through July 14,1999, covering all the days needed for modeling (July 8 through 13, 1999). Professor Bornstein developed factors for July 29 through August 3, 2000. Since July 27 through August 2, 2000 is being modeled, August 3 was selected to approximate July 27 and 28, 2000.

Emissions from ships are estimated for two air basins: San Francisco Bay Area (SF) and the Outer Continental Shelf (OCS). Emissions from ships within 3 miles of the coast are considered in the SF air basin; emissions from ships beyond the 3-mile limit are in the OCS air basin. However, the current shipping surrogates used by the ARB to distribute emissions into grid cells differentiate by county, but not air basin. Emissions from ocean-going vessels in both the OCS and SF air basins are evenly distributed among the San Francisco Bay, the 3-mile coast, and the coast beyond the 3-mile limit. For ocean-going vessels, the factors developed by Professor Bornstein were applied only to grid cells that are within the 3-mile limit of the San Francisco coast. Grid cells beyond the 3-mile limit of the coast were not adjusted.

6.4.4 Wildfires

Emissions were estimated for known wildfires that occurred during the CCOS episodes. There were about 30 fires that occurred during episodes in the summer of 2000. All of the fires were less than 1,000 acres except for two. Two large wildfires occurred during the July-August 2000 episode. The Manter fire was a large-scale wildfire (over 73,000 acres) which occurred in Tulare County in the Sequoia National Forest and adjoining Bureau of Land Management areas on July 22 through August 9, 2000. The Plaskett2 fire was a large-scale wildfire (over 58,000 acres) which occurred in the Los Padres National Forest in Monterey County on July 23 through July 31, 2000. Due to these fires' duration, scale, and coincidence with the Central California Ozone Study, modeling staff requested that an estimate of fire emissions be developed in order to assess these fires' potential impacts on regional emissions and photochemistry.

To develop emission estimates, the ARB emission inventory staff turned to an on-going contract with UC Berkeley's Center for the Assessment and Monitoring of Forest and Environmental Resources (CAMFER) laboratory. In a prior ARB contract, CAMFER staff implemented the fire emissions module of the USDA Forest Service First Order Fire Effects Model (FOFEM, Reinhardt et al. 1997) within a Geographic Information System (GIS). FOFEM is a standard fire effects model used by federal and state land management agencies. The CAMFER model, called the Emissions Estimation System (EES), was initially devised to develop annual ARB fire emission inventories. In the

current contract, CAMFER was tasked to extend the EES to enable the model to estimate temporally-resolved emissions for individual fires, for an expanded suite of pollutants (CARB,2000).

The CAMFER EES runs within ArcView software and utilizes emission algorithms, emission factors, combustion efficiencies, fuel loadings, and other parameters from FOFEM. In the EES, GIS-based spatial data layers (polygon shapefiles), representing burned areas, are overlaid onto a GIS vegetation data layer in which vegetation community types are coupled with corresponding FOFEM biomass fuel profiles. For each fuel component (there are 10 fuel components representing foliage, litter, and stem diameter classes) in each vegetation type, the EES determines pre-burn fuel loadings (tons per acre), fuel mass consumed by the fire, combustion efficiency, and emissions released. Burning occurs in two distinct phases: flaming and smoldering. The temporal evolution of emissions from a burning area is therefore a function of the phase in which a fire is burning, and the time elapsed since ignition. The FOFEM and CAMFER EES models generate daily emissions from both phases. Emissions generated by the EES from flaming and smoldering phases are combined in the final outputs.

These emissions were then utilized to develop a plume profile, using the techniques outlined in a recent report of the Fire Emissions Joint Forum (FEJF) of the Western Regional Air Partnership (WRAP) (Air Sciences, 2004). Appendix B describes the vertical distribution of emissions in greater detail.

For all other fires in the summer of 2000, emissions were calculated based on the number of acres of three vegetation types: chaparral, grass, and timber. The U.S. Forest Service provided fuel loading and emission factors. The number of acres, vegetation type, fire duration, and location information were taken from California Department of Forestry (CDF) fire incident reports and newspaper articles. The vertical distributions of the plumes were calculated using the FEJF methodology referenced above.

There were also about 15 fires, totaling approximately 6,000 acres, which occurred during the July 1999 episode. Emissions from these fires have not been calculated.

6.5 *Temporally and Spatially Resolved Emissions*

In addition to forecasting emissions, CEFS can create temporally resolved inventories for modeling purposes, for the base year and future years. The annual average emissions are adjusted to account for monthly and weekly variations. CEFS generates an inventory for point and area sources (including off-road mobile sources) for a weekday and a weekend day in the year and months needed for an episode (e.g. July 1999 or August 2000). Emissions are estimated for each county, air basin, and district combination. In addition, information on how the daily emissions are distributed to each hour of the day is provided for later incorporation.

The emission inventories for CCOS were developed from the 2002 annual average CEIDARS inventory for TOG, NOx, SO_X, CO, PM, and ammonia. Since the episodes to be modeled (1999 and 2000) were earlier than the inventory base year (2002), emissions were backcasted from 2002 (see Section 6.3 for more information on forecasting emissions). Inventories for point and area sources were developed for a weekday and a weekend day for each of the 12 months for all years from 1990 to 2030. Note that all of these years may not have been processed into the formats needed for input to air quality models.

The backcasting of emissions for point and area sources usesg the best available data. Backcasting is handled differently for point and area sources. Point sources use historical data as stored in that year's CEIDARS inventory. In other words, the 1999 point source emissions come from the 1999 CEIDARS database and the 2000 point source emissions come from the 2000 CEIDARS database. Area source emissions are backcast from 2002 using growth and control factors. This procedure allows emissions to reflect changes that may have occurred due to updated emission calculation methodologies.

6.6 *Surface Temperature and Relative Humidity Fields*

The calculation of gridded emissions for some categories of the emissions inventory is dependent on gridded air temperature (T), relative humidity (RH), and solar radiation fields. Biogenic emissions are sensitive to air temperatures and solar radiation, and emissions from on-road mobile sources are sensitive to air temperature and relative humidity. Gridded temperature, humidity, and radiation fields are readily available from prognostic meteorological models such as MM5, used to prepare meteorological inputs for the air quality model. However, analysis of the MM5 outputs prepared for the July-August 2000 episode revealed poor agreement between simulated humidity and temperature fields and the available measurements.

As an alternative to the data fields generated using the prognostic meteorological model, air temperature and humidity fields for calculation of the emission inventory were prepared by objective analysis. In the objective analysis, hourly temperatures for each grid cell within the study domain were calculated using a distance-weighted average of the nearest three temperature measurements. Because few temperature measurements were available at higher terrain elevations, temperatures were adjusted using a vertical lapse rate (-0.0098 C/m to -0.0065 C/m) multiplied by elevation differences prior to averaging. Since this is an assumed constant, there may be uncertainty in temperatures at higher elevations.

Relative humidity measurements show a wide range of variability. Within the CCOS study domain, it was not unusual to find differences in relative humidity of 40% among sites within a 25-kilometer radius. To reduce large horizontal variations in the relative humidity fields developed for the emission inventory calculations, relative humidity fields

were calculated assuming a daily constant absolute humidity for each grid cell. The absolute humidity was calculated from the minimum daily temperature and assuming a maximum daily relative humidity of 80%.

The solar radiation fields needed for biogenic emission inventory calculations were taken from the MM5 simulation.

6.7 *On-Road Mobile Source Emissions*

EMFAC is the ARB approved on-road motor vehicle emission inventory model. The current version is EMFAC2007 v2.3 (November 2006) (CARB, 2006). ARB staff sought public input on this new version of EMFAC (see http://www.arb.ca.gov/msei/msei.htm for workshop notices and technical documentation). The improved inventories have undergone public review as part of the SIP outreach process.

Here are the main areas of change between the last version of EMFAC, EMFAC2002, and EMFAC2007:

Diesel Vehicles:

- Redistribution of heavy-duty diesel vehicle miles traveled (VMT)
- Adjustment to heavy-duty diesel emission factors
- Modifications to the speed correction factors for heavy-duty diesel vehicles
- The inclusion of high idle emission rates for heavy-duty diesel vehicles
- Diesel fuel correction factors

Gasoline Vehicles

- The impact of ethanol in gasoline on evaporative emissions
- Addition of areas into the Enhanced Smog Check program

The EMFAC model provides emission estimates for 13 classes of vehicles for exhaust, evaporation, and PM emissions from tire wear and brake wear. EMFAC also produces estimates of fuel consumption, vehicle miles traveled (VMT), and the number of vehicles in use. EMFAC does not output a gridded emission file. However, EMFAC will produce a file of emission rates that can be used with the Direct Travel Impact Model (DTIM) or other external on-road motor vehicle emission gridding program. These same emission rates are part of the information used by EMFAC to produce emission estimates for California counties or air basins.

DTIM4 (Systems Applications, Inc. 2001) is the latest version of DTIM, and is used to estimate gridded on-road motor vehicle emissions. In addition to the EMFAC emission rate file, DTIM4 uses digitized roadway segments (links) and traffic analysis zone activity centroids to allocate emissions for travel and trip ends. DTIM4 gridded emission files have fewer categories than EMFAC outputs. Each DTIM4 output category will be used to spatially allocate emissions for several EMFAC emission categories. There are

also several categories of emissions that EMFAC produces that are not estimated by DTIM4.

DTIM4 is used to estimate both the spatial and temporal distribution of all on-road motor vehicle emissions. It is important to recognize that EMFAC (and its associated activity), and not DTIM, is used to calculate county-specific emissions. DTIM output, using the Integrated Transportation Network (ITN) activity as inputs, was used to create hourly emission *ratios* for each grid cell in a county. These ratios were used to distribute county-specific, daily EMFAC emissions to each hour and grid cell. A horizontal grid resolution of 4 x 4 km is used.

Below we describe the procedures that were used with EMFAC2007 and DTIM4 to produce day-specific gridded on-road motor vehicle emission estimates. The procedures described here are carried out separately for each county in the CCOS modeling domain.

6.7.1 EMFAC Emissions Categories

EMFAC2007 produces emission estimates for the following 13 vehicle classes:

1. LDA Light Duty Autos
2. LDT1 Light Duty Trucks < 3,750 pounds GVW
3. LDT2 Light Duty Trucks > 3,750 - 5,750
4. MDV Medium Duty Vehicles > 5,750 – 8,500
5. LHD1 Light Heavy Duty Vehicles > 8,500 – 10,000
6. LHD2 Light Heavy Duty Vehicles > 10,000 – 14,000
7. MHD Medium Heavy Duty Vehicles > 14,000 – 33,000
8. HHD Heavy Heavy Duty Vehicles > 33,000
9. OB Other Buses
10. SBUS School Buses
11. UBUS Urban Buses
12. MH Motorhomes
13. MCY Motorcycles

Additionally, there are up to 3 technology groups within each vehicle type:

1. Catalyst
2. Non-catalyst
3. Diesel

For each of the combinations of vehicle type and technology there can be many emission categories:

1. Start Exhaust
2. Running Exhaust

3. Idle Exhaust
4. Hot Soak
5. Running Evaporatives
6. Resting Evaporatives
7. Partial Day Resting Evaporatives
8. Multi-Day Resting Evaporatives
9. Diurnal Evaporatives
10. Partial Day Diurnal Evaporatives
11. Multi-Day Diurnal Evaporatives
12. Break Wear PM
13. Tire Wear PM

A DTIM4 preprocessor calculates fleet average emission factors for each EMFAC technology type for each emission category. The vehicle type distribution used to calculate fleet emission factors is an input, so it can be varied as needed.

6.7.2 DTIM4 Emissions Categories

During DTIM4 operation, all emissions are collapsed into a total of 40 emission categories, represented by the SCCs below, which depend on vehicle type, the technology, and whether the vehicle is catalyst, non-catalyst, or diesel. Light- and medium-duty vehicles are separated from heavy-duty vehicles to allow for separate reporting and control strategy applications.

SCC for Light-duty and Medium-duty Vehicles	SCC for Heavy-Duty Vehicles	Description
202	302	Catalyst Start Exhaust
203	303	Catalyst Running Exhaust
204	304	Non-catalyst Start Exhaust
205	305	Non-catalyst Running Exhaust
206	306	Hot Soak
207	307	Diurnal Evaporatives
208	308	Diesel Exhaust
209	309	Running Evaporatives
210	310	Resting Evaporatives
211	311	Multi-Day Resting
212	312	Multi-Day Diurnal
213	313	PM Tire Wear
214	314	PM Brake Wear
215	315	Catalyst Buses
216	316	Non-catalyst Buses
217	317	Diesel Bus
218	318	Catalyst Idle
219	319	Non-catalyst Idle
220	320	Diesel Idle
221	321	PM Road Dust

6.7.3 Creating the Emission Rate File

EMFAC will create an emission rate file for any desired combination of vehicle speeds, ambient temperatures, and relative humidities (RH). However, DTIM4 places restrictions on the total array size. The sets of values we use to build the array are:

Speed: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65

Temp: 30, 45, 60, 70, 75, 80, 85, 90, 100, 110

RH: 0, 30, 50, 70, 80, 90, 100

6.7.4 Day-Specific EMFAC Inventories

Emission estimates are produced by EMFAC for each day of each episode, by county. County average hourly temperatures, weighted by gridded VMT, are input to EMFAC to produce a 'BURDEN' inventory in a comma separated (.bcd) format. Both DTIM4 exhaust and evaporative emissions are scaled by category to the EMFAC emissions estimates for each county/air basin area. EMFAC bus and idle emission categories are not estimated by DTIM4. These categories are added to the gridded emission files.

6.7.5 CCOS Emissions Gridding

The method to estimate on-road mobile emissions at the grid cell level is described briefly in the following five steps:

Step 1. Gridded, hourly temperature (T) and relative humidity (RH) fields for each episode day are prepared for input to DTIM4. The T and RH fields are derived either from meteorological model predictions, observations, or some hybrid combination of model predictions and observations.

Step 2. EMFAC is run to prepare on-road mobile source emission factors by speed, temperatures, and relative humidity for each county.

Step 3. DTIM4 is run using data from the Integrated Transportation Network version 2 (ITNv2) and EMFAC to estimate gridded, hourly on-road mobile source emission estimates by day for DTIM4 categories.

Step 4. EMFAC is run again using episode-specific T and RH data to provide countywide on-road mobile source emission estimates by day for EMFAC categories. The episode-specific meteorological inputs for EMFAC are generated

via averaging (VMT-weighted) the gridded, hourly meteorology from Step1 by county and hour.

Step 5. Two sub-steps are taken:

Temporal adjustments

5a Sum the hourly volumes by vehicle type and county on the ITNv2 network.

5b For heavy-duty vehicles on core days (Tuesday through Thursday) redistribute the hourly emissions but make no daily VMT adjustment. Light duty vehicle emissions from EMFAC will not be adjusted at all for core days.

5c For Friday, Saturday, Sunday, and Monday, use Caltrans count data to develop a set of ratios of Caltrans daily VMT to core days. For example, develop ratios for Saturday to Tues-Thurs. Develop ratios for each Caltrans district for passenger cars, light and medium duty trucks, and heavy-duty trucks.

5d Apply Caltrans daily factors by county, and secondly, apply Caltrans' new hourly distributions by county to ITNv2 link activity.

5e Run DTIM with revised ITNv2 activity.

5f Run EMFAC with day-specific temperatures.

5g Adjust DTIM output emissions to EMFAC weekday by county.

5h For Friday, Saturday, Sunday, and Monday, apply daily ratios from step 5c to hourly DTIM emissions by county.

See Section 6.7.6 for more information.

Spatial/Temporal Distribution EMFAC daily, countywide emissions (adjusted for weekend days, if needed), are disaggregated by category into grid-cells for each hour of the day using the DTIM4 output (Step 3) as a spatial and temporal surrogate.

The disaggregation follows the equation:

$$E_{P,ij,hr,cat} = \frac{EF_{P,cat} \times DTIM_{P,ij,hr,cat}}{DTIM_{P,daily,cat,cnty}}$$

where:

E = grid cell emissions
EF = EMFAC emissions
DTIM = DTIM emissions
P = pollutant
ij = grid cell
hr = hourly emissions
cat = Emission Category
daily = daily emissions
cnty = county

6.7.6 Suggested Improvements for On-road Motor Vehicle Gridding

The five step process described above in section 6.7.5 is used to generate sets of day-specific, gridded on-road emissions. These emissions are our best estimates at the present time; however additional work in three areas would improve the estimates. One area of improvement, and likely the most important, is in the allocation of heavy-duty truck emissions. At present, the only transportation modeling done to explicitly model trucks is for Southern California counties covered by the Southern California Association of Governments (SCAG). For the remaining counties, heavy-duty trucks are assigned as a ratio of light-duty vehicles.

A second area of improvement is in developing emissions for weekend days. Both the spatial and temporal distribution of on-road motor vehicle emissions is different on weekend days than on weekdays. On-road motor vehicle emissions on weekend days should be considered an approximation since there are no transportation models to describe weekend traffic. In other words, people are still traveling to work; the emissions are just scaled down.

A third area of improvement is determining the hourly emissions from on-road motor vehicles. Local regional transportation agencies (RTPAs) and Caltrans supply traffic estimates for several time periods in a day. In the development of previous modeling inventories for CCOS, traffic within the time period was allocated to each hour using the hourly profiles that were developed by UC Davis. (Lam 2002). UC Davis developed two hourly profiles, one for weekdays and one for weekend days, which differed by county. However, there was no distinction by vehicle class. The same hourly profile

was used for heavy-duty vehicles as for light-duty vehicles within a county. This is of concern because trucks are known to have different diurnal distributions than cars and they have high NOx emissions.

Due to this concern, the Weekend Truck Subcommittee of the northern California SIP Gridded Inventory Coordination Group (GICG) was formed in 2004 to investigate a way to improve day-of-week adjustments, for vehicle types as needed, but particularly for heavy-duty trucks. Participants in the subcommittee are members of the GICG with particular knowledge and/or interest in improving the adjustment factors and include representatives from Caltrans, ARB, Bay Area AQMD, San Joaquin Valley APCD, and Alpine Geophysics (the developer of the ITN).

Caltrans staff acquired Automatic Vehicle Classifier (AVC) count data from about 139 sites in the state for calendar year 2004 (see Figure 6.1). Caltrans staff prepared hourly day of week factors for (1) passenger cars (LD), (2) light and medium duty trucks (LM), and (3) heavy-heavy duty trucks (HHDT). Caltrans count data are separated using the Federal Highway Administration (FHWA) vehicle classification scheme (see Table 6.3). Passenger cars are defined as FHWA classes 1 through 3. Light and medium heavy-duty trucks are defined as FHWA classes 7 and 8. Heavy-heavy duty trucks are defined as FHWA classes 9 through 14. Separate factors were prepared for each Caltrans District. One or more counties may fall into a single District. All counties within each Caltrans district will receive the same adjustment. Figure 6.2 shows a map of county and Caltrans district boundaries. Only counts during the summer of 2004 were used, specifically the months of June, July and August excluding data from July 2-5 to remove unusual traffic patterns around the July 4th holiday.

Temporal on-road activity adjustments by county were made for:

1. Heavy duty vehicles – all days
2. Light-duty vehicles – Friday, Saturday, Sunday, Monday

Daily total activity (daily VMT) adjustments were made for all vehicle types for Friday, Saturday, Sunday, and Monday. Tuesday, Wednesday, and Thursday are considered as one day. Adjustments applied to heavy-duty vehicles on Tuesdays, Wednesdays, and Thursdays were the same for each of the three days.

Since it is EMFAC emission estimates that are being adjusted to derive the final on-road inventory, the relation between EMFAC vehicle classes and Caltrans' adjustment factors is shown below.

EMFAC Class	Description	Caltrans' Factor
1	LDA	LD
2	LDT1	LD
3	LDT2	LD
4	MDV	LD
5	LHDT1	LM
6	LHDT2	LM
7	MHDT	LM
8	HHDT	HHDT
9	Other Bus	No data in ITNv2
10	School Bus	Unadjusted on weekdays, zero on weekend days
11	Urban Bus	LD
12	Motorhomes	LD
13	Motorcycles	LD

where LD based on count data for FhwA classes 1 through 3
LM based on count data for FhwA classes 7 and 8
HHDT based on count data for FhwA classes 9 through 14

To summarize, for core days light- and medium-duty vehicle emissions will equal EMFAC emissions by county and hour. For core days, heavy-duty emissions will equal EMFAC but have Caltrans hourly distribution. For Friday through Monday, EMFAC weekday emissions will be scaled to reflect Caltrans day of week factors. Appendix C provides more detail on the methodology developed by the Weekend Truck Subcommittee.

Although significant improvements have been made to improve the temporal distribution of on-road motor vehicles, some assumptions were made that may cause uncertainty in the adjustments. For example, one assumption is that the count data represent the temporal distribution of all road types, including local roads. The count data are gathered only on state highways. Another assumption is the link between EMFAC and FHWA classes. EMFAC classes are based on gross vehicle weight, whereas FHWA classes are based on type of vehicle and number of axles. It is not an easy process to determine which EMFAC class a specific type of vehicle falls into based on the number of axles, particularly for trucks. Additional work may provide improvements to estimating hourly emissions by vehicle type, especially on weekend days.

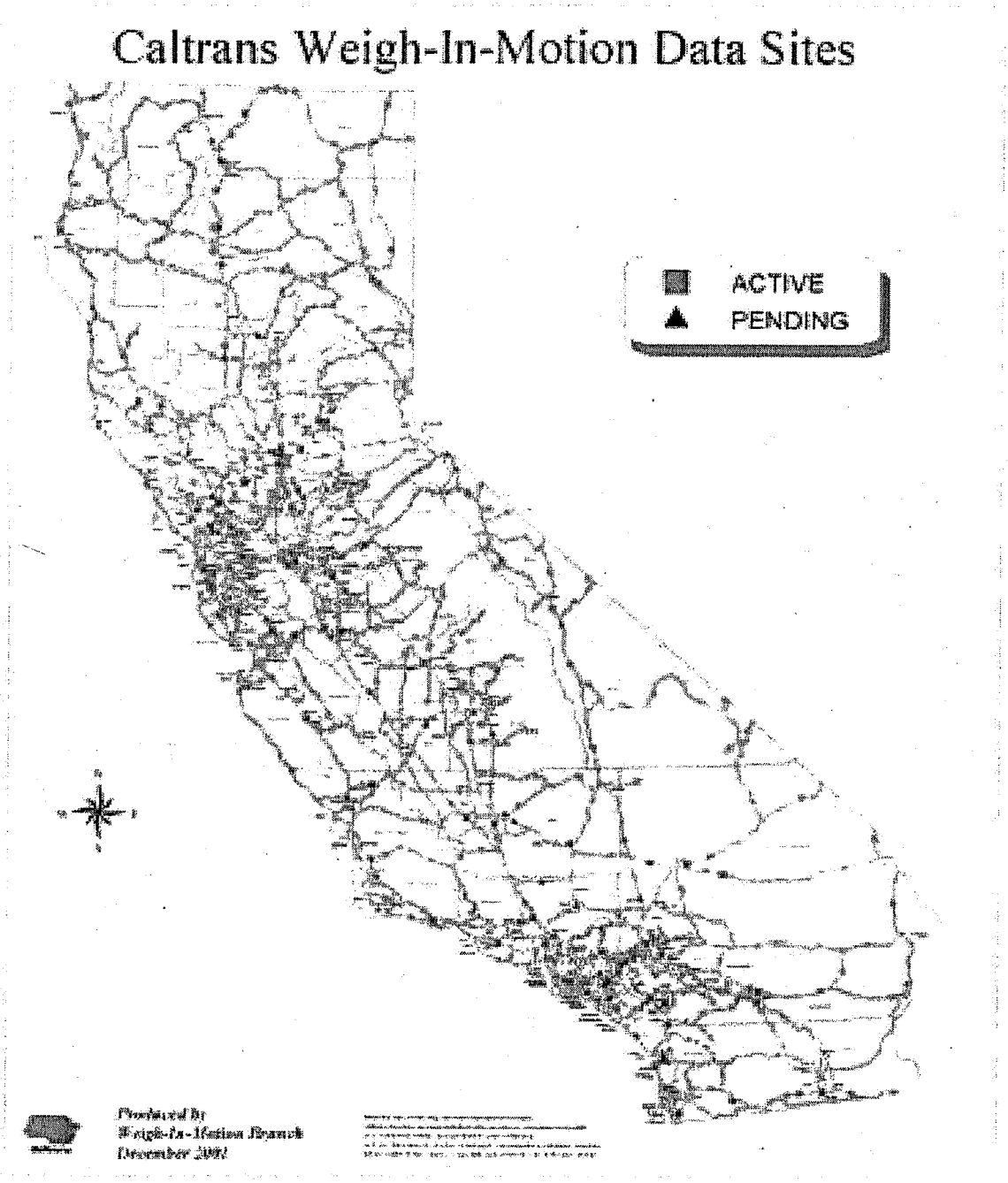


Figure 6.1 Caltrans Weigh-In-Motion Data Sites

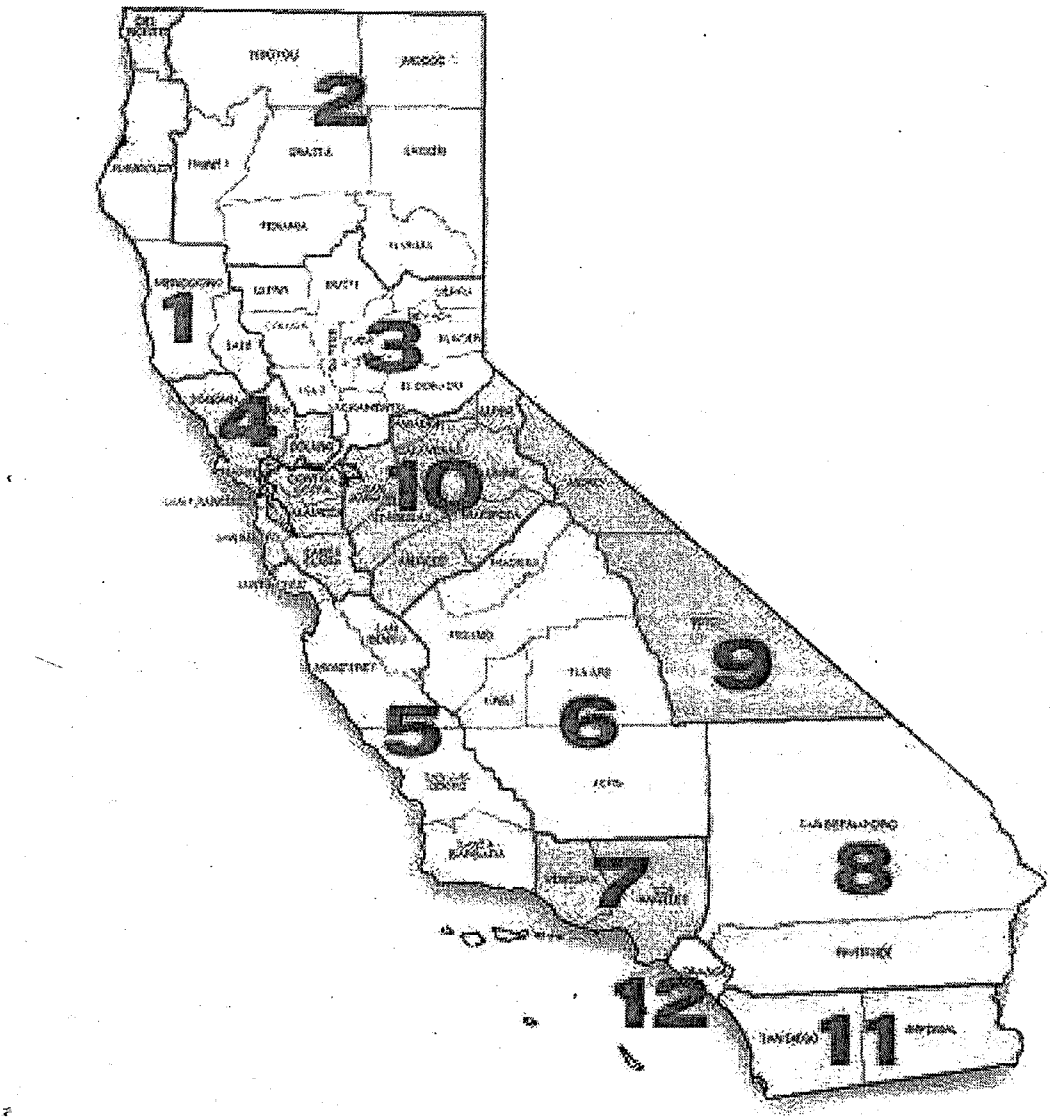
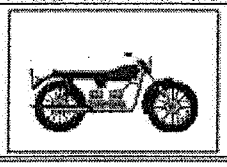
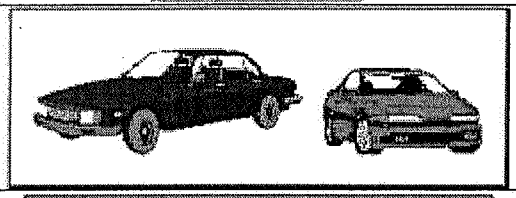
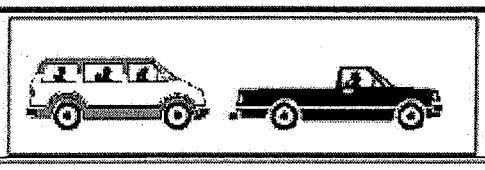
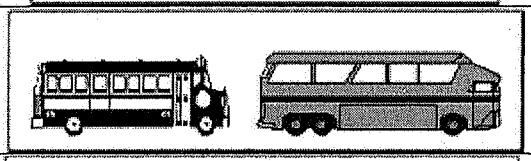
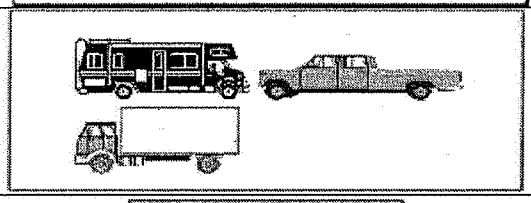
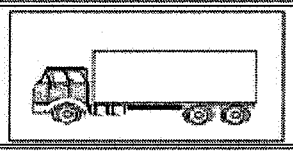
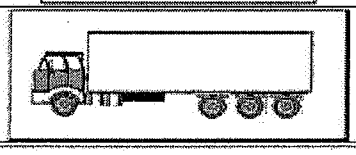
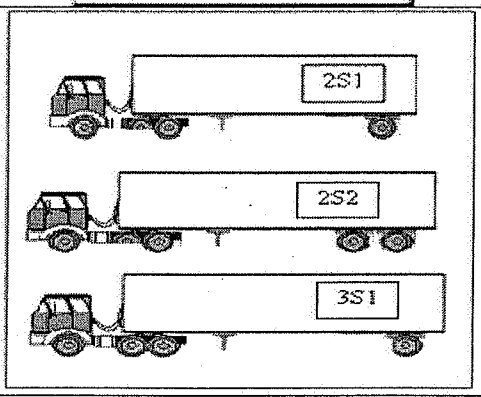
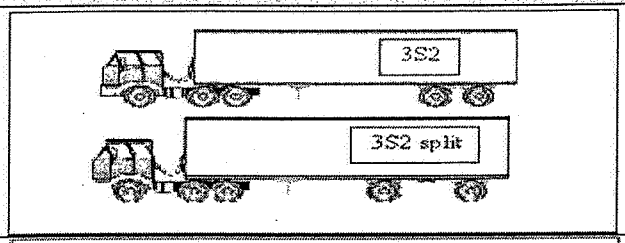
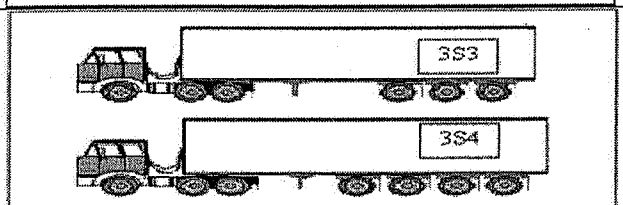
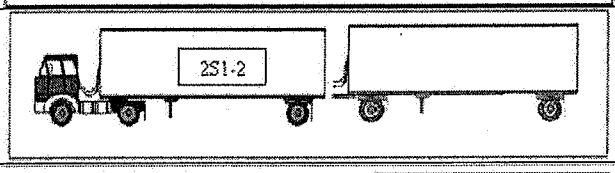
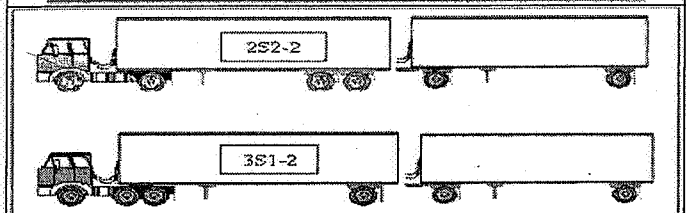
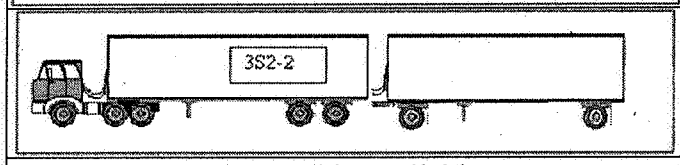


Figure 6.2 Caltrans District and County Boundaries

Table 6.3 Federal Highway Administration (FHwA) Vehicle Classification

Graphic Depiction	FHWA Class	Description
	1	Motorcycles
	2	Passenger Cars (With 1- or 2-Axle Trailers)
	3	2 Axles, 4-Tire Single Units, Pickup or Van (With 1- or 2-Axle Trailers)
	4	Buses
	5	2D - 2 Axles, 6-Tire Single Units (Includes Handicappe-Equipped Bus and Mini School Bus)
	6	3 Axles, Single Unit
	7	4 or More Axles, Single Unit
	8	3 to 4 Axles, Single Trailer

Graphic Depiction	FHWA Class	Description
	9	5 Axles, Single Trailer
	10	6 or More Axles, Single Trailer
	11	5 or Less Axles, Multi-Trailers
	12	6 Axles, Multi-Trailers
	13	7 Axles, Multi-Trailers
No graphic available	14	5 Axles: 3 axle tractor pulling a 2 axle trailer (FHWA considers this type of truck a class 9;Caltrans counts these trucks separately for operational purposes.)

6.7.7 Fleet Emission Factors

An important input to DTIM4 is the vehicle type weighting for emission rate. The vehicle type VMT for each county/air basin output from EMFAC is used, which is then reformatted by the CONVIRS4 computer program and composited by vehicle type distribution from BURDEN in the IRS4 computer program. For the counties in CCOS that are covered by the ITN network, we process light/medium duty (LM) and heavy-duty vehicles (HDV) separately. The VMT for LM is the sum of EMFAC categories LDA, LDT1, LDT2, MDV, SBUS, UB, MCY and MH. The HDV VMT is the sum of LHD1, LHD2, MHD and HHD.

Besides the composite emission rate file, DTIM4 needs link and trip end activity files. All activity has been resolved to one-hour periods for each county using the method described in Sections 6.7.5 and 6.7.6 above. Specifically, temporal on-road activity (link and trip end) adjustments by county were made for:

- Heavy duty vehicles – all days
- Light-duty vehicles – Friday, Saturday, Sunday, Monday

Link and trip end activity adjustments were made for all vehicle types for Friday, Saturday, Sunday, and Monday. Tuesday, Wednesday, and Thursday are considered as one day. Adjustments applied to heavy-duty vehicles on Tuesdays, Wednesdays, and Thursdays were the same for each of the three days.

Additionally, EMFAC has different fleet mixes by county based on vehicle registrations. It is the fleet mixes in EMFAC that ultimately are the basis for the on-road mobile source emissions processing that has been done in support of CCOS. The fleet mixes in the DTIM4 runs are based on the fleet mixes in EMFAC. The DTIM4 runs are based on the composite emissions factors that are generated by EMFAC. During the preprocessing of the EMFAC output, which occurs prior to a complete DTIM4 run that is performed by the IRS/CONVIRS programs, there is generally an adjustment applied to the EMFAC emissions factors based on vehicle counts. In most cases, the regional transportation planning agencies (RTPAs) who supplied the transportation data provided the vehicle counts that were used to adjust the EMFAC emissions factors. In the remaining cases, the vehicle count data were taken directly from EMFAC.

6.7.8 Differences Between DTIM4 and EMFAC

6.7.8.1 Evaporative Emissions

DTIM4 and EMFAC use different methods to estimate evaporative emissions. However, as mentioned previously, we use the DTIM4 evaporative emissions as spatial and temporal "surrogates" to resolve EMFAC emission estimates. During processing, we drop the DTIM4 evaporative categories 211, 212, 311, and 312 (because those emissions are included in EMFAC's estimates for diurnal and resting emissions) and put all EMFAC resting emissions in DTIM4 category 210/310, and all diurnal emissions in DTIM4 category 207/307.

6.7.8.2 Exhaust Emissions

The exhaust emissions from EMFAC are also resolved spatially and temporally by DTIM4 emission estimates. Since transportation models do not estimate VMT for buses or excess idling categories, these are added to DTIM4 emissions. The exhaust CO, NOx, SOx, and PM emissions that DTIM4 allocates to category 1 are reassigned to catalyst starts, non-catalyst starts, catalyst stabilized, non-catalyst stabilized, and diesel exhaust categories according to the appropriate day-specific EMFAC inventory.

6.7.9 Integrated Transportation Network (ITN)

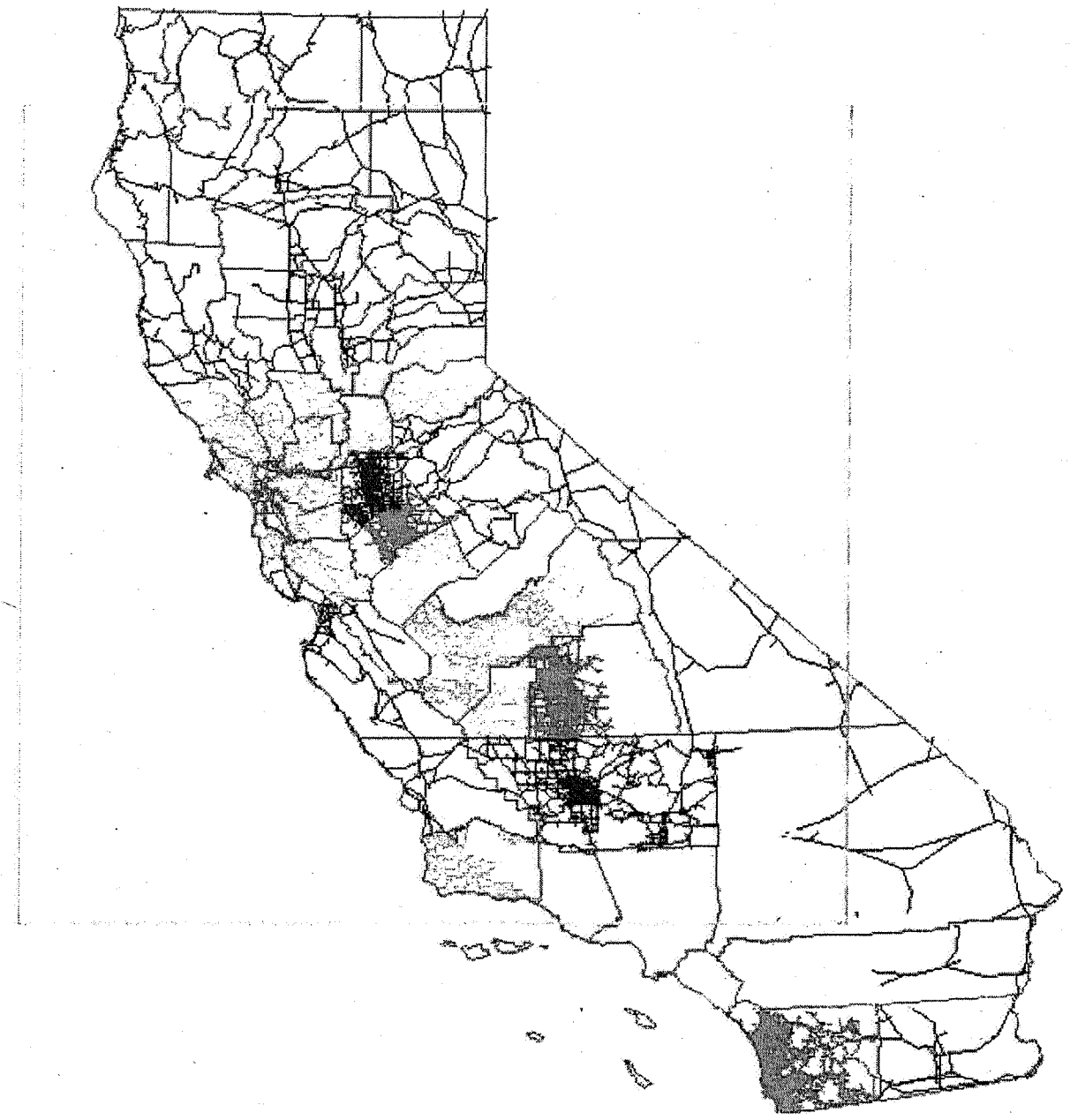
The Integrated Transportation Network (Wilkinson 2003) is a seamless on-road transportation network that covers all of California. The ITN was developed from many regional transportation planning agencies (RTPAs) as well as the California Department of Transportation (Caltrans) Statewide Model. The San Joaquin Valleywide Air Pollution Study Agency and Air Resources Board contracted with Alpine Geophysics to develop the ITN. After the ITN was developed, additional local transportation networks became available that were not included in the first version. Some RTPAs had also updated their networks since the original development. For these reasons, version two of the ITN (ITNv2.0) was developed (Wilkinson 2005). As mentioned earlier, the ITNv2.0 is used to spatially distribute the on-road mobile source emissions generated by EMFAC. Figure 6.3 shows the link-based ITNv2.0 for California.

Local networks were used for all or portions of the following counties: Alameda, Contra Costa, El Dorado, Fresno, Kern, Kings, Los Angeles, Madera, Marin, Merced, Napa, Orange, Placer, Riverside, Sacramento, San Bernardino, San Diego, San Francisco, San Joaquin, San Mateo, Santa Barbara, Santa Clara, Solano, Sonoma, Stanislaus, Sutter, Tulare, Ventura, and Yolo. Data that were provided for Imperial and San Luis Obispo could not be used because the parameters to conflate the networks to real world

coordinates were not available. The Caltrans statewide model was used to supplement the local data. More details on the ITNv2.0 can be found in Appendix D, the final report "Development of Version Two of the California Integrated Transportation Network (ITN)".

It is important to recognize that EMFAC (and the associated activity), and not DTIM4, will be used to calculate county-specific emissions. DTIM4 output, using the ITN activity as inputs, will simply be used to create hourly emission *ratios* for each grid-cell in a county. These ratios will be used to distribute county-specific, daily EMFAC emissions to each hour and grid-cell. This intended use negates the need to update countywide VMT on the ITN. That is, if up-to-date VMT in a specific county were 10% higher than is currently reflected in the ITN, all the VMT on ITN links for that county would be increased by 10%. Since both the county VMT and link VMT (in the same county) are factored by the same amount, the ratio of link-to-county VMT for every link in that county does not change. Similarly, DTIM4 grid-cell-to-county emissions *ratios* do not change. Thus, for the intended use and assuming no changes to ITN activity distribution, adjusting the ITN county totals to more accurate countywide VMT will not affect the outcome.

With regard to the spatial accuracy of the ITN, it is important to recognize that current modeling efforts in the region utilize square grid cells that are four kilometers on each side. Thus, the spatial accuracy of the statewide or local components of the ITN only requires enough resolution to distribute EMFAC emissions into the proper four by four kilometers grid cell. Given that the intended purpose of the ITN is for use in estimating on-road mobile source emissions for photochemical modeling efforts, this accuracy is sufficient.



Note: The county boundaries are in red. The Caltrans statewide network is in black. The various individual networks are in colors other than black or red. The 190 x 190 4 kilometer CCOS emissions modeling domain is shown as the green box.

Figure 6.3. Link-based Integrated Transportation Network (ITN) version 2.0

6.7.10 Motor Vehicle Activity

Motor vehicle activity data are an important part of EMFAC for estimating emissions. As part of an on-going effort to use the best data available, ARB periodically updates the vehicle miles traveled (VMT) and speed distributions by VMT used in the model. In November 2004, ARB sent letters to transportation planning agencies (TPAs) statewide requesting updated activity data for base years and forecasted years. A sample letter can be found in Appendix E. All major urban areas in the state responded. The data was reviewed and processed by ARB staff in coordination with the TPAs. ARB's Technical Memorandum on the activity data update is provided in Appendix F. The memorandum provides summaries of the data and refers to supporting documents that provide additional details as well as discussions of issues. ARB included additional updates as time permitted before finalizing EMFAC2007.

