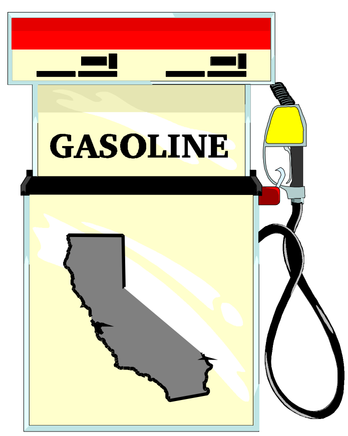
California Environmental Protection Agency

Air Resources Board

Proposed 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



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State of California

California Environmental Protection Agency
AIR RESOURCES BOARD
Stationary Source Division

STAFF REPORT: INITIAL STATEMENT OF REASONS PROPOSED CALIFORNIA PHASE 3 GASOLINE REGULATIONS

Public Hearing to Consider 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

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Principle Authors:

Tony Brasil, Fuels Section
Kevin Cleary, Fuels Section
Tom Jennings, Office of Legal Affairs
Richard Vincent, Fuels Section
Erik White, Industrial Section

Contributing Authors:

Nelson Chan, Fuels Section
Jim Aguila, Industrial Section
Jim Guthrie, Fuels Section

With Special Thanks for Administrative Support to:
Valentine Montoya

Reviewed by:

Michael Scheible, Deputy Executive Officer
Peter D. Venturini, Chief, Stationary Source Division
Dean C. Simeroth, Chief, Criteria Pollutants Branch
Steve Brisby, Manager, Fuels Section
Gary Yee, Manager, Industrial Section

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A. Introduction

This report is the initial statement of reasons in support of the proposed amendments to the "California Phase 2 Reformulated Gasoline (CaRFG2) Regulations". These amendments are being proposed in response to Governor Davis' March 25, 1999 Executive Order D-5-99 regarding the phase-out of the use of methyl-tertiary-butyl-ether (MTBE) in California gasoline. The Governor's Executive Order included two directives prompting this proposal. First, that MTBE be removed from California gasoline at the earliest possible date, but no later than December 31, 2002. Second, that the Air Resources Board (ARB) adopt by December 1999, Phase 3 Reformulated Gasoline (CaRFG3) regulations to provide additional flexibility in lowering or removing oxygen, to maintain current emission and air quality benefits from the CaRFG2 regulations, and to allow compliance with the State Implementation Plan (SIP) for achieving ambient air quality standards.

In response to the Governor's Executive Order, the staff is proposing amendments to the current CaRFG2 regulations. These proposed amendments are collectively referred to as the CaRFG3 regulations. These amendments include a prohibition on the use of MTBE in gasoline, revised specifications for Phase 3 gasoline, and an improved and expanded Predictive Model. In developing the proposed amendments, the staff's objectives were to provide flexibility to refiners to make or import CaRFG3 without MTBE, to preserve the significant emissions benefits realized from the current CaRFG2 regulations, and to obtain additional emission reductions where technically feasible and economically reasonable. In developing the proposal, the staff was also sensitive to the growing demand for gasoline in California and the realization that gasoline imports will be increasingly needed on a routine basis to meet this growing demand. Finally, the staff also provided flexibility in its proposal to facilitate the use of ethanol in California gasoline in a manner that does not adversely impact air quality. This was done in recognition that substantial quantities of ethanol would likely be used in California gasoline in the future.

Presented below are background information and an overview of the staff's proposal. Subsequent chapters provide a more detailed discussion. The proposed amendments are contained in Appendix A.

B. What Are the Existing Requirements for California Gasoline?

California gasoline production is governed by both state and federal regulations. The CaRFG2 regulations were adopted by the ARB in 1991 and were implemented statewide in 1996. These regulations established a comprehensive set of specifications including limits for eight gasoline properties as shown in Table 1. The CaRFG2 regulations have provided very significant reductions of ozone and particulate matter precursor emissions and toxic air pollutants. The benefits of the program have been equivalent to removing 3.5 million vehicles from California's roads. The CaRFG regulations are also a major component of California's plan for achieving ambient air quality standards.

Table 1
Basic CaRFG2 Limits and Caps

Property	**Pre-CaRFG2** (summer)	**Flat Limits**	**Averaging Limits**	**Cap Limits**[(1)]
Reid vapor pressure, psi, max	7.8	7.0	---	7.0
Benzene, vol%, max	2.0	1.00	0.80	1.20
Sulfur, ppmw, max	150	40	30	80
Aromatic HC, vol%, max	32	25	22	30
Olefins, vol%, max	9.9	6.0	4.0	10
Oxygen, wt%	0	1.8 to 2.2	---	1.8 (min)[(2)] 3.5 (max)
T50 (temp. at 50% distilled) ^{o}F, max	220	210	200	220
T90 (temp. at 90 % distilled) ^{o}F, max	330	300	290	330

(1) The "cap limits" apply to all gasoline at any place in the marketing system and are not adjustable.
(2) The 1.8 weight percent minimum applies only during the winter and only in certain areas.

For each batch of gasoline being supplied from the refinery, the gasoline producer can comply with the regulations in one of three ways. First, for a given property, each producer may choose to meet either the flat limit or the averaging limit, as shown in the table. When choosing the flat limits, a producer may not exceed the flat limits for any gasoline sold. Whereas under the averaging limits, the volume weighted average value of individual gasoline properties can not exceed the averaging limits. The second compliance option allows producers the use of a Predictive Model to identify other sets of property limits (flat, averaging, or mixed) that may be more optimal for refiners. The Predictive Model is basically a set of equations relating gasoline properties to vehicle emissions that are used to identify alternative limits that correspond to equal or better exhaust emissions than the flat or averaging limits. The third compliance option allows for certification of alternative gasoline formulations based on the results of vehicle emission testing. Currently, most of the gasoline sold in California complies with the CaRFG regulations through the use of the Predictive Model.

Finally, cap limits are included for the various gasoline properties. These cap limits provide an upper limit for fuel properties for all compliance options and allow enforcement throughout the gasoline distribution system.

The United States Environmental Protection Agency (U.S. EPA) also has enacted federal reformulated gasoline (RFG) regulations. Nationally, about 30 percent of the gasoline produced must meet these requirements. These regulations impose emission performance standards in conjunction with specific requirements for oxygen content (year-round average of 2.0 percent by weight), and limits on benzene content. The federal requirements are being implemented in two phases. The first phase began in 1995 and the second phase begins in

December 1999. For California, the federal RFG regulations were first implemented in 1995 in the South Coast and San Diego, and then in 1996 in the Sacramento Metropolitan Region. These areas of the State account for about 70 percent of the gasoline sold in California. California's own CaRFG2 regulations achieve greater emission reductions than the federal RFG program. The U.S. EPA, in the September 15, 1999 Federal Register, made the finding that the emission reduction benefits of California gasoline are at least as great as those from federal Phase II RFG.

Because of the 1990 federal Clean Air Act Amendments requirement that mandated the use of a minimum oxygen content (2.0 percent by weight) year-round in federal RFG areas, the use of oxygenates, and MTBE in particular, has grown significantly. MTBE has favorable characteristics as a gasoline blending component, and has become the oxygenate of choice among gasoline producers for meeting CaRFG2 and federal RFG standards.

C. Why Do We Have Concerns with the Use of MTBE?

Since the implementation of the CaRFG2 and federal RFG requirements and the use of large quantities of MTBE, the detection of MTBE in Califonia's surface and ground water has occurred at an increased frequency. This led to a greater awareness of the potential threat posed by MTBE, especially to ground water resources. As a result, California legislation was enacted in 1997, which required an assessment of risks and benefits of MTBE to human health and the environment. The law required the study to be conducted by the University of California (UC), and required the Governor to take appropriate action if, based on the UC study, he determined that MTBE posed a significant risk to health and/or the environment.

Based on the UC study, public hearings on the study's findings, and peer review comments by the United States Geological Survey and the Agency for Toxic Substances and Disease Registry, Governor Davis on March 25, 1999, determined that "on balance, there is significant risk to the environment from using MTBE in gasoline in California" and through Executive Order D-5-99 directed specific action to be taken. ARB's analysis of the University of California Report and the "UC Report: MTBE Fact Sheet" are contained in Appendix B.

Prior to the completion of the University of California study and the Governor's action in March of 1999, the ARB took several steps to facilitate the reduction of MTBE use and to reduce contamination of surface water by MTBE and other gasoline components. The ARB acted in December 1998 to adopt emission standards for personal watercraft and outboard engines; certain watercraft engine technologies emit significant amounts of unburned fuel (including MTBE) in their exhaust. The ARB also removed the wintertime oxygen requirement in areas of the State that were in attainment of the federal and State CO standards. The ARB staff also began discussions with gasoline producers to revisit the CaRFG2 regulations. The goal was to provide greater flexibility to produce gasoline without MTBE, while maintaining or improving the emissions reductions obtained by the CaRFG2 regulations.

D. What Are the Elements of the Governors Executive Order?

The Executive Order contained several directives for State agencies to determine the most expeditious means to phase-out MTBE and to consider alternatives to MTBE and their potential impacts. The full Executive Order D-5-99 is included in Appendix C.

In summary, the Governor's Executive Order directs various State agencies to take steps to determine an appropriate timeframe for the removal of MTBE, and for an investigation into the potential environmental consequences of using ethanol or other oxygenates in gasoline. The Governor further directed that steps be taken immediately to significantly reduce MTBE usage in the Lake Tahoe area and to require the labeling of gasoline pumps where MTBE is used. Finally, the Governor directed that the U.S. EPA be requested to waive the federal oxygen mandate in California and urged the passage of Congressional legislation removing the oxygen mandate in California.

In addition to the Governor's Executive Order, Senate Bill 989 (Sher) was signed by the Governor on October 10, 1999. It enacts a law requiring, in part, that the CEC develop a timetable for the removal of MTBE from gasoline at the earliest possible date, and requiring the ARB to ensure that the CaRFG3 regulations maintain or improve upon emissions and air quality benefits achieved by CaRFG2 as of January 1, 1999 and to provide additional flexibility to reduce or remove oxygen from motor vehicle fuel. Senate Bill 529 (Bowen), also signed by the Governor on October 10, establishes a mechanism for conducting environmental assessments of revisions to the ARB's CaRFG standards proposed before January 1, 2000, and the mechanism will be used in connection with this rulemaking.

E. What Actions Have Been Taken to Implement the Governor's Executive Order?

The Executive Order calls for a number of steps to be taken to prohibit the use of MTBE, to evaluate the appropriate phase out period, and to investigate the environmental effects of alternative oxygenates. The Executive Order is being implemented by State agencies including the ARB, the State Water Resources Control Board (SWRCB), the Office of Environmental Health Hazard Assessment (OEHHA), the California Energy Commission (CEC), and the Department of Health Services (DHS).

To prohibit the use of MTBE as directed by the Executive Order, the ARB and CEC have worked closely together on several tasks. At a hearing on June 24, 1999, the ARB removed the wintertime oxygen requirement in Lake Tahoe, and adopted statewide regulations requiring prominent pump labeling that informs consumers when gasoline contains MTBE. In a joint effort, the CEC and ARB successfully worked with refiners to provide MTBE-free gasoline to the Lake Tahoe area. Also, the CEC, in coordination with the ARB staff, determined at a hearing on June 28, 1999, that the December 31, 2002 timeline was appropriate for the phase-out of MTBE. A copy of the CEC analysis of the appropriate time table to phase-out MTBE is in Appendix D.

Since the issuance of the Executive Order, the Governor has requested that the U.S. EPA issue a waiver from the federal oxygen requirement. In addition, the ARB has provided ongoing technical information to the U.S. EPA that supports the waiver request. Copies of the Governor's request and the ARB support letters are in Appendix E.

One of the essential elements for the most expeditious and least-costly phase-out of MTBE in California is a waiver from the oxygen mandate in federal RFG sold in California. The regulatory mandate imposed by the U.S. EPA pursuant to the federal Clean Air Act requires that federal RFG contain at least 2.0 percent by weight oxygen year-round. About 70 percent of all gasoline sold in California is subject to the federal reformulated gasoline requirements.

California's CaRFG2 requirements result in greater emission benefits than federal RFG, but do not require a minimum concentration of oxygen in all gasoline. Application of the current minimum oxygen content requirement serves no essential purpose in meeting California's air quality goals to reduce ozone and particulate matter precursors, and toxic pollutant emissions from vehicles. The results of the University of California study, a National Research Council study, and a U.S. EPA Blue Ribbon Panel report all support the position that oxygen is not necessary for reformulated gasoline to provide the same or better ozone benefits as gasoline containing oxygen.

Efforts have also begun to evaluate the potential use of ethanol as a substitute for MTBE, as called for in the Governor's Executive Order. The ARB and the SWRCB are each conducting an environmental fate and transport analysis of ethanol. The ARB discussed a draft report on the effect of ethanol on air quality at a workshop held October 4, 1999. The findings will be coordinated with the SWRCB analysis and evaluated by OEHHA to prepare an analysis of the health risks associated with the use of ethanol. Also, the CEC is continuing its efforts to evaluate steps to foster waste-based or other biomass to ethanol development in California provided that ethanol is an acceptable substitute for MTBE.

And finally, the Executive Order directed the ARB to promulgate new regulations for CaRFG3. In this regard, the ARB has been actively working with the affected stakeholders to amend the CaRFG2 regulations to achieve the goals set by the Executive Order. This initial statement of reasons is in response to the Executive Order directing the Board to make appropriate amendments by the end of 1999, to allow refiners time to make necessary changes to phase out MTBE by the end of 2002.

F. Why are Changes to the Existing CaRFG2 Regulations Necessary?

Amendments to the CaRFG2 regulations are needed for several reasons. Most importantly, the removal of MTBE from gasoline seriously limits the refiners' ability to produce gasoline that meets all of the current CaRFG2 requirements. Removing MTBE reduces gasoline volume produced by about 11 percent and raises the 50 percent distillation temperature (T50) by about 10 °F. This increase in T50 makes it difficult to produce full historic California refinery volumes of gasoline that complies with the CaRFG2 specifications. Furthermore, without MTBE, the octane of the remaining gasoline blend goes down by about 2 octane numbers, making it more difficult to produce premium and mid-grade gasoline.

Amendments to the CaRFG2 regulations to improve compliance flexibility can significantly reduce the loss in production associated with the loss of MTBE as a blending component. Amendments are also needed because ethanol and other blending components (alkylates) do not have all of the favorable blending characteristics (in terms of making complying gasoline) that MTBE has. Furthermore, unless the California oxygenate waiver request is approved, ethanol would present the only viable option in meeting the oxygen mandate in federal RFG areas, making the year-round use of ethanol mandatory in over 70 percent of California's gasoline.

The use of ethanol in gasoline presents additional challenges because when blended with gasoline, ethanol increases the Reid vapor pressure (RVP) of the resulting blend by about 1 pound per square inch (psi). To meet a summertime RVP limit of 7.0 psi, a refiner must produce a base fuel with an RVP less than 6 psi. This would require the pentane portion of the gasoline to be removed from the base fuel, thus decreasing gasoline production further.

The end result is that in order to enable California refiners and gasoline importers to preserve as much gasoline production volume as possible and to maintain the air quality benefits of CaRFG2, revisions to the CaRFG2 regulations are necessary.

G. What are the Objectives of the Proposed CaRFG2 Amendments?

In developing the CaRFG3 proposals, the staff had several key objectives:

1. *Remove MTBE from California gasoline.*
2. *Maintain the significant emission benefits obtained from the current CaRFG2 program.*
3. *Provide additional flexibility to California refiners to facilitate the removal of MTBE.*
4. *Identify additional opportunities for further emission reductions that are cost-effective.*
5. *Be sensitive to the increasing need to import gasoline to meet the increasing demand for gasoline in California.*
6. *Provide flexibility where possible, without sacrificing emission benefits, to facilitate the expected significant use of ethanol in California gasoline.*

H. How Were the Proposed Amendments Developed?

The staff began work in early 1998 to develop amendments to provide additional flexibility in the CaRFG regulations. The work began at the request of the refining industry via the Western States Petroleum Association (WSPA). Among other things, the WSPA requested changes to the "cap" limits and the Predictive Model in the CaRFG2 regulations. The refiners' purpose was to facilitate reducing their reliance on MTBE in blending gasoline.

However, two problems arose to limit the proposals that the staff could bring to the Board in 1998. First, there were insufficient data and time to develop appropriate changes to the Predictive Model. Second, it became clear that the contemplated changes to the cap limits and the Predictive Model could lead to a reduction in actual emissions benefits unless some of the limits in the regulations were changed as well. These changes could not be developed in time for proposal in 1998. As a result, the regulatory proposals that the Board heard and approved in 1998 were limited to reducing the geographical extent of the requirement for oxygen in winter gasoline and raising the oxygen cap limit to 3.5 percent by weight to allow use of up to 10 volume percent ethanol. Work on developing improvements to the CaRFG regulations continued.

From February 1999 through September 1999, the staff held eight public workshops to discuss possible amendments to the CaRFG2 regulations and the elimination of MTBE. Also, there have been numerous meetings with representatives from WSPA, individual refiners, environmental organizations, the ethanol industry, and representatives of other interests, such as vehicle manufacturers, fuel suppliers, marketing associations, and other organizations. Many of these meetings were held jointly with the staff of the California Energy Commission.

I. What Are the Staff's Proposed Amendments?

The staff is recommending that the Board amend the CaRFG2 regulations to eliminate the use of MTBE while providing refiner flexibility, preserving the benefits of the CaRFG2 program, and making continued progress towards clean air goals. The proposed amendments are contained in Appendix A. A brief summary of the proposal is discussed below.

The staff is recommending that the CaRFG2 regulations be amended to prevent the production of gasoline with MTBE and other ethers and alcohols. Specifications are also being proposed to define de minimus levels of MTBE in gasoline.

The staff is also recommending changes to various fuel property limits, substantive changes to the Predictive Model, and several other changes. The proposed changes to the Predictive Model include adding new emissions data to the model database, and updating the model to reflect vehicle emissions and fleet make-up in 2005. Other proposed changes to the Predictive Model include adding a new element to account for evaporative emissions (with variable RVP) and an element to account for the ozone benefits of reducing CO emissions. These new elements of the model would only apply during the RVP season in a given area. The staff is also proposing to include a new specification for a driveablity index, to shorten the wintertime oxygenate period in the South Coast AQMD by one month, and to amend the CARBOB (ethanol blending) provisions.

The proposed specifications are designed to preserve existing air quality benefits, improve a refiner's ability to make complying gasoline without the use of MTBE and to obtain modest additional cost-effective emissions benefits for California. The proposed gasoline specifications provide a balance between additional flexibility for refiners, preserving and obtaining additional emissions benefits, maintaining sufficient gasoline supplies to meet California demand, and preserving vehicle driveability. The specifications are also designed to allow the continued importation of gasoline to meet California's increasing demand. Table 2 below summarizes the proposed amendments to the flat, averaging, and cap limits of various fuel properties compared to the existing CaRFG2 limits.

Table 2
Proposed Amendments to the CaRFG Property Limits

Property	Flat Limits		Averaging Limits		Cap Limits	
	Original	Proposed	Original	Proposed	Original	Proposed
RVP, psi, max	7.0	7.0(1)	na(2)	no change	7.0	6.4-7.2
Benzene, vol. %, max	1.00	0.80	0.80	0.70	1.20	1.10
Sulfur, ppmw, max	40	20	30	15	80	60/30(3)
Aromatic HC, vol. %, max	25	no change	22	no change	30	35
Olefins, vol. %, max	6.0	no change	4.0	no change	10	no change
Oxygen, wt. %	1.8 to 2.2	no change	na(2)	no change	0-3.5	0-3.7(4)
T50 ^{o}F, max	210	211	200	201	220	225
T90 ^{o}F, max	300	305	290	295	330	335
Driveability Index(5)	none	1225	na(2)	na(2)	none	none

1) Equal to 6.9 psi if using the evaporative element of the Predictive Model
2) Not Applicable
3) 60 ppmw will apply December 31, 2002; 30 ppmw will apply December 31, 2004
4) If the gasoline contains more than 3.5 weight percent but no more than 10 volume percent ethanol, the cap is 3.7 weight percent
5) Driveability Index=1.5*T10+3*T50+T90+20*(wt% oxygen)

J. What Is the Rationale for the Staff's Proposed Amendments?

In summary, the staff is proposing increases in the flat, averaging and cap limits for T50 and T90 to increase refiners flexibility to eliminate MTBE. The staff is also proposing reductions in sulfur and benzene content to preserve current emissions benefits and to gain additional hydrocarbon (HC), NOx and toxic pollutant emissions reductions. The staff is proposing reductions in sulfur and benzene because they can be reduced in conjunction with increasing T50 and T90 limits without significantly reducing flexibility while preserving and gaining emissions benefits. Sulfur is the only fuel parameter that simultaneously reduces emission of HC, NOx and toxics. Because changes in T50 and T90 have little effect on NOx emissions, lowering sulfur provides additional NOx reductions. Finally, the staff is proposing a driveability index (DI) to prevent emission increases arising from poor driveability. The rationale for the individual changes are presented below.

1. ***Prohibition of MTBE***

The staff is proposing that the use of MTBE be prohibited in gasoline by December 31, 2002, consistent with the CEC's recommendation. However, residual amounts of MTBE cannot be completely removed from the distribution system by this date. Therefore, the staff is proposing limits for the allowable amount of residual MTBE that may be detected in gasoline after the phase-out.

The staff is proposing that no MTBE be allowed to be added to California gasoline, and that the detectable amount of MTBE in gasoline produced by a California refiner or imported into

California be limited to 0.3 percent by volume beginning December 31, 2002. This level corresponds to the current specification set by California's primary common carrier pipeline for gasoline produced as "non-MTBE." To further reduce the amount of MTBE in California's distribution system, the staff is proposing that the limit be reduced to 0.15 percent by volume on December 31, 2003, and 0.05 on December 31, 2004. The staff intends to monitor the ability of refiners to meet the 0.05 percent by volume level and will re-evaluate this level in 2002. This re-evaluation is necessary because if MTBE continues to be used outside California in significant quantities, MTBE can find its way into California as a contaminant in imported fuel.

2. *Reduced Sulfur Limits*

Since adoption of the CaRFG2 program, further research has shown that reducing sulfur is more effective in lowering emissions than originally estimated. Sulfur reduction is also one of the most cost-effective changes that can be made. Therefore, the staff is proposing lower sulfur limits to ensure that the benefits of the current program are maintained or enhanced. The sulfur flat limit is being reduced from 40 parts per million by weight (ppmw) to 20 ppmw. Sulfur, when decreased, is the only fuel parameter that simultaneously reduces emissions of HC, NOx and toxics. Setting a lower sulfur level will allow consideration of other specification changes, which if done alone, could reduce the benefits of CaRFG. Lower sulfur will also reduce the potential catalyst deactivation from sulfur contamination. Finally, a lower sulfur cap will further facilitate the ARB's ability to detect illegal blending of non-complying material into gasoline after it has left the refiners' control, because most noncomplying fuels sold outside California have sulfur concentrations that are higher than what is sold in California. The staff is proposing to phase-in the sulfur cap over a two year period by setting the sulfur cap at 60 ppmw on December 31, 2002 and 30 ppmw on December 31, 2004. The current sulfur cap is 80 ppmw.

3. *Reduced Benzene Limits*

The staff proposes that benzene limits be further reduced to ensure toxic emissions do not increase and to obtain additional toxic emissions reductions. Benzene is a known human carcinogen and additional benzene emission reductions will reduce public exposure to this carcinogen.

4. *Increased Flat, Averaging, and Cap Limits for T50 and T90*

Removing MTBE from gasoline will significantly decrease gasoline production and will increase the T50 of the gasoline. To help minimize the resulting loss in volume and give some relief in the middle distillation range, the staff proposes increases of the flat, averaging and cap limits for both T50 and T90. Reductions in other property limits are proposed to preserve emissions benefits of the overall gasoline blend, so these changes will not lead to poorer air quality.

5. Increased Aromatic Hydrocarbon Cap

The staff proposes that the aromatic hydrocarbon cap be increased from 30 percent to 35 percent to give refiners the flexibility to use aromatic hydrocarbons in meeting volume and octane requirements. This proposal would be emissions neutral because the staff is not recommending a change to the flat or averaging limits for aromatic hydrocarbons; thus, refiners using higher aromatics would still be required to offset any increase in emissions by changing other fuel properties.

6. Added Evaporative Emissions Element to the Predictive Model

The staff proposes amendments that would allow refiners to take advantage of the new ability to control RVP by permiting them to certify gasoline with variable RVP during the RVP season. This is a significant change from the current regulations where RVP is fixed. However, it would make the California regulations more similar to those established by the U.S. EPA, which allows RVP to be varied. Variable RVP will allow refiners to offset other parameters to balance hydrocarbon emissions. To facilitate the use of variable RVP, the staff proposes that an evaporative hydrocarbon emissions element be added to the Predictive Model that will allow varying RVP. An evaporative emissions model and variable RVP will provide significant flexibility. For refiners using ethanol, the evaporative emissions model will allow a refiner to produce a fuel with higher RVP provided that the increase in evaporative emissions is offset by reductions in exhaust emissions. And refiners who chose to produce a non-oxygenated gasoline could produce a low RVP gasoline and use the reduction in evaporative emissions to provide more flexibility in setting other fuel parameters.

7. Changes to Recognize the Benefits of Reducing CO

The staff also proposes Predictive Model amendments that would allow a credit based on the relative reactivity of CO emissions to offset changes in either evaporative or exhaust hydrocarbon emissions during the RVP season. Both the National Research Council and the U.S. EPA Blue Ribbon Panel, in separate reports, recognize that CO can play a role in ozone formation. With all other emissions kept the same, using a fuel that produces lower CO emissions would tend to reduce ozone. The staff believes that CO reductions should be credited based on CO’s relative reactivity to exhaust and evaporative emissions. With the elimination of MTBE, adding ethanol is the only viable method to increase a fuel’s oxygen content. Therefore, this CO adjustment will provide additional incentives to use ethanol as a blending component.

