Air Resources Board

PUBLIC MEETING AGENDA

April 20, 2006

9:00 a. m

Agenda Items to be heard;

06-4-1: 06-4-2: 06-4-3:

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California Environmental Protection Agency

ELECTRONIC BOARD BOOK

California Environmental Protection Agency
Air Resources Board

PUBLIC MEETING AGENDA

LOCATION:
Long Beach Convention & Entertainment Center
300 East Ocean Boulevard
Seaside Ballroom
Long Beach, CA 90802

This facility is accessible by public transit. For transit information, call (562) 591-8753, website: http://www.lbtransit.com
(This facility is accessible to persons with disabilities.)

April 20, 2006
9:00 a.m.

Item #

06-4-1: Public Meeting to Update the Board on a Health Update: Nitrogen Dioxide Exposure Increases Allergic Asthmatic Responses

Staff will present the results from four published articles that have reported on how exposure to nitrogen dioxide can adversely affect the health of adult asthmatics. The studies show that exposure to 0.26 ppm nitrogen dioxide may worsen the allergic reactions in the airways of asthmatics. These results support ARB's assessment that the current state ambient air quality standard for nitrogen dioxide is inadequate.

06-4-2: Public Hearing to Consider Two Research Proposals

"Characterization of Ventilation Rates and Indoor Environmental Quality (IEQ) on Small Commercial Buildings," University of California, Berkeley, Proposal No. 5608-251.

"Effects of Inhaled Fine Particles on Lung Growth and Lung Disease," University of California, Irvine, Proposal No. 2609-251.

06-4-3: Public Hearing to Consider the Emission Reduction Plan for Ports and Goods Movement in California

The Board will consider approval of the proposed Emission Reduction Plan for Ports and Goods Movement to establish the framework for actions to reduce the air quality and health impacts from these operations statewide.

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

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

TO SUBMIT WRITTEN COMMENTS ON AN AGENDA ITEM IN ADVANCE OF THE MEETING:

CONTACT THE CLERK OF THE BOARD, 1001 I Street, 23rd Floor, Sacramento, CA 95814 (916) 322-5594
FAX: (916) 322-3928
ARB Homepage: www.arb.ca.gov

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- TTY/TDD/Speech-to-Speech users may dial 7-1-1 for the California Relay Service.
- Assistance for Disability-related accommodations, please go to http://www.arb.ca.gov/html/ada/ada.htm or contact the Air Resources Board ADA Coordinator, at (916) 323-4916.
- Assistance in a language other than English, please go to http://www.arb.ca.gov/as/eeo/languageaccess.htm or contact the Air Resources Board Bilingual Coordinator, at (916) 324-5049.

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

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

California Environmental Protection Agency

Air Resources Board

PUBLIC MEETING AGENDA

INDEX

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April 20, 2006
9:00 a.m.

NOTICE OF PUBLIC MEETING TO CONSIDER THE "EMISSION REDUCTION PLAN FOR PORTS AND GOODS MOVEMENT IN CALIFORNIA."

The Air Resources Board (the Board or ARB) will conduct a public meeting at the time and place noted below to consider approval of the "Emission Reduction Plan for Ports and Goods Movement in California." This notice summarizes the proposed plan and its contents.

DATE: April 20, 2006

TIME: 9:00 a.m.

PLACE: Long Beach Convention and Entertainment Center
300 East Ocean Blvd.
Long Beach, California

This item will be considered at a one-day meeting of the Board, which will start at 9:00 a.m., April 20, 2006. If you wish to testify, please plan to attend on April 20, 2006.

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

SUMMARY OF THE PROPOSED PLAN

Overview

Air pollution from international trade and goods movement in California is a major public health concern. Emissions from the ships, trucks, and locomotives involved in goods movement pose a health risk to nearby communities and are a substantial contributor to regional air quality problems. The ARB staff has developed a proposed plan to identify and initiate specific actions necessary to reduce these emissions and protect public health.

In the proposed plan, ARB staff quantifies the emissions from ports and goods movement-related activities (both international and domestic), estimates their health impacts, establishes goals for reducing emissions and health risk, and defines strategies to meet these goals. The plan would result in a net decrease in emissions, after including anticipated growth. The goals of this plan are linked to the air quality goals in the broader Goods Movement Action Plan (Phases I and II) developed jointly by the California Environmental Protection Agency (Cal/EPA) and the Business, Transportation, and Housing Agency.

- **Statewide Goal for 2010**: reduce projected 2010 statewide emissions from ports and goods movement to 2001 levels or below to mitigate the impacts of growth. The proposed plan would more than meet that goal by reducing emissions 20-40% below 2001 levels for the four pollutants targeted – diesel particulate matter (PM), oxides of nitrogen (NOx), reactive organic gases (ROG) and sulfur oxides (SOx).

- **Statewide Goal for 2020**: reduce the statewide health risk from diesel PM from ports and goods movement by 85% between 2000 and 2020. The proposed plan meets this goal with an 86% overall risk reduction.

The plan sets specific NOx emission reduction goals for international goods movement for the South Coast Air Basin to aid in attainment of federal air quality standards for particulate matter and ozone. These emission reduction targets of 30% by 2015 and 50% by 2020 would be met with the proposed plan.

The plan also explicitly recognizes the need for statewide application of the strategies in areas outside the South Coast -- especially the San Joaquin Valley, San Francisco Bay Area, Sacramento, and San Diego. The benefits of the plan are calculated for each of these regions as well as on a statewide basis. Specific emission reduction targets to address federal air quality standards will be developed later this year as part of State Implementation Plan (SIP) preparation. This will occur through a public process involving ARB, the U.S. Environmental Protection Agency, local air districts, metropolitan planning organizations and all other stakeholders. New SIPs for ozone and fine particles (PM2.5) are due in 2007 and 2008, respectively.

Health Impacts

The ARB staff assessment quantifies the following health effects, both statewide and for the five regions: premature death, hospital admissions (respiratory causes), hospital admissions (cardiovascular causes), asthma and other lower respiratory symptoms, acute bronchitis, work loss days, minor restricted activity days, and school absence days. The quantified effects are those associated with air pollution levels above State air quality standards. The ARB staff estimates that current emissions from goods movement activities result in approximately 2,400 premature deaths per year. Existing emission reduction programs will reduce that number to about 1,700 by 2020, after accounting for projected growth.

With implementation of this plan, an estimated 820 annual premature deaths would be avoided in 2020. The plan strategies would significantly reduce regional air quality impacts and health risk in communities adjacent to ports, rail yards, intermodal facilities, distribution centers, and highways. Since many communities in California exceed State standards by a large margin, the plan greatly reduces but does not eliminate the estimated premature deaths in 2020. But achieving the plan goals would reduce health risk substantially in the most impacted communities and provide large regional benefits.

The Proposed Strategy

Successful implementation of the ARB emission reduction plan relies on actions by all levels of government and partnerships with the private sector. Regulatory actions provide the framework for the plan -- incentive programs, lease agreements, careful land use decisions and other mechanisms will also play a role. The plan measures address all the key sources including ships, harbor craft, cargo handling equipment, trucks, and locomotives.

Ships. The plan proposes a mix of approaches that would steadily increase the supply of cleaner fuel and of lower-emitting vessels with clean engines, as well as the use of shore-based electrical power at dock. The strategies for ocean going ships would reduce projected emissions from this category 50% or more in 2015, and 70% or more in 2020.

Commercial Harbor Craft. Shore power for harbor craft is also under consideration. Emission reductions would be achieved primarily through an ARB rule to clean up the existing fleet, tighter U.S EPA or ARB emission standards for new engines and use of shore power at dock. The plan targets a 70% plus reduction in this category by 2020.

Cargo Handling Equipment. Most of the new reductions for this sector will come from a rule ARB adopted in December 2005 requiring new and existing cargo handling equipment to use available cleaner technologies beginning in 2007. The last element of the strategy would be to step up diesel PM control to the 85% level in the future as additional verified retrofit technologies become available and seek zero- or near-zero emission equipment. By 2020, emissions from this sector will be reduced by over 80%.

Trucks. The primary new strategies in this plan are to apply the best available control technology to the entire fleet of existing heavy diesel trucks in private ownership, with a targeted program to modernize the subset of trucks serving ports. The plan targets an 88% reduction in diesel PM, and about a 60% reduction for NOx and ROG, by 2020.

Locomotives. The plan proposes to reduce locomotive emissions primarily by upgrading switching locomotives to diesel-electric hybrid or equivalent technology in the near-term; relying on U.S. EPA adoption of cleaner new engine standards (Tier 3 at 90% control for diesel PM and NOx), more stringent rebuild requirements, and national idling limit devices; and implementing a comprehensive program to bring these cleaner locomotives to California (90% of the fleet at Tier 3 levels by 2020). The plan targets an 85% reduction or better for all pollutants by 2020.

Other Strategies. The plan includes two additional strategies that are conceptual in nature and would be implemented by other agencies and segments of the goods movement industry. These are improved land use decision-making and site specific mitigation at the project or community level.

Benefits/Costs

The cumulative cost to implement the plan strategies for both international and domestic goods movement is estimated at $6-$10 billion between 2006 and 2020. This estimate includes costs of reducing health risk to communities most impacted by goods movement as well as costs to reduce emissions that contribute to regional violations of State and federal air quality standards. For every dollar invested to implement the plan's strategies, there would be $3 to $8 dollars in economic benefits realized by avoided health effects, including premature death.

AVAILABILITY OF DOCUMENTS

The proposed Emission Reduction Plan for Ports and Goods Movement in California is available at: http://www.arb.ca.gov/planning/gmerp/gmerp.htm. Copies of the plan may also be obtained at ARB's Public Information Office, 1001 I Street, Visitors and Environmental Services Center, 1st Floor, Sacramento, California 95814, (916) 322-2990.

SUBMITTAL OF COMMENTS

The public may present comments relating to this matter orally or in writing at the meeting, and in writing or by email before the hearing. To be considered by the Board, all written submissions not physically submitted at the meeting must be received by the Board **no later than 12:00 noon (Pacific Standard Time) April 19, 2006**, and addressed to as follows:

- Postal mail sent to: Clerk of the Board, Air Resources Board, 1001 I Street, 23rd Floor, Sacramento, CA 95814.
- Electronic submittal: http://www.arb.ca.gov/lispub/comm/bclist.php
- Facsimile transmissions to: Clerk of the Board at (916) 322-3928.

The Board encourages members of the public to bring to the attention of staff in advance of the meeting any suggestions or comments. The Board requests, but does not require, that 30 copies of any written statement be submitted and that all written statements be filed at least ten days prior to the meeting.

CALIFORNIA AIR RESOURCES BOARD

Catherine Witherspoon
Executive Officer

Date: April 4, 2006

PROPOSED

Emission Reduction Plan for Ports and Goods Movement in California

Release Date: March 21, 2006
Board Consideration: April 20-21, 2006

California Environmental Protection Agency
Air Resources Board

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State of California
California Environmental Protection Agency
AIR RESOURCES BOARD

PROPOSED Emission Reduction Plan for Ports and Goods Movement in California

BOARD CONSIDERATION

The Air Resources Board (the Board or ARB) will conduct a public meeting at the time and place noted below to consider approval of the "Emission Reduction Plan for Ports and Goods Movement in California."

DATE: Thursday, April 20, 2006
TIME: 9:00 a.m.
PLACE: Long Beach Convention and Entertainment Center
333 East Ocean Blvd.
Long Beach, California

This item will be considered at a two-day meeting of the Board, which will start at 9:00 a.m., April 20, 2006, and may continue at 8:30 a.m., April 21, 2006. While Board action may not take place on the item until April 21, there is a chance that public testimony may conclude on April 20. If you wish to testify, please plan to attend on April 20.

SUBMITTAL OF COMMENTS

The public may present comments relating to this matter orally or in writing at the meeting, and in writing or by email before the hearing. To be considered by the Board, written submissions not physically submitted at the meeting must be received **no later than 12:00 noon April 19, 2006,** and addressed to the following:

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The Board encourages members of the public to bring to the attention of staff in advance of the meeting any suggestions or comments. The Board requests, but does not require, that 30 copies of any written statement be submitted and that all written statements be filed at least ten days prior to the meeting.

DOCUMENT AVAILABILITY

Electronic copies of this document, the April Board meeting notice, and related materials can be found at: http://www.arb.ca.gov/planning/gmerp/gmerp.htm. Alternatively, paper copies may be obtained from the Board's Public Information Office, 1001 I Street, 1st Floor, Visitors and Environmental Services Center, Sacramento, California, 95814, (916) 322-2990.

If you are a person with a disability and desire to obtain this document in an alternative format, please contact the Americans with Disabilities Act Coordinator at (916) 323-4916, or TDD (916) 324-9531, or (800) 700-8326 for TDD calls from outside the Sacramento area.

DISCLAIMER

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

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We would also like to recognize the many other managers and staff throughout the Air Resources Board who shared their expertise on this plan. While too numerous to list individually, their contributions were vital to the final product.

QUESTIONS

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TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

TECHNICAL SUPPLEMENTS

The following supporting documents will be posted on our website at: http://www.arb.ca.gov/planning/gmerp/gmerp.htm

- Technical Supplement on Quantification of the Health and Economic Impacts of Air Pollution from Ports and Goods Movement in California

- Technical Supplement on Emission Inventory

WHAT'S NEW IN THIS PLAN

On December 1, 2005, ARB staff released the *Draft Emission Reduction Plan for Ports and International Goods Movement in California* for public review and comment. We held four community meetings (in Wilmington, Commerce, Oakland, and Fresno) with the Business, Transportation & Housing Agency and the California Environmental Protection Agency on the State's goods movement activities, including the draft Emission Reduction Plan. We heard concerns and suggestions at those meetings, and received extensive written public comments as well. Leading academic experts in California also responded to our request for scientific peer review of the health analyses and emission inventory.

Based on all of this input, this proposed plan includes the following significant changes from the December 2005 draft plan:

EXPANDED SCOPE

- Includes Ports and All Goods Movement. We have expanded the scope of the plan to address all goods movement (whether domestic or international) and retained all port-related activity. The effect is to include significant additional emissions from truck and train trips associated with transporting domestic cargo. Trucks become the largest sector for all pollutants except SOx.

  Compared to the inventory for international goods movement in the draft plan, the overall 2010 emissions of diesel PM, NOx, and ROG more than doubled. In 2020, diesel PM increases by 30%, NOx by 80%, and ROG by 90% before applying the benefits of plan controls. But SOx levels show only a minimal increase since ships dominate the SOx inventory and were included in both the draft and proposed plans.

- Increases the Health Impacts and Health Costs in Response to Added Emissions. The estimated statewide premature deaths associated with *all* goods movement is substantially larger than the 750 annual cases attributed to just ports and international goods movement in the draft plan. Due to adding the domestic emissions, the new estimate for all goods movement is 2,400 premature deaths annually, mostly from particulate pollution. Measures already in place are expected to reduce these premature deaths by about 30 percent by 2020, despite increases in goods movement activities and population growth. With implementation of the plan, an additional 820 premature deaths would be avoided in 2020 compared to 500 in the draft plan. The health impacts remaining even with the benefits of plan are high, which reflects the challenging nature of the State standards. The combination of existing control measures, new measures in this plan, and new measures in future regional air quality plans are all needed to ensure these health effects due to air pollution exposures are avoided.

  The draft plan estimated the cumulative cost of health impacts from ports and international goods movement at roughly $70 billion for the time period 2005 through

2020. With much greater emissions introduced by including domestic goods movement, this cumulative impact rises to about $200 billion in this plan for the same period.

- Increases the Cost to Implement Plan Strategies. Because the universe of sources and emissions are much larger, the cumulative costs went from $3-$6 billion in the draft plan, up to $6-$10 billion in this proposed plan. But the benefit to cost ratio remains very positive -- for every $1 invested in reducing emissions, there would be $3 to $8 in benefits from health impacts avoided.

HEALTH ANALYSIS

- Expands the Health Impacts Quantified and Valued. The health analyses include more quantitative endpoints and economic value from avoided health impacts. In addition to premature death, we also quantify and value hospitalizations for respiratory and cardiovascular causes, asthma and other lower respiratory symptoms, acute bronchitis, and lost work and school days. The quantitative analysis was expanded to include the effects from secondary organic aerosols and other primary PM2.5 sources (like brake and tire wear). All of this new information feeds into the benefit-cost analysis.

- Qualitatively Links SOx Emissions to Substantial Health Risk. The health analysis notes that SOx emissions are a substantial contributor to ambient particle levels based on air quality monitoring data. We discuss the steps staff will take to apportion responsibility for ambient levels of sulfate-based particles to man-made sources, natural sources (like the ocean), and other factors beyond California's control like transport. Once we identify the contribution of goods movement emissions, we will quantify the associated health impacts.

REGIONAL IMPACTS

- Assesses Regional Impacts. This plan contains region-specific analyses of emissions and health impacts for the South Coast, San Joaquin Valley, San Francisco Bay Area, San Diego County, and the Sacramento Region. These analyses show that the plan strategies would reduce 2010 emissions to well below 2001 levels in each region.

TARGETS AND STRATEGIES

- Achieves the 85% Diesel PM Risk Reduction Target. Driven by the dramatic decline in truck emissions with existing programs and new strategies, this plan shows an 86% reduction in the statewide health risk from exposure to diesel PM from port and all goods movement activities between 2001 and 2020. This plan continues to reduce statewide emissions 20-40% below the 2010 targets for all pollutants, and to reduce South Coast NOx emissions below the preliminary 2015 and 2020 targets for that region.

- More Effective in Reducing Emissions. The percent emission reduction achieved between 2001 and 2020 with implementation of the strategies is greater for each pollutant in this plan than in the draft plan -- diesel PM is down 79% compared to 44% in the draft plan, while NOx decreases 63% over this time period compared to 55% previously. SOx is also reduced more (78% reduction now versus 73% before).

- Adds a New Strategy for the Entire Fleet of Older Trucks in California. This strategy would reduce diesel PM and NOx emissions from approximately 250,000 heavy-duty trucks under private ownership by companies or individuals in California. Like other diesel control fleet rules, ARB staff is currently considering a strategy that would make use of best available control technology, including replacement, repowers, and retrofits.

- Revises the Port Truck Modernization Program. After further analysis, we revised the port truck modernization strategy to accelerate reductions in diesel PM and achieve NOx reductions more cost-effectively.

- Highlights the Potential for ARB Regulations on Marine Operations. Strengthens ship strategies by noting that ARB may require widespread use of lower sulfur marine fuels in main engines and increased use of shore power if ARB determines that these actions are the most effective mechanism to quickly reduce emissions of SOx, diesel PM, NOx, and other pollutants.

- Uses Updated Information on Truck Activity and Emissions. The latest truck studies show greater emissions than expected from heavy trucks with current technology – roughly three times higher for diesel PM today, diminishing to nearly the same level by 2020. NOx is roughly 30% higher today and 60% higher than previous estimates by 2020. These data change the emission trends for trucks, reducing diesel PM more quickly over time, and NOx less quickly.

- Identifies Key Inputs to Emission Reduction and Cost Calculations. This plan now includes the key inputs and assumptions used in our emission benefit and cost calculations for each sector. This should provide greater clarity regarding what is or is not assumed in each sector's strategies.

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Executive Summary

Air pollution from international trade and all goods movement in California is a major public health concern at both regional and community levels. These activities are a key contributor to the State's economic vitality, but this prosperity comes at a price. Goods movement is now the dominant contributor to transportation emissions in the State. The staff of the Air Resources Board (ARB or Board) has developed this proposed plan to identify and initiate specific actions necessary to reduce these emissions and protect public health.

This plan updates our December 2005 draft plan in several important ways. Most significantly, the plan now includes domestic as well as international goods movement, the strategies would meet the 85% diesel particulate matter (PM) risk reduction target, the port truck strategy has been further developed, and the health analysis is updated. The impacts of the expanded scope and refined analyses are summarized in the "What's New" section of the plan and reflected throughout the document.

The emission reduction plan is part of the broader Goods Movement Action Plan being jointly carried out by the California Environmental Protection Agency (Cal/EPA) and the Business, Transportation & Housing Agency (BT&H). Cal/EPA and BT&H's Phase 1 Action Plan released in September 2005 highlighted the air pollution impacts of goods movement and the urgent need to mitigate localized health risks in affected communities. The Phase I Action plan established four specific goals for addressing this problem: reduce emissions to 2001 levels by 2010; continue reducing emissions until attainment of applicable standards is achieved; reduce diesel-related health risks 85% by 2020; and ensure sufficient localized risk reduction in each affected community. The draft Phase II Action Plan (February 2006) retained these goals and explicitly references this plan as a key component.

Successful implementation of the ARB emission reduction plan will depend upon actions at all levels of government and partnership with the private sector. No single entity can solve this problem in isolation. The basic strategies to reduce emissions include regulatory actions, incentive programs, lease agreements, careful land use decisions and voluntary actions. The measures address all significant emission sources involved in international and domestic goods movement including trucks, locomotives, marine vessels, harbor craft, and cargo handling equipment.

Since ARB staff released the draft *Emission Reduction Plan for Ports and International Goods Movement* on December 1, 2005, we have held community meetings, sought scientific peer review of its health risk assessment methodology and conclusions, and reviewed public comments from the general public, affected industries, the Cal/EPA and BT&H Goods Movement Action Plan work groups, local air districts and other stakeholders. ARB's Governing Board will consider approval of this proposed plan at a public meeting on April 20-21, 2006 in Long Beach, California.

Specific actions to reduce goods movement emissions are already underway. Rules for sources under ARB's direct regulatory authority have been adopted and more are on the way. Likewise, the U.S. Environmental Protection Agency (U.S. EPA) is working on national regulations affecting marine vessels, locomotives and harbor craft, scheduled for promulgation this year. Together, ARB staff, U.S. EPA staff and other state representatives are exploring a potential "Sulfur Emission Control Area" (SECA) designation for parts of the U.S. coastline, which would require all visiting vessels to use lower sulfur fuels. A significant amount of existing incentive funds has been applied to goods movement emission sources and ARB has prioritized continued funding on this source of statewide significance. Finally, several local entities are pursuing elements of this emission reduction plan through their own ordinances, regulations, lease agreements, environmental mitigation requirements, and voluntary efforts. Staff expects all of those activities to continue.

Public Health Assessment

As part of the emission reduction plan, ARB staff estimated the public health impacts of the goods movement system in California. Health impacts of pollutants commonly associated with emissions from goods movement include premature death, cancer risk, respiratory illnesses, and increased risk of heart disease. Particulate matter, primarily from diesel engines, and gases that form ozone and particulate matter in the atmosphere, are key pollutants associated with these health effects. The large body of scientific research on these pollutants forms the basis for air quality standards and risk assessments used in ARB programs.

In the draft plan, ARB staff estimated that emissions from current (2005) ports and international goods movement activities result in approximately 750 premature deaths per year. With the addition of emissions from domestic goods movement, the new estimate of premature deaths for *all* goods movement is 2,400 annually, mostly from particulate pollution. With implementation of the plan, an estimated 820 premature deaths would be avoided in 2020 compared to 500 in the draft plan

Since many communities in California exceed State standards by a large margin, the estimate of premature deaths remaining after plan implementation is still very significant. However, achieving the emission reduction goals of this plan would be a major milestone of progress towards meeting California's stringent State standards. Meeting the 85% risk reduction target for diesel particulates would reduce health risk substantially in the communities most impacted by diesel particulate pollution.

The economic valuation of these health effects is substantial. For example, the standard value of a life ended prematurely is $7.9 million today, rising to $8.6 million by 2020. For the 15-year period between 2005 and 2020, staff estimates an aggregate health impact equivalent to approximately $200 billion in present value dollars. Reducing these health impacts as quickly as possible is essential.

Emission Inventory

The emissions associated with ports and all goods movement are categorized by source and shown in Table 1 for 2001 and 2020. This plan evaluates the following pollutants: diesel particulate matter (diesel PM), nitrogen oxides (NOx), reactive organic gases (ROG), and sulfur oxides (SOx). For each category, staff estimated 2001 "baseline" emissions, current (2005) levels and future forecasts for 2010, 2015 and 2020. The future forecasts include the benefits of existing requirements and assumed growth rates. Without further action, ship emissions will increase through 2010 and beyond, making this the single most challenging category to address. Truck, rail, cargo handling and harbor craft emissions are expected to decrease continuously from current levels, but not at a rate fast enough to meet public health goals.

Table 1
2001 and 2020 Statewide Emissions from Ports and Goods Movement
(tons per day)

Source	Diesel PM		NOx		ROG		SOx	
	2001	2020	2001	2020	2001	2020	2001	2020
Ships	7.8	23.3	95	254	2	7	60	180
Harbor Craft	3.8	1.8	75	39	8	4	<1	<1
Cargo Handling Equipment	0.8	0.2	21	6	3	1	<1	<1
Trucks	37.7	6.2	655	255	56	23	5	1
Transport Refrigeration Units	2.5	0.1	22	28	13	4	<1	<1
Locomotives	4.7	4.5	203	139	12	12	8	<1
Total	**57.3**	**36.1**	**1071**	**721**	**94**	**51**	**74**	**181**

The ship inventory (baseline and growth forecast) tracks with the June 2005 Port of Los Angeles report, adjusted to include all other ports in California. The emission inventory includes all ship emissions within 24 nautical miles of shore. Off-shore emissions are most important from the standpoint of regional ozone and fine particulate matter (PM2.5) levels. Dockside emissions are especially important in terms of health risk to nearby communities. Ship emissions estimates for 2020 have slightly increased compared to the draft plan.

Emission estimates and growth factors were calculated separately for harbor craft (tug boats, ferries, fishing boats, other vessels) and cargo handling equipment. The harbor craft inventory has been revised downward since the draft plan to include only the emissions within 24 nautical miles of the California coast and to better reflect fleet turnover to cleaner engines under existing emission standards.

With the expanded scope of the plan, the most significant emission inventory changes are for trucks and locomotives. Adding the domestic component and incorporating the latest testing data increased truck emissions by three to ten-fold (depending on the pollutant and year) compared to the draft plan. Nearly all goods are moved by truck at some point, whether imported through the ports, from other states, Mexico, or Canada, whether generated and consumed within California, or whether generated and exported from California. Locomotive emissions are also significant and growing. Including all rail trips in this plan increased locomotive emissions by a factor of two to three from the draft plan. In addition to statewide emissions estimates, ARB staff has included regional goods movement emissions analyses for South Coast, San Francisco Bay Area, San Joaquin Valley, San Diego, and Sacramento (see Appendix B – Regional Analyses).

<u>Emission Reduction Targets</u>

As noted above, the Phase I and II Goods Movement Action Plans include goals to reduce goods movement-related emissions over time. This plan defines several additional targets for each emission source category, based on staff's assessment of technological feasibility and probable timing. In every case, the emission reduction targets are inclusive of anticipated growth. When implemented, they will result in a net *decrease* in emissions.

This plan also anticipates what the potential attainment needs of the South Coast air basin will be with respect to the national 8-hour ozone and PM2.5 standards. For ports and international goods movement sources, the plan seeks to reduce NOx emissions by 30% in 2015 beyond current control levels, and an additional 50% beyond current control levels in 2020. These NOx targets are based on very preliminary "carrying capacity" estimates that will be refined through modeling as part of the upcoming State Implementation Plan (SIP) process. We did not revise this target with the inclusion of domestic goods movement. The goal in the draft plan was intended to be a preliminary step in the attainment planning process. Once the South Coast region has an ozone attainment target and firm attainment date, the goods movement target can be revisited.