6.7.11 Forecasted Emissions for On-Road Motor Vehicles

Forecasted modeling inventories were developed for on-road motor vehicles as needed to complete the inventory inputs to episodes being modeled. For future year inventories, emissions and other needed data were taken from EMFAC for the desired future year. The method used to calculate the future year emissions was the same as the base year for each episode, including the same gridded, hourly temperature and relative humidity information.

6.8 *Biogenic Emissions*

Development of effective ozone control strategies in California requires accurate emission inventories, including biogenic volatile organic compounds (BVOCs) such as isoprene and monoterpenes. Due to the heterogeneity of vegetation land cover, species composition, and leaf mass distribution in California, quantifying BVOC emissions in this domain requires an emission inventory model with region-specific input databases and a high degree of spatial and temporal resolution. In response to this need, the California Air Resources Board (CARB) has developed a Geographic Information System (GIS)-based model for estimating BVOC emissions, called BEIGIS, which uses California-specific input databases with a minimum spatial resolution of 1 square kilometer (km^2) and an hourly temporal resolution.

The BEIGIS isoprene emission algorithm (Guenther et al. 1991, 1993) is of the form

$$I = I_S \times C_L \times C_T$$

where I is the isoprene emission rate (grams per gram dry leaf mass per hour) at temperature T and photosynthetically active radiation flux PAR. I_S is a base emission rate (grams per gram dry leaf mass per hour) at a standard temperature of 30 °C and

PAR flux of 1000 μmol $m^{-2}s^{-1}$. C_L and C_T are environmental adjustment functions for PAR and temperature, respectively. The monoterpene emission algorithm adjusts a base monoterpene emission rate by a temperature function (Guenther et al. 1993). Methylbutenol (MBO) emissions are modeled with an algorithm developed by Harley et al. (1998) similar to that for isoprene. Dry leaf mass/leaf area ratios, and base emission rates for isoprene, monoterpenes, and MBO are plant species-specific and assembled from the scientific literature. Modeled BVOC emissions for a given spatial domain therefore represent the contribution by various plant species (through their leaf mass and emission rates) to the total BVOC emissions.

The main inputs to BEIGIS are land use and vegetation land cover maps, gridded leaf area indices (LAI) derived from AVHRR satellite data (Nikolov 1999), leaf area/dry leaf mass factors, base emission rates, and gridded hourly ambient temperature and light intensity data (from a meteorological model). For urban areas, land use/vegetation land cover databases were developed from regional planning agency data and botanical surveys (Horie et al. 1990; Nowak 1991; Sidawi and Horie 1992; Benjamin et al. 1996, 1997; McPherson et al. 1998). Natural areas are represented using the GAP vegetation database (also satellite-derived and air photo interpreted) developed by the U.S.G.S. Gap Analysis Program (Davis et al. 1995). Agricultural areas are represented using crop land cover databases developed by the California Department of Water Resources (http://www.waterplan.water.ca.gov). Ground surveys have been funded by CCOS to validate the vegetation land cover and LAI input databases used in BEIGIS (Winer et al. 1998; Karlik and McKay 1999; Winer and Karlik 2001, Karlik 2002). Validation using flux measurements in the field is on going.

Using BEIGIS, the ARB developed hourly-resolved emissions of isoprene, monoterpenes, and methyl butanol (MBO), gridded at a 1-km resolution. Each 4-kilometer (km) grid cell, using the statewide 4-km grid cell domain defined by the ARB, was divided into 16 1-km grid squares. After the biogenic emissions were calculated, the emissions from the 1-km cells were aggregated for each 4-km grid cell. Two additions are then made to the biogenic emissions estimates for input to air quality models.

First, biogenic OVOCs (other VOCs) are added. Biogenic OVOCs comprise around twenty percent of some biogenic inventories and are known to affect air quality modeling predictions (e.g. Hanna et al., 2002). Guenther et al. (1994) estimates that the OVOCs comprise 8-73% of total BVOCs. OVOCs are estimated by ARB as an added fraction of 30%, scaled to the total isoprene, monoterpene, and MBO emissions.

The estimate of OVOC emissions used by ARB is the result of an August 2001 peer review of modeling procedures by Dr. William P. L. Carter (Carter 2001). During the discussion with ARB modeling staff, it was noted that estimates of OVOC were reported by some sources to be as great as the inventoried species (isoprene, m-butenol, and monoterpenes). Since OVOCs are very uncertain in both mass and species characterization, ARB had not been including them in the modeling programs. Dr. Carter suggested this omission was inappropriate. He recommended that OVOC

emissions be included with the best estimates we could make. During this discussion it was decided that doubling the known species would be like an upper limit which was felt to be too high. Collectively it was decided that an OVOC amount equal to 30% of the total known species would be a reasonable estimate.

ARB reviewed the literature to find a reasonable speciation to assign to OVOCs. Arthur Weiner sent a list of the compounds that were intended at that time to be included in BEIS-3. No amounts were fixed to species and ARB could not derive an OVOC profile. Allen Goldstein had published an article "In Situ Measurements of C2-C10 Volatile Organic Compounds Above a Sierra Nevada Ponderosa Pine Plantation" in the Journal of Geophysical Research (9-20-1999) which did allow us to create a profile to use until better information could be obtained. This profile is dominated by methanol and acetone and also contains ethene, propene, hexanal, and acetaldehyde. These compounds were all part of the species proposed for BEIS3.

ARB's intention is to use this profile for all OVOC from all vegetation types until better information becomes available. In the future, use of information from BEIS-3 or other models may allow ARB to create BVOC inventories that contain enough compounds so that the additional step of adding a chosen amount of 'OVOCs' can be eliminated.

The second addition is to include biogenic NO emissions. Biogenic NO emissions were estimated using a soil NO algorithm found in BEIS-3.

For a more detailed description of the estimation of biogenic emissions, see Appendix G.

Biogenic emissions are not estimated for future years because future inputs to BEIGIS, such as changes in climate and land use/land cover, are highly uncertain. Photochemical modeling for future years uses the biogenic emissions developed for the base year.

6.9 *Spatial Allocation*

Once the base year or future year inventories are developed, as described in the previous sections, the next step of modeling inventory development is to spatially allocate the emissions. Air quality modeling attempts to replicate the physical and chemical processes that occur in an inventory domain. Therefore, it is important that the physical location of emissions be determined as accurately as possible. Ideally, the actual location of all emissions would be known exactly. In reality, however, the spatial allocation of emissions in a modeling inventory only approximates the actual location of emissions.

Before any spatial allocation can be performed, the modeling grid domain must be defined. A modeling grid domain is a rectangular area that is sufficient in size to contain

all emission sources that could affect modeling results. The definition of the CCOS modeling domain is described below in Section 6.9.1.

Once a grid is defined, the spatial allocation of emissions can be performed. Each area source category is assigned a spatial surrogate that is used to allocate emissions to a grid cell. Examples of surrogates include population, land use, and other data with known geographic distributions for allocating emissions to grid cells. Section 6.9.2 discusses in detail the spatial surrogates developed for CCOS.

Point sources are allocated to grid cells using the UTM coordinates reported for each stack. If there are no stack UTM coordinates, the facility UTM coordinates are used. When location data are not reported, the county centroid is used.

Emissions are also distributed vertically into their proper layer in the air quality model. The vertical layer is determined from the calculation of buoyancy for those emissions that are released from an elevated height with a significant upward velocity and/or buoyancy. Most vertical allocation is from significant point sources with stacks. In most modeling exercises, low-level point sources are screened out at this point and placed with the area sources. However, in this modeling exercise, all point sources from the inventory were kept as possible elevated sources. The air quality model will then place the point sources in the appropriate layer of the model. Additionally in this modeling exercise, day-specific wildfire emissions were also distributed vertically. Please refer to section 6.4.4 and Appendix C for more information.

The spatial treatment of area and point sources has been described above. The spatial allocation of on-road motor vehicles is based on activity on the Integrated Transportation Network version 2 (ITNv2.0) as described in Section 6.7.9. For biogenic emissions, the spatial allocation is built "from the ground up" since ARB's biogenic model, BEIGIS, estimates emissions using a Geographic Information System (GIS) at a 1 square kilometer resolution. Section 6.8 describes how biogenic emissions are estimated.

6.9.1 Grid Definition

The CCOS emissions inventory domain was defined based on the MM5 model used to generate the meteorological parameter fields used for air quality modeling. However, the MM5 model uses only an approximation to the shape of the Earth. Therefore, there was a small offset error between the MM5-defined domain and the emissions domain defined using GIS software, which uses a more exact Earth shape.

The emissions inventory domain was defined using a Lambert Conical Projection with two parallels. The Parallels were at 30 and 60 N latitude, with a central meridian at 120.5 W longitude. The coordinate system origin was offset to 37 N latitude. The emissions inventory was gridded with a resolution of 4 km. However, because of differences between the MM5-defined domain and the GIS defined domain, the lower,

left-hand corner of the emissions inventory domain was not a integer multiple of 4-km (cell size) from the domain origin. The specifications of the emissions inventory domain grid were:

DEFINITION OF GRID
190 x 190 cells (4 km x 4 km)
Lambert Origin @ (-385131.6m , -302910.3m)
Geographic Origin @ -124.7423 deg. Latitude and 34.1210 deg. Longitude

MAP PROJECTION
LAMBERT
Units: Meters
Datum: NONE (Clarke 1866 spheroid)

PARAMETERS
1st Standard Parallel: 30 0 0.000
2nd Standard Parallel: 60 0 0.000
Central Meridian: -120 30 0.00
Latitude of Projection Origin: 37 0 0.000
X-Shift (meters): 0.0000
Y-Shift (meters): 0.0000

6.9.2 Spatial Surrogates

Spatial allocation factors are used to geographically distribute countywide area source emissions to individual grid cells. These spatial allocation factors were developed from spatial surrogate data. Spatial surrogates are economic, demographic, and land cover patterns that vary geographically.

In this context, "area source emissions" refers to all source categories that are not point sources, biogenics, or on-road motor vehicles (see Table 6.2 for description). As has previously been discussed, point source emissions are allocated to grid cells using the location of the emission source. On-road motor vehicle emissions are allocated by DTIM4 (see Section 6.7). Biogenic emissions are allocated by BEIGIS (see Section 6.8).

In support of CRPAQS and CCOS, Sonoma Technology, Inc. (Funk et al. 2001) was contracted to develop spatial allocation factors. Using a GIS-based approach, STI developed gridded spatial allocation factors for a 2000 base-year and three future years (2005, 2010, and 2020) for the entire state of California based on the statewide 4-kilometer (km) grid cell domain defined by the ARB. The definition and extent of the 4-km grid were used to create a 2-km nested grid for which spatial allocation factors were developed.

Each area source category is assigned a spatial surrogate. This assignment provides a cross-reference between the spatial allocation factors and the emission inventory categories. A total of 65 unique surrogates were developed as part of this project. A summary of the spatial surrogates, for which spatial allocation factors were developed, is listed in Table 6.4.

A listing of all surrogates and spatial allocation factors, and their corresponding spatial surrogate codes (SSC), are contained in Appendix H. Appendix H also includes the surrogate-to-emission inventory cross-reference list. Designating the surrogate-to-emission inventory assignments was an iterative process among STI staff, ARB staff, and local air district staff. Note that the spatial allocation factors and emissions category assignments vary by county depending on the data available for each county.

Three basic types of surrogate data were used to develop the spatial allocation factors:

- land use and land cover
- facility location
- demographic and socioeconomic data

Land use and land cover data are associated with specific land uses, such as agricultural tilling, feedlots, or recreational boats. Facility locations are used for sources such as gas stations and dry cleaners. Demographic and socioeconomic data, such as population and housing, are associated with residential, industrial, and commercial activity (e.g. residential fuel combustion). Table 6.5 shows the sources of land use and land cover data as well as facility location information used to develop spatial allocation factors. Table 6.6 shows the sources of demographic and socioeconomic data used to develop spatial allocation factors. Table 6.7 provides a list of the counties covered by each data set. To develop spatial allocation factors of high quality and resolution, local socioeconomic and demographic data were used when available; for rural regions for which local data were not available, the Caltrans Statewide Transportation Model data were used.

Table 6.4 Summary of spatial surrogates developed as part of the CCOS gridded surrogate project

Surrogate Description
Agricultural cropland
Agricultural land
Feedlots
Feedlots, dairies, and poultry farms
Non-pasture agricultural land
All airports
Commercial airport locations
Total employment & road density
Total housing and locations of auto body/refinishing shops
Locations of hospitals, institutions, population, and commercial employment
Total housing, service, commercial, golf courses
Industrial employment and locations of auto body/refinishing shops
Road density & housing/employment (ft2/person)
Population, institutions, and commercial employment
Total housing and locations of restaurants/bakeries
Single dwelling units and non-urban land
Housing/employment (ft2/person)
Computed surrogate - residential
Computed surrogate - non-residential
Computed surrogate - residential & non-residential
Industrial employment + computed surrogate (residential & non-residential)
Population
Residential, service, commercial, golf courses
Industrial employment and population
Total housing and commercial employment
Total employment
Total housing
Total housing and total employment
Single dwelling units
Single and multiple dwelling units
Non-retail employment
Industrial employment
Service and commercial employment
Elevation > 5000 ft
Forest land
Locations of bulk plants

Table 6.5. Sources of land use/land cover and facility locations

Data Source	Parameter	Resolution	Vintage	Coverage
United States Electronic Yellow Pages (ProCD Select Phone)	Autobody shops, dry cleaners, restaurants, gas stations, and wineries	Address locations	1997	Statewide
Environmental Systems Research Institute	Airports, parks, golf courses, hospitals, institutions	Coordinate locations and polygon coverages	1997	Statewide
U.S. Census Bureau (ESRI ADOL version)	Water bodies	Polygon coverages	2000	Statewide
United States Geological Survey	Land use and land cover for 38 counties	Gridded data	1993	Statewide
ARB CEIDARS Database	Bulk plant locations	Coordinate locations	1999	Statewide
National Atlas	Mine locations	Coordinate locations	1998	Statewide
Bureau of Transportation Statistics	Ports and shipping lanes	Coordinate locations and line coverages	Publication date is 2000; source date varies	Statewide
State Water Resources Control Board	Publicly owned water treatment works locations	Coordinate locations	2001	Statewide
Integrated Waste Management Board	Landfill locations	Coordinate locations	Downloaded from the Internet, no dates	Statewide
StreetWorks	Military bases	Polygon coverages	1995	Statewide
Digital Chart of the World	Elevation data	Polygon coverages	1993	Statewide
California Department of Oil and Gas	Oil and gas well and field locations	Coordinate locations and polygon coverages	1998	Statewide
California Teale Data Center (from ARB)	Urban and rural roads and railroads	Line and polygon coverages	RR, updated 1991; RDS, updated 1993	Statewide
Department of Water Resources (from ARB)	Agricultural land cover	Polygon coverages	1995	San Joaquin Valley

Table 6.6. Sources of statewide and local TPA demographic and socioeconomic surrogate data

Data Source	Parameter (Years)	Resolution and Coverage
Caltrans Statewide Transportation Model (Caltrans STM)	Population, housing, employment (base and future)	TAZ[a] – data for rural counties only
Association of Bay Area Governments (ABAG) and 1990 U.S. Census	Population, housing, employment (base and future)	Census Tract – San Francisco Bay Area
Sacramento Area Council of Governments (SACOG)	Population, housing, employment (base and future)	TAZ[a] – Sacramento Urban Region
Tahoe Regional Planning Agency (TRPA)	Population, housing, employment (base and future)[b]	TAZ[a] – Lake Tahoe Region
Association of Monterey Bay Area Governments (AMBAG) and 1990 U.S. Census	Population (base and future)	Census Tract – Monterey Bay Area
South Coast Association of Governments (SCAG)	Population, housing, employment (base and future)	TAZ[a] – South Coast Region
Amador County Transportation Commission (ACTC)	Population, housing, employment (base and future)[b]	Growth Allocation Districts (unincorporated areas) and incorporated areas – Amador County
Council of Fresno County Governments (FresnoCOG)	Population, housing, employment (base and future)	TAZ[a] – Fresno County
San Diego Association of Governments (SANDAG)	Population, housing, employment (base and future)	TAZ[a] – San Diego County
San Joaquin Council of Governments (SJCOG)	Population, housing, employment (base and future)	TAZ[a] – San Joaquin County
Tulare County Association of Governments (TCAG)	Population, housing, employment (base and future)	Incorporated and unincorporated areas – Tulare County
Stanislaus Council of Governments (StanCOG)	Population, housing, employment (base and future)	Incorporated and unincorporated areas – Stanislaus County
Kern Council of Governments (KernCOG)	Population, housing, employment (base and future)	TAZ[a] – Kern County

Table 6.7. Counties covered by each of the demographic and socioeconomic data sets listed in Table 6.6

Data Source	County Coverage
Caltrans STM	Alpine, Butte, Calaveras, Colusa, Del Norte, Glenn, Humboldt, Imperial, Inyo, Kings, Lake, Lassen, Mariposa, Madera, Merced, Mendocino, Modoc, Mono, Nevada, Plumas, east Riverside, east San Bernardino, San Luis Obispo, Santa Barbara, Shasta, Sierra, Siskiyou, Tehama, Trinity, Tuolumne
ABAG	Alameda, Contra Costa Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, Sonoma
SACOG/TRPA	El Dorado, Placer, Sacramento, Sutter, Yolo, Yuba
AMBAG	Monterey, San Benito, Santa Cruz
SCAG	Los Angeles, Orange, west Riverside, west San Bernardino, Ventura
ACTC	Amador
FresnoCOG	Fresno
SANDAG	San Diego
SJCOG	San Joaquin
TCAG	Tulare
StanCOG	Stanislaus
KernCOG	Kern

6.10 *Speciation*

The ARB's emission inventory and photochemical air quality models both quantify organic compounds as Total Organic Gases (TOG). Photochemical models simulate the processes leading to ozone formation and fate in the lower atmosphere, and include all emissions of the important compounds involved in ozone photochemistry. Organic gases are one of the most important classes of chemicals involved in the formation of surface ozone. Organic gases emitted to the atmosphere are referred to as total organic gases (TOG). ARB's chemical speciation profiles (CARB 2006) are applied to characterize the chemical composition of the TOG emitted from each source type.

TOG includes compounds of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate. TOG includes all organic gas compounds emitted to the atmosphere, including the low reactivity, or exempt, VOC compounds (e.g., methane, ethane, various chlorinated fluorocarbons, acetone, perchloroethylene, volatile methyl siloxanes, etc.). TOG also includes low volatility or low vapor pressure (LVP) organic compounds (e.g., some petroleum distillate mixtures). TOG includes all organic compounds that can become airborne (through evaporation, sublimation, as aerosols, etc.), excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate.

Total Organic Gas emissions are reported in the ARB's emission inventory and are the basis for deriving the Reactive Organic Gas (ROG) emission components, which are also reported in the inventory. ROG is defined as TOG minus ARB's "exempt" compounds (e.g., methane, ethane, CFCs, etc.). ROG is nearly identical to U.S. EPA's term "VOC", which is based on EPA's exempt list. For all practical purposes, use of the terms ROG and VOC are interchangeable. Also, various regulatory uses of the term "VOC", such as that for consumer products exclude specific, additional compounds from particular control requirements.

6.10.1 Speciation Profiles

Speciation profiles are used to estimate the amounts of various organic compounds that make up TOG. A speciation profile contains a list of organic compounds and the weight fraction that each compound composes of the TOG emissions from a particular source type. Each process or product category is keyed to one of several hundred currently available speciation profiles. The speciation profiles are applied to TOG to develop both the photochemical model inputs and the emission inventory for ROG.

To the extent possible given available data, ARB's organic gas speciation profiles contain all emitted organic species that can be identified (ideally, detected to very low levels). This includes reactive compounds, unreactive and exempt compounds, and to the extent the data are available, low vapor pressure compounds. Research studies are conducted regularly to improve ARB's species profiles. These profiles support ozone modeling studies but are also designed to be used for aerosol and regional toxics modeling. The profiles are also used to support other health or welfare related modeling studies where the compounds of interest cannot always be anticipated. Therefore, organic gas emission profiles should be as complete and accurate as possible.

The speciation profiles used in the emission inventory are available for download from the ARB's web site at http://www.arb.ca.gov/ei/speciate/speciate.htm. The Organic Speciation Profiles (ORGPROF) file contains the weight fraction data (expressed as percent for ease of display) of each chemical in each profile. Each chemical fraction is multiplied by the Total Organic Gas (TOG) emissions for a source category to get the amount of each specific constituent chemical. In addition to the chemical name for each chemical constituent, the file also shows the chemical code (a 5-digit internal identifier) and the Chemical Abstracts Service (CAS) number, which is a unique identifying code (up to 9 digits) assigned to chemicals by the CAS Registry Service.

Also available for download from ARB's web site is a cross-reference file that indicates which Organic Gas profile is assigned to each source category in the inventory. The inventory source categories are represented by an 8-digit Source Classification Code (SCC) for point sources, or a 14-digit Emission Inventory Code (EIC) for area and

mobile sources. This file also contains the fraction of reactive organic gas (FROG) values for organic profiles. Some of the Organic Gas Speciation Profiles related to motor vehicles and fuel evaporative sources vary by the inventory year of interest, due to changes in fuel composition and vehicle fleet composition over time.

ARB has an ongoing effort to update speciation profiles as data become available, such as through testing of emission sources or surveys of product formulation. New speciation data generally undergo technical and peer review, and updating of the profiles is coordinated with users of the data. Several recent changes to ARB's speciation profiles were for: 1) consumer products, 2) aerosol coatings, 3) architectural coatings, 4) pesticides and 5) hot soak from gasoline-powered vehicles.

6.10.2 Chemical Mechanisms

Airshed models are essential for the development of effective control strategies for reducing photochemical air pollution because they provide the only available scientific basis for making quantitative estimates of changes in air quality resulting from changes in emissions. The chemical mechanism is the portion of the model that represents the processes by which emitted primary pollutants, such as TOG, carbon monoxide (CO), and oxides of nitrogen (NO_x), react in the gas phase to form secondary pollutants such as ozone (O_3) and other oxidants.

For State Implementation Plan (SIP) attainment demonstrations and evaluations, the U.S. EPA has approved the California Air Resources Board's photochemical air quality models. The air quality models used by the ARB for SIP attainment demonstrations use the SAPRC photochemical mechanism. This mechanism is based on extensive scientific research and is documented in the scientific literature (Carter 2000). Table 6.8 shows modeled ROG species (or species categories) for the SAPRC-99 chemical mechanism. Table 6.9 shows modeled species for NOx.

Table 6.8 ARB's SAPRC-99 Emitted Organic Model Species

Model Species Name	Description
HCHO	Formaldehyde
CCHO	Acetaldehyde
RCHO	Lumped C3+ Aldehydes
ACET	Acetone
MEK	Ketones and other non-aldehyde oxygenated products
PROD	
RNO3	Lumped Organic Nitrates
PAN	Peroxy Acetyl Nitrate
PAN2	PPN and other higher alkyl PAN analogues
BALD	Aromatic aldehydes (e.g., benzaldehyde)
PBZN	PAN analogues formed from Aromatic Aldehydes
PHEN	Phenol
CRES	Cresols
NPHE	Nitrophenols
GLY	Glyoxal
MGLY	Methyl Glyoxal
MVK	Methyl Vinyl Ketone
MEOH	Methanol
HC2H	Formic Acid
CH4	Methane
ETHE	Ethene
ISOP	Isoprene
TERP	Terpenes
MTBE	Methyl Tertiary Butyl Ether
ETOH	Ethanol
NROG	Non-reactive
LOST	Lost carbon
ALK1	Alkanes and other non-aromatic compounds that react only with OH, and have kOH < 5×10^2 ppm-1 min-1. (Primarily ethane)
ALK2	Alkanes and other non-aromatic compounds that react only with OH, and have kOH between 5×10^2 and 2.5×10^3 ppm-1 min-1. (Primarily propane and acetylene)
ALK3	Alkanes and other non-aromatic compounds that react only with OH, and have kOH between 2.5×10^3 and 5×10^3 ppm-1 min-1.
ALK4	Alkanes and other non-aromatic compounds that react only with OH, and have kOH between 5×10^3 and 1×10^4 ppm-1 min-1.
ALK5	Alkanes and other non-aromatic compounds that react only with OH, and have kOH greater than 1×10^4 ppm-1 min-1.
ARO1	Aromatics with kOH < 2×10^4 ppm-1 min-1.
ARO2	Aromatics with kOH > 2×10^4 ppm-1 min-1.
OLE1	Alkenes (other than ethene) with kOH < 7×10^4 ppm-1 min-1.
OLE2	Alkenes with kOH > 7×10^4 ppm-1 min-1.

Table 6.9 Model Species for NOx

Model Species Name	Description
HONO	Nitrous Acid
NO	Nitric Oxide
NO2	Nitrogen Dioxide

Both U.S. EPA's and ARB's models require estimates of total organic gases, which include the "exempt VOCs", and, to the extent data are available, any low vapor pressure compounds that become airborne. Model results for ozone non-attainment areas have demonstrated that even compounds with low photochemical reactivity or low vapor pressure contribute to photochemical ozone formation. For example, even an "exempt VOC" like ethane has been shown to have a contribution to ozone formation. If all exempt compounds and low vapor pressure compounds were omitted from photochemical model simulations, the ozone attainment demonstration would be compromised. The model takes into account that, individually, compounds with low reactivity or that are present in small amounts have a small impact on ozone formation. However, the cumulative effect of several low reactive compounds or many low emission compounds can be a significant contributor to photochemical ozone formation.

The implementation of the chemical mechanism is unique in each air quality model. In the case of the CAMx model, the chemical species ETOH (ethanol), MTBE (methyl tert-butyl ether) and MBUT (methyl butenol) are not treated explicitly. These species are considered important to ozone chemistry in California because ETOH and MTBE are motor-vehicle fuel components and MBUT is emitted by vegetation. Therefore, to include emissions of these species in the emissions inventory for CAMx, they were mapped as follows:

(moles of ETOH)*1.3 = moles converted to ALK3
(moles of MTBE)*1.2 = moles converted to ALK3
(moles of MBUT)*1.8 = moles converted to OLE1

7 MODEL PERFORMANCE EVALUATION

The following subsections summarize the recommended model performance evaluation procedures (Emery & Tai, 2001; Tesche et al., 2002; USEPA, 1991 & 2005) for meteorological and photochemical models.

7.1 Meteorological Model Performance

Meteorological model performance is assessed both quantitatively using statistical metrics as well as qualitatively against known conceptual meteorological flows and observed episodic meteorological features.

7.1.1 Quantitative Performance Evaluation

There are a number of statistical and graphical approaches for evaluating meteorological model outputs. However, none of them are independently conclusive. Most of these approaches involve comparisons between observed and simulated meteorological parameter values. These analyses pose a difficult challenge, since most of the available meteorological monitoring stations are located in urbanized areas. Thus, the majority of observations tend to represent those areas versus the full complexity of meteorology throughout the CCOS domain. Furthermore, since the use of objective analysis and observational nudging forces the meteorological modeling results towards the observations, model performance problems can increase in areas away from observation locations.

It also needs to be recognized that output from the various meteorological models must be preprocessed for input into the air quality model. This preprocessing may inadvertently perturb the meteorological fields. Therefore, meteorological model performance should be based on the air quality model input files, rather than the meteorological model outputs.

The SIP modeling domain is geographically very complex and the observational data on which meteorological model outputs were evaluated are not distributed uniformly. Therefore, it is unreasonable to evaluate model performance for the domain as a whole. For purposes of meteorological model performance analysis, the CCOS domain is divided into sub-regions, representing areas of similar meteorological features. The graphical and statistical model evaluations will be done for each of these sub-regions.

A number of standard statistical and graphical techniques are used for meteorological model performance analysis. The most widely used application is the METSTAT program (Tesche, 1994, Tesche et al, 2001). Two graphical representations of the METSTAT statistics were used in meteorological model performance analysis conducted here: a) "Root Mean Square Error (RMSE) of Wind Speed" vs. "Gross Error (E) of Wind Direction", and b) "Bias Error (B)" vs. "Gross Error (E)" for temperature.

Equations used for these comparisons were taken from the user documentation of the METSTAT program and are given below:

Bias Error (B): calculated as the mean difference in prediction-observation pairings with valid data within a given analysis region and for a given time period (hourly or daily):

$$B = \frac{1}{IJ}\sum_{j=1}^{J}\sum_{i=1}^{I}\left(P_j^i - O_j^i\right)$$

Here, *P* and *O* indicate model predictions and observations, respectively. Similarly, I and J are the indices of grid points in x and y directions, respectively.

Gross Error (E): calculated as the mean *absolute* difference in prediction-observation pairings with valid data within a given analysis region and for a given time period (hourly or daily):

$$E = \frac{1}{IJ}\sum_{j=1}^{J}\sum_{i=1}^{I}\left|P_j^i - O_j^i\right|$$

Note that the bias and gross error for winds are calculated from the predicted-observed residuals in speed and direction (not from vector components *u* and *v*). The direction error for a given prediction-observation pairing is limited to the range from 0 to ±180°.

Root Mean Square Error (RMSE): calculated as the square root of the mean squared difference in prediction-observation pairings with valid data within a given analysis region and for a given time period (hourly or daily):

$$RMSE = \left[\frac{1}{IJ}\sum_{j=1}^{J}\sum_{i=1}^{I}\left(P_j^i - O_j^i\right)^2\right]^{1/2}$$

The RMSE, as is the gross error, is a good overall measure of model performance. However, since large errors are weighted heavily (due to squaring), large errors in small subregions may produce a large RMSE even though the errors may be small and quite acceptable elsewhere.

Table 7-1 shows the criteria used to decide if the results of a given model fall within acceptable performance limits.

Table 7-1 Statistical comparisons between observed and simulated meteorological parameter values. Statistical comparisons are made by model performance sub-regions.

Parameter	Abbreviation	Benchmark
Wind Speed	RMSE: Bias: IOA:	$\leq$ 2 m/s $\leq \pm$0.5 m/s $\geq$ 0.6
Wind Direction	Gross Error: Bias:	$\leq$ 30 deg $\leq \pm$10 deg
Temperature	Gross Error: Bias: IOA:	$\leq$ 2 °K $\leq \pm$0.5 °K $\geq$ 0.8

In an ideal situation, meteorological field evaluation would be done independent of the air quality model results. However, in practice, meteorological field evaluation is limited by the relative paucity of observational data, especially aloft. Therefore, base year air quality model performance was also considered in the selection of meteorological fields used for air quality simulations.

Table 7-2 Graphical analysis of meteorological model fields. Time series plots are made for each station and spatial plots are made over the whole modeling domain.

Time-series plots of hourly mean air temperature
Time-series plots of hourly mean wind speeds.
Spatial plots of hourly wind vectors
Spatial plots of hourly air temperatures

7.1.2 Qualitative Performance Analyses

Given episode-specific information on the meteorological features that were observed with field measurements, additional subjective analyses of observed versus predicted mesoscale features can be conducted. Examples of such qualitative analyses that will be considered are described below.

1. Determine and compare modeled and observed horizontal flow patterns throughout the modeling domain. Features to consider include flow splitting, the structure of the sea breeze, urban circulations, local flows such as Fresno and Schultz eddy circulations, slope and drainage flows, up/down valley flows, and the existence of cloud formations (Described in Chapter 1).

2. Study the 3-D spatial characteristics of the flow field by using time-height cross sections of wind profiler observations and the simulated wind field at the wind profiler location.

3. Determine the spatial and temporal characteristics of the mixing layer height using available upper air observations, and compare it with the simulated behavior of mixing layer heights.

4. Perform sensitivity tests to see the effects of certain model parameters on the model results, such as observational nudging vs. analysis nudging, the choice of soil physics, and boundary layer parameterizations.

7.2 Air Quality Model Performance

Air quality model results are used to develop strategies for attaining the federal 8-hour ozone standard. The development of these strategies relies on the use of relative reduction factors (RRFs). A more detailed discussion of RRFs is provided in other documents. However, the use of RRFs requires an evaluation of relative air quality model response at specific monitoring sites in the base year(s), a reference year, and a future year.

Adequate model performance is a requirement for use of modeled results. The lack of acceptable performance greatly increases uncertainty in the use of the modeling results, and casts doubt on conclusions based on the modeling. Although it is desirable to include as many days as possible in the RRF calculations, our experience has demonstrated that not all modeled days meet the minimum performance standards, and are thus not suitable for use. Therefore only those days that satisfy the following model performance criteria will be utilized in RRF calculations.

The USEPA (1991) and ARB (1990) outline a number of procedures for analysis of base year, air quality model performance. These include spatial and time-series plots, statistical analyses, comparing simulated and observed pollutant concentrations, as well as sensitivity analysis of selected input fields. The purpose of the performance analysis is to provide some confidence that the air quality simulations – which are the basis of future-year ozone concentration estimates – are performing properly and for the right reasons.

The application of air quality modeling results to demonstrate attainment of the federal 1-hour ozone standard emphasized the simulated unpaired peak ozone concentration. Three statistical measures were recommended to evaluate model performance: unpaired peak ratio (UPR), paired mean normalized bias (NB), and paired gross error (GE). These statistical measures were calculated for the modeling domain as a whole, and the NB and GE were calculated from all hourly concentrations in excess of 60 ppb (to avoid biasing the statistical measures with low concentrations). To meet performance guidelines, recommendations were that the UPR should be within ± 20%, NB should be within ± 15%, and the GE less than 35%. However, California's geography is very complex and modeling domains have evolved to cover large geographic areas. Thus it is recommended that the domains be divided into subregions, and that the performance measures be calculated independently for each subregion. The configuration of these subregions is somewhat arbitrary; however, they should be configured to isolate "common" regions of higher ozone. Figure 7-1 illustrates the proposed subregions for the CCOS domain.

The USEPA (2005) recommends that model performance be evaluated for 8-hour concentrations as well. The recommended statistical measures to assess simulated versus observed maximum 8-hour ozone concentrations include paired (in space, but

not time) peak prediction accuracy (PPPA), paired mean normalized bias (NB), and paired gross error (GE). Although limited performance analysis has been completed for 8-hour ozone modeling in California, it seems prudent at this point to carry forward the 1-hour statistical goals and apply them for the 8-hour standard (UPR within ± 20%, NB within ± 15%, and the GE less than 35%). However, these limits may need to be revised as 8-hour SIP modeling progresses and rigorous model performance evaluations are completed.

While statistical measures for 1-hour model performance were typically calculated independently for each modeled day available, the USEPA also suggests that PPPA, NB, and GE be calculated for each site over all modeled days. However, because the number of episode days available may be very limited, the statistical uncertainties in these latter calculations would be large and they are not recommended or used herein.

In order to have confidence in future year estimates from air quality models, there must be confidence in the air quality modeling for the base year. That is, days not meeting model acceptance criteria provide high uncertainty, and should not be used for the modeled attainment test.

In addition to the issue of model performance, analyses conducted by the USEPA (2005) suggest that air quality models respond more to emission reductions at higher predicted ozone values. Correspondingly, the model predicts less benefit at lower concentrations. This is consistent with preliminary modeling in support of the 8-hour ozone standard conducted by the ARB and the districts. These results imply that RRF calculations should be restricted to days with predicted high ozone concentrations. It is thus reasonable to establish a minimum threshold for predicted peak 8-hour ozone concentrations in the reference year. Days for which the predicted daily peak 8-hour ozone concentrations at a site are less than the threshold, would not be used for calculating RRFs at that site. Consistent with USEPA's recommendation, we propose to use a value of 85 ppb for the reference year threshold. However, USEPA guidelines allow the use of the maximum 8-hour concentrations within 15km of the site for this purpose.

Based on the above discussion, we propose the following model performance based methodology for determining sites and modeled days to be used in the RRF calculations:

Only those modeled days meeting the following criteria will be used to calculate site-specific RRFs:

1) The modeled daily 8-hour peak ozone concentration within 15 km of the site for the base year of the modeling (the model performance year) must be within ±20% of the observed value at the site.
2) The modeled daily 8-hour peak ozone concentration within 15 km of the site in the reference year must be 85 ppb or greater.
3) The subregional 1-hour and 8-hour statistical measures of NB and GE must fall within the thresholds of ± 15% and 35%, respectively.

Of these three criteria, only the third is considered in this document.

Along with the statistical measures discussed above, the graphical and statistical tests recommended by the USEPA (1991 and 2005) and shown in Tables 7-3 and 7-4 will be used to assess overall model performance. Several sensitivity tests recommended by the USEPA (1991) will also be used (Table 7-5) for qualitative evaluation. While the results of these sensitivity analyses are inherently subjective, they are designed to provide confidence that the air quality model is not only performing well, but is also properly responding to changes in inputs.

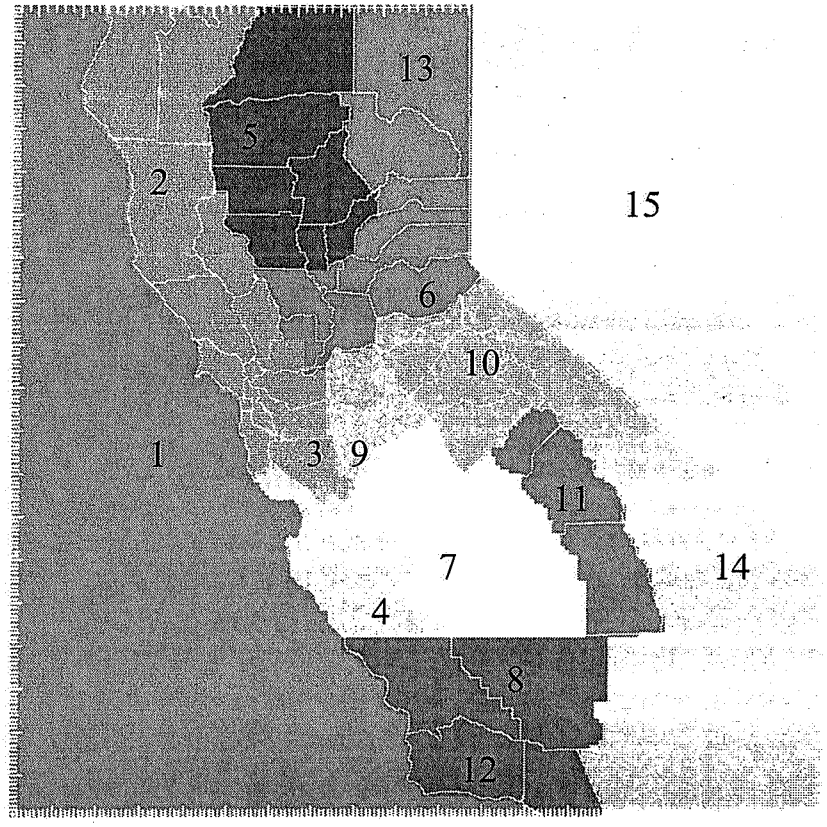


Figure 7-1 Sub-regions of air quality model performance evaluation (3: Bay Area region, 6: Sacramento Metro region, 7: Central San Joaquin Valley region , 8 Southern San Joaquin Valley region, 9: Northern San Joaquin Valley region).

Table 7-3. Statistics for evaluating base year air quality model performance for all sub-regions.

- Mean normalized bias for all 1-hour ozone concentrations (60 ppb), unpaired in time and space for all sites
- Mean normalized gross error for all 1-hour ozone concentrations (≥60 ppb), unpaired in time and space for all sites
- Peak 1-hour ozone concentration ratio, unpaired in time and space
- Mean normalized bias for all 8-hour ozone concentrations (≥60 ppb), unpaired in time for all sites
- Mean normalized gross error for all 8-hour ozone concentrations (≥60 ppb), unpaired in time for all sites
- Peak 8-hour ozone concentration ratio, unpaired in time and space

Table 7-4. Graphical tools for evaluating base year air quality model performance.

- Time-series plots comparing 1-hour measured and simulated concentrations of ozone, NO, NO2, and CO for each site.
- Hourly spatial plots of 1-hour measured and simulated concentrations of ozone, NO, NO2, and CO for the CCOS modeling domain.
- Scatter plot of 1-hour ozone concentrations for each day, and for each subregion of the modeling domain.

Table 7-5. Sensitivity tests for evaluation of Base Year air quality simulations. The results of these analyses will be tabulated by subregion.

1	Minimize vertical diffusivity based on land cover
2	Zero anthropogenic emissions
3	Zero biogenic emissions
4	Set lateral ozone boundary conditions to 50 ppb
5	Set lateral ozone boundary conditions to 90 ppb
6	Set initial ozone conditions to 40 ppb everywhere
7	Set initial conditions to 0.1 ppb NO2 and 0.0 NO (run with all emissions)
8	Set initial conditions to 0.1 ppb NO2 and 0.0 NO (run with biogenic emissions only)
9	Double biogenic emissions
10	Remove wildfires
11	Zero mobile emissions
12	Set top ozone boundary conditions to 135ppb at 15km

8 FUTURE-YEAR AIR QUALITY MODELING

The current thinking for the use of air quality modeling results in attainment demonstrations is to utilize relative model response to predict future-year 8-hour ozone concentrations. The Relative Reduction Factor (RRF) is calculated as the ratio of future-year and reference year ozone concentrations at a site. The RRF is then multiplied by a site-specific design value to estimate the future-year design value. In principle, this concept is simple. In practice, it is confounded by the limited record of available observed ozone concentrations during the available episodes and the uncertainties inherent in air quality modeling.

The emphasis of this document is on site-specific RRFs and the estimation of future year design values at non-attainment monitoring sites; however, the USEPA (2005) also requires analysis to demonstrate that high ozone concentrations occurring away from monitors (e.g., unpaired in space) will also be controlled in future years to meet air quality standards. This latter analysis is not addressed in this document.

There are two primary components to the application of air quality modeling results for the estimation of future-year ozone concentrations. The first is model performance analysis. The USEPA (1991) outlines a number of procedures for analysis of base-year air quality model performance. These include spatial and time-series plots comparing simulated and observed pollutant concentrations, statistical analyses comparing simulated and observed pollutant concentrations, and sensitivity analysis of selected input fields. This document will only address the more basic statistical analysis tests. The purpose of the performance analyses is to provide some confidence that the air quality simulations on which the estimates of future-year ozone concentrations will be based, will have some semblance to reality. The second is the issue of representative ozone concentrations for base- and future-year concentrations at each site from which the RRFs will be calculated.

8.1 Estimation of Future Design Value (DV_F)

The application of photochemical ozone models has a long history in California, for uses ranging from the preparation of State Implementation Plans to research activities to regulatory development. The modeling community has applied these tools in the State for over 30 years, and much has been learned about their proper uses and limitations.

One of the fundamental understandings that has evolved is that photochemical models are best used to estimate the relative difference between scenarios, rather than for absolute concentration estimates. That is, their strength is in estimating the relative change in concentration levels from a reference condition (e.g., a current year) to an alternative scenario (e.g., a future year), rather than predicting the exact concentration level that will result from the alternative scenario.

The USEPA's guidance on the use of models for attainment demonstrations in support of 8-hour ozone planning (USEPA, 2005) is consistent with the fundamental strength of models described above. USEPA's recommended modeled attainment test is to utilize relative model response on a site-by-site basis, in the form of a relative reduction factor (RRF), to predict future-year 8-hour ozone design values. This methodology relies on the base year for the modeling for conducting model performance analyses, a reference year of 2002 for projecting forward site-specific design values, and a future year for the attainment test.

$$\mathbf{DV_F = (RRF)\ (DV_R)}$$

where

DV_R = *a reference year (2002) concentration (design value) measured at a monitoring site*

DV_F = *the estimated future year design value at the same site*

RRF = *the relative reduction factor at the same site*

The RRF is calculated as the ratio of future year to reference year modeled ozone concentrations at a site:

$$RRF = \frac{FY_{8-hr}}{RY_{8-hr}}$$

where RRF = *the relative reduction factor for a monitor*
FY_{8-hr} = *the modeled future year 8-hour daily maximum concentration predicted near the same monitor*
RY_{8-hr} = *the modeled reference year 8-hour daily maximum concentration predicted near the same monitor*

In principle, this concept is simple. Unfortunately, it can be confounded by a number of factors, including the limited number of modeled days available, the choice of year(s) to use for specification of the reference design value, the uncertainties inherent in air quality modeling, and the presence of a non-zero background level of ozone. As a result of this, EPA technical staff have indicated that there is flexibility in the application of RRFs, as long as the methodology is technically sound and is properly documented.

8.1.1 Estimating Reference Year (2002) Design Values

Specification of the reference design value is a key consideration in the modeled attainment test, since this is the value that is projected forward and used to test for attainment at each site. Since the reference design value is presumably reflective of conditions in the reference year, it should be representative of the emissions used for that year. However, many areas experience fluctuations in their year-to-year meteorology, as well as emissions levels. In recognition of this year-to-year variability, the reference design value should in some fashion also reflect this variability. A standard methodology for minimizing the influence of year-to-year variations is to calculate an average value over multiple years. Therefore, the following methodology is recommended for specification of the reference design value at each monitoring site:

> **The reference design value (DV_R) will be calculated as the average of the three design values for the three years commencing with the reference year of the modeling. The reference year for modeling in support of the 8-hour ozone SIPs is 2002. Therefore, the reference design value will be calculated at each monitoring site as the average of the design values for 2002, 2003, and 2004.**

California design values are calculated as the three-year average of the 4th highest 8-hour ozone peak values, and are assigned to the last year. Thus, a design value for 2002 would be based on data for 2000-2002. The recommendation above implies that the reference design value at each monitoring site will be calculated as the average of nine design values over five years: the three years which make up the 2002 design value (2000-2002), the 2003 design value (2001-2003), and the 2004 design value (2002-2004). This gives the greatest weight to 2002, since that year is included in the calculation of the design value for all three years.