8. Oxygen Cap for 10 Percent Ethanol Blends

Some gasoline blends containing 10 volume percent ethanol may have up to 3.7 weight percent oxygen. Therefore, the 3.5 weight percent oxygen cap could prevent 10 volume percent ethanol from being used. The staff believes it is appropriate to make an exception for gasoline that contains more than 3.5 weight percent oxygen, but no more than 10 percent ethanol by volume. For such gasoline, the oxygen cap would be increased to 3.7 weight percent oxygen.

*9. **Proposed Updates to the Predictive Model***

Updates to the Predictive Model are proposed to more accurately reflect changes in the vehicle fleet and to account for changes in newer vehicles' response to changes in fuel properties. The update also provides an opportunity to incorporate the results of recent emission test programs in the model to increase the robustness of the data set that is used to create the model.

The current CaRFG2 Predictive Model was created and approved before data were available for federal Tier I and California low-emission vehicles (LEVs). Emission data for LEVs and weighting factors based on the current motor vehicle emissions inventory are now available and should be used to improve the Predictive Model's representation of the current and upcoming on-road vehicle fleets. The staff is proposing that new data in the 1986 to 1995 (Tech 4) technology group be added and a new technology group, 1996 to 2005 (Tech 5), be added to the Predictive Model. The staff believes it is appropriate to reflect LEVs as a separate class because these vehicles have improved emissions control technology compared to the "Tech 4" vehicles, and sufficient data are available to include them as a separate class. Consequently, the vehicle class weightings used to reflect the emissions from the vehicle technology classes used in the Predictive Model were updated. The weights reflected in the current Predictive Model were based on an older emissions inventory projected for 2000 and were adjusted in the updated model to reflect the fleet that will exist in 2005.

*10. **Added Driveability Index Limit***

The staff is proposing the addition of a new specification for driveability index, required at the refinery or import facility, to preserve vehicle driveability and to ensure that compliance with LEV II standards are not hampered by increases in the cap levels proposed for the distillation temperatures. Adverse vehicle driveability can result in increased emissions. The staff is proposing that the driveability index (DI), as defined by the form of the equation based on work done by the Coordinating Research Council, to 1225. The DI equation recommended by auto manufacturers is defined as:

$$DI=1.5\times T10+3\times T50+T90+20\times(\text{weight percent oxygen})$$

*11. **Proposed Changes to CARBOB Provisions***

Where feasible, without reducing the enforceability of the regulations, the staff is proposing streamlining of some of the CARBOB requirements, including elimination of quality audit requirements. The staff is aware of the additional CARBOB issues that need to be addressed; however, these issues will require significant time to resolve. The staff is proposing to address these issues in a later rulemaking. The staff is committed to address these issues in the 2000/2001 fiscal year which should provide sufficient time for fuel producers and distributors to make distribution changes prior to December 31, 2002.

12. *Wintertime Oxygenate Period*

The staff is proposing that the month of October be removed from the wintertime oxygen season in the South Coast Air Basin (SCAB) to eliminate the overlap with the RVP season, starting in 2003. This would leave the wintertime oxygenate program in effect from November through February, and improve a refiner's ability to use ethanol in gasoline during the winter months without the constraints on RVP. Air quality data indicates that there has only been one exceedance of the CO standard in October since 1993 and it occurred on October 31, 1997. Analysis by the staff, provided in Appendix F, shows that by 2004 no exceedances of the CO standard would be expected in the month of October.

K. What Other Factors Were Considered in Developing the Proposed Amendments?

1. *Relief from the Federal RFG Oxygenate Requirement*

To realize the full emissions benefit and flexibility that would be provided by the proposed amendments, relief from the federal RFG oxygenate requirement is necessary. Section 211(k)(2)(B) of the federal Clean Air Act expressly authorizes the U.S. EPA Administrator to waive the 2.0 weight percent minimum oxygen requirement for federal RFG, in whole or in part, "for any ozone non-attainment area upon a determination by the Administrator that compliance with such requirement would prevent or interfere with the attainment by the area of a national primary ambient air quality standard."

California has requested that the U.S. EPA waive the year-round 2.0 percent by weight oxygen requirement for federal RFG in each of California's three current federal RFG areas and any future California RFG areas. This waiver is justified by staff's technical analysis, contained in Chapter V of this report, which shows that maintaining the federal 2.0 weight percent oxygen requirement after MTBE has been eliminated in California gasoline will diminish the extent to which the California RFG regulations can achieve emission reductions over and above the reductions achieved by the federal program. This loss of additional benefits from the California program will interfere with attainment of the national ambient air quality standards for ozone, PM10, and PM2.5 in California's federal RFG areas.

Legislation has also been introduced in both the House of Representatives and the Senate that could eliminate the federal RFG year-round oxygen requirement in California. As introduced, H.R. 11 by Congressman Bilbray would provide that the CaRFG program applies in lieu of the federal RFG requirements in California if the CaRFG regulations will achieve equivalent or greater emission reductions than would result from the federal RFG requirements in the case of aggregate mass of emissions of toxic air pollutants and in the case of the aggregate mass of emissions of ozone-forming compounds. Similar legislation has been introduced in the Senate by Senator Feinstein (S. 266), who has also introduced a bill that would waive the federal RFG oxygen requirement for reformulated gasoline that results in no greater emissions of ozone-forming gasoline meeting the oxygen content requirement. The ARB has supported these bills.

2. *EPA Complex Model*

The U.S EPA, in consultation with other stakeholders, developed their Complex Model for certifying formulations of federal RFG. This model was developed based on criteria contained in the Clean Air Act which require the model to represent the nationwide fleet of vehicles representing the primary emission control technology available in 1990 and the average national gasoline properties in 1990.

The criteria set forth in the Clean Air Act severely limits the usefulness of this model in California. The federal Complex Model represents 1990 federal vehicle emission control technologies. The Complex Model database also contains vehicles that are considered 49-state vehicles which were never certified for sale in California. The California Predictive Model is not constrained by statute. Therefore, it was developed to account for the mix of vehicles in California and the more stringent vehicle and fuel standards in place in California. The proposed update allows the model to keep up with the changing vehicle fleet in California.

The federal Complex Model does account for evaporative emissions. This was not necessary with the current California Predictive Model because the Reid Vapor Pressure (RVP) of CaRFG2 was capped at 7.0 pounds per square inch. The federal reformulated gasoline regulations allow a varying RVP. The proposed changes to the current Predictive Model includes provisions for a evaporative emissions model and varying RVP.

3. *Other Models*

Other stakeholders have presented alternative models to the current CaRFG2 Predictive Model. The developers of most of these alternative models used very similar statistical techniques as the ARB staff used in developing the CaRFG2 Predictive Model. Most of these model were attempts to use the structure of the federal Complex Model with the statistical techniques of the current California Predictive Model. ICF Consulting developed a model that used higher-emitter adjustment factors to construct a model that represents the emissions response to changing fuel parameters in higher-emitters.

During the development of the CaRFG2 Predictive Model the ARB staff, in consultation with stakeholders and Dr. David Rocke of the University of California, Davis, attempted to develop a high-emitter model and found that high-emitters were so variable that they could not be used to develop a reliable high-emitter model. The test-to-test variability of these vehicles were so high that the difference between replicate tests of the same fuel on the same vehicles were often larger than the expected effects of changing fuel parameters on exhaust emissions. This conclusion is also consistent with the conclusions of the Auto/Oil – Air Quality Improvement Research Programs investigations into emissions from high-emitters. The staff concluded that it is still not appropriate to incorporate higher-emitter adjustment factors in the model.

4. *Off-Cycle Emissions*

The ARB staff was asked to investigate the possibility of developing a statistical model to augment the CaRFG2 Predictive Model to represent the effects of changing fuels parameters on emissions during off-cycle activities. The data used to develop the Predictive Model were based on emission tests from vehicles tested on the Federal Test Procedure (FTP).

The staff has researched the availability of off-cycle emissions data, and found there are still very little data available on off-cycle emissions with varying fuel properties. While there are a number of studies that conducted off-cycle emissions testing, the staff found there are insufficient data available to develop an off-cycle model similar to the Predictive Model. A more detailed discussion of the off-cycle studies evaluated is in Appendix G.

5. *Off-Road Vehicle Emissions*

The staff was also requested to investigate the effect of increased oxygen and RVP on emissions from off-road applications. There is considerable uncertainty in quantifying how the proposed CaRFG3 specifications would affect off-road sources because very little test data exist to show the impact on emissions of fuel changes for these sources. The staff looked into this and compared the predicted reductions in CO emissions associated with increased oxygen versus the predicted increased evaporative hydrocarbon emissions associated with an increase in RVP under the proposed variable RVP limits. The analysis is based on assessing the amount of evaporative hydrocarbon emissions that could be off-set on a reactivity basis by increasing the oxygen content of a gasoline from 2.0 percent to 3.5 percent by weight.

The staff's finding was that on a reactivity-adjusted basis in tons per day, the predicted decrease in CO is basically offset by the large predicted increase in evaporative emissions. Further, we would expect that directionally, exhaust hydrocarbon emissions should decrease and NOx emissions should increase. However, there are insufficient test data to reliably quantify these effects.

6. *Small Refiners*

Concern has been expressed by Kern Oil Refining that they cannot viably meet the staff's proposed CaRFG3 specifications and have asked for special consideration. Kern Oil is the only California small refiner producing CaRFG. The staff is continuing to work with Kern Oil and, if appropriate, the staff will present a proposal to address this issue.

L. What Additional Work Is in Progress?

The staff is expecting additional information as described below to become available following release of this report and prior to the Board hearing in December. To the extent this information changes the staff's current proposal, the staff will present adjustments to the proposal at the hearing.

1. Emissions Inventory EMFAC99

The EMFAC99 Emissions Inventory was recently released as a draft for public review and comment and will be heard by the Board in November 1999. The staff is using the draft inventory model to update the Predictive Model to reflect the 2005 vehicle fleet and in combining the proposed evaporative elements with the Predictive Model exhaust element. If there are any changes to the EMFAC99 draft, the staff will make the necessary changes and will present the results at the December Board hearing.

2. Vehicle Testing

A number of automobile manufacturers and oil companies are participating in a voluntary test program designed to provide data on the response of new generation catalyst control equipment to changes in the sulfur and oxygen content of gasoline. This information when available will be used to revise, as appropriate, the proposed changes to the Predictive Model.

3. Ethanol Environmental Fate and Transport

The staffs of the ARB and the State Water Resources Control Board are currently evaluating the environmental fate and transport analysis of ethanol in air, surface water, and groundwater. Preliminary air quality analysis indicates there are no significant increases in atmospheric concentrations of the products of incomplete combustion of ethanol in gasoline and any resulting secondary transformation products. The results of the air quality assessment will be presented at the December 1999 Board hearing and the water quality results will be available by the end of December 1999. Based on these results, the Board will consider the need for modifications to the current proposal that might mitigate any unacceptable impacts associated with increased ethanol use.

4. Health Effects Study

The OEHHA staff will be evaluating the potential public health impacts of ethanol in comparison to current MTBE formulations, and to gasoline with no added oxygenate. In addition, the OEHHA staff will be evaluating potential risks from groundwater contamination by fuel components. This will focus primarily on the differences between MTBE and ethanol in groundwater. The reports are to be peer reviewed and presented to the Environmental Policy Council by December 31, 1999. Preliminary data suggest there will be no significant increase in risk from the use of ethanol in gasoline compared to gasoline containing MTBE or no oxygenate.

5. CARBOB Provisions

As mentioned earlier, the staff was unable to address many of the CARBOB issues because of time and resource constraints. The staff is aware of the issues that need to be addressed; however, these issues can be dealt with more effectively at a later time when staff resources are available. The staff is committed to address these issues in the 2000/2001 fiscal year.

6. ***Economic Study***

The CEC is funding a study to update their estimates of the costs for refiners to remove MTBE while complying with the proposed CaRFG3 regulations. The ARB staff will use this information to evaluate and revise as appropriate the cost estimates associated with the proposed CaRFG3 regulations. This study could not be conducted until the proposed amendments were fully identified.

M. What Are the Emission Impacts of the Proposed Amendments?

The 2005 motor vehicle emission benefits of the proposed CaRFG3 specifications, estimated using the proposed Predictive Model, are 0.5 tons per day of hydrocarbons and 19 tons per day of NOx. Potency weighted toxic emissions are expected to decrease by about 7 percent. These emission reductions are based on comparing the properties of the 1998 average fuel to the properties of a representative CaRFG3 fuel. Since the proposed specifications for CaRFG3 achieve added emission reductions, the benefits of the 1998 average fuel as required by the S.B. 989 (Stats. 1999 ch. 812) by State Senator Sher are preserved.

Also, adoption of the proposed CaRFG3 regulations will result in preservation of the additional benefits the actual in-use fuel has been providing the environment above and beyond the original estimated benefits of the CaRFG2 program. Previously, the additional benefits of the in-use fuels have not been quantified. Based on the proposed CaRFG3 Predictive Model, in 2005 these additional benefits are estimated to be 30 tons per day of hydrocarbons and 20 tons per day of NOx, and an 8 percent reduction in potency weighted toxic emissions. The proposed CaRFG3 program preserves and enhances the motor vehicle emission reduction benefits of the current program and will further aid the Board in meeting the emission reductions required by the State Implementation Plan.

N. What Is the Cost of the Proposed Amendments?

1. ***Overall Costs***

Based on discussions with California refiners, pipeline distributors, and the CEC staff, and using reports prepared by the CEC and others, the ARB staff estimates that the first year costs of the CaRFG3 program will be four to seven cents per gallon of gasoline. However, after the first year, stability in the importation, price, and production of gasoline components (both hydrocarbon blendstocks and ethanol), as well as optimization of new equipment installed by refiners, should result in lower costs. Costs during the second year and beyond are expected to be two to six cents per gallon; averaging four to five cents per gallon. These cost estimates include: capital improvement costs at refineries of about one billion dollars; capital expenditures at pipeline terminals and ethanol off-loading sites for the handling, storage, and blending of ethanol of about $60 million; and increased costs, beyond those currently experienced for MTBE, to import ethanol, gasoline, and gasoline blendstocks.

2. *Effects of the Staff Proposal on Fuel Supply and Price*

The removal of MTBE from the State's gasoline will result in a loss in gasoline production capability by California refineries. Since MTBE now accounts for about 11 percent of current gasoline volume, refiners will need to make-up for this loss in volume. The loss in volume that refiners will need to make-up is actually greater than this because MTBE has helped refiners meet CaRFG2 specifications by providing octane and by diluting other undesirable gasoline properties. While refiners will be able to make-up for some of this loss in gasoline production capability by making modifications to their refineries, there is expected to be some net loss in gasoline production capability.

In developing its CaRFG3 proposal, the staff was sensitive to the loss in production volume, and some of the proposed changes to the CaRFG3 specifications were made to help refiners recover volume. Specifically, the proposed increase in the T90 and T50 specifications was made to provide refiners some flexibility to increase gasoline production. The staff was able to provide this flexibility without sacrificing emission benefits of the current program in large part because of the proposed tightening of the specifications for sulfur and benzene.

Overall, the net effect of the removal of MTBE and the proposed CaRFG3 regulations is an estimated net reduction in gasoline production capability by California refiners of about 10 to 20 percent.

In addition, California has experienced, and will continue to experience, ongoing increases in demand for gasoline. In 1996, gasoline consumption averaged about 890,000 barrels per day (over 37 million gallons per day). In 1998, consumption increased to about 920,000 barrels per day (about 38.5 million gallons per day). It is projected that by 2003, gasoline consumption in California will increase to about 970,000 barrels per day (almost 41 million gallons per day). This annual increase in gasoline consumption is about 1.5 percent per year.

California refineries are producing on average about 935,000 barrels of gasoline per day for California and have a maximum production capability on a short-term basis to produce about 1,000,000 barrels of gasoline per day for California. As a result of demand getting closer and closer to production capacities, we have seen increasing imports into California of finished gasoline and gasoline blending components. The CEC estimates that by 2003, California refineries will no longer be able to meet California demand and the importing of gasoline and gasoline blending components will become a routine occurrence, even when California refineries are operating at capacity.

With respect to gasoline prices, it is very difficult to predict what will occur in the marketplace. Gasoline prices are heavily influenced by supply/demand, crude oil prices, and competitive considerations. However, it is reasonable to assume that over time, refiners will recover the increased costs of production in the marketplace. With this assumption and the staff's estimate that the long-term production cost of CaRFG3 gasoline will be from two to six cents per gallon, it is reasonable to assume that this increase in production cost will, on average, be reflected in gasoline prices.

With respect to the stability of prices in the marketplace, that too is very difficult to predict. Recent refinery incidents in California have caused significant short-term swings in gasoline prices. Prices increased in the short term until imports arrived from other markets or refineries were repaired. The proposed regulations were designed to maintain the flexibility to import complying gasoline. In fact, as California becomes more of a routine importer of gasoline, it is expected that there should be more stability in the marketplace because refineries outside of California will, on an ongoing basis, be producing product for importation into California. Thus, the overall gasoline production system consisting of California refineries and imports should be no more subject to supply disruptions than under current regulations, and may be better able to readily adjust to any production disruptions that occur in the future.

3. Sulfur Reduction

It is not possible to precisely isolate the costs associated with the proposed lowering of the sulfur limits. This is because refiners are designing capital and operational improvements to comply with both the MTBE phase-out and the proposed sulfur reductions. It is expected that the anticipated capital improvements of $1 billion include the additional costs to lower gasoline sulfur levels. However, as part of the U.S. EPA's proposed Tier 2 sulfur limits for federal Phase II RFG, they have estimated the incremental cost to U.S. refineries to meet sulfur limits as low as 30 ppmw. That cost curve indicates a cost of about 0.4 cents per gallon for a 20 ppmw decline to the proposed CaRFG3 sulfur limits. This is consistent with the discussions the ARB staff held with refiners regarding these costs. The costs would escalate as the sulfur levels are decreased further.

O. What Is the Cost-Effectiveness of the Proposed Amendments?

Many of the proposed changes and most of the associated costs occur in order to eliminate MTBE from California gasoline. Since this is being done to avoid future water quality problems, it is not feasible to estimate the cost-effectiveness of these expenditures by using traditional methods commonly used in assessing air quality regulations. However, the proposed amendments are estimated to result in motor vehicle emission reductions in 2005 of about 0.5 ton per day of hydrocarbons and 19 tons per day of NOx and about a seven percent reduction in emissions of potency weighted toxics. These reductions are primarily the result of the proposed change to the sulfur standard. Using the emission reductions of NOx and the estimated cost of reducing sulfur results in a cost-effectiveness of about $8100 per ton of NOx controlled or about $4.2 per pound of NOx reduced. Since this estimate does not include consideration of the reduction in toxic emissions, it is viewed as being conservative, and is well within the range of cost-effectiveness values for other NOx reduction programs.

P. What Are the Environmental Impacts of the Proposed Amendments?

1. Water Quality

The proposed amendments will result in less risk to water quality by removing MTBE from gasoline introduced into the marketing/distribution system beginning December 31, 2002.

Existing MTBE contamination, including any that has not yet been detected, would continue until natural effects or remedial efforts would reduce it. The rate of new MTBE and other gasoline component leaks and contamination should be reduced with the completion of storage tank upgrading and further efforts to ensure new upgraded tank and piping systems are minimizing leaks.

To the extent that ethanol would replace MTBE and that gasoline will continue to contaminate water, ethanol would also contribute to further water contamination. Points of contamination could be marine terminals, rail terminals, gasoline storage tanks, service stations, ethanol storage tanks at pipeline terminals, and pleasure boat exhaust.

Ethanol is completely soluble in water. Unlike MTBE, microbes readily consume ethanol, so ethanol may not spread underground to the extent that MTBE spreads. However, the presence of ethanol can enhance the solubility of gasoline in water, and there has been speculation that it can reduce the microbial consumption of the benzene and other aromatic elements of gasoline in groundwater. If so, the plumes of those elements could spread further from the point of entry than they now do. The SWRCB has contracted with the Lawrence Livermore National Laboratory to analyze these effects as part of the "Ethanol Fate and Transport" study.

As described earlier, an environmental fate and transport analysis and a health risk evaluation of ethanol will be completed by the end of 1999 as directed in the Governor's Executive Order D-5-99 and recent legislation.

In addition, if production of non-oxygenated CaRFG increases in volume, it is anticipated that the amount of alkylates used in gasoline will increase by about 10 percent. Alkylates are branched alkane hydrocarbons which have low solubility in water and are biodegradable. These compounds have always existed in conventional and reformulated gasoline. Their increased use should not appreciably increase the risk to water over conventional gasoline.

The other proposed changes should not change the risk to water quality. Finally, the reduction in benzene will further limit the amount of benzene, a known human carcinogen, in CaRFG and reduce the risk to water.

2. Air Quality

The proposed amendments preserve and enhance existing air quality benefits. Reductions in ozone and PM precursor emissions will directionally reduce ozone levels and ambient PM levels. Reductions in benzene emissions will lead to reduced ambient levels of benzene. Further, with the elimination of MTBE, ambient MTBE levels will decrease.

The staff has conducted an analysis of the air quality impacts of the use of ethanol in gasoline. A draft analysis was released at the end of September for review and comment. The analysis included an evaluation of the emissions and air quality impacts associated with current fuels, ethanol containing fuel, and non-oxygenated fuel.

The preliminary findings from the analysis indicated that increases in acetaldehyde and ethanol emissions associated with ethanol containing fuels will not lead to any significant increase in peroxyacetylnitrate (PAN) concentrations, because other VOCs are larger contributors to PAN formation.

With respect to ambient ozone, the draft analysis found no significant change in ozone impact with the ethanol containing fuel compared to current MTBE containing fuel. There was an increase in predicted ozone from the non-oxygenated fuel. However, this draft analysis was based on increased aromatic levels in vehicle exhaust, although aromatic levels of expected real world complying fuel and the subsequent exhaust emissions should be lower. When this is corrected, it is expected that the ozone impacts of fuel with 2.0 weight percent oxygen with non-oxygenated complying fuels will be very similar. This aspect of the analysis is being reassessed and will be completed in time for consideration at the Board's December meeting.

The mixing of gasoline with ethanol and non-oxygenated gasoline in a vehicle tank can result in an increase in the RVP of the resulting blend and an increase in the evaporative hydrocarbon emissions from the vehicle. The staff has conducted a preliminary evaluation of the potential for this to increase evaporative emissions. At this time, the staff estimates that the potential increase is likely to result in only a small loss in benefits. However, the staff will need to monitor consumer refueling practices as the use of ethanol blends increases, and may need to develop appropriate recommendations to preserve the emission benefits of CaRFG3 if in the future it is determined that emissions are increasing as a result of mixing ethanol blended CaRFG with non-oxygenated CaRFG.

3. Greenhouse Gas Emissions

In determining the impact of the proposed amendments on greenhouse gas (GHG) emissions, the staff evaluated two possible scenarios that may develop in the production of CaRFG. First, gasoline in California will no longer be produced with oxygenates. This scenario may develop for certain grades of gasoline throughout the State if the federal minimum 2.0 weight percent oxygen mandate is eliminated in California. If this mandate is not removed, gasoline produced for federal RFG areas in California, as well as certain gasoline grades in non-federal RFG areas, will continue to be produced with oxygenates, most likely ethanol.

In determining the overall impact of the proposed amendments on GHG emissions in California, the staff has assessed GHG emissions in two phases – exhaust and fuel-cycle emissions (GHG emissions associated with the production of the fuel) for various types of gasoline. The sum of the emissions from these two phases yields the total GHG emissions associated with each gasoline type.

The proposed amendments to the CaRFG2 regulations are not expected to increase emissions of greenhouse gases that may contribute to global warming. The staff's assessment concluded that there is essentially no difference in GHG emissions between reformulated gasoline produced with MTBE versus gasoline blended with corn-derived ethanol. However, the proposed amendments may result in a net decrease in GHG emissions in California to the extent that ethanol produced from California biomass becomes available and is blended into the gasoline pool. In addition, the staff estimates that gasoline produced with a lower oxygen content (less than 2.0 percent by weight) may result in small reductions in GHG emissions.

Q. Staff Recommendation

The staff recommends that the Board adopt the proposed CaRFG3 regulations as contained in Appendix A, with the recognition that staff may propose some modifications to their proposal based on information and comments obtained subsequent to the release of the Staff Report and prior to the Board hearing in December 1999.

Chapter I. Background

This chapter presents a brief overview of the key gasoline properties that relate to vehicle emissions and which form the basis for the existing California Phase 2 Reformulated Gasoline Regulations (CaRFG2). This chapter also contains some general background information to help the reader understand the complexities of making gasoline without MTBE. Also, an overview of the current CaRFG2 regulations is presented. The chapter concludes with an overview of the federal RFG program, and the need for further emission reductions in California.

A. Effects of Gasoline Properties on Emissions

1. ***RVP***

Evaporative emissions of volatile organic compounds (VOCs) from gasoline have been reduced significantly in California by limiting the maximum Reid vapor pressure (RVP) of motor vehicle gasoline during the summer ozone season. The RVP is a measure of the ability of a fuel to evaporate and is an important parameter in the evaporation of gasoline in the combustion chamber for starting motor vehicles. A minimum RVP is necessary to provide the vaporization of gasoline that is required for avoiding problems with cold starting, warm-up operations and acceleration. Reductions in RVP also reduce evaporative hydrocarbon (HC) emissions throughout the gasoline distribution system.