The plan now explicitly recognizes the need for statewide application of the plan strategies, especially in the San Joaquin Valley. A qualitative goal has been added to reflect the need for 2015 and 2020 NOx reductions to aid in attainment of federal and State air quality standards. No additional regional targets have been added, but the plan specifies the anticipated reductions from goods movement emission sources in each region. During SIP preparation, final regional reduction targets will be developed, all source categories will be more closely assessed, and a complete list of SIP measures will be proposed taking into account technological feasibility and cost. This will occur through a public process involving ARB, U.S. EPA, local air districts, metropolitan planning organizations and all other stakeholders. New SIPs for ozone and PM2.5 are due in 2007 and 2008, respectively.

Emission Reduction Strategies

Expanding the universe of sources to cover ports and all goods movement increases overall emissions of diesel PM, NOx, ROG by two to three-fold in 2001 and 2005. When the new plan strategies would begin implementation by 2010, the gap begins to decrease and continues to do so through 2020. The plan is relatively more effective in reducing total goods movement emissions than the international goods movement portion, primarily due to measures already in place to reduce future truck emissions. The percent emission reduction that this plan would achieve by 2020 is greater for each pollutant than the draft plan -- diesel PM is reduced 79% compared to 44% in the draft plan, while NOx decreases 63% over this time period compared to 55% previously. SOx shows the smallest change (78% reduction now versus 73% before) because both versions of the plan included all ships, with roughly the same uncontrolled emissions in later years. Table 2 shows the emission trend for each pollutant with implementation of the plan strategies.

Table 2
Statewide
Trends in Emissions from Ports and Goods Movement with Full Implementation of Plan Strategies
(tons per day)

Pollutant	Year					
	2001	2005	2010	2015	2020	% Reduction 2001-2020
Diesel PM	57	53	32	17	12	79%
NOx	1,071	1,080	807	544	393	63%
ROG	94	90	71	50	39	58%
SOx	73	94	42	16	16	78%

Ships are the most challenging emission sources in the goods movement system. The vessels that transport goods in and out of California harbors have little or no emissions control and run on high emitting bunker fuel. Unless that changes, ship emissions will continue to increase as trade expands. Ocean going ships are the only sector that does not meet the 2010 goal for reducing diesel PM, NOx, and ROG emissions back to 2001 levels. Instead, this plan would achieve that goal by 2015. Ships are projected to lower SOx emissions to 2001 levels by 2010 with implementation of a new ARB regulation requiring lower sulfur fuels for auxiliary engines. The plan proposes a mix of strategies for ocean going ships that would reduce projected emissions from this category 50% or more in 2015 and 70% or more in 2020.

Commercial harbor craft were an early focus for ARB and air districts given proximity to coastal communities. More than $17 million in Carl Moyer Program funds have been used to clean up commercial harbor craft to date. In 2004, ARB adopted a regulation requiring harbor craft to use cleaner diesel fuel statewide starting in 2007. Later this year, ARB will consider a regulation to clean up existing harbor craft propulsion and auxiliary engines via replacement, rebuild, add-on controls, and/or alternative fuels. Shore power for harbor craft is also under consideration. The plan targets a 70% plus reduction in this category by 2020.

Cargo handling equipment poses a major health risk to near-port communities due to the location of the emissions. On December 8, 2005, the Board approved a new regulation to reduce these emissions. The regulation will accelerate the introduction of cleaner technologies beginning in 2007 with increasing benefits in 2010 through 2015. The overall strategy relies on implementation of new engine standards that phase in from 2007-2015. Overall, emissions from cargo handling will continue to decline through 2020 and beyond. The last element of the strategy would be to step up diesel PM control to the 85% level in the future as additional verified retrofit technologies become available. By 2020, emissions from this sector will be reduced by over 80% for the key pollutants.

Trucks are the largest contributor to port-related NOx and the largest on-shore source of diesel PM. Existing regulations are reducing these emissions each year but very significant impacts remain. Cleaning up the older, short-haul truck fleets (including those serving ports), reducing traffic congestion and idling, routing trucks away from neighborhoods, and providing the cleanest diesel fuel are components of the overall truck strategy. Recent ARB actions include anti-idling rules, controls for transport refrigeration units, community-based truck inspections, low sulfur fuel requirements, and reducing excess NOx from 1993-1998 trucks. The primary new strategies in this plan are to apply the best available control technology to the entire truck fleet in private ownership, with a targeted program to modernize the subset of trucks serving ports. The plan targets an 88% reduction in diesel PM, and about a 60% reduction for NOx and ROG by 2020.

Locomotives are subject to existing federal standards and the two memoranda of understanding negotiated with the ARB in 1998 and 2005. The plan proposes new strategies to upgrade engines in switcher locomotives and to retrofit diesel PM controls on existing engines. There are at least two technologies that could provide 95% percent control for diesel PM and over 70% for NOx from switchers by 2010: diesel-electric hybrids and multiple off-road diesel engine configurations. Particulate retrofits have not been used in California rail yards yet but they have been introduced in Europe. Both major railroads are testing locomotives equipped with diesel particulate filters right now. A third element of the strategy relies on U.S. EPA adoption of cleaner new engine standards (Tier 3), more stringent rebuild requirements, and national idling limit devices. ARB staff is recommending federal standards that would achieve 90% control of diesel PM and NOx for new engines. A comprehensive program to bring these cleaner locomotives to California could convert 90% of the fleet by 2020. The plan targets an 85% reduction or better in PM by 2020 for all pollutants.

The plan includes two additional strategies that are conceptual in nature and would be implemented by other agencies and segments of the goods movement industry. These are improved land use decision-making and site specific mitigation at the project or community level.

In 2005, ARB recognized the importance of land use decision-making with the approval of our guidance document "Air Quality and Land Use Handbook: A Community Health Perspective." This document recommends that local government consider the health impacts of air pollution in land use permitting and planning processes. A key recommendation is to provide appropriate separation between air pollution sources, like ports and rail yards, and sensitive land uses, like homes and schools.

The other overarching strategy is mitigation tailored to address existing community problems or the impacts of new projects. Environmental review provisions of State and federal law provide the legal framework for development of environmental mitigation where government approvals are required for a new project. For major expansions related to goods movement, development of a community benefits agreement may be a mechanism to address environmental and other community impacts. The concepts outlined in the plan for statewide application -- especially use of cleaner engines and fuels – may be feasible earlier in targeted situations. This provides opportunities for site specific mitigation prior to full implementation of the strategies on a statewide basis. This would help mitigate community impacts as quickly as possible with a priority on the most impacted areas. Mitigation of existing impacts near rail yards is an example of the need to address health risk issues in specific communities as well as on a statewide basis.

With the revised emission inventory and strategies, the plan would reduce combined emissions of the four pollutants by 163 tons per day in 2010; 375 tons per day in 2015; and 530 tons per day in 2020.

The complete list of plan strategies along with implementation timeframes is shown in Table 3.

Table 3
List of Strategies to Reduce Emissions from Ports and Goods Movement

Strategy	Status (Adopted or New Strategy)	Implementation Could Begin		
		2006-2010	2011-2015	2016-2020
SHIPS				
Vessel Speed Reduction Agreement for Southern California	2001	✓		
U.S. EPA Main Engine Emission Standards	2003	✓		
U.S. EPA Non-Road Diesel Fuel Rule	2004	✓		
ARB Rule for Ship Auxiliary Engine Fuel	New (2005)	✓		
Cleaner Marine Fuels	New	✓	✓	✓
Emulsified Fuels	New	✓	✓	✓
Expanded Vessel Speed Reduction Programs	New	✓	✓	✓
Engines with Emissions Lower than IMO Standards in New Vessels	New	✓	✓	✓
Dedication of Cleanest Vessels to California Service	New	✓		
Shore Based Electrical Power	New	✓		
Extensive Retrofit of Existing Engines	New		✓	✓
Highly Effective Controls on Main and Existing Engines	New		✓	✓
Sulfur Emission Control Area (SECA) or Alternative	New		✓	
Expanded Use of Cleanest Vessels in California Service	New		✓	
Expanded Shore Power and Alternative Controls	New		✓	
Full Use of Cleanest Vessels in California Service	New			✓
Maximum Use of Shore Power or Alternative Controls	New			✓
COMMERCIAL HARBOR CRAFT				
Incentives for Cleaner Engines	2001-2005	✓		
ARB Low Sulfur Diesel Fuel Rule	2004	✓		
ARB Rule to Clean Up Existing Engines	New	✓		
Shore Based Electrical Power	New	✓		
U.S. EPA or ARB New Engine Emission Standards	New		✓	
CARGO HANDLING EQUIPMENT				
ARB Low Sulfur Diesel Fuel Rule	2003	✓		
ARB/U.S. EPA Tier 4 Emission Standards	2004	✓		
ARB Stationary Diesel Engine Rule	2004	✓		
ARB Portable Diesel Equipment Rule	2004	✓		
Incentives for Cleaner Fuels	2001-2005	✓		

Strategy	Status (Adopted or New Strategy)	Implementation Could Begin		
		2006-2010	2011-2015	2016-2020
CARGO HANDLING EQUIPMENT, continued				
ARB Rule for Diesel Cargo Handling Equipment	New (2005)	✓		
ARB Rule for Gas Industrial Equipment	New	✓		
Upgrade to 85 Percent Diesel PM Control or Better	New		✓	
Zero or Near Zero Emission Equipment	New			✓
TRUCKS				
ARB/U.S. EPA 2007 New Truck Emission Standards	2001	✓		
Vehicle Replacement Incentives	2001-2005	✓		
ARB Low Sulfur Diesel Fuel Rule	2003	✓		
ARB Smoke Inspections for Trucks in Communities	2003	✓		
Community Reporting of Violators	2005	✓		
ARB Truck Idling Limits	2002-2005	✓		
ARB Low NOx Software Upgrade Rule	2005	✓		
ARB International Trucks Rule	New (2006)	✓		
ARB Private Truck Fleets Rule	New	✓	✓	
Port Truck Modernization	New	✓	✓	✓
Enhanced Enforcement of Truck Idling Limits	New	✓		
LOCOMOTIVES				
ARB Low Sulfur Diesel Fuel Rule	2004	✓		
ARB 2005 Agreement with Railroads to Cut PM Statewide	2005	✓		
Idle Enforcement Training	2006	✓		
Upgrade Engines in Switcher Locomotives	New	✓		
Retrofit Diesel PM Control Devices on Existing Engines	New	✓		
Use of Alternative Fuels	New	✓		
More Stringent National Requirements	New		✓	
Concentrate Tier 3 Locomotives in California	New		✓	✓
OPERATIONAL EFFICIENCY				
Efficiency Improvements	New	✓	✓	✓
Transport Mode Shifts	New	✓	✓	✓
LAND USE DECISIONS	New	✓	✓	✓
PROJECT AND COMMUNITY SPECIFIC MITIGATION	New	✓	✓	✓
PORT PROGRAMS TO REDUCE EMISSIONS	Ongoing/New	✓	✓	✓

Health and Economic Impacts

The strategies outlined in this plan will provide significant statewide health benefits and in the communities adjacent to ports, rail yards, intermodal facilities, distribution centers, and highways. These strategies are projected to reduce health impacts by 50% in 2020 after accounting for growth, as compared to a no further action baseline. Table 4 shows the health benefits in 2020, expressed as the number of cases avoided in that year with the plan strategies. We recognize that the health impacts that would remain after plan implementation are still very significant. But achieving the goals in this plan would clearly advance our efforts to meet California's health protective standards for particulate matter and ozone, as well as cut the health risk from diesel PM in communities highly impacted by goods movement.

Table 4
Health Benefits[1] of New Plan Strategies in 2020

Health Outcome	Cases[2] Expected without Plan in 2020	Cases[2] Avoided with Plan in 2020
Premature Death	1,700	820
Hospital Admissions (respiratory causes)	1,500	530
Hospital Admissions (cardiovascular causes)	580	300
Asthma and Other Lower Respiratory Symptoms	42,000	21,000
Acute Bronchitis	3,400	1,800
Work Loss Days	250,000	130,000
Minor Restricted Activity Days	2,800,000	1,200,000
School Absence Days	860,000	270,000

[1] Does not include the reduction in contributions from particle sulfate formed from SOx emissions, which is being evaluated with several ongoing emissions, measurement, and modeling studies.
[2] Ranges and uncertainty bounds can be found in Appendix A.

The projected health benefits from the plan strategies also have an economic benefit, as shown in Table 5 below.

Table 5
Value of Health Benefits from New Plan Strategies in 2020
(present value)

[corrected]

Health Outcome	Value in 2020 (in millions)	Uncertainty Range[1] (in millions)
Premature Death	$3,700	$850 to $8,800
Hospital Admissions (respiratory causes)	$11	$5 to $20
Hospital Admissions (cardiovascular causes)	$8	$4 to $15
Asthma and Other Lower Respiratory Symptoms	$0.2	$0.06 to $0.4
Acute Bronchitis	$0.4	-$0.1 to $1
Work Loss Days	$15	$10 to $22
Minor Restricted Activity Days	$39	$18 to $70
School Absence Days	$16	$5 to $32
Total	**$4,000**	**$900 to $9,000**

[1] Range reflects statistically combined uncertainty in concentration-response functions and economic values, but not in emissions or exposure estimates.

By 2020, the total cumulative cost to implement the new plan strategies is $6-10 billion in present value dollars. Table 6 shows the range of cumulative costs.

Table 6
Cumulative Costs to Implement Plan Strategies
(present value)

Year	Range of Cumulative Cost (in billions)	
	Low End	High End
2007 - 2010	$2	$2
2007 - 2015	$4	$6
2007 - 2020	$6	$10

To derive a benefit-cost ratio, we looked at the cumulative benefits from health effects avoided (including premature death, hospitalization due to respiratory and cardiovascular causes, asthma and other lower respiratory symptoms, and acute bronchitis) and the economic value of those benefits over the 2005-2020 timeframe of the plan, in present value dollars.

Table 7
Benefit-Cost Ratio for Plan Strategies Through 2020
(present value)

	Cumulative Benefits and Costs
Cumulative Premature Deaths Avoided by Plan Strategies	7,200
Cumulative Economic Value of All Health Effects Avoided	$34 – $47 billion
Cumulative Costs to Implement Plan Strategies	$6 - $10 billion
Benefit-Cost Ratio	**3-8 to 1**

Thus, for every $1 invested to implement these strategies, $3 to $8 in economic benefits are realized by avoided health effects. Premature deaths avoided account for over 95 percent of the estimated economic value of all health benefits of the plan.

Plan Performance

ARB staff has evaluated whether the emission reduction plan is sufficient to meet the numerical goals set forth in the introduction above.

The first objective is to stop emissions growth. In Southern California, the Board of Harbor Commissioners set a goal of "no net increase" in emissions from the Port of Los Angeles using a 2001 baseline. This plan applies the same goal statewide. Staff calculated the reductions needed to meet the 2010 target on a statewide basis and for local air districts with the greatest port and goods movement activity -- South Coast, San Diego, San Francisco and the San Joaquin Valley. In every case, the 2010 target will be achieved, and in some geographical areas emissions will be reduced well below 2001 levels.

With respect to reducing the statewide health risk of diesel PM from ports and goods movement-related sources 85% by 2020, the plan now meets that goal. Staff estimates that the plan will achieve a 79% mass reduction in goods movement-related diesel PM by that date and a corresponding 86% exposure-weighted risk reduction.

For the South Coast NOx reduction targets, the picture is good. Compared to the 30% reduction target by 2015, the plan provides for 48% control. Similarly, for the 50% reduction target in 2020, the plan provides 67% control.

Vision for the Future

Meeting the public health challenge posed by goods movement requires a combination of innovative and readily available strategies. Government will do its part but cleaner technology and operational efficiencies must become the industry standard. The draft plan envisions that emissions reductions will be reduced at each step in the goods movement pathway – from ship to shore to truck or locomotive to the final destination. New emission standards for engines, cleaner fuels, performance standards and incentives, fleet upgrades and retrofits are all part of the picture.

Timing is crucial. There is already a public health threat that needs to be abated as quickly as possible while we prepare for even greater growth in international trade. ARB's strategy provides several near-term reductions, with longer term measures to provide a cleaner goods movement system by 2020. Steady progress is also needed. The proposed plan provides for reductions in statewide port and goods movement emissions after accounting for projected growth.

Staff's long term vision is an economically vibrant, environmentally sustainable, non-polluting goods movement industry that enhances the quality of life for all Californians.

Staff Recommendation

ARB staff recommends that the Board approve the *Proposed Emission Reduction Plan for Ports and Goods Movement in California* as a framework for action to protect the residents of California from the harmful effects of air pollution from goods movement operations.

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CHAPTER I

PUBLIC HEALTH IMPACTS

Air pollution from trade and goods movement is a major public health concern at the statewide, regional, and community level. Adverse health impacts from the pollutants associated with goods movement include but are not limited to premature death, cancer risk, respiratory illnesses, and increased risk of heart disease. This plan attempts to quantify the aggregate health effects of goods movement-related pollutants where such data are available. Where health studies suggest a link between air pollution and certain effects but data is limited, we discuss those effects qualitatively. A health impacts analysis (see Appendix A) underwent scientific peer review concurrent with the public review process for the draft plan.

The emissions inventory in this plan illustrates that goods movement activities occur throughout California. The emissions and associated health impacts are greatest in regions with major ports. However, there are goods movement-related truck emissions throughout the State and comparable locomotive emissions in several regions as well.

Health risk at the community level is of special concern because exposure is highest near ports, rail yards, and high-volume truck traffic. ARB staff recently did health risk assessments for the Ports of Los Angeles and Long Beach, and for the Roseville Rail Yard, which characterize the elevated health risks near these facilities. Additional facility-specific risk assessments are pending for the Port of Oakland and for 16 major rail yards in the State. The strategies in this plan are essential to reducing localized health risks and to meet the goal of an 85 percent reduction in health risk from diesel particulate matter by 2020.

A. PARTICULATE MATTER AND OZONE HEALTH IMPACTS

The health impacts analysis quantifies the following health effects on a statewide basis: premature death, hospital admissions (respiratory causes), hospital admissions (cardiovascular causes), asthma and other lower respiratory symptoms, acute bronchitis, work loss days, minor restricted activity days, and school absence days. These effects were calculated using the same scientific methodology used and peer-reviewed in ARB's recent reviews of the State ambient air quality standards for particulate matter and ozone. The concentration-response functions (that is, the relationship between air pollution exposure and the magnitude of health effect) are from peer-reviewed epidemiological studies.

There are other potential adverse health effects that are addressed in a sensitivity discussion. They are not included in the core calculations either because the information from the peer-reviewed epidemiological studies was not sufficient to quantify effects or the evidence is not strongly suggestive of a causal relationship with air pollution exposures. To avoid double-counting, certain health endpoints were not included if they are a subset of endpoints already quantified in the analysis. See Appendix A for further details.

The health outcomes shown in Table I-1 take into account a number of factors including the relationship between air pollutant concentrations and the effect found in health studies, the relative contribution of emission sources to monitored pollutants in a region, and the population in a region. The regional impacts (by air basin) were added to provide a statewide total. There is a range of values shown for each health effect reflecting the potential uncertainty in the assessment. The range is derived using a commonly accepted statistical method (i.e., the 95 percent confidence interval).

Table I-1
Statewide
Annual 2005 PM and Ozone Health Effects Associated with Ports and Goods Movement in California[1]

Health Outcome	Cases per Year	Uncertainty Range[2] (Cases per Year)	Valuation (millions)	Uncertainty Range[3] (millions)
Premature Death	2,400	720 to 4,100	$19,000	$5,900 to $36,000
Hospital Admissions (respiratory causes)	2,000	1,200 to 2,800	$67	$40 to $94
Hospital Admissions (cardiovascular causes)	830	530 to 1,300	$34	$22 to $53
Asthma and Other Lower Respiratory Symptoms	62,000	24,000 to 99,000	$1.1	$0.44 to $1.8
Acute Bronchitis	5,100	-1,200 to 11,000	$2.2	$-0.52 to $4.7
Work Loss Days	360,000	310,000 to 420,000	$65	$55 to $75
Minor Restricted Activity Days	3,900,000	2,200,000 to 5,800,000	$230	$130 to $350
School Absence Days	1,100,000	460,000 to 1,800,000	$100	$41 to $160
TOTAL VALUATION	NA	NA	$19,000	$6,000 to $37,000

[1] Does not include the contributions from particle sulfate formed from SOx emissions, which is being addressed with several ongoing emissions, measurement, and modeling studies.

[2] Range reflects uncertainty in health concentration-response functions, but not in emissions or exposure estimates. A negative value as a lower bound of the uncertainty range is not meant to imply that exposure to pollutants is beneficial; rather, it is a reflection of the adequacy of the data used to develop these uncertainty range estimates. Additional details on the methodology and the studies are in Appendix A.

[3] Range reflects statistically combined uncertainty in concentration-response functions and economic values, but not in emissions or exposure estimates.

In the draft plan, we estimated that the annual statewide premature deaths that can be associated with exposure to ozone and particulate pollution above State standards is 9,000. This estimate was based on the calculations done as part of ARB's most recent revisions to State standards using 1999-2003 data. We plan to update this estimate later this year pending review of the new mortality studies discussed below. We will also update the population and monitoring data. On a regional basis, monitoring data shows decreased particulate matter and ozone exposures in the last five years which would lower the estimates if nothing else changed. However, the new heath studies on PM and premature mortality seem to indicate that current estimates are underestimated. We won't know the net effect until later this year.

Although the methodology used here to quantify premature death from PM exposure is the same as that used in previous ARB analyses, these calculations are based on a concentration-response function from a more recent publication (Pope et al., 2002). This peer-reviewed, published paper expanded the available data set from the original epidemiological study. It also forms the basis for similar health impact analyses performed by other government agencies, including the U.S. Environmental Protection Agency (U.S. EPA). The end result is a more comprehensive analysis that increased the number of premature deaths associated with exposure to particulate matter by 25 percent compared to calculations based on Krewski et al., 2000.

Recent Mortality Studies. Several new epidemiology studies have recently been published which may also be relevant to the health impacts analysis. In November 2005, a study that analyzed PM exposure and premature death in the Los Angeles area was published (Jerrett et al., 2005). It found a 2.5 times higher estimate for premature death than the national study by Pope et al., 2002, but greater uncertainty. Several additional studies have either just been published or will be in the next few months. ARB staff intends to review all of these studies and will solicit the advice of the study authors and other experts in the field and U.S. EPA to determine how to best incorporate these new results into our future assessments.

The method used to quantify the health effects from ozone is detailed in ARB's review of the State ozone standard. The analysis was based on ozone concentrations above the ARB's newly approved State 8-hour ozone standard. Premature mortality was calculated based on a number of epidemiological studies of short-term (daily) exposure to ozone. As with particulate matter, other types of studies were used to estimate the relationship between air pollution and hospital admissions and other effects.

The health effects shown in Table I-1 are from a combination of exposure to ozone, directly emitted (primary) diesel particulate matter, particulate matter formed in the atmosphere (secondary), and other directly emitted sources of PM (like tire and brake wear) from goods movement emissions. Particulate and ozone related effects are analyzed separately based on the health studies linking a pollutant to an adverse health effect. For example, particulate matter and ozone are independently associated with premature death.

Table I-2 shows the relative contribution, by pollutant – primary PM, secondary PM, and ozone – for premature death for 2005, 2010, and 2020. This analysis shows substantially greater health impacts than the draft plan due to the addition of domestic goods movement emissions. The estimated impacts of the international portion of goods movement are slightly lower than in the draft plan due to emission inventory changes (see Appendix D for the health impacts of the international component). Looking at goods movement as a whole, the health impacts decrease over time with the existing control program (despite growth), but are more than double the impacts of the international component alone.

Table I-2
Mortality Effects Associated with Ports and Goods Movement: Pollutant Contributions[1]

Pollutant	**Number of Deaths in Each Year** (uncertainty range in parentheses)		
	2005	2010	2020[2]
Primary Diesel PM	1,200 (330-2,000)	920 (260-1600)	630 (170-1100)
Secondary Diesel PM (Nitrates)	940 (260-1600)	850 (240-1500)	790 (220-1400)
Secondary Diesel PM (Organic Aerosols)	29 (8-50)	25 (7-43)	20 (5-34)
Other Primary PM2.5[3]	23 (6-39)	26 (7-44)	41 (11-71)
Ozone	240 (120-350)	210 (100-310)	180 (88-260)
Statewide Total	2,400 (720 to 4,100)	2,000 (610 to 3,400)	1,700 (500 to 2,800)

[1] Does not include the contributions from particle sulfate formed from SO_X emissions, which is being evaluated with several ongoing emissions, measurement, and modeling studies.
[2] These values may overestimate the health impacts if the State ambient air quality standards for particulate matter and ozone are attained by the year 2020 (see methodology in Appendix A).
[3] PM2.5 includes tire wear, brake wear, and particles from boilers, which are not covered under primary diesel PM.

ARB's health impacts analysis (Appendix A) provides additional detail on the data used to calculate the statewide values in Table I-2. This includes exposure estimates by pollutant and mortality effects for each basin. Not surprisingly, 50 percent of premature deaths associated with ports and all goods movement are in the South Coast Air Basin. The South Coast Air Basin has more emissions and more people. For example, the San Diego, San Francisco Bay Area, and San Joaquin Valley Air Basins collectively account for 27 percent of the premature deaths, with the remaining distributed primarily among a few other urban areas.

Health effects from sulfate emissions. Emissions of sulfur oxides (SOx) contribute to particle sulfate formation (and PM-related health effects) through complex chemical reactions and physical processes in the atmosphere. Stringent regulations on the sulfur content of motor fuels and stationary source controls have minimized SO_X emissions from most California sources. The largest uncontrolled fossil fuel sulfur source in California is the burning of residual oil as fuel in ocean-going vessels.

The December 2005 draft of this plan did not include a quantitative health assessment of particle sulfates formed from goods movement-related emissions of SOx. Any analysis is complicated by the fact that, in addition to sulfate formed from fossil fuel use in California, there are three other sources of atmospheric sulfate in California – natural "background" sulfate formed over the ocean by biologic activity, global "background" sulfate that is distributed throughout the Northern Hemisphere by the upper air westerly winds, and sulfate blown into Southern California from combustion in Mexico.

New analyses of air quality and emissions data conducted in the intervening period indicate that uncontrolled SOx emissions from ships increase the estimates of total goods movement-related health effects by about one quarter. However, this preliminary estimate contains several uncertainties and a fully quantitative analysis must await the completion (by end of 2006) of research being jointly conducted by ARB staff, five university groups, U.S. EPA, and Environment Canada as part of a feasibility study for establishing a SOx Emission Control Area (SECA) to reduce sulfur emissions from West Coast shipping. The research includes a refined inventory of ship activity and ship emissions, analysis of historical PM data from sites along the West Coast to look for evidence of ship emissions, development of new monitoring methods that can distinguish fossil fuel sulfate from that due to biologic activity in the ocean, and model development to allow simulation of sulfate formation and transport over the ocean and land areas of coastal California.

Table I-3 summarizes the known health effects that can be associated with the exposure to PM and ozone. The non-quantified effects in Table I-3 are of several types. For example, particulate air pollution is associated with increased risk of heart disease, but we cannot yet quantify the effects. Adverse birth outcomes, effects on the immune system, multiple respiratory effects, and neurotoxicity are additional potential health effects not captured by quantitative risk assessments. For those with underlying heart disease or diabetes, exposure to air pollution can compound the effects of their illnesses. Understanding the relationship between existing disease and increased exposure will be extremely important in further quantifying the health effects of air pollution. When the epidemiological studies provide sufficient information for quantification, these potential additional health effects will be quantified.