The following table summarizes the recommended process for calculating the reference design value at each monitoring site.

Year	Years Averaged for Design Value				
2002	2000	2001	2002		
2003		2001	2002	2003	
2004			2002	2003	2004
	Yearly Weighting for Average Design Value for Modeled Attainment Test				
2002-2004 Average	$DV_R = \frac{Year_{2000} + (2)(Year_{2001}) + (3)(Year_{2002}) + (2)(Year_{2003}) + Year_{2004}}{9}$				

8.1.2 Relative Reduction Factors

As discussed above, the relative reduction factor (RRF) is a monitor-specific value that is calculated based on daily peak 8-hour ozone concentrations simulated in a future year, divided by daily peak concentrations simulated in a reference year. To be consistent with the principle that the modeled attainment test and design values should be robust and stable over a number of different types of meteorology, the RRF should be based on multiple simulated days. The following methodology will be used to calculate site-specific RRFs:

Site-specific RRFs will be calculated as the ratio of the average daily peak 8-hour modeled ozone concentration in the future year, divided by the average daily peak 8-hour modeled ozone concentration in the reference year. Only those days satisfying the model performance and threshold criteria described below shall be included in the RRF calculation.

$$\mathbf{RRF_{AVG}} = \frac{\mathbf{(FY_{8-hr})_{AVG}}}{\mathbf{(RY_{8-hr})_{AVG}}}$$

where RRF_{AVG} = *the average relative reduction factor for a monitor*

$(FY_{8\text{-}hr})_{AVG}$ = *the average future year 8-hour daily maximum concentration predicted near the same monitor, averaged over those days which satisfy model performance and threshold criteria*

$(RY_{8\text{-}hr})_{AVG}$ = *the modeled reference year 8-hour daily maximum concentration predicted near the same monitor, averaged over those days which satisfy model performance and threshold criteria*

8.1.3 Criteria for Use of Modeled Days in RRF Calculations

Adequate model performance is a requirement for use of modeled results. The lack of acceptable performance greatly increases uncertainty in the use of the modeling results, and casts doubt on conclusions based on the modeling. Although it is desirable to include as many days as possible in the RRF calculations, our experience has demonstrated that not all modeled days meet the minimum performance standards, and are thus not suitable for use. Therefore only those days which satisfy the following model performance criteria will be utilized in RRF calculations.

The USEPA (1991) and ARB (1990) outline a number of procedures for analysis of base year, air quality model performance. These include spatial and time-series plots, statistical analyses, comparing simulated and observed pollutant concentrations, as well as sensitivity analysis of selected input fields. The purpose of the performance analysis is to provide some confidence that the air quality simulations – which are the basis of future-year ozone concentration estimates – are performing properly.

The application of air quality modeling results to demonstrate attainment of the federal 1-hour ozone standard emphasized the simulated unpaired peak ozone concentration. Three statistical measures were recommended to evaluate model performance: unpaired peak ratio (UPR), paired mean normalized bias (NB), and paired gross error (GE). These statistical measures were calculated for the modeling domain as a whole, and the NB and GE were calculated from all hourly concentrations in excess of 60 ppb (to avoid biasing the statistical measures with low concentrations). To meet performance guidelines, recommendations were that the UPR should be within ± 20%, NB should be within ± 15%, and the GE less than 35%. However, California's geography is very complex and modeling domains have evolved to cover large geographic areas. Thus it is recommended that the domains be divided into sub-regions, and that the performance measures be calculated independently for each sub-region. The configuration of these sub-regions is somewhat arbitrary; however, they should be configured to isolate "common" regions of higher ozone.

The USEPA (2005) recommends that the emphasis for 8-hour model performance be based on concentrations occurring at, or in the vicinity of, individual monitoring sites. Specifically, modeled concentrations occurring within 15 km of a site are considered to be in the vicinity of the site. The recommended statistical measures to assess simulated versus observed maximum 8-hour ozone concentrations include paired (in space, but not time) peak prediction accuracy (PPPA), paired mean normalized bias (NB), and paired gross error (GE). Although limited performance analysis has been completed for 8-hour ozone modeling in California, it seems prudent at this point to carry forward the 1-hour statistical goals and apply them for the 8-hour standard (UPR within ± 20%, NB within ± 15%, and the GE less than 35%). However, these limits may need to be revised as 8-hour SIP modeling progresses and rigorous model performance evaluations are completed.

While statistical measures for 1-hour model performance were typically calculated independently for each modeled day available, the USEPA also recommends that PPPA, NB, and GE be calculated for each site over all modeled days. However, because the number of episode days available may be very limited, the statistical uncertainties in these latter calculations would be large and they are not recommended herein.

In order to have confidence in future year estimates from air quality models, there must be confidence in the air quality modeling for the base year. That is, days not meeting model acceptance criteria provide high uncertainty, and should not be used for the modeled attainment test.

In addition to the issue of model performance, analyses conducted by the USEPA (2005) suggest that air quality models respond more to emission reductions at higher predicted ozone values. Correspondingly, the model predicts less benefit at lower concentrations. This is consistent with preliminary modeling in support of the 8-hour ozone standard conducted by the ARB and the districts. These results imply that RRF calculations should be restricted to days with predicted high ozone concentrations. It is thus reasonable to establish a minimum threshold for predicted peak 8-hour ozone concentrations in the reference year. Days for which the predicted daily peak 8-hour ozone concentration at a site is less than the threshold, would not be used for calculating RRFs at that site. Consistent with USEPA's recommendation, we propose to use a value of 85 ppb for the reference year threshold.

Based on the above discussion, we propose the following methodology for determining sites and modeled days to be used in the RRF calculations:

1) The modeled daily 8-hour peak ozone concentration within 15 km of the site for the base year (model performance year) of the modeling must be within ± 20% of the observed value at the site.
2) The modeled daily 8-hour peak ozone concentration within 15 km of the site in the reference year must be 85 ppb or greater.
3) The sub-regional 1-hour and 8-hour statistical measures of NB and GE must fall within the thresholds of ± 15% and 35%, respectively.

8.1.4 Estimating Future-Year Design Values

As discussed above, the USEPA's 8-hour modeling guidance recommends utilizing relative model response on a site-by-site basis, in the form of an average relative reduction factor (RRF_{AVG}), to predict future-year 8-hour design values for attainment planning. The average RRF is then multiplied by a site-specific design value to estimate the future-year design value. One of the confounding factors in this approach is consideration of the effects that background levels have on the effectiveness of emission control programs.

There is a large body of information that suggests that ambient concentrations consist of some (perhaps nonlinear) background value and a contribution due to anthropogenic emissions. That is, if all man-made emissions could be zeroed out, ozone concentrations would not go to zero but rather some finite value. The literature suggests that 40 ppb is a reasonable global background ozone value, and it is quite likely that continental background is some other, somewhat higher, value. One possibility for estimating background ozone values in a given modeling domain would be to exercise the model without anthropogenic emissions, and to thus develop a gridded "background" ozone field. One concern with this approach is that at such low levels, the model's boundary conditions exert a large influence, and appropriate temporally- and spatially-resolved data to specify boundary conditions rarely exist. Thus boundary conditions can be subjective and uncertain. Whether the background value is established at some finite value (e.g., 40 ppb) or is model-derived, it represents that portion of a site's ozone problem that cannot be mitigated by anthropogenic emission controls.

According to EPA's 8-hour ozone modeling guidance, the modeled attainment test requires that a future year Design Value (DV_F) be calculated at each site and compared to the standard to determine if the site is predicted to be in attainment. To calculate the future year Design Value, the Design Value for the reference year (DV_R) is multiplied by RRF_{AVG}. Although EPA's guidance says nothing about background ozone, we propose to calculate the future year Design Value with consideration of background. The Table below illustrates calculation of the DV_F with and without background. Because the model's boundary conditions exert a large influence on modeled background ozone levels, 40 ppb will be used to represent background ozone concentrations.

Calculation of the Average Relative Reduction Factor and Future Year Design Values* with and without Consideration of Background Ozone

Without consideration of background	With consideration of background
$RRF_{AVG} = \frac{(FY)_{AVG}}{(RY)_{AVG}}$	$RRF_{AVG} = \frac{(FY - BG)_{AVG}}{(RY - BG)_{AVG}}$
$DV_F = (RRF_{AVG}) \times (DV_R)$	$DV_F = [(RRF_{AVG}) \times (DV_R - BG)] + BG$

Definitions

DV_R	=	Design Value for the reference year
RY	=	Reference year model prediction
FY	=	Future year model prediction
BG	=	Background ozone

* Note: As per EPA guidance, future year design values are truncated rather than rounded.

9 REFERENCES

Air Sciences, Inc. 2004. 1996 Fire Emission Inventory for the WRAP Region – Methodology and Emission Estimates. Final Report. Lakewood, CO. At: http://www.wrapair.org/forums/fejf/documents/emissions/FEJF1996EIReport_040325_final.pdf

Battye, W. and Battye, R. 2002. Development of emissions inventory methods for wildland fires. U.S. EPA Contract No. 68-D-98-046. On-line link: http://www.epa.gov/ttn/chief/ap42/ch13/related/c13s01.html

Benjamin, M., Sudol, M., Bloch, L. and A. Winer. 1996. Low-emitting urban forests: a taxonomic methodology for assigning isoprene and monoterpene emission rates. Atmospheric Environment. 30 (9): 1437-1452.

Benjamin, M., Sudol, M., Vorsatz, D. and A. Winer. 1997. A spatially and temporally resolved biogenic hydrocarbon emissions inventory for the California south coast air basin. Atmospheric Environment. 31 (18): 3087-3100.

CARB. 1995. "Sacramento Area Modeling Analysis for the 1994 State Implementation Plan". California Air Resources Board. Technical Support Division. Sacramento, CA 95814. April, 1995.

CARB. 2000. "Extension and input refinement to the ARB wildland fire emissions estimation model," ARB agreement number 00-729

CARB. 2005 ARB Speciation Profiles: (a) California Air Resources Board, "Identification of Volatile Organic Compound Species Profiles: ARB Speciation Manual, Second Edition, Volume 1 of 2," August 1991; and (b) subsequent revisions. The latest ARB speciation profiles are available from ARB's web site at http://www.arb.ca.gov/ei/speciate/speciate.htm.

CARB. 2005. http://www.arb.ca.gov/airways/ccos/ccos.htm

CARB. 2006. http://www.arb.ca.gov/msei/msei.htm

Carter, W.P.L, 2000. "Documentation of the SAPRC-99 Chemical Mechanism for VOC Reactivity Assessment," Final Report to California Air Resources Board, Contract No. 92-329, and (in part) 95-308,May 8, 2000, http://pah.cert.ucr.edu/~carter/reactdat.htm

Carter, W.P.L, 2001. Personal Communication. http://pah.cert.ucr.edu/~carter/

Chang, J. S., J. Shengxin, L. Yinghong, M. Beauharnois, L., Cheng-Hsuan, and H. Ho-Chun. 1997. The SARMAP Air Quality Model. Planning and Technical Support Division. California Air Resources Board. Sacramento, CA. April, 1997.

Coe, D. 2003. "Assisstance to Rural Counties with Development of Area Source Emission Inventories." Technical Memoranda. Contract No. 00-24CCOS. San Joaquin Valleywide Air Pollution Study Agency and California Environmental Protection Agency – Air Resources Board. At: www.sonomatech.com/ccosii/; user name: "ccosii"; password: "emissions"

Cofer, W., Levine, J., Winstead, E. and Stocks, B. 1991. Trace gas and particulate emissions from biomass burning in temperate ecosystems. In: Global Biomass Burning: Atmospheric, Climatic and Biospheric Implications. Levine, J., editor. MIT Press.

Davis, F. W., P. A. Stine, D. M. Stoms, M. I. Borchert and A. D. Hollander. 1995. Gap analysis of the actual vegetation of California –1. The southwestern region. Madrono 42: 40-78.

Dudhia, J., 1989: Numerical study of convection observed during the winter monsoon experiment using a mesoscale two-dimensional model. J. Atmos. Sci., 46, 3077-3107.

Dudhia, J., 1996: A multi-layer soil temperature model for MM5. Preprints, 6th Annual MM5 Users Workshop, Boulder, CO.

Earth Tech. 2000. A User's Guide for the CALMET Meteorological Model (Version 5). Earth Tech. Concord, MA. 01742. January, 2000.

Einfeld, W., Ward, D. and Hardy, C. 1991. Effects of fire behavior on prescribed fire smoke characteristics: a case study. In: Global Biomass Burning: Atmospheric, Climatic and Biospheric Implications. Levine, J., editor. MIT Press.

ENVIRON. 2001. The program 'mm5camx_v3'. Personal communication. ENVIRON. Novato, CA. 95945. August, 2001.

ENVIRON. 2004. User's Guide. Comprehensive Air Quality Model With Extensions (CAMx) v4.10S. ENVIRON. Novato, CA 95945. August, 2004.

ENVIRON. 2005a. Personal communication. ENVIRON. Novato, CA. 95945. February, 2005.

ENVIRON. 2005b. The Development of a Photochemical Modeling System for the Bay Area Air Quality Management District to Support Ongoing Air Quality Analysis. BAAQMD. San Francisco, CA. January, 2005.

Fairley, D. and DeMandel, R. 1996. An Analysis of SARMAP Episode Day Representativeness. Final report. Prepared for the SARMAP Data Analysis Project by

the Bay Area Air Quality Management District, San Francisco, CA, Faust, B. C., Photochemistry of clouds, fogs and aerosols, Environ. Sci. Technol., 28A, 217, 1994.

Fujita, E., D. Campbell, R. Keilar, and J. Bowen. 2001. Central California Ozone Study – Volume III: Summary of Field Operations. Final Report. DRI. California Air Resources Board. Sacxramento, CA 95814. February, 2001.

Fujita, E., D. Campbell, R. Keisler, and J. Bowen. 1999. "Central California Ozone Study – Volume III. Summary of Field Operations". Planning and Technical Support Division, California Air Resources Board. Sacramento, CA. 95814. November, 1999.

Funk, T., Stiefer, P., Chinkin, L. 2001 "Development of Gridded Spatial Allocation Factors for the State of California". Final Report. Contract No. 00-24CCOS. San Joaquin Valleywide Air Pollution Study Agency and California Environmental Protection Agency – Air Resources Board.

Grell, G. A., J. Dudhia and D. R. Stauffer, 1994: A description of the fifth-generation Penn State/NCAR mesoscale model (MM5). NCAR Technical Note, NCAR/TN-398+STR, 117 pp. National Center for Atmospheric Research. Boulder, CO. June, 1994.

Griffith, D., Mankin, W., Coffey, M., Ward, D., Riebau, A. 1991. FTIR remote sensing of biomass burning emissions of CO2, CO, CH4, CH2O, NO, NO2, NH3, and N2O. In: Global Biomass Burning: Atmospheric, Climatic and Biospheric Implications. Levine, J., editor. MIT Press.

Guenther, A., P. Zimmerman and M. Wildermuth, Natural volatile organic compound emission rate estimates for U.S. woodland landscapes. *Atmos. Environ., 28* , 1197-1210, 1994.

Guenther, A. B., P. R. Zimmerman, P. C. Harley, R. K. Monson and R. Fall. 1993. Isoprene and monoterpene emission rate variability – model evaluations and sensitivity analyses. Journal of Geophysical Research. 98(D7): 12609-12617.

Guenther, A. B. R. K. Monson and R. Fall. 1991. Isoprene and monoterpene emission rate variability: observations with eucalyptus and emission rate algorithm development. Journal of Geophysical Research. 96: 10799-10808.

Hanna, S.R., A.G. Russell, J. Wilkinson and J. Vukovich. Review of BEIS3 Formulation and Consequences Relative to Air Quality Standards: Estimation of Uncertainties in BEIS3 Emissions Outputs, EPRI Tech. Report 1005159, EPRI, 3412 Hillview Ave., Palo Alto, CA 94304. 2002.

Hayes, T. P., J. J. R. Kinney, and N. J. M. Wheeler. 1984. "California Surface Wind Climatology". Planning and Technical Support Division. California Air Resources Board. Sacramento, CA. 95812. June, 1984.

Harley, P., V. Fridd-Stroud, J. Greenberg, A. Guenther and P. Vasconcellos. 1998. Emission of 2-methyl-3-buten-2-ol by pines: A potentially large natural source of reactive carbon to the atmosphere. Journal of Geophysical Research. 103: 25479-25486.

Horie, Y., Sidawi, S. and R. Ellefsen. 1990. Inventory of leaf biomass and emission factors for vegetation in California's south coast air basin. Final Technical Report III-C. South Coast Air Quality Management District. Diamond Bar, CA.

Hunman, R.C., D. J. Jacob, O.R. Cooper, M. J. Evans, C.L. Heald, R.J. Park, F. Fehsenfeld, F. Flock, J. Holloway, G. Hubler, K., Kita, M. Koike, Y. Kondo, A. Neuman, J. Nowak, S. Oltmans, D. Parrish, J. M Roberts, abd T. Ryerson. 2004. Ozone production in transpacific Asian pollution plumes and implications for ozone air quality in California. J. Geophys Research, 109:D23S10.

Janjic, Z., I., 1994: The step-mountain Eta coordinate model: Further development of the convection, viscous sublayer and turbulent closure schemes. Mon. Wea. Rev., 122, 927-945.

Janjic, Z. I., 2004: The NCEP WRF Core. 12.7, Extended Abstract, 20th Conference on Weather Analysis and Forecasting/16th Conference on Numerical Weather Prediction, Seattle, WA, American Meteorological Society.

Kain, J. S., and J. M. Fritsch, 1993: Convective parameterization for mesoscale models: Kain-Fritsch scheme. The representation of cumulus convection in numerical models, K. A. Emanuel and D. J. Raynond, Eds., Amer. Meteor. Soc., 246 pp.

Karlik, J. and A. McKay. 1999. Development of methodology and databases for estimating leaf masses in California airsheds. Final Report. Contract No. 97-719. State of California Air Resources Board. Sacramento, CA.

Karlik, J. 2002. Validation of databases for modeling biogenic volatile organic compound emissions in central California. Draft Final Report. Contract No. 00-16CCOS. San Joaquin Valleywide Air Pollution Study Agency and California Environmental Protection Agency – Air Resources Board.

Kleeman, M. 2000. "Updating Point Source Emissions Inventories in the Sacramento Valley and Mountain counties Using Student Assistants" Contract No. 00-22CCOS.

Lam, T. Niemeier, D., Jierranaitanakit, K. 2002. "Estimation of Hourly Allocation Factors for the Central California Ozone Study Using State-wide Model Data and Real Time Traffic Data." Final Draft Report. Contract No. 00-04PM. San Joaquin Valleywide Air Pollution Study Agency and California Environmental Protection Agency – Air Resources Board.

Lerhman, D., B. Knuth, and D. Fairly. 2003. "Characterization of the CCOS 2000 Measurment Period". T&B Systems Contract No. 01-2CCOS. California Air Resources Board -- Planning and Technical Support Division. Sacramento, CA 95814. September, 2003.

Lobert, J., Scharffe, D., Hao, W.-M., Kuhlbusch, T., Seuwen, R., Warneck, P., and Crutzen, P. 1991. Experimental evaluation of biomass burning emissions: nitrogen and carbon containing compounds. In: Global Biomass Burning: Atmospheric, Climatic and Biospheric Implications. Levine, J., editor. MIT Press.

McRae, G.J, W.R. Goodin, and J.H. Seinfeld. 1982, Mathematical Modeling of Air Pollution. EQL Report No. 18. Planning and Technical Support Division, CARB. Sacramento, CA 95814. April, 1982.

McPherson, E. G. 1998. Structure and sustainability of Sacramento's urban forest. Journal of Arboriculture. 24 (4): 174-190.

Mesinger, F., Z. I. Janjic, S. Nickovic, D. Gavrilov, and D. G. Deaven, 1988: The step-mountain coordinate: model description and performance for cases of Alpine lee cyclogenesis and for a case of an Appalachian redevelopment. *Mon. Wea.* Rev., 116, 1493-1518.

Mlawer, E. J., S. J. Taubman, P. D. Brown, M. J. Iacono, and S. A. Clough, 1997: Radiative transfer for inhomogeneous atmospheres: RRTM, a validated correlated-k model for the longwave. J. Geophys. Res., 102(D14), 16,663-16,682.

Myrup, L.O., R.G. Flocchini, and D. Ewell (1981) Transport of Atmospheric Aerosols Above the Sierra Nevada Slopes, Final Report, Contract A4-127-32. Prepared by University of California Davis, January 15, 1989.

Neff, W.D., J. Jorden. J. Gaynor, D. Wolfe, W. Ecklund, D. Carter, and K. Gage (1991) The use of 915 MHz radar wind profilers in complex terrain and regional air quality studies. Preprints, Seventh Joint Conference on Applications of Air Pollution Meteorology with AWMA. 14-18 January 1991, New Orleans, LA, American Meteorological Society. Boston, MA., J230-J233.

Newchurch, M. J., M. A. Ayoub, S. Oltmans, B. Johnson, and F.J. Schmidlin. 2003. Vertical distribution of ozone at four sites in the United States. J. of Geophys. Research, 108(D1):ACH 9-1,17.

Nikolov, N. T. 1999. 1-km resolution database of vegetation leaf area index and canopy clumping factor for the western U.S.A. Final Report, U.S.D.A. Forest Service Agreement No. PSW-99-001-RJVA. N&T Services. Oak Ridge, TN.

Nowak, D. J. 1991. Urban forest development and structure: Analysis of Oakland, California. PhD dissertation. University of California, Berkeley, CA.

Pielke, R. A., W. R. Cotton, R. L. Walko, C. J., Tremback, W. A. Lyons, L. D. Grasso, M. E. Nicholls, M. D. Moran, D. A. Wesley, T. J. Lee, and J. H. Copeland, 1992: A comprehensive meteorological modeling system – RAMS. Meteorology and Atmospheric Physics, 49, 69-91.

Pielke, R. A. and M. Uliasz. 1998. Use of meteorological models as input to Regional and mesoscale air quality models -- limitations and strengths. 1998. Atmospheric Environment 32:1455-1466.

Pun, B. K., J. F. Louis, and C. Seigneur. 1998. "A Conceptual Model for ozone formation in the San Joaquin Valley". AER Document No. CP049-1-98. Pacific Gas and Electric Co. San Ramon, CA 94583. December, 1998.

Radke, L., Hegg, D., Hobbs, P., Nance, D., Lyons, J., Laursen, K., Weiss, R., Riggan, P., and Ward, D. 1991. Particulate and trace gas emissions from large biomass fires in north America. In: Global Biomass Burning: Atmospheric, Climatic and Biospheric Implications. Levine, J., editor. MIT Press.

Reinhardt, E., Keene, R. and Brown, J. 1997. First Order Fire Effects Model: FOFEM 4.0 User's Guide. USDA Forest Service, Intermountain Research Station, General Technical Report INT-GTR-344.

Seaman, N.L., D. R. Stauffer, and A. M. Lario-Gibbs. 1995. A multiscale four-dimensional data assimilation system applied to the San Joaquin Valley during SARMAP. Part I: Modeling design and basic model performance characteristics. J. of Applied Meteorology 34:1739-1761.

SCAQMD. 2003. "2003 Air Quality Management Plan -- Modeling and Attainment Demonstrations." Final Report -- Appendix V. South Coast Air Quality Management District. Diamond Bar, CA 91765. August, 2003.

Scire J.S., R.J. Yamartino, S.R. Hamma, G.R. Carmichal, and Y.S. Chang. 1989. CALGRID: A Mesoscale Photochemical Grid Model. Volume I: Model Formulation Document. Planning and Technical Support Division, CARB. Sacramento, CA 95814. June, 1989.

Sidawi, S. and Y. Horie. 1992. Leaf biomass density for urban, agricultural and natural vegetation in California's San Joaquin Valley. Final Report. San Joaquin Valley Air Pollution Study Agency.

SJVAQMD. 1994. "The Ozone Attainment Plan". San Joaquin Valley Air Pollution Control District. Fresno, CA. November, 1994

Skaramarock, W. C., J. B. Klemp, J. Dudhia, G. O. Gill, D. M. Barker, W. Wang, and J. G. Powers, 2005: A description of the Advanced Research WRF Version 2. NCAR Technical Note NCAR/TN-468+STR, June 2005.

Smith, T.B., D.E. Lehrman, D.D Reible, and F.H. Shair (1981) The origin and fate of airborne pollutnats within the San Joaquin Valley, Rep. MRI FR-1838, Meteorology Research, Inc., Altadena, CA. Prepared for the California Air Resources Board.

Smith, T. B. (1994) Ozone Episode Forecasting in the San Joaquin Valley. Planning and Managing Regional Air Quality Modeling and Measurement Studies: A Perspective Through the San Joaquin Valley Air Quality Study and AUSPEX, ed. by P. A. Solomon. Published by Lewis Publishers, Chelsea, MI in conjunction with Pacific Gas and Electric Company, San Ramon, CA, pp. 507-528.

Susott, R., Ward, D., Babbitt, R. and Latham, D. 1991. The measurement of trace gass emissions and combustion characteristics for a mass fire. In: Global Biomass Burning: Atmospheric, Climatic and Biospheric Implications. Levine, J., editor. MIT Press.

Systems Applications, Inc. 2001. DTIM 4 User's Guide. Prepared for the California Department of Transportation, Sacramento.
Tonneson, G. 2003. Personal Communication. CE-CERT. U.C. Riverside, Riverside, CA. April, 2003.

Ward, D. and Hardy, C. Smoke emissions from wildland fires. 1991. Environment International. V17. Pp.117-134.

Wilkinson, J. 2003, "Development of the California Integrated Transportation Network (ITN)", Draft Final Report. Contract No. 93-2PM. San Joaquin Valleywide Air Pollution Study Agency and California Environmental Protection Agency – Air Resources Board.

Wilkinson, J. 2005, "Development of Version Two of the California Integrated Transportation Network (ITN)", Final Report. Contract No. 04-2CCOS. San Joaquin Valleywide Air Pollution Study Agency and California Environmental Protection Agency – Air Resources Board.

Winer, A., Karlik, J. and J. Arey. 1998. Biogenic hydrocarbon inventories for California: generation of essential databases. Final Report. Contract No. 95-309. State of California Air Resources Board. Sacramento, CA.

Winer, A. and Karlik, J. 2001. Development and validation of databases for modeling biogenic hydrocarbon emissions in California's airsheds. Final Report. Contract No. 97-320. California Environmental Protection Agency – Air Resources Board. Sacramento, CA.

USEPA. 1990. Carbon Bond IV: Morris, R.E. and Meyers, T. E., "User's Guide for the Urban Airshed Model," Volume I, Appendix 1: "The Carbon Bond IV Chemical Kinetics

Mechanism for Urban and Regional Scale Computer Modeling," EPA-450/4-90-007A, June 1990.

USEPA. 1991. Guideline for the Regulatory Application of the Urban Airshed Model. OAQPS, USEPA. Research Triangle Park, NC 27711.

USEPA, 1991. "Guideline for Regulatory Application of the Urban Airshed Model". EPA-450/4-91-013. USEPA, OAQPS. Research Triangle Park, NC 27711. July, 1991.

USEPA. 1999. "Science Algorithms of the EPA Models-3 Community Multiscale Air Quality Model (CMAQ) Modeling System. USEPA. EPA/600/R-99/030. Office of Research and Development. Washington, D. C. 20460. March, 1999.

USEPA, 2005. "Guidance on the Use of Models and Other Analysis in the Attainment Demonstration for the 8-Hour Ozone NAAQS". USEPA, OAR/OAQPS, Research Triangle Park, NC 2771. October, 2005.

Appendix D

Proposed Updates to the Transportation Conformity Budgets Identified in the San Joaquin Valley 2007 Ozone Plan.

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Appendix D

Proposed Updates to the Transportation Conformity Budgets Identified in the San Joaquin Valley 2007 Ozone Plan.

The transportation conformity budgets established in the San Joaquin Valley 2007 Ozone Plan were created using the EMFAC2007 on-road mobile source emissions forecasting model. EMFAC2007 allows users to input the most up-to-date planning estimates for a wide array of input parameters used to drive the model, via a user-friendly interface. These input parameters include vehicle travel activity, vehicle population data, and vehicle speed profile data. If specific data are not provided, the EMFAC2007 model provides default data specific to the region for which the estimates are being generated.

Summary of Update: Madera County

Years Affected
2008, 2011, 2014, 2017, 2020, and 2023.

Reason for update:

As discussed in Chapter 9 of the 2007 Ozone Plan, the Madera County transportation conformity budgets were developed using EMFAC2007 default vehicle activity data, which reflects data previously submitted by the Madera County MPO. Madera County recently provided more refined vehicle activity; however, this updated activity data was not available in time for inclusion in the District Final draft 2007 Ozone Plan. Subsequently, the MPO has requested that ARB update the conformity budgets for Madera County to reflect this refined data. Table 1 lists the vehicle miles traveled (VMT) activity and population activity that underlie this update. Table 2 lists the 2007 Ozone Plan transportation conformity budgets for Madera County as well as the proposed updates to the transportation conformity budget which, upon Air Resource Board approval, will replace those included in the San Joaquin Valley 2007 Ozone Plan.

Table 1
Updated Madera County On-road Vehicle Activity Projections
(x 1,000)

Year	EMFAC2007 Default Vehicle Travel (VMT)	Updated Madera Vehicle Travel (VMT)	EMFAC2007 Default Vehicle Population	Updated Madera Vehicle Population
2008	5,059	5,065	112	112
2011	5,578	5,558	124	123
2014	6,107	6,022	134	132
2017	6,711	6,673	145	144
2020	7,327	7,324	156	156
2023	7,728	7,890	166	170

Table 2
Updated On-road Transportation Conformity Budgets for Madera County
(Summer Planning tons per day)

Year	ROG		NOx	
	2007 Ozone Plan	Updated Activity Data	2007 Ozone	Updated Activity Data
2008	~~4.5~~	4.4	~~14.6~~	14.6
2011	~~3.7~~	3.7	~~12.2~~	12.2
2014	~~3.1~~	3.1	~~9.8~~	9.7
2017	~~2.6~~	2.6	~~7.8~~	7.7
2020	~~1.9~~	1.9	~~4.8~~	4.8
2023	~~1.9~~	1.9	~~4.4~~	4.5

Summary of Update: San Joaquin County

Years Affected
2008.

Reason for Update

While reviewing the San Joaquin Valley 2007 Ozone Plan, ARB staff, working with the District and the transportation planning agency staffs, identified a technical error in the input file used to generate the 2008 transportation conformity budgets. The vehicle speed profile input file only included updates for passenger car speed for light-duty automobiles. Light- and medium-duty trucks and motorcycles all relied on EMFAC2007 defaults for these categories, rather

than the updates provided by the San Joaquin County Council of Governments. Table 3 lists the corrected 2008 transportation conformity budget for San Joaquin County.

Table 3
Updated On-road Transportation Conformity Budgets for San Joaquin County
(Summer Planning tons per day)

Year	ROG		NOx	
	2007 Ozone Plan	Updated	2007 Ozone	Updated
2008	~~13.9~~	13.9	~~39.9~~	40.0

Recommendations

ARB staff proposes to update the Madera County transportation conformity budgets for 2008, 2011, 2014, 2017, 2020, and 2023 in the San Joaquin Valley 2007 Ozone Plan to include the updated activity data.

ARB staff proposes to update the 2008 San Joaquin County transportation conformity budgets in the San Joaquin Valley 2007 Ozone Plan to reflect vehicle speed data consistent with San Joaquin County's transportation data submitted for the 8-hour Ozone SIP development.
Additional data is available on-line at:

http://www.arb.ca.gov/planning/sip/2007sip/2007sip.htm

TITLE 13. CALIFORNIA AIR RESOURCES BOARD

NOTICE OF PUBLIC HEARING TO CONSIDER 2007 AMENDMENTS TO THE PHASE 3 CALIFORNIA REFORMULATED GASOLINE REGULATIONS

The Air Resources Board (ARB or Board) will conduct a public hearing at the time and place noted below to consider adoption of amendments to the California Reformulated Gasoline (CaRFG) Regulations. The proposed amendments would: (1) help preserve the benefits of the Phase 2 CaRFG standards and update the Predictive Model to reflect the current motor vehicle fleet and new data on how fuel properties affect motor vehicle emissions, (2) lower the sulfur cap limit from 30 parts per million by weight (ppmw) to 20 ppmw, (3) restore the 7.00 pounds per square inch (psi) Reid vapor pressure (RVP) flat limit when the evaporative emissions portion of the Predictive Model is used to certify ethanol blends, (4) add provisions allowing for the use of alternative emission reduction plans to mitigate emissions associated with permeation, (5) add provisions to allow the option of using short term averaging to address emissions occurring when sulfur levels unintentionally exceed applicable flat or averaging limits, and (6) include other miscellaneous changes to improve consistency, flexibility, and enforceability.

DATE: June 14, 2007

TIME: 9:00 a.m.

PLACE: San Joaquin Valley Air Pollution Control District
1990 East Gettysburg Avenue
Fresno, California 93726

or Via Videoconference (2 Locations)
District Northern Region Office
4230 Kiernan Avenue, Suite 130
Modesto, California 95356

District Southern Office
2700 M Street, Suite 275
Bakersfield, California 93301

This item will be considered at a one-day meeting of the Board, which will commence at 9:00 a.m. on Thursday, June 14, 2007. The agenda for the meeting will be available at least 10 days before June 14, 2007.

For individuals with sensory disabilities, this document is available in Braille, large print, audiocassette or computer disk. Please contact ARB's Disability Coordinator at (916) 323-4916 by voice or through the California Relay Services at 711, to place your request for disability services. If you are a person with limited English and would like to request interpreter services, please call ARB's Bilingual Manager at (916) 323-7053.

INFORMATIVE DIGEST OF PROPOSED ACTION AND POLICY STATEMENT OVERVIEW

Sections Affected: Proposed amendments to sections 2261, 2262, 2262.3, 2262.4, 2262.5, 2262.9, 2263, 2263.7, 2264.2, 2265 (and the incorporated "California Procedures for Evaluating Alternative Specifications for Phase 3 Reformulated Gasoline Using the California Predictive Model"), 2266, 2266.5, 2270, 2271, and 2273, and proposed new sections 2260(a)(0.5), (0.7), (7.5), (8.5), (10.5), (10.7), (19.7), (23.5), and (23.7), 2262.3(d), 2264.2(a)(3), (b)(5), and (d), 2265(c)(4), 2265.1, 2265.5, and 2266(b)(3), (4), and (5) of Title 13, California Code of Regulations (CCR).

Background

The ARB administers the CaRFG regulations, which have applied to all California gasoline since March 1996; the Phase 3 CaRFG standards have applied since December 31, 2003. The CaRFG regulations establish specifications for the following eight gasoline properties: sulfur, benzene, olefin, aromatic hydrocarbon, and oxygen contents, 50 percent distillation temperature (T50), 90 percent distillation temperature (T90), and summertime RVP. The Phase 3 CaRFG regulations also prohibit the use of oxygenated compounds (oxygenates) other than ethanol in CaRFG, and regulate the composition of denatured ethanol that can be blended with California reformulated gasoline blendstock for oxygenate blending (CARBOB) to produce CaRFG.

The CaRFG regulations allow refiners to use a "Predictive Model" to certify alternative formulations. The Predictive Model is a set of mathematical equations that relate emissions rates of exhaust and evaporative hydrocarbons and carbon monoxide (CO), oxides of nitrogen (NOx), and potency-weighted toxics for four toxic air contaminants (benzene, 1,3-butadiene, formaldehyde, and acetaldehyde) to the values of the eight regulated gasoline properties. An alternative gasoline formulation based on the Predictive Model is acceptable if emissions of reactivity-weighted hydrocarbons and CO (total ozone forming potential), NOx, and potency-weighted toxics resulting from this formulation are no greater than emissions from gasoline having the specifications set forth in the CaRFG standards. Currently, most of the gasoline sold in California complies with the CaRFG regulations through the use of the Predictive Model.

Since 1995, most of the State's gasoline has contained about 2 percent oxygen by weight. From 1995 to 2002, methyl tertiary-butyl ether (MTBE) was the oxygenated compound used in most California gasoline. Since December 31, 2003 – the Phase 3 CaRFG compliance deadline – ethanol has been the only oxygenate allowed in California gasoline. The widespread use of oxygenated compounds in California gasoline has primarily resulted from two programs mandated by the federal Clean Air Act – the federal reformulated gasoline (RFG) program administered directly by the U.S. Environmental Protection Agency (U.S. EPA) in the smoggiest areas of the country, and the wintertime oxygenates program which is ultimately administered by the states. The federal Energy Policy Act of 2005 directed U.S. EPA to lift the federal

oxygen content requirement for federal RFG and set a renewable fuels standard (RFS) which requires an increasing use of renewable transportation fuel nationwide. In February 2006, U.S. EPA lifted the federal oxygen content requirement for federal RFG. The federal wintertime oxygen content requirement for carbon monoxide nonattainment areas is still in effect for wintertime gasoline sold in the South Coast Air Basin and Imperial County. Almost all gasoline marketed in California today contains ethanol.

The Proposed Amendments

Health and Safety Code 43013.1 requires that the Phase 3 CaRFG regulations preserve the emissions and air quality benefits of the Phase 2 CaRFG program. The ARB staff has determined that the use of ethanol in Phase 3 CaRFG increases evaporative emissions, relative to Phase 2 CaRFG, through a process known as permeation. Permeation occurs in both on-road vehicles and off-road engines and portable fuel containers.

The staff is proposing amendments to the CaRFG regulations and an update to the Predictive Model to mitigate the excess emissions associated with permeation from on-road motor vehicles. Under the proposed amendments, starting December 31, 2009, a fuel formulation cannot be treated as fully complying with the Phase 3 CaRFG standards unless the excess emissions associated with permeation from on-road vehicles are fully mitigated.

At this time, staff does not have adequate data to design amendments to the CaRFG3 rules to ensure that the increase in evaporative emissions due to the use of ethanol in off-road engines and portable fuel containers is fully mitigated. Staff is initiating additional test programs to evaluate the effect of ethanol in gasoline on both exhaust and evaporative emissions and plans to propose appropriate mitigation strategies as soon as practical.

To mitigate the excess emissions associated with permeation from on-road vehicles, the refiners can choose one of two options. First, they can use the Predictive Model to develop an alternative fuel formulation. Using this approach will likely require the use of a very low sulfur fuel content and ethanol amounts approaching 10 percent by volume. As such, refinery modifications are needed to produce the very low sulfur fuels and rebalance the production to accommodate the higher ethanol contents. Therefore, the staff is proposing a second option, referred to as an alternative emissions reduction plan (AERP).

The AERP would allow a producer, or an importer that produces gasoline, to mitigate the excess emissions associated with permeation by obtaining emission reductions from combustion or other gasoline-related sources. The producer or importer must still comply with the default flat limits, averaging limits, a test-certified alternative gasoline formulation, or the non-permeation portion of the Predictive Model. All alternative emissions reduction plans sunset on December 31, 2011, unless the Executive Officer approves an extension in advance.

The need to address excess emissions associated with permeation caused by the use of ethanol will make it more difficult and costly for refiners to comply with the amended Phase 3 CaRFG regulations as proposed. Therefore, the staff is also proposing to provide some additional flexibility to the producers and importers to address the expected ongoing difficulties in meeting the very low sulfur content requirements. This option allows producers and importers to specifically offset a batch of gasoline that does not meet CaRFG3 standards due to an unintentionally high sulfur content. In this case, the producer or importer would be permitted to offset any increased emissions by producing a series of subsequent batches that are cleaner than the Phase 3 CaRFG standards. In no event could any batch exceed the cap limit for sulfur. This option would apply beginning December 31, 2009.

The Phase 3 CaRFG regulations added provisions allowing gasoline producers or importers to elect to use a new evaporative emissions element of the Predictive Model. In this Predictive Model evaporative emissions element, the Phase 3 CaRFG standard for RVP was set at 0.10 psi below the regular Phase 3 CaRFG flat limit for RVP in order to compensate for an expected increase in volatility due to the commingling of California gasolines blended with ethanol and California gasoline blended without ethanol. Since the use of the evaporative portion of the Predictive Model is voluntary, there is no assurance that any increase in emissions associated with commingling is actually being offset. The vast majority of gasoline now sold in California is produced with ethanol, and it is expected this will continue in the future given the federal RFS. Therefore, an emissions increase from commingling ethanol blended gasolines and non-ethanol blended gasolines in the fuel tanks of motor vehicles will only occur when non-ethanol blends are introduced in the California market. Staff is accordingly proposing that all non-ethanol blends of gasoline be certified based on a flat limit of 6.90 psi RVP, while the normal Phase 3 CaRFG flat limit of 7.00 psi RVP be used for ethanol blends using the evaporative emissions element of the Predictive Model.

The staff is also proposing that the enforcement caps for sulfur content in gasoline be lowered from 30 parts per million by weight (ppmw) to 20 ppmw (21 ppmw for CARBOB). Based on its analysis of projected complying formulations using the Predictive Model, staff believes that refiners will generally not be able to produce complying California gasoline with sulfur limits higher than 20 ppmw. The proposed lower sulfur cap will not significantly affect flexibility to make complying fuels. It will, however, increase the enforceability of the CaRFG program by making it easier to detect noncomplying gasoline and help to protect the performance of sulfur-sensitive emission control components.

The staff is proposing other amendments to the CaRFG regulations to improve consistency, flexibility, and enforceability. This includes proposed amendments to section 2262.9 and section 2266.5 that would change the maximum allowed denaturant content in denatured ethanol, consistent with the current standards of the American Society of Testing and Materials.

COMPARABLE FEDERAL REGULATIONS

The federal RFG regulations apply to about 80 percent of California's gasoline and are contained in 40 CFR §§ 80.40 and following. The CaRFG regulations apply to all gasoline sold, supplied, or offered in California. All CaRFG meets or exceeds the requirements of the federal RFG regulations resulting in significant additional emission reductions. Under 40 CFR § 80.81, gasoline meeting the Phase 3 CaRFG standards is exempt from several of the enforcement requirements of the federal RFG regulations.

The RFS standard of the Energy Policy Act of 2005 requires the use of renewable transportation fuels nationwide in an increasing amount annually. On April 10, 2007, the U.S. EPA Administrator announced the adoption of regulations for an RFS program for 2007 and beyond, contained in 40 CFR §§ 80.1100 and following.

AVAILABILITY OF DOCUMENTS AND AGENCY CONTACT PERSONS

The ARB staff has prepared a Staff Report: Initial Statement of Reasons (ISOR) for the proposed regulatory action, which includes a summary of the environmental and economic impacts of the proposal and supporting technical documentation. The report is entitled "Proposed 2007 Amendments to the Phase 3 California Reformulated Gasoline Regulations."

Copies of the ISOR and the full text of the proposed regulatory language, in underline and strikeout format to allow for comparison with the existing regulations, may be accessed on the ARB's web site listed below, or may be obtained from the Public Information Office, Air Resources Board, 1001 I Street, Visitors and Environmental Services Center, First Floor, Sacramento, CA 95814, (916) 322-2990 at least 45 days prior to the scheduled hearing (by April 26, 2007).

Upon its completion, the Final Statement of Reasons (FSOR) will also be available and copies may be requested from the agency contact persons in this notice, or may be accessed on the ARB's web site listed below.

Inquiries concerning the substance of the proposed amendments may be directed to the designated agency contact persons, Mr. Dean C. Simeroth, Chief, Criteria Pollutants Branch, Stationary Source Division, at (916) 322-6020, or Mr. Steven Brisby, Manager, Fuels Section, (916) 322-6019.

Further, the agency representative and designated back-up contact persons to whom nonsubstantive inquiries concerning the proposed administrative action may be directed are Alexa Malik, Manager, Board Administration & Regulatory Coordination Unit, (916) 322-4011, or Amy Whiting, Regulations Coordinator, (916) 322-6533. The Board staff has compiled a record for this rulemaking action, which includes all the information upon which the proposal is based. This material is available for inspection upon request to the contact persons.

This notice, the ISOR and all subsequent regulatory documents, including the FSOR, when completed, will be available on the ARB Internet site for this rulemaking at http://www.arb.ca.gov/regact/2007/carfg07/carfg07.htm.

COSTS TO PUBLIC AGENCIES AND TO BUSINESSES AND PERSONS AFFECTED

The determinations of the Board's Executive Officer concerning the costs or savings necessarily incurred by public agencies, private persons and businesses in reasonable compliance with the proposed regulations are presented below.