2. ***Aromatics***

Aromatic hydrocarbons are hydrocarbons that contain one or more benzene rings. Their presence in gasoline has been connected with the formation of volatile organic compounds, toxics (benzene), oxides of nitrogen (NOx), and CO in exhaust emissions. Aromatic hydrocarbons have high combustion temperatures; therefore, their presence in gasoline increases NOx emissions. Higher aromatic hydrocarbon levels in fuel also result in higher aromatic hydrocarbon levels in the exhaust because the volatile organic compound composition of engine-out emissions closely follows the fuel composition. Aromatic hydrocarbons are also precursors for the formation of benzene. The presence of aromatic hydrocarbons in the vehicle exhaust could have an adverse impact on the reactivity of the exhaust emissions because some of the aromatic hydrocarbon components, especially heavy aromatic hydrocarbons (C_{8+} aromatic hydrocarbons), are highly reactive.

The reduction of aromatic hydrocarbons in a refinery is a multifaceted strategy. The addition of oxygenates or alkylates reduces aromatic hydrocarbons by dilution. Reducing T90 (the temperature at which 90 percent of the fuel evaporates) will also remove from the gasoline pool a significant part of the heavier aromatic hydrocarbons. Fuel producers basically have three options to reduce aromatic hydrocarbons. Since most of the aromatic hydrocarbons in gasoline are derived from the reformate, the fuel producer could choose to operate the reformer at a less severe condition, thereby decreasing the level of aromatic hydrocarbons in the reformate blend stock. A second option is to remove aromatic hydrocarbons through separation or decrease aromatic hydrocarbons through saturation. A third option is to add new process units to produce blend stocks which are high in octane and low in aromatic hydrocarbons. The ultimate choice is refinery dependent.

*3. **Olefins***

Olefins are hydrocarbons having one or more double bonds. They are created by the refining process of cracking napthas or other petroleum fractions at high temperatures. Olefins have high ozone reactivity potential and contribute to the reactivity of evaporative emissions. Past studies have also identified higher olefin content as an important contributor to NOx emissions.

Olefins in gasoline are derived principally from refining operations involving the fluid catalytic cracking unit (FCCU). Reducing olefins depends on the particular refinery configuration. Some refiners may be able to meet an olefin standard by changing the operating conditions of the FCCU. Other fuel producers may have to hydrotreat the FCCU gasoline to reduce sulfur, which in turn will reduce the olefin content.

*4. **Sulfur***

Studies have demonstrated that sulfur, even in small amounts, causes significant deactivation of motor vehicle catalysts, resulting in increases in emissions of CO, volatile organic compounds, and NOx. Sulfur in gasoline also results in vehicular sulfur dioxide emissions. More recent studies have suggested that greater emissions benefits than originally expected could result from reducing sulfur content well below 30 ppmw.

The blendstocks in gasoline which contribute the most to gasoline sulfur levels are gasoline blendstocks obtained from the FCCU and, to a lesser extent, gasoline blendstocks obtained from the coker unit. These blendstocks have high sulfur because they are produced from the heavier components of the crude oil, which have higher sulfur contents. The sulfur is removed by hydrotreating either the feed to the FCCU or fractionating and hydrotreating the heavier components of the products from the FCCU or the coker.

*5. **Distillation Temperatures***

A distillation curve represents gasoline in terms of the percent of the gasoline which evaporates at different temperatures. For example, in a typical distillation curve, 10 percent of the fuel will have evaporated at 130 degrees Fahrenheit, 50 percent of the fuel will have evaporated at 215 degrees Fahrenheit, and 90 percent of the fuel will have evaporated at 330 degrees Fahrenheit. These points on the distillation curve are represented as the T10, T50, and T90 distillation temperatures, respectively. The RVP of the gasoline primarily affects the T10 distillation temperature. The heavier molecular weight, less volatile compounds primarily affect T90.

Reducing T90 results in substantial reductions in exhaust emissions of volatile organic compounds, but some marginal adverse effects on both CO and NOx emissions may occur. The precise mechanism as to why exhaust emissions are reduced is not well understood at this time. One theory holds that by eliminating the heavier components of gasoline, both fuel vaporization and air-to-fuel mixing prior to entrance into the combustion chamber are improved, thus improving combustion efficiency.

Reducing the T90 of gasoline requires fuel producers to separate the heavy hydrocarbon streams from the fuel by selectively fractionating the gasoline blendstocks. This process significantly reduces aromatic hydrocarbons, since many of these compounds are found in the T90 distillation range.

Reducing T50 results in a decrease in emissions of volatile organic compounds and CO, and has no significant effect on emissions of NOx. However, too low of a T50 might result in adversely affecting evaporative emissions, whereas too high of a T50 may result in higher exhaust emissions. The staff estimates that the T50 of gasoline should be in the range of 180 to 210 degrees Fahrenheit to minimize both evaporative and exhaust emissions of volatile organic compounds, and exhaust emissions of CO.

*6. **Toxic Air Contaminants***

The predominant toxic air contaminants emitted from gasoline-powered vehicles are benzene and 1,3-butadiene. These two compounds are responsible for 95 percent of the estimated potential cancer risk from gasoline-powered vehicles. Most of the remaining risk is from formaldehyde and acetaldehyde. Benzene was identified by the ARB in 1987 as a toxic air contaminant. Formaldehyde and 1,3-butadiene, and acetaldehyde were listed as toxic air contaminants in 1992.

While benzene, 1,3-butadiene, formaldehyde and acetaldehyde are all emitted from gasoline-powered vehicles, only benzene can be directly controlled by limiting its concentration in gasoline. Benzene is a hydrocarbon that occurs naturally in crude oil and forms when oil is refined into gasoline. Emissions of 1,3 butadiene are reduced by lowering precursor compounds, such as olefins.

Motor vehicle emissions of benzene result from the following:

- evaporation of benzene from gasoline in vehicles,
- the passage of benzene in gasoline through the engine and catalyst without destruction, and
- the combustion of other aromatic hydrocarbons in gasoline, of which one product is benzene.

The precursors of benzene emissions are simply benzene and other aromatic hydrocarbons. Limiting the benzene content of gasoline is an effective way of reducing both exhaust and evaporative benzene emissions.

The CaRFG2 regulations significantly reduced toxic emissions by reducing benzene and 1,3-butadiene emissions and to a lesser extent increased emissions of formaldehyde and acetaldehyde. Formaldehyde emissions increase with the use of MTBE and acetaldehyde increases with the use of ethanol. Any increase in formaldehyde or acetaldehyde emissions was more than offset by the reduced toxic risk due to the reductions in benzene and 1,3 butadiene emissions.

Toxic air contaminant emissions from vehicles are also generally controlled by any measures designed to reduce hydrocarbon emissions. For example, vehicle emissions standards, the Inspection and Maintenance program, and the requirement for on-board diagnostic equipment on vehicles all help to reduce toxic emissions to the extent that these control measures reduce hydrocarbon emissions.

The benzene in gasoline has been reduced substantially by standard processing techniques. Many refiners distill certain blending stocks to isolate most of the benzene into smaller volumes of liquid. These distillates are either reacted with hydrogen (hydrotreated) to convert benzene to cyclohexane or extracted with a solvent to remove the aromatic hydrocarbons. In the latter case, the aromatic hydrocarbons are distilled to separate the benzene from the other aromatic hydrocarbons, which are returned to gasoline blending. The volume and octane value that had been provided by the benzene would have to be replaced.

7. Oxygen

The addition of oxygenates to gasoline is expected to reduce exhaust emissions of CO and volatile organic compounds and increase NOx emissions. Studies conducted to date show that an oxygen content of two percent will result in about a 10 percent decrease in CO, a three percent decrease in exhaust emissions of volatile organic compounds, and a small increase in NOx emissions. As oxygen content is increases beyond 2 percent by weight, NOx emissions increase significantly. An advantage of using oxygenates is their dilution effects on undesirable components (aromatics, sulfur, olefin and benzene) that are limited by the California gasoline regulations. The dilution effect of oxygenates is directly proportional to the volume used in gasoline.

a. *MTBE*

MTBE has a 110 octane rating (R+M)/2 and contains 18.2 percent oxygen by weight. When combined with gasoline at 11 percent by volume, the blend will contain 2.0 weight percent oxygen. The maximum amount of MTBE that can be used in gasoline is 15 percent by volume (2.7 percent by weight oxygen). Blending with MTBE also makes it easier for refiners to meet distillation temperature requirements for reformulated gasoline, due to its relatively low boiling point. MTBE also depresses the distillation temperature of the gasoline blend. The blending of 11 percent MTBE into gasoline reduces the gasoline's T50 by 10 to 20 °F, and the T90 by 2 to 6 °F. MTBE in gasoline also reduces evaporative emissions of benzene. Because of the favorable blending properties, MTBE became the oxygenate of choice by refiners to meet the federal minimum oxygen requirements.

b. *Ethanol*

Ethanol has an octane rating of 115 and contains 34.8 percent oxygen by weight, almost twice as much as MTBE. When combined with gasoline at 5.7 percent by volume, the blend will contain 2.0 weight percent oxygen. Thus, ethanol provides less dilution than MTBE when blended at the same oxygen level. The maximum amount of ethanol that can be used in gasoline is 10 percent by volume (3.5 percent by weight). Ethanol also has a blending RVP of 18 which is significantly higher than MTBE, making ethanol more difficult to use in meeting RVP limits in the summer months. The most undesirable blending property of ethanol is that it increases the RVP of the gasoline blend by about 1 psi, thus requiring refiners to reduce the RVP of the base gasoline by about 1 psi to account for the RVP increase when ethanol is added.

8. ***Alkylates***

Alkylates are a type of blend stock normally used in gasoline. Alkylates have been typically used at about 15 percent by volume in finished gasoline. Alkylates have been used increasingly in gasoline to replace volume and octane lost by removing aromatics. Alkylates are not water soluble and are biodegradable. Increased volumes of alkylates can be used to dilute the less favorable properties in gasoline much like oxygenates are used. Alkylates typically have an octane rating of about 96 which is lower than MTBE or ethanol.

B. **Overview of the CaRFG2 Regulations**

1. ***Basic Limits and Compliance Options***

The CaRFG2 regulations took effect on March 1, 1996 and limit eight gasoline properties shown in Table I-1. The table shows “cap” limits that apply to all gasoline anywhere in the gasoline distribution and marketing system and do not vary. The table also shows “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 (collectively, the “producer limits”) are adjustable by gasoline producers, through use of the Predictive Model, as explained below.

Gasoline producers may 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 shown in the table. 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), except for RVP, that can be applied to that producer's gasoline. The Predictive Model is used to identify alternative limits that correspond to exhaust emissions of hydrocarbons, NOx, and toxic pollutants that are no greater than the emissions corresponding to the limits in the table. 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.

In actual practice, most gasoline produced in California since the inception of the CaRFG regulations has been produced under alternative limits set with the Predictive Model. About 75 percent of all California gasoline is at this time being made using the flat limits in the Predictive Model.

Table I-1
CaRFG2 Limits and Caps

Property	**Pre-CaRFG** (summer)	**Flat Limits**	**Averaging Limits**	**Cap Limits(1)**
Reid vapor pressure, psi, max	7.8	7.0	---	7.0
Benzene, vol%, max	2.0	1.00	0.80	1.20
Sulfur, ppmw, max	150	40	30	80
Aromatic HC, vol%, max	32	25	22	30
Olefins, vol%, max	9.9	6.0	4.0	10
Oxygen, wt%	0	1.8 to 2.2	---	1.8 (min)(2) 3.5 (max)
T50 (temp. at 50% distilled) °F, max	220	210	200	220
T90 (temp. at 90 % distilled) °F, max	330	300	290	330

(1) The "cap limits" apply to all gasoline at any place in the marketing system and are not adjustable.
(2) The 1.8 weight percent minimum applies only during the winter and only in certain areas.

The CaRFG2 flat-limit range for the oxygen content (min. 1.8 percent, max. 2.2 percent) was set for conformity with federal law. Under federal law, the federal RFG required in all severe and extreme ozone non-attainment areas must contain year-round at least 2.0 percent oxygen by weight for every gallon, or 2.1 percent by weight on average with at least 1.5 percent oxygen in every gallon. In contrast, except during the wintertime in CO nonattainment areas, the ARB does not require oxygen in CaRFG because producers can use the Predictive Model to reduce or eliminate oxygen in CaRFG-compliant gasoline as long as the HC, NOx and toxics emissions benefits are still achieved. The CaRFG regulations do not distinguish among oxygenates.

The RVP standard applies during specified warmer months in each air basin. In the South Coast Air Basin and Ventura County, it applies from April through October throughout the distribution system, as well during March for gasoline being shipped from production facilities.

2. *Predictive Model*

The CaRFG2 Predictive Model is a set of mathematical equations that relate emission rates of exhaust hydrocarbons, NOx, and combined exhaust toxic species[1] to the values of the eight regulated gasoline properties. Emissions of each pollutant type are predicted by equations formulated separately for vehicles of 1981 to 1985 model years ("tech 3" class) and vehicles of 1986 to 1995 model years ("tech 4"). The equations were derived by regression analyses applied to several thousand emissions observations and the associated values of the fuel properties. For each pollutant, the predictions for the two class models are combined with weights proportional to the contributions of the vehicle classes to the ARB's emission inventory for that pollutant. The weights are based on the MVEI-7F inventory.

In its regulatory use, the Predictive Model compares the emission predictions for a candidate set of property limits to the predictions for the basic flat or averaging limits in Table I-1. If each prediction for the candidate limits 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 the values in Table I-1 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 CaRFG requirements, taking into consideration the configuration of the refinery. The current regulations do not allow the RVP limit to be adjusted by the Predictive Model. That is why there is no evaporative emissions component in the current Predictive Model.

To date, most gasoline released from refineries in California has been regulated according to alternative limits validated by the Predictive Model. Refiners have reported major improvements in the cost and feasibility of compliance through the use of the Model.

3. *California Wintertime Oxygen Requirement*

The federal Clean Air Act conditionally requires states with violations of the federal ambient air quality standards for CO to require oxygen in gasoline in the winter in the areas with the violations. Initially, the ARB applied the winter oxygen requirement of 1.8 to 2.2 volume percent to all gasoline in California because CO exceedances occurred in most of the State's urban areas. In 1998, the Board ended the oxygen requirements in areas that had achieved compliance with the CO standard. At that time the ARB continued the winter oxygen requirement on a permanent basis in the counties of Imperial, Los Angeles, Orange, Riverside, San Bernardino, and Ventura. Fresno County, Madera County and the Lake Tahoe Air Basin were only required to have oxygenated gasoline for two additional years. In June 1999, the Board ended the requirement in Lake Tahoe.

[1] 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.

Except for Imperial County, the Federal RFG standards apply in the six counties where the state winter oxygen requirement will remain, so gasoline sold used in those areas must contain oxygen year round regardless of the winter requirement. Although gasoline in Imperial County would not have to contain oxygen, except in winter, the county receives its gasoline from the same sources that supply the South Coast (where oxygen is federally required year-round).

4. CARBOB Provisions

Most gasoline in California is distributed by pipeline. The operator of the major common-carrier pipelines does not allow gasoline containing ethanol in its facilities.[2] Therefore, gasoline delivered by pipeline must have ethanol added at the downstream pipeline terminals (where it is loaded onto trucks) rather than at the refinery or importation facility.
Because of this, the regulations have been structured to enable producers to take advantage of the benefits of oxygenate blending in meeting the CaRFG requirements while maintaining enforcement of the flat and averaging standards at the refinery. Producers are allowed to ship non-oxygenated gasoline from the refinery without complying with the CaRFG standards as longs as it is specially formulated as a "California reformulated gasoline blendstock for oxygen blending," or "CARBOB," to be combined with oxygenate "downstream" of the refinery to produce a blend that is fully complying. This approach was originally developed in the federal RFG program.

C. Emission Benefits of CaRFG2

Table I-2 shows the emission benefits associated with the CaRFG2 program. These figures were calculated as if gasoline properties were actually at their flat limit values.

Table I-2
Emission Effects of CaRFG2 Limits, 1996

	Reduction(1)	
Pollutant	Tons per Day	Percent
Hydrocarbons	190	17%
NOx	110	11%
CO	1300	11%
Sulfur oxides	30	80%
Potency-weighted sum of toxic species	--	40%

(1) Decrease in emissions from vehicles produced before 1996

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

[2] Gasoline containing ethanol can pick up water and re-deposit it elsewhere. The pipeline operator is responsible for preserving the quality of the fuels it transports and will not jeopardize that quality by introducing the possibility of contamination by water.

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.

Air monitoring has recorded major reductions in the ambient concentrations of benzene and ozone since the inception of the CaRFG regulations. Concentrations of benzene in the ambient air declined almost immediately by about 50 percent. This reflects closely the amount of benzene reduced by the CaRFG limits. An analysis of ambient air quality data for ozone from May through October 1996 indicated that CaRFG accounted for improvements in ozone by 10-percent in the South Coast, 12 percent in Sacramento, 5 percent in eastern Contra Costa County, and 6 percent in Santa Clara County.

D. Other Unquantified Benefits of CaRFG2

The emissions benefits claimed by the staff for the adoption of the CaRFG2 regulations understate the actual air quality benefits of the regulations. These effects were not fully quantified in previous estimates and are not claimed in the currently adopted SIP. The actual benefits are greater than originally claimed for the following reasons:

- Refiners blend gasoline to have property values somewhat less than applicable limits. In particular, the mean actual RVP (in the summer) is 6.7 to 6.8 psi. The reduction relative to the limit at 7.0 psi produces reductions of evaporative emissions that are not reflected in original estimates shown in Table I-2.
- In using the Predictive Model, most refiners have reduced their sulfur contents to allow higher limits on other properties. It is widely recognized that the current sensitivities (slopes) in the Predictive Model for emissions versus sulfur are low for new vehicles. Thus, the lower than required sulfur levels produce emission reductions greater than what the present model indicates, and greater than was originally credited to the fuel.
- Each set of alternative limits must satisfy three criteria: no increase in hydrocarbon emissions, in NOx emissions, or in toxic emissions relative to the basic set of limits. Since these criteria are independent, one is usually constraining. That is, one criterion is marginally satisfied while the other two criteria may be met by larger margins.
- The reduced aromatic contents under the regulations help to limit the formation of deposits in the combustion chamber. This reduces NOx emissions.
- Reactivity of the fuel and vehicle emissions has decreased. Complying fuel has a significantly lower average exhaust reactivity than the fuel it replaced. Although this change does not result in a reduction in the mass of emissions, it does result in a decrease in peak ozone levels.
- Finally, CaRFG2 also facilitates vehicle and engine manufacturer's ability to produce low emission vehicles and ultra low emission vehicles.

E. Overview of Federal Gasoline Regulations

1. *Federal Reformulated Gasoline*

The federal Clean Air Act Amendments of 1990 require the U.S. EPA to adopt and enforce reformulated gasoline regulations for all gasoline used in on-road vehicles in severe and extreme non-attainment areas for ozone. The federal RFG regulations apply to about 30 percent of the gasoline consumed nationally and to about 70 percent of the gasoline consumed in California. The Clean Air Act requires at least 2 percent oxygen in each refiner's federal RFG year-round. Also, the Clean Air Act limits benzene to one percent of RFG, prohibits heavy metals, and requires a 15-percent reduction in volatile organic compound emissions (essentially equivalent to hydrocarbon emissions) and in toxic emissions through 1999. In 2000, the required reductions increase to 25 percent. These reductions refer to emissions from vehicles having 1990 technology and must be computed relative to emissions from using a baseline gasoline whose properties are prescribed in the Clean Air Act. To the standards prescribed in the Clean Air Act, the U.S. EPA has added a 5.5 percent NOx reduction for 2000.

The U.S. EPA federal RFG regulations require use of regression models - collectively, the "Complex Model"- that compare emissions between the actual measured properties of each batch of gasoline and the prescribed baseline gasoline properties. Unlike the CaRFG regulations, the federal RFG regulations do not impose a fixed RVP limit, and the Complex Model uses RVP as a variable. While similar in form to the Predictive Model, the Complex Model contains different sensitivities (slopes) of emissions to gasoline variables.

The U.S EPA in consultation with other stakeholders developed the Complex Model for certifying formulations of federal RFG. This model was develop based on criteria contained in the Clean Air Act which requires the model to represent the nationwide fleet of vehicles representing the primary emission control technology available in 1990 and the average national gasoline properties in 1990.

The criteria set forth in the Clean Air Act severely limits the usefulness of this model in California. The federal Complex Model represents 1990 federal vehicle emission control technologies. The Complex Model database also contains vehicles that are considered 49 state vehicles which were never certified for sale in California. The California Predictive Model is not constrained by statute. Therefore, it was developed to account for the mix of vehicles in California and the more stringent vehicle and fuel standards in place in California. The proposed update allows the model to keep up with the changing vehicle fleet in California.

The federal Complex Model does account for evaporative emissions. This was not necessary with the current California Predictive Model because theRVP of CaRFG2 was capped at 7.0 pounds per square inch. The federal reformulated gasoline regulations allow a varying RVP. The proposed changes to the current Predictive Model includes provisions for a evaporative emissions model and varying RVP.

2. *California Enforcement Exemption*

The federal RFG regulations include extensive data gathering, reporting, and other enforcement requirements for refiners. In recognition of the CaRFG regulations and ARB's direct field-enforcement program, the U.S. EPA has waived many of the federal enforcement requirements for California refiners as long as the refiners comply with the CaRFG requirements. This waiver is contingent on the U.S. EPA's determination that the CaRFG regulations are at least equivalent in emission control to the federal RFG regulations, as determined with the Complex Model. Evaporative emissions are a major element of the total predicted hydrocarbon emissions in the Complex Model. Therefore, any change to the CaRFG regulations to allow a variable RVP limit must be limited to maintain continued equivalency to the federal RFG standards.

3. *Future Limits on Sulfur (tier II)*

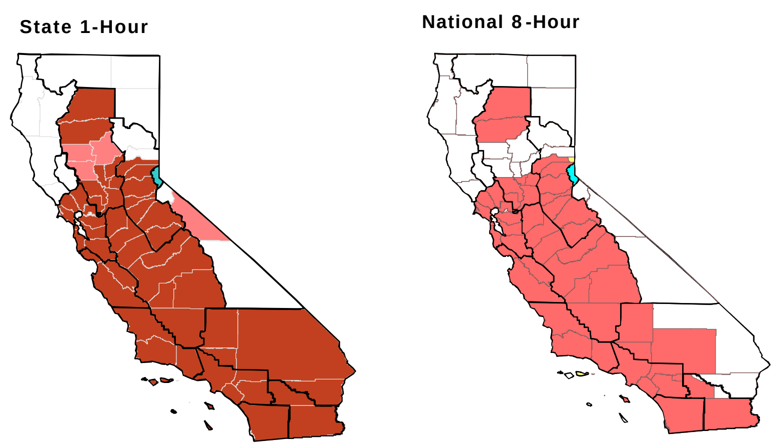
The U.S. EPA has proposed regulations that would impose new limits on the sulfur content of all on-road motor gasoline in the U.S. If promulgated as proposed, the new regulation would first take effect in 2003 with a phase in period and would eventually apply a 30 ppmw averaging limit and an 80 ppmw cap to all gasoline produced nationally.

F. Need for Emission Reductions

1. *Ozone Emissions*

California continues to violate state and federal ozone standards. As shown in **Figure I-1**, most of the state does not meet the state or federal ozone standards.

Figure I-1 Non-Attainment Areas for Ozone



California's plan for achieving the federal ozone standard is contained in the California State Implementation Plan (SIP) that was approved by the Board in 1994. A significant part of the emission reductions in the SIP are from controlling vehicles and their fuels. Table I-3 below shows the ROG and NOx contribution from motor vehicles and stationary sources. As shown in the table, mobile source emissions account for approximately 70 percent of ozone precursors statewide. The SIP also calls for additional motor vehicle emission reductions in the South Coast Air Basin of approximately 75 tpd ROG plus NOx, but it does not specify how the reductions are to be achieved.

Table I-3
Ozone Precursor Contribution from Motor Vehicles
1995 Statewide Emissions (tons/day)

	ROG	NOx	ROG+NOx	Percent
On-Road Gasoline Vehicles	1588	1574	3162	45%
On-Road Diesel Vehicles	64	507	571	8%
Other Mobile Sources	321	695	1016	14%
Stationary Sources	735	633	1368	20%
Area-wide Sources	779	95	874	13%
Total	3487	3504	6991	100%

Source: The 1999 California Almanac of Emissions & Air Quality

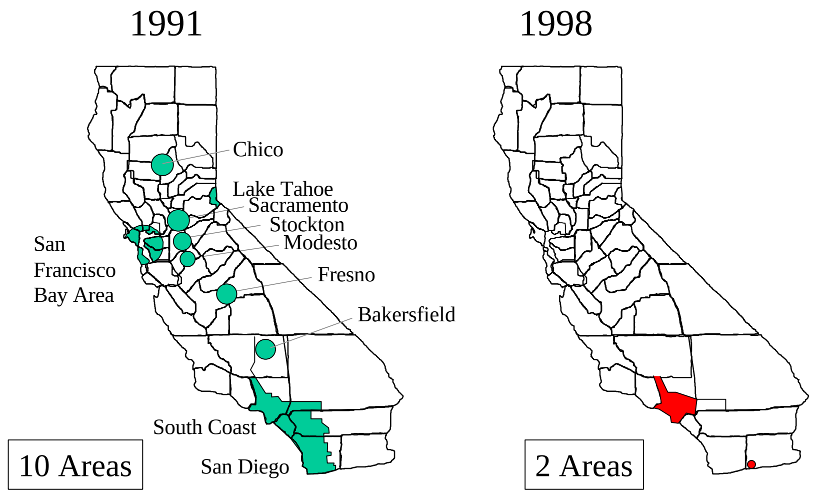
2. *CO Emissions*

The State and national CO standards are now attained in most areas of California. California has made tremendous progress in reducing CO concentrations in the last ten years. The requirements for cleaner vehicles and fuels have been primarily responsible for the reduction in CO, despite significant increases in population and the number of vehicle miles traveled each day. As shown in Figure I-2, only two areas in the state currently exceed CO emission standards.