Table I-3
Health Effects of PM and Ozone from Goods Movement: Quantified and Unquantified Effects

Health Effect	Identified		Included in Quantitative Analysis	
	PM	*Ozone*	*PM*	*Ozone*
Mortality				
All-cause mortality in adults	X	X	X	X
Cardiopulmonary mortality in adults	X	X	*	*
Lung cancer mortality in adults[1]	X	--	*	--
Infant mortality	X	--	†	--
Respiratory Hospital Admissions				
Hospital admissions for all pulmonary illnesses	X	X	X	X
Hospital admissions for chronic obstructive pulmonary disease	X	X	**	**
Hospital admissions for pneumonia	X	X	**	**
Hospital admissions for asthma	X	X	**	**
Cardiovascular Hospital Admissions				
Hospital admissions for all cardiovascular illnesses	X	--	X	--
Emergency Room Visits				
Emergency room visits for asthma	X	X	†	†
Other Morbidity Effects				
Myocardial infarction (heart attack)	X	--	†	--
Chronic bronchitis	X	--	†	--
Acute bronchitis	X	--	X	--
Asthma and other lower respiratory symptoms	X	--	X	--
Minor restricted activity days	X	X	X	X
Work loss days	X	--	X	--
School absences	--	X	--	X
Asthma onset	--	X	--	†
Low birth weight, pre-term birth	X	--	†	--
Respiratory Symptoms in Asthmatics				
Exacerbation of asthma	X	X	†	†
Respiratory symptoms (e.g., bronchitis, phlegm, cough)	X	X	X	†
Asthma attacks	X	X	†	†

1 Lung cancer mortality associated with exposure to ambient PM and lung cancer risk associated with diesel particulates.
X These endpoints have been identified and, if sufficient data available, were quantified.
* These endpoints were not included in the quantitative analysis because they are subsets of all-cause mortality, which is included.
** These endpoints are a subset of all-respiratory hospital admissions.
† These endpoints were not quantified due to insufficient information to perform a quantitative analysis. Please see Appendix A for more detail.
-- These pollutants have not been identified as associated with these health endpoints in this document.

B. COMMUNITY HEALTH

The concentration of diesel particulate emissions in communities is a major public health concern and focus of this plan. Diesel PM was identified by ARB as a toxic air contaminant in 1998. At that time, the health risk assessment focused on cancer risk based on the results of a number of epidemiological studies that found that exposure to diesel exhaust was linked to increased lung cancer risk. As a component of particulate matter pollution, diesel particulate matter also contributes to premature death and the other health effects quantified in our analysis. Many other health effects have been linked to diesel particulate matter either separately or as a component of particulate matter air pollution. While many of these effects cannot yet be quantified, they are important in the overall characterization of the health problem posed by diesel particulate emissions.

The effects of diesel PM are of special concern for individuals especially vulnerable to the effects of air pollution. This includes children, pregnant women, the elderly, and those with existing heart and lung illnesses. Understanding the types of exposures experienced by vulnerable populations in communities is necessary to define the scope of health risk posed by diesel PM. In short, close proximity to the source of air pollution will increase the health risk. For example, air pollution studies indicate that living close to high traffic increases health risk beyond regional risk levels. Many of these epidemiological studies focused on children living or attending school near heavily traveled roadways. The effects found include reduced lung function in children, asthma and bronchitis symptoms, and increased asthma hospitalizations. In these studies the distance from major roadways and truck traffic densities were key factors affecting risk.

Air quality modeling studies done for ports and rail yards have also shown that health risk varies with distance. ARB's study of the Roseville Rail Yard predicted potential cancer risk was highest immediately adjacent to the yard's maintenance operations (within 1000 feet). ARB has also adopted land use guidance that recommends providing appropriate distance between major air pollution sources (like freeways, rail yards, or ports) and new homes, schools, and other sensitive land uses. The goal is to prevent elevated health risk due to close proximity of sensitive land uses to air pollution sources, even as new air pollution control strategies continue to reduce existing health risks.

C. HEALTH RISK ASSESSMENTS FOR DIESEL PARTICULATE MATTER

About 70 percent of the potential cancer risk from toxic air contaminants in California is due to diesel PM. Goods movement activities are a significant source of exposure to this pollutant. The regional risk for diesel particulate in urban areas is about 500-800 potential cancers per million people over a 70-year period. For areas in close proximity to major diesel sources, such as ports, rail yards and along major transportation corridors, the increase in cancer risk from these sources alone can exceed 500 per million in some locations. Since the concentration of diesel PM in the air declines with distance from the sources, risk decreases the farther one moves away from goods movement activity centers. However, even several miles away, the associated cancer risk can exceed 10 per million.

The potential cancer risks are highly dependent on site specific variables such as meteorological conditions, the types of activities occurring, the locations and emission rates of the equipment, operating schedules and the actual location where people live in relation to a goods movement operation. To better understand the potential health risk associated with goods movement activities, ARB staff conducted two key health risk assessments. One is for a major port complex and the other for a large rail yard.

ARB's assessment of diesel PM health impacts of the Ports of Los Angeles and Long Beach characterized the increased risk of cancer and non-cancer health effects to nearby neighborhoods. In the health analysis for the draft plan, ARB staff updated the analysis of the non-cancer health effects from this assessment in three ways. First, the impact of the two ports was calculated for the entire area surrounding the ports (40 mile by 50 mile), not the smaller study area near the ports. Second, the updated methodology, using Pope et al (2002) for calculating premature death associated with particulate pollution was used. Third, the emissions inventory was updated from 2002 to 2005. For this plan, we show the updated analysis in Table I-4 with the revised emission inventory used throughout the plan. The effects include 67 premature deaths, 41 hospital admissions for respiratory or cardiovascular causes, and 2,100 cases of asthma and other lower respiratory symptoms. Similar analyses can be done for other ports once additional port-specific emissions inventories are completed.

The port assessment found that the areas with the greatest impact outside port boundaries have an estimated cancer risk of over 500 in a million. About 50,000 people live in these locations. The area where cancer risk is predicted to exceed 200 in a million is more widespread and includes over 400,000 people. Overall, the study found that the impact areas extend several miles from the ports. The predicted cancer risk at some locations at the edge of the study area was as high as 100 in a million, so not all impact areas were identified.

The port study also looked at the cancer risk for individual emissions sources and activities. The largest contributors to cancer risk were cargo handling equipment and ships using diesel engines at dock while hotelling. While ships in transit produce a substantial portion of total port-related diesel PM, they did not produce a comparable cancer risk because these emissions are released off-shore and dispersed over a very wide area.

Table I-4
Non-Cancer Health Effects from Activities at the Ports of Los Angeles and Long Beach[1]
(2005)

Health Outcome	Cases Per Year	Range[2]
Premature Death	67	18 to 120
Hospital Admissions (respiratory causes)	14	9 to 20
Hospital Admissions (cardiovascular causes)	27	17 to 41
Asthma and Other Lower Respiratory Symptoms	2,100	780 to 3,300
Acute Bronchitis	170	-40 to 390
Work Loss Days	12,000	10,000 to 14,000
Minor Restricted Activity Days	71,000	58,000 to 84,000

[1] Does not include the contribution from particle sulfate formed from SOx emissions, which is being evaluated with several ongoing emissions, measurement, and modeling studies.
[2] Range reflects uncertainty in health concentration-response functions, but not in emissions or exposure estimates. A negative value as a lower bound of the uncertainty range is not meant to imply that exposure to pollutants is beneficial; rather, it is a reflection of the adequacy of the data used to develop these uncertainty range estimates. Additional details on the methodology and the studies used in this analysis are given in Appendix A.

The risk assessment done for the Roseville Rail Yard estimated potential cancer risk from diesel particulate for all the locomotive operations at the yard. The total diesel particulate emissions at this yard break out as follows: moving locomotives account for about 50 percent, idling locomotives account for about 45 percent, and locomotive testing account for about 5 percent. ARB's air quality modeling predicts potential cancer risks greater than 500 in a million, based on 70 years of exposure, offsite and adjacent to the maintenance operation area. Risk levels of 100-500 in a million occur over an area where about 20,000 people live. Risk levels between 10 and 100 in a million occur over an area where about 150,000 people live. The health impacts of other rail yards will be site specific. Risk assessments for an additional 16 rail yards in California will be developed over the next two years.

D. HEALTH-RELATED COSTS

The costs associated with the health impacts discussed here are high. ARB staff has quantified the health impacts for premature death, hospital admissions, asthma symptoms, work loss days, minor restricted activity days, and school absence days. Using that data, we have also monetized the value of these impacts. ARB staff's assessment in Appendix A discusses the methodology applied. The valuations used for individual health effects are shown here in Table I-5.

Table I-5
Values for Health Effects per Case of Mortality, Hospital Admissions and Minor Illnesses
(2005 dollars)

Health Endpoint	2005	2010[1]	2020[1]	References
Mortality[2]				
Premature death ($ millions)	7.9	8.1	8.6	U.S. EPA (1999), (2000), (2004)
Hospital Admissions				
Cardiovascular ($ thousands)	41	44	49	ARB (2003), p.63
Respiratory ($ thousands)	34	36	40	ARB (2003), p.63
Minor Illnesses				
Acute bronchitis	422	440	450	U.S. EPA (2004), 9-158
Lower respiratory symptoms	19	19	20	U.S. EPA (2004), 9-158
Work loss day	180	195	227	2002 California wage data, US Department of Labor
Minor restricted activity day	60	62	64	U.S. EPA (2004), 9-159
School absence day	88	95	111	U.S. EPA (2004), 9-159

[1] Undiscounted values.
[2] The premature death values are adjusted by an income factor for the respective years.

The values for premature death, minor restricted activity days, acute asthma, and school absence days are based on U.S. EPA's monetary values. ARB calculated the cost of hospital admission for acute respiratory problems as the direct cost of illness plus associated costs such as time lost from productive activity. Work day loss was calculated using California wage data. The valuations for premature death increase over time based on expected increases in real income. The values assume that real income increases at a constant rate of 0.8 percent per year through 2020.

The statewide valuation of health effects is shown in Table I-6. These numbers are calculated using the health impacts estimates, the monetary valuations, and the discount rates recommended in U.S. EPA's guidance on social discounting.

Table I-6
Economic Value of Health Impacts of Statewide PM and Ozone From Ports and Goods Movement with Measures Adopted Through October 2005
(present value)

	Year		
	2005	2010	2020
Value (in millions)	$19,000	$13,000 to $15,000	$5,700 to $9,700
Uncertainty Range (in millions)	($6,000 to $36,000)	($4,000 to $28,000)	($2,000 to $18,000)

CHAPTER II

EMISSION INVENTORY

A. INTRODUCTION

This chapter describes the emissions associated with goods movement in California. The December 2005 draft plan focused on the movement of internationally destined import and export goods. In response to public comments, ARB staff has expanded the plan beyond port-related emissions to include all goods movement emissions. As a result, additional truck and locomotive emissions are included in the plan. These emissions are associated with goods moving into and through California on our roadways and rail lines without passing through a port. This includes domestic (U.S. based) and international goods movement to or from Mexico and Canada. Additional technical details on the emissions inventory can be found in the Technical Supplement on Emissions Inventory.

The emission inventory is the foundation for this plan. The inventory tells us what quantities of various pollutants are being emitted, as well as where and when. The emission inventory provides a critical tool in helping us decide what control strategies need to be developed to meet our emission reduction goals. It is important to emphasize that any emission inventory is our best estimate of emissions based on what we know today - "a snapshot in time." Because efforts are always underway to improve our understanding of emissions, estimates will change as new information is reflected in the inventory. However, it is important to note that as we track progress in achieving our emission reduction goals we will apply adjustments to ensure "apples to apples" comparisons when emission inventories change.

While the ARB has maintained statewide emission inventories for over 25 years, the inventory has not historically defined individual categories for goods movement activities. To develop such an inventory, the challenge was to extract the goods movement emissions from the broader statewide inventory. In some cases this was straightforward. For example, we assumed that all cargo handling emissions are associated with goods movement. For trucks, however, we separated the heaviest diesel trucks from smaller local delivery trucks. Only the larger, heavy trucks are included in the goods movement emission inventory. Another challenge was to be sure the inventory reflects important new information from research studies and efforts, such as the Port of Los Angeles No Net Increase project. Where possible, ARB staff has improved and updated the emission estimates in the December 2005 draft plan to better reflect goods movement activities, emission rates, and future growth.

Below, we describe what emission sources were included in the goods movement inventory, the pollutants estimated, the years for which estimates were made, and a comparison of the statewide goods movement emissions to emissions from other sources in California's statewide emissions inventory. In the following sections in this chapter, more detailed discussions on the inventory development are also provided.

The goods movement inventory includes emissions associated with each element of the goods movement process including:

- ocean-going ships that import and export goods through California ports[1];
- commercial harbor craft, such as tug boats and fishing vessels that operate primarily in and out of California ports;
- cargo handling equipment used to load and unload goods at ports and rail yards;
- trucks that transport goods within and through California[2], as well as the diesel engines on transport refrigeration units (TRUs) used to cool or heat perishable goods; and
- locomotives that are used in rail yards for switching and throughout California for line hauls[3].

The inventory reflects both domestic and international goods movement. All emissions at California's ports are included in the inventory, whether related to international trade or domestic goods movement. Emissions that occur over water are included as well as those emissions that occur on land. For example, some commercial harbor craft provide support functions at a port by moving crew or supplies to offshore oil rigs, by towing barges, providing coast guard services, and many other functions. Ferries move people across the San Francisco Bay for their daily commutes, and fishing boats leave the Ports of Los Angeles and Long Beach to work in California's fisheries. These emissions affect local air quality around ports even if they are not related to goods movement.

With respect to diesel particulate matter (diesel PM) emissions, it is important to acknowledge that these emissions when released over the ocean do not have the same health impacts as when they are released over land. This is because pollutant concentrations decrease with distance and health impacts are proportional to ambient concentrations. Nevertheless, the large mass of emissions at the ports, coupled with potential localized health impacts in communities surrounding ports, are the reasons the plan includes all emissions generated at ports.

Emission estimates are provided for the primary pollutants released by the engines that power equipment used to move goods including: particulate matter (PM), oxides of nitrogen (NOx), reactive organic gases (ROG), and oxides of sulfur (SOx). NOx, SOx, and ROG all contribute to the formation of fine particulate matter in the atmosphere; ROG and NOx also form ozone. Emission estimates are provided in tons per average day, determined by dividing annual emission estimates by 365.

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[1] This plan includes emissions generated by ocean-going ships and commercial harbor craft out to 24 nautical miles from shore.
[2] For trucks, we include all heavy-heavy duty trucks (weighing over 33,000 pounds). These trucks represent big rigs capable of moving goods in containers or in bulk. Smaller trucks that handle commercial deliveries are not considered in this plan; their emissions are regulated in other programs.
[3] All locomotive related emissions are included, whether moving goods or passengers.

It is important to know what the emission estimates from good movement activities are today and what the projected emissions are in future years since we expect to see significant growth in goods movement activities as global trade continues its expansion. For example, based on available information on container throughput, we expect to see almost a doubling of trade by 2010 and a tripling by 2020. In addition, there have been many steps already taken by ARB and U.S. EPA to reduce emissions from the engines associated with goods movement. Future year estimates reflect these efforts. For the goods movement inventory, the emissions were estimated for the years 2001, 2005, 2010, 2015, and 2020. The future year emissions were projected from the 2001 baseline emissions levels and reflect our best estimate of the expected growth in goods movement activities, as well as any reductions that are expected from measures that were adopted prior to October 2005.

Emissions from goods movement activities are a major contributor to statewide emissions. Overall, goods movement is currently responsible for roughly 30 percent of NOx emissions and 75 percent of diesel PM emissions in California. As shown in Figures II-1 and II-2, the contribution of goods movement emissions to statewide total NOx and diesel PM emissions is larger than all stationary sources, and larger than both passenger vehicles and off-road equipment in 2001 (the baseline year) and in the projected 2020 emissions inventory. In 2020, goods movement activities are predicted to be the largest source of diesel PM in California, larger than all other sources combined.

Figure II-3 compares NOx emissions in 2001 and 2020 by source type within the goods movement category. Currently, trucks are the largest contributor of NOx emissions within the goods movement category, responsible for 60 percent of all goods movement related NOx emissions. However, emissions from trucks are projected to decrease over time as new emission standards and regulations become effective. By 2020, NOx emissions from these trucks will represent 35 percent of overall NOx emissions in the goods movement category. Overall NOx emissions generated by goods movement sources will have been reduced from roughly 1,100 to 700 tons per day, a decrease of 30 percent. The vast majority of the decrease in goods movement NOx emissions between 2001 and 2020 is caused by projected reductions in truck emissions. At the same time, NOx emissions from ocean-going ships are projected to increase dramatically. By 2020, NOx emissions generated by ships will be equal to NOx emissions released by trucks.

Figure II-1
Statewide
NOx Emissions by Source Classification*
(tons per day)

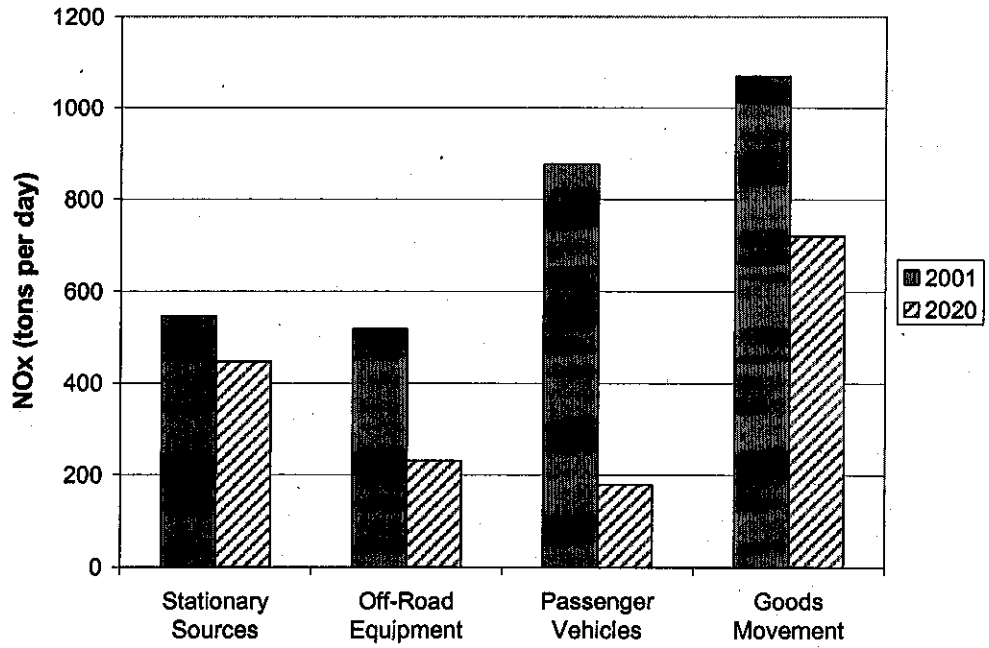
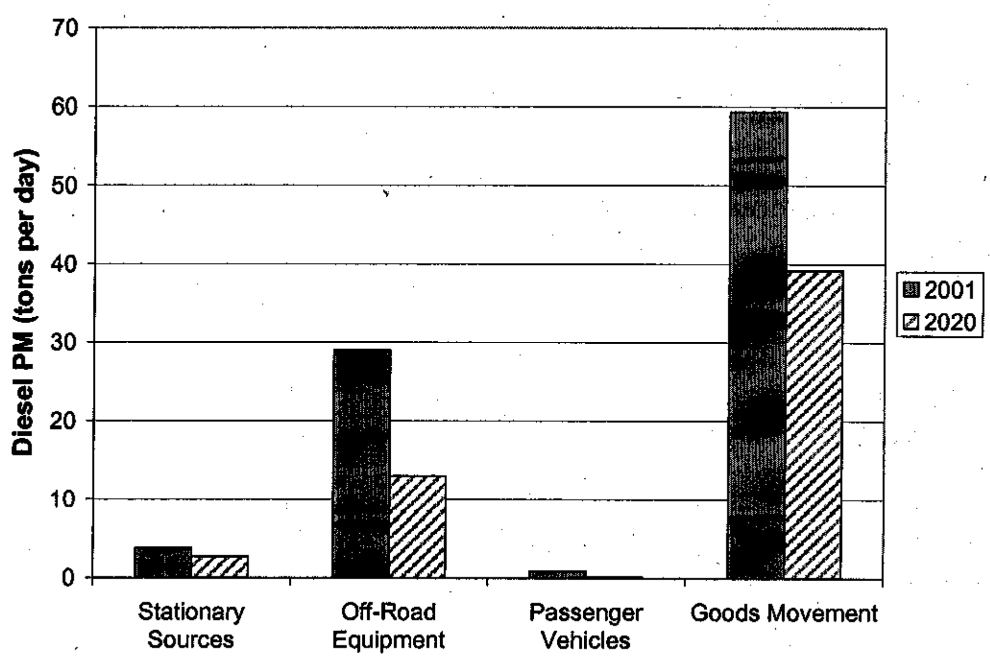
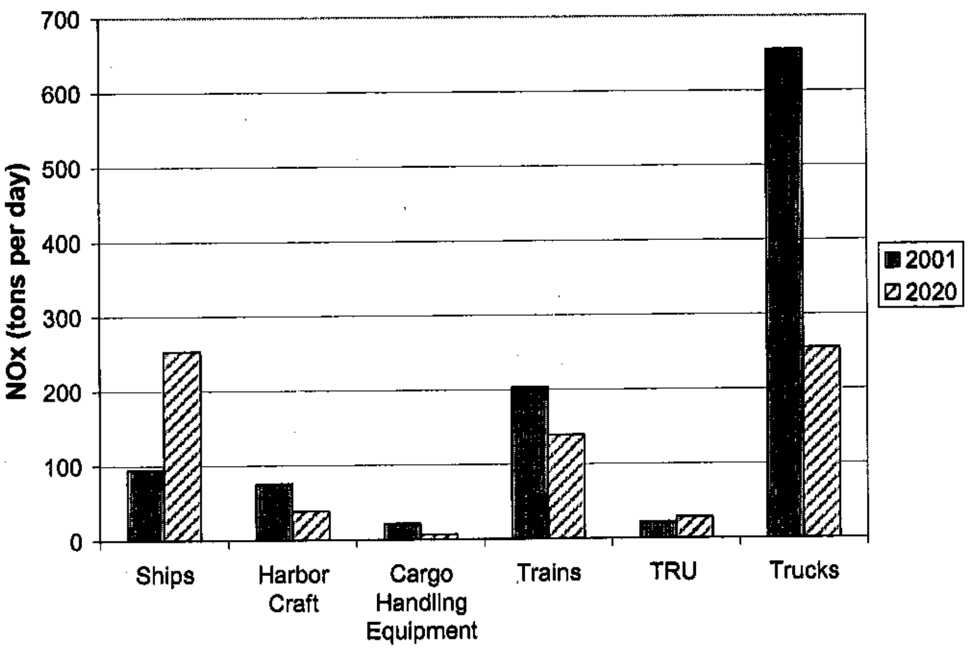


Figure II-2
Statewide
Diesel PM Emissions by Source Classification
(tons per day)



Note: The estimated emissions for 2020 were projected from the 2001 inventory and reflect both the expected growth in goods movement activities and the benefits of measures adopted prior to October 2005.

Figure II-3
Statewide
Goods Movement NOx Emissions by Source Classification
(tons per day)



Note: TRU (Transport Refrigeration Unit)

B. SUMMARY OF EMISSION INVENTORY REVISIONS

This section provides a brief overview of what changes have been made to the emission inventory since the release of the December 2005 draft plan. More details about the changes in each category are described later in the chapter.

- **This plan now considers the movement of international and domestic goods by trucks and locomotives.** The draft plan included only emissions associated with international goods movement. This plan considers the movement of both domestic and international goods. This leads to an increase in estimated emissions associated with trucks and locomotives engaged in goods movement.

- **Truck emission estimates now include the latest assumptions regarding emission rates and travel routes.** ARB staff is currently in the process of developing a new version of California's EMFAC model for estimating emissions from on-road motor vehicles. While this model is not yet complete, we included some recently available data for the trucks considered in this plan. Incorporating these new data increased the estimated truck emissions and changed the spatial allocation of these emissions within California.

- **Staff has revised methodologies for estimating the international fraction of truck and locomotive emissions in the base year inventory for this plan.** New methods account for the transport of international containers throughout California and reflect our latest data regarding the mode split between truck and rail transport.

- **Commercial harbor craft estimates are now limited to 24 nautical miles from shore and include the impact of adopted controls, fleet turnover, and emissions deterioration over time.** The commercial harbor craft inventory in the draft plan included emissions out to 100 miles from the California coast. We have now used the same 24 mile boundary applied to ships. The harbor craft estimates in the draft plan also involved a simplified methodology that did not accurately account for changes in emission rates over time, or fleet turnover and penetration of cleaner engines into the fleet. The revised inventory in this plan includes these factors.

- **International and domestic growth is explicitly considered for each source category.** In the draft plan, growth in the international category was considered independently for each source category. The inventory presented in this plan integrates projected container growth explicitly into growth estimates for every source category, and ensures consistency across categories.

These modifications have changed the emission estimates substantially from the previous estimates. As shown in Table II-1, the emissions of diesel PM, NOx and ROG in 2010 more than doubled as a result of the refinements to the inventory and the inclusion of domestic goods movement truck and rail activities.

Table II-1
Comparison of Draft December 2005 Goods Movement Emission Estimates with Revised March 2006 Emission Estimates
(tons per day)

Pollutant	2010		2020	
	International (December 2005)	**All Goods Movement** (March 2006)	**International** (December 2005)	**All Goods Movement** (March 2006)
Diesel PM	20	42	28	36
NOx	370	892	405	721
ROG	26	72	27	51
SOx	96	108	158	181

C. PROJECTING GROWTH

Projecting growth in goods movement activities is a key element of the emission inventory development process. Based on recent data, it is clear that California is experiencing a major increase in the amount of goods imported to our ports. Between 2000 and 2004, the number of containers measured as twenty-foot equivalent units

(TEU) increased by 40 percent at the Ports of Los Angeles and Long Beach.[4] Between 1990 and 2004, traffic doubled from one to two million TEU per year at the Port of Oakland.[4] The Southern California Association of Governments (SCAG) estimates freight volumes will double or triple in the Los Angeles region over the next two decades[5]. The Bay Area Metropolitan Transportation Commission projects total cargo tonnage will double at the Port of Oakland between 2002 and 2020.[6]

The draft goods movement emission inventory released in December 2005 included growth estimates for international goods movement. With the inclusion of domestic goods movement, we needed to develop estimates of growth for domestic goods separate from the international goods. We also took this opportunity to refine our growth estimates for international goods movement activities. Below, we briefly describe our refinements to the international goods movement growth estimates and our approach for determining the expected growth in domestic goods movement activities.

Staff has revised international goods movement growth estimates by making the growth rates of trucks and trains that transport goods to and from ports consistent with the growth rates applied to ships. These growth estimates are based upon the change in number and capacity of container ships that occurred in the years 1997-2003. Specifically, the change in total installed power of container ships was used to estimate growth. Total installed power is a function of the number and the total size of container ships visiting California between 1997 and 2003. These growth rates agree well with container forecasts projected for the Ports of Los Angeles for the No Net Increase Report, Long Beach, and Oakland. This plan assumes the numbers of containers processed by ports in California will nearly double by 2010 and nearly quadruple by 2020, relative to the number of containers processed in 2001.