In developing this regulatory proposal, ARB staff evaluated the potential economic impacts on representative private persons or businesses. The only entities in California that would incur significant compliance costs would be 12 large petroleum refineries and one small refinery. The potential total annualized cost would be about $100 million per year, or less than 1 cent per gallon of CaRFG produced.

The Executive Officer has made an initial determination that the proposed regulatory action will not have a significant statewide adverse economic impact directly affecting businesses, including the ability of California businesses to compete with businesses in other states, or on representative private persons.

In accordance with Government Code section 11346.3, the Executive Officer has determined that the proposed regulatory action will not affect the creation or elimination of jobs within the State of California, the creation of new businesses or elimination of existing businesses within the State of California, or the expansion of businesses currently doing business within the State of California. A detailed assessment of the economic impacts of the proposed regulatory action can be found in the ISOR.

The Executive Officer has also determined, pursuant to title 1, CCR, section 4, that the proposed regulatory action will not significantly affect small businesses because the affected refineries are not small businesses.

In accordance with Government Code sections 11346.3(c) and 11346.5(a)(11), the Executive Officer has found that the reporting requirements of the CaRFG regulations which apply to businesses are necessary for the health, safety, and welfare of the people of the State of California.

Pursuant to Government Code sections 11346.5(a)(5) and 11346.5(a)(6), the Executive Officer has determined that the proposed regulatory action will not create significant costs or savings to any state agency or in federal funding to the state, costs or mandate to any local agency or school district whether or not reimbursable by the state pursuant to Part 7 (commencing with section 17500), Division 4, Title 2 of the Government Code, or other nondiscretionary cost or savings to state or local agencies.

Before taking final action on the proposed regulatory action, the Board must determine that no reasonable alternative considered by the Board or that has otherwise been

identified and brought to the attention of the Board would be more effective in carrying out the purpose for which the action is proposed or would be as effective and less burdensome to affected private persons than the proposed action.

SUBMITTAL OF COMMENTS

The public may present comments relating to this matter orally or in writing at the hearing, and in writing or by e-mail before the hearing. To be considered by the Board, written submissions not physically submitted at the hearing must be received **no later than 12:00 noon, June 13, 2007**, and addressed to the following:

Postal mail: Clerk of the Board, Air Resources Board
1001 I Street, Sacramento, California 95814

Electronic submittal : http://www.arb.ca.gov/lispub/comm/bclist.php

Facsimile submittal: (916) 322-3928

Please note that under the California Public Records Act (Govt. Code section 6250 et. seq.), your written and oral comments, attachments and associated contact information becomes part of the public record and can be released to the public upon request. This includes your personal information, such as your home address, your home phone number, and your personal email address. Additionally, your comments, attachments and associated contact information may become available to Google or other search engines.

The Board requests but does not require that 30 copies of any written statement be submitted and that all written statements be filed at least 10 days prior to the hearing so that ARB staff and Board Members have time to fully consider each comment. The ARB encourages members of the public to bring to the attention of staff in advance of the hearing any suggestions for modification of the proposed regulatory action.

STATUTORY AUTHORITY AND REFERENCES

This regulatory action is proposed under that authority granted in sections 39600, 39601, 43013, 43013.1, 43018, and 43101, Health and Safety Code, and *Western Oil and Gas Ass'n.* v. *Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). This regulatory action is proposed to implement, interpret, and make specific sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43013, 43013.1, 43016, 43018, 43101, and 43830.8, Health and Safety Code, and *Western Oil and Gas Ass'n.* v. *Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

HEARING PROCEDURES

The public hearing will be conducted in accordance with the California Administrative Procedure Act, Title 2, Division 3, Part 1, Chapter 3.5 (commencing with section 11340) of the Government Code.

Following the public hearing, the Board may adopt the regulatory language as originally proposed or with nonsubstantial or grammatical modifications. The Board may also adopt the proposed regulatory language with other modifications, if the text as modified is sufficiently related to the originally proposed text that the public was adequately placed on notice that the regulatory language as modified could result from the proposed regulatory action. In such event, the full regulatory text, with the modifications clearly indicated, will be made available to the public for written comment at least 15 days before it is adopted.

The public may request a copy of the modified regulatory text from the ARB's Public Information Office, Air Resources Board, 1001 I Street, Visitors and Environmental Services Center, 1st Floor, Public Information Office, Sacramento, CA 95814, (916) 322-2990.

CALIFORNIA AIR RESOURCES BOARD

Catherine Witherspoon
Executive Officer

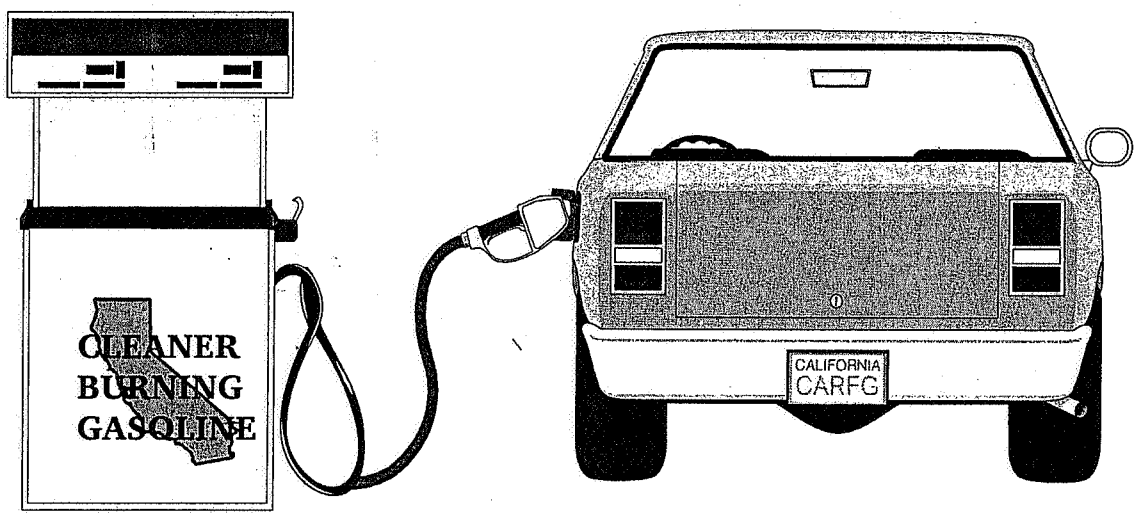
Date: April 17, 2007

California Environmental Protection Agency

Air Resources Board

Proposed 2007 Amendments to Phase 3 California Reformulated Gasoline Regulations

Staff Report: Initial Statement of Reasons



Release Date: April 27, 2007

State of California
California Environmental Protection Agency
AIR RESOURCES BOARD
Stationary Source Division

STAFF REPORT: INITIAL STATEMENT OF REASONS PROPOSED AMENDMENTS TO CALIFORNIA PHASE 3 GASOLINE REGULATIONS

Public Hearing to Consider Amendments to the California Reformulated Gasoline Regulations and Other Changes

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TABLE OF CONTENTS

Executive Summary

A. INTRODUCTION I
B. CALIFORNIA REFORMULATED GASOLINE REGULATIONS I
C. PROPOSED AMENDMENTS V
D. IMPLEMENTATION OF THE PROPOSED AMENDMENTS XII
E. DEVELOPMENT OF THE PROPOSED AMENDMENTS XII
F. ECONOMIC IMPACTS OF THE PROPOSED AMENDMENTS XIII
G. ENVIRONMENTAL IMPACTS OF THE PROPOSED AMENDMENTS XV
H. ALTERNATIVES TO THE PROPOSED AMENDMENTS XIX
I. RECOMMENDATIONS XXI

CHAPTER I. INTRODUCTION 1

CHAPTER II. REFORMULATED GASOLINE PROGRAMS 3

A. FEDERAL REFORMULATED GASOLINE PROGRAM 3
B. CALIFORNIA REFORMULATED GASOLINE PROGRAM 4
C. THE CALIFORNIA PREDICTIVE MODEL 8
D. IMPACT OF ETHANOL USE 10
E. CALIFORNIA GASOLINE CONSUMPTION 11
F. CARFG3 PROPERTIES AND COMPOSITION 13

CHAPTER III. PROPOSED AMENDMENTS TO THE CARFG3 REGULATIONS 15

A. REVISE THE PREDICTIVE MODEL 15
B. ADD AN ALTERNATIVE EMISSIONS REDUCTION PLAN 27
C. DECREASE THE SULFUR CAP LIMIT 35
D. ALLOW EMISSIONS AVERAGING FOR LOW LEVEL SULFUR BLENDS 35
E. ADJUST THE RVP FOR OXYGENATED FUELS 39
F. ALLOW FLEXIBILITY IN SETTING THE OXYGEN CONTENT IN THE PREDICTIVE MODEL 39
G. INCREASE THE MAXIMUM ALLOWABLE AMOUNT OF DENATURANT 40
H. ADOPTION OF THE CURRENT VERSION OF ASTM D4815-04 40
I. IMPLEMENTATION OF THE PROPOSED AMENDMENTS 41

CHAPTER IV. ECONOMIC IMPACTS OF THE PROPOSED AMENDMENTS 43

A. EFFECTS OF THE PROPOSED AMENDMENTS ON THE PRODUCTION OF CARFG3 43
B. COSTS TO PRODUCE CARFG3 GASOLINE FUEL 44
C. ETHANOL COSTS TO REFINERS 46
D. AERP OPTION COSTS 46
E. ETHANOL FUEL ECONOMY PENALTY 46
F. IMPACT ON GOVERNMENT REVENUE 47
G. SMALL REFINERS 47

H. Small Business Economic Effect 48
I. Effects on Production from the Proposed Changes on CaRFG3 49

CHAPTER V. ENVIRONMENTAL IMPACTS OF THE PROPOSED AMENDMENTS 51

A. California Environmental Quality Act (CEQA) 51
B. Multimedia Evaluation 52
C. Air Quality 52
D. Greenhouse Gas Emissions 55
E. Water Quality 55
F. Community Health and Environmental Justice 56

CHAPTER VI. ALTERNATIVES TO THE PROPOSED AMENDMENTS 57

A. Alternatives Related to the Predictive Model 57
B. Alternatives Related to the AERP 61
C. Alternatives Related to the Change in Specifications 61
D. Alternatives Related to Implementation Dates 63

CHAPTER VII. REFERENCES 65

Tables

Table 1: National Renewable Fuels Standard....4
Table 2: CaRFG Limits and Caps....8
Table 3: Vehicle Technology Groups....9
Table 4: Gasoline Consumption in California....12
Table 5: Weighted Averages of Predictive Model Reported Values and....13
Table 6: Properties and Composition of Summer CaRFG3....14
Table 7: Properties and Composition of Winter CaRFG3....14
Table 8: Exhaust Emission Weighting Factors by Vehicle Technology Group Statewide 2015 (GVW < 10,000 lbs)....17
Table 9: Average Reactivity Adjustment Factor....19
Table 10: On-Road Vehicles Ozone Forming Potential Emissions Statewide 2015 (Tech 1-5, GVW < 10,000 lbs)....19
Table 11: Weighting Factors for Reactivity-Weighted Hydrocarbons Statewide 2015 (GVW < 10,000 lbs)....20
Table 12: Summary of CaRFG Predictive Model Database....21
Table 13: New Tech 5 Datasets Added to the Predictive Model....21
Table 14: Tech 5 Vehicles by Emissions Control Technology....23
Table 15: Tech 5 Vehicles (1996 or newer, GVW < 10,000 lbs.)....24
Table 16: Summary of Sulfur Studies....25
Table 17: Estimated Tech 5 NOx Response Associated with Changing Fuel Sulfur Levels from 20 to 10 ppmw....26
Table 18: Estimated Tech 5 NOx Response Associated with Changing Fuel Sulfur Levels from 20 to 10 ppmw for U.S EPA and Existing Studies Combined....27
Table 19: Example 1 - Flat Limit Fuel Percent Change in Emissions Output from the CaRFG3 Predictive Model....31
Table 20: Accelerated Vehicle Retirement Emissions Reductions....32
Table 21: Estimated Total Costs and Cost Per Gallon....33
Table 22: Example 2 - Flat Limit Fuel Percent Change in Emissions Output from the CaRFG3 Predictive Model....33
Table 23: Estimated Total Costs and Cost Per Gallon....34
Table 24: Example of Emissions Averaging Triggered....38
Table 25: Candidate Alternative Gasoline Model Formulations for Summertime Gasoline....44

Figures

Figure 1: California Gasoline Consumption vs. Retail Price....12

Appendices

Appendix A: Proposed CaRFG3 Regulations, including Predictive Model Procedure and CARBOB Procedure Documents

Appendix B: Permeation/Emissions Inventory

Appendix C: Emissions from Off-Road Applications: Discussion of Impacts from Permeation due to Ethanol Blending

Appendix D: Data and Statistical Models

Appendix E: Reactivity Calculations

Executive Summary

A. Introduction

The Air Resources Board (ARB/Board) staff is proposing to amend the California reformulated gasoline (CaRFG) regulations. Over the years, the Board has approved and amended these regulations in three phases. The most recent amendments adopted in 1999 implemented the Governor's and Legislature's direction to phase out the additive methyl-tertiary-butyl-ether (MTBE) from California gasoline. The enabling legislation also required the Board to ensure that the emission benefits of Phase 2 CaRFG (CaRFG2) were fully preserved when adopting the Phase 3 CaRFG (CaRFG3) regulations.

As part of the CaRFG3 regulatory process, the Board directed staff to investigate the potential emissions impact of adding ethanol to gasoline, specifically related to the increase in hydrocarbon emissions through permeation. Permeation refers to the diffusive process whereby fuel molecules migrate through the materials of a vehicle's fuel system. Eventually, the fuel molecules are emitted into the air where they contribute to evaporative emissions from the vehicle. Recently completed studies on on-road motor vehicles now show that ethanol increases the evaporation emissions of gasoline through permeation over that of a comparable fuel without ethanol, or with MTBE.

Based on this new information, staff is proposing amendments to mitigate the increases in evaporative emissions from on-road motor vehicles resulting from the addition of ethanol to gasoline. The staff is also proposing additional amendments to the CaRFG3 regulations to increase the flexibility, enforceability, and consistency of the regulations. The proposed regulatory amendments are in Appendix A.

B. California Reformulated Gasoline Regulations

The following section provides a brief overview of the CaRFG2 and CaRFG3 regulations, a description of the California Predictive Model, and the impacts of adding ethanol to gasoline.

1. CaRFG2

The California Clean Air Act requires the ARB to adopt regulations that produce the most cost-effective combinations of control measures on motor vehicles and motor vehicle fuels. This directive led to many actions, including the Board approval of the CaRFG2 regulations in 1992. The CaRFG2 regulations set stringent standards for California gasoline that produced cost-effective emission reductions in new and in-use gasoline-powered vehicles. The regulations set specifications for the following eight fuel properties:

sulfur	50 percent distillation temperature
aromatics	90 percent distillation temperature
oxygen	olefins
benzene	Reid vapor pressure

With the exception of oxygen, the regulations set three limits for each property: a "cap" limit that applies to all gasoline anywhere in the gasoline distribution and marketing system and does not vary; and "flat" and "averaging" limits that apply to gasoline when it is released by refiners, importers, and blenders (collectively, "producers")[1]. For oxygen, the regulations establish a range of flat limits and caps that may vary depending on the location and the specific fuel formulation.

Gasoline producers could comply with the limits in one of three ways. First, for a given property, each producer may choose to meet either the flat limit or the averaging limit. Second, a producer may use the Predictive Model to identify other sets of property limits (flat, averaging, or mixed) that can be applied to that producer's gasoline. Third, a producer may validate an alternative set of property limits through emission testing per a prescribed protocol. Whether validated by the Predictive Model or by testing, no alternative limit may exceed the cap limit for the property.

To comply with the oxygen content requirement, producers chose to use MTBE. Soon after CaRFG2 implementation, the presence of MTBE in groundwater began to be reported. An investigation and public hearings were conducted resulting in the issuance of Executive Order D-5-99 on March 25, 1999. The Executive Order directed the phase-out of MTBE in California's gasoline. In addition, the Legislature passed Senate Bill 989. Among other provisions, the bill directed the ARB to ensure that regulations adopted pursuant to the Executive Order maintain or improve upon emissions and air quality benefits achieved by CaRFG2 as of January 1, 1999 (Health and Safety Code section 43013.1).

2. CaRFG3

In response to the Governor's and Legislature's directive, the Board approved the CaRFG3 regulations on December 9, 1999 and amended them on July 25, 2002. The CaRFG3 regulations prohibited California gasoline produced with MTBE starting December 31, 2003, established revised CaRFG3 standards, established a CaRFG3 Predictive Model, and made various other changes. The CaRFG3 regulations also placed a conditional ban, starting December 31, 2003, on the use of any oxygenate other than ethanol, as a replacement for MTBE in California gasoline. The current specifications for CaRFG3 are presented in Table ES-1.

[1] Throughout this report, we are using the producers to generally represent those that are affected by the regulations. The specific regulations, however, have requirements that sometimes differ depending on whether the affected entity is a refiner, importer, or blender. The reader is referred to the regulations for specific applicable requirements.

Table ES-1: CaRFG3 Limits and Caps

Property	Flat Limits	Averaging Limits	Cap Limits[1]
Reid vapor pressure, psi, max	7.00 or 6.90 [2]	---	6.40 - 7.20
Benzene, vol%, max	0.8	0.70	1.10
Sulfur, ppmw, max	20	15	30
Aromatic HC, vol%, max	25	22	35
Olefins, vol%, max	6.0	4.0	10
Oxygen, wt%	1.8 to 2.2	---	1.8 – 3.5[3] 0 – 3.5
T50 (temp. at 50% distilled) °F, max	213	203	220
T90 (temp. at 90% distilled) °F, max	305	295	330

(1) The "cap limits" apply to all gasoline at any place in the marketing system and are not adjustable.
(2) 6.90 psi applies when a producer is using the evaporative emissions element of CaRFG3 Predictive Model and gasoline may not exceed a cap of 7.20 psi; otherwise, the 7.00 psi limit applies.
(3) The 1.8 weight percent minimum applies only during the winter and only in certain areas.

3. California Predictive Model

Numerous studies have shown that the properties of gasoline affect motor vehicle emissions. Based on thousands of individual tests, equations have been developed that relate changes in fuel properties to changes in emissions. The Predictive Model takes advantage of these relationships to provide producers flexibility. The producers use the Predictive Model to identify alternative limits that achieve equal or better emission reductions compared to the use of the flat or averaging limits. The Predictive Model provides flexibility for the producers, while ensuring ARB's emissions reduction goals are met. This flexibility is highly valued by the producers and the vast majority of CaRFG is produced using the Predictive Model.

As originally developed for CaRFG2, the Predictive Model is a set of mathematical equations that relate emission rates of exhaust hydrocarbons, oxides of nitrogen (NOx), and combined exhaust toxic species[2] to the values of the eight regulated gasoline properties. Emissions of each pollutant type are predicted by equations formulated separately for vehicles of different technology classes.

In 1999, as part of the CaRFG3 regulations to phase-out MTBE from California gasoline, the CaRFG2 Predictive Model was revised. The new CaRFG3 Predictive Model included a limited data set for the newer class of low emission vehicles (LEVs). Also, an evaporative emissions model was incorporated to provide additional flexibility to consider both exhaust and evaporative

[2] Four toxic species are involved: benzene, 1,3-butadiene, formaldehyde, and acetaldehyde. Separate predictions for the four are combined with weights proportional to the ARB's unit-risk values for the species. The resultant sum is the "potency-weighted toxic" (PWT) emission rate.

hydrocarbon emissions. This change was done on an ozone-forming potential basis, by weighting hydrocarbon emissions using their average reactivity factors.

The equations were derived by statistical analyses applied to thousands of individual emission observations and the associated values of the fuel properties. For each pollutant, the predictions for the three vehicle classes representing groupings of vehicle technologies are combined with weights proportional to the contributions of the vehicle classes to the ARB's emission inventory for that pollutant.

The Predictive Model then allows producers to certify alternative formulations of CaRFG3 by comparing the emission predictions for a candidate set of property limits to the predictions for the flat or averaging limits. If each prediction for the candidate limit is no greater than 1.004 times the corresponding basic-limit prediction, the alternative set of limits is allowable. Separate determinations must be made for ozone-forming potential, oxides of nitrogen, and potency-weighted toxics. In effect, the model allows a producer to use one or more limits greater than the flat or averaging limits in exchange for compensating reductions in other limits. Thus, the model provides valuable flexibility to individual refiners by allowing refiners to most efficiently meet the CaRFG3 requirements, taking into consideration the configuration of the refinery.

To facilitate the use of the Predictive Model, ARB staff provide a procedures guide, "California Procedures for Evaluation Alternative Specifications for Phase 3 Reformulated Gasoline Using the California Predictive Model." The guide provides step by step instructions, including ARB staff notification requirements. Also, a computer spreadsheet is provided so that users can in effect insert the specifications for the candidate fuel and the spreadsheet will calculate if the candidate fuel passes or fails.

4. Impact of Ethanol Use

In general, oxygenates such as MTBE and ethanol are used in gasoline to reduce the exhaust emissions of hydrocarbons and carbon monoxide and improve the octane rating. It is well known that ethanol increases the vapor pressure of gasoline. For many years, blends of gasoline have had to be adjusted to ensure that the Reid vapor pressure (RVP) of the resulting blend met the limits and did not increase evaporative emissions. Available data also indicate that higher blends of ethanol increase the exhaust emissions of oxides of nitrogen.

In response to the Board's direction to investigate the impact of ethanol on permeation emissions, the ARB co-funded a research study with the Coordinating Research Council (CRC) to assess the magnitude of the permeation emissions associated with the use of ethanol in gasoline in on-road vehicles (CRC E-65 Study). Based on the study results, staff calculated the

increase in evaporative emissions from on-road motor vehicles due to the presence of ethanol in gasoline to be about 18.4 tons per day of hydrocarbons in 2010. This represents a seven percent increase in evaporative emissions and a four percent increase in overall hydrocarbon (HC) emissions.

Ethanol also affects off-road gasoline-powered engines and equipment, as well as portable gas containers. Available data indicate that ethanol may reduce the exhaust emissions of hydrocarbons and carbon monoxide, but increase the evaporative emissions due to permeation. In addition, the use of ethanol may also increase oxides of nitrogen emissions. Based on very limited testing, staff calculated that the net impact may have from little, if any, effect on increasing hydrocarbon emissions to about 20 tons per day (tpd) and slightly increase oxides of nitrogen emissions by about 1 to 2 tpd.

As discussed in Chapter V, ARB staff is collaborating with the small engine manufacturers and U.S. EPA to co-fund studies at Southwest Research Institute to assess the impact of ethanol of various types of off-road sources.

Pursuant to Health and Safety Code section 43013.1(b)(1), the ARB must ensure that CaRFG3 maintains or improves upon the emissions and air quality benefits achieved by CaRFG2. The data now show that there are increased and quantifiable evaporative emissions from on-road motor vehicles due to permeation caused by ethanol. As a result, staff is proposing amendments to fully mitigate the impacts from on-road motor vehicles. Due to the limited data available, staff is not proposing any modifications at this time to address permeation emissions from off-road sources.

C. Proposed Amendments

In summary, the staff is proposing the following amendments:

- Amend the California Predictive Model to ensure that permeation emissions associated with ethanol use are mitigated and to incorporate new data;
- Add an option to use an alternative emissions reduction plan (AERP) for a limited time period to help mitigate permeation emissions;
- Decrease the sulfur cap limit from 30 parts per million by weight (ppmw) to 20 ppmw to improve enforceability and facilitate new motor vehicle emissions control technology;
- Allow emissions averaging for low level sulfur blends to provide additional flexibility for producers;
- Apply the 7.00 psi RVP limit to oxygenated gasoline to reflect that virtually all gasoline will be oxygenated and commingling emissions are not a problem for these fuels; and retain the 6.90 RVP limit for non-oxygenated gasoline to ensure that no increase in hydrocarbon emissions from commingling with oxygenated gasoline will occur;

- Allow flexibility in setting oxygen content in the Predictive Model to account for variability in test methods;
- Increase the maximum allowable amount of denaturant in ethanol to be consistent with new federal requirements; and
- Update the test method for oxygenate content of gasoline.
- Require producers to use the revised Predictive Model starting December 31, 2009, which allows for the use of alternative emission mitigations. Require the production of CaRFG compliant with the revised Predictive Model by December 11, 2011

Each of these proposed amendments is described in the following text.

1. Revise the Predictive Model

There are five aspects of the Predictive Model that the staff is proposing to add or update as shown below:

- Add permeation emissions and require they be mitigated;
- Update the motor vehicle emissions inventory vehicle mix;
- Update the reactivity adjustment factors;
- Add new motor vehicle exhaust emissions test data; and
- Update the effect of carbon monoxide on ozone-forming potential.

Staff proposes to generally use a 2015 statewide ozone planning inventory as the baseline, including passenger vehicles to light heavy-duty trucks with gross vehicle weight (GVW) less than 10,000 pounds (lbs). An inventory year of 2015 allows the model to best reflect the in-use fleet in the 2010 – 2020 timeframe, and to appropriately model those fuel specifications that are most important in maintaining the emissions performance of advanced technology vehicles.

a. Add Permeation Emissions

As discussed above, there are increases in evaporative emissions due to the effects of ethanol on permeation. To develop appropriate mitigation, the staff is proposing to add this emissions increase to the Predictive Model.

In late 2006, ARB released the latest update to California's on-road motor vehicle emissions model, referred to as EMFAC2007. This model was updated to include permeation emissions.

In addition, the staff is proposing to revise the EMFAC2007 output to reflect higher temperatures than are included as default temperatures. Typically, days with high temperatures have high ozone levels. Permeation emissions are also higher on hot days. To ensure that the Predictive Model formulas adequately mitigate the permeation emissions, it is important to use a temperature profile that recognizes this relationship. For this analysis, ARB staff is using the

temperature profiles that occur when the California 8-hour ozone standard was exceeded by substantial amounts, and which have high ozone levels that would form the basis of the control strategy needed to attain the state ambient air quality standards for ozone. In general, the temperature profiles are about two to three degrees Fahrenheit higher than the default temperature profile included in EMFAC2007. The default temperature profile is represented by those temperatures where the federal 8-hour ozone standard is exceeded.

Using the EMFAC2007 model with the revised temperature profile, staff calculated the increased emissions from permeation that needed to be included in the Predictive Model. On a statewide basis in 2005, the increase in evaporative emissions due to permeation is about 28.8 tpd from on-road gasoline vehicles (GVW <10,000 lbs). The emissions increase declines to 18.4 tpd in 2010, 12.1 tpd in 2015, and 8.1 tpd in 2020. These reductions are due to a general reduction in emissions from motor vehicles.

b. Update the Motor Vehicle Emission Inventory Vehicle Mix

Using the most recent information from EMFAC2007, staff proposes to update the contribution of emissions from each vehicle technology class used in the model so that it more accurately reflects the California vehicle fleet setting in calendar year 2015. In 2015, the majority of the light-duty motor vehicles will have Tier II low emission vehicle (LEVII) and partial zero emission vehicle (PZEV) emissions control technologies.

c. Update the Reactivity Adjustment Factors

Staff proposes to update the exhaust hydrocarbons, evaporative hydrocarbons, and exhaust CO reactivity adjustment factors used in the Predictive Model. Reactivity adjustment factors are used to establish the ozone-forming potential of the gasoline formulation. Staff continues to recommend that the maximum incremental reactivity (MIR) scale developed by Dr. William Carter be used. This scale is the most appropriate for complementing California's dual program of reducing both NOx and volatile organic compounds (VOC) to control ozone and other pollutants.

In December 2003, the Board approved an updated list of reactivity values and reconfirmed the other MIR values. At that time, the MIR value for CO was updated to 0.06. Prior to Board consideration, the Reactivity Advisory Committee reviewed the list of values. After their review, the Reactivity Scientific Advisory Committee concluded that the proposed update did not substantially change the nature of the MIR values and were arrived through an appropriate scientific manner. For this update, the staff is proposing to use these MIR values.

d. Add New Motor Vehicle Exhaust Emissions Test Data

The Predictive Model is based on about 9,000 individual emissions tests showing how the exhaust emissions change with changing fuel properties. Since the last model update in 1999, there have been a number of additional tests conducted. Therefore, the staff is proposing to add about 1,000 new observations to the current database to update the Predictive Model. The new datasets reflect emissions testing of fuels in the newest class of vehicles, referred to as Tech 5 vehicles, ranging from low emission vehicles (LEV) to super low emission vehicles (SULEV).

e. Update the Effect of Carbon Monoxide on Ozone-Forming Potential

Staff proposes to update the methods used for estimating the effect of changing fuel properties on carbon monoxide (CO) in the reactivity adjusted hydrocarbons portion of the Predictive Model. The current Predictive Model only uses changes in oxygen level to calculate changes in CO emissions. The staff proposes to add to the Predictive Model a new mathematical formulation that accounts for the impact of seven properties on CO emissions. This approach for CO follows the approach taken for exhaust hydrocarbons and NOx.

2. Add an Alternative Emissions Reduction Plan

The staff is proposing to add a new provision that would allow producers to use an approved Alternative Emissions Reduction Plan (AERP) for a limited time. An AERP would allow a producer the option of creating emission reductions from other sources to fully mitigate any emissions increase from permeation not otherwise mitigated from the producer's fuel formulation. The AERP would not enable the producer to avoid meeting the majority of the CaRFG3 requirements; the producer would still have to comply with the non-permeation portion of the Predictive Model.

The addition of an AERP would enable mitigation of ethanol permeation effects more expeditiously and increase flexibility for producers to comply with the requirement to mitigate any increase in emissions associated with the use of ethanol blends. Producers will be required to certify fuel formulations or use an AERP to mitigate the increase in permeation emissions starting in December 31, 2009. Some producers may find it difficult to produce the desired amount of complying fuel without significant refinery and/or infrastructure modifications. The AERP option is proposed to be available to producers from December 31, 2009 until December 31, 2011. Producers will have four years to come into full compliance.

Staff is also proposing to allow producers to apply to the Executive Officer for a one year extension should circumstances warrant an extension. For small refiners, staff also proposes that a small refiner using the small refiner provisions be allowed to use the AERP option indefinitely.

The proposed AERP requires that emission reductions used in an AERP must come from combustion or gasoline related emission sources, such as motor vehicles, stationary or portable engines, off-road equipment, or portable fuel containers. A producer could not use emission reductions that are created at other types of sources or which are required through other programs. An AERP may not include emission reductions that may be part of on-going business practices. The producer would also need to show that emission reductions from an AERP occur in the same general region that the producer distributes fuel. Finally, the emission reductions must coincide within the applicable time period for the AERP.

3. Decrease the Sulfur Cap Limit

Staff proposes to reduce the sulfur cap limit from the current specification of 30 ppmw to 20 ppmw. Cap limits provide an upper limit for fuel properties for all compliance options and allow enforcement of the requirements throughout the gasoline distribution system.

Sulfur levels currently average about 10 ppmw, with 95 percent of production being below 18 ppmw. Staff believes that producers will significantly further reduce the sulfur content of California gasoline to certify gasoline if the proposed revisions are adopted. With the recent implementation of the federal Tier II sulfur rules for gasoline, nationwide gasoline sulfur levels must average less than 30 ppmw with a cap of 80 ppmw. The implementation of the federal Tier II sulfur rules will significantly reduce the historical difference between sulfur levels in California and those seen outside of the State.

Lowering the sulfur cap to 20 ppmw is not expected to significantly affect flexibility to make complying fuels, but will increase the enforceability of the program and help to protect the performance of sulfur-sensitive emissions control components. Staff believes that it will not be practical for producers to certify alternative formulations with sulfur levels above 20 ppmw. Staff believes that the sulfur cap should be set at the lowest level possible that does not significantly reduce production flexibility. From this perspective, the current cap of 30 ppmw is much higher than necessary.

The Alliance of Automobile Manufacturers and individual vehicle manufacturers have indicated that before lean burn gasoline technology can be successfully introduced, they need assurance that sulfur content will be less than 20 ppmw. A sulfur cap of 20 ppmw will provide this assurance. This new technology has the

potential to improve the feasibility of gasoline engines that have higher efficiencies and less greenhouse gas emissions per mile traveled.

4. Allow Emissions Averaging for Low Level Sulfur Blends

Staff expects producers will very likely choose to increase the use of ethanol in gasoline to offset the increase in permeation emissions. The addition of ethanol increases the oxygen content in the fuel blend. While this generally reduces the exhaust emissions of hydrocarbons and carbon monoxide, emissions of NOx increase. In many cases, this increase in NOx would, if not mitigated through some other fuel property, result in a non-complying blend. Staff expects producers to use sulfur as a lever to lower NOx emissions in their fuel formulations. Such action could result in sulfur levels below 10 ppmw in most CaRFG3 formulations.

At these low sulfur levels, the compliance margin for refiners is small and slight unexpected deviations in the refinery process could easily cause a batch to become non-compliant. Staff anticipates that it will be very difficult to blend a slightly higher than needed sulfur level batch to a compliant blend using the existing sulfur averaging provisions because it becomes increasingly more and more difficult to average out sulfur when the levels are very near the bottom of the range. Therefore, for a producer that experiences a problem with the sulfur content when blending a particular batch of gasoline, staff is proposing to add a compliance option that would permit that producer to use an averaging option that is based on emissions. Emissions must be mitigated within 90 days by subsequent cleaner than required blends. Any additional emissions reductions achieved under the emissions averaging provision may not be banked. In addition, this emissions averaging option can only be triggered by unexpected high sulfur levels.

Without such a flexibility provision, such batches would likely need to be shipped out-of-state at significant expense while reducing supplies of available product. Unlike most other fuel properties governed by the CaRFG3 rules, increases in sulfur levels in individual batches do not result in immediate emission increases in vehicles using the batch. Sulfur degrades catalyst performance, but the effect is reversible. Given this situation, staff believes it is reasonable to infrequently allow batches with slightly higher sulfur levels to be used, so long as the impacts of the higher sulfur batch are fully mitigated in the near future through subsequent batches.

5. Adjust the RVP for Oxygenated Fuels

When non-oxygenated and oxygenated fuels are mixed together in a vehicle fuel tank, the evaporative emissions of the blend increase due to an increase in RVP. This effect is referred to as commingling. In the existing CaRFG3 regulations, provisions were included to help mitigate any commingling that could have occurred as MTBE was phased out. Specifically, the RVP flat limit was reduced

by 0.10 psi and set at 6.90 psi for producers that used the evaporative emissions portion of the Predictive Model. However, virtually all gasoline has been blended with ethanol; therefore, the commingling impact has been negligible.

As a result of federal policies requiring ethanol use, and the likelihood that increases in oxygen content will be used to mitigate permeation, staff expects almost all fuel produced in California will continue to be blended with ethanol. Therefore, the required use of 6.90 psi rather than the original 7.00 psi reference level for RVP for ethanol blends is no longer needed. As such, staff is proposing to restore a flat limit of 7.00 psi for blends that use ethanol. This change will provide some additional flexibility for producers while preserving the emissions benefits.

While we expect that gasoline produced in California will be blended with ethanol, it is possible that some amount of non-oxygenated fuels could be introduced in the future. In this case, emissions could increase due to commingling. Therefore, to mitigate any potential increase in emissions associated with the commingling of non-oxygenated fuels with fuels containing ethanol, the non-oxygenated fuels will be required to be based on a flat limit of 6.90 psi RVP.

6. Allow Flexibility in Setting the Oxygen Content in the Predictive Model

In the Predictive Model, oxygen is specified in the form of a range. There are usually two candidate fuel specifications for oxygen, the upper end of the range (maximum) and the lower end of the range (minimum). This range generally represents the difficulty in precisely measuring oxygen content and was incorporated into the CaRFG3 Predictive Model as a flexibility provision. If the oxygen range of the candidate fuel specifications is within the range of 1.8 to 2.2 percent by weight, the oxygen content of the candidate fuel specifications is assumed to be 2.0 percent by weight (5.7 percent by volume). If the oxygen range of the candidate fuel specification is within the range of 2.5 to 2.9 percent by weight, the oxygen content of the candidate fuel specifications is assumed to be 2.7 percent by weight (7.7 percent by volume).

Staff proposes to allow the candidate fuel specification for oxygen to be evaluated at the midpoint of the minimum and the maximum oxygen values entered into the Predictive Model if the range between the minimum and the maximum oxygen value is 0.4 percent or less. This proposed change will provide flexibility for refiners to blend ethanol at any levels other than 5.7 percent, 7.7 percent, and 10 percent.

7. Increase the Maximum Allowable Amount of Denaturant

A denaturant is added to ethanol to ensure that it cannot be ingested. The CaRFG3 regulations include a requirement that all reformulated blendstocks for oxygenate blending contain no more than 4.76 percent by volume denaturant. This specification is based on earlier versions of the American Society of Testing and Materials (ASTM) standard specification for denatured fuel ethanol for blending with gasoline (ASTM Method D 4806-99).

ASTM recently changed the maximum amount of denaturant to 5.00 percent by volume (ASTM D 4806-06c). Therefore, the staff proposes to change the maximum denaturant content specification from 4.76 percent by volume to 5.00 percent by volume to be consistent with the recent change in ASTM D4806-06c and to update the appropriate references to the latest ASTM method. This change will align California fuel regulations with federal fuel regulations, and will create less confusion to suppliers. As a result, the proposed amendment will increase the supply of denatured ethanol available to be imported into California.

8. Adopt Current Version of ASTM D4815-04

Section 2263(b) lists ASTM D4815-99 as the test method for determining the oxygen content, ethanol content, MTBE content, and oxygenate content of gasoline. The designation "-99" means the 1999 version of the test method. Every 5 years or when the need arises, ASTM reviews its test methods and either amends or re-approves them. Staff proposes to change the test method to the current version (the 2004 version) which is labeled ASTM D4815-04.

D. Implementation of the Proposed Amendments

Staff is proposing that the proposed amendments would affect fuels produced on or after December 31, 2009. Producers that are unable to fully comply through the use of the Predictive Model may choose to offset any unmitigated permeation emissions associated with ethanol in gasoline through the use of an Alternative Emissions Reduction Plan. Starting December 31, 2011, producers will be required to fully offset the increase in emissions associated with ethanol in gasoline through the use of the Predictive Model. As mentioned above, the staff is proposing to allow a one year extension provided that any emissions increases associated with permeation are mitigated through an approved AERP. In addition, the start has added provisions that allow for early use of the new Predictive Model under specified conditions.

E. Development of the Proposed Amendments

In developing the proposal, staff hosted 14 workshops and public consultation meetings in 2006 and 2007. ARB staff and stakeholders also created four subgroups to investigate and make recommendations regarding changes to the

reformulated gasoline regulations. The subgroups were made of individuals with expertise in the following areas: 1) statistics, 2) emissions inventories, 3) hydrocarbon reactivity, and 4) refinery production. The subgroups reported on progress at various workshops. Staff also held individual meetings and conference calls with various stakeholders regarding individual concerns and created a Predictive Model website to ensure that information used to update the Predictive Model is available to all stakeholders. The Fuels Program e-mail listserver was used to notify interested parties when information became available. The Fuels Program e-mail listserver is a self subscription list with over one thousand individual e-mail addresses.

F. Economic Impacts of the Proposed Amendments

This section summarizes the overall costs of producing compliant fuels, as well as potential economic impacts on businesses and consumers. The costs are generally associated with modifications necessary to mitigate the permeation emissions through the use of the Predictive Model. To mitigate these emissions, staff believes that producers will likely reduce sulfur levels, increase oxygen levels, and reduce vapor pressure levels of the blends. These changes will likely require some refinery and infrastructure modifications. In addition, the use of ethanol will also result in a small decrease in fuel economy. In developing its cost estimates, staff has consulted with producers, pipeline distributors, California Energy Commission (CEC) staff, and other stakeholders.

1. Overall Costs

Staff estimates that the proposed amendments to the CaRFG3 regulations will increase gasoline production costs by between 0.3 to 0.8 cents per gallon of gasoline. These cost estimates are generally based on:

- Recovery of $200 to $400 million of collective capital improvement costs associated with all refinery modifications and increased costs associated with increased ethanol usage, including capital expenditures at pipeline terminals and ethanol off-loading sites for the handling and storage of increased amounts of ethanol; and
- Annual operating and maintenance costs of $20 to $80 million.

About 900 million gallons per year of ethanol is currently used in CaRFG3. The proposed amendments are expected to increase ethanol consumption in California from 300 to 600 million additional gallons per year, at an estimated cost of $600 to $1,200 million annually based on average spot market prices and ethanol subsidies. Note that the producers would most likely have met most of their ethanol needs via contracts, often at much lower costs than spot prices.

However, the use of ethanol will displace an equal volume of gasoline blendstocks, and therefore, the costs must be compared to the costs of

equivalent volumes. On average, ethanol costs have, after adjusting for the favorable tax treatment given to ethanol, been lower per gallon than gasoline blendstocks. Provided this price advantage continues, staff expects there to be a small cost advantage to using ethanol relative to gasoline production based on the spot market prices of gasoline.

2. Costs of the Alternative Emissions Reduction Plan

Staff believes that the AERP will not result in a significant increase in cost to producers compared to simple compliance with the proposed rule. Staff calculated the potential costs to the industry if all participants used an accelerated vehicle retirement program for an AERP. Staff estimates it would take approximately 290,000 retired vehicles to offset the 18.4 tpd of hydrocarbons (51 tpd of ozone-forming potential). At a cost of $750 per vehicle, the total AERP cost would be about $220 million. Taking into account that the credits are good for 3 years and spreading the cost over 16 billion gallons of gasoline consumed a year in California leads to producer costs of about 0.5 cents per gallon. This estimate could be substantially higher or lower depending on the funding needed to scrap vehicles.

3. Impacts on Consumers

There is a fuel economy penalty associated with increasing ethanol in gasoline. Ethanol has about 31 percent less energy per gallon than reformulated gasoline. Therefore, increasing the amount of ethanol in gasoline decreases the energy density of the blend and ultimately the fuel economy of the vehicle. Switching from a current fuel that contains 5.7 percent by volume ethanol to a fuel that contains 10 percent by volume ethanol results in a 1.3 percent fuel economy penalty.

For a typical consumer that drives 15,000 miles per year in a car with a fuel economy of 20 miles per gallon and gas prices at $3.00 a gallon, the effective cost of using a 10 percent ethanol blend would be about 0.20 cents per mile or $30 per year. The costs to the end user of increases in gasoline production costs range up to $6 per year. Combining the fuel economy penalty and the high end cost of production, staff estimates that the total cost to the end user will be about $36 per year or about 1.3 percent of total annual fuel costs for a typical California driver.

If all gasoline were to be produced at the E10 level rather than the current E6, total fuel use would increase by about 200 million gallons per year. If gasoline retails at $3.00 per gallon, net expenditures for fuel would increase by about $600 million per year.

4. Impacts on Small Refiners

Small refiners will be expected to offset the increase in evaporative emissions due to permeation. Small refiners will not be required to offset the permeation increase through fuel formulations changes, but will be allowed to use the AERP indefinitely. This would lead to small refiner costs of about 0.5 cents per gallon as discussed above.

5. Effects on Production from the Proposed Changes on CaRFG3

Staff has discussed with producers and CEC staff the impact on production that could result from implementation of the proposed amendments. In the short term production capability would be impacted by the proposed changes. For example, if producers were required to fully comply with the requirements in 2010 using newly required fuel formulations, many producers would not be able to comply while maintaining current refining capacity. In this scenario, staff estimates that there could be a five to 10 percent gasoline production loss at California refiners for one to two years. During this period, greater use of imports of gasoline or gasoline blending components would be needed. However, producers would be able to produce a complying alternative fuel formulation beginning in 2012 with no loss in production due to the completion of appropriate refinery projects.

As discussed above, producers have the option of using an AERP during the transition period from 2010 until 2012. Therefore, staff anticipates that emissions increases due to permeation can be mitigated by 2010 without production losses during this period when refinery changes are underway.

G. Environmental impacts of the Proposed Amendments

This section summarizes the expected environmental impacts of the proposed amendments. The summary addresses the need for a multimedia evaluation and impacts on air quality, greenhouse gases, water quality, and community health and environmental justice.

As mentioned above, Health and Safety Code section 43013.1 requires that CaRFG3 preserve the emission benefits of CaRFG2. These benefits include emission reductions for pollutants, including precursors, identified in the State Implementation Plan for ozone, and emission reductions in potency-weighted air toxics compounds. The staff does not anticipate any significant adverse environmental impacts associated with the proposed amendments. However, as discussed below, the proposed amendments do not fully comply with the requirements of Health and Safety Code section 43013.1 in that potential emission increases associated with off-road sources are not fully mitigated.