While the South Coast Air Basin is designated as non-attainment, violations of the State and national CO standards are now limited to only a small portion of Los Angeles County. No violations have occurred in the other three counties of the South Coast Air Basin since 1992. Based on projected emissions, the South Coast Air Quality Management District predicts Los Angeles County will attain the national CO standards sometime after the year 2000.

The introduction of CaRFG2 in 1996 has helped bring the rest of the State into attainment. While CaRFG2 has a continuing beneficial impact on CO levels, additional emission reductions will be needed in the future to keep pace with the increases in population and vehicle usage. These reductions will come from continued fleet turnover, expanded use of low emission vehicles, and measures to promote less polluting modes of transportation. In addition, the introduction of zero emission vehicles, such as the electric car, will play an increasingly important role in the coming years.

Figure I-2 Areas in California in Non-Attainment for CO



CO emissions are decreasing as new vehicles replace old ones

3. *Particulate Matter Emissions*

The majority of California is designated as non-attainment for the State PM_{10} standards. Only Lake County Air Basin is designated as attainment in California. Three counties in the northern half of the State remain unclassified. Table I-4 shows the average number of exceedances of the state 24 hour standard for PM_{10} from 1995 to 1997.

Table I-4 Exceedances Of State PM10
24-Hour Ambient Air Quality Standards
(Averaged from Years 1995-1997)

Air Basin	# of Days
Great Basin Valleys	26
Lake Tahoe	3
Mojave Desert	11
Mountain Counties	12
North Central Coast	13
North Coast	5
Northeast Plateau	5
Sacramento Valley	25
Salton Sea	60
San Joaquin	61
San Diego	20
San Francisco	5
South Central Coast	23
South Coast	52

Source: The 1999 California Almanac of Emissions and Air Quality

Chapter II. Gasoline Consumption and Properties of CaRFG2

A. Overview of California Gasoline Consumption

The consumption of gasoline in California is steadily increasing. This increase is 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 (all with low corporate average fuel economy (CAFE) ratings) has had an impact on the consumption of gasoline.

Table II-1 shows the annual average California gasoline consumption by month and year in thousands of barrels per day. The data cover the period from 1996 (the beginning of the CaRFG2 program) through the present. Table II-2 shows the average annual gasoline consumption for 1996 through 1998 and estimates for 1999 through 2003. These projections show that gasoline consumption is expected increase by about 1.5 percent per year from 1998 through 2003, an increase of 50,000 barrels per day by 2003. In 2003, gasoline consumption is expected to be close to 15 billion gallons per year, or about 41 millions gallons per day.

Table II-1
Historic Consumption of CaRFG2
(Thousand bpd) (1)

Month/Year	1996	1997	1998	1999
January	830	832	855	900
February	873	857	882	868
March	898	883	921	925
April	898	906	933	957
May	886	949	910	959
June	900	922	955	959
July	907	935	957	--
August	929	922	963	--
September	876	893	852	--
October	893	911	911	--
November	910	883	927	--
December	873	900	952	--
Annual Average	**892**	**900**	**918**	**928**(2)

Source: State of California Board of Equalization Tax Tables
1) One barrel contains 42 gallons.
2) Average through June 1999.

California refineries are producing on average about 935,000 barrels of gasoline per day for California and have a maximum production capability on a short-term basis to produce about 1,000,000 barrels of gasoline per day for California. As a result of demand getting closer and closer to production capacities, we have seen increasing imports into California of finished gasoline and gasoline blending components. The CEC estimates that by 2003, California refineries will no longer be able to meet California demand and the importing of gasoline and gasoline blending components will become a routine occurrence.

Table II-2
Historic and Projected Gasoline Consumption in California[(1)]

Year	Consumption (bpd)
1996	892,000
1997	900,000
1998	918,000
1999	923,000
2000	936,000
2001	947,000
2002	958,000
2003	969,000

Source: State of California Board of Equalization Tax Tables
1) Estimated consumption for July 1999 through 2003

Table II-3 shows annual average imports of finished gasoline, blendstocks and oxygenates by California refineries. Notice that the import volume is not consistent and tends to vary based on need and price. Preliminary data for 1999 indicates that except for 1998, the amount of imports is increasing each year. In addition, in about 2002 or 2003, refineries will no longer be able to meet California demand without significant routine imports. As mentioned earlier, the importation of gasoline and gasoline components is becoming a commonplace occurrence in California.

Table II-3
Imports of Finished Gasoline, Blendstocks and Oxygenates
By California Refineries

Year	Imports (bpd)
1994	38,000
1995	44,000
1996	70,000
1997	74,000
1998	43,000

Source: California Energy Commission

B. 1998 Gasoline Properties

The staff analyzed the available information regarding the fuel properties for 1998 to determine actual in-use fuel properties. The staff used a database of 1998 fuel properties reported by each refiner certifying alternative formulations using the Predictive Model, as well as the results of ARB Compliance Division tests of fuel samples taken from refineries.

Refiners actually produce fuels with properties that are less than what they report to the ARB. Refiners typically allow themselves a "safety or compliance margin" between their own measurements of a property and the limit they provide to the ARB. The staff has estimated the typical margin for each property by averaging the mean difference between the ARB's own measurements of samples taken at refineries in 1998 and the limits that applied to the gasoline batches that were sampled. The results are in Table II-4.

Table II-4
Mean Results of 64 Samples at Refineries in 1998

Gasoline Property	Average Reported	Average Measured	Compliance Margin
Aromatic HC, vol.%	24.6	22.2	2.4
Benzene, vol%	0.73	0.54	0.19
Olefin, vol%	6.5	5.0	1.5
Sulfur, ppmw	27	24	3
T50, (°F)	206	198	8
T90 (°F)	318	311	7
Oxygen, wt% (min)	1.88	2.0	0.12
RVP, psi	7.0	6.7	0.32

Using the compliance margins from Table II-4, the staff subtracted these margins from the flat limit fuel properties reported by refiners to estimate properties of the fuel actually being marketed. The reported flat limits were chosen because about 75 percent of the fuel is produced to the flat limits, and the flat limits are used to evaluate emission reductions. Table II-5 shows these results

Table II-5
Estimated Actual In-Use Properties in 1998

Gasoline Property	Annual	RVP Season(2)
Aromatic HC, vol.%	22.2	22.4
Benzene, vol%	0.63	0.6
Olefin, vol%	5.6	5.8
Sulfur, ppmw	28	25
T50, (°F)	196	197
T90 (°F)	311	310
Oxygen, wt% (max)	1.9	2
(min)	1.8	
RVP, psi	6.7	6.7

(1) Refinery means weighted by shares of total gasoline production
(2) April 1 – October 31

1. ***Driveability Index of California Gasoline***

Automotive engineers have recognized that engine performance depends in part on the distillation properties of gasoline. The "driveability index" (DI (^{o}F) = 1.5*T10+3.0*T50+T90), derived from the distillation properties of gasoline, relates to the quality of engine performance as judged by trained drivers. Lower values of DI correspond to better performance. Because the distillation temperatures (T50 and T90) are limited in the CaRFG2 regulations, California gasolines have very favorable DI's (about 1060 to 1180). DI's generally below 1200 to 1250 are desired, while higher DI's can adversely affect vehicle driveability and emissions. Recent data have shown a correlation between the DI and fuel oxygen content. The corrected equation as recommended by automobile manufacturers for calculating the DI of a fuel to include the effect of oxygen is DI (^{o}F) = 1.5*T10+3.0*T50+T90+20*oxygen weight percent.

Automobile manufacturers have indicated that the DI of in-use gasoline will also be an important factor in achieving compliance with the upcoming LEV II exhaust emission standards. To ensure customer satisfaction, the air/fuel controls should be capable of providing good performance over the entire range of DI's found among in-use fuels. Automobile manufacturers claim that providing good performance for high-DI fuels compromises the operation of the air/fuel controls when emission-certification fuel is used. They have stated that certification to LEV II standards will be unreasonably difficult if the air/fuel controls must accommodate large in-use DI's. ASTM has adopted a DI standard of 1250 without the correction for oxygen. The auto manufacturers believe a DI, with oxygen correction, of 1200 is needed to ensure good driveability.

There are three sources of data related to the DI's of gasolines in California:

- proprietary data from spot-sampling by the Association of American Automobile Manufacturers (replaced by the Alliance of Automobile Manufacturers) at retail stations in Los Angeles and the Bay Area
- RVP, T50, and T90 of samples taken by the ARB Compliance Division at refineries
- property limits used by refiners for T50 and T90

Table II-6 shows statistics for the average DIs (with and without the oxygen effect) from these sources. Appendix H shows the ARB data and explains how DI was estimated when data include RVP but not T10. Appendix I shows the gasoline flat-limit data and their analysis. The data indicate that CaRFG2 fuels have exhibited very favorable DI's with average DI's well below 1,200 with the oxygen correction. California DI's for 1997 and 1998 were calculated based on AAMA fuel survey data. The averages and the maximums of the DI's for fuels sold during the RVP season in 1997 and 1998 are listed in Table II-7.

Table II-6
Statistics on DI in California Gasoline in 1998
Volume Weighted

	# samples	Mean		Maximum	
		With oxygen	Without Oxygen	With oxygen	Without Oxygen
AAMA retail samples[1]	31	1163	1123	1205	1165
ARB refinery sampling[1,2]	39	1162	1122	1207	1167
Mean property limits [2]	~2500	1158	1118	1217	1177

1. During RVP season
2. DI estimated from RVP, T50, T90

Table II-7
Summary of DI's from AAMA Fuel Survey
(With Oxygen Effect)

Year	# samples	Means	Maximum
1997[1]	30	1137	1205
1998[1]	31	1163	1215

1. Includes oxygen effects

Finally, Table II-8 shows estimates of DI if the values of T50 and T90 were at their cap limits (both the current cap limits and the proposed higher limits). These estimates are based on 2.7 percent oxygen for current fuels. For the proposed CaRFG3 fuel, the staff estimated maximum DI's for both 2.0 percent and 3.5 percent oxygen cases.

Table II-8
DI's Estimated [(1)] for Worst-Case Property Values

	T50 & T90 at:		
		Proposed Caps	
RVP (psi)	Current Caps	2.0 wt % Oxygen	3.5 wt % Oxygen
6.4	1259	1265	1295
7.0	1254	1240	1270

These data show the potential for somewhat higher maximum potential DI's in California fuel. To ensure CaRFG3 does not result in fuels with poorer driveability and the resulting potential adverse emission increases, the staff has proposed a DI specification of 1225, with an oxygen correction.

Chapter III. Proposed CaRFG3 Regulations

This chapter presents the proposed CaRFG Phase 3 (CaRFG3) amendments and the rationale for the changes. Amendments are proposed to remove MTBE from California gasoline and to preserve the benefits of the existing gasoline program. Amendments are also being proposed to increase flexibility in making gasoline without MTBE and to obtain additional emissions benefits that are technically and economically feasible. The proposed amendments, referred to as the CaRFG3 regulations, are contained in Appendix A.

A. Overview of Amendments and Rationale

1. ***Prohibition of MTBE***

The staff is proposing that the use of MTBE in gasoline be prohibited by December 31, 2002, consistent with the Governor's directive and the CEC's recommendation. The proposal is that no MTBE will be allowed to be added to gasoline and the allowable amount of residual MTBE in gasoline will be limited to 0.30 percent by volume for all California gasoline supplied from a production or import facility beginning December 31, 2002. This level corresponds to the current specification set by California's primary common carrier pipeline for gasoline produced as "non-MTBE." The residual MTBE limit will be further reduced to 0.15 percent by volume on December 31, 2003, and to 0.05 percent by volume on December 31, 2004. The staff intends to monitor the ability of refiners and importers to meet these limits and re-evaluate the limits in 2002. This re-evaluation is necessary because if MTBE continues to be used outside of California in significant quantities, MTBE can find its way into California as an unintended contaminant in imported fuel.

The proposed amendments would also provide that other non-MTBE ethers, and alcohols other than ethanol, cannot be added to gasoline starting December 31, 2002, unless a multimedia evaluation of their use in California gasoline has been conducted and the California Environmental Policy Council, established by Public Resources Code section 71017, has determined that such use will not cause a significant adverse impact on public health or the environment.

2. ***Increased Flexibility***

To increase flexibility in meeting CaRFG requirements without MTBE, the staff is proposing several changes for CaRFG3. First, the staff is proposing increases to the T50 and T90 flat, averaging, and cap limits. Second, the staff is proposing an increase of the aromatic hydrocarbon cap without changing the flat and averaging limits. Third, the staff is proposing changes to the Predictive Model that add an evaporative emissions element to allow a variable RVP specification, and a hydrocarbon credit to reflect the benefits of reducing CO on ozone formation. These new elements of the model would only apply during the RVP season for a given area. Fourth, the staff is proposing changes to shorten the wintertime oxygenate period in the South Coast Air Basin by one month to remove the October overlap with the RVP season. As a result, refiners marketing gasoline in Southern California would not be required to meet RVP and winter oxygen limits simultaneously.

3. Emissions Benefits

To meet the directive in the Governor's Executive Order that CaRFG3 result in no loss of benefits, staff proposes that the flat and averaging sulfur limits be lowered to offset the emissions increase associated with increasing the flat and averaging limits of T50 and T90; the sulfur cap limit would also be reduced in two phases. Because changes in T50 and T90 have little effect on NOx emissions, lowering sulfur provides additional NOx reductions. Furthermore, the flat, averaging and cap limits for benzene will be lowered to ensure that toxic emissions do not increase.

4. Other Changes

The staff is also recommending other changes that are appropriate and necessary as part of this rulemaking. The staff proposes that new data be added to the Predictive Model database, and that the model be updated to reflect vehicle emissions in 2005. The staff also proposes that a new specification for driveablity index be included to protect vehicle performance and to facilitate compliance with existing and future low emission vehicle standards. All of the above changes would be applicable starting December 31, 2002. The staff is also proposing several changes to the CARBOB provisions which would apply as soon as the amendments become operable.

B. Prohibition of MTBE in California Gasoline

The staff is proposing a prohibition of California gasoline produced with the use of MTBE, which would apply to all gasoline supplied from production and import facilities starting December 31, 2002. This is consistent with the directive in the Governor's Executive Order D-5-99 and the schedule approved by the CEC. The prohibition would be phased-in downstream of the production and import facilities according to the same basic schedule used in the phase-in of CaRFG2 in 1996. It will apply 45 days later - starting February 14, 2003 - to all downstream facilities except bulk plants, retail outlets, and bulk purchaser-consumer facilities. After another 45 days - starting March 31, 2003 - the prohibition on California gasoline produced with the use of MTBE will apply throughout the distribution system. For low-throughput service stations, a very limited affirmative defense will be available if there have been no new deliveries of gasoline since March 16, 2003.

The amendments would effectively prohibit entities from adding any MTBE to gasoline intended for the California market. The staff understand that facilities converted to produce the gasoline component iso-octane may produce extremely low levels - about 10 parts per million - of MTBE as a contaminant in the iso-octane. When blended with other gasoline components, the MTBE level would be no greater than about 3 parts per million, or 0.0003 volume percent. Use of such iso-octane in gasoline would not be considered production of gasoline using MTBE.

Along with the prohibition on the use of MTBE in producing gasoline, the staff proposes a three-phase reduction in the allowable residual levels of MTBE in California gasoline. Once MTBE is no longer added to gasoline, it is expected that very low levels of MTBE may continue to exist in parts of the gasoline distribution system. This will most likely be the case for imported gasoline, to the extent that MTBE is still used in gasoline in other parts of the country. Even though a refiner produces a batch of California gasoline without the use of MTBE, there could be limited contamination from other batches in which MTBE has been used. An initial limit that is too restrictive could make it so difficult to import California gasoline that there could be periodic threats of supply shortages. During the first year after the MTBE phase-out, starting December 31, 2002, California gasoline could not contain more than 0.30 volume percent MTBE. This prohibition would initially apply just to gasoline being supplied from the production or import facility. It would be phased in downstream over 90 days in the same manner as the prohibition of California gasoline produced with the use of MTBE. Starting December 31, 2003, gasoline would be prohibited from containing 0.15 volume percent or more MTBE, and a permanent prohibition of 0.05 percent or more MTBE would apply starting December 31, 2004 - both with 90 day phase ins. In 2002, the 0.05 volume percent limit will be evaluated to determine if it would unduly restrict imports. This would largely depend on how extensively MTBE is used outside California.

We believe that it is appropriate to prohibit the use of MTBE in California. This is consistent with the Governor's directive regarding MTBE and is consistent with the findings of the UC Study and the U.S. EPA Blue Ribbon Panel. Furthermore, these studies and prior experience in California have shown that reformulated gasoline does not need to contain oxygenates to obtain the ozone benefits associated with the RFG program. Finally, and most important, elimination of MTBE will remove a real threat to our surface and ground water resources, and will essentially eliminate public exposure to ambient MTBE associated with vehicle refueling and vehicle emissions.

The staff also proposes a conditional prohibition on and after December 31, 2002 of the use of ethyl tertiary-butyl ether (ETBE), tertiary amyl methyl ether (TAME), any other non-MTBE ether, and alcohols other than ethanol. The prohibition would apply unless a multimedia evaluation of the use of the ether or alcohol in California gasoline has been conducted and the California Environmental Policy Council has determined that such use will not cause a significant adverse impact on public health or the environment. Available data indicate that the characteristics of MTBE that result in increased threats of groundwater contamination are generally shared by other ethers and higher molecular-weight alcohols. Accordingly, the considerations that justify the ARB's elimination of MTBE in California gasoline would also justify an equivalent prohibition on the use of other ethers or higher molecular-weight alcohols. However, since the other ethers and alcohols have not been studied as much as MTBE, it is appropriate to include a provision allowing use of another ether or alcohol if the California Environmental Policy Council (Council) finds that the use would be environmentally benign. The Council consists of the Secretary of Environmental Protection, the Chairpersons of the Air Resources Board, the State Water Resources Control Board and the California Integrated Waste Management Board, the Directors of the Departments of Pesticide Regulation and Toxic Substances Control, and the Director of the Office of Environmental Health Hazard Assessment. A multimedia evaluation mechanism has been established by recently enacted SB 529 (Stats. 1999 ch. 813 (Bowen)). The staff expect that the person or entity desiring to use a prohibited non-MTBE substance would be responsible for conducting the multimedia assessment that would be reviewed by the Council.

C. Proposed CaRFG3 Specifications

The proposed CaRFG3 specifications are necessary to improve a refiner's ability to make complying gasoline and to preserve and gain some additional emissions benefits. The proposed gasoline specifications represent a balance between providing refiners additional flexibility, preserving and obtaining additional emissions benefits, maintaining sufficient gasoline supplies to meet California demand, and preserving vehicle driveability. The proposed amendments to the specifications are summarized in Table III-1, and are compared to the existing CaRFG2 limits.

Table III-1
Proposed CaRFG3 Property Specifications

Property	Flat Limits		Averaging Limits		Cap Limits	
	Original	Proposed	Original	Proposed	Original	Proposed
RVP, psi, max	7.0	7.0(1)	na(2)	no change	7.0	6.4-7.2
Benzene, vol. %, max	1.00	0.80	0.80	0.70	1.20	1.10
Sulfur, ppmw, max	40	20	30	15	80	60/30(3)
Aromatic HC, vol. %, max	25	no change	22	no change	30	35
Olefins, vol. %, max	6.0	no change	4.0	no change	10	no change
Oxygen, wt. %	1.8 to 2.2	no change	na(2)	no change	0-3.5(4)	no change
T50 ^{o}F, max	210	211	200	201	220	225
T90 ^{o}F, max	300	305	290	295	330	335
Driveability Index(5)	none	1225	na(2)	na(2)	none	none

1) Equal to 6.9 psi if using the evaporative element of the Predictive Model
2) Not Applicable
3) 60 ppmw will apply December 31, 2002; 30 ppmw will apply December 31, 2004
4) Allow 3.7 weight percent oxygen for gasoline containing more than 3.5 weight percent oxygen, but no more than 10 volume percent ethanol
5) Driveability Index=1.5*T10+3*T50+T90+20*(wt% oxygen)

D. Rationale for Proposed CaRFG3 Specifications

The staff is proposing that the flat, averaging and cap limits for T50 and T90 be increased to increase flexibility in meeting CaRFG regulations. However, the staff is also proposing reductions in sulfur and benzene to preserve emissions benefits and to gain additional NOx and toxic emissions reductions. The staff is proposing reductions in sulfur and benzene in conjunction with the increases in T50 and T90 because they can be reduced without significantly reducing flexibility and additional emissions benefits can be gained. Sulfur is the only fuel parameter that simultaneously reduces emissions of HC, NOx and toxics. And, because changes in T50 and T90 have little effect on NOx emissions, lowering sulfur provides additional NOx reductions.

1. *Increase the Flat, Averaging and Cap Limits for T50 and T90*

Removing MTBE from gasoline will significantly decrease the available volume and will increase the T50 of the gasoline. To help minimize the loss in volume and give refines some relief in the middle distillation range, the staff proposes increases in the flat, averaging and cap limits for both T50 and T90.

2. *Increase the Aromatic Hydrocarbon Cap*

The staff is proposing an increase in the aromatic hydrocarbon cap to give refiners the flexibility to use aromatic hydrocarbons in meeting volume and octane requirements. This proposal would be emissions neutral because the staff is not recommending a change to the flat or averaging limits for aromatic hydrocarbons; thus, refiners using higher aromatics would still be required to offset any increase in emissions by changing other fuel properties.

3. *Lower Sulfur Limits*

The staff is proposing lower sulfur limits to ensure that net emissions do not increase with the proposed increases in T50 and T90. Sulfur, when decreased, is the only fuel parameter that simultaneously reduces emission of HC, NOx and toxics. Because changes in T50 and T90 have little effect on NOx emissions, lowering sulfur provides additional NOx reductions. Lower sulfur would also reduce the potential catalyst deactivation from sulfur contamination. Finally, a lower sulfur cap would further facilitate the ARB’s ability to detect illegal blending of non-complying material into gasoline after it has left the refiners’ control, because most non-complying fuels sold outside California have sulfur concentrations that are higher than what is sold in California.

4. *Lower Benzene Limits*

The staff proposes that the benzene flat, averaging and cap limits be further reduced to obtain additional toxic emissions reductions. This will lead to reduced public exposure to a known human carcinogen.

5. *Driveability Index Limit of 1225*

The staff is proposing the addition of a new specification for driveability index to preserve vehicle driveability and to ensure that compliance with LEV II standards is not hampered by increases in distillation temperatures. The staff is proposing use of a form of the driveability index (DI) equation based on work done by the Coordinating Research Council. The DI equation recommended by the automobile manufacturers is defined as:

$$DI=1.5\times T10+3\times T50+T90+20\times(\text{weight percent oxygen})$$

Automotive engineers have long recognized that engine performance depends on the boiling-point curve of gasoline (curve of temperatures needed to distill specified fractions of the fuel). The "driveability index" - derived from the boiling curve - has been found to relate to the quality of engine performance as judged by trained drivers. Lower values of DI correspond to better performance. Automakers claim that the DI of in-use gasoline will also be an important factor in achieving compliance with the upcoming LEV II emission standards for exhaust. Thus, a DI limit will prevent emission increases associated with poor driveability. Staff is proposing a DI limit of 1225. Further discussion of DI was presented earlier in Chapter 2.

E. Proposed Amendments for the CaRFG3 Predictive Model

The following section describes the staff's proposal for updating the Predictive Model to reflect the California vehicle fleet for 2005, adding new data to the Predictive Model database, and introducing an optional evaporative emissions element and a CO credit mechanism.

1. *Updates for the CaRFG3 Predictive Model*

The CaRFG2 Predictive Model was created and approved before data were available for federal Tier I and California LEVs. Emission data for LEVs and weighting factors based on the current motor vehicle emissions inventory are now available and should be used to improve the Predictive Model's representation of the current and upcoming on-road vehicle fleets.

The equations used to predict exhaust emissions in the CaRFG2 Predictive Model were derived by regression analysis of the Predictive Model Database. For each pollutant, the predictions for the two class models (Tech 3 and Tech 4) are combined with weights proportional to the contributions of the classes to the ARB's emission inventory for that pollutant. The weights reflected in the CaRFG2 Predictive Model were based on the MVEI-7F emissions inventory projected for 2000.

New observations have been added to the CaRFG3 Predictive Model database and new equations have been developed. The new data are mostly for vehicles from the 1986 model year and newer. The staff is proposing the creation of a new technology group "Tech 5" primarily representing 1996 and newer vehicles in the Predictive Model.

Further details on the analysis of the data and methodology used in analyzing the data are in Appendix J. The staff believes it is appropriate to reflect LEVs as a separate class because these vehicles have advanced emissions control technology compared to the "Tech 4" vehicles, and sufficient data are available to include them as a separate class. During the development of the Tech 5 portion of the model, only new terms involving oxygen and sulfur were allowed to enter the model. There are insufficient data regarding the other fuel parameters in the new studies to estimate effects for them.

Additionally, ARB staff believes it is appropriate to update the weights used to reflect the emissions from the vehicle technology classes to more accurately reflect a newer vehicle fleet. The staff proposes to re-weight the vehicle classes with the draft EMFAC99 Motor Vehicle Emissions Inventory for 2005. The weights for each vehicle class are shown in the following table.

Table III-2
Weighting Factors by Vehicle Technology Group
2005

		HC Weighting Factor		NOx Weighting Factor	
Tech Group	Model Years	EMFAC-7G	EMFAC-99	EMFAC-7G	EMFAC-99
Tech 3	1981-1985	0.198	0.155	0.174	0.103
Tech 4	1986-1995	0.802	0.509	0.826	0.408
Tech 5	1996-2005	na	0.336	na	0.489

Source: California Procedures for Evaluating Alternative Specifications for Phase 2 Reformulated Gasoline Using the California Predictive Model, April 20, 1995.
EMFAC99 Inventory.