Trucks and locomotives not involved in port-related goods movement are expected to grow at slower rates that those transporting goods to and from ports. The fraction of trucks and locomotives involved in goods movement was estimated, and then this fraction was grown using the container ship growth rate described above. The remaining fraction of trucks and locomotives was grown at slower rates specific for these categories. Growth in vehicle miles traveled (VMT) for trucks is largely provided by local planning organizations, and locomotive growth was based on national trend data. Domestic growth rates are projected to be much lower than international growth rates. For example, we expect total truck VMT in South Coast will increase about 60 percent between 2001 and 2020. At the same time, this plan assumes international truck VMT in South Coast will increase by twice that rate.

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[4] American Association of Port Authorities (2005). US / Canada Container Traffic in TEUs. Available at: http://www.aapa-ports.org/industryinfo/statistics.htm

[5] Southern California Association of Government (2004), Southern California Regional Strategy for Goods Movement, A Plan for Action. At: http://www.scag.ca.gov/goodsmove/pdf/GoodsmovePaper0305.pdf

[6] San Francisco Bay Conservation and Development Commission and Metropolitan Transportation Commission (2003), San Francisco Bay Area Seaport Plan

D. STATEWIDE EMISSION SUMMARY

This section provides emission summaries on a statewide basis. Baseline emissions are provided for 2001, and projected to 2010, 2015, and 2020. Future year baseline estimates reflect the expected growth in goods movement activities and the emission reductions from all measures adopted prior to October 2005. The future year projections do not reflect any of the measures adopted since then or the new strategies proposed in this plan. In Table II-2, we present the estimated statewide goods movement emissions for 2001, the base year for this plan. As you can see, trucks are currently the largest source of NOx, ROG, and diesel PM in the goods movement emission inventory. The contribution of trucks has increased relative to the contribution estimated in the draft plan due to the inclusion of domestic goods movement. Ships are the dominant source of SOx emissions because ships burn fuels with high sulfur content, while harbor craft and emission sources over land are required to burn low sulfur fuels mandated by ARB regulations.

Table II-2
Statewide
2001 Emissions from Ports and Goods Movement
(tons per day)

Pollutant	Ships	Harbor Craft	Cargo Handling Equipment	Trucks	TRU	Trains	Total
Diesel PM	7.8	3.8	0.8	37.7	2.5	4.7	**57.3**
NOx	95	75	21	655	22	203	**1071**
ROG	2	8	3	56	13	12	**94**
SOx	60	0.4	<0.1	5	0.2	8	**74**

In the following sections, we discuss the baseline emissions estimate (2001) and the projected future emission estimates by pollutant type. For each pollutant we provide an emissions summary table that presents the emissions estimates by category for each year. Pie charts are also included for diesel PM and NOx which demonstrate the relative contribution of each source category to the total emissions for a particular pollutant for the different years included in the inventory. As you will see, the relative impact of each source category will change over time, as growth and controls affect future year estimates.

- **Diesel PM:** As shown in Table II-3, statewide diesel PM emissions are projected to decrease by 37 percent between 2001 and 2020 due to regulations that have already been adopted. Figure II-4 presents pie charts that depict the relative contribution of each source category to the statewide goods movement emissions in 2001, 2010, 2015, and 2020. As Figure II-4 shows, the emissions contribution from trucks, cargo handling equipment, transportation refrigeration units, and commercial harbor craft are all decreasing substantially over time, while the contribution of ship emissions is increasing. Over the past decade ARB and U.S. EPA have both taken steps to enact new engine standards and require the use of cleaner fuels. These regulations are working to reduce emissions now and into the future from trucks, locomotives, harbor craft, and cargo handling equipment. In the past, these regulations have not applied to ocean-going ships and only recently have the first steps been taken to reduce their emissions. As a result, ocean-going ship emissions and their contribution to the total diesel PM emissions are increasing.

Table II-3
Statewide
Projected Diesel PM Emissions
(tons per day)

	Diesel PM				
Source Category	**2001**	**2005**	**2010**	**2015**	**2020**
Ships	7.8	10.6	13.8	17.8	23.3
Harbor Craft	3.8	3.7	2.9	2.1	1.8
Cargo Handling Equipment	0.8	0.7	0.5	0.4	0.2
Trucks	37.7	30.6	19.4	11.1	6.2
Transport Refrigeration Units	2.5	2.6	1.6	0.6	0.1
Locomotives	4.7	4.7	4.2	4.3	4.5
Total	**57.3**	**52.9**	**42.4**	**36.3**	**36.1**

* Includes benefits of regulations adopted through October 2005.

- **NOx:** As Table II-4 and Figure II-5 show, the emission trends for NOx are similar to the diesel PM trends with overall emissions decreasing over time. Again, emissions from ships are projected to increase due to the lack of effective controls, while emissions from most other categories are projected to decrease as adopted regulations are implemented.

Table II-4
Statewide
Projected NOx Emissions
(tons per day)

	NOx				
Source Category	**2001**	**2005**	**2010**	**2015**	**2020**
Ships	95	125	158	200	254
Harbor Craft	75	69	56	44	39
Cargo Handling Equipment	21	19	16	11	6
Trucks	655	684	517	359	255
Transport Refrigeration Units	22	24	27	28	28
Locomotives	203	159	117	129	139
Total	**1071**	**1080**	**891**	**771**	**721**

* Includes benefits of regulations adopted through October 2005.

- **ROG:** ROG emission rates are generally lower from diesel engines than from gasoline engines. Since vehicles that move goods are predominantly diesel-fueled, the total ROG emissions from goods movement activities are much smaller than the NOx emissions. As shown in Table II-5, ROG emissions are projected to decrease in future years. This decrease is in large part due to a decrease in emissions from trucks and transport refrigeration units.

Table II-5
Statewide
Projected ROG Emissions
(tons per day)

			ROG		
Source Category	**2001**	**2005**	**2010**	**2015**	**2020**
Ships	2	3	4	5	7
Harbor Craft	8	7	6	5	4
Cargo Handling Equipment	3	2	1	1	1
Trucks	56	55	43	31	23
Transport Refrigeration Units	13	11	7	4	4
Locomotives	12	12	11	12	12
Total	**94**	**90**	**72**	**58**	**51**

* Includes benefits of regulations adopted through October 2005.

- **SOx:** Total SOx emissions are projected to increase, as shown in Table II-6. While sources other than ships currently contribute about 20 percent of the statewide goods movement SOx emissions, the use of low sulfur fuels in the future will reduce emissions from these sources. Because ship emissions are largely unregulated, their SOx emissions are projected to increase substantially, by a factor of three between 2001 and 2020.

Table II-6
Statewide
Projected SOx Emissions
(tons per day)

			SOx		
Source Category	**2001**	**2005**	**2010**	**2015**	**2020**
Ships	60	81	106	137	180
Harbor Craft	0.4	0.4	0.1	0.1	0.1
Cargo Handling Equipment	<0.1	<0.1	0.1	0.1	<0.1
Trucks	5	5	1	1	1
Transport Refrigeration Units	0.2	0.3	<0.1	<0.1	0.1
Locomotives	8	7	1	0.1	0.1
Total	**74**	**94**	**108**	**138**	**181**

* Includes benefits of regulations adopted through October 2005.

Figure II-4 Projected Statewide Goods Movement Diesel PM Emissions: 2001-2020

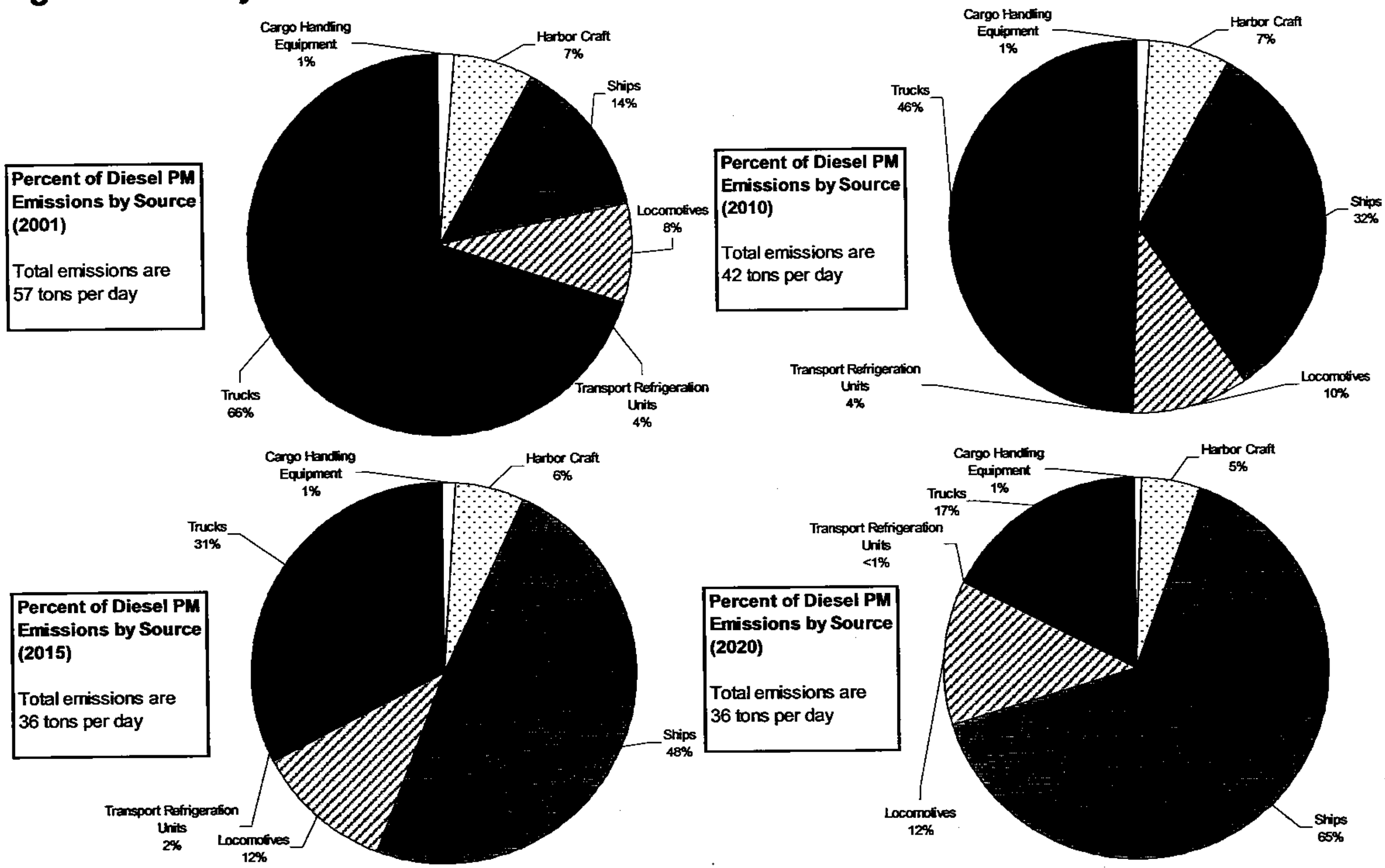
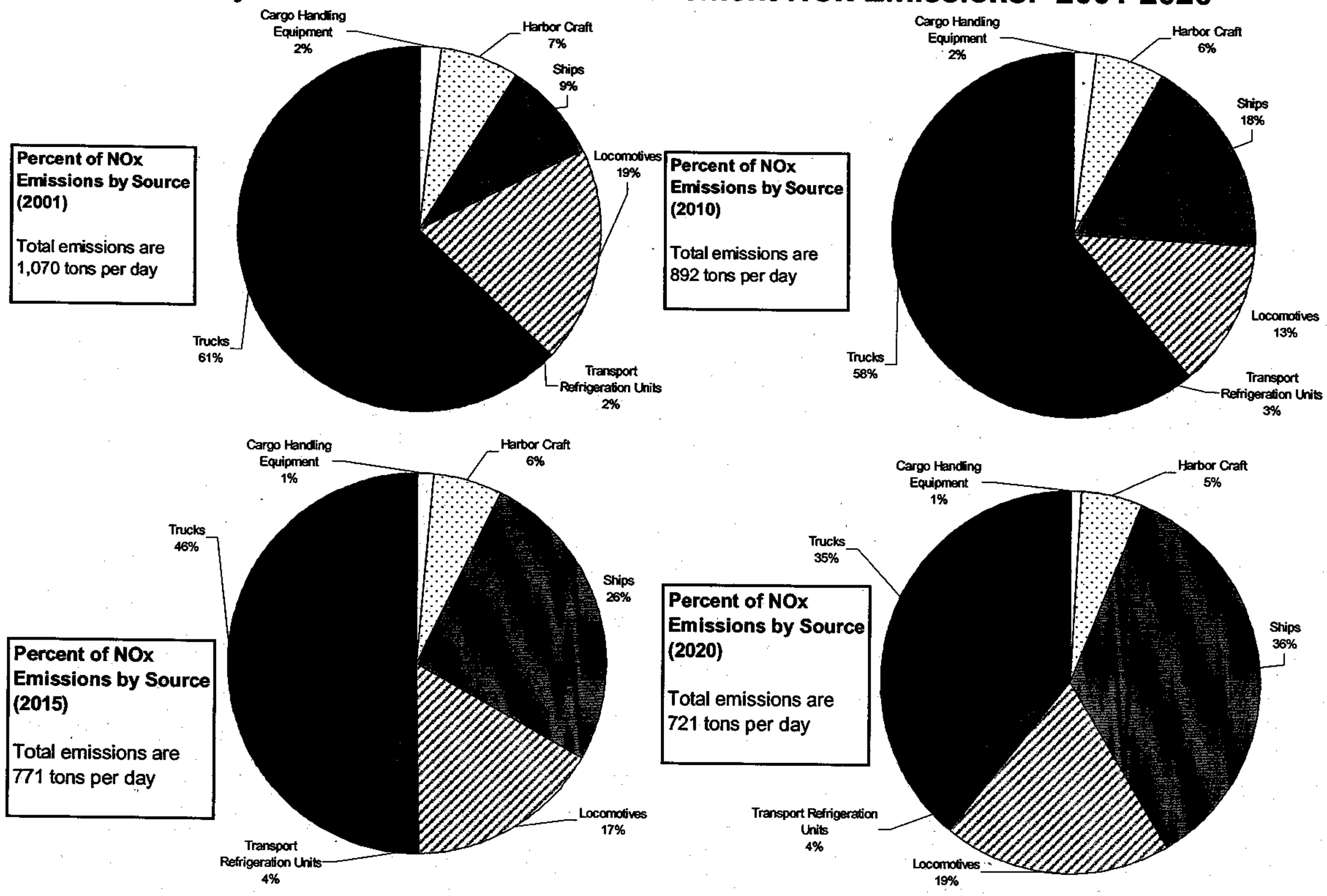


Figure II-5 Projected Statewide Goods Movement NOx Emissions: 2001-2020



E. EMISSIONS SUMMARY FOR SELECTED REGIONS

Emissions associated with goods movement are generated throughout California. The contributions from the various emission source categories associated with goods movement varies by region. For example, coastal areas are heavily affected by ships and, in many cases, by a combination of all source categories. Inland areas are impacted most heavily by trucks and trains. This section provides a description of the goods movement emissions in five regions of the state. Estimates are provided for the South Coast region, the San Joaquin Valley, the San Francisco Bay Area, San Diego County, and the Sacramento region. Additional details on regional emissions are provided in Appendix B – Regional Analyses.

- **South Coast:** The South Coast region is the most populous region in the state, encompassing portions of Los Angeles, San Bernardino, Riverside, and Orange counties. The region contains the ports of Los Angeles and Long Beach which, when combined, are the third largest container port in the world. The South Coast region also contains a complex web of rail and freeway networks that transport both people and goods within and through the region. As a result of these factors, goods movement emissions in South Coast represent about 25 percent of the statewide goods movement inventory. Currently trucks are the dominant source of diesel PM and NOx. As adopted regulations continue to be implemented, truck emissions are projected to decrease. Ship emissions are projected to increase by a factor of three, based on projected container growth at the Ports of Los Angeles and Long Beach. Even so, trucks and other categories will still generate significant emissions in 2020.

- **San Joaquin Valley:** The San Joaquin Valley is the agricultural heart of California. Stretching from Stockton in the north to Bakersfield in the south, it contains major freeways including I-5 and Highway 99, major rail routes, and the Port of Stockton. Because the Port of Stockton is primarily a bulk goods port and does not handle the same magnitude of ship traffic as the Ports of Los Angeles, Long Beach, or Oakland, ship emissions are a small contributor to overall goods movement diesel PM and NOx emissions. However, ships are the dominant contributor of SOx in the region. In the San Joaquin Valley, goods movement emissions of other pollutants are dominated by trucks. Even as truck emissions decrease in the future, they are still the source for the majority of diesel PM and NOx emissions.

- **San Francisco Bay Area:** The San Francisco Bay Area (Bay Area) is impacted by all types of goods movement sources. Emissions from trucks represent about 40 percent of current goods movement emissions in the Bay Area, and are projected to decrease with time. Harbor craft emissions currently represent about 20 percent of the regional goods movement inventory, a larger fraction than other areas because of the higher number of ferries and fishing vessels. Ship emissions in the Bay Area are significant because of activity at the Port of Oakland and the numerous smaller ports designed to service tankers and other bulk commodities. By 2020, ships will contribute more than 70 percent of the diesel PM emissions and slightly less than half of the NOx emissions.

- **San Diego County:** The goods movement emissions profile in San Diego is very similar to South Coast and the Bay Area. Trucks are the most significant current contributor to emissions of diesel PM and NOx, but are projected to decrease over time, while ships are projected to increase significantly over time. Currently, ship emissions in San Diego are generated primarily by cruise ships. Growth in the cruise ship category is predicted to be larger than for container ships, and as a result, ship emissions are projected to increase by a factor of five.

- **Sacramento Region:** The Sacramento region, like the San Joaquin Valley, has highly traveled roadways and significant rail traffic. Trucks and trains are projected to be the dominant source of goods movement emissions now and into the future.

F. EMISSION ESTIMATION METHODS BY SECTOR

Below we describe the methodologies used to develop emissions estimates for each source category - the ships, harbor craft, cargo handling equipment, trucks, and locomotives – associated with goods movement. In each case we built upon and refined estimates for these source categories that historically have been included in the statewide emissions inventory as either a discrete and independent category (i.e. ships and harbor craft) or combined in a more generalized category (i.e. on-road trucks) in the statewide emissions inventory. In the development of the goods movement emission inventory, we took steps to ensure the inventory reflected the most up-to-date information on emission rates, activity patterns, expected growth rates and current control measures. In the following sections, we provide a brief overview of how these inventories were calculated. Additional details are also provided in the Technical Supplement on Emission Inventory.

1. Ocean-Going Ships

Ocean-going ships can be classified into many different categories, including container ships that move goods in containers, tankers that move liquids like oil, bulk material transports, and others. Some vessel types, like container ships, directly move imported goods into the State. Other vessel types, like passenger ships, are not engaged in goods movement, but do contribute emissions to the overall port-wide total. All types of ocean-going vessels are included in this analysis, out to 24 nautical miles from shore.

The ocean-going ship category is defined by size; the category includes all ships exceeding 400 feet in length or 10,000 gross tons in weight. These ships are typically powered by diesel and residual oil fueled marine engines. Ocean-going ships have two types of engines. The main engine is a very large engine used mainly to propel the vessel at sea. Auxiliary engines are engines that in general provide power for uses other than propulsion, such as electrical power for ship navigation and crew support. Passenger vessels use diesel electric engines, where a diesel or residual oil fueled engine acts as a power plant, providing power for propulsion and ship operations. ARB considers engines on passenger vessels to be in the auxiliary category.

ARB staff recently developed an improved emissions inventory that accounts for emissions based on a variety of factors including type of vessel, transit locations, various ship engine sizes and loads, and other factors. This inventory covers three modes of ship operation: in-transit emissions generated as a ship travels at cruising speeds, generally in between ports of call; maneuvering emissions generated as a ship slows down in anticipation of arriving, moving within or departing a port; and hotelling emissions generated by auxiliary engines as a ship is docked at port. This inventory was incorporated into the draft plan. Since that time we have further refined the ocean-going ship inventory. Specifically, the emission factor associated with maneuvering was adjusted for low-load conditions, and emissions generated by boilers operating on ships and barges were added to the inventory. We also fixed a minor error that had resulted in overestimating the fraction of emissions from hotelling in the draft plan.

Emissions are calculated on a statewide basis for each port in California. Emissions are also calculated for hotelling and maneuvering operating modes that occur within ports and transit emissions as ships move up and down the California coastline. Emissions calculated within 24 nautical miles of the shore are included in this emissions inventory. For emissions inventory tracking purposes, emissions are allocated to a port when they occur within three miles of shore. Emissions outside of three miles are allocated to the outer continental shelf air basin.

Estimating growth of ocean-going vessel emissions is an important issue. For this inventory, ARB staff worked with experts at the University of Delaware to compile data on the number and size of main engines visiting each port in California over time. These data account for any increase in the number of ships visiting each port over time as well as the increasing size of these ships. Using data collected representing the years 1997-2003, we developed growth rate estimates for each port. For emissions at the Ports of Los Angeles and Long Beach, we used the growth rates developed for the Port of Los Angeles' No Net Increase Report, which agree with ARB growth projections based on main engine size. As a result, growth rate estimates for 2020 used in this plan are consistent with the No Net Increase report. Our estimates for container growth at the Port of Oakland were also consistent with previous estimates.[7]

Table II-7 presents statewide emissions by pollutant and ship type for 2001 and future years. Container ships are the dominant ship type, although major growth is also forecast for passenger ships, which has a significant impact on emissions in San Diego County. Table II-8 presents those same emissions by mode: hotelling, maneuvering, and transit.

[7] Metropolitan Transportation Commission, *Regional Goods Movement Study for the San Francisco Bay Area: Final Summary Report*. Available at: http://www.mtc.ca.gov/pdf/rgm.pdf

Table II-7
Statewide
Ship Emissions to 24 Miles from Shore by Ship Type*
(tons per day)

	NOx				Diesel PM				SOx			
Ship Type	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**
Container Ship	59	102	127	156	4.8	8.7	11.0	13.9	37	66	84	106
Tanker	10	15	18	22	0.8	1.3	1.6	1.9	6	10	12	15
Passenger Ship	7	18	29	48	0.7	1.8	2.9	4.9	5	14	23	39
Other Cargo Ships	18	22	25	28	1.5	1.9	2.2	2.6	11	15	17	21
Total	**94**	**157**	**199**	**254**	**7.8**	**13.7**	**17.7**	**23.3**	**59**	**105**	**136**	**181**

* Includes benefits of regulations adopted through October 2005; does not include ARB auxiliary engine fuel regulation.

Table II-8
Statewide
Ship Emissions to 24 Miles from Shore by Operating Mode
(tons per day)

	NOx				Diesel PM				SOx			
Operating Mode	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**
Hotelling	15	33	40	49	1.3	3.0	3.7	4.6	10	25	31	38
Maneuvering	2	5	7	8	0.2	0.4	0.5	0.6	1	3	4	5
Transit	77	120	153	197	6.4	10.5	13.6	18.2	48	79	103	137
Total	**94**	**158**	**200**	**254**	**7.9**	**13.9**	**17.8**	**23.4**	**59**	**107**	**138**	**180**

* Includes benefits of measures adopted through October 2005; does not include ARB auxiliary engine fuel regulation.

2. Commercial Harbor Craft

Harbor craft are commercial boats that operate generally within or near harbors, or are smaller vessels that support a commercial or public purpose. The harbor craft category includes many types of vessels including crew and supply vessels, pilot vessels, tug and workboats, fishing vessels and ferries. This category does not include recreational vessels used for private use.

ARB staff recently developed an improved statewide emissions inventory for the harbor craft category. This emissions inventory was developed using the statewide population of harbor craft, in conjunction with information about the size and activity of propulsion engines by vessel type obtained by survey to estimate emissions. Harbor craft have both propulsion and auxiliary engines; both are generally powered by diesel fuel. For most commercial harbor craft, the propulsion engines are the primary engines and move the vessel through the water. The auxiliary engines generally provide power to the vessels electrical systems and can also provide additional power to unique, essential vessel equipment (e.g. refrigeration units) during the normal day-to-day operation of the vessel.

Growth in harbor craft emissions was assessed by vessel category. Growth in tug boat emissions were assumed proportional to growth in the number of visits to each port by ocean-going ships in each year, which is not projected to increase with time. The growth in container traffic is expected to be accommodated by increasing ship size, rather than the number of ship visits. No growth was assumed in other harbor craft ship types unless location specific information was provided by local authorities.

For the goods movement inventory, we are using the statewide inventory for harbor craft. However, since the release of the draft plan we have refined our estimates. Specifically, to be consistent with the ocean-going ship inventory, only emissions released within 24 nautical miles of shore are now included in the goods movement inventory. In addition, emission factors were updated to account for fleet turnover, current engine standards, and the increase in emission factors with engine age. The combined effect of these assumptions is to reduce future year emissions. Table II-9 provides emissions by harbor craft type by pollutant for 2001 and future years.

Table II-9
Statewide
Harbor Craft Emissions to 24 Miles from Shore by Ship Type
(tons per day)

	NOx				Diesel PM			
Ship Type	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**
Fishing Vessels	19	14	11	10	1.0	0.8	0.5	0.5
Tug Boats	15	11	8	7	0.8	0.6	0.4	0.4
Ferry/Excursion	35	26	20	18	1.6	1.3	0.9	0.8
All Others	6	5	4	4	0.3	0.3	0.2	0.2
Total	**75**	**56**	**43**	**39**	**3.7**	**3.0**	**2.0**	**1.9**

* Includes benefits of measures adopted through October 2005.

3. Cargo Handling Equipment

The cargo handling equipment category includes many different types of off-road vehicles that are used to move goods through California's ports and intermodal facilities. ARB staff recently developed a new statewide emissions inventory representing cargo equipment that estimates the emissions from cranes, forklifts, container handling equipment such as yard hostlers, top picks and side picks, bulk handling equipment such as excavators, tractors, and loaders used at ports and intermodal rail yards.

The goods movement inventory provides emissions by equipment type and for each port and major intermodal facility in California. The inventory reflects updated population and activity data for cargo handling equipment statewide by equipment type based on a survey conducted by ARB in early 2004 and recent emission inventories prepared for the ports of Los Angeles and Long Beach. Growth rates were developed by equipment type from survey responses. The cargo handling equipment inventory in the draft plan has not changed. Table II-10 presents cargo handling equipment emissions estimated for 2001 and future years by pollutant and equipment type.

Table II-10
Statewide
Cargo Handling Equipment Emissions
(tons per day)

	NOx				Diesel PM			
Equipment Type	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**
Yard Tractor	15	10	7	3	0.6	0.3	0.2	0.1
Material Handling Equip	3	3	3	2	0.1	0.1	0.1	0.1
Crane	2	2	2	1	0.1	0.1	0.05	0.04
All Others	1	1	1	0	0.1	0.03	0.02	0.01
Total	**21**	**16**	**13**	**6**	**0.9**	**0.5**	**0.4**	**0.2**

* Includes benefits of measures adopted through October 2005; it does not reflect the cargo handling equipment.

4. Trucks

Trucks are an integral and important component of California's goods movement transportation system. Nearly all goods moved through California are moved by a truck at some time during their transport. Emissions released by trucks are a substantial component of statewide, regional, and goods movement emissions inventories.