1. Multimedia Evaluation

Health and Safety Code section 43830.8, enacted in 1999 (Stats. 1999, ch. 813; S.B. 529, Bowen) generally prohibits ARB from adopting a regulation establishing a specification for motor vehicle fuel unless the regulation is subject to a multimedia evaluation by the California Environmental Policy Council (CEPC). A multimedia evaluation is the identification and evaluation of any significant adverse impact on public health or the environment, including air, water, or soil, that may result from the production, use, or disposal of the motor vehicle fuel that may be used to meet the state board's motor vehicle fuel specifications. The statute provides that the Board may adopt a regulation that establishes a specification for motor vehicle fuel without the proposed regulation being subject to a multimedia evaluation if the CEPC, following an initial evaluation of the proposed regulation, conclusively determines that the regulation will not have any significant adverse impact on public health or the environment.

The proposed amendments do not substantially change specifications of CaRFG3 gasoline and will not require a gasoline ingredient to be added or removed beyond what is allowed by the existing regulations or is currently already used to produce gasoline for sale in California. Therefore, staff believes that the proposed amendments to the CaRFG3 regulations are not subject to the requirement for a multimedia evaluation.

2. Air Quality

This section presents the air quality impacts of the proposed amendments.

a. Emissions Associated with the Replacement of MTBE with Ethanol

The proposed amendments are generally designed to address the emissions impacts associated with the replacement of MTBE with ethanol pursuant to the provisions of Health and Safety Code section 43013.1. Among other provisions, this section requires that CaRFG3 must maintain or improve upon emissions and air quality benefits achieved by CaRFG2 as of January 1, 1999, including emission reductions for all pollutants identified in the State Implementation Plan for ozone, and emissions reductions in potency-weighted air toxic compounds.

In approving the CaRFG3 regulations in late 1999, it was found that CaRFG3 maintained or improved upon the CaRFG2 regulations as required by Section 43013.1 except for increases in hydrocarbon permeation emissions associated with the use of ethanol.

As discussed in Chapter II, the addition of ethanol increases permeation emissions from both on-road and off-road sources.

(1) Impact on On-road Sources

The proposed amendments are specifically designed to mitigate the increase of permeation emissions from on-road sources. The estimated increase of permeation emissions is 28.8 tpd in 2005, 18.4 tpd in 2010, 12.1 tpd in 2015 and 8.1 tpd in 2020. The mitigation is provided through the use of alternative fuel formulations or, for a limited time for most producers, through the use of an AERP. The mitigation begins no later than December 31, 2009. This date was chosen as the earliest practical date to implement either alternative fuel formulations or AERPs.

(2) Impact on Off-road Sources

The proposed amendments may not fully mitigate the impact of permeation on off-road sources. Off-road gasoline applications include sources such as lawnmowers, string trimmers, airport ground equipment, recreational equipment (snowmobiles, pleasure craft), and portable gas containers.

As discussed previously, the addition of ethanol is likely to reduce the exhaust emissions of hydrocarbons and carbon monoxide, but will likely increase permeation emissions. At higher levels of ethanol, the emissions of oxides of nitrogen may increase. However, staff is unable to define a method that ensures permeation effects in off-road sources are fully mitigated at this time. Available data are not sufficient to reasonably quantify the effect that ethanol in gasoline has on permeation emissions or the effect of fuel property changes on the exhaust emissions from off-road sources.

Based on limited test programs, staff estimates for 2015 that the addition of ethanol to gasoline will increase evaporative hydrocarbon emissions by about 15 to 39 tpd. Similarly, staff estimates that the use of additional ethanol in gasoline could decrease the exhaust emissions of hydrocarbons by 15 to 21 tpd and increase slightly the exhaust emissions of NOx by about 1 to 2 tpd. Further work is needed to determine the emission impacts of greater ethanol use and to define what additional mitigation, if any, is necessary.

To improve the data and enable the design of an effective mitigation strategy, staff is developing an emissions test program to provide enough information to reasonably quantify the impacts of ethanol on the emissions from off-road sources. This will allow a mitigation program, if appropriate, to be developed. Impacts on permeation due to ethanol blending, engine exhaust emissions, changes due to increased oxygenates, and benefits of catalysts on reducing engine emissions will be studied.

b. Impact on the State Implementation Plan

The ARB's 2007 State Implementation Plan (SIP) proposal is a comprehensive strategy designed to attain federal air quality standards as quickly as possible through a combination of technologically feasible, cost-effective, and far reaching measures. The total magnitude of the reductions to be achieved through new actions is primarily driven by the scope of the air quality problems in the San Joaquin Valley and South Coast Air Basin.

When introduced in 1996, gasoline meeting the CaRFG2 specifications was estimated to produce about a 15 percent overall reduction (300 tons per day) in ozone precursor emissions from motor vehicles. These emission reductions were equivalent to removing 3.5 million vehicles from California's roads. The CaRFG2 program is also a major component of the California SIP. In 1996, the CaRFG2 program accounted for 25 percent of the ozone precursor emission reductions in the SIP. The CaRFG3 regulations, approved by the Board in 1999, removed MTBE from California gasoline, however, the substitute oxygenate, ethanol, has resulted in increased evaporative emissions due to fuel system permeation. This proposed measure would make modifications to the CaRFG3 program to eliminate or offset all ethanol permeation effects from motor vehicles and a significant portion of the permeation effect from off-road applications.

3. Greenhouse Gas Emissions

Staff expects that the CaRFG3 amendments would ultimately result in a small (less than one percent)[3] net decrease in CO_2 equivalent greenhouse gas emissions from California gasoline production and use. This is due to the expected increase in ethanol blending ratio from 5.7 to as high as 10 percent by volume.[4] As currently produced in the U.S., ethanol creates about zero to 30 percent less CO_2 equivalent greenhouse gases (GHG) per unit of energy output than would occur from the gasoline displaced due to ethanol use[5].

In January 2007, the Governor's Executive Order S-01-07 required a Low Carbon Fuel Standard (LCFS) for transportation fuels be established for California. This first of–its-kind standard will support the AB 32 climate change emissions target as part of California's overall strategy to fight global warming. ARB is expected to initiate rulemaking activities for the LCFS in July 2007. The proposed changes to the CARFG3 rules are expected to provide additional flexibility for producers to comply with the LCFS.

Expected changes to the production of California gasoline are expected to result in an additional but much less significant change in CO_2 equivalent emissions.

[3] The actual benefits will depend greatly on how ethanol used in California is produced.
[4] This would be an ethanol energy content increase from about 3.9 percent to about 6.9 percent.
[5] http://www.energy.ca.gov/ab1007/documents/2007-03-02_joint_workshop/presentations/TIAX-2_2007-03-02.PDF

This is due to the need to use more energy in the production of lower sulfur feedstocks. The expected reduction in sulfur content could cause small (less than 0.01 percent)[6] net increases in CO_2 equivalent emissions. Generally, the more hydrotreating required in producing a given type of fuel, the more CO_2 equivalent GHGs are emitted in the production of the fuel.

4. Water Quality

The proposed amendments do not change either the flat limits or averaging limits or cause any fuel property to exceed the cap limits. Staff expects that there will be a reduction in sulfur content and an increase in the volume of ethanol. These potential fuel formulation changes are not expected to have any significant effect on the quality of both ground and surface water beyond what is currently allowed.

5. Community Health and Environmental Justice

Environmental justice is a core consideration in ARB's efforts to provide clean air for all California communities (CARB 2001, i.e. Policies and Actions for Environmental Justice, PTSD, 2001). The increased ethanol required for blending would require additional number of trucks delivering ethanol to pipeline terminals. Staff has estimated that to supply the necessary additional ethanol to the distribution terminals there will likely be about an additional 8300 miles driven each day by heavy duty diesel trucks. This represents about 0.02 percent of the total miles driven each day by heavy duty diesel trucks (38,204,000 miles per day in 2006-source: ARB EMFAC 2007). The impacts of this however, could be localized near blending terminals. To accommodate the additional ethanol most of the terminals must have their ethanol storage and blending equipment upgraded; this will be subject to local permitting requirements and California Environmental Quality Act (CEQA), and any significant increases in emissions must be mitigated. Also, the expansion of hydrotreating capacity at producer facilities and other associated changes will require either new permits or amendments to existing permits. Again, increases in emissions must be mitigated.

H. Alternatives to the Proposed Amendments

1. Alternatives Related to the Predictive Model

Staff believes that it is appropriate to update the Predictive Model to add the permeation emissions, update the motor vehicle emissions inventory vehicle mix, update the reactivity adjustment factors, add the new motor vehicle exhaust emissions test data, and update the effect of carbon monoxide on ozone-forming potential. During the development of these proposed amendments to the Predictive Model, stakeholders proposed alternatives related to the general

[6] See ARB staff report, Appendix J, "Effect of Low Sulfur Diesel Fuel on Greenhouse Gas Emissions," June 6, 2003.

construction of the Predictive Model. These proposed alternatives consisted of issues such as reactivity values for CO and dividing the vehicle datasets in the Predictive Model. Stakeholders also proposed the inclusion of off-road emissions into the Predictive Model.

Staff reviewed the stakeholder proposed alternatives related to the general construction of the Predictive Model and determined that the related data and information conclusively supported staff's suggested revisions to the Predictive Model. A detailed description and analysis of the proposed alternatives related to the Predictive Model is contained in Chapter VI.

a. Incorporate Off-Road Emissions Into the Predictive Model

The CaRFG program was adopted to reduce emissions from motor vehicles. The data developed to support this rulemaking came from studies that related fuel properties to on-road motor vehicle emissions. Then, as now, adequate emission studies do not exist to allow inclusion of off-road emissions into the CaRFG program including the Predictive Model. This is due in part to low consumption of fuels in off-road applications, less than five percent of total gasoline. Emission studies are being implemented to provide the necessary data to allow an assessment to be made of the appropriateness of incorporating off-road emissions into the CARFG program.

2. Alternatives Related to the Alternative Emission Reduction Plan

There are two basic alternatives related to the AERP. The first alternative would be to extend the AERP to address off-road emissions. As discussed in Chapter V, there are insufficient data available to reliably estimate the impact of the addition of ethanol to gasoline. Staff has initiated several new studies designed to provide the data necessary to make further improvements to the off-road emissions estimates. Also, once these studies are complete, staff proposes to return with appropriate mitigation approaches and/or changes in the Predictive Model.

The second alternative would be to allow the use of the AERP indefinitely. As proposed, the AERP can only be used by the large producers until December 31, 2011. Small producers can use the AERP indefinitely. Staff does not support the use of the AERP beyond the sunset date. While it is expected that an AERP can provide emission mitigation, only fully complying fuel can ensure that the full benefits are obtained. Small producers supply less than 5 percent of gasoline consumed in the State and the risk by allowing them access to the AERP on an ongoing basis is limited.

3. Alternatives Related to the Change in Specifications

There were four staff proposals related to specification changes. These proposals were relating to denatured ethanol, the modeling of oxygen content,

adjusting the RVP limit, and lowering the sulfur cap. Regarding the first three, no alternatives exist that would provide an acceptable alternative. A detailed description and analysis of the proposed alternatives related to specification changes is contained in Chapter VI.

a. Sulfur Cap

The first alternative is to lower the sulfur cap limit even further than 20 ppmw. Lowering the sulfur cap limit below 20 ppmw would make sense, if the current CaRFG flat limit is also changed to be below 20 ppmw. Lowering both the sulfur cap and the flat limits would decrease flexibility for refiners to make compliant CaRFG. This lack of flexibility could adversely affect the supply of gasoline in California, and would severely limit the options available to producers to use higher oxygen level to mitigate permeation emissions.

The second alternative is to leave the sulfur cap at 30 ppmw. Given the implementation of the new federal Tier II sulfur limits for federal gasoline, it would make it more difficult to enforce the requirement that only complying California Phase 3 reformulated gasoline be sold for use in California. No alternative considered by the agency would be more effective in carrying out the purpose for which the regulation is proposed or would be as effective and less burdensome to affected stakeholders than the proposed regulation.

4. Alternatives Related to Implementation Dates

Staff considered alternative implementation dates for producers to certify fuel formulations that mitigate the increase in permeation emissions. Staff also considered alternative dates for the use of the AERP option, including implementing the requirements sooner. After discussions, with stakeholders, staff determined that December 31, 2009 was a sufficient date for producers to certify fuel formulations that mitigate the increase in permeations along with the option using the AERP option. Staff was also able to determine that the producers would have sufficient time to certify formulations that could fully mitigate permeation emissions with the use of the AERP option by December 31, 2011.

I. Recommendations

The staff recommends that the Board adopt the following proposed amendments to the California Reformulated Gasoline regulations.

1. Update the Predictive Model and the CaRFG3 performance standards to require the mitigation of increases in permeation emissions due to the use of ethanol. Require mitigation of these emissions no later than the 2010 smog season.

2. Between 2010 and 2012, allow producers to utilize an Alternative Emissions Reduction Plan to mitigate emissions associated with permeation, thus allowing additional flexibility to come into compliance at an earlier date or more time to offset emissions, if needed. In general, sunset this provision after 2012, but provide for a one year extension under specified situations.
3. Lower the sulfur cap limit from 30 ppmw to 20 ppmw and restore the RVP flat limit of 7.00 psi allowed in CaRFG2 when using the evaporative emissions portion of the Predictive Model to certify ethanol blends. Maintain the requirement to use 6.90 psi RVP as the flat limit for non-oxygenated blends, adopted originally to mitigate the effects of commingling.
4. Allow refiners the option of averaging emissions associated with unexpected high sulfur levels over a period no more than 90 days. This is a modification of the current averaging provisions, which will allow flexibility while preserving emission benefits.
5. Approve other miscellaneous changes to increase enforceability, flexibility, and consistency of the regulations.

Chapter I. Introduction

This report presents the Initial Statement of Reasons in support of proposed amendments to the California reformulated gasoline (CA RFG) regulations. Over the years, the Air Resources Board (ARB/Board) developed and amended these regulations in three phases. The most recent amendments implemented the Governor's and Legislature's directions to phase out methyl-tertiary-butyl-ether (MTBE) from California gasoline. Legislation, Senate Bill 989, establishing Heath and Safety Code Section 43013.1 requires the Board to preserve the air quality benefits of the existing reformulated gasoline program as it existed in 1999.

The purpose of the proposed amendments is to address increases in emissions resulting from the addition of ethanol to gasoline. Ethanol replaced MTBE to ensure that the oxygen requirements of the federal regulations were met. However, recently completed studies on on-road motor vehicles now show that ethanol increases the evaporation emissions of gasoline through a process known as permeation. Permeation refers to the diffusive process whereby fuel molecules migrate through the polymeric material of a vehicle's fuel system. Eventually the fuel molecules are emitted into the air where they contribute to evaporative emissions from the vehicle. Permeation emissions are higher with ethanol blended gasoline than with a comparable fuel without ethanol, or with MTBE.

To address the permeation emissions, the staff is proposing several amendments. The most significant change is to the California Predictive Model. The gasoline producers use the Predictive Model to establish alternative formulations that are most cost-effective for their specific situation, while ensuring that the emissions benefits of the fuel are achieved. A description of the Predictive Model is presented in the next chapter. The proposed amendments are presented in Chapter III. Additional amendments are proposed to lower the maximum allowable sulfur content of the fuel, provide additional flexibility to the producers in blending very low sulfur fuels, and add conforming changes throughout the regulations.

The proposed amendments will not result in any additional environmental impacts. However, ethanol also affects off-road gasoline-powered engines and equipment, as well as portable gas containers. This includes lawnmowers and other types of gasoline-powered lawn and garden equipment. Available data indicate that ethanol may reduce the exhaust emissions of hydrocarbons and carbon monoxide, but increase the evaporative emissions due to permeation. However, there are limited data available to accurately quantify this impact. Therefore, the staff is conducting an emissions test program that will provide the data necessary to quantify the impacts and will return to the Board in about 18 months with additional proposed amendments, if necessary, to fully mitigate

the impacts of ethanol on off-road sources. Additional details on costs to producers and consumers are provided in Chapter IV.

The proposed amendments will result in additional costs to the producers, as the new requirements will likely require lower sulfur limits than are produced today. In addition, the blends are likely to have higher ethanol content. Because, the energy value of ethanol is lower than gasoline, a small decrease in the average fuel economy is expected. These costs are discussed in Chapter V.

In developing the proposed amendments, the ARB staff hosted 14 workshops and public consultation meetings in 2006 and 2007. ARB staff and stakeholders also created four subgroups to investigate and make recommendations regarding changes to the reformulated gasoline regulations. The subgroups were made of individuals with expertise in the areas being investigated. The areas covered by the subgroups were: statistics; emissions inventories; hydrocarbon reactivity; and refinery production. The subgroups reported on progress at various workshops. The individuals participating in the subgroups are listed in the acknowledgements.

Staff also held individual meetings and conference calls with various stakeholders regarding individual concerns. ARB staff created a Predictive Model website to ensure that information used to update the Predictive Model is available to all stakeholders. ARB staff used the Fuels Program e-mail listserver to notify interested parties when information becomes available. The Fuels Program e-mail listserver is a self subscription list with over one thousand individual e-mail addresses.

Chapter II. Reformulated Gasoline Programs

This chapter presents a brief overview of the United States Environmental Protection Agency's (U.S. EPA) Reformulated Gasoline (U.S. EPA RFG) program and California's Reformulated Gasoline (CaRFG) program. As part of this overview, a description of the California Predictive Model is presented. In addition, the Chapter presents background information on current gasoline consumption, the average fuel properties of California gasoline, and the impact that the use of ethanol has had in California.

A. Federal Reformulated Gasoline Program

The 1990 Federal Clean Air Act required the U.S. EPA to establish reformulated gasoline regulations. The Clean Air Act requires areas with high ozone concentrations to use U.S. EPA RFG. Nationally, about 30 percent of the gasoline produced must meet these requirements. These regulations impose emission performance standards for reducing volatile organic compounds (VOCs) and toxic air contaminants (air toxics). In addition, the regulations imposed a ban on heavy metals and a limit on benzene content.

Phase I U.S. EPA RFG regulations (1995-1999) set 15 percent emission reduction performance requirement for VOCs and air toxics against baseline emissions. The baseline emissions are the emissions of 1990 model year vehicles operated on a specified baseline fuel. Phase II U.S. EPA RFG (2000-present) specifies that the VOC and air toxics performance standards must meet a 25 percent reduction from the baseline. In California, fuel sold in the South Coast, San Diego, San Joaquin Valley, and the Sacramento regions must meet federal U.S. EPA RFG requirements, but can do so through the use of CaRFG because the California program produces significantly greater emission reductions than the Federal RFG program. These regions account for about 80 percent of the gasoline sold in California.

The U.S. EPA RFG requirements mandated the use of a minimum average oxygen content (2.0 percent by weight) year-round in U.S. EPA RFG areas. However, the Energy Policy Act of 2005 (EPAct), among other things, authorized the U.S. EPA to lift the reformulated gasoline oxygen content requirement. The removal of the two percent oxygen content requirement for U.S. EPA RFG took effect nationwide May 6, 2006. Instead of a minimum oxygen content requirement, the EPAct established a renewable fuels standard that requires increasing quantities of renewable fuels be consumed each year. Beginning in 2006, the renewable fuels standard requires that 4 billion gallons of renewable fuel be consumed with the amount increasing annually up to 7.5 billion gallons of renewable fuel consumed in 2012. The phase-in schedule is shown in Table 1.

Table 1: National Renewable Fuels Standard

Year	Renewable Fuels (billions of gallons)
2006	4.0
2007	4.7
2008	5.4
2009	6.1
2010	6.8
2011	7.4
2012	7.5

In 2004, the U.S. EPA implemented Tier II vehicle emissions and gasoline sulfur standards. The U.S. EPA set the refinery sulfur average at 30 parts per million by weight (ppmw), with a corporate average of 90 ppmw and a cap of 300 ppmw. A cap standard cannot be exceeded anywhere in the distribution system. Both of the average standards could be met with use of credits generated by other refiners who reduced sulfur levels early. In 2006, refiners were required to meet a 30 ppmw average sulfur level with a maximum cap of 80 ppmw.

In February 2007, EPA finalized a rule to reduce hazardous air pollutants from mobile sources. The rule requires that, beginning in 2011, refiners must meet an annual average gasoline benzene content standard of 0.62 percent by volume (vol%) on all their gasoline, both reformulated and conventional, nationwide. The national benzene content of gasoline today is about 1.0 vol%. Gasoline sold in California will not be covered because California has already implemented more stringent standards similar to those the U.S. EPA has established.

The regulations include a nationwide averaging, banking, and trading program. In addition to the 0.62 vol% standard, refiners must also meet a maximum average benzene standard of 1.3 vol% beginning on July 1, 2012, which acts as an upper limit on gasoline benzene content when credits are used to meet the 0.62 vol% standard. A refinery's or importer's actual annual average gasoline benzene levels may not exceed this maximum average standard.

B. California Reformulated Gasoline Program

California Health and Safety Code section 43018 requires the Air Resources Board (ARB or Board) to achieve the maximum feasible reductions from motor vehicles and motor vehicle fuels. In carrying out this requirement, ARB is to adopt standards and regulations that produce the most cost-effective combination of control measures on all classes of motor vehicles and motor vehicles fuels, including the specification of vehicular fuel composition. In response, the Board has adopted numerous regulations, including the California Reformulated Gasoline Program (CaRFG).

The CaRFG program is a vital part of ARB's strategy to address motor vehicles and fuels as a system by combining cleaner fuels and motor vehicle controls to achieve the maximum emission reductions at the lowest cost. CaRFG also substantially reduced emissions from existing vehicles. The Board initially adopted the CaRFG program in two phases. Phase 1 of the program required changes to gasoline that could be made in a short time frame and only required small investments by producers and importers (Note: Producers from this point forward will refer to both producers and importers, unless otherwise specified) . Phase 2 was significantly more complex and achieved more emissions reductions. Phase 3 implemented the Governor's and Legislature's direction to remove MTBE from California gasoline. Each of these phases is discussed in more detail below.

1. Phase 1

The Phase 1 CaRFG regulations (CaRFG1) were approved in 1990 and implemented in 1992. CaRFG1 lowered the limit on Reid vapor pressure (RVP), required the addition of deposit control additives, and eliminated leaded gasoline. CaRFG1 resulted in a reduction in vehicle emissions of 210 tons per day of VOC emissions, about a 10 percent reduction of this pollutant. These standards were implemented relatively quickly as they did not require significant producer facility modifications.

2. Phase 2

The Board approved CaRFG2 in 1992; the requirements were implemented in 1996. For the first time, the Board considered the vehicle and the fuel as a system. This action not only achieved emission reductions from new and existing vehicles, but ensured the fuel vehicle manufacturers needed to employ better emission control techniques for future vehicles. CaRFG2 compliant fuel reduced emissions of ozone precursors from motor vehicles by about 15 percent, or 300 tons per day (tpd), and reduced air toxic emissions by 40 percent. These emission reductions were equivalent to removing approximately 3.5 million vehicles from California's fleet.

CaRFG2 set limits for the eight gasoline properties shown below:

RVP	90% distillation temperature (T90)
Sulfur	50% distillation temperature (T50)
Benzene	Aromatic Hydrocarbons
Olefins	Oxygen

With the exception of oxygen, the regulations set three limits for each property: a "cap" limit that applies to all gasoline anywhere in the gasoline distribution and marketing system and does not vary; and "flat" and "averaging" limits that apply to gasoline when it is released by refiners, importers, and blenders (collectively,

"producers"). In actual use, the flat and averaging limits are adjustable by gasoline producers through the use of the Predictive Model, as explained below. Gasoline producers could comply with the producer limits in one of three ways. First, for a given property, each producer may choose to meet either the flat limit or the averaging limit. Any gallon of gasoline released for sale by the producer may not exceed the flat limit (if used). If the averaging limit is used for a property, the producer assigns a "Designated Alternative Limit" (DAL) to each batch of gasoline and all batches with a DAL over the averaging limit must be offset by batches with lower DALs that are shipped from the production facility within 90 days before or after the high DAL batch. Second, a producer may use the Predictive Model to identify other sets of property limits (flat, averaging, or mixed) that can be applied to that producer's gasoline. Third, a producer may validate an alternative set of property limits through emission testing per a prescribed protocol. Whether validated by the Predictive Model or by testing, no alternative limit may exceed the cap limit for the property.

To comply with the oxygen content requirement, producers chose to use MTBE. Soon after CaRFG2 implementation, the presence of MTBE in groundwater began to be reported. An investigation and public hearings were conducted resulting in the issuance of Executive Order D-5-99 on March 25, 1999. The Executive Order directed the phase-out of MTBE in California's gasoline. In addition, the Legislature passed Senate Bill 989. Among other provisions, the bill directed the ARB to ensure that regulations adopted pursuant to the Executive Order maintain or improve upon emissions and air quality benefits achieved by CaRFG2 as of January 1, 1999 (Health and Safety Code section 43013.1).

3. Phase 3

The Board approved the CaRFG3 regulations on December 9, 1999. The CaRFG3 regulations prohibited California gasoline produced with MTBE starting December 31, 2002, established CaRFG3 standards applicable the same date, established a CaRFG3 Predictive Model, and made various other changes. The CaRFG3 standards modify the specifications for five of the eight gasoline properties regulated by CaRFG2, with the objective of providing additional flexibility in lowering or removing the oxygen content requirement while maintaining current emissions and air quality benefits.

The CaRFG3 regulations also placed a conditional ban, starting December 31, 2002, on the use of any oxygenate other than ethanol, as a replacement for MTBE in California gasoline. No other oxygenate may be used unless a multimedia evaluation is conducted, and the California Environmental Policy Council has determined that its use will not have a significant adverse impact on the public health or the environment. To date, no other oxygenate has been approved for use in California gasoline.

Originally, the CaRFG3 regulations banned gasoline produced with the use of MTBE, for all California gasoline supplied from production and import facilities starting December 31, 2002 and established a three-stage schedule for reducing residual MTBE levels. Subsequent data indicated that the timetable for removal of MTBE would not satisfy the directive of Executive Order D-5-99 that there be an adequate supply and availability of gasoline for California consumers. At that time, there was still uncertainty regarding the supply and availability of ethanol necessary to meet California's requirements.

Therefore, on March 14, 2002, Governor Davis issued Executive Order D-52-02, which directed the ARB to take the necessary actions, by July 31, 2002, to postpone for one year the prohibitions of the use of MTBE and other specified oxygenates in California gasoline, and the related requirements for California Phase 3 reformulated gasoline. The Governor found that it was not possible to eliminate use of MTBE starting December 31, 2002 without significantly risking disruption of the availability of gasoline in California. Such disruption would substantially increase prices, harm California's economy, and impose an unjustified burden upon California motorists.

Therefore, the Board approved amendments to the CaRFG3 regulations on July 25, 2002. In this rulemaking, the Board approved the following amendments consistent with the Governor's Executive Order D-52-02, along with a few other amendments designed to ensure that the regulations work effectively.

- The amendments postponed the prohibition of the use of MTBE and other oxygenates other than ethanol in California gasoline from December 31, 2002 to December 31, 2003, with the downstream phase-in requirements also postponed by one year. Similarly, the schedule for reducing residual levels of MTBE in CaRFG3 would be postponed one year. Starting December 31, 2003, California gasoline could not contain more than 0.30 volume percent MTBE. This residual limit of 0.15 volume percent MTBE would apply starting December 31, 2004, with the 0.05 volume percent residual limit starting December 31, 2005.

- The amendments also postponed the imposition of the CaRFG3 standards for gasoline properties from December 31, 2002 to December 31, 2003. With the delay in the prohibition of the MTBE prohibition, it was appropriate to allow refiners to meet the CaRFG2 standards for an additional year for producing gasoline oxygenated with MTBE. The amendments also delayed for one year (from December 31, 2004 to December 31, 2005) the reduction of the CaRFG3 sulfur content cap limit from 60 ppmw to 30 ppmw.

The CaRFG3 limits now in effect are shown in Table 2.

Table 2: CaRFG Limits and Caps

Property	Flat Limits	Averaging Limits	Cap Limits[1]
Reid vapor pressure, psi, max	7.00 or 6.90 [2]	---	6.40 - 7.20
Benzene, vol%, max	0.8	0.70	1.10
Sulfur, ppmw, max	20	15	30
Aromatic HC, vol%, max	25	22	35.0
Olefins, vol%, max	6.0	4.0	10.0
Oxygen, wt%	1.8 to 2.2	---	1.8 – 3.5[3] 0 – 3.5
T50 (temp. at 50% distilled) °F, max	213	203	220
T90 (temp. at 90% distilled) °F, max	305	295	330

(1) The "cap limits" apply to all gasoline at any place in the marketing system and are not adjustable.

(2) 6.90 psi applies when a producer is using the evaporative emissions element of CaRFG3 Predictive Model and gasoline may not exceed a cap of 7.20 psi; otherwise, the 7.00 psi limit applies.

(3) The 1.8 weight percent minimum applies only during the winter and only in certain areas.

C. The California Predictive Model

Numerous studies have shown that the properties of gasoline affect motor vehicle emissions. Based on thousands of individual tests, equations have been developed that relate changes in fuel properties to changes in emissions. The Predictive Model takes advantage of these relationships to provide producers flexibility. The producers use the Predictive Model to identify alternative limits that achieve equal or better emission reductions compared to the use of the flat or averaging limits. The Predictive Model provides flexibility for the producers, while ensuring California's emissions reduction goals are met. This flexibility is highly valued by the producers and the vast majority of CaRFG is produced using the Predictive Model.

As originally developed for CaRFG2, the Predictive Model is a set of mathematical equations that relate emission rates of exhaust hydrocarbons, oxides of nitrogen (NOx), and combined exhaust toxic species[7] to the values of the eight regulated gasoline properties. Emissions of each pollutant type are predicted by equations formulated separately for vehicles of different technology classes.

The CaRFG2 Predictive Model divides vehicles into five basic emissions control technology groups. Table 3 shows the vehicle technology group definition used in the development of the Predictive Model. Each group represents a different emissions standard required on California fleet vehicles. The contribution of

[7] Four toxic species are involved: benzene, 1,3-butadiene, formaldehyde, and acetaldehyde. Separate predictions for the four are combined with weights proportional to the ARB's unit-risk values for the species. The resultant sum is the "potency-weighted toxic" (PWT) emission rate.

each group changes with time as older vehicles are retired, or new vehicles met more stringent standards. Regression equations were derived from vehicle emission observations associated with fuel property changes. The limited data for older vehicles prevented the construction of Tech 1 and Tech 2 models; originally, there were no data available to construct the Tech 5 model in 1994.

Table 3: Vehicle Technology Groups

Tech Group	Vehicle MY	Emissions Control Technology
Tech 1	Pre-1975	Non-Catalysts
Tech 2	1975-1980	Open-Loop Oxidizing Catalysts
Tech 3	1981-1985	Closed-Loop Three-Way Catalysts
Tech 4	1986-1995	Advanced Closed-Loop Three-Way Catalysts
Tech 5	1996 and newer	Low Emission Vehicles (LEV, ULEV, SULEV, and PZEV)

The equations were derived by statistical analyses applied to thousands of individual emissions observations and the associated values of the fuel properties. For each pollutant, the predictions for the three classes are combined with weights proportional to the contributions of the vehicle classes to the ARB's emission inventory for that pollutant.

The Predictive Model then allows producers to certify alternative formulations of CaRFG2 by comparing the emission predictions for a candidate set of property limits to the predictions for the flat or averaging limits. If each prediction for the candidate limit is no greater than 1.004 times the corresponding basic-limit prediction, the alternative set of limits is allowable. In effect, the model allows a producer to use one or more limits greater than flat or averaging limits in exchange for compensating reductions in other limits. Thus, the model provides valuable flexibility to individual refiners by allowing refiners to most efficiently meet the CaRFG2 requirements, taking into consideration the configuration of the refinery. The CaRFG2 Predictive Model did not allow for the RVP limit to be adjusted, thus there was no evaporative emissions component.

In 1999, as part of the CaRFG3 regulations to phase-out MTBE from California gasoline, the CaRFG2 Predictive Model was revised. Also, an evaporative emissions model was incorporated to provide additional flexibility to offset emissions, by allowing tradeoffs between exhaust and evaporative HC emissions based on their ozone forming potential differences estimated by using reactivity weighting factors.

To facilitate the use of the Predictive Model, ARB staff provide a procedures guide, "California Procedures for Evaluation Alternative Specifications of Phase 3 Reformulated Gasoline Using the California Predictive Model." The guide provides step by step instructions, including ARB staff notification requirements. Also, a computer spreadsheet is provided so that users can in effect insert the specifications for the candidate fuel and the spreadsheet will calculate if the candidate fuel passes or fails.

D. Impact of Ethanol Use

In general, oxygenates such as MTBE and ethanol are used in gasoline to reduce the exhaust emissions of hydrocarbons and carbon monoxide and improve the octane rating. It is well known that ethanol increases the vapor pressure of gasoline. For many years, blends of gasoline have had to be adjusted to ensure that the RVP of the resulting blend met the limits and did not increase evaporative emissions. Available data also indicate that higher blends of ethanol increase the exhaust emissions of oxides of nitrogen.

When the Board approved CaRFG3 in 1999, if recognized that there was another potential source of evaporative emissions associated with the use of ethanol, referred to as permeation, and directed the staff to investigate. Permeation refers to the diffusive process whereby fuel molecules migrate through the polymeric material of a vehicle's fuel system. Eventually the fuel molecules are emitted into the air where they contribute to evaporative emissions from the vehicle. Permeation emissions were suspected of being higher with ethanol blended gasoline than with a comparable fuel without ethanol, or with MTBE. At the time, however, there was insufficient data available to quantify the impact of permeation on evaporative emissions.

To investigate, the ARB co-funded a research study with the Coordinating Research Council (CRC) to assess the magnitude of the permeation emissions associated with the use of ethanol in gasoline in on-road vehicles (CRC E-65 Study). Based on the study results, staff calculated the increase in evaporative emissions from on-road motor vehicles due the presence of ethanol in gasoline to be about 18 tons per day of hydrocarbons in 2010. Additional detail is presented in Chapter III. Appendix B provides the calculations supporting the emissions inventory.

Ethanol also affects off-road gasoline-powered engines and equipment, as well as portable gas containers. This includes lawnmowers and other types of gasoline-powered lawn and garden equipment. Available data indicate that ethanol reduces the exhaust emissions of hydrocarbons and carbon monoxide, but increase the evaporative emissions due to permeation. However, data available are too limited to accurately quantify this impact. As discussed in Chapter V, ARB staff is collaborating with the small engine manufacturers and U.S. EPA to co-fund studies at Southwest Research Institute to assess the

impact of ethanol of various types of off-road sources, including portable gas containers. Appendix C presents additional details on the status of testing on off-road sources.

Pursuant to Health and Safety Code section 43013.1(b)(1), the ARB must ensure that CaRFG3 maintains or improves upon the emissions and air quality benefits achieved by CaRFG2. The data now show that there are increased evaporative emissions from on-road motor vehicles due to permeation caused by ethanol. As a result, staff is proposing amendments to fully mitigate the impacts from on-road motor vehicles.

E. California Gasoline Consumption

As shown in Table 4, the consumption of gasoline in California has steadily increased from the inception of the CaRFG program in 1992 through at least 2004. This increase was a result of various factors, such as population growth, longer commutes to work, and an increase in the number of vehicles per family. Also, the recent public preference for sport utility vehicles, vans, and trucks with lower fuel economy ratings has had an impact on the consumption of gasoline. In 2006, gasoline consumption was about 15.8 billion gallons per day.

Historically, gasoline consumption in California has been relatively price inelastic. This means that increases in price have relatively little impact on demand. Gasoline prices have exceeded three dollars a gallon in 2006 and have continued to hover around that level today (see Figure 1). As a result, the impact of even the relatively small price elasticity seems to have appeared in the gasoline market, as gasoline consumption decreased in 2006 from 2005 by 0.6 percent. Figure 1 shows the recent flat trend in gasoline consumption with increasing gasoline prices.

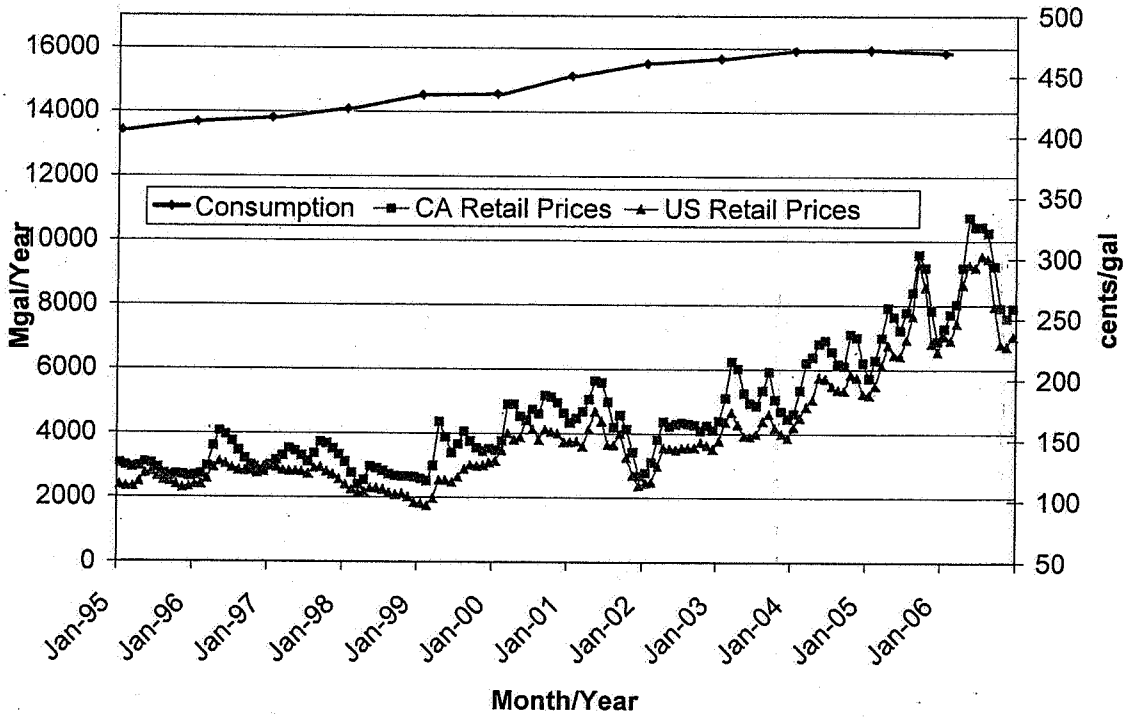
California refineries are producing gasoline very near their maximum production capability. Between 1999 and today, average demand in the markets supplied by California producers has exceeded production capacities, and imports have been increasing into California of finished gasoline and gasoline blending components.

Table 4: Gasoline Consumption in California

Year	Consumption (billion gallons/year)
1990	13.4
1991	13.2
1992	13.1
1993	13.2
1994	13.3
1995	13.4
1996	13.5
1997	13.8
1998	13.9
1999	14.5
2000	14.5
2001	15.1
2002	15.5
2003	15.7
2004	15.9
2005	15.9
2006	15.8

Source: State of California Board of Equalization Tax Tables

Figure 1: California Gasoline Consumption vs. Retail Price



F. CaRFG3 Properties and Composition

The staff analyzed the available information regarding the fuel properties for 2005 and 2006 to determine average in-use fuel properties. The staff used a database of 2005 and 2006 fuel properties reported by each producer certifying alternative formulations using the Predictive Model, as well as the results of ARB tests of fuel samples taken from refineries for 2003 through the first half of 2006.

Producers make fuels with properties that are less than what they report to the ARB. If ARB staff tests a fuel and it is above the reported values, it may be subject to enforcement action. Therefore, producers typically allow themselves a "safety or compliance margin" between their own measurements of a property and the limit they provide to ARB. The staff has estimated the typical margin for each property by averaging the mean difference between the ARB's Enforcement Division staff measurements of samples taken at refineries in 2005 and 2006 and the limits that applied to the gasoline batches that were sampled. The results are presented in Table 5.

Table 5: Weighted Averages of Predictive Model Reported Values and ARB Measured Values at California Refineries

Gasoline Property	RVP controlled (summer)			RVP uncontrolled (winter)		
	Average of Reported PM Results	Average Measured	Apparent Compliance Margin	Average of Reported PM Results	Average Measured	Apparent Compliance Margin
Aromatics (vol%)	24.2	22.8	1.4	24.6	24.0	0.6
Benzene (vol%)	0.67	0.55	0.12	0.69	0.54	0.15
Olefins (vol%)	7.9	5.3	2.6	7.2	4.9	2.3
Sulfur (ppmw)	13	10	3	15	11	4
T50 (°F)	213	212	1	206	200	6
T90 (°F)	313	308	5	316	308	8
RVP (psi)	6.95	6.83	0.12	-	11.00	-
Ethanol (vol%)	5.28	5.45	-0.17	5.27	5.23	0.04
No. of samples	3,945	344	-	2,095	140	-

Source: ARB Enforcement Division

The predictive model has an option which allows the producers to elect to use an evaporative hydrocarbon emissions model. Of the summer samples, the producers chose to use this option 39 percent of the time. Six percent of the summer samples and sixteen percent of the winter samples had a sulfur concentration greater than 20 ppm.

Data collected from fuel sampling at production and importation points, performed by ARB Enforcement Division staff during the period of January 2003 through June 2006 and shown in Tables 6 and 7. Fuel analyses were performed by ARB Monitoring and Laboratory Division staff. For all data, the tabulated

averages and numbers of samples have been weighted as ninety percent regular grade and ten percent non-regular grade. The total (regular plus non-regular) numbers of samples are shown in parentheses. The non-regular grade samples are almost all premium grade with a few middle grade samples included. The volume-weighted averages incorporate production volumes provided by the CEC staff for the period January 2003 through August 2006.

Table 6: Properties and Composition of Summer CaRFG3 2003 through mid-2006 [1]

Gasoline Property	No. of Samples	Average	Volume-Weighted Average	Maximum	95th Percentile	5th Percentile	Minimum
Aromatics (vol. %)	225 (344)	22.3	22.8	34.8	31.5	14.3	10.5
Benzene (vol. %)	225 (344)	0.53	0.55	0.86	0.71	0.23	0.07
Olefins (vol. %)	225 (344)	4.9	5.3	10.3	8.5	0.4	0.0
Sulfur (ppmw)	224 (342)	10	10	33	18	2	1
T50 (°F)	230 (352)	212	212	230	220	203	195
T90 (°F)	230 (352)	307	308	328	321	293	219
RVP (psi)	230 (352)	6.83	6.83	7.23	7.08	6.53	6.38
Ethanol (vol. %)	230 (352)	5.52[2]	5.45[1]	7.40	5.70	5.69	0.00

1) Source: ARB Enforcement Division
2) The fuels used to calculate the mean include non-oxygenated fuels. The average percent volume for fuels containing ethanol is 5.7 vol%

Table 7: Properties and Composition of Winter CaRFG3 2003 through mid-2006 [1]

Gasoline Property	No. of Samples	Average	Volume-Weighted Average	Maximum	95th Percentile	5th Percentile	Minimum
Aromatics (vol. %)	129 (185)	25.7	24.0	36.5	31.9	17.1	10.8
Benzene (vol. %)	128 (184)	0.48	0.54	0.97	0.75	0.22	0.12
Olefins (vol. %)	127 (181)	3.5	4.9	10.5	8.4	0.0	0.0
Sulfur (ppmw)	125 (180)	8	11	32	18	1	1
T50 (°F)	114 (161)	197	200	222	216	183	150
T90 (°F)	126 (180)	305	308	330	322	288	218
RVP (psi)	100 (140)	10.81	11.00	14.50	14.11	8.51	8.40
Ethanol (vol. %)	141 (197)	3.77[1]	5.23[1]	8.26	5.70	0.00	0.00
DI	99 (139)	1069	1077	1163	1142	1003	868

1) The fuels used to calculate the mean include non-oxygenated fuels. The average percent volume for fuels containing ethanol is 5.7%.

Chapter III. Proposed Amendments to the CaRFG3 Regulations

This chapter presents the staff's proposal to amend the CaRFG3 regulations. In summary, the staff is proposing the following amendment:

- Amend the California Predictive Model to ensure that permeation emissions associated with ethanol use are mitigated and to incorporate new data;
- Add an option to use an alternative emissions reduction plan for a limited time period to help mitigated permeation emissions;
- Decrease the sulfur cap limit from 30 ppmw to 20 ppmw to improve enforceability and facilitate new motor vehicle emissions control technology;
- Allow emissions averaging for low level sulfur blends to provide additional flexibility for producers;
- Apply the 7.00 psi RVP limit to oxygenated CaRFG to reflect that virtually all CaRFG will be oxygenated and commingling emissions are not a problem for these fuels; and retain the 6.90 RVP limit for non-oxygenated CaRFG to ensure that no increase in hydrocarbon emissions from commingling with oxygenated CaRFG will occur;
- Allow flexibility in setting oxygen content in the Predictive Model to account for variability in test methods;
- Increase the maximum allowable amount of denaturant in ethanol to be consistent with new federal requirements;
- Update the test method for oxygenate content of gasoline; and
- Require producers use the revised Predictive Model starting in December 31, 2009, which allows for use of alternative emission mitigations. Required the production of CaRFG complaint with the revised Predictive Model by December 31, 2011.