2. Additions to the CaRFG3 Predictive Model

Evaporative Emissions Model to Facilitate Variable RVP. The ARB staff proposes that refiners be allowed to take advantage of their ability to control RVP by permitting them to certify gasolines at different RVPs. However, to preserve emissions benefits, the staff proposes that the baseline RVP be set at 6.9 psi when this feature of the model is used. The lower RVP assures that refiners who are already producing gasoline at 6.7 psi to comply with the 7.0 psi limit will not be able to claim an evaporative emissions reduction without making any changes. Data collected by staff show that the average margin of safety for RVP is about 0.2 psi. Further, the 6.9 psi baseline also provides some assurance that the non-linear effects of commingling and some uncertainties in comparing evaporative and exhaust emissions do not lead to higher emissions when the evaporative element is used.

Variable RVP would allow refiners to offset exhaust hydrocarbon emissions with evaporative hydrocarbon emissions. To facilitate the use of variable RVP, the ARB staff proposes the addition of an evaporative hydrocarbon emissions element to the hydrocarbon element of the Predictive Model. An evaporative emissions model and variable RVP will provide significant flexibility. And refiners who chose to produce a non-oxygenated gasoline could produce a low-RVP gasoline and use the reduction in evaporative emissions to provide more flexibility in setting other fuel parameters. Details are provided in Appendix K.

Recognition of CO Credit Both the National Research Council and the U.S. EPA Blue Ribbon Panel recognize that CO emissions can play a role in ozone formation. With all other emissions kept the same, using a fuel that produces lower CO emissions would tend to have lower ozone impacts because CO is somewhat photochemically reactive. The staff believes that CO reductions should be credited to exhaust and evaporative emissions based on CO's relative reactivity. Accordingly, the ARB staff is proposing that a credit be provided based on the relative reactivity of CO to offset changes in either evaporative or exhaust hydrocarbon emissions. The staff proposes that a credit be allowed against hydrocarbon emissions for fuels with oxygen greater than 2.0 weight percent and a debit against hydrocarbon emissions for fuels with less than 2.0 weight percent oxygen.

Additional information on the methodology used to develop the CO credit and the analysis of the CO reactivity adjustment is discussed in Appendix G, and the analysis of the reactivity of gasoline vehicle exhaust emissions is in Appendix L.

F. Implementation of the CaRFG3 Standards and Predictive Model Amendments

1. *CaRFG3 Flat and Averaging Limits*

The flat and averaging limits apply to gasoline when it is supplied from the production facility (typically a refinery) at which it was produced or the import facility at which it was imported. Under the proposal, the CaRFG3 flat and averaging limits will apply to all shipments of final blends of California gasoline supplied from the production or import facility on or after December 31, 2002. Since one of the objectives of CaRFG3 is to facilitate the production of cleaner burning gasoline without the use of MTBE, it is appropriate for the new CaRFG3 flat and averaging limits to become applicable at the same time as the December 31, 2002 prohibition on MTBE in California gasoline being supplied from the production or import facility.

2. *CaRFG3 Predictive Model*

The staff is proposing that the CaRFG3 Predictive Model be implemented at the same time as the CaRFG3 flat and averaging limits, on December 31, 2002. At that time the CaRFG2 Predictive Model would become inapplicable. The evaporative element of the CaRFG3 Predictive Model could only be used in connection with the CaRFG3 standards, because the CaRFG2 standards do not allow RVP to vary. The staff is not recommending that refiners be given the choice of using either the CaRFG2 or CaRFG3 models prior to December 31, 2002. Such an option could have adverse emission impacts, because for any given blend a refiner would be expected to choose the model that provides the most emissions flexibility, meaning the least emissions reductions. Also, enforcement at terminals and service stations would be impaired, as only the least stringent caps could be enforced; however, this is being reviewed. The staff seeks comments on the need to allow gasoline producers to comply with the CaRFG3 specifications (including the revised Predictive Model) prior to December, 31, 2002.

3. *CaRFG3 Cap Limits*

Four of the proposed CaRFG3 cap limits for aromatics content, T50, T90 and RVP provide greater flexibility than the corresponding CaRFG2 cap limits. Any final blends of CaRFG3 supplied from a production or import facility on or after December 31, 2002, could legally equal the new cap limit, and this gasoline could in some cases move quickly through the distribution system. Accordingly, the staff proposes that the CaRFG3 cap limits for those four properties, as well as the olefin cap limit that remains unchanged, become applicable throughout the distribution system starting December 31, 2002.

The more stringent CaRFG3 sulfur content cap limits of 60 ppmw and 30 ppmw, and the more stringent benzene cap limit of 1.10 volume percent, would be phased in with the same basic schedule that was successfully utilized when the CaRFG2 caps were implemented in the spring of 1996. The initial sulfur content cap of 60 ppmw and the more stringent benzene cap of 1.10 volume percent would apply starting December 31, 2002 to sales and supplies of gasoline from the production or import facility. They will apply 45 days later starting February 14, 2003 to all downstream facilities except bulk plants, retail outlets, and bulk purchaser-consumer facilities. After another 45 days, the cap limits will apply throughout the distribution system.

As was the case in the spring of 1996, the cap limits will be inapplicable to sales or supplies of gasoline from a retail outlet or bulk purchaser-consumer facility where it is shown by affirmative defense that the exceedance of the sulfur cap limit was caused by gasoline delivered prior to February 14, 2003 (or from a bulk plant prior to March 31, 2003). This is intended to provide relief for low-throughput facilities that may not receive sufficient deliveries of CaRFG3 to turn their tanks by March 31. Such relief is intentionally limited, however, and the retailer or other end-user would have the burden of demonstrating that the cap violation was caused by gasoline delivered when suppliers were not required to meet the cap limit for sulfur. The same provisions would apply two years later when the 30 ppmw sulfur cap is implemented.

G. Amendments Pertaining to the Treatment of CARBOB (California Reformulated Gasoline Blendstock for Oxygenate Blending)

1. *Overview of the CARBOB Provisions*

When gasoline is oxygenated with ethanol, certain characteristics of the resulting blend make it infeasible to be transported through pipeline systems. Because of this, ethanol is typically added at the terminal, either in a stationary blend tank or by splash blending the ethanol and the non-oxygenated gasoline in the cargo tank truck that will deliver the oxygenated gasoline to service stations and other outlets. Adding the ethanol affects the properties of the resulting gasoline blend in various ways. Since denatured ethanol typically has very low levels of the compounds for which the ARB has adopted weight or volume percent CaRFG specifications (sulfur, benzene, aromatics and olefins), adding the ethanol to gasoline reduces the concentration of these compounds in the resulting blend by simple dilution. Thus adding the ethanol assists in meeting the CaRFG specifications for these compounds. Adding 5-10 percent ethanol will increase the RVP of the resulting blend by approximately 1 psi, and it will also depress T50 and, to a lesser extent, T90.

The U.S. EPA structured the federal RFG regulations to allow refiners to ship non-oxygenated gasoline from the refinery without complying with the federal RFG standards if it is specially formulated to be combined with oxygenate downstream from the refinery and the resulting blend will meet all of the federal RFG standards. This allows entities wishing to oxygenate gasoline downstream from the refinery to take advantage of the contribution oxygenates can make in meeting the federal RFG standards. U.S. EPA calls the specially formulated product Reformulated Gasoline Blendstock for Oxygen Blending, or RBOB. In a 1995 rulemaking, the ARB amended the CaRFG2 regulations to incorporate a similar approach, allowing refiners to supply a non-oxygenated blendstock called California reformulated gasoline blendstock for oxygen blending, or CARBOB.

The CARBOB provisions require the producer of a batch of CARBOB to take a representative sample, add the appropriate level of oxygenate, and test the resulting blend to determine all of the properties covered by the CaRFG standards. The producer must notify the ARB about the batch of CARBOB before it is transferred from the refinery. Whenever the CARBOB is transferred, it must be accompanied by a document identifying the oxygenate type or types and amount or range of amounts that must be added before the CARBOB is supplied from the final distribution facility. Like the federal regulations, the CARBOB provisions prohibit combining CARBOB that has been shipped from the refinery with any other CARBOB, gasoline, blendstock or oxygenate, except for the oxygenate for which the CARBOB was designed, or other CARBOB for which the refiner has designated the same type and amount or range of oxygenate. Oxygenate blenders must be registered, and after blending oxygenate into CARBOB in a stationary storage tank, blenders must determine the oxygen content. There are also quality audit provisions for both refiners and oxygen blenders, based on the federal regulations.

To date, relatively small amounts of CARBOB have been shipped by refiners, because of the limited use of ethanol. The prohibition of MTBE is expected to result in substantial increases in ethanol use. Refiners have urged that more flexibility be provided in the CARBOB regulations to make compliance more practical. The staff has evaluated various elements and is recommending several targeted changes at this time. We will continue to meet with interested parties and may recommend additional changes at a later date. We emphasize, however, the importance of maintaining sufficient safeguards to assure that effective compliance programs are in place.

2. Eliminating the Requirement that the Oxygenate Used in Testing the Oxygenated CARBOB at the Refinery Must Be Representative of the Oxygenate Expected To Be Added Downstream

The existing CARBOB provisions require that the oxygenate the producer uses in testing the oxygenated CARBOB at the refinery must be representative of the oxygenate expected to be added downstream. They also require the producer to enter into a protocol with the ARB Executive Officer on how representativeness will be determined. These requirements were included because of concerns that an oxygenate such as ethanol or MTBE could vary in ways that have a significant impact on the properties of the oxygenated gasoline blend. Once the use of ethanol is widespread and CARBOBs designed for identical oxygenation are commingled in pipelines and storage tanks, it will probably be less likely that a refiner will know the identity of the particular oxygen blender that will oxygenate the refiner's CARBOB. The staff believes that it would be preferable to eliminate the requirement for a representative oxygenate for each batch, and to substitute a system-wide set of pertinent specifications for denatured ethanol intended for use as an additive in California gasoline. This will provide greater predictability for refiners and oxygen blenders.

The proposed specifications are 1 ppmw sulfur, 1 volume percent aromatic hydrocarbon content, 0.1 percent benzene , and 0.1 volume percent olefins. These specifications were developed using the assumption that the denaturant would meet the flat proposed limits for sulfur, olefins, aromatics and benzene. These limits were then adjusted for the dilution expected from mixing the denaturant into the ethanol. The test methods are the same as those specified for CaRFG3.

3. Eliminating CARBOB Quality Audit Requirements for Producers, Importers and Oxygenate Blenders.

The ARB's CARBOB regulations include quality audit requirements closely based on (and referencing) quality audit requirements in the federal RBOB regulations. Section 2266.5(g) requires producers or importers supplying CARBOB from their production or import facilities to conduct a quality assurance sampling and testing program substantially satisfying the requirements in 40 C.F.R. 80.69(a)(7). The program is to be carried out at the facilities of each oxygenate blender who blends any of the producer's CARBOB with oxygenate, to determine whether the CaRFG produced after oxygenate blending complies with the applicable standards. Where the oxygenate blending occurs in a stationary storage tank, the required frequency is one sample for every 400,000 barrels of the producer's CARBOB oxygenated by that blender, or one per month, whichever is more frequent. Where the CARBOB is splash blended in delivery trucks with computer-controlled in-line blending, the frequency is at least one sample per 200,000 barrels of CARBOB; without the computer-controlled in-line blending it is at least one sample per 50,000 barrels of CARBOB. If any test result shows noncompliance, the frequency must be doubled. The federal regulations allow the producer or importer the option of presuming the volume of ethanol will be such that the resulting RFG has an oxygen content of 2.0 weight percent oxygen instead of conducting the quality audit program; the California regulations do not provide that option.

Section 2266.5(h)(4) requires oxygen blenders who conduct splash blending to follow the federal RFG quality audit requirements calling for oxygen content tests at a rate of one per 500 instances of splash blending or one every three months (if using computer-controlled in-line blending). The required rate is one per 100 instances of splash blending or once a month if computer controls are not used. Neither the federal nor the state program allows an option to this requirement.

The staff is recommending that these quality audit requirements be eliminated because of the potential burdens they impose. The CARBOB regulations require the producer in determining compliance to add the designated minimum oxygenate level where an oxygenate range is identified, and this should provide some assurance that refiners are not taking credit for more oxygenate than is really being added. The tax benefits that result from the use of at least 5.7, 7.7 and 10.0 volume percent ethanol (2.0, 2.7 and 3.5 weight percent oxygen, respectively) also provide an incentive for blenders not to add less oxygenate than specified.

4. Concerns Pertaining to the Fungibility of Different CARBOBs

As noted above, the current regulations impose restrictions on combining CARBOB that is downstream from its production or import facility with other CARBOB, gasoline, blendstock or oxygenate. (2266.5(h).) Downstream CARBOB can only be commingled with other CARBOB that has been designed to have the same type and amount (or range of amounts) of oxygenate added; CARBOB of course can also be combined with the type and amount of oxygenate for which the CARBOB was designed. Once the CARBOB has been oxygenated and converted to CaRFG, there are no restrictions on blending it with other CaRFG, as long as the blend continues to comply with the cap limits.

Refiners have expressed concerns that reduced fungibility of downstream CARBOB compared to downstream gasoline will cause serious problems in the distribution system, especially with regard to common carrier pipelines. Some refiners have urged that the ARB eliminate the restriction against combining CARBOBs designed to be oxygenated at different oxygen levels. The staff believes that restriction is necessary at this time in order for oxygen blenders to know how much oxygenate is to be added to a particular batch of CARBOB. If a pipeline commingles CARBOB designed to be oxygenated at 2.0 weight percent oxygen with CARBOB designed to be oxygenated at 2.7 weight percent oxygen, how can one assure that the necessary amounts of oxygenate levels are added? Moreover, if some kind of averaging or mass balance approach were used, there could be situations where CARBOB designed to be right at the cap limit for one property is legally under-oxygenated, thus resulting in an exceedance of the cap limit. This phenomenon would cast doubt on the downstream enforceability of the cap limits.

At least one refiner has suggested that the ARB actually specify one or two levels of permissible oxygenation, to avoid situations where CARBOBs with different designated oxygen levels must be kept separate. The staff believes such an intrusion into the gasoline marketplace would be inappropriate. But the current tax structure for ethanol in gasoline - which provides graduated benefits for ethanol at 5.7, 7.7 and 10.0 volume percent - suggests that there are some natural cut points that could be reinforced through application of the Predictive Model.

We expect that as a practical matter, virtually all CARBOB will be designed to be oxygenated to a range of oxygen levels rather than a precise oxygen level. This is because there would be an insufficient margin of error when an exact oxygen level is specified - unless the blending is perfect, the oxygen would be at least a little above or below the specified level. If a refiner chooses not to use the Predictive Model with respect to a particular CaRFG blend, the applicable oxygen content standard is 1.8-2.2 weight percent oxygen and the specified oxygenate range would reflect that. A refiner using the CaRFG2 Predictive Model for a CaRFG blend has two basic options when it comes to specifying oxygen content. One is to specify a range of 1.8-2.2 weight percent oxygen, in which case the candidate and reference oxygen property value used in the Predictive Model equation is treated as 2.0 weight percent. The other option is to specify a range other than 1.8-2.2 weight percent, in which case the candidate blend must pass the Predictive Model criteria at both the low and high end of the oxygen range. The staff proposes that this not be the case for candidate CaRFG3 Predictive Model formulations that have an oxygen range of 2.5-2.9 weight percent. In that case as in the 1.8-2.2 weight percent situation the candidate oxygen content would be treated simply as 2.7 weight percent. Similarly, the oxygen range of 3.3-3.7 weight percent would be treated as 3.5 weight percent. This could result in a higher percentage of CARBOB batches designated at that oxygen level, and a greater likelihood of fungibility.

*5. **Restrictions During the RVP Season on Blending Gasoline Containing Ethanol with California Gasoline not Containing Ethanol***

As noted elsewhere in this report, adding ethanol to gasoline will increase the RVP of the blend by around 1 psi. If finished non-oxygenated California gasoline having an RVP of 6.8 psi is mixed with an equal amount of finished California gasoline oxygenated with 5 to 10 percent ethanol and also having an RVP of 6.8 psi, the RVP of the resulting blend would be about 7.3 psi. This is because the half of the mixture that did not contain ethanol would experience an RVP increase of about 1 psi.

The federal RFG regulations (40 CFR 80.79(a)(8)) prohibit persons from combining any federal RFG that is subject to RVP limits (called VOC-controlled RFG") and is produced using ethanol with any VOC-controlled RFG that is produced using any other oxygenate during January 1 through September 15 (note that *all* federal RFG must be oxygenated year-round). This requirement applies in California because it is not covered by the California Enforcement Exemption in the federal RFG regulations. The reason for the prohibition is to avoid the RVP increases described in the previous paragraph. The staff is concerned that the increased use of ethanol resulting from this rulemaking could increase the frequency in which RVP and emissions increases are experienced as a result of commingling gasoline containing ethanol with non-oxygenated gasoline. While commingled gasoline exceeding the RVP cap is noncompliant and subject to enforcement action, such an action would depend on the presence of ARB inspectors to sample and test the gasoline.

To avoid the emissions increases from commingled gasoline with an elevated RVP, the staff is proposing an amendment adding the EPA mechanism in a more limited fashion. Rather than a flat-out prohibition on commingling during the RVP season, the prohibition would be conditional. The amendment would prohibit persons from combining California gasoline produced using ethanol with gasoline produced without using ethanol during the RVP season, unless the person can affirmatively demonstrate that the resulting blend complies with the RVP cap limit. (section 2266.5(i)(1)). There would be exceptions for those instances in which the RVP standard would not apply to the gasoline for one reason or another. The regulation would also state that the prohibition does not apply to commingling California gasolines that are in a motor vehicle's fuel tank.

6. Other CARBOB Changes Considered

a. *Sampling and Testing CARBOB Before Shipment From the Production or Import Facility.*

The CaRFG regulations require that refiners sample and test each final blend of CARBOB before it is shipped from the refinery, and retain the test results. To do this, the refiner must take a sample of the CARBOB and then add the specified kind and amount of oxygenate before running the tests. Both the sampling and the testing must be conducted using methodologies specified in the regulations, or those found by the ARB to be equivalent. Refiners have pointed out that final blends of California gasoline being supplied from a refinery are only required to be sampled and tested if the gasoline is subject to an averaging standard, and then only for the properties being averaged. They accordingly argue that the ARB should delete the requirement for CARBOB sampling and testing, at least where no averaging is being used. They claim that the CARBOB sampling requirements restrict their operations more than where CaRFG is being shipped from the refinery, because the step of adding the oxygenate effectively precludes in-line sampling.

At this time the staff is not proposing changes to the sampling and testing requirements for CARBOB. There is a significant difference between CARBOB and finished California gasoline at a refinery. The rationale for the CARBOB testing requirement is that, since compliance is premised on the addition of the oxygenate, the actual effect of the oxygenate should accordingly be verified. Otherwise there would be an additional element of uncertainty with CARBOB production.

b. *Certification to CARBOB Standards*

Refiners have recommended that the ARB establish certification standards for CARBOB, so that CARBOB compliance would be measured directly against those standards rather than needing the step of adding the oxygenate and then testing the blend. One problem with this approach is that the effects of adding oxygenate on T50 and T90 are not linear, so that it is difficult to model what the CARBOB standards for T50 and T90 (and for the proposed Driveability Index standard) should be. However, the staff will continue to explore the feasibility of this approach.

The existing regulations do prohibit the supply of CARBOB from a production facility where the sulfur, benzene, olefin and aromatic hydrocarbon content of the CARBOB, when multiplied by (1 - the designated minimum volume the oxygenate will represent, expressed as a decimal fraction, after it is added to the CARBOB), results in a sulfur, benzene, olefin or aromatic hydrocarbon content value exceeding the applicable limit for that property. For example, where the oxygenate will make up 5.4 percent of the oxygenated blend, the measured properties of the CARBOB would be multiplied by 0.946. Any CARBOB found to be out of compliance under this mathematical adjustment would necessarily be out of compliance after the minimum designated amount of oxygenate is added, since for these four properties the only effects adding the oxygenate is expected to have are dilution and the possible introduction of impurities. This provides ARB inspectors with a useful compliance tool.

H. Other Regulatory Changes

*1. **Accommodating Gasoline Containing no more than 10 Percent by Volume Ethanol but Having an Oxygen Content Greater than the Current 3.5 Percent by Weight Limit***

The regulations allow the Predictive Model to be used for gasoline having up to 3.5 weight percent oxygen. This value was chosen because it typically represents the oxygen content of gasoline containing 10 volume percent ethanol. However, differences in gasoline density can result in some instances in which gasoline containing 3.5 weight percent oxygen contains a bit less than 10 volume percent ethanol. In this case, the gasoline will not qualify for the full tax benefits that accrue to gasoline containing 10 volume percent ethanol. Because of this, the staff is proposing regulatory amendments that would increase the cap limit to 3.7 weight percent for gasoline containing more than 3.5 weight percent oxygen, but containing no more than 10 volume percent ethanol.

*2. **Implementation of the 2003 RVP Season***

The RVP season normally starts in the South Coast Air Basin and Ventura County on March 1 at production and import facilities, and on April 1 throughout the distribution system. The staff is proposing that these two implementation dates be delayed for one month in the spring of 2003 because the oxygenated gasoline required in January and February will in many cases be changing from MTBE blends to ethanol blends. Whether or not the federal RFG year-round oxygen requirement will still apply, South Coast and Ventura County gasoline is subject to a state wintertime minimum oxygen requirement through February. The RVP increase associated with adding ethanol to gasoline will present challenges to refiners during the transition period, and the delay in the 2003 RVP season will give refiners more flexibility as they gain experience with CaRFG3. The challenge is not as great in other areas because the RVP season starts a month or more later outside the South Coast Air Basin and Ventura County.

3. ***Elimination of the October Wintertime Oxygenate Mandate in the South Coast Area Starting in 2003.***

The CaRFG2 regulations currently identify a five-month, October through February mandatory wintertime oxygenates period in the counties of Los Angeles, Orange, Riverside, San Bernardino, and Ventura (collectively referred to in the regulation as the South Coast Area). The staff is proposing that the wintertime oxygenates mandate be eliminated for October starting in 2003, because the October program will no longer be necessary for CO attainment, and elimination of the mandate in October will provide more flexibility to refiners in meeting the October RVP season requirements without MTBE being available.

The ARB originally adopted the wintertime oxygenates program in a 1991-1992 rulemaking in response to section 211(m) of the federal Clean Air Act, added by the Clean Air Act amendments of 1990. Since the Los Angeles-South Coast Air Basin Area was designated non-attainment for the federal ambient CO standard, section 211(m)(2) of the Clean Air Act conditionally required California to submit a SIP revision establishing a wintertime oxygenates requirement for the area in the portion of the year (not less than four months) found by U.S. EPA to be prone to high ambient concentrations of CO. U.S. EPA identified the October through February period (57 F.R. 47853, 47855 (October 20, 1992)) because exceedances of the national CO standard had been experienced in all five of those months.

The air quality analysis in Appendix F demonstrates that it is very unlikely there would be exceedances of the national and state ambient CO standard in October 2003 and subsequent Octobers. This is largely because of the continuing reductions in mobile source CO emissions due to the replacement of older, higher-emitting vehicles with newer, lower-emitting vehicles. Accordingly, the staff is proposing that October be eliminated from the mandatory wintertime oxygenates period for the South Coast Area starting in 2003. The staff also proposes that a request be transmitted to U.S. EPA, seeking deletion of the designation of October as one of the months in which the South Coast Area is prone to high ambient concentrations of CO.

The summertime RVP season has historically run through October 31 in the South Coast Air Basin and all but four of the other fourteen air basins in the state. After this winter, the South Coast Area will be the only part of the state where gasoline is subject to both the RVP and the wintertime oxygenate requirements in October. Meeting the RVP standard with gasoline oxygenated with ethanol presents greater challenges than meeting the RVP standard with gasoline oxygenated with MTBE, because adding the necessary amounts of ethanol will raise the RVP of the gasoline blend by about one psi. If California is successful in having the federal RFG year-round 2.0 weight percent oxygen requirement rendered inapplicable in the state, elimination of the October oxygenates mandate would provide refiners with the flexibility of meeting the RVP standard with non-oxygenated gasoline if they choose to do so.

4. *Restructuring the Regulatory Provisions on the CaRFG standards.*

The CaRFG2 regulations included a separate section on each of the different properties subject to a standard (except for T50 and T90, which were included in the same section). This presentation meant there was no single place in the regulations that identified all of the standards in tabular form. Because the advent of the CaRFG3 standards would make maintenance of the separate sections more unwieldy, the staff has restructured the regulations so that one section - new section 2262 - contains a table with all of the CaRFG2 and CaRFG3 standards in a more readable form. A second new section - 2262.3 - sets forth the compliance requirements for the six properties for which averaging is allowed. Separate sections are maintained for compliance with the RVP and the oxygen standards (sections 2262.4 and 2262.5 respectively) because of their unique seasonal qualities and the lack of an averaging option.

The section on RVP compliance includes changes necessary to reflect the new option of using the Predictive Model to vary the flat limit for RVP when the Predictive Model is used. During the basic RVP season when the RVP standard applies throughout the distribution system, the 7.00 psi RVP standard has been changed to a cap limit of 7.20 psi. Instead of having production and import facilities subject to a one-month preseason standard as is presently the case, a 7.00 psi flat limit standard would be imposed at the production and import facility level extending from one month before the start of the basic RVP season through the end of the RVP season on either September 30 or October 31 (depending on the air basin). The refiner or importer will be able to elect whether the gasoline is subject to the default RVP flat limit or a Predictive Model flat RVP limit.