The calculation of emissions from trucks is not a simple process. Estimating emissions requires some knowledge about population / engine characteristics, travel activity, and emission factors for individual types of trucks. Engine characteristics include engine model year, manufacturer and technologies. Travel activity includes not just an assessment of the number of trucks and the distance each truck travels in an area, but also the distribution of speeds at which trucks travel and the number of miles the average truck travels per year. Both fleet characteristics and travel activity are typically provided by local and state governments to ARB.

Emission factors relate a given activity level to emissions of each pollutant. These data are obtained by conducting controlled tests of many individual vehicles and then analyzing resulting data to extract average emission factors and trends for different types and ages of engines. Emission factors also include estimates of how emissions change at different speeds, and how emissions increase as engines in trucks become older. All of this information is integrated across a predicted fleet of trucks in a region to calculate emissions. ARB's motor vehicle emissions model, EMFAC, incorporates these factors for the calculation of vehicle emissions.

Truck emissions estimates have changed substantially since the draft plan was released in December 2005, due to a number of revisions. Most significantly, the inclusion of domestic goods movement has led to a major increase in emissions for the category. Two additional changes led to major revisions in the inventory.

- **This plan includes new information regarding motor vehicle emissions.**

ARB staff is currently in the process of developing a new version of EMFAC. This model has not yet been completed, but staff has developed draft emissions calculation methods that include new information about engine populations and characteristics; travel activity; and emission factors. To ensure truck emission estimates are as accurate as possible, staff included the new data and assumptions in the goods movement truck inventory. Incorporating new data and assumptions increased emission estimates and changed the statewide spatial allocation of truck emissions.

The current version of the EMFAC model allocates heavy duty truck emissions spatially based upon where vehicles are registered. For this plan, staff allocated emissions based on where trucks are expected to travel. This change results in travel decreases in areas like South Coast and the Bay Area where most trucks in California are registered, and travel increases in areas like the San Joaquin Valley and Mojave Desert where trucks tend to travel on longer routes.

Second, truck emission factors in the current version of EMFAC are based upon an extremely limited set of data representing tested trucks. Over the past several years ARB and other organizations have funded new studies to test emissions from trucks. These data were integrated into truck emission estimates for this plan. Generally truck emission factors for NOx and diesel PM increased substantially, leading to higher emissions relative to the current EMFAC model.

- **This plan includes significant revisions to methods for estimating truck emissions associated with international goods movement.**

The EMFAC model provides emission estimates by vehicle class and by county. It does not provide emission estimates for a specific industry or sector of the economy, such as goods movement. As a result, estimating emissions associated with international goods movement required the development of new methods. The goal of these new methods was to estimate the VMT associated with trucks that haul international goods. For each region, the fraction of total truck VMT from international goods movement is then multiplied by all truck emissions to estimate international goods movement emissions.

This section describes the development of those methods, which have changed significantly since the release of the draft plan. Our new method is based on the concept of balancing the number of inbound containers to California, outbound containers from California, and empty containers moved out of California. Our assumption is that the number of containers should be balanced; and the flow of containers on ships needs to be consistent with the number of containers moved by trucks and trains.

To illustrate this assumption, it is useful to consider how international goods move in California. Imported goods enter California through the Ports of Los Angeles, Long Beach, Oakland, and others. These goods arrive on ocean-going ships, much of which are packaged in containers. Once at port, containers are removed from the ship and staged for land-side transportation. Containers may be moved directly on to a train without the assistance of a truck. This is referred to as "on-dock" rail. Containers may also be moved by truck to a rail yard, such as the Intermodal Container Transfer Facility in Long Beach, only a few miles away from the port. This is referred to as "near-dock" rail. Containers may also be moved by truck to a more distant rail yard, such as the Hobart yard in Los Angeles. This is referred to as "off-dock" rail. Rail transportation is most cost-effective over long distances and most containers loaded on to rail at California's ports are moved out of California.

Other containers are moved by truck directly to their destination, which is most often a distribution center. When trucks carry containers to a distribution center, several things may happen. In many cases the container contents are distributed to smaller trucks for local delivery. Emissions associated with these local deliveries are not included in this plan. In other cases a container may be picked up by a long-haul trucking firm and the container may be moved out of state. In some cases the container is transloaded. Transloading is the practice of repacking generally 40 foot containers into 53 foot containers. Since the cost to move a container is about the same regardless of container size it is more cost effective to move larger containers by truck of rail than smaller containers. Over longer distances transloading can be a cost-effective and efficient method to transport goods.

Our container balancing method was first applied to the South Coast region. Staff collected data from the ports and local government agencies in the South Coast region. Based on these data, we developed an estimate of the number of containers moving into the region's ports, and projected these numbers into the future. The total number of containers in each year was then allocated to different travel modes. Table II-11 presents our estimate of the number of containers in 2001 and future years moved by each travel mode. The data indicate more than 50 percent of containers passing through the Ports of Los Angeles and Long Beach travel by rail.

Table II-11
Container Balance by Travel Mode: South Coast
(number of containers)

Mode		Containers in Each Year		
		2000	2010	2020
Rail	On-Dock	933,476	2,624,477	2,954,121
Truck	Near-Dock (ICTF)	375,899	1,286,991	1,442,947
	Off-Dock (Hobart)	658,070	1,164,786	1,895,245
	Transload	1,568,539	2,018,570	4,487,726
	Local	1,730,801	2,227,388	5,117,500
Total		**5,266,785**	**9,322,212**	**15,897,539**

About 10,000 trucks are estimated to service the ports by moving containers on short routes to and from rail yards and distribution centers. These trucks, called port trucks in this plan, are generally older than other truck fleets in the South Coast region[8]. Because trucks emit more as they get older, the port truck fleet is dirtier than the regional average fleet.

To estimate port truck emissions in South Coast, staff estimated an average distance traveled per container for each travel mode. The number of containers was then multiplied by the average distance traveled by truck in each mode to calculate VMT. Staff calculated a ratio of port truck VMT to total VMT in South Coast, and adjusted this ratio to account for the higher emission rate of port trucks based on model year distribution. This ratio was then multiplied by total truck emissions in South Coast to estimate emissions generated by port trucks.

A fraction of goods transported to distribution centers, primarily transloaded containers, are moved by truck through and potentially out of California to other regional destinations such as Oregon, Utah, Nevada, and other states. Using technical reports generated by local transit agencies in the Los Angeles region, we estimated an additional amount of heavy-duty truck miles traveled in each air basin in California as a result of these secondary transload trips. We adjusted the ratio of transload VMT to air basin total VMT to account for the fact that trucks pulling transloads likely involve national fleets that are much cleaner than the air basin average. This adjusted ratio was also multiplied by emissions in each air basin to calculate emissions associated with transloaded containers originating from the Ports of Los Angeles and Long Beach.

To estimate the fraction of port truck and transload truck emissions associated with other ports in California we applied the method used for South Coast to the Bay Area. Port trucks servicing the Port of Oakland were assumed to travel in the Bay Area and San Joaquin Valley, and transload VMT generated for containers originating in Oakland was estimated in each air basin. For ports outside the Bay Area, we scaled port truck VMT by the total non-petroleum related tonnage throughput at each port. Only Oakland and the San Pedro Bay ports were assumed to generate transload long-haul truck trips.

Table II-12 presents domestic truck, port truck, and transload truck emissions projected on a statewide basis for 2001 and future years. International emissions decreased from the draft plan because we used the container balance method. We believe current emissions more accurately reflect international goods movement, and projections in the draft plan were over-estimated. One might expect port truck emissions to increase with container growth, but as Table II-12 shows it does not. Container growth is accounted for in the calculation; however existing controls on the truck fleet are projected to reduce emissions more quickly than container growth would increase emissions. Overall, the inclusion of all goods has led to a dramatic increase in total diesel PM and NOx emissions attributable to goods movement compared to the draft plan. NOx emissions are five times higher, and diesel PM is ten times higher than in the draft plan.

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[8] Port of Los Angeles (2004). Port of Los Angeles Baseline Air Emissions Inventory – 2001. Available at: http://www.portoflosangeles.org/DOC/POLA_Final_BAEI.pdf

Table II-12
Statewide
Heavy Truck Emissions
(tons per day)

	NOx				Diesel PM			
Truck Type	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**
Domestic Trucks	623	492	336	234	36.0	18.5	10.4	5.7
Port Trucks	19	20	21	18	1.4	0.7	0.6	0.4
International Long Haul Trucks	13	5	3	3	0.3	0.2	0.1	0.1
Total	**655**	**517**	**360**	**255**	**37.7**	**19.4**	**11.1**	**6.2**

* Includes benefits of measures adopted through October 2005.

Emissions in the South Coast and Bay Area reflect container balancing, as shown in Tables II-13 and II-14. Table II-15 provides results for the San Joaquin Valley. While the San Joaquin Valley has significant transload traffic, these trucks are relatively cleaner than domestic truck fleets that are likely to be generally older and dirtier.

Table II-13
South Coast
Heavy Truck Emissions
(tons per day)

	NOx				Diesel PM			
Truck Type	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**
Domestic Trucks	120	104	68	44	7.0	4.0	2.2	1.1
Port Trucks	16	17	17	15	1.2	0.6	0.5	0.4
International Long Haul Trucks	4	2	1	1	0.1	<0.05	<0.05	<0.05
Total	**140**	**123**	**86**	**60**	**8.3**	**4.6**	**2.7**	**1.5**

* Includes benefits of measures adopted through October 2005.

Table II-14
Bay Area
Heavy Truck Emissions
(tons per day)

	NOx				Diesel PM			
Truck Type	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**
Domestic Trucks	49	37	23	16	2.4	1.2	0.6	0.3
Port Trucks	3	3	3	2	0.2	0.1	0.1	0.1
International Long Haul Trucks	1	<0.5	<0.5	<0.5	<0.05	<0.05	<0.05	<0.05
Total	**53**	**40**	**26**	**18**	**2.6**	**1.3**	**0.7**	**0.4**

* Includes benefits of measures adopted through October 2005.

Table II-15
San Joaquin Valley
Heavy Truck Emissions
(tons per day)

	NOx				Diesel PM			
Truck Type	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**
Domestic Trucks	179	133	92	64	9.9	4.7	2.7	1.5
Port Trucks	<0.5	<0.5	<0.5	<0.5	<0.05	<0.05	<0.05	<0.05
International Long Haul Trucks	4	2	1	1	0.1	<0.05	<0.05	<0.05
Total	**183**	**135**	**93**	**65**	**10.0**	**4.7**	**2.7**	**1.5**

* Includes benefits of measures adopted through October 2005.

5. Locomotives

Trains, and the diesel-fueled locomotives that power them, travel throughout California. The vast majority of trains in California move freight; a fraction of this freight is imported into and through California from overseas, while the balance represents freight generated in California that is bound for export, and freight generated and consumed within California.

ARB's inventory of emissions from locomotives was first developed in 1987 and has been updated periodically since that time. The inventory accounts for generalized locomotive activity patterns over broad geographical regions. The inventory covers two types of train locomotives. Line-haul locomotives are larger, more modern locomotives that are used to move trains over long distances. Switchers are smaller, older locomotives used to transport trains within a rail yard or over short distances. Line-haul locomotives operate in rail yards as they travel through to their final destination.

To estimate both domestic and international locomotive emissions generated in California, ARB staff updated the statewide locomotive inventory. The statewide inventory accounts for several types of line haul trains, all of which are pulled by the same fleet of locomotives. These types include intermodal trains that haul containers; mixed trains that haul bulk materials and other goods such as wood products, agricultural products and petroleum products; and local trains that operate on privately owned local runs. This inventory also includes passenger trains.

To update the inventory we reassessed the fraction of intermodal trains operating in each air basin. We then estimated the fraction of international intermodal trains operating in each air basin based on rail yard specific data provided to ARB by class I rail companies. We then reassessed growth to be consistent with expected growth in the number of containers that will be moving through each air basin in California. These estimates were calibrated using the container balancing method developed for trucks, as discussed above. Switching associated with international intermodal trains was considered international; all other switching emissions were considered domestic. Table II-16 presents international line haul, international switching, domestic line haul, and domestic switching emissions by pollutant for 2001 and future years.

Table II-16
Statewide
Locomotive Emissions
(tons per day)

		Diesel PM				NOx			
Train Type		**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**
Line Haul									
	International	1.2	1.4	1.6	1.8	49	34	42	51
	Domestic	3.3	2.7	2.6	2.5	144	76	81	82
Switching									
	International	0.04	0.03	0.03	0.03	2	1	1	1
	Domestic	0.2	0.1	0.1	0.1	9	6	5	5
Total		**4.7**	**4.2**	**4.3**	**4.4**	**204**	**117**	**129**	**139**

* Includes benefits of measures adopted through October 2005.

G. FUTURE REFINEMENTS

ARB staff works continually to improve emission inventories as new data are received. There are several efforts underway that will potentially provide new information that can be used to refine our emission estimates for goods movement in the future. Staff are actively working to obtain better data representing locomotive activity and emissions on a statewide, regional, and local basis. Staff is continuing to refine commercial harbor craft emissions estimates, and is planning a new future release of the EMFAC model for on-road vehicles, including trucks. Development of the State Implementation Plans for the federal PM2.5 and 8-hour ozone standards also involves efforts to improve the statewide inventory for all emission categories. Finally, we are also working to improve the detail and accuracy of emission estimates on fine spatial scales, such as regions around the Ports of Los Angeles and Long Beach, as well as specific freeway segments in key regions throughout the State.

CHAPTER III

EMISSION REDUCTION STRATEGIES

A. BACKGROUND

1. Drivers for Action

Governor Schwarzenegger's Environmental Action Plan commits to reducing overall air pollution in California by 50 percent by 2010. In addition, there are four other initiatives driving the development of this plan:

- *Community Health/Environmental Justice.* Neighborhoods near ports, intermodal rail yards and high-traffic corridors suffer disproportionate air pollution impacts as compared to other locations. ARB has committed to addressing these issues through focused research, pilot programs, guidelines, regulations, targeted incentives and other efforts.

- *ARB's Diesel Risk Reduction Plan.* Diesel soot is prevalent in California air, especially around areas where diesel sources like those used for goods movement are concentrated. Diesel PM accounts for more than 70 percent of the known cancer risk from air toxics in the State. In 2000, ARB adopted a comprehensive *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-fueled Engines and Vehicles,* establishing a goal of 85 percent reduction in risk from diesel PM by 2020.

- *California's State Implementation Plan.* The national ambient air quality standards for ozone and fine particles are important benchmarks for public health. Federal law requires California to develop a State Implementation Plan (SIP) for each region that violates national standards that identifies sufficient emission reduction measures to attain the standard(s) by the applicable deadline(s). California is preparing SIPs for 15 ozone areas and two fine particulate (PM2.5) areas, due in 2007-2008. Emissions from goods movement must be significantly reduced by 2015 to fulfill these requirements.

- *Business, Transportation & Housing Agency (BT&H) - California Environmental Protection Agency (Cal/EPA) Goods Movement Action Plan.* ARB's emission reduction plan is also an important part of the State's overall initiative to accommodate the anticipated growth in goods movement while mitigating the existing and future impacts on California's environment and communities.

2. Scope of Plan

Emission Sources. This revised plan quantifies the emissions from five sectors associated with ports or the distribution of goods (both international and domestic) throughout California:

- All ships (cargo and passenger vessels) operating in California ports and up to 24[9] nautical miles from the California coast.
- All commercial harbor craft (tugs, ferries, and fishing vessels) operating in California ports and up to 24[1] nautical miles from the California coast.
- Cargo handling equipment used to move goods at ports and intermodal rail yards.
- Heavy-duty trucks moving goods throughout California, and the transport refrigeration units used to protect perishable goods in transit.
- Locomotives pulling trains (cargo and passenger) at rail yards and throughout California.

For each sector, the plan describes the kinds of equipment and engines used, highlights actions taken since 2001 to reduce emissions, and then identifies additional emission reduction strategies needed to protect public health.

Pollutants. The strategies are designed to reduce the highest priority pollutants – diesel particulate matter (diesel PM) and nitrogen oxides (NOx) – that are responsible for most of the quantified mortality and health risk associated with goods movement. The plan also seeks to reduce two additional pollutants where possible, reactive organic gases (ROG) and sulfur oxides (SOx). Emissions of SOx are an important contributor to particulate pollution. ROG is a key ingredient of ozone and also contributes to formation of particulate pollution.

Timeframe. Further emission reductions from all sectors are needed to reduce existing health impacts in communities as quickly as possible and to meet air quality standards by federal deadlines. ARB staff used the 2001 calendar year as the starting benchmark for this analysis because it is the first year for which there is extensive data on port-related emissions. It is also close to the 2000 starting point in ARB's Diesel Risk Reduction Plan and the 2002 base year required for the new State Implementation Plans. The Port of Los Angeles' No Net Increase effort used 2001 as the base year as well. 2005 emissions for each sector are provided to illustrate current levels. Future baseline emissions with "on-the-books" controls are projected for 2010, 2015, and 2020, with corresponding emission goals for each milestone through 2020.

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[9] We have used 24 nautical miles because this distance is consistent with the ARB regulation adopted in December 2005, to require the use of cleaner fuels in ship auxiliary engines. In development of the new State Implementation Plans, we will consider the appropriate range for that purpose.

3. Emission Reduction Goals

The statewide emissions from all ports and goods movement operations in California are over 1,300 tons per day. Table III-1 shows the emissions of each pollutant over time, with the benefits of air pollution controls already adopted by ARB, local air districts, U.S. EPA, and other agencies. Although ARB has adopted some of the new strategies since publication of the December 2005 draft plan, we used the same point in time (October 2005) to mark where the existing program stops and the new strategies begin. Thus, the emissions with the existing program shown in Table III-1 (and all other similarly labeled tables) do not reflect the reductions from measures adopted in December 2005 or later. Those benefits are included under the new strategies.

Table III-1
Statewide Emissions from Ports and Goods Movement with Benefits of All Measures Adopted as of October 2005
(tons per day)

Pollutant	Year				
	2001	2005	2010	2015	2020
Diesel PM	57	53	42	36	36
NOx	1070	1080	892	771	721
ROG	94	90	72	57	51
SOx	73	94	108	138	182

The extensive suite of measures already in place ensures that trucks, cargo handling equipment, harbor craft, and locomotives will get cleaner into the future. But the very minimal controls on ships, and the anticipated increase in international cargo, will reverse our emission reduction progress without significant new strategies. To meet our health goals, we must do much more, much faster.

The statewide goals for this emission reduction plan are carried over from the draft plan, with a new one added to ensure that all regions benefit from the plan strategies:

- **Statewide 2010**: Reduce projected 2010 statewide emissions of diesel PM, NOx, SOx, and ROG from ports and goods movement to 2001 levels or below to mitigate the impacts of growth.

- **Statewide 2020**: Reduce the health risk from diesel PM from port and goods movement by 85 percent, compared to 2000 levels.

- **Statewide 2015 and 2020.** Apply the strategies in the plan on a statewide basis to achieve NOx reductions to aid in attainment of federal and State air quality standards.

The South Coast specific goals of the plan are:

- **South Coast 2015.** Reduce the projected 2015 emissions of NOx from ports and international goods movement in the South Coast by 30 percent to aid attainment of the federal PM2.5 standards.

- **South Coast 2020.** Reduce projected 2020 emissions of NOx from ports and international goods movement in the South Coast by 50 percent to aid attainment of the federal 8-hour ozone standard.

Goals for other areas will be determined through the State Implementation Plan process.

4. Implementation Mechanisms

Successfully mitigating the air quality impacts from goods movement activities will require aggressive action to reduce emissions from all sources regulated by state, local, national and international agencies. Certain strategies, such as emission standards for new engines, are best applied as a regulation. Other strategies such as the early replacement of older diesel trucks operations with cleaner models will require a mix of regulatory and incentive approaches. Where California authority is questionable and international emission standards are not aggressive enough to meet our needs, voluntary agreements with enforcement provisions may be the fastest way to secure rapid emission reductions. The complexity of the goods movement arena and its multi-jurisdictional nature necessitate a full spectrum of approaches. The implementation mechanisms that California could pursue include:

- California Rules and Regulations. ARB and local agencies throughout the State can adopt regulations that compel the use of clean technologies by setting new emission standards or by requiring the use of cleaner technologies. These regulatory approaches are most effective where there is clear legal authority vested in the State or local agency.

- National and International Actions. National regulations, other actions, and funding programs can fulfill the federal government's responsibility to clean up air pollution sources under its jurisdiction. Also, the federal government's advocacy is essential to secure further international actions on emission standards for ships through the International Maritime Organization.

- Incentives. Incentive programs encourage owners and operators of port equipment to voluntarily reduce their emissions and to accelerate the reduction of port-related emissions. There are two types of incentive programs – those that provide funding to purchase cleaner equipment (like California's Carl Moyer Program), and those that use incentives such as reduced port fees to reward lower-emitting or more efficient operations.

- Market Participation Concepts. Market forces can also influence the actions that private companies take to reduce emissions. These concepts could include the lease agreements mentioned above and/or mitigation fees to achieve comparable reductions from other sources affecting the nearby community.

- Enforceable Agreements. Properly executed enforceable agreements can be effective in reducing emissions, without the potential lag time associated with litigation, in situations where regulatory authority is lacking or not unclear. On July 21, 2005, the Board adopted procedures to be used when entering into or amending future agreements with the owners of air pollution sources. Under these procedures, ARB's Executive Officer will notify the Board and the public, and solicit public comment on the subject of the proposed agreement prior to starting negotiations. The Executive Officer can then negotiate an agreement with the source, but the resulting agreement must be approved by the Board before it can take effect. The Board's Ombudsman will inform the Board of the public's involvement when the Board considers ratification.

- Robust Environmental Review and Mitigation. The California Environmental Quality Act (CEQA) includes a comprehensive check list for evaluating environmental impacts and determining the need for mitigation. However, there is also provision for a finding of "overriding considerations," whereby certain impacts and/or mitigation options may be set aside. Applying greater rigor to the CEQA review could prevent excess emissions from occurring during construction and operation of the project. Alternatively, a consolidated CEQA process—such as one that would examine the combined impact of all goods movement projects in a specified area—might do a better job of capturing the aggregate impacts and benefits of modifications to the goods movement system, enabling more effective mitigation measures to be identified and implemented.

- Lease Agreements. Port authorities may stipulate environmental conditions as part of their negotiations for new and expanding leases. This mechanism has been successfully used to create the greenest terminal on the West Coast. The Port of Los Angeles also used this approach when it adopted a comprehensive policy requiring new and renewing leases to contain emission reduction provisions.

B. SHIPS

Strategy "Snapshot." The plan proposes to reduce ship emissions through application of demonstrated control technologies to ships, both in transit and at dockside, as well as use of cleaner fuels for main and auxiliary engines.

1. Introduction

Ocean-going vessels, or "ships," bring the vast majority of international imported goods into California. Ships include vessels such as container ships, bulk carriers, general cargo ships, tankers, and the "roll-on, roll-off" ships used to transport automobiles. Passenger cruise ships are not part of the goods movement sector, but are included in our analyses because their emissions impact communities near ports. Military vessels are not addressed in this report. The smaller vessels that tend to operate primarily in California's coastal waters (such as ferries, tugboats, and commercial fishing vessels) are addressed in the "commercial harbor craft" category.

Most ships are propelled by large diesel piston engines, although some are powered by steam turbines or diesel-fueled turbines. Most vessels use diesel propulsion engines that are mechanically connected to the ship's propeller; these vessels are called "motorships." Some ships use their diesel engines to drive generators that produce electricity for an electric propulsion motor; these vessels are referred to as "diesel-electric." This configuration is commonly used in passenger cruise ships. The propulsion diesel piston engines powering the majority of ocean-going ships are referred to by U.S. EPA as "category 3" engines.

In addition to the propulsion engines, ocean-going ships generally run auxiliary diesel generators and boilers. Diesel generators provide electrical power for lights and equipment, and boilers provide steam for hot water and fuel heating. Most vessels turn off their propulsion engines while at dockside ("hotelling") and only operate their auxiliary engines and boilers, which are significant emission sources at ports.

Although the power systems described above are characterized as "diesel-fueled," the types of fuel vary. Most ocean-going ships run their main propulsion engines and auxiliary engines on heavy fuel oil (or "bunker fuel"), which typically costs between 30 to 50 percent less than distillate marine fuels. This fuel is very viscous and requires heating to allow it to be pumped and injected into an engine. Bunker fuel typically contains much higher levels of sulfur, nitrogen-containing compounds, ash, and other compounds that increase exhaust emissions. For example, typical bunker fuel used by ships visiting California ports averages about 25,000 parts per million (ppm) sulfur, compared to about 120 ppm sulfur for California on-road diesel today and 15 ppm sulfur for most California diesel beginning statewide in June 2006. Some propulsion and auxiliary engines use lighter "distillate" diesel fuel (also referred to as marine gas oil or marine diesel oil). These fuels have much lower levels of sulfur and other contaminants compared to bunker fuel, but higher sulfur levels than land-based diesel fuels.

The factors that determine the level of emissions from ships are ship engine standards and age, the fuel used, and operational practices such as vessel speed, how auxiliary engines are used while in port, and the amount of time spent in and near ports. Ocean-going ships emit more of almost every pollutant addressed in this plan than any other goods movement sector, primarily because the engines and fuels used in these ships have been relatively uncontrolled.

Ship emissions can be reduced with many of the same technologies and fuels that are reducing land-side emissions. Staff also expects that ship engines will at some point be as clean as those used in stationary diesel engines and off-road equipment, when compared in terms of energy output. There are significant logistical, infrastructure, and legal considerations that will affect how quickly these technologies can be adapted or required for use on ships. For example, it can take years, from order to completion, to build most ocean-going vessels and these large ships are designed to operate for up to 40 years. It might be possible to add some of the emission control technologies under consideration during the construction process, but others must be incorporated when a ship is designed. These factors affect both the time needed to introduce cleaner engines into the fleet and the speed with which cleaner ships will be added to the fleet.

International concern about the impact ships have on the environment, particularly in portside cities, is feeding a growing international demand for less polluting ships. Ships are currently subject to very few emission limits. The international nature of the shipping industry presents a major hurdle, as illustrated by the fact only 13 percent of the approximately 1,900 ships that visited California ports in 2004 were U.S.-flagged vessels. Ships are subject to even fewer fuel quality restrictions. In theory, individual ports can impose operational restrictions to reduce emissions. However, there are advantages to using a consistent approach on a statewide level, or beyond.

Within the last several years, action has been taken at both the international and national level to begin to address the emissions from commercial marine vessels. As explained below, these regulations are expected to achieve relatively modest emission reductions in California. Other programs established within California are also described below.

The International Maritime Organization (IMO) established NOx emission standards in 1997. The standards apply to all new diesel engines used on ocean-going vessels. Engine manufacturers have generally produced compliant engines since 2000. However, the rule is expected to result in only modest reductions in NOx emissions, and no reductions in other pollutants. In 1999, U.S. EPA set national emission standards for new "category 1 & 2" engines, which would apply to most auxiliary engines. This rule will reduce NOx, ROG, and diesel PM emissions. However, this rule applies to new engines in U.S.-flagged vessels, which make up about 13 percent of the vessels that visit California ports.

2. Actions Taken – 2001 Through October 2005

- ✓ Vessel Speed Reduction Agreement. In May 2001, a voluntary speed reduction program was initiated at the Ports of Los Angeles and Long Beach. The agreement calls for ocean-going vessels entering or leaving the ports to slow to 12 knots within 20 nautical miles of the ports. The speed reduction reduces fuel use and lowers NOx emissions. Current compliance levels are running at about 50 percent – we assumed the same level into the future for our emission calculations. However, the ports are implementing programs to increase the compliance rate in the future.