These proposed amendments are presented in strike out underline form in appendix in Appendix A.

A. Revise the Predictive Model

There are five aspects of the Predictive Model that the staff is proposing to add or update as shown below:

- Add permeation emissions and require they be mitigated;
- Update the motor vehicle emissions inventory vehicle mix;
- Update the reactivity adjustment factors;
- Add new motor vehicle exhaust emissions test data; and
- Update the effect of carbon monoxide on ozone-forming potential.

In order to develop a new Predict Model and to ensure interactions between staff and stakeholders, staff formed working subgroups on statistics, emissions inventory, reactivity, and producer production. These workgroups provided valuable feedback throughout the development process.

Staff proposes to generally use a 2015 statewide ozone planning inventory as the baseline, including passenger vehicles to light heavy-duty trucks with gross vehicle weight (GVW) less than 10,000 pounds. An inventory year of 2015 allows the model to best reflect the in-use fleet in the 2010 – 2020 timeframe, and to appropriately model those fuel specifications that are most important in maintaining the emissions performance of advanced technology vehicles.

A more detailed discussion regarding each section can be found in the Appendices provided at the end of this report.

1. Add Permeation Emissions

As discussed in the previous chapter, there are increases in evaporative emissions due to the effects of ethanol on permeation. CRC Report No. E-65 and CRC Report No. E-65-3 concluded that the use of ethanol fuel increased permeation emissions by about 1.40 grams/day or 65 percent more than MTBE fuel. Therefore, the staff is proposing to add an element that ensures that permeation emissions associated with ethanol use in on-road motor vehicles are mitigated.

In late 2006, the ARB released the latest update to California's on-road motor vehicle emissions model, referred to as EMFAC2007. This model was updated to include permeation emissions. Typically, days with high temperatures have high ozone levels. Permeation emissions are also higher on hot days. To ensure that the CaRFG Predictive Model formulas adequately mitigate the permeation emissions, it is important to use a temperature profile that recognizes this relationship. For this analysis, ARB staff is using the temperature profiles that occur when the California 8-hour ozone standard was exceeded. Details are provided in Appendix B. In general, the temperature profiles are about 2-3 degrees Fahrenheit higher than the default temperature profile included in EMFAC2007. The default temperature profile is represented by those temperatures where the federal 8 hour ozone standard is exceeded.

On a statewide basis in 2005, the increase in evaporative emissions due to permeation is about 28.8 tpd from all on-road gasoline vehicles. The emissions increase declines to 18.4 tpd in 2010, 12.1 tpd in 2015 and 8.1 tpd in 2020. These reductions are due to a general reduction in emissions from motor vehicles. The detailed emission calculations are presented in Appendix B.

The Predictive Model includes three different regression models for evaporative emissions, representing the different processes: diurnal/resting losses; hot soak,

and running losses. Using the emissions results, staff proposes to update the three evaporative emission regression models. For non-oxygenated fuel, staff assumes the evaporative emissions are the same as the MTBE emissions. Therefore, the non-oxygenated regression models are identical to the MTBE models. Appendix D provides staff's statistical work on the evaporative models.

2. Update the Motor Vehicle Emission Inventory Vehicle Mix

Using the most recent information from EMFAC2007, the staff proposes to update the contribution of emissions from each vehicle technology class used in the model so that it more accurately reflects the California vehicle fleet setting in calendar year 2015. In 2015, the majority of the light-duty motor vehicles will have LEVII and PZEV emissions control technologies.

The fraction of emissions contributed by each vehicle class is referred to as a weighting factor. The weighting factors are used in two portions of the Predictive Model. The first is to reflect the relative contribution of each vehicle technology group to overall emissions, and the second is to do the same for the reactivity-weighted hydrocarbons that will be discussed in the following section.

As discussed, staff proposes to use the 2015 statewide ozone planning inventory as the baseline, again using the California 8-hour temperature profile. The exhaust hydrocarbons, NOx, CO, and potency-weighted toxics emissions inventory weighting factors for each vehicle class are shown in Table 8.

Table 8: Exhaust Emission Weighting Factors by Vehicle Technology Group Statewide 2015 (GVW < 10,000 lbs)

Tech Group	Model Years	Weighting Factors (Fraction of Emissions)			
		THC/TOG	NOx	CO	Toxics
Tech 3	1981-1985	0.075	0.052	0.063	0.075
Tech 4	1986-1995	0.380	0.325	0.288	0.380
Tech 5	1996-2015	0.546	0.622	0.649	0.546
Total*		1.000	1.000	1.000	1.000

Source: EMFAC2007
*May not add to 1.000 due to rounding

As expected, in 2015, Tech 5 vehicles are responsible for the majority of emissions for each of the pollutant categories. The EMFAC model does not directly estimate emissions for the potency-weighted air toxics. However, the four potency-weighted toxics (1,3-butadiene, benzene, formaldehyde, and acetaldehyde) are all hydrocarbons. Therefore, staff proposes to use the exhaust hydrocarbons weighting factors for air toxics.

3. Update the Reactivity Adjustment Factors

Staff proposes to update the exhaust hydrocarbons, evaporative hydrocarbons, and exhaust CO reactivity adjustment factors used in the Predictive Model. Staff continues to recommend that the maximum incremental reactivity (MIR) scale developed by Dr. William Carter be used. This scale is the most appropriate for complementing California's dual program of reducing both NOx and VOC to control ozone and other pollutants

Dr. Carter's MIR scale is defined in terms of environmental conditions in which ozone production is most sensitive to changes in hydrocarbon emissions and, therefore, represents conditions where hydrocarbon controls are most effective. As such, it complements ARB's NOx control program which is designed to reduce ozone under conditions that are sensitive to NOx reductions. Staff believes that Dr. Carter's MIR scale is the most appropriate scale to be used for assessing the relative contribution of various hydrocarbons and CO to ozone formation.

In December 2003, the Board approved an updated list of reactivity values and reconfirmed the other MIR values. At that time, the MIR value for CO was updated to 0.06. Prior to Board consideration, the Reactivity Advisory Committee reviewed the list of values. After their review, the Reactivity Scientific Advisory Committee concluded that the proposed update did not substantially change the nature of the MIR values and were arrived at in an appropriate scientific manner. For this update, the staff is proposing to use these MIR values. A listing of the specific MIR values is presented in Appendix E.

These values were applied to speciated emission data from ARB's Vehicle Surveillance Program to calculate average specific reactivity values for exhaust hydrocarbon emissions, and diurnal/resting and hot soak evaporative hydrocarbon emissions. The running loss reactivity adjustment factor needed to be a calculated value because of a lack of testing data available on running loss hydrocarbon emissions. The surveillance data were collected in 2004-2006. As virtually all gasoline sold in that period was CaRFG3 containing ethanol, staff believes these data are the most appropriate for updating the reactivity methodology in the Predictive Model.

Table 9 presents the reactivity factors proposed to be used in the Predictive Model update. Appendix E details the calculations for the reactivity adjustment factors. Using these average specific reactivity adjustment factors, Tables 10a and 10b show how hydrocarbons and CO combine to form total ozone forming potential for the baseline gasoline with MTBE and ethanol, respectively.

Table 9: Average Reactivity Adjustment Factor

Pollutant	Average Specific Reactivity (g O_3/g TOG)
Exhaust TOG	4.01
Evap TOG:	
Diurnal	2.74
Hot Soak	3.12
Running Loss	2.73
CO	0.06

Table 10: On-Road Vehicles Ozone Forming Potential Emissions Statewide 2015 (Tech 1-5, GVW < 10,000 lbs)

(a) Baseline Gasoline Containing MTBE

Pollutant	Emissions (tpd)*	MIR (tons O3/ tons TOG)	OFP (tpd)
Exhaust TOG	156	4.01	627
Evap TOG:			
Diurnal/Resting	60	2.74	164
Hot Soak	39	3.12	121
Running Loss	107	2.73	292
Carbon Monoxide	3,082	0.06	185
T o t a l			**1,389**

(b) Current In-use Gasoline Containing Ethanol

Pollutant	Emissions (tpd)*	MIR (tons O3/ tons TOG)	OFP (tpd)
Exhaust TOG	156	4.01	627
Evap TOG:			
Diurnal/Resting	69	2.74	189
Hot Soak	40	3.12	125
Running Loss	109	2.73	297
Carbon Monoxide	3,082	0.06	185
T o t a l			**1,422**

*Source: EMFAC2007, including permeation

There are five emission categories in the reactivity weighted hydrocarbons model: exhaust CO, exhaust hydrocarbons, diurnal and resting loss, hot soak,

and running loss emissions. Table 11 shows the weighting factors for these five emission categories in 2015.

Table 11: Weighting Factors for Reactivity-Weighted Hydrocarbons Statewide 2015 (GVW < 10,000 lbs)

Pollutant	Weighting Factors
Exhaust TOG	0.0454
Evap TOG:	
Diurnal/Resting	0.0174
Hot Soak	0.0113
Running Loss	0.0310
CO	0.8949
Total*	1.0000

Source: EMFAC2007
*May not add to 1.0000 due to rounding

4. Add New Motor Vehicle Exhaust Emissions Test Data

The Predictive Model is based on thousands of individual emissions tests showing how the exhaust emissions change with changing fuel properties. Since the last model update in 1999, there have been a number of additional tests conducted. This section describes the new data sets and how these new data sets were used.

The CaRFG2 Predictive Model was constructed from about 7,000 data points that were compiled from 20 vehicle/fuel studies. These studies involved 250 different fuels and over 1,000 California certified vehicles. The effect of fuel properties on emissions is a function of emissions control technology. As a result, separate equations were developed within the Predictive Model to take into account these differences. Due to limited testing of other vehicle types, the CaRFG2 Predictive Model developed in 1994 included equations for Tech 3 and Tech 4 vehicles only.

In 1999, the Predictive Model was revised and updated as part of the effort to reflect new data, facilitate the removal of MTBE from California gasoline, and increase flexibility to use ethanol while preserving the emission benefits of the CaRFG2 program. Several new studies were added to the CaRFG2 database and reflected in the model. These studies formed the basis for the addition of Tech 5 group in the CaRFG3 Predictive Model (Appendix B)

a. New Tech 5 Test Results

In the current rulemaking, staff proposes to add about 1,000 new observations to the current database to update the CaRFG3 Predictive Model. Table 12 presents a summary of the Predictive Model database. The new datasets reflect emissions testing of fuels in Tech 5 vehicles, ranging from low emission vehicles (LEV) to super low emission vehicles (SULEV). The new data are weighted more toward LEVs and limited to several fuel property effects, such as oxygen and sulfur, that most impact Tech 5 vehicle emissions. A summary of the new datasets added to the Predictive Model database is presented in Table 13. Details of staff's work on statistical modeling are given in Appendix D.

Table 12: Summary of CaRFG Predictive Model Database

Description	CaRFG2 (Adopted 1994)	CaRFG3 (Adopted 1999)	Revised CaRFG3 (Being Proposed)
# Studies	20	35	40
# Observations	6,900	9,000	10,000
# Fuels	250	290	320
# Vehicles	1,100	1,280	1,320
Vehicle Added (Model Year)	California Certified (1981-1992)	California Certified (1983-1997)	California Certified (1998-2003)

Table 13: New Tech 5 Datasets Added to the Predictive Model

Study	Emission Class (MY)	# Observations	# Cars	# Fuels
AAM/AIAM/Honda	LEV, ULEV, SULEV (MY Unknown)	323	13	6
Toyota	LEV, TLEV, ULEV (MY Unknown)	33	9	2
CRC E-60	LEV, ULEV, SULEV (2000-2001)	201	14	3
CRC E-67	LEV, ULEV, SULEV (2001-2003)	326	12	12
ExxonMobil	LEV, ULEV (1998-1999)	42	5	4

b. Tech 5 Response to Sulfur

In the CaRFG3 Predictive Model, the emissions response of Tech 5 vehicles to sulfur was based on a limited data set. The modeled emissions response to changing sulfur concentrations for the Tech 5 vehicles was based on the two studies available at that time: "AAMA/AIAM Study on the Effects of Fuel Sulfur on Low Emission Vehicle Criteria Pollutants (1997)" and "CRC Sulfur/LEV Program (CRC E-42, 1997)". In the current update, two more sulfur studies have been added to the Predictive Model database: "Sulfur Oxygen Vehicle Emissions Test Program (AAM/AIAM, 2001)" and "The Effect of Fuel Sulfur on NH3 and Other Emissions from 2000-2001 Model Year Vehicles (CRC E-60, 2003)."

Staff believes these two later studies are much more relevant to both the actual California vehicle mix and in-use fuels and is, therefore, proposing to only use these two studies to estimate the average Tech 5 vehicle response to changes in fuel sulfur concentrations in 2015. Our rationale is based on several considerations. Staff believes that using all four datasets to calculate the Tech 5 portion of the Predictive Model would significantly over represent the LEV I and earlier vehicle emissions control technologies.

Table 14 summarizes the Tech 5 vehicles included in all four studies and the range of fuel sulfur content. Unlike the two earlier studies, the two new studies included testing with fuel sulfur levels in the CaRFG3 range of sulfur concentrations; that is, 0 to 30 ppmw. The average sulfur concentration in California for CaRFG3 is about 10 ppmw. Use of the previous studies necessitated extrapolation of data from levels many times higher that the CaRFG3 cap limit and was based on an assumption that responses to sulfur at very low levels is the same as that at high levels.

Table 14: Tech 5 Vehicles by Emissions Control Technology and Sulfur Levels Tested

Study	# Vehicles						S Levels Tested (ppmw)	# Obs
	LEV 1 and older	ULEV 1	SULEV 1	Euro 3	LEV 2	Tot		
Existing Studies:								
AAMA/AIAM Study (1997)	21	0	0	0	0	21	40 - 600	105
CRC Sulfur/LEV Program (1997)	22	0	0	0	0	22	30 - 630	168
New Studies:								
AAM/AIAM Study (2001)	10	3	0	0	0	13	1 -100	65
CRC E-60 (2003)	4	6	2	2	0	14	5 - 150	84

The older two sulfur studies, which focused on the early LEV emission control technologies, included about 43 different vehicle identifiers and about 275 observations. The two newer studies focused on a much broader range of vehicle emissions control technologies, including LEV, ULEV, and SULEV, and contained only about half the number of vehicles (27) and observations (150). Using the combined dataset biases the results of the sulfur effect towards the dataset dominated by over 80 percent LEV I vehicles and earlier emission control technologies. Using the data on the sulfur effects from the two newer studies leads to a dataset with about 50 percent LEV Is and earlier emissions control technologies, with the rest being made up of ULEV and SULEVs.

By 2015, as shown in Table 15, emissions in Tech 5 will be dominated by LEV I and newer technology vehicles. The table presents the predictive proportions of vehicle population, vehicle-miles-traveled (VMT), and NOx emissions for the Tech 5 vehicle group in 2015 based on EMFAC 2007. Only about 25 percent of the vehicles on the road in 2015 are projected to have LEV I or earlier emissions control technologies. The majority of vehicle population and VMT is associated with the newer or more advanced technology vehicles (i.e. lowest emission technologies). It is these advanced technology vehicles that are more sensitive to sulfur, that should be represented in the Predictive Model to properly reflect sulfur level effect on their high control efficiencies. This is also critical for enabling even more sophisticated vehicle technology that are about to be introduced, such as lean burn gasoline engines.

Table 15: Tech 5 Vehicles (1996 or newer, GVW < 10,000 lbs.)
2015 Statewide

Emissions Control Technology (NOx Standard, g/mi)	2015 (%)		
	Population	VMT	NOx Emissions
Older Tech (1 or greater)	4.9	3.1	17.0
Early LEVs			
TLEV (0.2 PC/LDT; 0.7 Others)	0.4	0.2	1.2
LEV I (0.2 PC/LDT; 0.6 Others)	19.7	14.9	44.0
Subtotal	**20**	**15.1**	**45.2**
ULEV (0.2 PC/LDT; 0.4 Others)	3.3	2.5	7.4
LEV II (0.07 PC/LDT; 0.2 Others)	17.1	17.5	10.7
ULEV (0.07 PC/LDT; 0.2 Others)	15.1	16.8	8.5
SULEV (0.02 PC/LDT; 0.1 Others)	34.5	38.9	9.9
PZEV (0.02 PC/LDT; 0.1 Others)	5.1	5.9	1.2
Subtotal	**75.1**	**81.6**	**37.7**
T o t a l*	**100**	**100**	**100**

Note: 2015: Pop = 24 million (90% of Tech 3-5); VMT = 875 million mi/d (94%); NOx = 175 tpd (62%)
*May not add up to 100 due to rounding errors

Table 16 combines Tables 14 and 15 together to illustrate the emission inventory breakdown and the vehicle study breakdown in terms of LEV and earlier technology and ULEV and newer technology. This table clearly illustrates that if all 4 studies are included in the sulfur response, this approach disproportionately represents early LEVs and other older technology 81 percent to 19 percent for the newer technology, where the LEVs and earlier technology represent only 25 percent of the estimated vehicle population. The inclusion of just the two new studies better represents the future California vehicle population. Using all four studies to the sulfur response skews the response towards early LEVs and other older technologies. Successive years after 2015 would continue to see the older technologies disappear from the vehicle population and the newer technology vehicle population increase. As a result, staff concluded that the two most recent studies best represent the emission response in the expected fleet composition in 2015 and beyond.

Table 16: Summary of Sulfur Studies

Vehicle Emission Control Technology	2015 California Vehicle Population (%)	2015 VMT (%)	2015 NOx Emissions (%)	All 4 Studies Vehicle Breakdown (%)	2 New Studies Vehicle Breakdown (%)
≤ LEV	25	18	62	81	52
≥ ULEV and LEV II	75	82	38	19	48

Recent conversations with representatives of the automobile manufacturers further support the premise that the NOx emissions from the newer vehicle emission control technologies are expected to be more sensitive to changes in sulfur concentration than the older Tech 5 vehicles. To investigate this differential, staff estimated the reduction in NOx emissions associated with reducing fuel sulfur levels from 20 ppmw to 10 ppmw with three different datasets of Tech 5 sulfur data: the two older datasets, all four datasets combined, and the two newer datasets. Table 16 presents the results of this analysis.

As shown in Table 17, the percent change in NOx emissions associated with reducing fuel sulfur levels from 20 ppmw to 10 ppmw is significantly larger for the vehicles in the two newer datasets (-6.2 percent) than the older datasets (-2.9 percent) or the combined datasets (-3.0 percent). This result is consistent with the information provided by representatives of the automobile industry. When all four datasets are combined, the response is very similar to the response from using only the two older datasets. Staff believes that this occurs because the two older datasets have significantly more observations across a much wider range of sulfur levels, well above the CaRFG3 sulfur cap limit. Staff believes the preponderance of LEV I vehicles and vehicles with earlier emission control technologies, along with the assumption that the sulfur response is linear from very high to very low levels, are "masking" the response from the newer vehicles in the two new studies. Therefore, staff believes that the best way to model the likely NOx response to changes in sulfur level for the Tech 5 vehicles in 2015 is to use only the two newer datasets.

Table 17: Estimated Tech 5 NOx Response Associated with Changing Fuel Sulfur Levels from 20 to 10 ppmw (All Other Fuel Properties @ Flat Limits)

Studies (Year)	Percent Change in NOx Emissions
AAMA/AIAM Study (1997); CRC Sulfur/LEV Program (1997)	-2.9
AAMA/AIAM Study (1997); CRC Sulfur/LEV Program (1997); AAM/AIAM Study (2001); CRC E-60 (2003)	-3.0
AAM/AIAM Study (2001); CRC E-60 (2003)	-6.2

To gain an additional perspective on this issue, ARB staff compared these results to results that recently became available from a joint U.S. EPA/Automobile Industry study of fuel effects in federal Tier 2 vehicles. In this study, nine Tier 2 compliant vehicles, MY 2004-2007 meeting approximately the Tier 2 Bin 5 emission standards (NOx limit of 0.07 grams per mile equivalent to LEV II standards) were tested on chassis dynamometers at three industry labs and the U.S. EPA's National Vehicle Fuels and Emissions Laboratory. These vehicles were equipped with laboratory-aged catalysts to simulate a service life of approximately 120,000 miles.

One of the comparisons was between a fuel with 6 ppmw sulfur and the same fuel with the sulfur level increased to 32 ppmw. The results of this comparison indicate that increasing the sulfur level from 6 ppmw to 32 ppmw increased NOx emissions by about 45 percent. Further, these results indicate that, for the sampled fleet, decreasing fuel sulfur levels from 20 ppmw to 10 ppmw would lead to about a 14 percent reduction in NOx emissions. The U.S. EPA results are consistent with the staff conclusion that the Tech 5 emissions/sulfur response is best modeled using the two newer datasets.

For a comparison, staff calculated the percent change in NOx emissions for changes from 20 ppmw to 10 ppmw if the existing sulfur studies results (i.e. LEV and earlier technology vehicle studies) were combined with the U.S. EPA results (i.e. ULEV and newer technology). Table 18 shows these calculated results. Combining the existing studies and U.S. EPA's results showed a decrease of NOx emissions by about seven percent. This closely follows the six percent NOx emissions decrease estimated by the two most recent sulfur studies. Whereas the two exiting studies and the two recent studies combined gave a three percent NOx emissions decrease.

Table 18: Estimated Tech 5 NOx Response Associated with Changing Fuel Sulfur Levels from 20 to 10 ppmw for U.S EPA and Existing Studies Combined

Studies	Emission Control Technology in studies	EMFAC NOx Emissions	Percent Change in NOX Emissions	Weighted Percent Change in NOX Emissions
AAMA/AIAM Study (1997); CRC Sulfur/LEV Program (1997)	≤ LEV	0.62	-3	-1.86
U.S. EPA	≥ ULEV	0.38	-14	-5.32
		Total NOx Emission Change		**-7.18**

5. Update the Effect of Carbon Monoxide on Ozone-Forming Potential

Staff proposes to update the methods used for estimating the effect of changing fuel properties on CO in the reactivity adjusted hydrocarbons portion of the Predictive Model. The current model only uses changes in oxygen level to calculate changes in CO emissions. The staff proposes to use a new model that accounts for all seven properties. This modeling approach for CO follows the approaches taken for the exhaust HC and NOx models.

B. Add an Alternative Emissions Reduction Plan

1. Description of the Alternative Emissions Reduction Plan

The staff is proposing to add a new provision that would allow producers to use an approved Alternative Emissions Reduction Plan (AERP) for a limited time. An AERP would allow a producer the option of creating emission reductions from other sources to fully mitigate any emissions increase from permeation not otherwise mitigated from the producer's fuel formulation. The AERP would not enable the producer to avoid meeting the majority of the CaRFG3 requirements; the producer would still have to comply with the non-permeation portion of the Predictive Model.

The addition of an AERP would enable mitigation of ethanol permeation effects more expeditiously and increase flexibility for producers to comply with the requirement to mitigate any increase in emissions associated with the use of ethanol blends. Producers will be required to certify fuel formulations that mitigate the increase in permeation emissions starting in December 31, 2009. Some producers may find it difficult to produce the desired amount of complying fuel without significant production facility and/or infrastructure modifications. The

AERP option is proposed to be available to producers from December 31, 2009 until December 31, 2011. This will allow producers four years to produce fuels that will offset the permeation impact of ethanol. Permeation emissions will have to be compensated for during the RVP regulatory period. Producers typically begin producing summer CaRFG blends beginning March 1 to comply with the RVP regulatory period. The RVP regulatory period typically begins in April and ends in October. The RVP regulatory period varies slightly in each air basin. (See page 26, section 2262.4 of the CaRFG regulations for explicit dates.)

Staff is also proposing to allow producers to apply for a one year extension should circumstances warrant an extension. For small refiners, staff also proposes that a small refiner using the small refiner provisions be allowed to use the AERP option indefinitely.

The proposed AERP requires that all emission reductions used in an AERP must come from combustion or gasoline related emission sources, such as motor vehicles, stationary or portable engines, off-road equipment, or portable fuel containers. A producer could not use emission reductions that are created at other types of sources or which are required through other programs. An AERP may not include emission reductions that may be part of on-going business practices. The producer would also need to show that emission reductions from an AERP occur in the same general region that the producer distributes fuel. The emission reductions must coincide within the applicable time period for the AERP. Emission reductions may not be banked for future time periods.

The main focus of the AERPs will be to mitigate NOx and hydrocarbons. Air toxics are not a focus of the AERP because staff believes that air toxic emissions will track OFP and NOx and separate actions are not required.

2. Description of the Alternative Emissions Reduction Plan

A producer will enter the desired fuel formulation into the Predictive Model and calculate the necessary OFP and NOx emissions that must be offset through an AERP from the emission debits predicted. The producer will then describe and demonstrate the type of program that will provide the necessary emission credits to offset the debit of emissions produced by the fuel formulation.

The AERP approval process would require a refiner to submit an application that would provide the following information:

- The company name, address, phone number, and contact information,
- The producer's or importer's name, batch name, number or other identification, grade of California gasoline, and other information that uniquely identify the California gasoline subject to the AERP,

- An explanation describing why the producer or importer cannot eliminate the emissions associated with permeation by reformulation or reprocessing its gasoline,
- The total emissions of oxides of nitrogen (NOx), total ozone forming potential, and potency-weighted toxics that would be associated with the use of California gasoline were the producer or importer to eliminate the emissions associated with permeation from its gasoline,
- Documentation, calculations, emissions test data, or other information that establishes the amount of NOx and associated with the producer's or importer's gasoline,
- The emission reduction strategy(ies) for the AERP and the date(s) that the offsets will accrue and expire for each strategy,
- The applicant's market share for the fuel produced under the AERP,
- Demonstration that the emission reduction strategy(ies) in the AERP will result in equivalent or better emission benefits for NOx, total ozone forming potential, and potency-weighted toxics than would be achieved through elimination of emissions associated with permeation from the gasoline for the same affected region and for the period the AERP will be in effect, during and outside the RVP regulatory control periods in section 2262.4(b)(2),
- Demonstration that the emission reductions are achieved in the general region where the fuel is sold,
- The proposed recordkeeping, reporting, monitoring, and testing procedures that the applicant plans to use to demonstrate continued compliance with the AERP and achievement of each increment of progress toward compliance,
- Adequate enforcement provisions,
- For each final blend of California gasoline to which the AERP applies, the NOx, total ozone forming potential, and potency-weighted toxics emission limits during the period the AERP will be in effect,
- The projected volume of each final blend of California gasoline subject to the AERP during the period the AERP will be in effect,
- The period that the AERP will be in effect,
- A compliance plan that includes increments of progress (specific events and dates) that describe periodic, measurable steps toward compliance during the proposed period of the AERP,
- The date by which the producer or importer plans to discontinue using the AERP,
- A statement, signed by a legal representative for the producer or importer that all information submitted with the AERP application is true and correct, and
- The producer's or importer's agreement to be bound by the terms of the AERP.

Once the staff determines that the submitted application is complete, the application package will be made available to all interested parties for public

comments for a period of 30 days. An optional public meeting may be held to accept public comment on the application. After the 30 day comment period, the executive officer will either approve or deny the application. The notice of approval or denial will then be made available to interested parties.
A producer using the AERP would have to submit an update on progress towards compliance each year the AERP is in effect.

3. AERP Examples

This section provides two examples of how an applicant might calculate the amount of mitigation necessary to offset excess emissions not mitigated through fuel formulations. This section also provides example costs that may occur if accelerated vehicle retirement were used in an AERP. The first example shows the amount of mitigation required and the associated AERP costs if a producer uses the flat limits for their fuel formulation and does not choose to mitigate any increased permeation emissions through an alternative fuel formulation. The second example shows the mitigation requirement and AERP costs for the situation where a producer chooses to mitigate some of the increased emissions using an alternative fuel formulation. In the second example, the basic fuel formulation is the same except the oxygen content is increased from 2.0 percent by weight to 3.5 percent by weight and the sulfur content is decreased from 20 ppmw to 10 ppmw.

To determine the amount of mitigation required, the following equations can be used:

$$\text{OFP mitigation} = \frac{\Delta OFP}{2.39} * 18.4 * MarketShare\% * 2.80$$

$$\text{NOx mitigation} = \frac{\Delta NOx}{100} * 427.8 * MarketShare\%$$

Where:

- OFP mitigation = amount of ozone forming potential that must be mitigated by the AERP in tons per day
- NOx mitigation = amount of oxides of nitrogen that must be mitigated by the AERP in tons per day
- ΔOFP = percent change in ozone forming potential output from Predictive Model. This is variable and is dependent on the fuel formulation entered into the Predictive Model.
- ΔNOx = percent change in NOx output from Predictive Model. This is variable and is dependent on the fuel formulation entered into the Predictive Model.
- MarketShare% = individual producer's market share expressed as a percentage of gasoline supplied to California that is subject to the AERP.

- The evaporative hydrocarbons due to permeation are based on the emissions inventory year of 2010 and are equal to 18.4 tons per day. This is a constant.
- The NOx emissions are also based on the emissions inventory year of 2010 and are equal to 427.8 tons per day. This is constant
- The 2010 emission inventory was used because the AERPs would most likely be between in 2009 and 2012.
- The calculated average maximum incremental reactivity factor or evaporative emissions is 2.80. This is a constant

a. Example 1 – All Mitigation Provided Through the AERP

Assume a producer is responsible for eight percent of the gasoline supplied in California and decides to produce gasoline at the CaRFG3 flat limits while improvements are being made to meet the December 31, 2011 deadline for compliant gasoline. The following analysis shows the amount and cost of emissions reductions that must be mitigated by an AERP. Table 19 shows the output from the revised predictive model in a producer or refiner enters the CaRFG3 flat limits for the eight specified fuel properties.

Table 19: Example 1 - Flat Limit Fuel Percent Change in Emissions Output from the CaRFG3 Predictive Model

Predictive Model Results	Percent
%Change in NOx Emissions (ΔNOx)	0.00
%Change in Ozone Forming Potential (ΔOFP)	2.39

Using mitigation equations, the amount of mitigation required by the AERP can be calculated as shown below:

$$\frac{2.39}{2.39} * 18.4 * 0.08 * 2.80 = 4.12 \text{ tpd of OFP}$$

$$\frac{0.00}{100} * 427.8 * 0.08 = 0.00 \text{ tpd of NOx}$$

As shown above, the producer would be required to obtain 4.1 tons per day of hydrocarbons emission reductions.

Staff used the ARB report, The Carl Moyer Program Guidelines, 2006 Project Criteria for Light-Duty Vehicles to determine emission benefits from the use of the accelerated vehicle retirement. Table 20 below shows the amount of emissions reductions for the retirement of model year vehicles between the years

1980 and 1985. Staff is assuming that the vehicles that will be retired will be from vehicles that are from model years 1980-1985.

Table 20: Accelerated Vehicle Retirement Emissions Reductions (Total Pounds per Vehicle over 3 Years Credit Life)

Model Year	Emissions Reductions Per Vehicle (lbs/Vehicle over 3 years)						
	Total ROG	NOx	CO	PM10	ROG Exhaust	ROG Evap	OFP [1]
80	122	74	1,195	0.74	58	64	484
81	104	56	928	1.00	45	59	402
82	102	60	912	0.92	43	58	390
83	93	63	791	0.84	34	58	347
84	100	63	751	0.84	32	68	364
85	95	57	499	0.89	25	70	327

[1] OFP is calculated as (CO)*(CO MIR)+(ROG Exhaust)*(ROG Exhaust MIR)+(ROG Evap)* (ROG Evap MIR), where CO MIR= 0.06, ROG MIR=4.01, ROG Evap MIR=2.80

To determine number of vehicles needed to be retired to offset the emissions not mitigated by refiner X's fuel formulation, we first need to calculate the average OFP and NOx emission reduction values for vehicles that would be retired in tpd. We begin by determining the average emissions reductions for NOx and OFP in pounds per year (lbs/yr).

$$\text{Average OFP (1980-1985)} = \frac{484+402+390+347+364+327}{5} = 385 \text{ lbs/3yr}$$

$$= \frac{385}{3} = 128 \text{ lbs/yr}$$

$$\text{Average NOx (1980-1985)} = \frac{74+56+60+63+63+57}{5} = 62$$

$$= \frac{62}{3} = 21 \text{ lbs/yr}$$

Next we convert lbs/yr to tpd:

$$\text{OFP emission reductions} = 128 \text{ lbs/yr} * \frac{1ton}{2000lbs} * \frac{1yr}{365days} = 1.75\text{e-}4 \text{ tpd}$$

To determine the number of vehicles needed to offset the emissions not mitigated by refiner X's fuel formulation we divide the OFP mitigation by the OFP emission reductions.

$$\text{Number of retired vehicles needed} = \frac{4.12}{.000175} = 23{,}543 \text{ vehicles}$$

Table 20 shows the estimated costs and cost per gallon that a producer could incur in an example where all of the emissions increases associated with permeation are mitigated with an AERP. In this example, an accelerated vehicle retirement approach was used assuming a total annual gasoline use of 16 billion gallons. Also, the cost was spread over the 3 years life of the emission credit

Table 21 shows the emission mitigation costs for vehicle retirement costs of $500, $750, and $1000. The total costs are estimated to be between $11.8 million to $23.5 million, which equates to about 0.46 to 0.92 cents per gallon over the three year life of the emission credits. Note that this option will lead to an additional reduction in NOx emissions of 0.68 tpd.

Table 21: Estimated Total Costs and Cost Per Gallon to Mitigate Permeation Emissions in Example 1

# of Retired Vehicles	Estimated Vehicle Cost ($)	Total Mitigation Cost ($)	Cost Per Gallon (cents/gallon)
23,543	$500	$11,800,000	0.3
23,543	$750	$17,700,000	0.5
23,543	$1,000	$23,500,000	0.6

Note: 16 billion gallons was used as the estimated total gasoline consumption in California for this calculation. Also, the cost was spread over the 3 years life of the emission credit.

b. Example 2- Partial Mitigation Provided by the AERP

Again assume that a producer is responsible for eight percent of the gasoline supplied in California. In this example, the producer determines that an alternative fuel formulation using 3.5 percent oxygen (10 percent ethanol) and 10 ppmw sulfur can be produced by December 31, 2009. All the rest of the gasoline properties are the same as in example 1. Refinery modifications are necessary to meet the December 31, 2011 deadline for compliant gasoline. The following example shows the amount of mitigation required to be provided through the AERP. Table 22 presents the predictive model results.

Table 22: Example 2 - Flat Limit Fuel Percent Change in Emissions Output from the CaRFG3 Predictive Model

Predictive Model Results	Percent
%Change in NOx Emissions (ΔNOx)	0.61
%Change in Ozone Forming Potential (ΔOFP)	0.40

Apply the same formulas as in Example 1 and get:

$$\frac{0.40}{2.39} * 18.41 * 0.08 * 2.80 = 0.69 \text{ tpd of OFP}$$

$$\frac{0.61}{100} * 427.8 * 0.08 = 0.21 \text{ tpd of NOx}$$

In this example, the producer would have to provide 0.69 tpd of hydrocarbon emission reductions and 0.21 tpd of NOx through the use of an AERP. To determine the number of retired vehicles needed to offset Example 2, the limiting emission factor must be determined:

$$\text{No. of retired vehicles needed to offset OFP} = \frac{0.69}{.000175} = 3{,}942 \text{ vehicles}$$

$$\text{No. of retired vehicles needed to offset NOx} = \frac{0.21}{.0000287} = 7{,}317 \text{ vehicles}$$

Therefore, the limiting determinant is NOx and 7,317 vehicles would need to be retired to mitigate the emissions from the fuel formulation in Example 2.

Table 22 shows the estimated costs and cost per gallon that a producer could incur in an example where only a portion of the emissions increases associated with permeation are mitigated with an AERP. As with example 1, an accelerated vehicle retirement approach was used assuming a total annual gasoline use of 16 billion gallons. Also, the cost was spread over the 3 years life of the emission credit.

As shown in Table 23, the total costs are estimated to be between $3.7 million to $7.3 million, which equates to about 0.1 to 0.3 cents per gallon depending on the cost to retire a vehicle. This option will lead to an additional reduction in ozone forming potential emissions of 1.04 tpd.

Table 23: Estimated Total Costs and Cost Per Gallon to Mitigate Permeation Emissions in Example 2

# of Replacement Vehicles	Estimated Vehicle Cost ($)	Total Mitigation Cost ($)	Cost Per Gallon (cents/gallon)
7,317	$500	$3,700,000	0.1
7,317	$750	$5,500,000	0.2
7,317	$1,000	$7,300,000	0.3

C. Decrease the Sulfur Cap Limit

Staff proposes to reduce the sulfur cap limit from the current specification of 30 ppmw to 20 ppmw. Cap limits provide an upper limit for fuel properties for all compliance options and allow enforcement of the requirements throughout the gasoline distribution system.

As presented in Chapter II, sulfur levels currently average about 10 ppmw, with 95 percent of production being below 18 ppmw. Staff believes that producers will significantly further reduce the sulfur content of California gasoline to certify gasoline if the proposed revisions are adopted. With the recent implementation of the federal Tier II sulfur rules for gasoline, nationwide gasoline sulfur levels must average less than 30 ppmw with a cap of 80 ppmw. The implementation of the federal Tier II sulfur rules will significantly reduce the historical difference between sulfur levels in California and those seen outside of the State.

Lowering the sulfur cap to 20 ppmw is not expected to significantly affect flexibility to make complying fuels, but will increase the enforceability of the program and help to protect the performance of sulfur-sensitive emissions control components. Staff believes that it will not be practical for producers to certify alternative formulations with sulfur levels above 20 ppmw. Staff believes that the sulfur cap should be set at the lowest level possible that does not significantly reduce production flexibility. From this perspective, the current cap of 30 ppmw is much higher than necessary.

The Alliance of Automobile Manufacturers and individual vehicle manufacturers have indicated that before lean burn gasoline technology can be successfully introduced, they need assurance that sulfur content will be less than 20 ppmw. A sulfur cap of 20 ppmw will provide this assurance. This new technology has the potential to improve the feasibility of gasoline engines that have higher efficiencies and less greenhouse gas emissions per mile traveled.

D. Allow Emissions Averaging for Low Level Sulfur Blends

1. Description of the Emissions Averaging Option

Staff expects producers will very likely change to increase the use of ethanol in gasoline to offset the increase in permeation emissions. The addition of ethanol increases the oxygen content in the fuel blend. While this generally reduces the exhaust emissions of hydrocarbons and carbon monoxide, emissions of NOx increase. In many cases, this increase in NOx would, if not mitigated through some other fuel property, result in a non-complying blend. Staff expects producers to use sulfur as a lever to lower NOx emissions in their fuel formulations. Such action would result in sulfur levels below 10 ppmw in most CaRFG3 formulations.

At these low sulfur levels, the compliance margin for refiners is small and slight unexpected deviations in the refinery process could result in a non-compliant batch due to slightly elevated sulfur. Staff anticipates that it will be very difficult to blend a slightly higher than needed sulfur level batch to a compliant blend using the existing sulfur averaging provisions because it becomes increasingly more and more difficult to average out sulfur when the levels are very near the bottom of the range. Therefore, for a producer that experiences a problem with the sulfur content when blending a particular batch of gasoline, staff is proposing to add a compliance option that would permit that producer to use an averaging option that is based on emissions. The emissions must be mitigated within 90 days by subsequent cleaner than required blends. Any additional emissions reductions achieved under the emissions averaging provision may not be banked. In addition, this emissions averaging option can only be triggered by unexpected high sulfur levels.

Without such a flexibility provision, such batches would likely need to be shipped out-of-state at significant expense and reduction in supplies of available product. Unlike most other fuel properties governed by the CaRFG3 rules, increases in sulfur levels in individual batches do not result in immediate emission increases in vehicles using the batch. Sulfur degrades catalyst performance, but the effect is reversible. Given this situation, staff believe t is reasonable to infrequently allow batches with slightly higher sulfur levels to be used, so long as the emission impacts of the higher sulfur batch are fully mitigated in the near future through subsequent batches.

2. Application Process

If a producer determines that the final batch of gasoline has a sulfur level that is too high to certify, the producer may request to the ARB's Enforcement Division to initiate the emissions averaging option. The producer must demonstrate that there exists a sulfur limit, and other property limits, that would have led to the batch being certified. The calculated emissions percentages for ozone-forming potential, NOx, and potency-weighted toxics for the complying formulation become the reference baseline for estimating the increase in emissions. This reference baseline also becomes the reference point for calculating emissions and volume to be credited against the initial emissions increase. Alternative formulations certified under this provision could not exceed the cap limit for sulfur.

Any producer entering into an emissions averaging option must report all relevant and necessary information to the ARB's Enforcement Division, such as batch number, volume, and alternative formulation and any other information requested by the Enforcement Division. A producer may have subsequent requests to enter into emissions averaging for other batches, but each batch reported as initiating the averaging provision must be fully mitigated within the designated

time limit. This provision requires that the producer maintain some of that fuel in the tank for at least 12 hours after sending the notification to the ARB so that an ARB inspector has the opportunity to sample and test the fuel for compliance.

3. Example of an Emissions Averaging Option

Table 24 provides an example of how the emissions account may be calculated. Column 1 presents the alternative formula that the refiner was targeting; this is the reference batch. Column 2 presents the resulting alternative formulation that would not be certified due to excess emissions associated with higher than intended sulfur concentrations and volume that would be reported to the ARB under the emissions offsetting provisions. Columns 3 through 8 present examples of candidate formulations and volumes that could result in the cumulative emissions being reduced to a level that would terminate the emissions offsetting provision. To generate offsetting emissions reductions the offsetting batches must result in emissions that are less than the reference batch.

Table 24: Example of Emissions Averaging Triggered by an Inadvertently High Sulfur Fuel

	Complying Reference Specs	Non-complying Batch #0 Specs	Offsetting Batch #1 Specs	Offsetting Batch #2 Specs	Offsetting Batch #3 Specs	Offsetting Batch #4 Specs	Offsetting Batch #5 Specs	Offsetting Batch #6 Specs
Volume (gals)	NA	215,000	210,000	220,000	205,000	215,000	210,000	200,000
RVP (psi)	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
T50 (°F)	213	213	213	213	213	213	213	213
T90 (°F)	305	305	305	305	305	305	305	305
Arom. (vol. %)	23	23	21	21	21	21	21	21
Olefin (vol. %)	6	6	6	6	6	6	6	6
O (wt. %), max	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
S (ppmw)	5	10	5	5	5	5	5	5
C_6H_6 (vol. %)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Emissions (percent)								
NOx	-0.03	2.11	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42
O_3 Potential	-0.37	-0.17	-1.01	-1.01	-1.01	-1.01	-1.01	-1.01
Pot. Wt'd Toxic	-2.77	-2.64	-4.03	-4.03	-4.03	-4.03	-4.03	-4.03
Cumulative Emissions (percent)[1]								
NOx	NA	2.14	1.76	1.36	0.99	0.6	0.22	-0.15
O_3 Potential	NA	0.2	-0.43	NA	NA	NA	NA	NA
Pot. Wt'd Toxic	NA	0.13	-1.1	NA	NA	NA	NA	NA

[1] Cumulative Emissions (%) = [Batch #0 Emissions (%) – Reference Emissions (%)] + [Batch #1 Emissions (%) – Reference Emissions (%)] × Batch #1 Volume ÷ Batch #0 Volume+ [Batch #2 Emissions (%) – Reference Emissions (%)] × Batch #2 Volume ÷ Batch #0 Volume+ [Batch #3 Emissions (%) – Reference Emissions (%)] × Batch #3 Volume ÷ Batch #0 Volume

E. Adjust the RVP for Oxygenated Fuels

When non-oxygenated and oxygenated fuels are mixed together in a vehicle fuel tank, the evaporative emissions of the blend increase due to an increase in RVP. This effect is referred to as commingling. In the existing CaRFG3 regulations, provisions were included to help mitigate any commingling that could have occurred as MTBE was phased out. Specifically, the RVP flat limit was reduced by 0.10 psi and set at 6.90 psi for producers that used the evaporative emissions portion of the Predictive Model. However, virtually all gasoline has been blended with ethanol; therefore, the commingling impact has been negligible.

As a result of federal policies requiring ethanol use, and the likelihood that increases in oxygen content will be used to mitigate permeation, staff expects almost all fuel produced in California will continue to be blended with ethanol. Therefore, the required use of 6.90 psi rather than the original 7.00 psi reference level for RVP for ethanol blends is no longer needed. As such, staff is proposing to restore a flat limit of 7.00 psi for blends that use ethanol. This change will provide some additional flexibility for producers while preserving the emissions benefits.

While we expect that gasoline produced in California will be blended with ethanol, it is possible that some amount of non-oxygenated fuels could be introduced in the future. In this case, emissions could increase due to commingling. Therefore, to mitigate any potential increase in emissions associated with the commingling of non-oxygenated fuels with fuels containing ethanol, the non-oxygenated fuels will be required to be based on a flat limit of 6.90 psi RVP.

The staff proposes to keep the cap limit, of 6.40 to 7.20 psi for RVP.