There are numerous references in the CaRFG2 regulations to the various cap, flat, and averaging standards. Restructuring the sections in the regulations on the actual standards necessitates changes in other sections that directly or indirectly reference the standards. The staff is proposing conforming changes to sections 2263 (Sampling Procedures and Test Methods), 2264 (Designated Alternative Limits), 2264.2 (Election of Applicable Limit for Gasoline Supplied From a Production or Import Facility), 2265 (Gasoline Subject to PM Alternative Specifications Based on the California Predictive Model), 2266 (Certified Gasoline Formulations Resulting in Equivalent Emissions Reductions Based on Motor Vehicle Emission Testing, 2266.5 (Requirements Pertaining to California Reformulated Gasoline Blendstock for Oxygen Blending (CARBOB) and Downstream Blending, 2270 (Testing and Recordkeeping), and 2271 (Variances).

5. *Miscellaneous Other Changes*

The CaRFG2 regulations included a section requiring producers to submit annual compliance plans showing the producer’s schedule for achieving compliance by the March 1, 1996 implementation date. Rather than a repeal of this section, the staff recommends that it be amended to substitute requirements for compliance plans showing how the producer plans to comply with the CaRFG3 requirements by December 31, 2002. The proposed amendments would require submittal of compliance plans by September 1, 2000, September 1, 2001, and September 1, 2003.

The staff also recommends repeal of section 2264.4, which provided a special mechanism for extending the offset requirements under the averaging limits during 1996 and 1997 when refiners were first operating under the CaRFG2 requirements. During the two years in which it applied, no refiners elected to use the mechanism.

The staff also proposes a technical correction to the designation of the test method designated in section 2263 for determining olefin content. In the 1995-96 test methods rulemaking, ASTM D1319-95a was referred to as ASTM D 1319-9X pending final ASTM approval. The proposed amendment updates and corrects the reference to ASTM D 1319-95a.

The staff also recommends an amendment to the definition of gasoline, which currently is defined as “any fuel that is commonly or commercially known, sold or represented as gasoline.” It has been the staff’s consistent view that this definition includes gasoline-like products sold for use in automotive spark-ignition engines, whether or not the seller chooses to refer to the product as “gasoline.” The proposed amendment would make explicit that the existing definition of gasoline includes any volatile mixture of predominantly liquid hydrocarbons that is sold or represented as suitable for use in an automotive spark-ignition engine. This would not constitute a change in, but would be declaratory of, the existing definition. The terminology is similar to language in the definition of “gasoline” in Business and Professions Code section 13401, administered by the Division of Weights and Measures in the Department of Food and Agriculture.

Chapter IV. Other Issues Considered

A. Relief from the Federal RFG Oxygen Requirement

Probably the single most effective action for an accelerated and least cost removal of MTBE in California would be relief from the oxygen mandate in federal RFG areas in California. This federal mandate requires that gasoline sold in federal RFG areas must contain at least 2.0 percent by weight oxygen year-round. About 70 percent of all gasoline sold in California is sold in federal RFG areas.

California's reformulated gasoline (CaRFG2) produces greater emission benefits than federal RFG, but does not necessitate a minimum concentration of oxygen in all gasoline. Application of the current federal year-round minimum oxygen content requirement serves no purpose in meeting California's air quality goals to reduce ozone precursors and toxic pollutant emissions from vehicles.

1. Basis for a Waiver from the Federal Oxygen Requirement for California

Section 211(k)(2)(B) of the federal Clean Air Act expressly authorizes the U. S. EPA Administrator to waive the 2.0 weight percent minimum oxygen requirement for federal RFG, in whole or in part, "for any ozone non-attainment area upon a determination by the Administrator that compliance with such requirement would prevent or interfere with the attainment by the area of a national primary ambient air quality standard." Therefore, it is clear that Congress recognized that the minimum oxygen requirement could be waived under certain circumstances where justified by air quality considerations.

California has requested that the U.S. EPA waive the year-round 2.0 percent by weight oxygen requirement for federal RFG in each of California's three current federal RFG areas and any future California RFG area. This waiver is justified by the technical analysis of the ARB which shows that maintaining the federal 2.0 weight percent oxygen requirement after MTBE has been phased out of California gasoline will diminish the extent to which the California RFG regulations can achieve emission reductions over and above the reductions achieved by the federal program. This loss of additional benefits from the California program will interfere with attainment of the national ambient air quality standards for ozone, PM10, and PM2.5 in California's federal RFG areas.

Because California faces the most severe air pollution problems in the nation, the ARB has designed the CaRFG program to achieve significantly greater overall emission reductions than those resulting from the federal RFG program. ARB's assessment shows that revised California regulations accommodating a federal RFG requirement for 2.0 weight percent oxygen in the fuel year-round will necessarily be less effective in reducing vehicular emissions than would be the case if the regulations could be based on oxygen-content flexibility. This loss of additional potential emission reductions from

CaRFG would delay attainment of the ozone standards in all three of California's federal RFG areas, and threaten timely attainment of the ozone and PM2.5 standard in the Los Angeles region. The ARB staff analysis regarding the effects of the oxygen mandate is presented in Appendix E.

The staff's analyses prepared for the CaFRG3 proposal support California's request for a waiver of the year-round 2.0 percent by weight oxygen requirement for federal RFG areas. Chapter V of this report includes comparisons of the predicted emissions associated with representative in-use gasoline blends having varying oxygen levels. These include gasoline produced to meet the flat limits with 2.0 percent by weight oxygen, and gasolines that could be produced as CaRFG3 alternative formulations under the CaRFG3 predictive model.

Table V-6 shows three sets of possible alternative specifications with zero oxygen, 2.7 percent by weight oxygen, and 3.5 percent by oxygen. The expected properties of the actual in-use gasolines that would be produced under these sets of alternative specifications – adjusted to reflecting a typical compliance margin – are shown in Table V-7. The similarly adjusted expected properties of the actual in-use gasoline sold under the flat limits are shown in Table V-3. The emissions resulting from these in-use gasoline blends were then compared to the emissions associated with the actual CaFRG3 flat limits, using the CaRFG3 Predictive Model. These comparisons show that the representative in-use flat-limit gasoline with 2.0 percent by weight oxygen would result in a 2.0 percent reduction in NOx (Table V-4), while the equivalent in-use alternative specification gasoline with zero oxygen would result in a 5.4 percent reduction in NOx (Table V-8). This translates to a difference of about 28 tons per day NOx in 2005. It is clear that requiring every gallon of gasoline to contain oxygen to meet the federal RFG year-round oxygen mandate results in a loss of the additional NOx benefits associated with the zero oxygen blends and would interfere with California's attainment of the national ambient standards identified above.

Moreover, since in-use zero-oxygen fuels are expected to achieve greater NOx reductions, the Board could "capture" some of these additional reductions if 2.0 percent by weight oxygen fuels did not have to be accommodated year-round in the 70 percent of the state's gasoline that is subject to the federal RFG requirements.

*2. **Pending Federal Legislation that could Provide Relief from the Federal RFG Oxygen Requirement***

Legislation has been introduced in both the House of Representatives and the Senate that could eliminate the federal RFG year-round oxygen requirement in California. As introduced, H.R. 11 by Congressman Bilbray would provide that the CaRFG program applies in lieu of the federal RFG requirements in California if the CaRFG regulations will achieve equivalent or greater emission reductions than would result from the federal RFG requirements in the case of aggregate mass of emissions of toxic air pollutants and in the case of the aggregate mass of emissions of ozone-forming compounds. Similar legislation has been introduced in the Senate by Senator Feinstein (S. 266), who has also introduced a bill that would waive the federal RFG oxygen requirement for reformulated gasoline that results in no greater emissions of ozone-forming volatile organic compounds and toxic air contaminants than reformulated gasoline meeting the oxygen content requirement. The ARB has supported these bills.

3. U.S. EPA's Response to the Findings of the Blue Ribbon Panel on MTBE

On July 26, 1999, Carol Browner, U. S. EPA Administrator, released at statement on the findings by the U.S. EPA's Blue Ribbon Panel regarding MTBE. Ms. Browner indicated in that statement that "the recommendations that I am receiving from the Panel confirm EPA's belief that we must begin to significantly reduce the use of MTBE in gasoline as quickly as possible without sacrificing the gains we've made in achieving cleaner air." Further, Ms. Browner stated "EPA is committed to working with Congress to provide a targeted legislative solution that maintains our air quality gains and allows for the reduction of MTBE, while preserving the important role of renewable fuels like ethanol."

On September 14, 1999, Margo T. Oge, Director of the Office of Mobile Sources for U.S. EPA, gave testimony to the U. S. House of Representatives Subcommittee on Energy and Environment where she explained future steps that U.S. EPA would take to address issues regarding the use of oxygenates in the federal RFG program. Ms. Oge indicated in her testimony that U.S. EPA intended to "address the (Blue Ribbon MTBE) panel's recommendations to the extent possible within the Agency's current administrative authority. This included… providing more flexibility to states and refiners as they move to decrease the use of MTBE in gasoline." Further, Ms. Oge stated that "EPA is moving forward on implementing panel recommendations that are within our purview and will work with Congress where additional legislative action may be taken."

B. Usefulness Of The U.S. EPA Complex Model For California's Regulatory Program

Section 221(k) of the Clean Air Act requires that gasoline sold in the worst ozone non-attainment areas of the United States be reformulated to result in reduced emissions of volatile organic compounds and toxics compounds. The Clean Air Act also states that the emissions from gasoline in other areas of the United States cannot simultaneously increase above 1990 levels. Refiners must certify their gasoline for sale by demonstrating that their fuel meets the requirements of either the reformulated gasoline or anti-dumping programs. To this end the U.S EPA in consultation with other stakeholders developed the Complex Model for certifying formulations of federal RFG. This model was developed based on criteria laid forth in the Clean Air Act. This requires the model to represent the nationwide fleet of vehicles representing the primary emission control technology available in 1990. The complex Model database contains some vehicles that where manufactured prior to 1990. Since the database and model were developed in the early 1990's there is very little data reflected in the model for vehicles from later model years.

The criteria set forth in the Clean Air Act severely limit the usefulness of this model to represent the actual effects of fuel changes on the current fleet in California. The Complex Model represents 1990 emission control technologies. By the time the proposed new California Predictive Model would be implemented in 2003, the majority of vehicles in California will have emission control technologies that are much more effective than those in production in 1990. The Complex Model database also contained vehicles that are considered 49-state vehicles. These vehicles were never certified for sale in California. Most likely these vehicles could not meet California's stricter emission control standards.

The Complex Model does account for evaporative emissions. This was not necessary with the CaRFG2 Predictive Model because the RVP of CaRFG2 was capped at 7.00 psi. The federal reformulated gasoline regulations allow a varying RVP. The proposed changes to the current California Predictive Model includes provisions for a evaporative emissions model and variable RVPs.

The vehicle technology groups modeled in the Complex Model were weighted together using emission proportions that represented the 50-state fleet. The U.S. EPA mobile source emissions inventory model, MOBILE5, was used to estimate vehicle technology group weighing. California's Predictive Model is designed to reflect the make-up of the California fleet, and therefore is more representative for California than the federal Complex Model.

The Complex Model also has an adjustment factor for the differential effects of changing fuel parameters on high-emitting vehicles. The definition of "high-emitters" used by the developers of the Complex Model was any vehicle that had exhaust emissions of hydrocarbons greater than twice the tail-pipe hydrocarbon standard for that vehicle when tested on the certification fuel. The developers of the Complex Model did not use all the data that was available to them that fit their definition of high-emitter. They only included 'stabilized' high-emitters. They excluded much of the high-emitter data because it represented vehicles that were too unstable to be reliably modeled.

C. Other Models Suggested by Stakeholders

Several other stakeholders have presented alternative models to the current CaRFG2 Predictive Model. The developers of most of these alternative models used very similar statistical techniques as the ARB staff used in developing the CaRFG2 Predictive Model. Most of these models were attempts to use the structure of the Complex Model with the statistical techniques of the CaRFG2 Predictive Model. ICF Consulting developed a model that used higher-emitter adjustment factors to construct a model that would represent the emissions response to changing fuel parameters in higher-emitters.

During the development of the CaRFG2 Predictive Model, the ARB staff in consultation with stakeholders and Dr. David Rocke of the University of California, Davis, attempted to develop a high-emitter model and found that high-emitters were so variable that they could not develop a reliable high-emitter model. The test-to-test variability of these vehicles were so high that the difference between replicate tests of the same fuel on the same vehicles were often larger than the expected effects of changing fuel parameters on exhaust emissions. This conclusion is consistent with the conclusions of the Auto/Oil Air Quality Improvement Research Program's investigations into emissions from high-emitters. Thus, it was determined that high-emitters could not provide reliable results separately but should be included with the rest of the data in developing a model. This remains true today, and the staff believes this is the most appropriate way to treat high-emitters in developing a model.

D. Off-Cycle Emissions

The ARB staff was asked to investigate the possibility of developing a statistical model to augment the Predictive Model to represent the effects of changing fuels parameters on emissions during off-cycle activities. The data used to develop the Predictive Model was based on emission test from vehicles tested on the Federal Test Procedure (FTP). There are over 8000 data points in the Predictive Model database, representing over 1000 vehicle by study combinations and about 250 different fuels. Even then there is insufficient data to develop models for the pre-1981 vehicles.

The staff researched the availability of off-cycle emissions data. There are very little data available. Those that are available include the ARB ethanol testing program where only two fuels were tested. The Auto/Oil Air Quality Improvement Research Program Technical Bulletin 19 presents the results of off-cycle testing of only two gasoline formulations. The ARB Mobile Source Division Emissions Factor study tested three fuels on the test cycles used to produce the Motor Vehicle Emissions Inventory speed correction factors. The Automotive Testing Laboratories study, 'Effect of Use of Low Oxygenate Gasoline Blends upon Emissions from California Vehicles,' reports the results of testing five fuels on 13 California-certified vehicles. A study for the Coordinating Research Council conducted by the Colorado Department of Public Health and Environment. The purpose of the study was to examine the effectiveness of oxygenated fuels as a CO reduction strategy for late model motor vehicles. This study used fuels commercially available in Colorado. These fuels were not complying California fuels. Also, all tests were on a chassis dynamometer at 35^{o} F.

The staff determined that there are insufficient data available to develop an off-cycle model similar to the Predictive Model.

E. Effects of Increasing Oxygen and RVP on Emissions from Off-Road Sources

The ARB staff was asked to investigate the effect of increased oxygen and RVP on emissions from off-road applications. The staff conducted an analysis to compare the reductions in CO emissions associated with increased oxygen versus increased evaporative hydrocarbon emissions associated with an increase in RVP. The analysis is based on assessing the amount of evaporative hydrocarbon emissions that could be offset on a reactivity basis by increasing the oxygen content of a gasoline from 2.0 percent to 3.5 percent. The staff found that there are very little data available on the effect of fuel oxygen on exhaust emissions from off-road engines and none on California fuels. There are no evaporative emissions data for off-road engines.

To estimate the emissions effects associated with changing oxygen and RVP it is necessary to have a baseline inventory. To determine a baseline emissions inventory for off-road engines, the staff used the exhaust emission estimates from the ARB off-road emissions inventory model for the year 2005. The staff had to estimate the evaporative hydrocarbon emissions based on the volatility of the fuels.

To calculate the changes in emissions, the staff collected as much emissions data as were available for similar fuels with different oxygen content. There are data for emission differences associated with switching from a 2.0 percent to 3.5 percent oxygen fuel for only four 4-stroke engines and four 2-stroke engines. None of the fuels tested represent in-use complying California gasoline. The evaporative hydrocarbon emissions were estimated using the U.S. EPA's off-road diurnal emission model, the evaporative emission portion of the proposed Predictive Model, and SHED testing data for evaporative emissions from portable fuel containers.

Bishop and Stedman collected remote sensing data on 2-stroke snowmobiles operating in Yellowstone National Park. Part of their study involved measuring the emission differences between non-oxygenated gasoline and a 10 volume percent ethanol gasoline for in-use snowmobiles. Bishop and Stedman report a 7 percent reduction in CO from in-use snowmobiles and no statistically significant difference in hydrocarbon emissions. Bishop and Stedman's data were collected during the winter in Yellowstone National Park and may not reflect actual in-use applications in California.

The staff believes that there are insufficient data to quantify how evaporative hydrocarbon emissions could be offset by CO emissions. However, based on staff's analysis, the predicted decrease in CO emissions, on a reactivity adjusted basis in tons per day, is basically offset by the large predicted increase in evaporative emissions. We would expect that directionally, exhaust hydrocarbon emissions should decrease and NOx emissions should increase. However, there are insufficient test data to reliably quantify these effects.

What little data are available, though, suggests that the most effective way to reduce emissions from off-road vehicles is to implement control standards as has been done in recent years by the U.S. EPA and the ARB. Tighter vehicle emissions standards should lead to the use of more sophisticated emissions control technology such as advanced fuel control systems, catalytic converters, and evaporative controls. As the number of newer off-road vehicles increase, the effect of fuel property changes on their emissions will be more like automobile emissions. Because of the lack of information and because emissions from off-road vehicles will be more similar to automobile emissions in 2005, staff does not believe it is feasible to model the effects of CaRFG3 on off-road engines and include these effects as part of the equivalency determination made using the CaRFG3 Predictive Model. More information on the staff analysis of available off-road vehicle emissions is in Appendix M.

F. Proposed Amendments to CARBOB Provisions

As discussed earlier, the staff is unable to address many of the CARBOB issues because of time and resource constraints. The staff is aware of the issues that need to be addressed; however, these issues can be dealt with more effectively at a later time when more staff resources are available. The staff is committed to address these issues in the 2000/2001 fiscal year, which should provide sufficient time for making any distribution changes prior to January 1, 2003.

G. Small Refiners

The staff is currently evaluating a request by Kern Refining for special consideration for small refiners. Kern Refining is the only small refiner in California producing CaRFG2. Kern has indicated that they could not economically meet the staff's proposed CaRFG3 specifications. The staff is continuing to evaluate Kern's situation. If appropriate, consideration will be given to small refiners who produced fully complying CaRFG2 in 1998.

Chapter V. Effects of Proposed Changes on Emissions

This chapter summarizes the estimated emission benefits associated with the proposed CaRFG3 regulations. It demonstrates that the directives of the Governor's Executive Order and recently enacted legislation (Sher, SB 989) are met, and that some additional emission reductions would be achieved. The emissions comparisons were made two ways. The first was to verify that the CaRFG3 specifications would preserve emissions benefits in comparison to the CaRFG2 specifications. The second approach was to evaluate the impact on real world benefits.

A. Comparing Emissions with the CaRFG2 and CaRFG3 Predictive Models

Preserving the existing benefits of the current California Phase 2 Reformulated Gasoline (CaRFG2) program was a fundamental consideration in the development of the CaRFG3 proposal. It would be inappropriate to compare the results from the current CaRFG2 Predictive Model and the proposed CaRFG3 Predictive Model. The two models are sufficiently different that direct comparisons would be misleading. The CaRFG2 Predictive Model uses regression equations to estimate exhaust emissions for two vehicle technology groups weighted together using the year 2000 emission inventory. The proposed CaRFG3 Predictive Model is constructed using regressions for three technology groups. The 1996 through 2005 model years technology group has been added. An evaporative hydrocarbons emissions model has also been added to the total hydrocarbon portion of the proposed CaRFG3 Predictive Model to accommodate the proposed variable RVP specification. Further, the weighting factors in the proposed CaRFG3 Predictive Model are based on the year 2005 emission inventory. The CaRFG2 Predictive Model assesses the expected change in year 2000 on-road exhaust emissions, while the proposed CaRFG3 Predictive Model assesses the expected change in year 2005 total on-road emissions. Because of the differences in the models it is inappropriate to compare them; however, the difference in fuel specifications could be compared in each model independently.

1. ***Comparison of CaRFG2 and CaRFG3 Specifications Using the CaRFG2 Predictive Model***

One comparison is to use the current CaRFG2 Predictive Model and to compare the expected emission differences between the CaRFG2 flat limits and the CaRFG3 flat limits. As shown in Table V-1, switching from the CaRFG2 limits to the proposed CaRFG3 limits would be expected to preserve the benefits of the current program using this evaluation method.

Table V-1
Expected Emissions Differences:
Proposed CaRFG3 Versus CaRFG2
Using CaRFG2 Predictive Model

Pollutant	Percent Change
Oxides of Nitrogen	-0.8
Total Hydrocarbons	-0.5
Potency-Weighed Toxics	-2.8

2. Comparison of CaRFG2 and CaRFG3 Specifications Using the Proposed CaRFG3 Predictive Model

Another method to compare the emissions benefits of the proposed CaRFG3 specifications is to evaluate the emissions differences between the CaRFG2 flat limits and the CaRFG3 flat limits using the CaRFG3 Predictive Model. In this example, the proposed CaRFG3 flat limit specifications are compared to the current CaRFG2 flat limits. The CaRFG2 flat limit specifications were entered in the model as the baseline fuel. As shown in Table V-2, the CaRFG3 specifications provide greater emissions benefits than the CaRFG2 specifications.

Table V-2
Expected Emissions Differences:
Proposed CaRFG3 Versus CaRFG2
Using CaRFG3 Predictive Model

Pollutant	Percent Change
Oxides of Nitrogen	-3.3%
Exhaust Hydrocarbons	-0.9%
Potency-Weighed Toxics	-1.1%

B. Ensuring Real World Benefits Are Maintained

Recently enacted S.B. 989 (stats. 1999 ch.812) requires the ARB to ensure that regulations for CaRFG3, adopted pursuant to Executive Order D-5-99, "maintain or improve upon emissions and air quality benefits achieved by CaRFG2 in California as of January 1, 1999, including emission reductions for all pollutants, including precursors, identified in the State Implementation Plan for ozone, and emission reductions in potency-weighted air toxics compounds." (New Health and Safety Code section 43013.1(b).)

To ensure the maintenance of the emissions and air quality benefits achieved as of January 1, 1999, by CaRFG2, the staff compiled available information regarding the fuel properties of in-use fuels in California. Since it is not feasible to provide an analysis for a single day, staff used the average, in-use fuel for the 1998 ozone season as the baseline for this assessment.

1. *Selection of Fuel Properties*

To assess the relative air quality benefits of the current program and the proposed regulatory changes it is necessary to compare the average 1998 ozone season in-use fuel to a representative in-use fuel after implementation of the proposed regulatory changes. While it is not possible to precisely predict what such a fuel would look like, there is sufficient information available to provide an estimate of representative fuel properties that would comply with the proposed regulations. Table V-3 presents the average 1998 ozone season in-use fuel from Chapter II and the staff's estimate of a representative future in-use fuel under the proposed regulatory changes.

Table V-3
Fuel Properties Comparison:
Average 1998 in-use Fuel and a Representative Future Fuel Based on Proposed CaRFG3 Flat Limits

Fuel Properties	1998 In-Use Fuel	Representative Future Fuel
Aromatic HC, vol.%	22.4	22
Benzene, vol%	0.6	0.4
Olefin, vol%	5.8	4.0
Sulfur, ppmw	25	15
T50, (°F)	197	203
T90, (°F)	310	298
Oxygen, wt% (max)	2.1	2.2
(min)	1.9	1.8
RVP, psi	6.7	6.7

The factors that went in to the development of the future in-use fuel properties are: refinery compliance margins, MathPro Inc.'s analysis of future fuels, and the proposed CaRFG3 flat limit specifications.

Refinery Compliance Margins. As presented in Chapter II, each refiner in practice produces fuels with properties that are lower than what they report to the ARB. Refiners typically allow themselves a safety or compliance margin between their own measurements of a property and the official limit that they report to the ARB. The ARB staff presume that such "safety or compliance margin" practices will be continued. This implies that one would continue to expect future in-use fuel properties to be less than the specifications.

Analysis of expected future fuels by MathPro Inc. MathPro Inc. (MathPro) under contract to the CEC provided estimates of what fuels would look like using their refinery operations model. MathPro used an aggregate industry average refinery model to estimate what the optimal production fuels would look like if MTBE was eliminated from California gasoline. This modeling effort was done prior to the development of the proposed CaRFG3 regulations, and are based on the CaRFG2 specifications. Even though the MathPro analysis is based on CaRFG2, their work suggests that with the eliminated of MTBE refiners would have to increase the T50 of their fuels. To increase the T50 and remain emissions neutral, the MathPro's model predicts that aromatics and T90 would be decreased. MathPro also predicts that olefins would be reduced.

Proposed CaRFG3 Specifications. While the proposed CaRFG3 specifications are similar to the CaRFG2 specifications, there are several significant differences as already discussed. The flat limits for T50 and T90 are increased. The increase is to provide flexibility to facilitate the elimination of MTBE while retaining some of the volume lost associated with removing MTBE. The proposed specifications also call for a reduction in sulfur and benzene. The sulfur reduction is necessary to ensure that air quality benefits are maintained and to provide modest additional reductions. The proposed flat limit for benzene is being reduced to decrease exposure to this known human carcinogen.

Putting all this information together the staff has generated a representative future in-use fuel.

2. *Comparison of Real World Emission Benefits of CaRFG2 to CaRFG3*

To compare the 1998 ozone season average in-use fuel to the future representative in-use fuel meeting the proposed CaRFG3 limits, both fuels are compared to the proposed CaRFG3 specifications using the proposed CaRFG3 Predictive Model. Table V-4 and Table V-5 present the expected benefits associated with using either of the two fuels. Use of the representative future in-use fuel would lead to a significant reduction in NOx and potency-weighted toxics emissions. NOx emissions are reduced by about 19 tons per day in 2005 and potency-weighted toxics emissions by about 7 percent over the current fuel. The expected reduction in hydrocarbons is smaller, about a half ton per day. Since the future in-use fuel would lead to a reduction in emissions from the 1998 average in-use fuel, the benefits to air quality are not only preserved, but are enhanced. Also note that the 1998 in-use fuel results in increased NOx emissions under the proposed CaRFG3 Predictive Model. This means that this fuel would not be certifiable for sale in California under the new model. This provides further assurance the proposed CaRFG3 specifications and Predictive Model will not only preserve existing real-world benefits, but will actually enhance the benefits when the regulations become applicable.