- ✓ U.S. EPA Main Engine Emission Standards. In 2003, U.S. EPA set NOx standards for new "category 3" engines used for propulsion of ocean-going vessels. The standards are identical to the IMO NOx standards and thus achieve few NOx emission reductions and no diesel PM reductions. In addition, the rule applies only to new engines on U.S.-flagged vessels, which represent a small proportion of the vessels visiting California ports.

- ✓ U.S. EPA Non-road Diesel Fuel Requirements. In 2004, U.S. EPA acted to limit the sulfur content of diesel fuels for non-road applications. For marine use, the rule would limit the fuel sulfur content to 500 ppm in 2007 and 15 ppm in 2012. The rule does not apply to marine diesel oil or heavy fuel oil. Since most ocean-going vessel auxiliary engines use heavy fuel oil, the federal rule will have little impact in reducing emissions from this source.

Table III-2 shows that emission increases due to anticipated growth in both cargo-related ships and cruise ships are far outpacing the slight reductions achieved by existing international and U.S. EPA regulations.

Table III-2
Statewide
Emissions from All Ships
with Benefits of Measures Adopted as of October 2005
(tons per day)

Pollutant	Year				
	2001	2005	2010	2015	2020
Diesel PM	7.8	10.6	13.8	17.7	23.3
NOx	94.7	124.9	158.2	199.6	253.6
ROG	2.4	3.2	4.2	5.3	6.8
SOx	59.6	81.1	106.1	136.9	180.4

With only the minimal controls in place today, ship emissions would increase steadily over time based on growth in cargo operations. Ships will become an even more significant source of diesel PM and NOx as a result of this growth. Ships also dominate the SOx inventory, accounting for over 85 percent of SOx emissions from goods movement today and over 99 percent by 2010.

Emissions from ships are associated with three distinct modes of operation. In 2005, approximately 75 percent of ship emissions statewide occurred when ships were "in transit" – moving between ports in open water. Maneuvering within a port as ships approach and leave terminals accounted for approximately 3 percent of total ship emissions, while the remaining 22 percent of ship emissions occur when the ship is "hotelling" at berth. Chapter II provides detail about the level of emissions from each mode of operation.

3. Strategies to Further Reduce Emissions

The marine industry is diverse and has only recently been subject to air quality regulation. Information regarding duty cycles, emission factors, and the effectiveness of controls on marine engines is less definitive than for other mobile sources. Many of the measures proposed in this document will require the cooperation and collaboration of multiple agencies on the local, State, national, and international level. These efforts may include the formation of an international coalition of environmental agencies, shipping companies, engine manufacturers, and/or port authorities.

To provide a central point in California for the coordination and discussion of air quality strategies for the maritime community, the ARB established the Maritime Air Quality Technical Working Group (Maritime Working Group) in 2001. The group is open to all interested parties and includes representatives from California ports, commercial shipping companies, U.S. EPA, local air quality districts, maritime industry associations and community and environmental groups.

The Maritime Working Group has facilitated emission reduction measure development by providing a forum for discussion of strategies at the early, conceptual stage. Engine manufacturers and emission control technology suppliers have presented information to help the process as well. The Maritime Working Group has also facilitated emissions testing projects, and is currently assisting in the demonstration of retrofit emission control technologies on a large container ship. We envision the Maritime Working Group to be the forum for continuing cooperation and collaboration as we work to achieve emission reductions from this category over the next several years.

The strategies discussed below are based on potential emission reduction approaches that can be categorized broadly as: (1) cleaner engines; (2) cleaner fuels; (3) exhaust control devices/capture of emissions; and (4) operational controls, such as speed reduction zones. The strategies are organized by estimated date of implementation. However, there is significant overlap since many of these strategies will develop over many years and will be phased in. Due to complex jurisdictional issues and the international nature of ships, alternative implementation mechanisms may be needed in addition to traditional regulations. These mechanisms may include voluntary, enforceable agreements; market-based approaches; emission reduction credit programs; and incentive programs.

Vision for Cleaner Ships. The technology exists to significantly reduce ship emissions. Accordingly, this plan envisions the steady phase-in of much cleaner vessels between now and 2020. In terms of an individual vessel, several of the approaches discussed below could be combined to produce cleaner ships (either newly built or retrofitted) with dramatically lower emissions of diesel PM, NOx, and SOx. For example, newly built vessels, and in many cases retrofitted vessels, could apply a combination of the following approaches.

- Incorporate catalytic exhaust controls such as selective catalytic reduction (SCR) on the main (new vessels only) and auxiliary engines. The use of this technology could control NOx emissions by 90 percent or greater.

- Modify dockside facilities, and retrofit or build the vessels with the capability to utilize shore-side power at dock. The use of shore-side power would reduce emissions of diesel PM, NOx, and SOx from auxiliary engines by over 95 percent each during hotelling.

- Install fuel tanks, piping, and other modifications, if necessary, to allow the main engines to operate on marine distillate, which generally contains less than 5,000 ppm sulfur. The use of this fuel could reduce emissions of diesel PM and SOx by about 75 percent or greater, and reduce emissions of NOx by about 6 percent, compared to the standard heavy fuel oil now used by most vessels.

- Install equipment necessary for the main engine to use emulsified fuels. The use of emulsified fuels can reduce NOx emissions by 30 percent or more. Further reduce NOx from the main engine through increased compliance with speed reduction zones.

- Use advanced fuel injection. The fuel injection systems used by large marine engines are generally less advanced than those used by onroad diesel engines. It is expected that more advanced fuel injection system (e.g. "slide valve" designs and electronically controlled injection systems) will provide PM reductions in the future.

- Install diesel particulate filters. Filters are not currently used on large marine engines due to the high sulfur content of the fuels used (which poison catalysts), the massive size of the engines (requiring similarly large filter devices), and the limited space onboard vessels. However, there may be opportunities for modified filter designs if lower sulfur fuels are used in the future and filter technology continues to evolve.

- Use modified stationary source-type controls. PM controls similar to those used in landside stationary source applications (such as scrubbers) are typically too large for use onboard ships. However, modified designs that use more compact systems may be possible in the future.

The disadvantage of such systems is the initial (capital) cost, and ongoing higher costs for operation and maintenance. For example, in the case of selective catalytic reduction, ammonia or urea is injected into the catalyst during operation, which imposes ongoing costs. Selective catalytic reduction and other control devices can also displace space on a vessel and reduce its cargo capacity.

Implementation of the overall strategy will require a combination of regulatory efforts, incentive or market based programs, and cooperative agreements. Some fuel related measures can be accomplished by actions by ARB or U.S. EPA. Engines standards by IMO could become an important component. Increased use of shore power could be done via regulation, or by other means such as port leases. Measures that involve modifying or building ships to exceed IMO emission standards and the preferential deployment of those vessels to California services will likely require some combination of incentive, market-based, regulatory and cooperative agreement approaches.

For each strategy described below, we identify the approach and any relevant performance benchmark(s) – like percent emission control and/or fleet penetration -- that we believe are, or will be, feasible. These strategies envision that all of the implementation mechanisms will be considered for this sector. For each implementation time period, we have estimated the aggregate emission reductions that can be achieved with a mix of the approaches identified for that period, without attributing reductions to each individual strategy.

In this version of the plan, we are highlighting the potential for future ARB regulations to require widespread use of lower sulfur marine fuels in main engines and increased use of shore power if ARB determines that these actions are the most effective mechanism to quickly reduce emissions of diesel PM, NOx, SOx, and other pollutants.

The goal is to produce a viable approach that results in a steadily increasing supply of lower-emitting vessels with clean engines and/or shore power capability, and ensures a rapid increase in the use of these vessels in California service. Emission reduction goals begin in 2010, with increasingly aggressive targets by 2015 and as full as possible implementation by 2020.

a. Implementation Possible by 2010

The following approaches can significantly reduce ship PM, NOx, and SOx emissions by 2010.

i. ARB Rule for Ship Auxiliary Engine Fuel (Adopted December 2005)

In December 2005, ARB adopted a regulation to require auxiliary engines on ocean-going vessels to significantly reduce diesel PM, NOx, and SOx emissions. The regulation will apply while vessels are within 24 nautical miles of the California coastline. Ships and shippers can comply by using cleaner-burning marine distillate fuels instead of the bunker fuel typically used by vessels, or by implementing equally effective strategies under an alternative approach. Vessels that choose the clean fuel option will have to use marine gas oil, or marine diesel oil meeting a 5,000 ppm sulfur limit, starting in 2007, and meet a 1,000 ppm limit beginning in 2010. If operators choose to develop an alternative control of emissions plan, they must demonstrate that the alternative strategies will result in no greater emissions than what would have occurred by complying with the fuel requirements. The regulation applies to both U.S.-flagged and foreign-flagged vessels.

ii. Cleaner Marine Fuels for Main Engines

An option to cut ship emissions in the near term is to operate main engines on lower sulfur heavy fuel oil or marine distillate fuels. The clean fuel requirement ARB adopted in December 2005 does not apply to the propulsion engines that are used to power ships from one port to another (except for diesel-electric vessels). However, ARB evaluating such an approach for main engine fuels, and will develop it for the Board's consideration if we determine that it would be the most effective path to quickly reduce diesel PM, NOx, and SOx emissions. Currently most vessels operate their main engines on heavy fuel oil, which contains high levels of sulfur, ash, and nitrogen compounds. Marine distillate fuels could reduce emissions of diesel PM and SOx by about 75 percent compared to typical heavy fuel oil, and NOx emissions by about 6 percent. The use of lower sulfur heavy fuel oil (5,000 ppm sulfur) would result in about an 80 percent SOx reduction, and about a 35 percent PM reduction. The main disadvantage of using these cleaner burning fuels is higher cost: distillate marine fuels typically cost 50 to 100 percent more than heavy fuel oil and lower sulfur bunker is available in limited quantities. In addition, there are various technical issues with operating some main engines on distillate fuels for extended periods of time that must be resolved.

iii. Emulsified Fuels

Another fuel-based option is to operate main and auxiliary engines on emulsified fuels. This technology has already been demonstrated on marine engines and marine-type engines used in land-based power-plant applications. On-board systems that can produce emulsified fuels by mixing heavy fuel oil and water under high pressure can be installed on vessels. Emulsified fuels reduce emissions of NOx by reducing peak temperatures within the combustion chamber, which reduces the formation of NOx. These systems generally reduce NOx emissions in proportion to the amount of water in the emulsified fuel. We expect that a 30 percent or greater reduction in NOx is possible.

Drawbacks include the need to store large quantities of fresh water (saltwater cannot be used), and slight increases in fuel consumption and PM emissions that are possible with high levels of water.

iv. Expanded Vessel Speed Reduction Programs

An approach to reduce ship NOx emissions is to investigate the feasibility and benefits of expanding the existing vessel speed reduction program at the Ports of Los Angeles and Long Beach by extending existing speed reduction zone further offshore, or by extending the program to other ports. Slower speeds reduce main engine fuel consumption and result in significant NOx reductions. However, compliance with the existing program has been below 50 percent for some time periods, so options for increasing voluntary compliance, or a mandatory program, may be necessary. Another potential drawback is concern with the increased time it takes a vessel to reach its destination, which could impact ship schedules if the area covered by the program is increased. There have also been some concerns expressed about potential increases in diesel PM emissions fro some vessels operating at slow speeds, and about additional that may be needed to track vessels further offshore.

v. Install Engines that Exceed IMO Standards in New Vessels

International shipping is growing, and new vessels are being introduced into service at a fairly rapid pace. Newer vessels with cleaner engines could begin to be placed into California service by 2010. Some technologies, such as fuel emulsion systems, slide valves, lower emission auxiliary engines and the capability to use shore power could be incorporated into vessels now under construction. Other technologies such as main engine SCR systems could be designed and deployed into a limited number of vessels put into service by 2010. Many new ship engines built in this timeframe could achieve emissions 30 percent below IMO levels for PM and for NOx, and existing engines undergoing major maintenance during this timeframe could be modified or retrofitted to achieve similar emission reductions. It is possible that new ships with SCR systems could be put into service by 2010. Because of the long lead times in vessel design and construction, the impact of these strategies on main engines would be limited in 2010.

vi. Dedicate the Cleanest Vessels to California Service

A key option to reduce ship emissions is to accelerate the use of vessels with cleaner new or retrofitted engines at California ports. This could be accomplished by assigning the cleanest vessels to routes that frequently visit California ports. Possible reductions by 2010 are expected to be modest, because of the limited availability of cleaner vessels by that date. It is difficult to predict how quickly cleaner ships will become available and can be deployed to California ports in the 2010 timeframe. We believe that 20 percent of the ship calls at California ports by 2010 can be made by vessels with new or retrofitted engines that achieve at least 30 percent lower NOx and PM than current IMO standards. For example, this could be accomplished if 100 ships that visit California most frequently (5 percent of the total ships) are equipped with these engines.

vii. Shore Based Electrical Power

Another near-term approach that could achieve significant reductions would be to increase the use shore-side electrical power (called cold ironing) to allow vessel operators to turn off their diesel powered auxiliary engines at dock. This approach dramatically reduces vessel hotelling emissions, and could be partially implemented by 2010. Increasing use of shore power could be accomplished via regulation, lease agreements, or incentives and other voluntary approaches.

Shore based power is technically feasible. Shore power is currently being used or planned for passenger ships, container ships, bulk ships, and oil tankers, as well as having been practiced routinely for decades at U.S. Navy ports all over the world.

In March 2006, ARB staff released a report, *Evaluation of Cold-Ironing Ocean-Going Vessels at California Ports,* that includes a detailed assessment of the feasibility, benefits and costs of increasing the use of shore-based power. This report also identifies 18 California ports as candidates for cold-ironing. Ports on the West Coast, including several in California, are already using or considering shore-based power at some terminals. We include several examples below from the ARB report.

- The Port of Los Angeles runs a voluntary Alternative Maritime Power program to provide shore power to container and passenger ships. The Port of Los Angeles retrofitted the China Shipping Terminal to include a shore-power infrastructure. Two ships began connecting to shore power in June 2004. According to the Port, there are now currently 15 ships that are equipped to plug into shore power while at the terminal. The Port recently built shore-side infrastructure to provide power to a container ship (NYK Atlas) when in port. The NYK Atlas was equipped with shore power capabilities when built in 2004. The Port also has shore-side infrastructure at Pier 400, although no ships calling at this terminal are currently equipped to connect to shore power. Shore-side infrastructure will also be built at berths 206-209. The lease for the container terminal's new tenant, P&O Nedlloyd, will require that 70 percent of ships calling there be connected to shore power within three years. Additionally, the Port has indicated that they will begin designing a shore-power infrastructure at their passenger ship terminal (berths 91-93) once they receive a firm commitment from a tenant to utilize shore power when in port.

- The Port of Long Beach has committed to providing shore-side power to all new and reconstructed container terminal berths and other berths as appropriate. Through lease language, the Port will require selected vessels to use shore power and all other vessels to use low-sulfur diesel in their auxiliary generators. Cold-ironing projects are being developed at three berths at the Port—one of them a voluntary project with the tenant. British Petroleum (BP) will equip two of its new Alaskan-class tankers that dock in Long Beach with shore-power capabilities when they are built in 2006.

- In the Bay Area, the Port of Oakland plans to evaluate the feasibility of adding shore power to its terminals in the future. The Port of San Francisco has recently completed a feasibility study for adding shore power to its new passenger ship terminal at Piers 30-32 and will now develop more specific cost estimates and pursue potential funding for building a shore power project at the terminal.

- The Port of San Diego is considering providing shore power to passenger ships calling at the Port. The Port is developing a conceptual design for including shore power at its B-Street Pier, which the Port plans to redevelop.

- In Pittsburg, California, four dry-bulk ships cold-iron while docked at USS POSCO Industries' steel facility. The ships are also equipped with selective catalytic reduction (SCR) technology. Connection to shore power began in 1991 as part of the POSCO facility's plan to mitigate emissions from an expansion.

- The U.S. Navy cold-irons ships while in port at bases all over the world. The Navy connects to shore power as a matter of routine and has done so for several decades. The ships are also hooked up to water, sewer, communications, and steam while docked. Cold-ironing is routine at the San Diego Naval Station.

- Princess Cruises began cold-ironing its ships docked in Juneau, Alaska in 2001 and Seattle, Washington in 2005. According to Princess Cruises, there are currently six ships that are equipped to cold-iron in Juneau and two ships in Seattle.

The disadvantage of cold ironing is the high cost of dockside infrastructure and vessel retrofits, as well as the high cost of electricity relative to shipboard generation from diesel engines. Shore power is likely to be cost-effective for ships that frequently visit California ports, but a high-cost strategy for the remaining ships that visit California ports infrequently. Alternative technologies such as barge-mounted control systems may be a sensible alternative for many of these vessels, and such systems could begin to be deployed by 2010.

We believe that at least 20 percent of the ship calls at California ports by 2010 can be made by vessels that use shore power, and 20 percent of the other vessels visits utilize alternative at-dock reduction technologies, if such technologies can be proven effective over the next few years.

b. Implementation Possible by 2015

The following strategies, in addition to continued progress on the previous measures, can further reduce emissions by the 2015 timeframe.

i. Extensive Retrofit of Existing Engines

By 2015, shipping lines could install cleaner technology on existing vessels during major engine maintenance operations. For example, retrofit existing fuel injectors with slide-valve designs, or install technology to reduce engine oil consumption. Programs to install such technology could provide substantial emission reductions by 2015 if engine manufacturers continue to expand the selection of retrofit devices. Currently such technologies are relatively limited, and only available on certain models. However, increased interest and advances in technology may result in an increasing array of low emission retrofits. The disadvantage will be higher costs compared to standard replacement parts.

ii. Highly Effective Emission Controls on Main Engines and Auxiliary Engines

A critical approach is to install emission control devices on new or existing engines that frequently visit California ports. We expect that additional emission control systems will be available for marine applications in 2015, such that at least 90 percent NOx control and 60 percent PM control can be achieved on newly built ship engines.

For example, exhaust emission controls such as selective catalytic reduction are available now and can be installed on new vessels, or in some cases retrofitted on existing auxiliary engines. This technology can reduce NOx and ROG emissions by 90 percent or greater, and in some cases may reduce diesel PM emissions as well.

There are a number of potential approaches that might be feasible in this timeframe to reduce PM emissions by 60 percent or more from new ships, as described under "Vision for Cleaner Ships" in the beginning of this section.

iii. Sulfur Emission Control Area (SECA) or Alternative

Require the use of low-sulfur fuels in a vessel. ARB is working with U.S. EPA to establish a SECA off California's coast (or beyond) under the provisions of the International Maritime Organization, MARPOL Annex 6. A SECA designation would limit the sulfur content of marine heavy fuel oil to no more than 15,000 ppm, well below the current average of about 25,000 ppm. Currently, U.S. EPA is in the process of evaluating the feasibility of a North America SECA that would include the California coastline. At a minimum, we are advocating a SECA requirement limiting the sulfur content to 15,000 ppm as soon as possible and to 5,000 ppm or below by 2015. The use of 5,000 ppm level heavy fuel oil would reduce PM emissions by about 35 percent, and SOx emissions by about 80 percent.

A national or West Coast approach would be the most effective way to implement uniform lower sulfur fuel requirements for all ships that travel to California's ports or along the coast en route to other ports. ARB is performing the bulk of the technical analysis needed by U.S. EPA to support this approach. However, if the potential to obtain a SECA designation that lowers sulfur levels to 5,000 ppm or less in the timeframe described above does not look promising, or if ARB determines there is a need to go further or faster, ARB may develop a statewide regulation for main ship engine fuels. We could pursue an approach similar to the one used in the auxiliary engine fuels rulemaking adopted by the Board in December 2005.

iv. Build New Ships that Far Exceed IMO Standards or Expand the Use of Cleanest Vessels in California Service

One of the most effective approaches to reduce ship emissions is to greatly increase the use of vessels built with cleaner new engines, or existing engines with added emission control systems, at California ports. To make this feasible, ship builders would need to construct a significant number of new ships with equipped with SCR or similarly highly effective controls in response to customer demand and shipping lines would need to assign the cleanest vessels to routes that frequently visit California ports. Significant emission reductions are possible by 2015, assuming that cleaner vessels have become widely available by that date.

We believe that 25 percent of the visits can be by new ships that achieve reductions of 90 percent for NOx and 60 percent for PM. Another 50 percent of the ship calls at California ports by 2015 can be made by vessels with new or retrofitted engines that achieve 30 percent lower NOx and PM than current IMO standards. This can be accomplished if 200 ships that visit California most frequently (approximately 10 percent of all ships that visit California's ports) are new vessels built with the best available controls (90%NOx/60%PM) and 400 additional vessels are equipped with engines that achieve 30 percent NOx and PM reductions.

v. Expanded Shore Power and Alternative Controls

Use of shore-side power dramatically reduces vessel hotelling emissions, and could be widely deployed and result in very substantial reductions by 2015. We believe that 60 percent of the ship calls at California ports by 2015 can be made by vessels that use shore power, and 20 percent of the other vessels visits utilize alternative at dock reduction technologies. This would require approximately 500 vessels (25 percent of the total) to be capable of using shore power, or deploy equivalent on-board controls.

c. Implementation Possible by 2020

As cleaner ship technologies become available, additional emission reductions can be achieved by continuing to direct those vessels to California.

i. Full Use of the Cleanest Vessels in California Service

To maximize the use of vessels with cleaner new engines or existing engines retrofitted with emission control systems, shipping lines could assign the cleanest vessels to routes that frequently visit California ports. We believe that 50 percent of the visits can be by new ships that achieve 90 percent NOx and 60 percent PM reductions. Another 40 percent of the ship calls at California ports by 2015 could be made by vessels with new or retrofitted engines that achieve 30 percent lower NOx and PM than current IMO standards. This could be accomplished if 400 ships that visit California most frequently (20 percent of all ships that visit California) were new vessels built with the best available controls (90%NOx/60%PM) and 800 additional vessels were equipped with engines that achieve 30 percent NOx and PM reductions. This measure recognizes that another approximately 800 vessels that have not been equipped with any additional emission controls and that call in California infrequently will continue to use California ports.

ii. Maximum Use of Shore Power or Alternative Controls

To achieve the full potential of the use of shore-side electrical power or other dockside controls, these approaches could be fully deployed by 2020. We believe that 80 percent of the ship calls at California ports by 2020 can be made by vessels that use shore power, and half of the remaining vessel calls (10 percent) would be made by vessels that could use utilize alternative at dock reduction technologies. This would require approximately 600 vessels (30 percent of the total vessels) to be capable of using shore power, or deploy equivalent on-board controls.

4. Emission Reductions

Emission reduction estimates for the mix of strategies described above are based on: implementing lower sulfur fuels, bringing cleaner vessels (from any combination of lower emission engines and fuels), and increasing use of shore power or alternative "at dock" measures.

Key Inputs. We describe the key inputs for the emission reduction calculations below.

- We used future year emission projections for each port that reflect potential growth, including an increase in vessel size. This growth rate corresponds roughly to a tripling of trade between 2001 and 2020.

- We split the total ship emissions from all at-dock, maneuvering, and transit operations (out to 24 nautical miles off the California coast) into two parts – (1) *auxiliary* engine at dock and underway emissions (roughly 30 percent of total ship emissions in this inventory), and (2) *main engine* underway emissions (roughly 70 percent of total ship emissions in this inventory).

- To the *auxiliary* engine emissions, we applied ARB's 2010 auxiliary fuel requirements (at 96% SOx reduction) and revised the projected future year emissions. From these new projections, we reduced emissions using the targets for use of shore power:

	Percent Control		Percent of Ship Visits		
	PM	NOx	2010	2015	2020
Shore power	90%	90%	20%	60%	80%
Other "at-dock" reduction measures	50% fleet average		20%	40%	20%
Total visits with reduced emissions at dock			40%	100%	100%

- To the *main engine* underway emissions, we first incorporated the benefits of current IMO/U.S. EPA Tier 1 emission standards and the Southern California Vessel Speed Reduction agreement (assuming 50 percent compliance) to determine the emissions with the existing program. We then applied a SECA-based 1.5 percent sulfur content fuel limit in 2010, and a 0.5 percent sulfur content limit in 2015 and subsequent years to reduce SOx. From these new projections, we estimated reductions in PM, NOx and SOx emissions based on ships using any combination of cleaner new engines or retrofits, cleaner fuels or other approaches:

	Percent Control		Percent of Ship Visits		
	PM	NOx	2010	2015	2010
Vessels cleaner than IMO standards	>30%	>30%	20%	50%	40%
Vessels with best available controls	60%	90%	--	25%	50%
Total visits with reduced emissions underway			20%	75%	90%

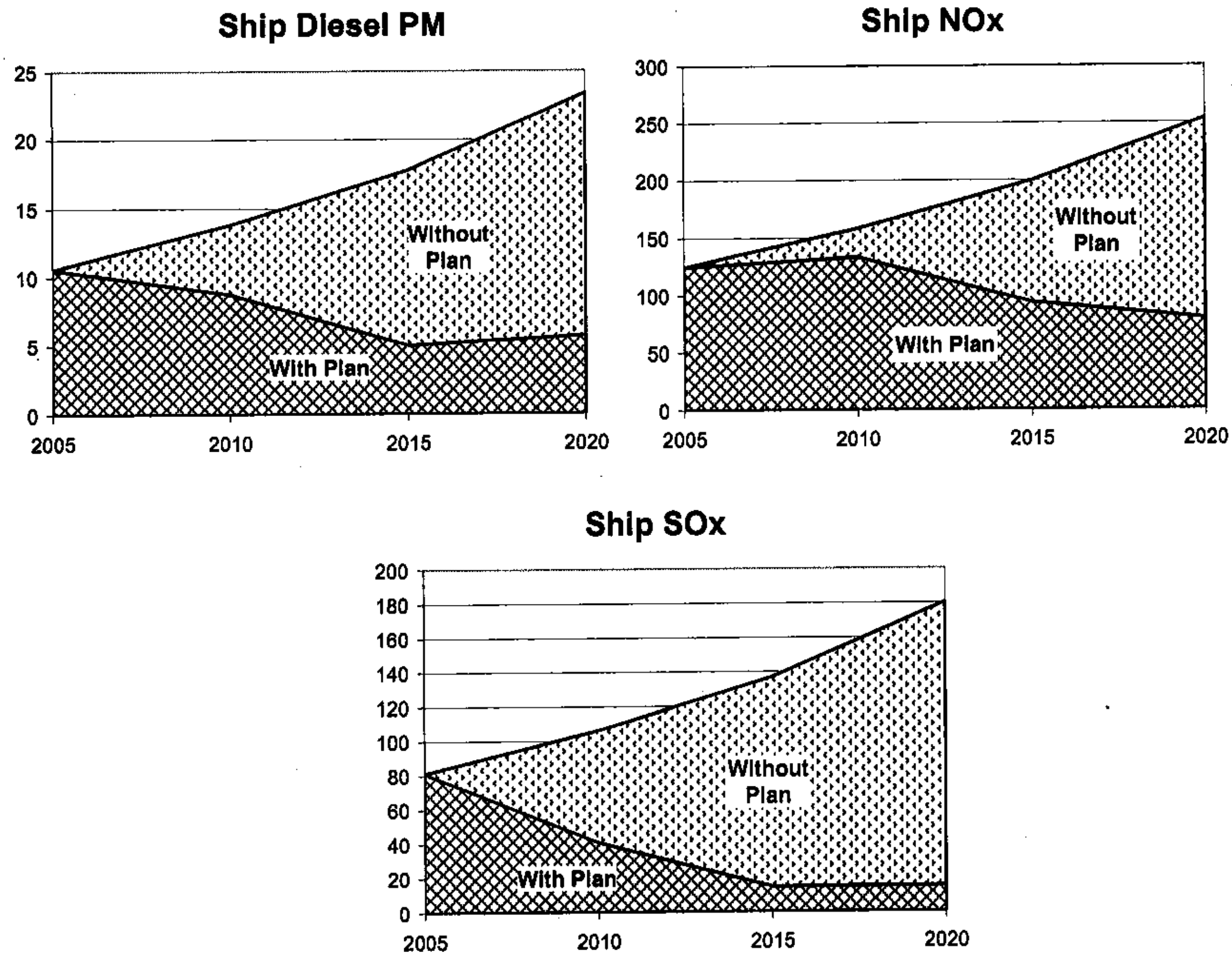
- We recombined the *auxiliary* and *main engine* emission projections that reflect the benefits of the plan strategies.