F. Allow Flexibility in Setting the Oxygen Content in the Predictive Model

In the Predictive Model, oxygen is specified in the form of a range. There are usually two candidate fuel specifications for oxygen, the upper end of the range (maximum) and the lower end of the range (minimum). This is to allow for variation in the blending of ethanol into CaRFG. The weight of oxygen being added depends on the density of the CaRFG the ethanol is being added to and this varies from batch to batch. Usually, this range represents the reproducibility of the test method for oxygen which is 0.4 percent by weight. If the oxygen range of the candidate fuel specifications is within the range of 1.8 to 2.2 percent, and 2.5 to 2.9 percent, and 3.3 to 3.7 percent by weight, the oxygen content of the candidate fuel specifications is assumed to be 2.0 percent, 2.7 percent, and 3.5 percent by weight respectively. Producers can enter any range they choose but the wider the range, the more difficult it is to produce complying fuels.

Staff proposes to allow the candidate fuel specification for oxygen to be evaluated at the midpoint of the minimum and the maximum oxygen values entered into the Predictive Model if the range between the minimum and the maximum oxygen value is 0.4 percent or less, the reproducibility of the test method. Also, this allows for some variation in the densities of the different batches of CaRFG. Without this allowance it would be necessary to determine the density before a volume of ethanol could be determined to supply a known weight percent of oxygen to CaRFG. It is the weight percent of oxygen that determines the emissions impact of the oxygenate.

G. Increase the Maximum Allowable Amount of Denaturant

A denaturant is added to ethanol to ensure that it cannot be ingested. It also allows for ethanol to be transported and handled as an industrial fluid rather than a controlled substance which would place it under supervision and control of the Bureau of Alcohol Tobacco and Firearms (BATF). Typical denaturants include natural gas oils, diesel and natural gasoline. The CaRFG3 specifications (Title 13, California Code of Regulations, section 2262,9) include a requirement that all reformulated blendstocks for oxygenate blending contain no more than 4.76 percent by volume denaturant. This specification is based on earlier versions of the American Society of Testing and Materials (ASTM) standard specification for denatured fuel ethanol for blending with gasoline (ASTM D4806-99).

Upon consulting with the Bureau of Alcohol, Tobacco and Firearms (BATF) and the Internal Revenue Service (IRS), the maximum amount of denaturant has been increased to 5.00 percent by volume. Therefore, staff proposes to change the maximum denaturant content specification in section 2262.9 from 4.76 percent by volume to 5.00 percent by volume to be consistent with the recent change and to update the appropriate references to the latest ASTM specification (ASTM D4806-06c) which reflects the new federal limit. This change will align California fuel regulations with federal fuel regulations, and will create less confusion to suppliers. As a result, the proposed amendment will increase the supply of denatured ethanol available to be imported into California.

H. Adoption of the Current Version of ASTM D4815-04

Section 2263(b) lists ASTM D4815-99 as the test method for determining the oxygen content, ethanol content, MTBE content, and oxygenate content of gasoline. The designation "-99" means the 1999 version of the test method. Every 5 years, or sooner when the need arises, ASTM reviews its test methods and either amends or re-approves them. Staff proposes to change the test method to the current version (the 2004 version) which is labeled ASTM D4815-04.

I. Implementation of the Proposed Amendments

Staff is proposing that the proposed amendments would affect fuels produced on or after December 31, 2009. Producers that are unable to fully comply through the use of the Predictive Model may choose to offset any unmitigated permeation emissions associated with ethanol in gasoline through the use of an Alternative Emissions Reduction Plan. Starting December 31, 2011, producers will be required to fully offset the increase in emissions associated with ethanol in gasoline through the use of the Predictive Model. As mentioned above, the staff is proposing to allow a one year extension provided that any emissions increases associated with permeation are mitigated through an approved AERP. In addition, the start has added provisions that allow for early use of the new Predictive Model under specified conditions.

Chapter IV. Economic Impacts of the Proposed Amendments

This chapter presents a summary of potential effects of the proposed amendments on the production of CaRFG3 and an analysis of the costs to produce CaRFG3 gasoline in compliance with the proposed amendments. In addition, the chapter outlines potential economic impacts on businesses and consumers.

Health and Safety Code section 43013.1(b)(1) requires that CaRFG3 preserve the emission benefits of CaRFG2. The proposed amendments will result in the emissions reductions necessary to preserve the benefits associated with the use of CaRFG3 in on-road motor vehicles. The proposed amendments will require producers to mitigate the increase in evaporative emissions from permeation from on-road motor vehicles either through the use of a revised and strengthened Predictive Model or an Alternative Emissions Reduction Plan. The increase in permeation emissions associated with ethanol is estimated to be about 18.4 tpd in 2010, 12.1 tpd in 2015, and 8.1 tpd in 2020. To mitigate these emissions through the use of the Predictive Model, staff believes that producers will likely reduce sulfur levels, increase oxygen levels, and reduce vapor pressure levels of the blends.

A. Effects of the Proposed Amendments on the Production of CaRFG3

The proposed amendments to the Predictive Model ensure previous air quality benefits achieved from the CaRFG program will be restored, at least as they relate to on-road motor vehicle emissions. The proposed Predictive Model now accounts for potential increases in evaporative permeation emissions from the presence of ethanol in gasoline. Based on our current assessment, gasoline ethanol formulations blended to existing flat limit specifications will exceed allowable potential emission increases.

The proposed revisions would require all production of CaRFG that includes ethanol to be formulated with the Predictive Model. The existing flat limits did not consider permeation for gasoline blended with ethanol. However, these flat limits would serve as a baseline to ensure benefits of CaRFG2, other than permeation, are preserved.

Table 25 lists several fully compliant potential future in-use alternative gasoline formulations capable of fully mitigating on-road permeation emissions using different oxygen levels of 0, 2, 2.7 and 3.5 percent by weight. Staff chose the listed formulas to demonstrate the types of blends that can pass the proposed Predictive Model. The formulas were chosen to keep as many of the fuel properties near the average current in-use fuel properties as possible. The 3.5% oxygen content (10% ethanol) fuel required the least adjustment from the average current in-use fuel properties.

Table 25: Candidate Alternative Gasoline Model Formulations for Summertime Gasoline

Property (units)	Percent Ethanol			
	0.0%	5.7%	7.7%	10.0%
RVP* (psi)	6.60	6.91	6.92	6.99
T50 (deg. F.)	204	206	209	212
T90 (deg. F.)	315	310	313	313
Aromatic (vol.%)	25.0	25.0	25.0	25.0
Olefin (vol.%)	8.0	9.0	9.0	6.0
Total Oxygen (wt. %**)	0.0	2.0	2.7	3.5
Sulfur (ppmw)	5	5	5	5
Benzene (vol.%)	0.50	0.50	0.50	0.50
CaRFG3 Predictive Model Criteria	% Change in Emissions			
Ozone Forming Potential	-0.67	-0.38	-0.59	-0.05
Predictive Model (Pass/Fail)	Pass	Pass	Pass	Pass
% change in emissions must be < 0.04% to Pass.				
* In wintertime season (11/1 thru 2/29), there is no RVP control.				
** If wintertime season, then minimum oxygen content in ozone non-attainment area = 1.8 wt. %				
***OFP is the must limiting performance requirement				

Gasoline blends are not limited to the combinations listed above. The table is intended to demonstrate that a wide variety of California gasoline formulations can comply if the proposed Predictive Model is adopted. Producers are allowed to vary gasoline blend components as long as the product meets California requirements.

B. Costs to Produce CaRFG3 Gasoline Fuel

Based on conversations with producers, pipeline distributors, CEC staff, and other stakeholders, staff estimates that, collectively, producers will incur capital expenditures of approximately $200 million to $400 million. The cost depends on the investment choices the producers make to comply with the proposed amendments and produce CaRFG3 gasoline.

As shown in the previous section, to produce CaRFG3 gasoline with the proposed amendments, producers will most likely choose to blend in higher

amounts of ethanol and decrease sulfur levels in their formulations to mitigate permeation, while still meeting required performances for NOx. Therefore, the majority of the capital expenditures are expected to go towards removing sulfur from the gasoline. These investments include increasing hydrotreating or alkylation capacity by expansion or addition of new units. These capital expenditures are considered one-time costs that will most likely be recovered over a period of time. To estimate the annualized capital costs, staff has assumed a recovery period of 10 years at an interest rate of seven percent per year. Thus, the associated annualized capital recovery cost of the proposed amendments can be determined according to the following equation:

Capital Recovery Cost = (Capital Cost) x (Capital Recovery Factor)

Where:

Capital Cost = $200 million to $400 million
Capital Recovery Factor = 14.2% (7% per year over 10 years)

This value, calculated to range from $28 to $57 million, represents the annualized capital cost to producers to upgrade producer facilities to comply with the proposed amendments.

Along with the initial capital investment, annual operating and maintenance (O&M) costs must also be considered. Usually, these are costs associated with labor, material (such as catalysts, etc.), sulfur disposal, maintenance, insurance, and repairs associated with the new or modified equipment. Staff conservatively estimated O&M costs based on the economic analysis preformed in the "Proposed Amendments to the California Diesel Fuel Regulations Staff Report: Initial Statement of Reasons (June 6, 2003)." This analysis showed that annual O&M costs would range from 10% to 20% of the capital expenditure. The O&M costs are estimated to collectively range from $20 to $80 million per year for producers.

Total annualized statewide refinery costs can be determined according to the following equation:

Annualized Statewide Refinery Cost = (*Capital Recovery Cost*)
+ (*Annual O&M Cost*)

Using this equation, the annualized statewide refinery costs of the proposed amendments are estimated to range from about $48 to $137 million.

To determine the per gallon annualized statewide refinery costs, staff used the 2005 California gasoline consumption data of approximately 15.9 billion gallons and an annual growth factor of 1 percent to grow California gasoline consumption

to a 2010 level of about 16.5 billion gallons. Staff estimates that the annualized CaRFG production costs will be about 0.3 to 0.8 cent per gallon.

C. Ethanol Costs to Refiners

About 900 million gallons per year of ethanol is currently used in CaRFG3. The proposed amendments are expected to increase ethanol consumption in California from 300 to 600 million additional gallons per year, at an estimated cost of $600 to $1,200 million annually based on average spot market prices and ethanol subsidies. Note that the producers would most likely have met most of their ethanol needs via contracts, often at much lower costs than spot prices.

However, the use of ethanol will displace an equal volume of gasoline blendstocks, and therefore, the costs must be compared to the costs of equivalent volumes. On average, ethanol costs have, after adjusting for the favorable tax treatment given to ethanol, been lower per gallon than gasoline blendstocks. Provided this price advantage continues, staff expects there to be a small cost advantage to using ethanol relative to gasoline production based on the spot market prices of gasoline.

D. AERP Option Costs

Staff believes that the new alternative compliance options will not result in a significant increase in cost to producers compared to simple compliance with the proposed rule. In fact, the increased number of options will likely result in a decrease in cost for some producers to the extent that the compliance option is used. Staff calculated the potential costs to the industry if all participants used an accelerated vehicle retirement program for an AERP. This calculation is very similar to that shown in Example 1 from Chapter III, except the market share used in the calculation was 100 percent. It would take approximately 290,000 retired vehicles to offset the 18.4 tpd of HC or 51 tpd of OFP. At a cost of $750 per vehicle, the total AERP cost would be about $220 million. Taking into account the credits are good for 3 years and spreading the cost over 16 billion gallons of gasoline consumed a year in California leads to refiner costs of about 0.5 cent per gallon. This estimate could be substantially higher or lower depending on the funding needed to scrap vehicles.

E. Ethanol Fuel Economy Penalty

There is a fuel economy penalty associated with increasing ethanol in gasoline. Ethanol has about 31 percent less energy per gallon than reformulated gasoline. Therefore, increasing the amount of ethanol in gasoline decreases the energy density of the blend and ultimately the fuel economy of the vehicle. A 0.7 percent fuel penalty occurs in switching from a fuel containing about 5.7 percent by volume (E6) to a blend containing 7.7 percent by volume (E8); similarly, switching from an E6 fuel to a fuel that contains 10 percent by volume ethanol

results in a 1.3 percent fuel economy penalty. For a typical consumer that drives 15,000 miles per year in a car with a fuel economy of 20 miles per gallon and gas prices at $3.00 a gallon, the effective cost of going from E6 to E8 will be 0.10 cents per mile or about $16 per year. The effective cost for going from E6 to E10 will be 0.20 cents per mile or about $30 per year.

If all gasoline were to be produced at the E10 level rather than the current E6, total fuel use would increase by about 200 million gallons per year. If gasoline retails at $3.00 per gallon, then net expenditures for fuel would increase by about $600 million per year.

F. Impact on Government Revenue

The fuel economy penalty for increasing amounts of ethanol will result in increased gasoline consumption in California. This increase in gasoline consumption will increase federal and State excise tax revenue placed on gasoline and increase sales tax revenue.

1. Federal

The federal excise tax for gasoline is 18.3 cents per gallon. However, there is an ethanol subsidy of $0.51 per gallon of ethanol. Going from E6 to E8 will result in an increase in federal excise tax revenue by about $20 million, but increase the federal ethanol subsidy cost by $168 million. The total overall cost to the federal government for going to E6 to E8 will be about $148 million. Going from E6 to E10 will result in additional $43 million in federal tax revenue, but increase the federal ethanol subsidy cost by $363 million. The total overall cost to the federal government for going from E6 to E10 will be about $320 million.

2. State

The State excise tax on gasoline is 18 cents per gallon. Going from E6 to E8 will result in an increase in State excise tax revenue by about $20 million. Going from E6 to E10 will result in additional $43 million in State tax revenue.

3. Local and State Sales Tax Revenue

In estimating the increase in sales tax revenue, staff assumed a price of $3.00 per gallon of gasoline and a sales tax rate of 7.75%, or about 23 cents per gallon. Going from E6 to E8 will result in an increase in sales tax revenue by about $26 million. Going from E6 to E10 will result in additional $56 million in sales tax revenue.

G. Small Refiners

Small refiners will be expected to offset the increase in evaporative emissions due to permeation. Small refiners will not be required to offset the permeation increase through fuel formulations changes, but will be allowed to use the AERP

indefinitely. This would lead to small refiner costs of about 0.5 cent per gallon as discussed in part D above.

H. Small Business Economic Effect

Government Code sections 11342 et. seq. require the ARB to consider any adverse effects on small businesses that would have to comply with a proposed regulation. In defining small business, Government Code section 11342 explicitly excludes refiners from the definition of "small business." Also, the definition includes only businesses that are independently owned and, if in retail trade, gross less than $2,000,000 per year. Thus, our analysis of the economic effects on small business is limited to the costs to gasoline retailers and jobbers, retailers, and gasoline fuel end-users. A jobber is an individual or business that purchases wholesale gasoline and delivers and sells it to another party, usually a retailer or other end-user.

1. Jobbers and Retailers

If the wholesale price of gasoline rose as a result of additional costs to producers to comply with the production of CaRFG3 gasoline, retailers and jobbers would pay more for every gallon of gasoline that they resell in the State. Any adverse impacts on retailers and jobbers would occur only if their profits decreased as a result of the higher wholesale prices. The decrease in profits would likely only occur if retail prices did not increase by the corresponding increase in wholesale prices, or if the demand for gasoline declined as a result of higher retail prices. Historically, small changes in wholesale fuel prices have not had substantial impacts on gasoline purchases. Also, over time, changes in wholesale prices have been passed on to consumers through changes in retail prices.

2. Gasoline Fuel End-Users

The potential economic effects of the new fuel requirements are not limited to jobbers and gasoline retailers. Individual consumers who operate typical gasoline fueled vehicles could be impacted. Combining the cost to produce amended CaRFG3 fuel, the cost of ethanol, and fuel economy losses, staff estimates that total additional cost to produce CaRFG3 could cost gasoline fuel end-users about three to six cents per gallon, with approximately two to five cents per gallon of that total attributed to fuel economy loss.

To calculate total costs to the end user, staff assumed the average end user drove 15,000 miles per year with a vehicle that had a fuel economy of 20 miles per gallon. Staff also assumed an average price of gasoline of $3.00 per gallon. As discussed above, staff calculated the fuel economy cost penalty in going from E6 to E8 would be about $16 per year and going from E6 to E10 would be $30 per year.

The increased cost to produce fully complying gasoline is estimated to be about 0.3 to 0.8 cents per gallon. Using the same assumptions as above, the cost to

the end user for increases in gasoline production costs are about $2 per year to $6 per year. Combining the fuel economy penalty and the cost of production, the total cost to the end user will be between $18 a year and $36 a year. Assuming the total fuel cost is approximately $2,250 per year, the increased costs are about 0.8 to 1.6 percent of total annual fuel costs.

I. Effects on Production from the Proposed Changes on CaRFG3

Staff has discussed with producers and CEC staff the impact on production that could result from implementation of the proposed amendments. In the short term production capability would be impacted by the proposed changes. For example, if producers were required to fully comply with the requirements in 2010 using newly required fuel formulations, many producers would not be able to comply while maintaining current production capacity. In this scenario, staff estimates that there could be a five to 10 percent gasoline production loss at California refiners for one to two years. During this period, greater use of imports of gasoline or gasoline blending components would be needed. However, producers would be able to produce a complying alternative fuel formulation beginning in 2012 with no loss in production due to the completion of appropriate refinery projects.

As discussed above, producers have the option of using an AERP during the transition period from 2010 until 2012. Therefore, staff anticipates that emissions increases due to permeation can be mitigated by 2010 without production losses during this period when refinery changes are underway.

Chapter V. Environmental Impacts of the Proposed Amendments

This chapter summarizes the expected environmental impacts of the proposed amendments. Health and Safety Code section 43013.1 requires that CaRFG3 preserve the emission benefits of CaRFG2. These benefits include emission reductions for all pollutants, including precursors, identified in the State Implementation Plan for ozone, and emission reductions in potency-weighted air toxics compounds. The staff does not anticipate any significant adverse environmental impacts associated with the proposed amendments. However, as discussed below, the proposed amendments do not fully comply with the requirements of Health and Safety Code section 43013.1 in that potential emission increases associated with off-road sources are not fully mitigated.

A. California Environmental Quality Act (CEQA)

CEQA and ARB policy require an analysis to determine the potential adverse environmental impacts of the proposed amendments. ARB's program involving the adoption of regulations has been approved by the Secretary of Resources (see Public Resources Code, section 21080.5). Therefore, the CEQA environmental analysis requirements are included in the ARB's Initial Statement of Reasons in lieu of preparing an environmental impact report or negative declaration. In addition, ARB will respond in writing to all significant environmental issues raised by the public during the public review period or the public Board hearing. These responses are to be contained in the Final Statement of Reasons for the proposed amendments.

Public Resources Code section 21159 requires that the environmental impact analysis conducted by the ARB include the following:

- An analysis of the reasonably foreseeable environmental impacts of the methods of compliance;
- An analysis of reasonably foreseeable mitigation measures; and
- An analysis of reasonably foreseeable alternative means of compliance with the standard.

Our analysis of the reasonable foreseeable environmental impacts of the methods of compliance and the analysis of reasonably foreseeable mitigation measures, if appropriate, are presented in the following sections. In general, ARB staff has not identified any significant environmental impacts associated with the proposed amendments and therefore, there has been no need to identify mitigation measures.

An assessment of potential alternatives to the proposed amendments is presented in Chapter VI. ARB staff has concluded there is no alternative considered by the agency that would be more effective in carrying out the

purpose for which the regulation is proposed or would be as effective as and less burdensome to affected private persons than the proposed regulation.

B. Multimedia Evaluation

Health and Safety Code section 43830.8, enacted in 1999 (Stats. 1999, ch. 813; S.B. 529, Bowen) generally prohibits ARB from adopting a regulation establishing a specification for motor vehicle fuel unless the regulation is subject to a multimedia evaluation by the California Environmental Policy Council (CEPC). A multimedia evaluation is the identification and evaluation of any significant adverse impact on public health or the environment, including air, water, or soil, that may result from the production, use, or disposal of the motor vehicle fuel that may be used to meet the state board's motor vehicle fuel specifications. The statute provides that the Board may adopt a regulation that establishes a specification for motor vehicle fuel without the proposed regulation being subject to a multimedia evaluation if the CEPC, following an initial evaluation of the proposed regulation, conclusively determines that the regulation will not have any significant adverse impact on public health or the environment.

The proposed amendments do not change specifications of CaRFG3 gasoline and will not require a gasoline ingredient to be added or removed beyond what is already used to produce gasoline for sale in California. Therefore, staff believes that the proposed amendments to the CaRFG3 regulations are not subject to the requirement for a multimedia evaluation.

C. Air Quality

This section presents the air quality impacts of the proposed amendments.

1. Emissions Associated with the Replacement of MTBE with Ethanol

The proposed amendments are generally designed to address the emissions impacts associated with the replacement of MTBE with ethanol pursuant to the provisions of Health and Safety Code section 43013.1. Among other provisions, this section requires that CaRFG3 must maintain or improve upon emissions and air quality benefits achieved by CaRFG2 as of January 1, 1999, including emission reductions for all pollutants identified in the State Implementation Plan for ozone, and emissions reductions in potency-weighted air toxic compounds.

As discussed in Chapter II, the addition of ethanol increases permeation emissions from both on-road and off-road sources.

a. Impact on On-road Sources

The proposed amendments are specifically designed to mitigate the increase of permeation emissions from on-road sources. The estimated emissions increase

of permeation emissions is estimated to be 28.8 tpd in 2005, 18.4 tpd in 2010, 12.1 tpd in 2015, and 8.1 tpd in 2020. The mitigation is provided through the use of an alternative fuel formulation or, for a limited time for most producers, through the use of an AERP. The mitigation begins no later than December 31, 2009. This date was chosen as the earliest practical date to implement either alternative fuel formulations or AERPs.

Adoption of CARFG3 in 1999 to eliminate MTBE and require ethanol resulted in regulations for gasoline properties being revised. In the 1999 staff report, it was demonstrated that benefits of CARFG2 are preserved except due to permeation from use of ethanol. The limits for the fuel properties are not being changed at this point. The only change is the inclusion that an amount of hydrocarbons be mitigated equivalent to the increase related to permeation from the use of ethanol in on-road vehicles. Off-road impacts can not be quantified at this time; but once available, a mitigation proposal can be developed to address the impact from this category.

b. Impact on Off-road Sources

The proposed amendments will likely potentially mitigate, but not fully offset the impact of permeation on off-road sources. Off-road gasoline applications include sources such as lawnmowers, string trimmers, airport ground equipment, recreational equipment (snowmobiles, pleasure craft), and portable gas containers.

As discussed previously, the addition of ethanol is likely to reduce the exhaust emissions of hydrocarbons and carbon monoxide, but will likely increase permeation emissions. At higher levels of ethanol, the emissions of oxides of nitrogen may increase. However, staff is unable to define a method that ensures permeation effects in off-road sources are fully mitigated at this time. Available data are not sufficiently available to reasonably quantify the effect that ethanol in gasoline has on permeation emissions or the effect of fuel property changes on the exhaust emissions from off-road sources.

There are a few limited test programs that have addressed the impacts of fuel properties on off-road sources, including the impact of ethanol on permeation emissions. For exhaust emissions, use of 10 percent ethanol blends provided small to moderate (3 to 40 percent) reductions in hydrocarbons, and moderate to significant reductions in carbon monoxide (10 to 70 percent). Most results indicated a slight, but not statistically significant, increase in emissions of oxides of nitrogen. From studies reviewed on evaporative emission increases, staff has determined that use of ethanol blends leads to increase in evaporative emissions due to permeation. Two studies specifically conducted by the ARB on lawnmowers have provided a wide range of probable impacts that drawing any specific conclusions at this time has not been attempted. The lawnmower studies however, have been used to estimate the range of impacts for the entire

off-road category. A detailed discussion of these test programs is presented in Appendix C.

Based on limited test programs, staff estimates for 2015 that the addition of ethanol to gasoline will increase evaporative hydrocarbon emissions by about 15 to 39 tpd. Similarly, staff estimates that the use of additional ethanol to gasoline could decrease the exhaust emissions of hydrocarbons by 15 to 21 tpd and increase slightly the exhaust emissions of NOx by about 1 to 2 tpd. Further work is needed to determine the emission impacts of greater ethanol use and to define what additional mitigation, if any is necessary.

To improve the data and enable the design of an effective mitigation strategy, staff is developing an emissions test program to provide enough information to reasonably quantify the impacts of ethanol on the emissions from off-road sources. This will allow a mitigation program, if appropriate, to be developed. Different off-road categories likely have different ethanol permeation rates. Therefore, staff is proposing to significantly expand the existing database of evaporative and exhaust emissions data for the off-road equipment. Impacts on permeation due to ethanol blending, engine exhaust emissions, changes due to increased oxygenates, and benefits of catalysts on reducing engine emissions will be studied.

The proposed program will be conducted in two phases. The first phase will be conducted at a Southwest Research Institute with a report made available within a year. The second phase will be conducted in-house by ARB staff and is expected to be completed in a longer time frame (2-3 years). This project will expand the number and types of engines being tested.

c. Impact on the State Implementation Plan

The ARB's 2007 State Implementation Plan (SIP) proposal is a comprehensive strategy designed to attain federal air quality standards as quickly as possible through a combination of technologically feasible, cost-effective, and far reaching measures. The total magnitude of the reductions to be achieved through new actions is primarily driven by the scope of the air quality problems in the San Joaquin Valley and South Coast Air Basin.

When introduced in 1996, gasoline meeting the CaRFG2 specifications was estimated to produce about a 15 percent overall reduction (300 tons per day) in ozone precursor emissions from motor vehicles. These emission reductions were equivalent to removing 3.5 million vehicles from California's roads. The CaRFG2 program is also a major component of the California SIP. In 1996, the CaRFG2 program accounted for 25 percent of the ozone precursor emission reductions in the SIP. The CaRFG3 regulations approved by the Board in 1999, removed MTBE from California gasoline. However, the substitute oxygenate, ethanol, has resulted in increased evaporative emissions due to fuel system

permeation. This proposed measure would make modifications to the CaRFG3 program to fully mitigate ethanol permeation effects from motor vehicles and a significant portion of the permeation effect from off-road applications.

D. Greenhouse Gas Emissions

Staff expects that the CaRFG3 amendments would ultimately result in a small (less than one percent)[8] net decrease in CO_2 equivalent greenhouse gas emissions from California gasoline production and use. This is due to the expected increase in ethanol blending ratio from 5.7 to as high as 10 percent by volume.[9] As currently produced in the U.S., ethanol creates about zero to 30 percent less CO_2 equivalent greenhouse gases (GHG) per unit of energy output than would occur from the gasoline displaced due to ethanol use[10].

In January 2007, the Governor's Executive Order S-01-07 a Low Carbon Fuel Standard (LCFS) for transportation fuels be established for California. This first of–its-kind standard will support the AB 32 climate change emissions target as part of California's overall strategy to fight global warming. ARB is expected to initiate rulemaking activities for the LCFS in July 2007. The proposed changes to the CARFG3 rules are expected to provide additional flexibility for producers to comply with the LCFS.

Expected changes to the CARBOB component of California gasoline are expected to result in an additional but much less significant change in CO_2 equivalent emissions. This is due to the need to use more energy in the production of lower sulfur feedstocks. The expected reduction in sulfur content could cause small (less than 0.01 percent)[11] net increases in CO_2 equivalent emissions. Generally, the more hydrotreating required in producing a given type of fuel, the more CO_2 equivalent GHGs are emitted in the production of the fuel.

E. Water Quality

The proposed amendments do not change flat or average limits of CaRFG3 gasoline. Therefore, no major changes in fuel formulation are expected except for a small decrease in sulfur level and a likely increase in ethanol use. These expected fuel formulation changes are not expected to have a significant negative effect on the quality of both ground and surface water. The findings of the environmental fate and transport analysis and a health risk evaluation of ethanol performed in 1999 supports this analysis. In 1999, the Board approved the environmental assessment of CaRFG3 with ethanol. This assessment

[8] The actual benefits will depend greatly on how ethanol used in California is produced.
[9] This would be an ethanol energy content increase from about 3.9 percent to about 6.9 percent.
[10] http://www.energy.ca.gov/ab1007/documents/2007-03-02_joint_workshop/presentations/TIAX-2_2007-03-02.PDF
[11] See ARB staff report, Appendix J, "Effect of Low Sulfur Diesel Fuel on Greenhouse Gas Emissions," June 6, 2003.

included ethanol levels up to 10 percent by volume. In 2000, the California Environmental Policy Council approved the multimedia environmental assessment of ethanol in gasoline for ethanol levels up to 10 percent by volume.

F. Community Health and Environmental Justice

Environmental justice is a core consideration in ARB's efforts to provide clean air for all California communities (CARB 2001, i.e. Policies and Actions for Environmental Justice, PTSD, 2001). The increased ethanol required for blending would require additional number of trucks delivering ethanol to pipeline terminals. Staff has estimated that to supply the necessary additional ethanol to the distribution terminals there will likely be about an additional 8300 miles driven each day by heavy duty diesel trucks. This represents about 0.02 percent of the total miles driven each day by heavy duty diesel trucks (38,204,000 miles per day in 2006-source: ARB EMFAC 2007). The impacts of this however, could be localized near blending terminals. To accommodate the additional ethanol most of the terminals must have their ethanol storage and blending equipment upgraded; this will be subject to local permitting requirements and CEQA, and any significant increases in emissions must be mitigated. Also, the expansion of hydrotreating capacity at producer facilities and other associated changes will require either new permits or amendments to existing permits. Again, increases in emissions must be mitigated.

Chapter VI. Alternatives to the Proposed Amendments

This chapter presents an analysis of alternatives to the proposed amendments. In general, the proposed amendments are driven by the need to mitigate the impacts of ethanol permeation effects on CaRFG3, as required by Health and Safety Code section 43013.1. Therefore, there is not a "no project" alternative. As there are documented increases in permeation emissions associated with the addition of ethanol, staff believes the Board must take action to mitigate this increase. There are, however, various alternative approaches that could be taken as part of the revisions to the CaRFG3 regulations, or in establishing alternative compliance options. Based on an analysis of these alternatives, the staff has not identified any alternative that is as effective, or less burdensome, as the approach taken with the proposed amendments to the CaRFG3 regulations.

The following sections outline the different alternatives that the staff has identified or that have been discussed in the process of developing the proposed amendments. These alternatives are related to the Predictive Model, the AERP, and the proposed changes in specifications.

A. Alternatives Related to the Predictive Model

Staff believes that it is necessary and appropriate to update the Predictive Model to add the permeation emissions, update the motor vehicle emissions inventory vehicle mix, update the reactivity adjustment factors, add the new motor vehicle exhaust emissions test data, and update the effect of carbon monoxide on ozone-forming potential. During the development of these proposed amendments to the Predictive Model, one or more stakeholders introduced alternatives discussed below related to the general construction of the Predictive Model. These alternatives were related to the inclusion of off-road emissions into the Predictive Model, reactivity adjustment factors for carbon monoxide, the construction of the Tech 4 model, the studies used to evaluate the sulfur/NOx response for the Tech 5 class, and miscellaneous comments on the construction of the Predictive Model. The specific alternatives are discussed in the following sections.

1. Incorporate Off-Road Emissions Into the Predictive Model

The CaRFG program was adopted to reduce emissions from motor vehicles. The data developed to support this rulemaking came from studies that related fuel properties to on-road motor vehicle emissions. Then, as now, adequate emission studies do not exist to allow inclusion of off-road emissions into the CaRFG program including the Predictive Model. This is due in part to low consumption of fuels in off-road applications, less than five percent of total gasoline. Emission studies are being implemented to provide the necessary data

to allow an assessment to be made of the appropriateness of incorporating off-road emissions into the CARFG program.

2. Reactivity Adjustment Factors for Carbon Monoxide

Some stakeholders requested that staff review submitted information regarding the MIR factor for CO. These parties believed that the MIR value for CO was too low relative to other hydrocarbons and requested that staff consider using a significantly higher value for the MIR of CO.

Staff reviewed this information and concluded that the information was insufficient to provide a basis for changing the approach used to estimate the reactivity in the Predictive Model. Staff recommends that the MIR scale developed by Dr. William Carter continues to be used. This was specifically to complement California's dual program of reducing both NOx and VOC to control ozone and other pollutants.

In 2003, the Board approved an updated list of reactivity values and reconfirmed the other MIR values. At that time, the MIR value for CO changed slightly to 0.06. Prior to Board consideration, the Reactivity Advisory Committee reviewed the list of values. After their review, the Reactivity Scientific Advisory Committee concluded that the proposed update did not substantially change the nature of the MIR values and were arrived at in an appropriate scientific manner.

3. Construction of the Tech 4 NOx Portion of the Predictive Model

During the workshop process, several stakeholders requested that the staff consider dividing the Tech 4 dataset into a higher and lower emitter group to be modeled separately, and presented the results of an analysis of dividing the datasets. The basic concept was that a Tech 4 NOx model would provide an overall higher statistical fit if the dataset were divided into two distinct vehicle groups. The cut point would be at 0.6 times the NOx emissions standard and each portion modeled separately. Proponents believe that this approach produces a much lower response of NOx to oxygen content and it would require less adjustment to other fuel properties to be able to increase the amount of ethanol into CARFG.

Staff discussed this issue with the ARB's vehicle experts and consulted representatives of the Alliance of Automobile Manufacturers and the Association of International Automobile Manufacturers. These discussions focused on determining if there was some physical design factor in vehicle emission control systems that change how they respond to fuel property changes at the levels indicated by the stakeholder analysis. Staff learned that while many manufacturers do calibrate their emission control systems to emit at levels below the actual standard, there is no physical response differences between vehicles emitting just below 0.6 times the standard and those emitting just above

0.6 times the standard. This was important because the alternative statistical method did not produce consistent results at other cut points. Lacking a technical reason for using the suggested 0.6, staff was concerned that the result was more the product of a statistical anomaly than a meaning point that defines vehicle emission performance. Staff also is concerned that the rational for the cutoff point of 0.6, applied specifically to NOx to produce an optimal statistical model, is not applicable to hydrocarbons and CO. The cutoff points that maximize the likelihood function for THC and CO are 1.0 and 1.6 times their tailpipe standard, respectively.

Staff also consulted with Dr. David Rocke of the University of California, Davis to provide comments and guidance regarding the validity of the Tech 4 NOx modeling approach proposed by the stakeholders. He concurred with staff that while the alternative approach might provide some improvement in statistical performance, other factors should be considered. In this case, it is essential that emissions modeling be consistent with sound engineering judgment and good science and have a sound basis relative to vehicle control system design and combustion chemistry. Relying on statistics as the sole guide to model construction could lead to misleading results. As a result, staff believes the suggested alternative is not appropriate and the approach taken to model Tech 4 vehicles in the previous Predictive Model modeling efforts should be maintained. This current approach was subject to independent scientific peer reviewed by appointees from the University of California in 1994 and 1999 and found to be reasonable and scientifically supportable. Appendix D presents the information provided by the stakeholders.

4. Sulfur/NOx Response for the Tech 5 Class

To provide the best representation of the Tech 5 fleet in 2015 using the available data, staff chose to use the two newest datasets for modeling the Tech 5 emissions response to changes in sulfur levels. Staff chose not to include the two older datasets because there were larger datasets that are based on emissions testing in the early LEV I vehicles and pre-LEV vehicles. In 2015, only about 25 percent of the on-road vehicles are the LEV I and earlier technologies. Using the combined dataset, with the earlier and later datasets, would lead to the modeling of a fleet with only 25 percent LEV I and earlier vehicles with a data with about 80 percent LEV I and earlier vehicles.

Stakeholders suggested that using the larger combined dataset should lead to comparable results and that the results would provide better estimates of the emissions response to changes in sulfur levels. To investigate this, staff made estimates using the larger and smaller datasets and found that including the data from the two older datasets overwhelmed the response from the two newer and smaller datasets. Staff also compared the results of this analysis with results published as part the U.S. EPA MSAT rule making where they, in conjunction with the Alliance of Automobile Manufactures, tested a low sulfur fuel (6 ppmw)

sulfur fuel against the same fuel with higher sulfur levels (32 ppmw) in 9 Tier II 2003 to 2007 model year vehicles and found results that clearly indicate that in LEV II/Tier II and later emission control technology vehicles, reductions in sulfur will provide significantly higher emissions benefits than indicated by using the combined Tech 5 sulfur data to model the 2015 California light-duty vehicle fleet. These results are consistent with the staff's earlier analysis. More details are provided in Chapter III.

5. Miscellaneous Comments on the Development of the Predictive Model

a. Coefficients for Tech 5 model

Stakeholder suggested that staff should consider different methods for estimating coefficients for the Tech 5 terms in the model. Staff reviewed two other methods of estimation coefficients for the Tech 5 model: model Tech 4 first and then model Tech 5 from the residuals, and modeling the Tech 5 terms in pairs with the corresponding Tech 4 terms. Staff has worked extensively with the Statistical Working Subgroup and determined that the other methods gave essentially the same estimates within the expected uncertainty ranges associated with the coefficients being estimated while being significantly less complicated.

b. Quantification of Increases in Permeation due to Ethanol

Stakeholder suggested that staff should directly use the emissions data from the Coordinating Research Council's E-65 Fuel Permeation from Automotive Systems rather than use the percent change from a baseline fuel to the ethanol fuel. Staff believes that the method chosen best uses the limited information from the CRC E-65 study. To accurately estimate increase in permeation emissions associated with the presence of ethanol in gasoline, staff must incorporate the effect of temperatures and vehicle operations into the calculations. This is best done by incorporating the permeation by temperature response to ethanol directly into the EMFAC2007 model. Details of this effort and the resulting calculations are presented in Appendix B.

c. New Tech 6 Group

Stakeholders suggested that the staff should develop a new Tech 6 vehicle emissions technology group for modeling the Predictive Model database. This was because the stakeholders believed that vehicles produced after 2000 would respond differently than the 1994 to 2000 vehicle model portion of Tech 5. Staff worked with the stakeholders and the Statistical Working Subgroup to investigate the merits of developing a new Tech 6 vehicle emissions control group. Staff and stakeholders determined that there was insufficient data available for the newest vehicle emission control technologies to develop a new statistical response model using only most recent vehicles emissions test information.

d. Distillation Temperature

Stakeholders suggested that the impact of T_{50} on total organic gas should be examined. Below a T_{50} value of 190°F, emissions appear to rise as T_{50} decreases. While there are some data to support this effect, the data is not adequate to precisely determine where the upturn occurs other than it is less than 190°F. Also, it is to be expected that little or no gasoline will be produced with values below 190°F. The response should be modified to be flat below 190°F. Similarly, the impact of T_{90} on exhaust TOG should be examined. Below a T_{90} value of 305°F, the TOG emissions appear to rise as T_{90} decreases. Again, there are not adequate data to support this effect. Therefore, the response should be modified to be flat below 305°F. Staff agrees and the hydrocarbon response functions were flattened out as they were in both the CaRFG2 and CaRFG3 models.

B. Alternatives Related to the AERP

There are two basic alternatives related to the AERP. The first alternative would be to extend the AERP to address off-road emissions. As discussed in Chapter V, there is insufficient data available to reliably estimate the impact of the addition of ethanol to gasoline. Staff has initiated several new studies designed to provide the data necessary to make further improvements to the off-road emissions estimates. Also, once these studies are complete, staff proposes to return with appropriate mitigation approaches and/or changes in the Predictive Model.

The second alternative would be to allow the use of the AERP indefinitely. As proposed, the AERP can only be used by the large producers until December 31, 2011. Small producers can use the AERP indefinitely. Staff does not support the use of the AERP beyond the sunset date. While it is expected that an AERP can provide emission mitigation, only fully complying fuel can ensure that the full benefits are obtained. Small producers supply less than 5 percent of gasoline consumed in the State and the risk by allowing them access to the AERP on an ongoing basis is limited.

C. Alternatives Related to the Change in Specifications

1. *Denatured Ethanol*

The only practical alternative to the proposed amendments to section 2262.9 would be to leave the section as is. Staff recommends against this alternative. This approach would force fuel suppliers to supply California denatured ethanol that is different from the rest of the country. The best way to assure fungibility of denatured ethanol throughout the ethanol storage and distribution system is to amend section 2262.9. No alternative considered by the agency would be more effective in carrying out the purpose for which the regulation is proposed or would

be as effective as and less burdensome to affected private persons than the proposed regulation.

2. *Modeling Oxygen Content*

An alternative would be to leave the oxygen flat spots as they are in the current Predictive Model. Doing this would discourage refiners from using oxygen contents other than 2 percent and 2.7 percent (5.7 percent and 7.7 percent in terms of ethanol) and decrease needed flexibility for refiners to find the optimum ethanol levels to offset the evaporative emissions due to permeation. Such an approach could have a significant negative impact on California refinery's ability to produce and supply gasoline to California's consumers.

a. RVP Limit

An alternative is to leave the RVP flat limits as they currently exist when the evaporative portion of the Predictive Model is used. However, since commingling has not occurred, there is no need to retain the lower RVP limit for oxygenated gasoline. The only other alternative is to lower the RVP limit. This was not considered because a minimum RVP of 6.4 psi is required to avoid vehicle performance problems related to cold starts. Lowering the upper limit would effectively mean that refiners would have little flexibility in producing fuels and batches of gasoline would be susceptible to being found out of specification and have to be reprocessed resulting in lost production with tight supplies and cost excursions.

b. Sulfur Cap

The first alternative is to lower the sulfur cap limit even further than 20 ppmw. Lowering the sulfur cap limit below 20 ppmw would make sense, if the current CaRFG flat limit is also changed to be below 20 ppmw. Lowering both the sulfur cap and the flat limits would decrease flexibility for refiners to make compliant CaRFG. This lack of flexibility could adversely affect the supply of gasoline in California, and would severely limit the options available to producers to use higher oxygen level to mitigate permeation emissions.

The second alternative is to leave the sulfur cap at 30 ppmw. Given the implementation of the new federal Tier II sulfur limits for federal gasoline, it would make it more difficult to enforce the requirement that only complying California Phase 3 reformulated gasoline be sold for use in California. No alternative considered by the agency would be more effective in carrying out the purpose for which the regulation is proposed or would be as effective and less burdensome to affected stakeholders than the proposed regulation.

D. Alternatives Related to Implementation Dates

Staff considered alternative dates for producers to certify fuel formulations that mitigate the increase in permeation emissions. Staff also considered alternative dates for the use of the AERP option. Based on available information, staff determined that December 31, 2009 was a sufficient date for producers to certify fuel formulations that mitigate the increase in permeations along with the option to use the AERP. Staff was also able to determine that the producers would have sufficient time to certify formulations that could mitigate permeation emissions with the use of the AERP option by December 31, 2011.

Chapter VII. References

2006 California Almanac of Emissions and Air Quality (http://www.arb.ca.gov/aqd/almanac/almanac06/almanac06iu.htm)

Alliance of Automobile Manufacturers and Association of International Automobile Manufacturers: Sulfur Oxygen Vehicle Emissions Test Program

Braddock, J., Snow, R. F., and Crews, W., "Emissions profile from new and in-use handheld, 2-stroke engines", J. Volckens, Atmospheric Environment, 41 (2007) 640-649

Carter, W. P.L. (1994) "Development of Ozone Reactivity Scales for Volatile Organic Compounds,"Journal of the Air and Waste Management Association, 44, 881-899, (1994).

Carter, W. P. L. Tonnensen G. and Yarwood G., (2003) "Investigation of VOC Reactivity Effects Using Existing Regional Air Quality Models," Contract SC-20.0-UCR-VOC-RRWG, Final Report to American Chemical Council, April.
Carter, W. P. L. (2006), personal communication, August.

Coordinating Research Council, CRC Project No. E-60: The Effect of Fuel Sulfur on NH3 and Other Emissions from 2000-2001 Model Year Vehicles, May 2003

Coordinating Research Council, CRC Project No. E-67: Effects of Ethanol and Volatility Parameters on Exhaust Emissions, January 30, 2006.

Coordinating Research Council, CRC Report No. E-65-3 Interim Report: Fuel Permeation from Automotive Systems: E0, E6, E10 and E85, August 2006.

Coordinating Research Council, CRC Report No. E-65-3: Fuel Permeation from Automotive Systems: E0, E6, E10, E20, and E85, December 2006.

Coordinating Research Council, CRC Project No. E-65: Fuel Permeation from Automotive Systems, September 2004.

"Exhaust Emission Effects of Fuel Sulfur and Oxygen on Gasoline Nonroad Engines", USEPA Memo No. EPA420-R-05-016, December 2005.

ExxonMobil: LEV/ULEV Gasoline Oxygenate Study.

Ford Motor Company, Presentation: Sulfur Effects on Advanced Catalyst Formulations
Submission to CARB Predictive Model Process, April 19, 2007.

Guenther, Mark; Lapan, Morgan; DeWaard, David; Siegl, Walter; Jensen, Ted; Loo, Jeff Baldus, Steve, Comparison of Vehicle Running Loss Evaporative Emissions Using Point Source and Enclosure Measure Techniques. SAE Technical Paper Series 980403. February 23-26,1998.