It is also important to notice that the additional hydrocarbon emission benefits are very small. In essence, raising T50 and T90 to provide refiners flexibility limits the ability to obtain additional hydrocarbon benefits. It is expected that under the proposed CaRFG3 Predictive Model, hydrocarbons will tend to be the limiting factor for most refiners. Therefore, in assuring their fuels meet the hydrocarbon component of the proposed Predictive Model, there will be some additional benefits gained in NOx and potency-weighted toxics emissions. Further, it would be difficult to provide refiners additional flexibility by reducing the NOx benefits, because the properties that could be changed to increase flexibility, such as T50 and T90, have very little effect on NOx.

Table V-4
Expected Change in Emissions
1998 Average In-Use Fuel Versus Future Representative In-Use Fuel

Pollutant	1998 Average In-Use Fuel	Future Representative In-Use Fuel Based on Flat Limits	Difference
NOx	0.3%	-2.0%	-2.3%
Exhaust Hydrocarbons	-3.6%	-3.7%	-0.1%
Evaporative Hydrocarbons	-6.6%	-6.6%	0%
Total Hydrocarbons	-4.5%	-4.6%	-0.1%
Potency-Weighted Toxics	-8.0%	-15.2%	-7.2%

Table V-5
Expected Change in Emissions
(Tons Per Day)

Pollutant	1998 Average In-Use Fuel		Future Representative In-Use Fuel Based on Flat Limits		Difference
	2005	2010	2005	2010	2005
NOx	2.1	1.7	-16.6	-13.6	-18.7
Exhaust Hydrocarbons	-16.0	-9.3	-16.5	-9.6	-0.5
Evaporative Hydrocarbons	-14.4	-11.3	-14.4	-11.3	0
Total Hydrocarbons	-30.4	-20.6	-30.9	-20.9	-0.5

C. Comparison of Real World Benefits (1998 Average Fuel Versus Other Future Fuels)

The representative future fuel is an example of what an in-use fuel could look like if a refiner was certifying a fuel based on the proposed CaRFG3 flat limits. To extend the comparison to fuels that could exist based on alternative formulations certifiable using the proposed CaRFG3 Predictive Model, the staff used the proposed Predictive Model to create alternative specifications for a zero oxygen, a 2.7 percent oxygen, and a 3.5 percent oxygen fuel. The oxygen values for the 2.7 percent and 3.5 percent fuels are entered as ranges. The three alternative sets of specifications are presented in Table V-6. To provide an estimate of what an in-use fuel could look like, the refinery compliance margins used to generate the 1998 average in-use fuel were subtracted from the alternative specifications or various properties. The compliance margins are presented in Table II-4. The probable in-use properties of future fuels that would be produced using these three alternative specifications are presented in Table V-7.

Table V-6
Three Sets of Possible Alternative Specifications for Producing Future Fuels Using the CaRFG3 Predictive Model

Fuel Properties	Zero Oxygen	2.7 Percent Oxygen	3.5 Percent Oxygen
Aromatic HC, vol.%	25	25	25
Benzene, vol%	0.6	0.7	0.7
Olefin, vol%	6	4.0	1.0
Sulfur, ppm	10	14	5
T50, (°F)	208	204	211
T90, (°F)	305	310	310
Oxygen, wt% (max)	0	2.9	3.7
(min)	0	2.5	3.3
RVP, psi	6.8	7.2	7.2

Table V-7
Three Sets of Possible Future In-Use Fuels Meeting Table V-6 Alternative Specifications

Fuel Properties	1998 In-Use Fuel	Zero Oxygen	2.7 Percent Oxygen	3.5 Percent Oxygen
Aromatic HC, vol.%	22.4	22	22	22
Benzene, vol%	0.60	0.4	0.5	0.5
Olefin, vol%	5.8	4	2	1
Sulfur, ppm	25	7	11	2
T50, (°F)	197	200	196	203
T90, (°F)	310	298	303	303
Oxygen, wt% (max)	2.1	0	2.9	3.7
(min)	1.9	0	2.5	3.3
RVP, psi	6.7	6.5	6.9	6.9

The three sets of in-use properties from Table V-7 were entered into the proposed Predictive Model and the estimated percent change in emissions was calculated. The estimated percent change in emissions are presented in Table V-8. The 1998 ozone season average in-use fuel from Table I-2 has been added to provide a baseline for comparison. The estimated percent change in emissions were converted to the estimated change in tons per day emissions by multiplying the estimated percent change by the predicted tons per day for the inventory year 2005. These tons per day estimates are based on the mobile source emissions inventory model, EMFAC7G. The CO credit applies for fuels with oxygen content above 2 percent. In calculating the tons per day benefits associated with the three alternative formulations, the carbon monoxide decrease is shown in Table V-9 in relative reactivity-adjusted tons. The decrease in CO is presented as tons per day equivalent evaporative hydrocarbons. This was done by multiplying the change in number of tons of CO by the relative reactivity factor for CO, and then dividing that product by the average relative reactivity factor for evaporative hydrocarbons. Table V-9 shows that as oxygen is increased NOx benefits decrease as expected. The zero oxygen fuel provides almost a 5 percent greater emissions reduction (about 38 additional tons per day) over a fuel with 3.5 percent oxygen. For hydrocarbons the difference between the fuels is similar when accounting for the CO reduction from the oxygenated fuel as equivalent evaporative hydrocarbon emissions. The net differences are shown below in Table V-10. The data further demonstrate that to maintain the federal RFG minimum oxygen mandate precludes the use of fuels that do not contain oxygen and achieve greater emission benefits, principally in terms of NOx reductions.

Table V-8 Expected Change in Emissions

1998 Average In-Use Fuel Versus Three Fuels Based on Alternative Specifications
Using the Proposed CaRFG3 Predictive Model
(2005)

	1998 In-Use Fuel	Zero Oxygen	2.7 Percent Oxygen	3.5 Percent Oxygen
NOx	0.3%	-5.4%	-1.7%	-0.7%
Hydrocarbons				
Exhaust	-3.6%	-1.7%	-6.0%	-6.0%
Evaporative	-6.6%	-12.6%	0%	0%
Carbon Monoxide	0%	0%	-4.2%	-8.9%
Toxics(1)	-7.9%	-14.7%	-15.6%	-15.7%

(1) Potency weighted

Table V-9 Expected Tons per Day Change in Emissions

1998 Average In-Use Fuel Versus Three Fuels Based on Alternative Specifications
Using the Proposed CaRFG3 Predictive Model
(2005)

	1998 In-Use Fuel	Zero Oxygen	2.7 Percent Oxygen	3.5 Percent Oxygen
NOx	**2.1**	**-44.4**	**-13.8**	**-5.7**
Hydrocarbons				
Exhaust	-16.0	-7.9	-27.0	-27.0
Evaporative	-14.4	-27.6	0	0
Total Hydrocarbons	-30.4	-35.5	-27.0	-27.0
CO Equivalent(1)	0.0	0.0	-7.4	-15.9
Total HC Equivalent	**-30.4**	**-35.5**	**-34.4**	**-42.9**

(1) Reductions in CO have been converted to evaporative hydrocarbons using relative reactivity factors.

Table V-10
Expected Benefits (tons per day)
1998 Average In-Use Fuel Versus Three Fuels Based on Alternative Specifications
Using the Proposed CaRFG3 Predictive Model
(2005)

	Zero Oxygen	2.7 Percent Oxygen	3.5 Percent Oxygen
NOx	-46.5	-15.9	-7.8
Hydrocarbons			
Exhaust	+8.1	-11	-11
Evaporative	-13.9	+14.4	+14.4
Total HC	-6.2	+3.4	+3.4
CO Equivalent	0	-7.4	-15.9
Total Hydrocarbon	-6.2	-4.0	-12.5

Chapter VI. Economic Effects of the Proposed CaRFG3 Regulations

This chapter presents a summary of the analysis of the economic impact of the staff's proposal. This analysis was prepared in consultation with CEC staff.

A. Background

To comply with the proposed CaRFG3 specifications, refiners must be capable of increasing their flexibility to produce various gasoline components (blendstocks) that have specific chemical properties. The challenge facing refiners in the future will be to produce the needed volumes of gasoline meeting the new proposed set of specifications while simultaneously trying to maintain minimum octane and other performance qualities. Refiners must do this without the use of MTBE, and at a cost that would not be prohibitive to the refiner resulting in a decreased competitive advantage in the marketplace. Generally, the more complex refineries will have an advantage in managing this compared to less complex refineries.

In developing the cost estimates for this chapter, the staff has generally relied on information provided by the refiners, as well as the CEC, which developed cost and supply estimates for various scenarios. The CEC is funding a new study to update its estimates of the costs to refiners to remove MTBE while complying with the proposed CaRFG3 regulations. The ARB staff will use this information to evaluate and revise as appropriate the estimated cost associated with the proposed CaRFG3 regulations. The CEC's study could not be conducted until the proposed amendments were fully identified.

B. Costs of Removing MTBE and Complying with the Proposed CaRFG3 Limits

The staff's proposal will require changes in refining, gasoline distribution, and oxygenate use. The calculated costs in this chapter to comply with the proposed CaRFG3 regulations are based on estimates of how much more expensive gasoline production may be if ethanol were to completely replace MTBE in the California gasoline supply. It is important to note that the majority of the costs identified are associated with the MTBE prohibition, and overall costs of compliance may be reduced if relief from the federal oxygenate mandate is granted, as discussed later in this chapter.

It is also important to recognize that any changes in production costs will not necessarily be reflected in retail prices. Retail prices reflect not only production costs, but also other market conditions (supply/demand, crude oil prices, competitive considerations, etc.) not associated with the proposed amendments, all of which will influence the final price. However, it is reasonable to assume that over time, refiners will recover the increased costs of production in the marketplace.

*1. **ARB Cost Estimates of Removing MTBE***

A combination of capital modifications and an increased level of imports (either of blendstocks or finished gasoline) will be needed to ensure that California refineries maintain close-to-current production levels when the use of MTBE is eliminated. The necessary refinery changes are greater in refineries that must add ethanol in lieu of MTBE, either to provide sufficient octane or to meet the federal law requiring oxygen in federal RFG areas.

Based on discussions with California refiners and the CEC, the staff estimates the necessary capital improvement costs to refiners to comply with the proposed amendments are approximately $1 billion. These are just the capital costs to refineries, and do not include a consideration of the impact of increased importation of gasoline blendstocks or the necessary distribution system improvements to accommodate the blending of ethanol at the gasoline terminal. A discussion of these other costs is also included in this section.

a. *Capital Improvement Costs*

In order to determine the costs associated with the production of CaRFG3, the staff has used estimates based on discussions with refiners and consultations with the CEC. Based on these discussions, the staff estimates refineries will incur capital expenditures of approximately $1 billion to comply with the proposed CaRFG3 regulations. The staff has determined that the associated annualized costs can be determined according to the following equation:

$$\text{Annualized Cost} = (\textit{Capital Recovery Factor}) \times (\textit{Capital Expenditure})$$

Where:

Capital Expenditure - $1 billion (anticipated)
Capital Recovery Factor - 16% (10% per year over 10 years)

This value, calculated to be $160 million, represents the annualized cost to refiners to upgrade refineries to comply with the proposed CaRFG3 regulations, including the prohibition on the use of MTBE in gasoline.

In addition, staff conservatively estimated, based on figures calculated during the development of the CaRFG2 regulations, that annual operating and maintenance costs of approximately 40 percent of the capital expenditure will occur each year. These are costs associated with labor, material (such as catalysts, etc.), maintenance, and repairs associated with the new equipment. These costs are estimated to be approximately $400 million annually.

Therefore, total before-tax annual expenditure and operational costs to refiners to comply with the proposed CaRFG3 regulations are estimated to be $560 million. Using the CEC estimate of 965,000 barrels per day of gasoline consumption in 2003, staff estimates that this cost is equivalent to about 4 cents per gallon. A detailed analysis of the CEC's cost estimates and assumptions is contained in Appendix P.

b. *Importation Costs*

The above cost estimate does not include the costs of importing whatever gasoline or blending materials that would be needed to cover any shortfall of California production relative to demand. Staff has assumed that importation may consist of finished CaRFG3 gasoline, hydrocarbon blendstocks (such as alkylates), and ethanol. In developing the costs associated with importation, the staff has assumed transportation costs of 10 cents per gallon from the Midwest or the Gulf Coast. It is important to note that refiners will not choose to solely import one product to satisfy their individual needs. Importation strategies will be based on maximizing production to meet demand, at the lowest cost to the refiner. Therefore, the costs determined in this section are conservative, and actual refiner costs will likely be lower as market conditions and optimal importation strategies develop.

(1) Finished Gasoline

If refiners choose to import finished CaRFG3 gasoline to supplement any lost refinery volume, it can be expected that the cost (including transportation costs) will be comparable to gasoline produced within California. This is because refiners will not choose to import gasoline if the price would be substantially higher than gasoline being sold in the State.

(2) Hydrocarbon Blendstocks

The costs associated with importing and blending hydrocarbon blendstocks are dependent on the amount of these materials that will be required. Staff estimates that with the removal of MTBE, refinery output volume will be 80 to 85 percent of current levels. Approximately 10 to 15 percent of this reduction is due to refinery operational changes to produce gasoline without MTBE, and approximately five percent is due to the fact that when replacing MTBE with ethanol, half as much ethanol is needed to provide the same oxygen content as MTBE. Assuming that 10 to 15 percent of the refinery shortfall is made-up of both imported finished gasoline and hydrocarbon blendstocks from the Gulf Coast region, the associated costs would be about 10 cents per gallon of blendstock imported (transportation costs), translating into approximately 1 to 1.5 cents per gallon of gasoline, and approximately 1 to 2 cents per gallon of gasoline associated with acquiring premium blending components. This results in total cost associated with importation of hydrocarbon blendstocks to be approximately 2 to 3.5 cents per gallon.

(3) Ethanol

In addition to importing hydrocarbon blendstocks, it will be necessary to import ethanol from the Midwest to meet federal oxygen requirements, if relief from the oxygenate mandate is not obtained, and to provide octane enhancement in certain gasoline grades.

Currently, over 80 percent of the MTBE used in California is imported. It is assumed that after MTBE is eliminated, ethanol imported from the Midwest will replace MTBE. Costs associated with the use of ethanol as a gasoline blendstock are lower than MTBE because approximately half as much ethanol is needed to provide the same oxygen content as MTBE and therefore transportation costs for ethanol per gallon of gasoline produced are lower than for MTBE. In addition, the federal government currently provides a 54 cents per gallon tax credit for ethanol blended into gasoline.

In performing a cost analysis of the impacts of replacing MTBE with ethanol, the staff relied on projected cost data supplied by the CEC in the Appendices to the "Supply and Cost of Alternatives to MTBE in Gasoline". Table VI-1 shows the forecasted oxygenate costs to refiners, on a per barrel of MTBE and ethanol basis, and include delivery to California. They are based on a sliding scale, where the cost per barrel of oxygenate used varies as demand for the oxygenate varies.

Table VI-1
Forecasted Price of MTBE and Ethanol in 2003

Volume Used (BPD)	Price (Per Oxygenate Barrel)
MTBE	
Up to 16,000	$ 31.92
Each Additional, up to 25,000 more	$ 34.86
Each Additional, above 41,000	$ 39.90
Ethanol	
Up to 51 Thousand	$ 37.80
Each Additional, up to 10,000 more	$ 39.48
Each Additional, up to 33,000 more	$ 43.68

Source: CEC, 1998

Based on a daily gasoline consumption of 965,000 barrels per day, to provide 2.0 weight percent oxygen would require imports of 85,000 barrels per day of MTBE (assuming 80 percent is imported), or 55,000 barrels per day of ethanol. The cost savings (including transportation) of replacing MTBE with ethanol, based on the projected costs of these oxygenates, is 2.6 cents per gallon of gasoline. As capacity to produce ethanol in California increases in the long-term, and to the extent that production costs of California ethanol are comparable to ethanol produced in other states, additional cost savings could be realized. This is because California ethanol producers would have some cost advantage over Midwest ethanol producers based on reduced transportation costs.

(4) Future of Imports in California

While the proposed CaRFG3 regulations will require additional imports to supplement reduced refinery output volume, it is important to note that even without the proposed CaRFG3 regulations, California is already becoming a net importer of gasoline. California has experienced, and will continue to experience, ongoing increases in demand for gasoline. In 1996, gasoline consumption averaged about 890,000 barrels per day (over 37 million gallons per day). In 1998, consumption increased to about 920,000 barrels per day (about 38.5 million gallons per day). It is projected that by 2003, gasoline consumption in California will increase to about 970,000 barrels per day (almost 41 million gallons per day). This annual increase in gasoline consumption is about 1.5 percent per year.

California refineries are currently producing, on average, about 935,000 barrels of gasoline per day for California and have a maximum production capability on a short-term basis to produce about 1,000,000 barrels per day of CaRFG2 for California. As a result of demand getting closer and closer to production capacities, we have seen increasing imports into California of finished gasoline and gasoline blending components. The CEC estimates that by 2003, even without the proposed CaRFG3 regulations, California refineries will no longer be able to meet California demand and the importing of gasoline and gasoline blending components will become a routine occurrence, even when California refineries are operating at capacity.

c. *Ethanol Fuel Economy Penalty*

Because gasoline blended with ethanol has a slightly lower energy content than gasoline produced with MTBE, more gasoline produced with ethanol will be consumed on a per mile basis than gasoline produced with MTBE. The staff estimates that the fuel economy penalty of gasoline blended with ethanol is approximately 0.6 percent. This translates to about 0.7 cents per gallon to the average price of gasoline.

d. *California Gasoline Distribution System Cost Estimates*

A CEC assessment of California's distribution infrastructure was used to determine what level of capital improvements would be necessary before gasoline blended with ethanol could be dispensed throughout the entire system. The distribution infrastructure consists of a system of pipelines, storage tanks, railroad spurs, and tanker truck loading equipment.

Based on CEC estimates, capital expenditures will be needed at pipeline terminals and ethanol off-loading sites for the handling and storage of ethanol and ethanol blended gasoline. These costs are estimated to be approximately $60 million, and include new and modified gasoline storage tanks, increased rail capacity to handle railroad shipments of ethanol, new and modified truck facilities for shipments of ethanol, and increased transportation costs for truck deliveries of ethanol. These costs are estimated to add about 0.1 cent per gallon to the before-tax supply cost of gasoline.

e. *Price Sensitivity*

In consultation with the CEC, staff has estimated that certain non-recurring costs may occur in the short-term (likely the first year of implementation). These costs could result from temporary limits on supply and capacity, as well as price increases of blending components (both hydrocarbon blendstocks and ethanol). Staff estimates that these factors could result in potential first year additional cost increases of up to 1 cent per gallon.

2. *CEC Cost Estimates of MTBE Removal Only*

The CEC has made several estimates (contained in Appendix P) of the costs associated with the removal of MTBE from California gasoline. These costs are segregated into two timeframes of interest. First, the CEC has defined an intermediate-term as the period of time 3 years from now, which allows for limited adjustments to refining capabilities and is premised on the ability of refiners to achieve new supply and demand balances between the importation of gasoline blendstocks and oxygenates (while the CEC report looks at several oxygenates, this section is focused only on their analysis of ethanol). During this intermediate-term, the CEC estimates the cost of replacing MTBE with ethanol to be 6 to 7 cents per gallon.

The CEC has also defined a long-term period of time to be six years. This long-term period allows for the same supply and demand balances to be achieved as in the intermediate-term, but also allows time for refiners to make major process unit modifications such as equipment replacement or capacity expansions. The CEC estimates that the costs associated with the replacement of MTBE with ethanol during this period range from 2 to 3 cents per gallon.

In developing these cost numbers, the CEC developed cost estimates that require much less capital expenditure than what refiners actually appear to be planning, but with substantial importation of gasoline blending materials. For example in the "intermediate, flat-limits" case for oxygen-free CaRFG, the CEC predicted importation equaled 38% of gasoline demand. However, the staff's own estimate is that statewide refinery capacity will be 80 to 85 percent of current values, thereby reducing imports 50 to 60 percent over CEC estimates.

3. *Overall Cost Estimate*

In determining the overall cost estimate of the staff's proposal, the staff is estimating that first year costs of the proposed program will be 4 to 7 cents per gallon. These costs are summarized in Table VI-2. This cost estimate is consistent with the CEC intermediate cost analysis of 6 to 7 cents per gallon for MTBE removal.

However, after the first year, stability in the importation, price and production of gasoline components (both hydrocarbon blendstock and ethanol), as well as optimization of new equipment installed by refiners, should result in lower costs. Based on its long-term estimate, the CEC estimates these program costs to be 2 to 3 cents per gallon and the ARB estimate is 4 to 6 cents per gallon. The ARB estimate is higher than the CEC estimate because the ARB has assumed a larger refinery capital investment than that used in the CEC study. Based on this estimate, costs during the second year and beyond are expected to be 2 to 6 cents per gallon, averaging about 4 to 5 cents per gallon. These costs are also summarized in Table VI-2. These are the before-tax costs that would likely appear at the pump if all costs were passed to the consumer. These cost estimates may be revised before the December Board hearing as additional data from the CEC becomes available.

Table VI-2
Overall Cost Estimates of the Proposed Amendments

Expenditure	1st Year (cents per gallon)	Subsequent Years (cents per gallon)
ARB Estimate		
Capital Investment	4	4
Imports		
Blendstock	2 to 3.5	2 to 3.5
Ethanol	(2.6)	(2.6)
Fuel Economy Penalty	0.7	0.7
Distribution Upgrade	0.1	0.1
Price Sensitivity	0 to 1	--
ARB Estimate Range	4 to 7	4 to 6
CEC Estimate Range	6 to 7	2 to 3
Overall Range	4 to 7	2 to 6

4. ***Proposed Changes to the CaRFG Limits***

One major purpose for the proposed CaRFG amendments is to facilitate refiners' compliance with the prohibition of MTBE. The provisions that would enhance compliance flexibility - higher distillation flat limits, higher cap limits, adjustable RVP limit, evaporative emission model, and more realistic sulfur slopes - should reduce the net cost of meeting the MTBE prohibition. While refiners may spend money in response to the proposed regulatory changes, those expenditures should be - on the whole- remunerative in that they should moderate the basic costs of meeting the MTBE elimination. The enhanced flexibility should help to preserve the producibility of gasoline, thereby reducing the cost to California of having to import CaRFG-compliant gasoline to meet its increasing gasoline demand. For every gallon that would not have to be imported under the prohibition of MTBE, about ten cents would be saved.

a. *Sulfur Reduction*

Currently, the California gasoline pool has an average sulfur content of about 25 ppmw. It is expected that with the proposed flat limit of 20 ppmw and the proposed averaging limit of 15 ppmw, the average sulfur content in the California gasoline pool will be reduced to about 10 ppmw. As part of the U.S. EPA's proposed Tier 2 sulfur limits for federal Phase 2 gasoline, the U.S. EPA has estimated the incremental cost to U.S. refineries to meet sulfur limits as low as 30 ppmw. That cost curve indicates a cost of about 0.4 cents per gallon for a 20 ppmw decline to the proposed sulfur limits. This appears to be consistent with information provided during discussions with individual refiners.

However, there is no way to isolate the cost of meeting the regulatory changes within the overall costs of the proposed amendments, as calculated in the previous section. This is because refiners are designing capital and operational improvements to comply with both the prohibition of MTBE and the proposed sulfur reduction. It is expected that the anticipated capital improvements of 1 billion dollars include the additional costs to lower gasoline sulfur levels.

Staff has also evaluated the incremental cost of further sulfur reductions below the levels currently proposed. Staff has concluded that reducing sulfur levels further would result in a significant cost escalation, since it becomes more difficult to reduce and maintain the gasoline sulfur content as the sulfur content approaches zero. This is because further reductions in gasoline sulfur levels beyond those contained in the current proposal would require the installation of duplicate refinery desulfurization capacity (an essential doubling of the desulfurization capacity needed to achieve 20 ppmw).

Staff estimates that refiners have already incurred costs of approximately 3 cents per gallon to comply with the CaRFG2 sulfur limits, and as previously stated, will incur costs of 0.4 cents per gallon to comply with the proposed CaRFG3 sulfur limits. To reduce sulfur levels further, staff estimates additional costs of 3 to 7 cents per gallon, with the likely costs being closer to 7 cents per gallon. The main reason that staff would expect the costs to be closer to the higher end of the range is that refiners would not use this additional desulfurization capacity on a regular basis, and this additional capacity does not translate into increased refinery capacity. In addition, it may be necessary for refiners to construct additional hydrogen production capacity to supplement the new desulfurization units, and as with any capital project, unexpected construction hardships can occur to increase costs. Staff estimates that costs to reduce and maintain gasoline sulfur levels at near zero could result in nearly $1 billion of additional costs per year.

b. *T50/T90 Specification*

The proposed changes to the T50 and T90 specifications will provide additional flexibility to refiners by allowing them to increase their production volumes and decrease compliance costs. The reduction in costs is achieved through a decrease in imported blending components and finished gasoline to meet commitments they otherwise could not meet because of reduced refining capacity. The staff estimates that every 1 degree increase in T50 allows for a corresponding 1 to 2 percent increase in gasoline volume (as compared to the current levels). The impact of changes to T90 is less dramatic, providing a ½ to 1 percent increase in volume (again, as compared to current levels) for every 1 degree increase.