Results. Table III-3 shows the benefits of the new strategies described in this section for ships. Fully implementing the new strategies would cut diesel PM and SOx in half over the next decade. Figure III-1 shows the impact that the proposed strategies would have on ship emissions through 2020 if fully implemented. Reductions achieved through 2005, from controls that have already been enacted, are included in the starting emissions. Reductions shown for 2010 and later strategies are dependent on the future actions and further development of control technologies. Some of the technologies we relied on for this analysis are widely used in other applications, but are still being demonstrated for use in ships in a limited number of applications. Selective catalytic reduction is such a technology. The new reductions – 2020 strategies are conceptual at this point. We believe that global concern about emissions from ships and health impacts near ports will compel the development of the new technologies that will allow ships to eventually be nearly as clean as land-based transportation sources.

Table III-3
Statewide Emissions from All Ships Within 24 Miles of California Coast with Full Implementation of Plan Strategies
(tons per day)

Pollutant	Year				
	2001	2005	2010	2015	2020
Diesel PM					
Emissions with Existing Program	7.8	10.6	13.8	17.8	23.3
New Reductions - ARB Auxiliary Engine Fuel Rule			-4.25	-5.81	-8.28
New Reductions – 2010 Strategy			-0.76		
New Reductions – 2015 Strategy				-6.98	
New Reductions - 2020 Strategy					-9.34
New Reductions - Total			-5.0	-12.8	-17.6
Emissions with Plan	7.8	10.6	8.8	5.0	5.7
NOx					
Emissions with Existing Program	94.7	124.9	158.2	199.6	253.6
New Reductions - ARB Auxiliary Engine Fuel Rule			-3.5	-4.8	-6.8
New Reductions - 2010 Strategy			-21.5		
New Reductions - 2015 Strategy				-101.1	
New Reductions - 2020 Strategy					-167.3
New Reductions - Total			-25.0	-105.9	-174.1
Emissions with Plan	94.7	124.9	133.2	93.7	79.5
ROG					
Emissions with Existing Program	2.4	3.2	4.2	5.3	6.8
New Reductions - ARB Auxiliary Engine Fuel Rule			Not quantified		
New Reductions - 2010 Strategy					
New Reductions - 2015 Strategy					
New Reductions - 2020 Strategy					
New Reductions - Total			0.0	0.0	0.0
Emissions with Plan	2.4	3.2	4.2	5.3	6.8
SOx					
Emissions with Existing Program	59.6	81.1	106.1	136.9	180.4
New Reductions - ARB Auxiliary Engine Fuel Rule			-38.9	-53.0	-75.2
New Reductions - 2010 Strategy			-26.5		
New Reductions - 2015 Strategy				-69.3	
New Reductions - 2020 Strategy					-90.1
New Reductions - Total			-65.4	-122.3	-165.3
Emissions with Plan	59.6	81.1	40.7	14.6	15.1

Figure III-1
Impact of Plan Strategies on Statewide Ship Emissions
(tons per day)



5. Costs

We used multiple methods to estimate the cost to implement the strategies for this sector. For auxiliary engine fuel and shore power, we developed specific cost estimates based on ship travel to and from California ports and along California's coast. For the other ship strategies, we used a more general approach because we anticipate that shipping companies and ports may pursue a mix of different approaches to meet the targets, depending on their operational needs and the availability/cost of cleaner technology and fuels.

Key Inputs. To estimate costs for this sector, we used these approaches.

- For the auxiliary engine fuel rule, we relied on the cost estimates detailed in ARB's staff report on that rulemaking.[10] For increased use of shore power, we used the cost estimates in ARB staff's March 2006 report on that topic.

- It is not yet clear what combination of technologies and approaches will be used to achieve the emission reductions for the remaining strategies. Because of this, we developed the cost estimate by applying a cost effectiveness number based on other ARB programs to the total amount of emission reductions expected from these strategies. We projected cost-effectiveness in the range of $6,500 to $18,000 per ton of NOx + diesel PM reduced. The lower end of this range is based on approximately 150 percent of the average current cost-effectiveness of the Carl Moyer program. The upper end reflects our estimate of how costs may escalate in the future, as sources get cleaner and it becomes more difficult and costly to get additional emission reductions.

- We then estimated the emission reductions from these other ship strategies for each year from 2007 through 2020, interpolating between the years for which we projected emission reductions in the prior section. We multiplied the cost-effectiveness range by the tons of NOx + diesel PM reductions that we are projecting each year from the combined strategies to calculate the total cost per year in 2005 dollars.

- Finally, we summed up the annual costs from 2007 through 2020 to project the cumulative cost to implement the plan strategies for this sector.

Results. The cumulative costs to fully implement the strategies for the ship sector are given below. Each time period is cumulative, thus the 2007-2020 value is the total cost (stated in 2005 dollars) of implementing the strategies for this sector. In subsequent chapters, we convert these amounts to present value.

	Cumulative Costs 2007-2010 (in millions)	**Cumulative Costs 2007-2015 (in millions)**	**Cumulative Costs 2007-2020 (in millions)**
Ships	$514 to $678	$2,075 to $3,420	$4,227 to $7,971

[10] *Auxiliary Diesel Engines and Diesel-Electric Engines Operated on Ocean-Going Vessels within California Waters and 24 Nautical Miles of the California Baseline,* October, 2005, available at http://www.arb.ca.gov/regact/marine2005/isor.pdf .

C. COMMERCIAL HARBOR CRAFT

Strategy "Snapshot." Emission reductions will be achieved primarily through an ARB rule to clean up the existing fleet and from new federal engine emission standards. Smaller reductions will come from shore-based electrical power.

1. Introduction

Harbor craft operate primarily along California's coastline and inland waterways. These vessels generally stay within California coastal waters, and usually leave and return to the same port. The commercial vessels related to goods movement include tug/tow boats, pilot boats, workboats, crew/supply boats, and others. These vessels, as well as other harbor craft such as ferries and fishing vessels, operate in and around ports and their emissions contribute to community health risk. We have included all types of harbor craft, not just those used in goods movement, in our analyses in this plan.

Most harbor craft use diesel-powered propulsion and auxiliary engines. In 2002, there were approximately 4,100 commercial harbor craft, with 7,400 engines, operating in California's waters. Of that number, approximately 250 were tugboats, towboats and workboats – boats that serve import goods movement – with 700 engines.

In 1999, U.S. EPA established new engine standards for new "category 1 & 2" engines – engines with a displacement less than 30 liters per cylinder that are used for propulsion in most harbor craft. This rule specifies standards for NOx plus hydrocarbons, particulate matter, and carbon monoxide. The standards are effective beginning in 2004, 2005, or 2007, depending on the engine size. The emission reductions from the federal rule are expected to be modest. The NOx standards will not achieve significant emission reductions until after 2010, since the standards only apply to new engines introduced beginning 2004-2007. In addition, the PM and carbon monoxide standards are effectively caps in many cases, designed primarily to prevent increases.

2. Actions Taken – 2001 Through October 2005

Several key actions have been taken since 2001 to reduce emissions from harbor craft:

✓ Incentives for Cleaner Engines. Since 1998 the Carl Moyer Program has been offering monetary incentives to reduce NOx emissions from diesel engines below the levels required by current standards, agreements, and regulations. The most common action has been to replace an older diesel engine with a cleaner diesel, resulting in up to a 60 percent decrease in NOx and PM emissions. ARB and local air districts have provided over $17 million to replace more than 300 older, dirty diesel engines in harbor craft with new, cleaner engines.

✓ Low Sulfur Diesel Fuel Rule. In 2004, ARB adopted a regulation that requires harbor craft to use cleaner diesel fuel statewide starting January 2007. Diesel fuel sold or supplied to most commercial (and recreational) harbor craft must meet the same fuel specifications as the diesel used in on-road trucks. This fuel has a low sulfur content (15 ppm) and lower aromatic hydrocarbons. For vessels not already using California's on-road diesel fuel, NOx reductions of five percent and PM reductions of nine percent are expected. More importantly, the fuel enables these vessels to apply high efficiency emission control devices (such as diesel particulate filters) that will reduce diesel PM by 85 percent or more.

3. Strategies to Further Reduce Emissions

Table III-4 shows the projected emissions from commercial harbor craft, including the reductions that are expected from existing ARB and U.S. EPA regulations, plus other programs that are currently reducing emissions from individual harbor craft.

Table III-4
Statewide
Emissions from All Harbor Craft*
with Benefits of All Measures Adopted as of October 2005
(tons per day)

Pollutant	Year				
	2001	2005	2010	2015	2020
Diesel PM	3.8	3.7	2.9	2.1	1.8
NOx	75.4	69.2	56.4	43.6	38.6
ROG	7.6	7.0	5.9	4.5	4.0
SOx	0.4	0.4	0.1	0.1	0.1

Below we outline additional strategies that can reduce emissions from harbor craft.

a. Implementation Possible by 2010

i. ARB Rule to Clean Up Existing Engines

ARB is in the process of developing a regulation to reduce emissions from the main propulsion and auxiliary engines used in commercial harbor craft. The goal is to reduce emissions by re-powering existing harbor craft with cleaner engines, by using cleaner alternative fuels, or by applying add-on emission control technologies.

Due to the diversity within the harbor craft category, specific emission reduction proposals will vary with the type of vessel, industry, and other factors. For example, tugs and ferries tend to operate primarily near ports and neighboring communities and have high annual hours of operation. The engines on these vessels are also typically newer and the vessels are larger. These factors provide more opportunity for the application of retrofit devices or the repowering of vessels with newer, cleaner engines.

Fishing vessels, however, tend to be much older and operate several miles off the coastline for a large percentage of the time. The fishing industry is also facing difficult economic times due in part to increased competition with the globalization of the industry, and other factors such as restrictions on fishing off the California coast. These issues will need to be considered as part of the economic analysis for the measures.

Cleaner Engines. The diesel engines typically used in harbor craft were built for durability, with little or no consideration for emissions control. On some vessels, older dirty engines can be replaced or repowered with newer, cleaner engines. Ease of engine replacement varies widely vessel to vessel. For example, many fishing vessels are older, use two-stroke engines, and have limited space. A cleaner new four-stroke model is physically larger and may not fit into the engine compartment without major hull, vessel, and electrical modifications.

Nevertheless, there are many examples of vessels being repowered with cleaner engines. For example, the engines in many tugboats working in Los Angeles Harbor have been successfully repowered with newer, cleaner engines since 2001 under the South Coast Air Quality Management District Rule 1631 to generate credits for use by industrial sources. This program also demonstrated that equivalent emission reductions can be achieved from remanufactured engines. Remanufacturing marine engines is the process where all engine components, except for the existing engine block, are replaced with new original equipment manufacturer parts. Some engines have newer fuel injectors, aftercoolers, turbochargers and other parts added to the original engine setup to lower the engine emissions. The Port of Oakland and the Carl Moyer Program have also subsidized a number of cleaner engine repowers for tugboats and other marine vessels.

Cleaner Fuels. Under State law, all other harbor craft except military vessels will be required to use California low-sulfur diesel fuel beginning in 2007 statewide. Additional NOx and diesel PM reductions can be achieved using water/diesel emulsions. ARB estimates that emulsified diesel fuel used in on-road engines can reduce NOx by 15 percent and PM by 50 percent. Additional testing is required to determine whether similar reductions are possible in marine engines.

Biodiesel is another alternative fuel option. Biodiesel is derived from vegetable oils or recycled restaurant grease, and can be mixed with diesel fuel or used straight. Pure biodiesel can reduce PM emissions by over 50 percent but generally results in a NOx increase. For this reason, biodiesel is best used in combination with NOx control strategies. Biodiesel manufacturers are also working on additives that can be used to prevent increases in NOx emissions.

The use of compressed or liquefied natural gas or diesel/CNG dual fuel applications can result in significant reductions in NOx and PM. The results vary with specific application and the ratio of diesel to CNG used. Additional testing is required to determine whether similar reductions are possible in marine engines.

<u>Add-On Emission Control Devices</u>. ARB-verified diesel emissions control systems, such as a bolt-on device (like a filter or catalyst) and/or a lower-emission fuel (like a diesel blend or other alternative fuel) have been shown to dramatically reduce emissions when used with heavy-duty diesel engines. ARB has established requirements for system performance, durability, and warranties to ensure that the equipment works as expected in operation.

- *Diesel particulate filters* (filters) contain a semi-porous material that permits gases in the exhaust to pass through but traps the diesel soot, with a PM control efficiency of 85 percent or more. There are two kinds of filters available – passive and active. Passive filters must be maintained periodically to remove the particles collected on the filter. Active filters clean themselves at the end of the day or shift.

- *Diesel oxidation catalysts* (catalysts) use a catalyst material and oxygen in the air to trigger a chemical reaction that converts a portion of diesel PM and ROG into carbon dioxide and water. Their diesel PM control efficiency is limited to about 30 percent.

- *Selective catalytic reduction* systems work very well on vessels that are designed around the system. This technology reduces NOx to nitrogen and water through the use of a catalyst and a reducing agent (e.g., urea solution). It has been shown to reduce NOx by 65 to 90 percent in many marine applications. Selective catalytic reduction systems are currently used in over 50 marine vessels of various types, primarily in Europe. The system is quite large and consumes a large amount of vessel area, making it a poor candidate for retrofitting.

  Other NOx exhaust treatment controls include lean-NOx catalysts and rapidly developing technologies such as NOx adsorbers and plasma-catalyst systems. Controls such as water injection, injection timing retard, exhaust gas recirculation, and humid air motor technology can achieve significant NOx reductions from existing engines. NOx can also be reduced via mechanical changes to the engine, particularly during engine rebuilding. There is an emerging trend in the development of add-on control systems that can control both PM and NOx. For example, combination systems incorporate both filters and selective catalytic reduction, or filters and NOx adsorbers, or add-on controls with cleaner fuels. Applying these technologies to the marine sector is in the demonstration stages. There are several marine demonstration projects currently running on a ferry fleet and naval vessels to determine the feasibility of using land-based technology on marine engines.

Status: ARB staff began holding workshops on the approach in 2004. We expect to present a formal proposal to the Board in late 2006.

ii. Shore Based Electrical Power

When not actively guiding incoming or outgoing ships, assist vessels use diesel auxiliary generators to maintain electrical power or simply idle while waiting for another ship to require assistance. Emissions from these auxiliary generators or engine idling can significantly contribute to a port's emissions of NOx and PM. One option to reduce emissions from auxiliary generators while at dock is to allow harbor tugboats, towboats and workboats to use shore power (known as cold ironing) when not actively assisting vessels through the harbor. Harbor tugs would be modified to accept power from shore facilities.

This strategy would require the ports to work with the vessel operators to provide the necessary infrastructure to provide power to run harbor craft while waiting at dock for ships to assist. A necessary component of this concept is to modify the assist tugs and tugboats to accept shore side power. This would make it unnecessary to use auxiliary generators or long periods of engine idling simply to maintain power.

Ports would need to find appropriate space on their property for the infrastructure necessary to install shore side power. This would depend on anticipated demand, and could range from simply cables and dock modifications to dockside substations. Ports could condition operating agreements or leases to require harbor craft to be equipped to utilize shore side power. The feasibility of cold ironing harbor craft is likely dependent on existing electrification for other vessel types such as ships, which would increase significantly with the shore power strategies for ships. Another factor is the location of the harbor craft berths in relation to any existing electrification for ships. Ports may be much less likely to commit to infrastructure improvements if electric power is being installed for harbor craft only and not other vessel types.

Some ports will have operational issues that may prevent the same rate of participation by harbor craft, and therefore limit potential benefits. For example, tugs serving the Port of Oakland may be based and berthed in San Francisco, Oakland, Richmond or elsewhere in the Bay Area. The proximity of harbor craft berths to the ship berths may make implementation in some areas more difficult.

b. *Implementation Possible by 2015*

i. U.S. EPA or ARB New Engine Emission Standards

U.S. EPA has proposed[11] standards for new auxiliary marine diesel engines (Categories 1 and 2). The regulation would be modeled after the advanced diesel control technology being developed for on-road trucks and land-based off-road equipment. PM levels would be based on state-of-the-art emission controls such high-efficiency catalytic after-treatment. To date, no technical barriers have been identified that would

[11] *Federal Register*, Vol.69, No. 124, Tuesday, June 29, 2004 "Control of Emissions of Air Pollution from New Locomotive Engines and New Marine Compression-Ignition Engines Less Than 30 Liters per Cylinder.

prevent the transfer of advanced technology engines already required for other sources to marine applications. If U.S. EPA does not adopt more effective new engine standards for harbor craft in the near-term that take advantage of these technology advances, ARB will consider doing so. If California moves ahead, our new standards can then be used as the foundation for equally stringent national standards.

c. Implementation Possible by 2020

Based on the expectation of advanced technology standards (adopted by ARB or U.S. EPA) taking effect by 2015, incentive programs to accelerate early introduction of complying engines would provide additional emission reductions by 2020.

4. <u>Emission Reductions</u>

The emission reduction estimates are based on cleaning up existing harbor craft main engines and auxiliary engines using any combination of cleaner engine retrofits, add-on control technologies, cleaner alternative fuels in combination with implementing cleaner new engine standards. An additional emission reduction estimate is based on providing shore power to tugboats and assist tugboats.

Key Inputs. We describe the key inputs for the emission reduction calculations below.

- We used future year emission projections that reflect potential growth for all harbor craft out to 24 nautical miles from the California coast. Tugboats were assumed to have no growth because shipping lines are using larger vessels to accommodate cargo growth, rather than increasing the number of ships that would need tug assistance. Local air districts provided growth rates for other types of vessels.

- After deducting the benefits of ARB's requirement that harbor craft use low sulfur diesel fuel beginning in 2007, we calculated the benefits of the new strategies.

- All harbor craft would be subject to the clean up measure; however, some harbor craft have already been controlled through local programs and not all technologies will be feasible for all harbor craft. The controls will need to be tailored to the unique parameters of each craft. We assumed that 30 percent of the fleet (1,250 vessels) would be cleaned up by 2010. Since add-on control technologies and cleaner fuels can achieve 80 percent or more emission reductions, we assumed that the clean up measure in combination with new U.S. EPA or ARB cleaner engine standards would achieve 25 percent emission reductions from the harbor craft fleet for ROG, NOx, and PM in 2010 and 40 percent in 2020. These estimates are based on the 2003 SIP and the No Net Increase Report.

	Percent Control		
	2010	**2015**	**2020**
Cleaning up Existing Harbor Craft and U.S. EPA or ARB Cleaner Engine Standards	25%	30%	40%

- We incorporated the anticipated emission reductions from cleaning up existing harbor craft and from U.S. EPA or ARB cleaner engine standards before calculating the benefits associated with providing shore power to tugboats and assist tugs.

- The tugboat shore power measure assumes that operating time on fuel will be reduced by 30 percent. Participation rates are assumed to be 40 percent in 2010 for both assist tugs and tugboats, rising to 80 percent for tugboats and 100 percent for assist tugs by 2025. We assumed that the fleet mix is half tugboats and half assist tugs. Only tugboats and assist tugs were assumed to participate. Other vessels such as workboats and fishing vessels were assumed not to participate. The control percentages were based on the No Net Increase Report.

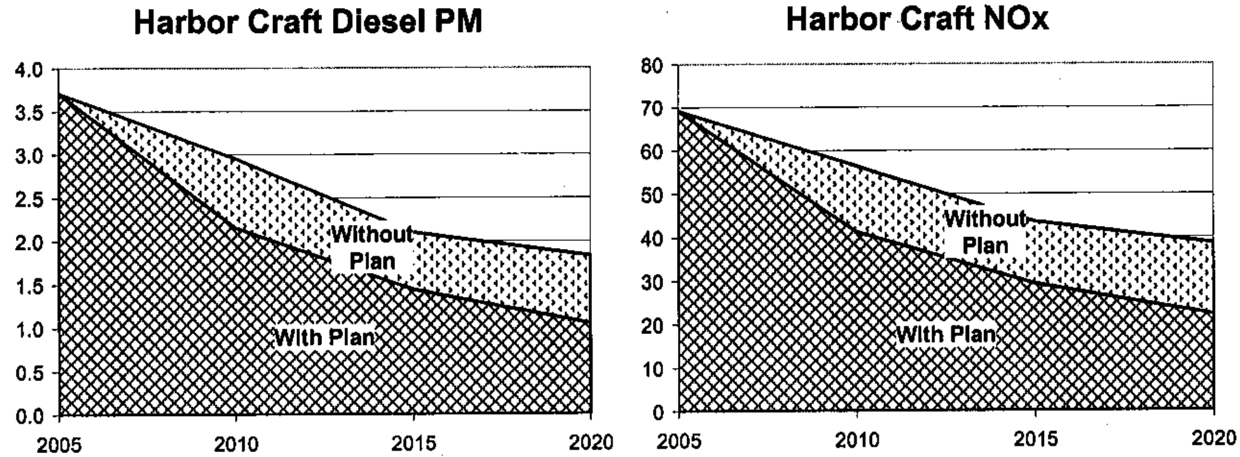
Percent Operating time reduced = 30% **Shore Power Participation Rates**					**Weighting Assist Tug/Tugboats = 0.5** **NOx and Diesel PM Percent Control**			
	2010	2015	2020	2025	2010	2015	2020	2025
Assist Tugs	40%	70%	85%	100%	12%	21%	26%	30%
Tugboats	40%	65%	72%	80%	12%	20%	22%	24%
Weighted					12%	20%	24%	27%

Results. The result of the strategies described for harbor craft are shown in Table III-5, and in Figure III-2. The reductions that we've identified to occur by 2010 would result from an existing requirement for the use of cleaner fuels, which takes effect in 2007, and from a regulation that ARB staff is developing and expects to bring before the Board in 2007. The 2010 reductions also anticipate the use of shore-side power, add-on filters or catalysts, and the introduction of cleaner engines that comply with U.S. EPA's or ARB's harbor craft emission standards. Reductions shown to be possible by 2015 are projected to result from the standard that U.S. EPA has proposed for new auxiliary marine diesel engines (categories 1 and 2). ARB will consider the adoption of such advanced technology standards if U.S. EPA fails to establish effective emission standards within the needed timeframe. Emissions shown for 2020 rely on the same State or national regulation, but anticipate an incentive program to speed up introduction of those cleaner engines.

Table III-5
Statewide Emissions from All Harbor Craft with Full Implementation of Plan Strategies
(tons per day)

Pollutant	Year 2001	2005	2010	2015	2020
Diesel PM					
Emissions with Existing Program	3.8	3.7	2.9	2.1	1.8
New Reductions – Shore-Based Electrical Power			-0.05	-0.06	-0.05
New Reductions – ARB Rule to Clean Up Existing Engines			-0.74		
New Reductions – U.S. EPA/ARB Engine Standards				-0.64	-0.73
New Reductions - Total			-0.8	-0.7	-0.8
Emissions with Plan	3.8	3.7	2.1	1.4	1.0
NOx					
Emissions with Existing Program	75.4	69.2	56.4	43.6	38.6
New Reductions – Shore-Based Electrical Power			-1.0	-1.1	-0.9
New Reductions – ARB Rule to Clean Up Existing Engines			-14.1		
New Reductions - U.S. EPA/ARB Engine Standards				-13.1	-15.4
New Reductions - Total			-15.1	-14.2	-16.3
Emissions with Plan	75.4	69.2	41.3	29.4	22.3
ROG					
Emissions with Existing Program	7.6	7.0	5.9	4.5	4.0
New Reductions – Shore-Based Electrical Power			Not quantified		
New Reductions – ARB Rule to Clean Up Existing Engines			-1.5		
New Reductions - U.S. EPA/ARB Engine Standards				-1.4	-1.6
New Reductions - Total			-1.5	-1.4	-1.6
Emissions with Plan	7.6	7.0	4.4	3.1	2.4
SOx					
Emissions with Existing Program	0.4	0.4	0.1	0.1	0.1
New Reductions – Shore-Based Electrical Power			Not quantified		
New Reductions – ARB Rule to Clean Up Existing Engines					
New Reductions - U.S. EPA/ARB Engine Standards					
New Reductions - Total					
Emissions with Plan	0.4	0.4	0.1	0.1	0.1

Figure III-2
Impact of Plan Strategies on Statewide Harbor Craft Emissions
(tons per day)



5. Costs

In estimating potential costs for the commercial harbor craft sector, we considered the costs associated with the potential rule to clean up existing engines in combination with new engine standards separately from the strategy for the use of shore-based power for harbor craft.

ARB Rule to Clean up Existing Engines and New U.S. EPA or ARB Engine Standards

- The costs for this strategy were based on estimates for the South Coast taken from the Port of Los Angeles's No Net Increase (NNI) Report.
- Our calculation assumed that the average harbor craft re-power would cost \$160,000 per engine. This average cost estimate includes the incremental costs associated with new technologies that will be needed to meet anticipated U.S. EPA or ARB engine standards. In the South Coast, this concept assumes that 250 harbor craft will be re-powered at a total cost of \$40 million.
- The cost of add-on controls varies by technology. Average cost estimates are \$300,000 for selective catalytic reduction; \$2,000 for diesel oxidation catalyst; \$10,000 for diesel particulate filter, and \$50,000 for lean NOx catalysts. Total costs for the South Coast are estimated to be \$10 million.
- The NNI Report assumes that alternative fuels, such as emulsified diesel fuels, cost \$ 0.22 per gallon more than regular diesel fuel. In the South Coast, total cost estimates are \$2 million per year. If we assume funding for five years, the total alternative fuels cost for the South Coast equals \$10 million.

- Thus, total cost estimates are approximately $60 million (for 250 vessels) to implement this concept in the South Coast. Since the South Coast has 20% of the harbor craft vessels statewide, we assumed that $300 million would clean up 1,250 vessels statewide over a five to seven year period and reduce emissions by 25% in approximately 2010.

Shore Based Electrical Power

- Emission reductions are estimated based on the control factors calculated in the NNI report. The control factors assume that the availability of shore based electrical power would reduce engine operating time by 30 percent. The NNI report assumes a conversion cost of $3,000 per tug, and $150,000 per berth area.

- Our statewide cost estimates assume a total of 111 tugs and 37 berths, statewide, for a total cost of $5,883,000.

- We assumed a 40 percent participation rate in 2010 for both assist tugs and tugboats, rising in later years. The control factors in the NNI report assume participation only from assist tugs and tugboats. Other vessels such as workboats and fishing vessels were assumed not to participate.