C. T. Hare and J. J. White, "Toward the Environmentally-Friendly Small Engine: Fuel, Lubricant, and Emission Measurement Issues", SAE Paper 911222, 1991.

Harley, Robert A., and Coulter-Burke, Shannon C. "Relating Liquid Fuel and Headspace Vapor Composition for California Reformulated Gasoline Samples Containing Ethanol." Environmental Science and Technology Vol. 34 Nov 2000: 4088-4093.

W. Hsieh, R. Chen, T. Wu, and T. Lin, "Engine Performance and Pollutant Emission of a SI Engine using Ethanol-Gasoline Blended Fuels", Atmospheric Environment, 36(2002), 403-410.

http://www.arb.ca.gov/fuels/gasoline/premodel/pmdevelop.htm

http://www.arb.ca.gov/msei/offroad/offroad.htm

http://www.crcao.org/, "Permeation from Automotive Fuel Systems", CRC Project No. E-65, September 2004.

http://www.crcao.org/, Running Loss Emissions from In-Use Vehicles CRC Project No. E-35-2, 1999.

L. Jia, M. Shen, J. Wang, and M. Lin, "Influence of Ethanol-Gasoline Blended Fuel on Emission Characteristics from a Four-Stroke Motorcycle Engine", Journal of Hazardous Materials, A123 (2005) 29-34.

C.C. Lela and J. J. White, "Laboratory Testing of Snowmobile Emissions", Report prepared for Yellowstone National Park and the Montana Department of Environmental Quality, July 2002.

Personal Communication with Craig Harvey, U.S. EPA, OTAQ, Assessment and Standards Division, 2006.

Personal Communication with the Laboratory Group of the USEPA in Ann Arbor, MI, USA, (2007).

Portella, Debra, Voluntary Commercial Lawnmower Retirement Pilot Program for Maricopa County, Arizona Final Report, Release Date: January 1997.

Rubin, Juli; Kean, Andrew; Harley, Robert; Milley, Dylan; Goldstein, Allen, "Temperature Dependence of Volatile Organic Compound Evaporative

Emissions from Motor Vehicles." Journal of Geophysical Research Vol. 111 D03305.

State of California, California Environmental Policy Council, Environmental Assessment of the Use of Ethanol as a Fuel Oxygenate Subsurface Fate and Transport of Gasoline Containing Ethanol.

State of California, California Environmental Policy Council, Health and Environmental Assessment of the Use of Ethanol as a Fuel Oxygenate.

State of California, Air Resources Board Staff Report: Air Quality Impacts of the Use of Ethanol in California Reformulated Gasoline, 1998.

State of California, Air Resources Board, Staff Report Proposed Amendments to the California Reformulated Gasoline Regulations, Including a December 31, 2002 Prohibition of Using MTBE in Gasoline, Adoption of Phase 3 Gasoline Standards, a Phase 3 Predictive Model, and Other Changes - Release Date: October 22, 1999.

State of California, Air Resources Board, Staff Report: Proposed Amendments to the California Reformulated Gasoline Regulations Including Denatured Ethanol Specifications, Small Refiner Provisions, CARBOB Model, and Other Changes - Release Date: September 29, 2000.

State of California, Air Resources Board, Staff Report: Proposed Amendments to the California Reformulated Gasoline Regulations Postponing Imposition of the CaRFG3 Standards and the Prohibition of MTBE and Oxygenates Other than Ethanol in California Gasoline from December 31, 2002 to December 31, 2003. - Release Date: June 7, 2002.

State of California, Air Resources Board, Staff Report: Proposed Amendments to the California Reformulated Gasoline Regulations Including Refinements to the Prohibitions of MTBE and Other Oxygenates - Release Date: October 25, 2002.

State of California, Air Resources Board, Staff Report: Proposed 2004 Amendments Refining the California Phase 3 Reformulated Gasoline Regulations - Release Date: October 1, 2004.

State of California, Air Resources Board, Staff Report: Reformulated Gasoline: Proposed Phase 1 Gasoline Regulation.

State of California, Air Resources Board, Staff Report: 1998 Ethanol in Gasoline RVP Impacts (with amendments to the California Wintertime Oxygenates Program), 1998.

State of California, Air Resources Board, Staff Report – Phase 2 Predictive Model, 1994.

State of California, Air Resources Board (2003), "Initial Statement of Reasons for Proposed Amendments to the Tables of Maximum Incremental Reactivity (MIR) Values," October 17.

State of California, Air Resources Board, Staff Report: Draft Assessment of the Real-World Impacts of Commingling California Phase 3 Reformulated Gasoline - August 2003.

State of California, Air Resources Board (2000), "Final Statement of Reasons for the Proposed Amendments to the Regulation for Reducing Volatile Organic Compounds Emissions from Aerosol Coatings Products and Proposed Table of Maximum Incremental Reactivity (MIR) Values, and Proposed Amendments to Method 310, "Determination of Volatile Organic Compounds," June 22.

State of California, Air Resources Board, The Carl Moyer Program Guidelines, Release Date: October 20, 2006.

State of California, Air Resources Board, Personal communication from Planning and Technical Support Division, Air Resources Board, 2007.

State of California, Air Resources Board, "Assessment of the Ozone and Aerosol Formation Potentials (Reactivities) of Organic Compounds over the Eastern United States, May 2003.

State of California, Air Resources Board, Luo D.M. (2004) "Comments on 'CO Reactivity'", September 2.

State of California, Air Resources Board, Estimation of the Impact of Ethanol on Off-Road Evaporative Emissions, Technical MemoJune 2006.

State of California, Air Resources Board, Martien, P.T., R.A. Harley, J.B. Milford, A. Hakami, & A.G. Russell (2002) "Development of Reactivity Scales via 3-D Grid Modeling of California Ozone Episodes," Final Report to Air Resources Board, May.

State of California, Air Resources Board, Proposed California Phase 3 Reformulated Gasoline Regulations, Release Date: October 22, 1999.

State of California, Air Resources Board, "Initial Statement of Reasons for Proposed Rulemaking Public Hearing to Consider the Adoption of Exhaust and Evaporative Emission Control Requirements for Small Off-Road Equipment and Engines Less Than or Equal to 19 Kilowatts", Staff Report, August 8, 2003.

Toyota Study: Effects of Ethanol on Emissions of Gasoline LDVs.

United States Environmental Protection Agency, Tier 2 Vehicle Fuel Effects Test Program Final Report, December 15, 2006.

United States Environmental Protection Agency, MSAT2 RIA Excerpt Section 6.12.

C. Wang, S. Lin, and H. Chang, J. "Effect of Oxygenates on Exhaust Emissions from Two-Stroke Motorcycles", of Environmental Science and Health, Part A, Vol. A37(9) (2002) 1677-1685.

Y Yang and J. Milford, Env. Sci & Tech., Vol. 30, No. 1, 1996, pp-196-203.

Jon Holley, Letter to the United States Environmental Protection Agency, Building the NMHC Model, Work Assignment No. 2-9, Contract 68-C-98-169, SwRI Project 08.0475, December 20, 2000.

Jon Holley, Letter to the United States Environmental Protection Agency, Building the NOx Model, Work Assignment No. 2-9, Contract 68-C-98-169, SwRI Project 08.0475, December 20, 2000.

Jon Holley, Letter to the United States Environmental Protection Agency, Assessment of California Predictive Model, Work Assignment No. 2-9, Contract 68-C-98-169, SwRI Project 08.0475, December 20, 2000.

Math Pro, Inc., Analysis of the Production of California Phase 3 Reformulated Gasoline with and Without an Oxygen Waiver, submitted to the U. S. Environmental Protection Agency under EPA Purchase Order OW-2026-NASX, January 19, 2001.

United States Environmental Protection Agency, Letter to Governor Gray Davis on the denial of California's Waiver Request from the oxygen requirement of the federal reformulated gasoline program, June 1, 2001.

United States Environmental Protection Agency, Technical Support Document: Analysis of California's Request for Waiver of the Reformulated Gasoline Oxygen Content Requirement for California Covered Areas, Document Number II-B-2, June 2001

United States Environmental Protection Agency, Staff White Paper, Study of Unique Gasoline Fuel Blends ("Boutique Fuels"), Effect on fuel Supply and Distribution and Potential Improvements, October 2001.

United States Environmental Protection Agency, Study of Boutique Fuels Relating to Transition from Winter to Summer Gasoline, October 2001.

California Energy Commission, Consultant Report by Stillwater Associates, MTBE Phase Out in California, Publication No. 600-02-008CR, March 2002.

State of California, Air Resources Board, Assessment of the Real-World Impacts of Commingling California Phase 3 Reformulate Gasoline (Draft), March 27, 2002.

Acurex Environmental, Evaluation of Fuel-Cycle Emissions on a Reactivity Basis, Volume 1, Main Report, September 19, 1996

American Automobile Manufacturers Association/Association of International Automobile Manufacturers, AAMA/AIAM Study on the Effects of Fuel Sulfur on Low Emission Vehicle Criteria Pollutants, 1997

American Automobile Manufacturers Association/European Automobile Manufacturers Association/Engine Manufacturers Association/Japan Automobile Manufacturers Association, World Wide Fuel Charter, December, 1998.

Auto/Oil Air Quality Improvement Research Program, Dynamometer Study of Off-Cycle Exhaust Emissions, Technical Bulletin No.19, April 1996

Auto/Oil Air Quality Improvement Research Program, Effects of Fuel Sulfur Levels on Mass Exhaust Emissions, Technical Bulletin No. 2, February 1991

Auto/Oil Air Quality Improvement Research Program, Effects of Fuel Sulfur on Mass Exhaust Emissions, Air Toxics, and Reactivity, Technical Bulletin No. 8, February 1992

Auto/Oil Air Quality Improvement Research Program, Effects of Gasoline T50, T90, and Sulphur on Exhaust Emissions of Current and Future Vehicles, Technical Bulletin No. 18, August 1995

Auto/Oil Air Quality Improvement Research Program, Emissions Results of Oxygenated Gasolines and Changes in RVP, Technical Bulletin No. 6, September 1991.

Auto/Oil Air Quality Improvement Research Program, Gasoline Reformulation and Vehicle Technology Effects on Exhaust Emission, Bulletin No. 17, August 1995.

Auto/Oil Air Quality Improvement Research Program, Initial Mass Exhaust Emissions Results from Reformulated Gasoline, Technical Bulletin No.1, December 1990.

Blue Ribbon Panel, Achieving Clean Air and Clean Water: The Report of the Blue Ribbon Panel on Oxygenates in Gasoline, September 15, l999

MathPro, Potential Economic Benefits of the Feinstein-Bilbray Bill, March 18, 1999

National Renewable Energy Laboratory, Environmental Life Cycle Implications of Fuel Oxygenate Production from California Biomass, May 1999

National Research Council, Ozone-Forming Potential of Reformulated Gasoline, National Academy Press, Washington, D.C., 1999

State of California, Air Resources Board, The 1999 California Almanac of Emissions and Air Quality, 1999

State of California, Air Resources Board, An Overview of the Use of Oxygenates in Gasoline, September 1998

State of California, Air Resources Board, California Phase 2 Reformulated Gasoline Specifications, Volume 1, Proposed Regulations for California Phase 2 Reformulated Gasoline, Staff Report, October 4, 1991

State of California, Air Resources Board, California Procedures for Evaluating Alternative Specifications for Phase 2 Reformulated Gasoline Using the California Predictive Model, Adopted April 20, 1995

State of California, Air Resources Board, Comparison of The Effects of A Fully-Complying Gasoline Blend and A High RVP Ethanol Gasoline Blend on Exhaust and Evaporative Emissions, November 1998

State of California, Air Resources Board, Methodology for Estimating Emissions From On-Road Motor Vehciles, Volume I to V, November 1996.

State of California, California Energy Commission, 1997 Global Climate Change, Greenhouse Gas Emissions Reduction Strategies for California, Volume 2, January 1998, P500-98-00IV2

State of California, California Energy Commission, Supply and Cost of Alternatives to MTBE in Gasoline, October 1998, P300-98-013

State of California, California Energy Commission, Timetable for the Phaseout of MTBE from California's Gasoline Supply, June 1999, Docket No. 99-GEO-1.

United States Department of Energy, Argonne National Laboratory, Transportation Technology R & D Center, Effects of Fuel Ethanol Use on Fuel-Cycle Energy and Greenhouse Gas Emissions, January 1999, ANL/ESD-38

United States Environmental Protection Agency, Office of Air and Radiation, Fuel Sulfur Effects on Exhaust Emissions, EPA420-P-99-008, M6, FUL.0001, March 1999

United States Environmental Protection Agency, Office of Air and Radiation, Office of Mobile Sources, Assessment and Modeling Division, Fuel Oxygen Effects on Exhaust CO Emissions, Draft, Recommendations on MOBILE6, Report Number M6.FUL.002, Venkatesh Rao, March 16, 1998

United States Environmental Protection Agency, Office of Air and Radiation, Office of Mobile Sources, Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements, April 1999

United States Environmental Protection Agency, Office of Mobile Sources, Assessment and Modeling Division, Exhaust Emission Effects of Fuel Sulfur and Oxygen on Gasoline Nonroad Engines, Report No. NR-003, Christian E. Lindhjem, November 24, 1997

University of Denver, Department of Chemistry and Biochemistry, Real-time Remote Sensing of Snowmobiles Emissions at Yellowstone National Park: An Oxygenated Fuel Study, I999, Jerome A. Morris, et. al., August 1999

William L. Leffler, Petroleum Refining for the Non-Technical Person, 2nd Edition, PennWell Publishing Company, 1985

State of California, California Environmental Protection Agency, California Environmental Policy Council, Resolution on Environmental Impacts from Changes in Gasoline Due to the California Phase 3 Reformulated Gasoline Regulations, January 18, 2000.

State of California, California Environmental Protection Agency, California Environmental Policy Council, Transcript from Meeting on Environmental Impacts from Changes in Gasoline Due to the California Phase 3 Reformulated Gasoline Regulations, January 18, 2000.

California Air Resources Board, Health and Environmental Assessment of the Use of Ethanol as a Fuel Oxygenate, Report to the California Environmental Policy Council in Response to Executive Order D-5-99, Volume 1, Executive Summary, December 1999.

California Air Resources Board, Health and Environmental Assessment of the Use of Ethanol as a Fuel Oxygenate, Report to the California Environmental Policy Council in Response to Executive Order D-5-99, Volume 2, Background Information on the Use of Ethanol as a Fuel Oxygenate, December 1999.

State of California, Air Resources Board, Air Quality Impacts of the Use of Ethanol in California Reformulated Gasoline, Final Report to the California Environmental Policy Council with Appendices A-D, December 1999.

State of California, Air Resources Board and Office of Environmental Health Hazard Assessment, Health and Environmental Assessment of the Use of Ethanol as a Fuel Oxygenate, Volume 4 with Chapters 1-11, Potential Ground and Surface Water Impacts, December, 1999.

State of California, Office of Environmental Health Hazard Assessment, Health and Environmental Assessment of the Use of Ethanol as a Fuel Oxygenate, Volume5: Potential Health Risks of Ethanol in Gasoline, December 1999.

University of California, Report to the Governor and Legislature of the State of California as Sponsored by SB 521, Volume I - Summary and Recommendations, November, 1998.

University of California, Report to the Governor and Legislature of the State of California as Sponsored by SB 521, Volume II - An Evaluation of the Scientific Peer Reviewed Research and Literature on the Human Health Effects of MTBE, it Metabolites, Combustion Products and Substitute Compounds, John R. Froines, Ph.D., Principal Investigator, November, 1998.

University of California, Report to the Governor and Legislature of the State of California as Sponsored by SB 521, Volume III - Air Quality and Ecological Effects, Catherine Koshland, Ph.D., et al, November 1998.

University of California, Report to the Governor and Legislature of the State of California as Sponsored by SB 521, Volume IV - Impacts of MTBE on California Groundwater, Graham E. Fogg, et al, November, 1998.

University of California, Report to the Governor and Legislature of the State of California as Sponsored by SB 521, Volume V - Exposure of Humans to MTBE from Drinking Water, Michael L. Johnson, John Muir Institute of the Environment, University of California, Davis, November 1998.

Buxton, Herbert, et al., Interdisciplinary Investigation of Subsurface Contaminant Transport and Fate at Point-Source releases of Gasoline-Containing MTBE, Paper presented at the Petroleum Hydrocarbon on Conference, November 11-14, 1997, Houston, Texas.

State of California, California Environmental Protection Agency, Review of Senate Office of Research MTBE Paper, February 16, 1998.

California Senate Office of Research, Does California Need MTBE? February 1998.

Health Effects Institute, The Potential Health Effects of Oxygenates Added to Gasoline, February 1996.

Landmeyer, James, et al., Fate of MTBE Relative to Benzene in a Gasoline-Contaminated, Aquifer (1993-1998), Groundwater Monitoring & Remediation, April 17, 1998.

LFR Levine-Fricke & Santa Clara Valley Water District, Summary Report: Santa Clara Valley WaterDistrict, Groundwater Vulnerability Pilot Study, Investigation of MTBE Occurrence Associated with Operating UST Systems, July 22, 1999.

Mormille, Melanie et al., Anaerobic Biodegradation of Gasoline Oxygenates: Extrapolation of Information to Multiple Sites and Redox Conditions, Environmental Science and Technology, Vol. 28, No. 9, 1994.

Office of Science and Technology Policy, Executive Office of the President, Fuel Oxygenates And Water Quality: Current Understanding of Sources, Occurrence in Natural Waters, Environmental Behavior, Fate, and Significance, September 1996.

Pankow, James, et al., The Urban Atmosphere as a Non-Point Source for the Transport of MTBE and Other Volatile Organic Compounds (VOCs) to Shallow Groundwater, Environmental Science and Technology, Vol. 31, No. 10, 1997.

Poulsen, Mette, et al., Dissolution of Monoaromatic Hydrocarbons into Groundwater from Gasoline-Oxygenate Mixtures, Environmental Science and Technology, Vol 26, No. 12, 1992.

Professor Graham Fogg, University of California, Davis, memorandum to SB 1764 Committee Members, USGS News Releases on Gasoline Additive MTBE in Groundwater, April 28, 1995.

State of California, San Francisco Regional Water Quality Control Board, Recommended Interim Water Quality Objectives (or Aquatic Life Criteria) for Methyl Tertiary-Butyl Ether (MTBE), October 1, 1998.

Squillace, Paul, et al., Review of the Environmental Behavior and Fate of Methyl tert-Butyl Ether, Environmental Toxicology and Chemistry, Vol. 16, No. 9, September 1997.

Sulfita, Joseph, et al., Review of the Environmental Behavior and Fate of Methyl tert-Buytl Ether, Environmental Toxicology and Chemistry, Vol. 16, No. 9, September, 1997.

State of California, Office of Environmental Health Hazard Assessment, Public Health Goal for Methyl Tertiary Butyl Ether (MTBE) in Drinking Water, March 1999.

United States Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, Toxicological Profile for Methyl T-Butyl Ether: Draft for Public Comment, February 1995.

United States Environmental Protection Agency, Drinking Water Advisory: Consumer Acceptability and Health Effects Analysis on Methyl Tertiary-Butyl Ether (MtBE), December 1997.

United States Environmental Protection Agency, Reference Concentration for Chronic Inhalation Exposure, September 1, 1993.

United States Geological Survey, Denver's Urban Ground-Water Quality: Nutrients, Pesticides, and Volatile Organic Compounds, March 1995.

United States Geological Survey, MTBE in Ground Water of the United States – Occurrence, Potential Sources, and Long-Range Transport, 1999.

United States Geological Survey, Occurrence and Concentrations of Volatile Organic Compounds In Shallow Ground Water in the Lower Susquehanna River Basin, Pennsylvania and Maryland, June 1996.

United States Geological Survey, Occurrence of the Gasoline Oxygenate MTBE and BTEX Compounds in Urban Stormwater in the United States, 1991-1995, 1996.

United States Geological Survey, Occurrence of Volatile Organic Compounds in Streams on Long Island, New York, and New Jersey, June, 1997.

United States Geological Survey, Occurrence of Volatile Organic Compounds in Ground Water In the White River Basin, Indiana, 1994-5, June, 1996.

United States Geological Survey, Preliminary Assessment of the Occurrence and Possible Sources of MTBE in Ground Water of the United States, 1993-94, 1995.

United States Geological Survey, Volatile Organic Compounds in Groundwater in the Connecticut, Housatonic, and Thames River Basins, 1993-1995, April, 1997.

University of California, Lawrence Livermore National Laboratories, Environmental Protection Department - Environmental Restoration Division, An Evaluation of MTBE Impacts to California Groundwater Resources, June 11, 1998.

University of Wisconsin, Department of Engineering Professional Development, Special Issue on MTBE, Underground Tank Technology Update, Vol. 13, No. 4, July/August, 1999.

Westbrook, P., Shell Oil Co., Compatibility and Permeability of Oxygenated Fuels to Materials in Underground Storage and Dispensing Equipment, October 1998.

United States Environmental Protection Agency, Robert S. Kerr Environmental Research Laboratory, Complex Mixtures and Groundwater Quality, M.L. Brusseau, May, 1993.

Dupont Automotive, Personal Communication from Rick L. Bell, DuPont Automotive, to Steve Brisby, California Air Resources Board, November 17, 1999.

Ed Fead, Ravi Vengadam, Giuseppe Rossi, Albert Olejnik and John Thorn, Speciation of Evaporative Emissions from Plastic Fuel Tanks, SAE Technical Paper # 981376, May 1998

Mark Nulman, Albert Olejnik, Marsha Samus, Ed Fead and Giuseppe Rossi, Fuel Permeation Performance of Polymeric Materials Analyzed by Gas Chromatography and Sorption Techniques, SAE Technical Paper # 981360, May 1998.

W. M. Stahl and R. D. Stevens, Fuel-Alcohol Permeation Rates of Fluoroelastomers Fluoroplastics and Other Fuel Resistant Materials, SAE Technical Paper # 920163, February 1992.

MathPro, Inc. Subcontract No. LB60100 Submitted to the State of California, California Energy Commission, Analysis of California Phase 3 RFG Standards - including 1998 CaRFG gasoline composition data, December 7, 1999.

California Energy Commission, Printout Showing Monthly Refinery OperatingUtilization Rates, 1997-1999, Facsimile Dated March 29, 2000.

American Society for Testing and Materials, D 4806-99, Standard Specification for Denatured Duel Ethanol for Blending with Gasolines for Use an Automotive Spark-Ignition Engine Fuel, 1999.

American Society for Testing and Materials, D5453-00, Standard Test Method for Determination of Total Sulfur in Light Hydrocarbons, Motor Fuels and Oils By Ultraviolet Fluorescence, 2000.

American Society for Testing and Materials, D5580-00, Standard Test Method for Determination of Benzene, Toluene, Ethylbenzene, p/m-Xylene, o-Xylene, C_9 and Heavier Aromatics and Total Aromatics in Finished Gasoline by Gas Chromatography, 2000.

Archer Daniel Midland Co., Carl F. Reeder, Report on Ethanol Producers Survey, June 15, 2000.

Math Pro, Inc. Analysis of California Phase 3 RFG Standards submitted to California Energy Commission under Subcontract No. LB60100, December 7, 1999.

Reilman, M. A., Gunst, R. F., and Lakshminarayanan, M. Y., Stochastic Regression with Errors in Both Variables, Journal of Quality Technology, 18 (1986), 162-169

State of California, Air Resources Board, California Phase 3 Reformulated Gasoline Regulations, Proposed Amendments to the California Reformulated Gasoline Regulations, Including a December 31, 2002 Prohibition of Using MTBE in Gasoline, Adoption of Phase 3 Gasoline Standards, a Phase 3 Predictive Model, and Other Changes. Staff Report: Initial Statement of Reasons, October 22, 1999.

State of California, Air Resources Board, California Phase 3 Reformulated Gasoline Regulations, Proposed Amendments to the California Reformulated Gasoline Regulations, Including a December 31, 2002 Prohibition of Using MTBE in Gasoline, Adoption of Phase 3 Gasoline Standards, a Phase 3 Predictive Model, and Other Changes, Final Statement of Reasons, June 2000.

State of California, Air Resources Board, Resolution 99-39, December 9, 1999.

State of California, Air Resources Board, Letter to Robert Perciasepe, U.S.E.P.A. Additional Material supporting California's Request for a Waiver of the Federal RFG Year-Round Oxygen Mandate, December 24, 1999.

State of California, Air Resources Board, Letter to Robert Perciasepe, U.S.E.P.A. Additional Material supporting California's Request for a Waiver of the Federal RFG Year-Round Oxygen Mandate, February 7, 2000.

State of California, Air Resources Board, Letter to Robert Perciasepe, U.S.E.P.A. Additional Material supporting California's Request for a Waiver of the Federal RFG Year-Round Oxygen Mandate, February 17, 2000.

State of California, Air Resource Board, Motor Vehicle Emissions Inventory, EMFAC Version 7G, Calendar Year 1996, Model Years 1962 to 1996 inclusive.

State of California, Air Resources Board, Spreadsheet Calculations to Estimate the Overall Emissions Effects of Distribution Tank Transitions from a CaRFG3 CARBOB or Non-Oxygenated Gasoline to Another CaRFG3 CARBOB or Non-Oxygenated Gasoline Intended to Have a Different Ethanol Content, September 2000.

Southwest Research Institute, Investigation of the Effects of Fuel Composition and Injection and Combustion System Type on Heavy-Duty Diesel Exhaust Emissions, Terry L. Ullman, under contact to the Coordinating Research Council, Inc., March, 1989.

Southwest Research Institute, Study of Fuel Cetane Number and Aromatic Content Effects on Regulated Emissions from a Heavy-Duty Diesel Engine, Terry L. Ullman, et al., under contract to the Coordinating Research Council, Inc., September, 1990.

Western States Petroleum Association, California Model for California Reformulated Gasoline Blendstocks for Oxygenate Blending (CARBOB), July 21, 2000.

Western States Petroleum Association, Letter from Gina Grey to Dean Simeroth, Denatured Ethanol Specifications, July 21, 2000.

United States Code of Federal Regulations, Title 27, Volume 1, Part 21, Formulas For Denatured Alcohol and Rum, Code of Federal Regulations, revised as of April 1, 2000.

University of California, Davis, Graduate School of Management, Simulation Program to Estimate the Potential Range of the Emission Effect of Ethanol in Gasoline due to Commingling, David M. Rocke, December 2, 1999

2003 Low Sulfur Diesel ISOR - References

Final Report, 1996 American Petroleum Institute/National Petroleum Refiners Association, Survey of Refining Operations and Product Quality, July 1997.

[1] California Environmental Protection Agency. Air Resources Board. *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles.* October 2000, Appendix IV

[1] California Environmental Protection Agency. Air Resources Board. *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles.* October 2000, Appendix III.

[1] California Environmental Protection Agency. Air Resources Board. *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles.* October 2000, Appendix II.

[1] California Environmental Protection Agency, Air Resources Board,. *Draft State and Federal Element of South Coast State Implementation Plan.* January 2003.

[1] San Joaquin Valley Air Pollution Control District. *Amended 2002 and 2005 Ozone Rate of Progress Plan.* December 31, 2002.

[1] United States Environmental Protection Agency, Assessment and Standards Division, Office of Transportation and Air Quality. *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements.* EPA420-R-00-026, December 2000, Chapter II.

[1] Report to the Air Resources Board on the Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant. Part A. Exposure Assessment. As approved by the Scientific Review Panel on April 22, 1998, pp. A-5–A-7

[1] Arey J., Zeilinska, B., Atkinson, R. and A.M. Winer, 1988. Formation of Nitroarenes During Ambient High-Volume Sampling. *Environ. Sci. Technol.*, 22:457-462.

[1] Atkinson, R., Arey, J., Winer, A.M., Zielinska, B., Harger, W.P., and McElroy, P.A. 1988. A Survey of Ambient Concentrations of Selected Polycyclic Aromatic Hydrocarbons (PAH) at Various Locations in California. Final Report. California Air Resources Board, Sacramento, CA.

[1] California Environmental Protection Agency, Air Resources Board. *Findings of the Scientific Review Panel on The Report on Diesel Exhaust as Adopted at the Panel's April 22, 1998 Meeting.* Appendix II of Staff Report, Initial

Statement of Reasons - Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant.

[1] Report to the Air Resources Board on the Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant. Part A. Exposure Assessment. As approved by the Scientific Review Panel on April 22, 1998, p. A-50.

[1] California Environmental Protection Agency. Air Resources Board. *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles.* October 2000, Appendix VI.

[1] California Environmental Protection Agency. Air Resources Board. *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles.* October 2000, p. 15

[1] Kittelson, D.B., Arnold, M., Watts, W.F. (1999) Review of Diesel Particulate Matter Sampling Methods. Final Report. University of Minnesota www.me.umn.edu/centers/cdr/Proj_EPA.html.

[1] Report to the Air Resources Board on the Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant. Part A. Exposure Assessment. As Approved by the Scientific Review Panel on April 22, 1998.

[1] United States Environmental Protection Agency,. Assessment and Standards Division, Office of Transportation and Air Quality, *Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Nonroad Diesel Engines and Fuel.* EPA420-R-03-008, April 2003, Chapter II.

[1] California Environmental Protection Agency. *Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant: Health Risk Assessment for Diesel Exhaust; Appendix III, Part B*; Office of Environmental Health Hazard Assessment: Sacramento, CA, 1998

[1] California Air Resources Board. *Resolution 98–35: Identification of Particulate Emissions from Diesel-Fueled Engines as a Toxic Air Contaminant*; California Air Resources Board: Sacramento, CA, 1998, http://www.arb.ca.gov/regact/diesltac/res98-35.pdf

[1] Diaz-Sanchez, D.; Tsien, A.; Casillas, A.; Dotson, A.R.; Saxon, A. Enhanced Nasal Cytokine Production in Human Beings after in vivo Challenge with Diesel Exhaust Particles; *J. Allergy Clin. Immunol.* 1996, *98*, 114-123.

[1] Diaz-Sanchez, D.; Garcia, M.P.; Wang, M.; Jyrala, M.; Saxon, A. Nasal Challenge with Diesel Exhaust Particles Can Induce Sensitization to a Neoallergen in the Human Mucosa; *J. Allergy Clin. Immunol.* 1999, *104*, 1183-1188.

[1] Takano, H.; Ichinose, T.; Miyabara, Y.; Shibuya, T.; Lim, H.B.; Yoshikawa, T.; Sagai, M. Inhalation of Diesel Exhaust Enhances Allergen-related Eosinophil Recruitment and Airway Hyperresponsiveness in Mice; *Toxicol. Appl. Pharmacol.* **1998**, *150*, 328-337.

[1] Lloyd, A.C.; Cackette, T.A. Diesel Engines: Environmental Impact and Control; *J Air Waste Manage. Assoc.* 2001, 51: 809-847

[1] United States Environmental Protection Agency, Assessment and Standards Division, Office of Transportation and Air Quality. *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements*. EPA420-R-00-026, December 2000, Chapter II.

[1] Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements. Federal Register: January 18, 2001 (Volume 66, Number 12) Pages 5001-5134

[1] Control of Emissions of Air Pollution from Nonroad Diesel Engines and Fuel. Proposed Rules. Federal Register: May 23, 2003 (Volume 68, Number 100) Pages 28328-28603.

[1] Report to the Air Resources Board on the Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant. Part A. Exposure Assessment. As approved by the Scientific Review Panel on April 22, 1998.

[1] California Environmental Protection Agency. Air Resources Board. *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles.* October 2000.

[1] Documents developed by the Portable Equipment Workgroup are available for viewing or downloading at http://www.arb.ca.gov/diesel/portdiesel.htm

[1] The Proposed and Draft ATCMs and other relevant documents are available for viewing or downloading at http://www.arb.ca.gov/diesel/documents.htm

[1] Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements. Federal Register: January 18, 2001 (Volume 66, Number 12) Page 5090.

[1] United States Environmental Protection Agency, Assessment and Standards Division, Office of Transportation and Air Quality. *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel*

Fuel Sulfur Control Requirements. EPA420-R-00-026, December 2000, Chapter III.

[1] U.S. Department of Energy, Engine Manufaturers Association, and Manufacturers of Emissions Controls Association, *Diesel Emissions Control – Sulfur Effects (DECSE) Program Phase II Summary Report: NOx Adsorber Catalysts*. October 2000

[1] Clark, W., Sverdrup, G.M., Goguen, S.J., Keller, G., McKinnon, D., Quinn, M.J., and Graves, R.L. *Overview of diesel emission control - Sulfur effects program*; SAE #2000-01-1879; Society of Automotive Engineers, Inc.: Warrendale, PA, 2000.

[1] Manufacturers of Emission Controls Association. Catalyst-based diesel particulate filters and NO_X adsorbers: A summary of the technologies and the effects of fuel sulfur; 2000. http://www.meca.org.

[1] Diesel Emissions Control – Sulfur Effects (DECSE) Program Phase 1 Interim Data Report No. 4: Diesel Particulate Filters – Final Report. U.S. Department of Energy, Engine Manufaturers Association, and Manufacturers of Emissions Controls Association. January 2000.

[1] Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements", Federal Register: January 18, 2001 (Volume 66, Number 12) (Rules and Regulations). p. 12.

[1] United States Environmental Protection Agency, Assessment and Standards Division, Office of Transportation and Air Quality. *Strategies and Issues in Correlating Diesel Fuel Properties with Emissions*, "Staff Discussion Document," EPA420-P-01-001, , July 2001, pp. 41-42.

[1] Lee, R; Pedley, J; and Hobbs, C; 1998. "Fuel Quality Impact on Heavy-Duty Diesel Emissions – A Literature Review;" SAE 982649; Society of Automotive Engineers, Inc; Warrendale, Pennsylvania.

[1] Barbour, R.H., Rickeard, D.J., Elliot, N.G., "Understanding Diesel Lubricity", SAE #2000-01-1918; Society of Automotive Engineers, Inc.: Warrendale, PA, 2000

[1] United States Environmental Protection Agency,. Assessment and Standards Division, Office of Transportation and Air Quality, *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements*.. EPA420-R-00-026. December 2000, Chapter IV. pp 64 – 78.

[1] ASTM Standard D 975-98a, "Standard Specification for Diesel Fuel Oils", ASTM Standards, Section 5, Vol. 05.01 (1998).

[1] "Demand for Diesels: The European Experience", Diesel Technology Forum, July 2001, www.dieselforum.org/whitepaper/downloads/europeanexperience.pdf

[1] Lacey, P.I., Howell, S.A., "Fuel Lubricity Reviewed", SAE Technical Paper 982567, 1998.

[1] Nikanjam, Manuch, Henderson, Paul, Lacey, Paul, Caprotti, Rinaldo, Simeroth, Dean, Mithchell, Ken,, "Diesel Fuel Lubricity". Presented at the 8th Annual Fuels & Lubes. Asia Conferenc and Exhibition, F&L Asia , Inc, January 29 – February 1, 2002.

[1] Nikanjam, M., Crosby, T., Henderson, P., Cray, C., Meyer, K., Davenport, N., "ISO Diesel Fuel Lubricity Round Robin Program", SAE Technical Paper 952372, 1995.

[1] D6078-99 Standard Test Method for Evaluating Lubricity of Diesel Fuels by the Scuffing Load Ball-on-Cylinder Lubricity Evaluato (SLBOCLE).

[1] D6079-02 Standard Test Method for Evaluating Lubricity of Diesel Fuels by the High-Frequency Reciprocating Rig (HFRR).

[1] Nikanjam, Manuch, Chevron Products Company; "Diesel Fuel Lubricity: On the Path to Specifications", SAE Technical Paper 1999-01-1479, 1999.

[1] U.S. Ultra Low Sulfur Diesel Fuel Properties, EMA Engine Manufacturer's Association, September 20, 2002.

[1] The Diesel Fuel Task Force; "Report of the Diesel Fuel Task Force", DCN 93-674-062-01, February 18,1994. p.4-4.

[1] Meyer, Klaus, Livingston, Thomas C., Presentation "Diesel Fuel Lubricity Requirements for Light Duty Fuel Injection Equipment", CARB Fuels Workshop, Sacramento, CA, February 20, 2003.

[1] Westbrook, S.R., Lacey, P.I., McInnis, L.A., Lestz, S.J.,LePera, M.E.; "Survey of Low Sulfur Diesel Fuel and Aviation Kerosenes from U.S. Military Installations", SAE Technical Paper 952369, 1995.

[1] Nikanjam, Manuch, Chevron Products Company, California Air Resource Board Public Meeting Presentation, "Diesel Fuel Lubricity The Need For Specification", Sacramento, CA, Feb. 20 2003.

[1] Tucker, R.F., Stradling, R.J., Wolveridge, P.E., Rivers, K.J., Ubbens, A., "The Lubricity of Deeply Hydrogenated Diesel Fuels – The Swedish Experience", SAE Technical Paper 942016, 1994.

[1] "Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements", Federal Register: January 18, 2001 (Volume 66, Number 12) (Rules and Regulations Pages 5083-5084).

[1] Dimitrakis, William J., "The importance of lubricity", The Lubrizol Corporation, USA, Hydrocarbon Engineering, March 2003, pp.37-39.

[1] Nancy Strete, David Forrester, Lubrizol Corporation, Teleconference with ARB personnel Gary Yee, Robert Okamoto, and Cherie Cotter, April 21, 2003.

[1] Alan Melard, Infineum Corporation, Teleconference with ARB personnel Gary Yee, Robert Okamoto, and Cherie Cotter, April 22, 2003.

[1] Barbara Goodrich, BP, Teleconference with ARB personnel Gary Yee and Cherie Cotter, March 20, 2003.

[1] Mozdzen, Edward C., Wall, Stephen W., and Byfleet, William D., "The No-Harm Performance of Lubricity Additives for Low Sulphur Diesel Fuels", SAE Technical Paper 982571, 1998.

[1] Kenneth Mitchell, Shell Canada, Teleconference with ARB personnel Gary Yee and Cherie Cotter, April 25, 2003.

[1] Cameron, Frances, California Air Resources Board; "Lubricity of California Diesel Fuel", SAE Technical Paper 981362, 1998.

[1] Lacey, P.I., Mason, R.L., "Fuel Lubricity: Statistical Analysis of Literature Data", SAE Technical Paper 2000-01-1917, June 2000.

[1] American Society for Testing and Materials, ASTM D 2622-94. Standard Method for Sulfur in Petroleum Products by X-Ray Spectrometry, 1994

[1] American Society for Testing and Materials, ASTM D 5453-93. Standard Method for Determination of Total Sulfur in Light Hydrocarbons, Motor Fuels and Oils by Ultraviolet Fluorescence, 1993.

[1] Nadkarni, R.A. Determination of Sulfur in Petroleum Products and Lubricants: A Critical Review of Test Performance, American Laboratory, 2000,16.

[1] South Coast Air Quality Management District, September 6, 2000. Staff Report, Proposed Amended Rule 431.2 – Sulfur Content of Liquid Fuels.

[1] United States Environmental Protection Agency, Assessment and Standards Division, Office of Transportation and Air Quality. *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements*. EPA420-R-00-026, December 2000 .

[1] Charles River Associates, Inc. *An Assessment of the Potential Impacts of Proposed Environmental Regulations on U.S .Refinery Supply of Diesel Fuel*, CRA No. D02316-00, August 2000. http://www.crai.com/asst_diesel.pdf

[1] United States Department of Energy, Energy Information Administration. *The Transition to Ultra-Low-Sulfur Diesel Fuel: Effects on Prices and Supply,* May 2001.

[1] United States Environmental Protection Agency, Assessment and Standards Division, Office of Transportation and Air Quality. *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements*. EPA420-R-00-026, Chapter IV. December 2000, pp 30 – 32.

[1] United States Environmental Protection Agency, Assessment and Standards Division, Office of Transportation and Air Quality. *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements*. EPA420-R-00-026, Chapter III. December 2000, pp 96 – 98.

[1] "Lubrication Theory and Practice.", accessed May 1, 2003, www.lubrizol.com/lubetheory/theory.htm

[1] Whitacre, Shawn. "Catalyst Compatible" Diesel Engine Oils, DECSE Phase II, Presentation at DOE/NREL Workshop "Exploring Low Emission Diesel Engine Oils." January 31, 2000.

[1] "SwRI forms research consortium on diesel aftertreatment sensitivity to lubricants", January 31, 2001,www.dieselnet.com/news/0101swri.html

[1] United States Environmental Protection Agency; Office of transportation and Air Quality, *A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions: Draft Technical Report*, EPA 420-P-02-001, October 2000, www.epa.gov/otaq/models/analysis/biodsl/p02001.pdf

[1] Lovelace Respiratory Research Institute, Tier 2 Testing of Biodiesel Exhaust Emissions: Final Report. Study Report Number FY98-056 submitted to National Biodiesel Board, May 22, 2000, pp. 1-59.

[1] Economides. N. and Higgins, T. International diesel fuel policies will shape markets for years. World Diesel 2003. Pp. 25-28.

[1] Klavers, Kristine, Global Trends for Automotive Diesel Qualities. World Diesel 2003. Pp 29-34.

[1] European Conference of Ministers of Transport. Report to the Committee of Deputies: *Sulphur-Free Auto Fuels.* March 2001.

[1] World-Wide Fuel Charter, December 2002, Page 5.

[1] Cooper, B. H., and Knudsen, K.G. "What does it take to produce ultra-low sulfur diesel?" World Refining, November 2000.

[1] Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999. California Energy Commission Publication #600-02-001F-ES, November 2002.

[1] State of California, Air Resources Board, Public Hearing to Consider Amendments Adopting More Stringent Emission Standards for 2007 and Subsequent Model Year Heavy-Duty Diesel Engines. Staff Report: Initial Statement of Reasons, September 7, 2001.

[1] California Environmental Protection Agency. Air Resources Board. *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles.* October 2000, Chapter VIII.

[1] Final Program Environmental Assessment for: Proposed Fleet Rules and Related Rule Amendments. South Coast Air Quality Management District. SCAQMD No. 000307DWS. June 5, 2000.

[1] United States Environmental Protection Agency,. Assessment and Standards Division, Office of Transportation and Air Quality, *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements*.. EPA420-R-00-026. December 2000, Chapter 5.

[1] California Energy Commission – Weekly Fuels Watch Report, 2002, www.energy.ca.gov/database/fore/index.html

[1] Energy Information Adminstration, U.S. Department of Energy: The Transition to Ultra-Low-Sulfur Diesel Fuel: Effects on Prices and Supply, www.eia.doe.gov/oiaf/servicerpt/ulsd/pdf/ulsd.pdf, Chapter 6.

[1] MathPro Inc., Refining Economics of Diesel Fuel Sulfur Standards: Supplemental Analysis of 15ppm Sulfur Cap, October 1999, updated August 2000.

[1] National Petroleum Council, U.S. Petroleum Refining, Assuring the Adequacy and Affordability of Cleaner Fuels, June 2000, Chapter 3.

[1] EnSys Energy & Systems, Inc., Modeling Impacts of Reformulated Diesel Fuel, August 2000.

[1] MathPro Inc., Prospects for Adequate Supply of Ultra Low Sulfur Diesel Fuel in the Transition Period (2006-2007): An Analysis of Technical and Economic Driving Forces for Investment in ULSD Capacity in the U.S. Refining Sector, February 2002.

[1] Oil Price Information Service, Copyrighted data for AZ, CA, NV, OR from year 1996–2002, http://www.opisnet.com .

[1] Energy Information Administration - Department of Energy, http://www.eia.doe.gov/oil_gas/petroleum/data_publications/petroleum_marketing_monthly/pmm_historical.html .

[1] California Department of Food and Agriculture, 2002 Resource Directory, www.plant.cdfa.ca.gov/card/

[1] Studies from University California, Davis, Cooperative Extension, Department of Agricultural and Resource Economics, www.agecon.ucdavis.edu/outreach/crop/cost.htm

[1] Council of Economic Advisors, 108th Congress, 1st Session, Economic Indicators: January 2003, www.access.gpo.gov/congress/eibrowse/broecind.html

[1] California Agricultural Statistics Service - United States Dairy Association, California Cost of Production Annual 2001.

[1] Studies from Oregon Agricultural Enterprise Budgets, Extension Service, Oregon State University (http://oregonstate.edu/Dept/EconInfo/ent_budget/)

[1] State of California, Air Resources Board, Spreadsheet Calculations to Estimate the Average Gallons of Diesel Consumed, Vehicle Miles Traveled, and Cost Impacts, for HDDT based on data from EMFAC2002, Version 2.2.

[1] American Trucking Association, Information Center, Government's Cash Cow: The Trucking Industry (http://www.truckline.com/infocenter/position_papers/cashcow.html)

[1] US Department of Transportation, Federal Highway Administration, Motor Fuel Use – Special Fuel (Diesel) – Private and Commercial Highway Use

[1] US Census Bureau, Census 2000 PHC-T-2, Table 2, States Ranked by Numeric Population Change: 1990 to 2000

[1] ARB, October 2000. *Risk Reduction Plan to Reduce PM Emissions from Diesel-Fueled Engines and Vehicles*, including Appendices II and III, California Air Resources Board, Sacramento, California.