The cost benefit of the proposed changes to the T50 and T90 specifications has not been calculated separately from the overall costs. However, the impacts of these changes are reflected in the cost calculation for importing gasoline components, and the estimated level of imports needed reflects the increased production levels that would be provided by the flexibility in the T50 and T90 specifications. Refiners may determine they can further reduce the need to import hydrocarbon blendstocks or finished gasoline by making greater capital investments to address capacity limitations imposed by the limits on T50 and T90. In this case, the overall estimated costs associated with the proposed amendments would be less because refiners would make these investments only if they were, in the long-term, less costly than imports.

c. *Predictive Model*

The proposed changes to the Predictive Model will also provide refiners increased flexibility in their gasoline production. While it is unknown how individual refiners will operate in the future under the MTBE prohibition, staff expects that any costs associated with the changes in the Predictive Model have been captured in the $1 billion capital expenditure estimate. Although it is unknown how much of this expenditure can be associated with the proposed changes to the Predictive Model, staff expects that these costs may be offset or exceeded in the cost savings associated with by the increased gasoline production volume that the changes provide.

*5. **Effects of the Staff Proposal on Fuel Prices***

With respect to gasoline prices, it is very difficult to predict what will occur in the marketplace. Gasoline prices are heavily influenced by supply/demand, crude oil prices, and competitive considerations. However, it is reasonable to assume that over time, refiners will recover the increased costs of production in the marketplace. With this assumption, and the staff's estimate that the long-term increased production cost of CaRFG3 gasoline will be from two to six cents per gallon, it is reasonable to assume that this increase in production cost will, on average, be reflected in gasoline prices.

With respect to the stability of prices in the marketplace, that too is very difficult to predict. Recent refinery incidents in California have caused significant short-term swings in gasoline prices. Prices increased in the short-term until imports arrived from other markets or refineries were repaired. The proposed regulations were designed to provide the flexibility to import complying gasoline. In fact, as California becomes more of a routine importer of gasoline, it is expected that there should be more stability in the marketplace because refineries outside of California will, on an ongoing basis, be producing product for importation into California. Thus, the overall gasoline production system - consisting of California refineries and imports - should be no more subject to supply disruptions than under current rules, and may be better able to readily adjust to any production disruptions that occur in the future.

C. **Relief from the Federal RFG Oxygen Requirement**

The year-round minimum oxygen content requirements contained in the federal CAAA currently affect over 70 percent of the gasoline sold in California. The ARB believes that this requirement is not necessary to preserve the emission benefits of both the existing

CaRFG2 program, or the proposed CaRFG3 limits. Both the ARB and the Governor have requested the EPA to exempt California from the oxygen requirement and allow refiners to reduce the amount of oxygenates used in gasoline. Bills have also been introduced in both the House and the Senate to eliminate the minimum oxygen requirement based on a showing that it is not needed to preserve emissions benefits. Several estimates have been performed to determine the cost savings as they would apply to the phase-out of MTBE if relief from the federal oxygenate requirement was granted.

*1. **Removal of Federal Oxygenate Mandate***

The CEC study evaluated the cost impacts of removing the federal RFG oxygenate mandate in California. That analysis showed cost savings in the range of 0.2 to 0.8 cents per gallon in the intermediate-term, and long-term cost savings of 0.3 to 1.5 cents per gallon.

In a subsequent report prepared by MathPro for Chevron, Inc. and Tosco, Inc., the cost savings shown in the CEC report were further refined through additional analysis which considered fluctuations in the price of ethanol, as well as the production of a mix of oxygenated and non-oxygenated gasoline. MathPro estimated cost savings of 2.6 to 3.2 cents per gallon in the intermediate-term, and 0.3 to 0.9 cents per gallon in the long-term. The results of these two analyses show that removal of the federal oxygenate mandate could potentially reduce overall costs of compliance with the proposed amendments by one to three cents per gallon. The MathPro analysis is contained in Appendix O.

*2. **Impacts of a Nationwide MTBE Phase-Out***

The CEC report “Supply and Cost of Alternatives to MTBE in Gasoline”(December, 1998)” recognized that if MTBE were to be phased out of use in California, the rest of the United States could follow suit. The cases involving a U.S. ban on MTBE indicated that costs could increase by an additional 1.6 cents per gallon compared to those cases where MTBE was only banned in California.

D. Cost-Effectiveness

Many of the proposed changes and most of the associated costs occur in order to accomplish the elimination of MTBE from California gasoline. Since this is being done to avoid future water quality problems, it is not feasible to estimate the cost-effectiveness of these expenditures by using traditional methods commonly used in assessing air quality regulations. However, the proposed amendments are estimated to result in motor vehicle emission reductions in 2005 of about 0.5 ton per day of hydrocarbons and 19 tons per day of NOx and about a seven percent reduction in emissions of potency-weighted toxics. These reductions are primarily the result of the proposed change to the sulfur standard. Using the emission reductions of NOx and the estimated cost of reducing sulfur results in a cost-effectiveness of about $8100 per ton of NOx controlled or about $4.2 per pound of NOx reduced. Since this estimate does not include consideration of the reduction in toxic emissions, it is viewed as being conservative, and is well within the range of cost-effectiveness values for other NOx reduction programs.

E. Economic Effects on Small Businesses

Government Code sections 11342 et. Seq. requires 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 certain gasoline retailers and jobbers, where 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.

If the wholesale price of gasoline rose as a result of additional costs to refiners to comply with the proposed CaRFG3 specifications, retailers and jobbers would pay more for every gallon of gasoline that they re-sell 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, 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.

While the magnitude of any potential reduction in profits is difficult to estimate reliably for any particular wholesale price increase, large swings in price commonly occur in the current wholesale and retail gasoline markets and are part of the current business situation faced by jobbers and retailers. While there may be a short-term delay in passing these costs on to consumers, even large swings in wholesale prices are reflected in retail prices in a fairly rapid timeframe. Therefore, the staff do not anticipate any significant additional adverse effect upon small businesses because of cost impacts due to these regulations.

Chapter VII. Environmental Effects of the Proposed CaRFG3 Regulations

A. Effects of a Phase-Out of MTBE on Water Quality

MTBE presents a threat to California's groundwater, surface water, and drinking water systems. MTBE is highly soluble in water and will transfer to groundwater faster, and will travel farther and more easily than other gasoline constituents such as benzene when gasoline leaks from underground storage tanks or pipelines. Lawrence Livermore National Laboratory data shows that MTBE is likely present at over 4,600 leaking underground fuel tank sites in the state, even though only half the total sites have been inspected. While underground storage tanks were ordered replaced or upgraded by December 22, 1998, it is clear that even upgraded storage tanks are not leak-proof and future leaks from a small percentage of the many thousands of gasoline storage tanks in the state will continue in the future.

With the elimination of MTBE in California gasoline, the potential for more MTBE to be introduced into ground or surface water will be virtually eliminated. Existing MTBE contamination, including any that has not yet been detected, would continue until natural effects or remedial efforts would reduce it. The rate of attenuation of the contamination, once further introduction of MTBE is eliminated, is not known.

To the extent that ethanol would replace MTBE and that gasoline will still contaminate water, ethanol would contribute to further water contamination. Points of contamination could be marine terminals, rail terminals, gasoline storage tanks, service stations, ethanol storage tanks at pipeline terminals, and pleasure boat refueling and exhaust.

To the extent that gasoline is required to have a minimum oxygen content, the only viable MTBE replacement is ethanol. Ethanol is completely soluble in water and, based on theory, should travel at about the same rate as MTBE. However, unlike MTBE, ethanol is readily biodegradable, so ethanol may not spread underground to the extent that MTBE spreads. The presence of ethanol may enhance the solubility of gasoline in water, and there has been speculation that it can reduce the microbial consumption of benzene and other aromatic elements of gasoline in groundwater. If so, the plumes of those elements could spread further from the point of entry than they now do. This issue is under investigation by Lawrence Livermore National Laboratory as part of their work for the SWRCB to assess the environmental fate of ethanol per the Governor's directive.

Gasoline without oxygenates may also be used to replace gasoline with MTBE. Such a fuel would probably have substantially greater contents of branched-chain paraffins. MathPro, in a study prepared for the CEC, predicted that the main source of these compounds - the class of refining process products called "alkylates" - would increase in gasoline from the current 15 volume percent to 28 volume percent in ethanol-blended gasoline and to 32 volume percent in oxygen-free gasoline. Branched-species would be used to replace the octane and volume now provided by MTBE. Alkylates are a mix of high octane, low vapor pressure branched chain paraffinic hydrocarbons that can be made from crude oil through well established refinery processes, using the output from an FCCU unit. Because of these properties, alkylates are highly favored as streams for blending into gasoline.

Despite their considerable concentration in gasoline, branched-chain paraffins have posed less groundwater problems than have the aromatic elements in gasoline and MTBE. Based on alkylates' physical, chemical, and biological properties (alkylates are biodegradable), dissolution from the gasoline source and movement in groundwater are all expected to be significantly slower than other gasoline constituents. Therefore, their increased use in gasoline should not result in any increased risk from gasoline spills and leaks than would be encountered if more conventional, non-oxygenated fuels were to leak.

B. Effects of the Proposed CaRFG3 Regulations on Water Quality

With the proposed prohibition of MTBE in California gasoline after 2002, future contamination of existing water sources by MTBE will be limited to pre-existing MTBE contamination. Also, with the proposed lowering of the benzene limit, less benzene contamination will occur in California's surface and ground waters.

Some of the proposed changes to the CaRFG2Predictive Model and to the RVP limit would facilitate the use of ethanol in gasoline. To the extent that ethanol-blended gasoline might be more common, these changes could also increase the amount of water pollution that would occur from ethanol.

The effect of the proposed prohibition of MTBE on water quality will be further addressed in the SWRCB's report as part of the ethanol fate and transport assessment. The current SWRCB work plan is presented below.

1. State Water Resources Control Board Evaluation of Fate and Transport Issues Associated With the Use of Ethanol as a Fuel Oxygenate

The Governor's Executive Order D-5-99 directs the SWRCB to conduct an environmental fate and transport analysis of ethanol in air, surface water, and groundwater. The objective of the SWRCB study will be a peer-reviewed evaluation of the fate and transport of gasoline containing ethanol released into surface and subsurface environments within the State of California. Also, the SWRCB will evaluate the water quality issues associated with non-oxygenated RFG which includes increased amounts of alkylates. The types of releases that will be evaluated include:

- Gasoline containing ethanol released during underground storage and bulk fuel storage and transportation.
- Bulk transportation of unblended ethanol by rail or tanker truck.

- Gasoline containing ethanol released during the operation of gasoline-powered recreational watercraft.

An important outcome of this study will be the identification of key surface and groundwater fate and transport uncertainties associated with the use of ethanol as a fuel oxygenate and potential non-oxygenated fuels. Recommendations will be made regarding approaches to best reduce identified uncertainties, monitor potential risks to groundwater resources, and to cleanup any subsurface releases that may occur. A summary of identified uncertainties and recommendations to address identified knowledge gaps must be peer-reviewed and finalized by December 31, 1999, to meet the directives of the Governor's Executive Order D-5-99.

Key issues associated with the use of ethanol as a fuel oxygenate that will be addressed include:

- How will the presence of ethanol in gasoline affect the dissolution, transport, and degradation of fuel hydrocarbons released into surface and ground waters?
- What is the composition and fate of the products of gasoline combustion in the presence of ethanol that may be released into surface waters?
- What is the applicability of active and passive cleanup approaches that have historically been used for fuel hydrocarbon releases? Will these cleanup approaches work for ethanol combustion by-products?
- What difficulties may be encountered during the analysis of ethanol-containing gasoline in soil and water samples?

C. Effects of the Proposed CaRFG3 Regulations on Air Quality

The air quality impacts of the proposed amendments are positive. Reduction in ozone and particulate matter (PM) precursor emissions will directionally reduce ozone levels and ambient PM levels. Reductions in benzene emissions will lead to reduced ambient levels and reduced public exposure to benzene, a known human carcinogen. Further, with the elimination of MTBE, ambient exposure to MTBE will be virtually eliminated.

1. Emissions Effect on Stationary Sources

Significant changes in processing would be needed in refineries to comply with a phase-out of MTBE. There could be changes in the amounts of fuel consumed in refineries and its emissions. According to the CEC/MathPro study, fuel consumption would decline relative to the MTBE base case (in 2002) because of lower crude runs and lesser refinery output, for both ethanol-blended and oxygen-free gasoline. This is due to the assumption that imports will increase. Reducing fuel consumption would reduce combustion-derived emissions (mainly NOx from natural gas).

For some refineries, compliance with the proposed lower sulfur limits could mean more hydrogen production and more hydro-treating, which could increase fuel consumption and emissions from those processes. Such increases would be limited by the regulations of the air quality management districts under New Source Review.

The net volume of oxygenate imported into California would decline under a MTBE prohibition. Thus, evaporative emissions from transfers should decline. However, this is not certain because the mode of importation would change, from marine vessels to railcars (predominantly), and the ultimate destination would change, from the refinery to pipeline terminals. There could be a change in the typical number of transfers per unit volume of oxygenate. Emissions from the equipment used to do the transfers would be subject to permit conditions by the air quality management districts.

To the extent that ethanol would be used under a MTBE prohibition, truck and rail traffic would increase slightly. The numbers of trucks delivering ethanol to pipeline terminals would equal from five to ten percent of the number of trucks loading gasoline. The CEC has estimated that if all gasoline were ethanol-blended, the increased truck activity would add 21,000 miles of driving in the State per day. That would be an increase of about 0.06 percent of heavy-duty truck vehicle miles traveled (VMT) in 2003, per MVEI7G. The associated increases in emissions of particulate matter, CO, and NOx would each be less than 0.25 ton per day in the State. The increased traffic and emissions would be subject to conditions in the permit amendments needed for authority to modify the equipment and operations at terminals.

2. *Emissions Effect from Mixing Fuels in Vehicles*

There is an evaporative emissions effect associated with the mixing of a gasoline containing ethanol and a straight hydrocarbon gasoline. The addition of ethanol to a straight hydrocarbon fuel increases the RVP of the fuel by about 1 psi. For this reason, the federal RFG regulations prohibit the mixing of RFG with ethanol and RFG without ethanol in the gasoline distribution and marketing system from January 1, through September 15, and the staff is proposing a conditional restriction for the California program. However, neither the federal nor the California RFG regulations address mixing of ethanol RFG with non-oxygenated RFG in vehicle tanks. Since virtually all CaRFG has been made with MTBE and little ethanol, this has not been an issue.

With MTBE being prohibited from California gasoline, and with the regulatory requirement for oxygen in gasoline, the mixing of a non-oxygenated fuel and an ethanol blended fuel in vehicle tanks becomes an issue. There are two possible courses affecting this commingling issue that may occur depending on the outcome of California's request to the U.S. EPA for a waiver from the federal oxygen requirement.

<u>With No Waiver From the Federal Oxygen Requirement-</u> Today, federal RFG regulations apply to about 70 percent of the gasoline consumed in California. This will increase to about 80 percent when the San Joaquin Valley Air Basin is designated to be a severe non-attainment area for ozone. Without a waiver of the federal oxygen requirement, commingling of RFG containing ethanol with non-oxygenated RFG will not be a significant concern by 2003, because over 80 percent of the total gasoline consumed

in California will contain ethanol. Using the information from the U.S. EPA Blue Ribbon Panel report, the impact is estimated to be less than 0.04 psi increase in the gasoline pool average RVP.

With a Waiver From the Federal Oxygen Requirement- Under this course, it is more difficult to predict the potential for commingling of RFG containing ethanol, with non-oxygenated RFG. There are at least three scenarios that could realistically occur:

Scenario 1 Except for winter gasoline in the South Coast Air Basin, little or no ethanol would be used.

Since the RVP of gasoline is not controlled for air pollution purposes in the winter, Scenario 1 for the winter use of ethanol would not result in any concern about emissions from mixing RFG containing ethanol with non-oxygenated RGF in vehicle tanks.

Scenario 2 In addition to winter gasoline in the South Coast, refiners would use ethanol in the summer to produce premium and some mid-grade gasolines.

For the reasons described above, the winter use of ethanol in Scenario 2 would not be a concern. However, the non-winter use of ethanol in premium and mid-grade gasolines could result in increases in evaporative emissions as a result of consumers switching from regular grade to premium or mid-grade gasolines. We expect that due to the significant cost differential between regular grade and premium or mid-grade gasoline, the amount of switching between grades will be low, and the resulting increase in evaporative emissions would be insignificant. On the other hand, if switching between grades becomes a large occurrence, then the impact on evaporative emissions would be significant.

Scenario 3 Refiners would use ethanol in RFG to optimize the economics of producing RFG, and this could represent 30 to 60 percent of the gasoline consumed in California.

This scenario represents the worst case and is of most concern. This is in effect the situation identified by the Blue Ribbon Panel report as having the potential effect of raising the gasoline pool average RVP by 0.1 to 0.4 psi An RVP increase in this range would significantly increase evaporative emissions.

Staff is Continuing to Evaluate this Situation The University of California at Davis is currently conducting a study for the ARB to evaluate the potential for mixing of RFG containing ethanol and non-oxygenated RFG to occur in vehicle tanks. This will provide information for the ARB staff to further evaluate this issue. Staff will also monitor how ethanol is used in CaRFG in the future. If it is determined that a significant increase in emissions is occurring as a result of mixing RFG containing ethanol and non-oxygenated RFG in fuel tanks, staff will develop appropriate recommendations to preserve the emission benefits of CaRFG3.

3. *Effect on Motor Vehicle Emissions and Resulting Air Quality*

The ARB staff has prepared a draft report (Analysis of the Air Quality Impacts of the Use of Ethanol in Gasoline) in response to the Governor's Executive Order to assist OEHHA in its risk assessment. The draft report contains the staff's estimates of the changes in ambient air concentrations of potentially detrimental contaminants of exhaust and evaporative components and subsequent reaction products that would result from substituting ethanol-blended gasoline for gasoline blended with MTBE. The staff also included non-oxygenated gasoline in the draft analysis to provide some basis for comparison. The following sections summarize these initial estimates of volatile organic compound (VOC) emission profiles and emission inventories, modeling of air quality impacts, and data analysis of current and future air quality concentrations. The draft analysis included an assessment of emission and air quality impacts for the following four fuels:

- Current MTBE-based CaRFG2
- Ethanol-based fully complying fuel (with oxygen content of 3.5 wt%)
- Ethanol-based fully complying fuel (with oxygen content of 2.0 wt%)
- A non-oxygenated fully complying fuel

The staff also focused on the following air contaminants:

- Criteria air pollutants [carbon monoxide (CO), nitrogen dioxide (NO_2), ozone, and particulate matter (PM10, PM2.5)].
- Toxic air contaminants (acetaldehyde, benzene, 1,3-butadiene, and formaldehyde).
- Fuel oxygenates (ethanol and MTBE).
- Alkylates [branched alkanes such as 2-methylpentane, 3-methylpentane, methylcyclopentane, and 2,2,4-trimethylpentane ("isooctane")].
- Peroxyacetyl nitrate (PAN) and peroxypropionyl nitrate (PPN).
- Nitric acid (HNO_3).
- Additional compounds of interest to OEHHA (isobutene, toluene, xylene isomers, and *n*-hexane).

Preliminary results indicate that there is very little overall differences in reactivity (ozone-forming potential) and toxics between the various formulations of CaRFG2. This is consistent with the conclusions of the National Research Council's report on the ozone forming potential of reformulated gasoline. The National Research Council's report concluded that there were no statistically significant differences between the RFGs blended with MTBE or ethanol in the mass exhaust emissions of hydrocarbons or NOx. The National Research Council's report also states that there are no statistically significant differences between the hydrocarbon exhaust reactivities of the various blends of RFG.

There were some specific differences between the fuels, but they are relative to the type of oxygenate. The MTBE fuel is expected to have higher formaldehyde emissions than the ethanol fuel, while the ethanol fuel is expected to have higher acetaldehyde emissions that the MTBE fuel. With the non-oxygenated fuel having lower aldehyde emission than either oxygenated fuel.

The preliminary findings from the analysis indicated that increases in acetaldehyde and ethanol emissions associated with ethanol containing fuels could lead only to a very small increase in peroxyacetylnitrate (PAN) concentrations, because other VOCs are larger contributors to PAN formation.

With respect to ambient ozone, the draft analysis found very small changes in ozone impact with the ethanol-blended fuel compared to current MTBE containing fuel. There was a small increase in predicted ozone from the non-oxygenated fuel. However, this draft analysis was based on increased aromatic levels in vehicle exhaust although aromatic levels of expected real world complying fuel and the subsequent exhaust emissions should be lower. When this is corrected, it is expected that the ozone impacts of fuel with 2.0 weight percent oxygen with non-oxygenated complying fuels will be very similar. This aspect of the analysis is being reassessed and will be completed in time for consideration at the Board's December meeting.

The preliminary draft report and appendices are available from at the ARB on the internet at: http://www.arb.ca.gov/cbg/regact/ethanol/ethfate.htm.

D. Effects of the Proposed CaRFG3 Regulations on Greenhouse Gas Emissions

In determining the impact of the proposed amendments on greenhouse gas emissions (GHG), the staff evaluated two possible scenarios that may develop in the production of CaRFG. First, gasoline in California will no longer be produced with oxygenates. This scenario may develop for certain grades of gasoline throughout the State if the federal minimum 2.0 weight percent oxygen mandate is eliminated in California. If this mandate is not removed, gasoline produced for federal RFG areas in California, as well as certain gasoline grades in non-federal RFG areas, are expected to be produced with ethanol as the oxygenate.

In determining the overall impact of the proposed amendments on GHG emissions in California, the staff has assessed GHG emissions into two phases – exhaust and fuel-cycle emissions (GHG emissions associated with the production of the fuel) for various types of gasoline. The sum of the emissions from these two phases yields the total GHG emissions associated with each gasoline type. A detailed discussion of this evaluation is contained in Appendix N.

The proposed CaRFG3 regulations are not expected to increase emissions of greenhouse gases that may contribute to global warming. The staff's assessment concluded that there is essentially no difference in GHG emissions between reformulated gasoline produced with MTBE versus gasoline blended with corn-derived ethanol. However, the proposed amendments may result in a net decrease in GHG emissions in California to the extent that ethanol produced from California biomass becomes available and is blended into the gasoline pool. In addition, the staff estimates that gasoline produced with a lower oxygen content (less than 2 percent by weight) may result in small reductions in GHG emissions.

GHG are predominantly comprised of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The Intergovernmental Panel on Climate Change has developed the concept of Global Warming Potential, which compares the global warming impacts of various gases relative to CO_2. These are illustrated in Table VII-1, as well as equivalent CO_2 California emissions of three GHGs in 1994.

Based on data compiled by the CEC, CO_2 emissions from the consumption of motor gasoline constituted nearly 33 percent of the total California CO_2 emissions in 1994, or nearly 131 million tons. This is the single largest source of CO_2 emissions in California.

Table VII-1
California Greenhouse Gas Emissions (1994)
(by gas type)

Greenhouse Gas	Global Warming Potential	GHG Emissions in CO_2 Equivalent (thousand tons)
CO_2	1	400,227 (87.7%)
CH_4	21	49,327 (10.5%)
N_2O	310	8,637 (1.8%)

Source: California Energy Commission

E. Effects of Proposed CaRFG3 Regulations on Allowable Emissions

The proposed CaRFG3 regulations will maintain the emissions benefits gained in the existing CaRFG2 program. The proposed regulations will also achieve additional emissions benefits by reducing the sulfur and benzene specifications resulting in emissions reductions of HC, NOx, and toxics.

1. *Effects on HC and NOx Emissions*

The proposed decrease in the flat, averaging, and cap limits for sulfur will result in a reduction in 2005 of about 0.5 ton per day of HC emissions and about 19 tons per day of NOx emissions. The reductions in NOx emissions will result in reductions in secondary PM levels.

2. *Effects on Toxic Emissions*

The proposed decrease in the flat limit of benzene from 1.0 percent to 0.8 percent is expected decrease potency-weighted toxic emissions by about 4 percent. Total reduction in potency weighted toxic emissions is about 7 percent.

3. *Effects on the State Implementation Plan*

If the proposed CaRFG3 regulations are adopted, the additional benefits of the actual in-use fuel which have provided environmental benefits above and beyond the original estimated benefits of the current CaRFG2 program will be preserved. Based on the proposed CaRFG3 Predictive Model, in 2005 these additional benefits are estimated to be about 30 tons per day of hydrocarbons, 20 tons per day of NOx, and an 8 percent reduction in potency weighted toxic emissions. The proposed CaRFG3 program preserves and enhances the motor vehicle emission reduction benefits of the current CaRFG2 program and ensures compliance with the SIP.

4. ***Health Effects***

The proposed CaRFG3 regulations are expected to be directionally health protective by virtue of the emission reductions obtained. The OEHHA staff will be evaluating the potential public health impacts of ethanol as an oxygenate in gasoline. In order to do that with some frame of reference, the OEHHA staff proposes to evaluate ethanol in comparison to current MTBE formulations, and to gasoline with no added oxygenate. The ARB staff is working closely with the OHHEA staff and will be generating both emissions data and air modeling for OEHHA staff to use in the assessment. Rather than evaluating every possible fuel component, emission, and atmospheric transformation product, the OEHHA staff will consider the changes in combustion by-products, evaporative emissions, and atmospheric transformation products that occur from one fuel to the next. While some of the emissions and products are likely to be similar for all the fuel types of interest, it is anticipated that significant differences may be observed for other classes of compounds, in particular aldehydes.

In addition, the OEHHA staff will be evaluating potential risks from groundwater contamination by fuel components. This will focus primarily on the differences between MTBE and ethanol in groundwater. We will be relying on the results of the SWRCB efforts in determining whether ethanol gets into groundwater and whether the presence of ethanol increases the concentrations of other potential pollutants in the groundwater.

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