Results. The cumulative costs to fully implement the strategies for the commercial harbor craft sector are given below. Each time period is cumulative, thus the 2007-2020 value is the total cost (stated in 2005 dollars) of implementing the strategies for this sector. In subsequent chapters, we convert these amounts to present value.

	Cumulative Costs 2007-2010 (in millions)	**Cumulative Costs 2007-2015 (in millions)**	**Cumulative Costs 2007-2020 (in millions)**
Harbor Craft	$181	$381	$479

D. CARGO HANDLING EQUIPMENT

Strategy "Snapshot." The strategies will reduce emissions from cargo handling equipment primarily through a rule recently adopted by ARB that will require new and existing equipment to use available cleaner technologies, followed by stepping up diesel PM control to the 85 percent level or better on any equipment not already at that level. In the longer-term, there is potential for zero- or near-zero emission equipment.

1. Introduction

Cargo handling equipment is used at ports and intermodal rail yards to transfer container and bulk goods between ships, trains, trucks, or storage areas within the facility. The equipment may be owned by the facility operator or private companies operating as tenants, and includes yard trucks, cranes, forklifts, top handlers, side handlers, reach stackers, sweepers, loaders, dozers, excavators, railcar movers, and backhoes.

The most common type of cargo handling equipment at ports are yard trucks (also referred to as yard tractors, yard goats, hustlers, utility tractor rigs, or yard hostlers) – approximately 60 percent of the equipment by number. Yard trucks move trailers carrying containers within ports, rail yards, and distribution centers. Many are operated exclusively within the facility and can be equipped with either on-road or off-road engines.

The next most common types of equipment at ports are: forklifts (which move containers, other equipment, and palletized cargo by sliding prongs underneath them and raising the load), top picks (which are similar to forklifts, but raise containers from the top), rubber-tired gantry cranes (which are very large self propelled units that lift and move containers), and bulk handling equipment (which include tractors, loaders, dozers, excavators, and backhoes that scoop and move uncontained, bulk materials like cement, scrap metal, and petroleum coke). Over 90 percent of this equipment is currently powered by diesel fuel, with the rest (primarily forklifts) operating on gasoline or alternative fuels (such as natural gas, propane, and electricity). The largest stationary cranes used to move containers off ships are electric.

From a regulatory perspective, this is a complicated category because the wide range of equipment used can be classified as on-road mobile, off-road mobile (diesel or gas powered), stationary, or even portable. Each of these classifications is regulated under a different legal authority and subject to different emission standards.

The majority of the emissions in this sector are from off-road mobile equipment running on diesel fuel, with small contributions from the other types. We identified the emissions from off-road diesel cargo handling equipment used to move imports and exports as the universe of cargo handling emissions addressed quantitatively in this plan. We describe adopted or pending regulations that affect the other types of cargo handling equipment used to transfer goods in California. However, neither the emissions from this other equipment, nor the reductions expected from applicable regulations, are included in our accounting of plan benefits.

California and U.S. emission standards for off-road diesel equipment will significantly reduce emissions from this sector as new, cleaner equipment is phased in. Typical for diesel engines, the primary pollutants of concern from this equipment are diesel PM, NOx, and ROG. ARB is authorized under the federal Clean Air Act to regulate most off-road mobile sources of emissions, including cargo handling equipment. In some cases (e.g., applying new engine standards or requiring retrofits of existing engines), the California regulation must be at least as stringent as national requirements, and ARB would need to obtain U.S. EPA authorization (i.e., a waiver from preemption) to enforce such regulation.

ARB's October, 2005 *Draft Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach* identifies cargo handling equipment as a high contributor to the total health risks associated with port operations because this equipment operates full time on the port property, rather than passing through like ships, trains, and trucks.

2. Actions Taken – 2001 Through October 2005

ARB and U.S. EPA have adopted the next phase of cleaner technology and fuel requirements for off-road diesel equipment, which will steadily reduce emissions through 2025 as cleaner equipment replaces older equipment. ARB has also acted to cut emissions from other categories of equipment that may be used in small numbers to move goods at ports or rail yards. Complementary actions taken by port operators over the last few years are also accelerating the introduction of cleaner technologies, such as the use of alternative-fueled equipment, the use of alternative diesel fuels, low-sulfur diesel fuel, and the application of diesel emission control systems.

- ✓ Low Sulfur Diesel Fuel Rule. In 2003, ARB adopted a statewide sulfur limit of 15 ppm for diesel fuel for off-road equipment. The standard takes effect statewide in 2006, with accelerated implementation in the South Coast Air Basin as of 2005. The lower sulfur levels are essential to facilitate use of advanced control technology.

- ✓ Tier 4 Emission Standards for New Off-Road Engines. In 2004, ARB adopted more stringent emission standards for diesel off-road equipment, including cargo handling equipment covered in this plan and ground support equipment used at airports. This action aligned California's program with U.S. EPA's national standards. These standards for PM, NOx, and ROG will be phased in by the horsepower range of the equipment, starting in 2011, through 2015 for more powerful engines. We expect engine manufacturers to adapt the control technology being developed for 2007 and later on-road trucks to work in these off-road applications.

Tables III-6 and III-7 show the level of control required for horsepower ranges that include common diesel cargo handling equipment.

Table III-6
Increasingly More Stringent NOx+ROG Emission Standards for New Diesel Cargo Handling Equipment

Regulatory Horsepower Range	Examples of Equipment	Percent Emission Control* (Year Implementation Begins)			
		Tier 1	Tier 2	Tier 3	Tier 4
100 to <175 hp	Forklifts	22% (1997)	44% (2003)	66% (2007)	95% (2012)
175 to <300 hp	Yard tractors Top picks	11% (1996)	44% (2003)	66% (2006)	95% (2011)
300 to <600 hp	Rubber-tired gantry cranes	11% (1996)	46% (2001)	66% (2006)	95% (2011)

* Relative to uncontrolled equipment

Table III-7
Increasingly More Stringent PM Emission Standards for New Diesel Cargo Handling Equipment

Regulatory Horsepower Range	Examples of Equipment	Percent Emission Control* (Year Implementation Begins)			
		Tier 1	Tier 2	Tier 3	Tier 4
100 to <175 hp	Forklifts	0% (1997)	59% (2003)	59% (2007)	97% (2012)
175 to <300 hp	Yard tractors Top picks	27% (1996)	73% (2003)	73% (2006)	97% (2011)
300 to <600 hp	Rubber-tired gantry cranes	27% (1996)	73% (2001)	73% (2006)	97% (2011)

* Relative to uncontrolled equipment

- ✓ Stationary Diesel Engine Rule. In 2004, ARB adopted a regulation requiring stationary diesel engines (those anchored to a solid foundation like pumps) to meet cleaner emission standards and to use clean fuels. Depending on the use of the engine, new engines began meeting emission standards in 2005 at least as stringent as new off-road diesel engines, or better for diesel PM in the event the engine is not used as an emergency back-up engine. In-use engines were also required to reduce emissions beginning in 2005 through the application of cleaner technologies or by reducing the hours of operation.

- ✓ Portable Equipment Rule. In 2004, ARB adopted a regulation requiring most portable diesel equipment (which can be towed from site to site, but is not self-propelled) to also meet progressively more stringent emission standards. By 2010, existing portable engines must comply with Tier 1, 2, or 3 emissions standards for new off-road equipment. Owners of multiple portable engines need to meet fleet average targets from 2013 through 2020.

✓ Incentives for Cleaner Fuels. In 2002, ARB awarded a grant for over $1 million to the Ports of Los Angeles and Long Beach to implement an emulsified diesel fuel program for yard trucks and other equipment.

Table III-8 shows that the impact of ARB regulations and other programs in place as of October 2005 on cargo-handling equipment emissions.

Table III-8
Statewide Emissions from Cargo Handling Equipment with Benefits of All Measures Adopted as of October 2005
(tons per day)

Pollutant	Year				
	2001	2005	2010	2015	2020
Diesel PM	0.8	0.7	0.5	0.4	0.2
NOx	21.1	18.9	16.2	11.4	6.4
ROG	2.5	1.9	1.2	0.8	0.7
SOx	<0.05	<0.05	0.1	0.1	<0.05

3. Strategies to Further Reduce Emissions

a. *Implementation Possible by 2010*

i. ARB Cargo Handling Equipment Rule (Adopted December 2005)

Cargo handling equipment used at ports and rail yards typically lasts 8 to 24 years before being replaced with new equipment. These long equipment lives mean that the benefits of more stringent emission standards for new engines are slow to accumulate as long as they are dependent on the purchase of new equipment in the normal business cycle. To accelerate the pace of emission reductions and the associated health benefits, ARB adopted a new regulation in December 2005 for mobile cargo handling equipment operating at ports and intermodal rail yards. The rule will reduce diesel PM and NOx emissions by applying best available control technology.

The advanced control technology is being developed as an integral component of new engine design to meet the off-road diesel Tier 4 standards, and as an add-on to be used with existing equipment. ARB has established requirements to verify the effectiveness, durability, and warranty of diesel emission control systems for existing equipment, such as a bolt-on device (like a filter or catalyst) and/or a lower-emission fuel (like a diesel blend or other alternative fuel). Verified emission control systems reduce diesel PM, or diesel PM plus other pollutants. There are three benchmarks that diesel emission control systems can be verified to – Level 1 (at least 25 percent PM control), Level 2 (at least 50 percent PM control, and Level 3 (at least 85 percent PM control). NOx reduction technology can also be verified, starting at a 15 percent NOx control level. Some technologies have been verified for use on off-road equipment, but there are not yet verified systems for all makes and model years of cargo-handling equipment.

The rule will generally require all newly purchased, leased, or rented equipment to have either a 2007 or later on-road engine, a Tier 4 off-road engine, or the cleanest available off-road engine equipped with a verified diesel PM emission control system, beginning January 2007. Alternative fuels are an option to reduce emissions to the required levels. For existing yard trucks, the rule requires an accelerated phase-in for all vehicles to meet similar requirements. Similar provisions will apply to other types of existing cargo handling equipment. Some cargo handling equipment will be subject to a second step requirement in 2015 to either meet the Tier 4 off-road diesel engine requirements or apply a verified level 3 diesel PM control, depending on the type of equipment and the level of control originally applied.

ii. ARB Rule for Gas Industrial Equipment

ARB staff has also proposed a regulation[12] for industrial equipment typically powered by gasoline or propane, including forklifts. There are small number of these gas forklifts used in cargo-handling at ports and rail yards. The engines in these forklifts are similar to those in cars, but lack the advanced automotive emission controls that have so effectively cut overall vehicle emissions. The proposal would establish tighter NOx and ROG emission standards for new engines and set fleet average requirements for owners of multiple forklifts or other equipment to accelerate replacement.

Status: The Board heard public testimony on this proposal in June 2005 and will revisit it in April 2006.

b. Implementation Possible by 2015

i. Upgrade To 85 Percent Diesel PM Control or Better

The regulation adopted by the Board in December 2005 for diesel cargo-handling equipment relies on the best available control technology to achieve significant reductions in diesel PM and NOx emissions starting December 31, 2007. As one of the compliance options for existing equipment (other than yard trucks), it would allow owners and operators to use the most effective diesel PM emission control systems verified by ARB that are available by the applicable compliance date. The most effective control level for verification is a Level 3 system that achieves 85 percent or better control of PM emissions.

If Level 3 control systems are not available by the compliance date, but are later verified, there is a potential opportunity for further reductions. The concept for this strategy is to upgrade the diesel PM controls on all cargo-handling equipment affected by the regulation to 85 percent control or better by 2015, if such an action would be technically feasible and cost-effective in reducing emissions.

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[12] *Rulemaking To Consider Adoption Of New Emission Standards, Fleet Requirements, And Test Procedures For Forklifts And Other Industrial Equipment (April 20, 2006)*, see http://www.arb.ca.gov/regact/lore2006/lore2006.htm.

ARB staff plans to form a technical working group on cargo handling equipment as part of the implementation effort. This working group would be a useful forum to discuss the development of Level 3 diesel emission control systems for existing cargo handling equipment and the effectiveness of requiring a second upgrade to this equipment.

The potential emission reductions would depend on how many pieces of equipment were not already at the 85 percent control level in 2015, and the proportion of engines certified to Tier 1, 2, or 3 standards.

Some verified diesel emission control systems will only reduce diesel PM, while others may also reduce ROG or NOx. For purposes of assessing the potential benefits from this strategy, we used staff's assumptions about the percentage of each type of cargo handling equipment that would be at each expected combination of emission standard tier and diesel emission control system verification level after implementation of ARB's proposed regulation. We assumed only diesel PM would be reduced and that the benefits would last only until the end of the useful life of the equipment, at which time the equipment would be replaced by a new model meeting the Tier 4 standards (at 97 percent PM control).

c. Implementation Possible by 2020

i. Zero or Near-Zero Emission Equipment

Opportunities for additional emission reductions will require the development of new technology for heavy duty off-road equipment, such as reliable and cost-effective electric models that can meet the power requirements, diesel-electric hybrids, or fuel cell technology. The technology is being developed and tested for heavy-duty buses, but substantial resources and time would be required to transfer these technologies to the varied operations of heavy-duty cargo-handling equipment.

The absolute emission reductions from zero or near-zero emission cargo handling equipment would be quite small because the Tier 4 off-road emission standards and the adopted ARB rule for diesel cargo handling equipment reduce emissions to very low levels. Other benefits might include the reduction or elimination of greenhouse gas emissions and reduced dependence on fossil fuels.

4. Emission Reductions

Key inputs. Emission reductions from cargo handling equipment result from a combination of accelerated equipment (or engine) turnover, application of control devices to the engine exhaust, increased use of alternative fuels, and development of innovative technology to reduce fuel or engine use.

- In projecting emissions out to future years, we made adjustments to account for activity growth over time at a rate of about six percent per year. We also adjusted the projected emissions to account for reductions that will occur due to fleet turnover, U.S. EPA's new engine standards requiring the manufacture of cleaner engines, and other regulations in place prior to October of 2005.

- The reductions for these strategies were evaluated sequentially starting with the reductions from the ARB cargo equipment rule adopted in December 2005. The effect of requiring additional control technology in 2015 was evaluated next and then the effect of diesel hybrid or cleaner power sources. Each subsequent emission reduction was applied to the emissions remaining after applying the previous measure.

ARB Cargo Handling Equipment Rule

- The emission reductions for the ARB rule were derived from the *Staff Report: Initial Statement of Reasons for Rulemaking Regulation For Mobile Cargo Handling Equipment At Ports And Intermodal Rail Yards.*

Upgrade to 85% PM Control or Better

- To evaluate the equipment and control mix in 2015 following full implementation of the cargo handling rule, we attributed the population to each engine tier based on the year each tier was introduced and the useful life of the engine (24 years for cranes and 16 years for other types). For cranes, we assumed 40 percent will have Level 1 PM control and 40 percent will have Level 2 PM control. For bulk material handling equipment and container handling equipment, we assumed 80 percent will have Level 2 PM control.

- The level of control obtained would depend on whether the engine was replaced or whether the control device was replaced. For cranes, we assumed half would switch to Tier 4 engines. For bulk material handling equipment and container handling equipment, we assumed 60 percent would switch to Tier 4 engines.

- To project the emission reductions out to future years, we adjusted the reductions to account for the equipment that would have been expected to reach the end of its life and be replaced. While these could result in reductions of NOx and ROG we are only quantifying the PM reductions. These calculations resulted in the following percent reductions of the remaining emissions from this industry sector.

Pollutant	Reduction		
	2010	2015	2020
Diesel PM	24%	47%	31%

Zero or Near-Zero Emission Equipment

- To evaluate reductions from zero or near zero emission equipment, we assumed a 30 percent reduction in the remaining emissions. This was based on the assumption that diesel-electric hybrid technology could achieve at least as much reduction as gasoline-electric hybrid passenger cars. If hydrogen fuel cell powered equipment became available, it would eliminate the emissions from the equipment it replaced.

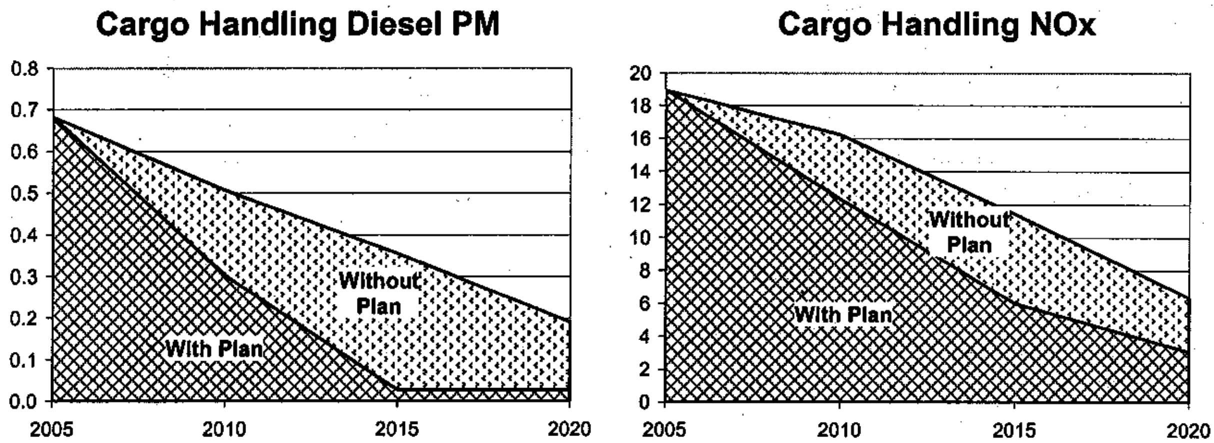
Results. Table III-9 shows that with the plan strategies, the statewide emissions from cargo handling equipment would be reduced by over 80 percent between 2001 and 2020. Figure III-3 shows the impact on cargo handling equipment emissions with and without the plan's strategies.

Approximately one-third of the projected diesel PM and SOx reductions will occur because of ARB's Cargo Handling Equipment Rule, adopted in December 2005. This rule is also expected to increase the availability of cleaner off-road diesel engines and diesel PM controls, which will enable future strategies that would require 85 percent or better control for this equipment in time to provide emission reductions by 2015. The reductions projected, starting in 2020, from the use of zero or near-zero technologies in this sector will depend on technology transfer.

Table III-9
Statewide Emissions from Cargo Handling Equipment with Full Implementation of Plan Strategies
(tons per day)

Pollutant	Year 2001	2005	2010	2015	2020
Diesel PM					
Emissions with Existing Program	0.8	0.7	0.5	0.4	0.2
New Reductions - ARB Diesel Cargo Handling Rule			-0.20	-0.23	-0.07
New Reductions - ARB Gas Industrial Equipment Rule			Not applicable		
New Reductions - Upgrade To 85% Diesel PM Control or Better				-0.08	-0.08
New Reductions - Zero or Near Zero Emission Technology					-0.01
New Reductions - Total			-0.2	-0.3	-0.2
Emissions with Plan	0.8	0.7	0.3	0.1	<0.05
NOx					
Emissions with Existing Program	21.1	18.9	16.2	11.4	6.4
New Reductions - ARB Diesel Cargo Handling Rule			-3.9	-5.4	-2.0
New Reductions - ARB Gas Industrial Equipment Rule			Not applicable		
New Reductions - Upgrade to 85% Diesel PM Control or Better				Not quantified	
New Reductions - Zero or Near Zero Emission Technology					-1.3
New Reductions - Total			-3.9	-5.4	-3.3
Emissions with Plan	21.1	18.9	12.3	6.0	3.1
ROG					
Emissions with Existing Program	2.5	1.9	1.2	0.8	0.7
New Reductions - ARB Diesel Cargo Handling Rule			Not quantified		
New Reductions - ARB Gas Industrial Equipment Rule			Not applicable		
New Reductions - Upgrade To 85% Diesel PM Control or Better				Not quantified	
New Reductions - Zero or Near Zero Emission Technology					-0.2
New Reductions - Total			0.0	0.0	-0.2
Emissions with Plan	2.5	1.9	1.2	0.8	0.5
SOx					
Emissions with Existing Program	<0.05	<0.05	0.1	0.1	<0.05
New Reductions - ARB Diesel Cargo Handling Rule			Not quantified		
New Reductions - ARB Gas Industrial Equipment Rule					
New Reductions - Upgrade To 85% Diesel PM Control or Better					
New Reductions - Zero or Near Zero Emission Technology					
New Reductions - Total					
Emissions with Plan	<0.05	<0.05	0.1	0.1	<0.05

Figure III-3
Impact of Plan Strategies on
Cargo Handling Equipment Emissions
(tons per day)



5. <u>Costs</u>

Key Inputs. To estimate costs for this sector, we used two approaches.

<u>ARB Cargo Equipment Handling Rule</u>

- For the cargo handling equipment rule, we relied on the cost estimates in ARB's staff report on that rulemaking, which estimated average annual costs for the cargo handling equipment rule adopted in December 2005 at about $5.1 million between 2007 and 2020. Total compliance cost is expected to be about $71 million. Total costs to a typical business between 2007 and 2020 are estimated to be $343,000 to $1,373,000 depending on the number and type of equipment regulated.

<u>Other Strategies</u>

- Because a combination of technologies and approaches will be used to achieve the emission reductions for the remaining strategies, we developed the cost estimate for the remaining strategies by applying a cost effectiveness number based on other ARB programs to the total amount of emission reductions expected from these strategies. We projected cost-effectiveness in the range of $6,500 to $18,000 per ton of NOx + diesel PM reduced. The lower end of this range is based on approximately 150 percent of the average current cost-effectiveness of the Carl Moyer program. The upper end reflects our estimate of how costs may escalate in the future, as sources get cleaner and it becomes more difficult and costly to get additional emission reductions.

We then estimated the emission reductions from these other cargo handling equipment strategies for *each* year from 2007 through 2020, interpolating between the years for which we projected emission reductions in the prior section. We multiplied the cost-effectiveness range by the tons of NOx + diesel PM reductions that we are projecting each year from the combined strategies to calculate the total cost per year in 2005 dollars.

Results. The cumulative costs to fully implement the strategies for the cargo handling equipment sector are given below. Each time period is cumulative, thus the 2007-2020 value is the total cost (stated in 2005 dollars) of implementing the strategies for this sector. In subsequent chapters, we convert these amounts to present value.

	Cumulative Costs 2007-2010 (in millions)	**Cumulative Costs 2007-2015 (in millions)**	**Cumulative Costs 2007-2020 (in millions)**
Cargo Equipment	$20	$47-$48	$83-$102

E. TRUCKS

Strategy "Snapshot." The proposed truck strategy focuses on upgrading the heavy duty diesel truck fleets that service the ports and move goods within California primarily by retrofitting or replacing the older, dirtier trucks. Increasing compliance with truck idling limits and ensuring that international trucks meet U.S. emission standards are also part of the overall strategy. This approach will provide significant near-term emission reductions in the areas that need them most – the ports and other areas that have large concentrations of old, high-emitting trucks.

1. Introduction

The largest heavy-duty trucks – weighing over 33,000 pounds – travel over 25 million miles daily in California. Most of these trucks are powered by diesel fuel, and emit about 30 percent of diesel PM emissions and 20 percent of NOx emissions statewide. The draft plan focused on modernization of port truck fleets as a critical near term measure. With the inclusion of all goods movement emissions in the plan, we have added ARB's overarching statewide fleet rule proposal. However, port truck modernization remains a key strategy due to the localized impacts and the economic factors specific to port trucks. This plan addresses emissions from the heaviest diesel trucks involved in goods movement; emissions from smaller trucks involved in local delivery of goods are being reduced by other programs. The changes to the truck emission inventory since release of the draft plan are described in Chapter II.

Trucks serving California seaports are a vital part of the goods movement system. Trucks transfer incoming cargo containers from the ports to intermodal distribution centers for transport via long-haul rail or truck to their ultimate destination in California or throughout the U.S. Trucks also carry agricultural products from the Central Valley and other farming regions, and exports, to the ports for shipment overseas.

The high number of trucks traveling to and from ports through adjacent communities, or into communities to seek services (like fuel and food), can create disproportionate pollution, safety, and nuisance impacts on those communities. Concentrated truck activity near distribution centers and along highway corridors can result in negative impacts in adjacent neighborhoods. Reducing the negative impacts to communities can be accomplished by actions such as reducing the number of truck trips required to move goods from the ports, and by stricter enforcement of idling limits, speed limits and parking regulations.

Port-related truck activity is growing. The number of containers carried by truck to and from the Ports of Los Angeles and Long Beach, for example, is expected to grow by a factor of 2.5 within twenty years.[13] Despite the growth expected in goods movement activity due to increases in population and trade, California is on a course for substantial reduction in overall heavy-duty truck emissions. This includes vehicles serving our

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[13] *Report to Mayor Hahn and Councilwoman Hahn by the No Net Increase Task Force*, June 24, 2005, p. 2-19.

seaports. We expect emissions of all pollutants from heavy trucks to decline by about one-half or more by 2020, as the existing truck fleet slowly turns over to the cleaner engines required by ARB and U.S. EPA regulations. In the case of trucks, we refer to these increasingly stringent emissions standards by the first year that vehicles meeting those standards are introduced, as shown in Table III-10. For example, the advanced technologies phased into new trucks between 2007 and 2010 will achieve 98 percent control of both NOx and diesel PM emissions.

Table III-10
Increasing Stringency of Truck Emission Standards Over Time

Model Year of Engine	Percent Emission Control When Engine Is New	
	NOx	PM
1986 and older	0%	0%
1987 – 1990	44%	0%
1991 – 1993	53%	58%
1994 – 1997	53%	83%
1998 – 2002	63%	83%
2003[14] – 2006	81%	83%
2007 – 2009	90%	98%
2010 and later	98%	98%

Typically the truck fleet used for long-distance hauling is newer and cleaner than the trucks used for shorter or regional trips. Thus, there is a trickle down effect – new trucks are purchased for long-haul trips, the trucks they replace are sold for progressively shorter trips, and the oldest trucks are eventually retired. The trucks that would be addressed by ARB's proposed statewide fleet rule and the port truck modernization strategy tend to older and dirtier. Although these trucks would eventually be replaced in the normal course of business, the impacts of these vehicles need to be mitigated more quickly to address community health issues and to meet air quality standards.

ARB programs established since the 2001 are the starting point for this plan and set in place the next round of emission standards for new engines through 2010, require diagnostic equipment to ensure those engines run clean throughout their lives, accelerate software upgrades for existing engines, restrict idling, and increase enforcement of applicable requirements. These actions, combined with pre-existing programs, will produce the bulk of the emission reductions from the truck sector through 2020. However, substantial additional reductions would be achieved with the plan strategies that address the existing fleet.

Transport refrigeration units are essential devices to protect temperature-sensitive goods in transit. These units are diesel-powered engines designed to refrigerate or

[14] Most model year 2003 trucks meet 2004 engine standards due to "pull-ahead" agreements with truck engine manufacturers.

heat products on semi-trailer vans, truck vans, shipping containers, and rail cars. Because the most transport refrigeration units are found on trucks, we have chosen to include and address the associated emissions under the truck sector in this plan.

2. Actions Taken – 2001 Through October 2005

ARB has already adopted or implemented programs to cut emissions from the heavy truck fleet through 2020. Complementary actions by U.S. EPA, local air districts and governments, and port operators are further reducing these emissions near ports, distribution centers, and high-traffic corridors.

- ✓ <u>2007 New Truck Emission Standards</u>. In 2001, ARB adopted a rule that requires 98 percent control of NOx and PM emissions from new heavy-duty truck engines, via a phase in that begins in 2007. U.S. EPA previously set similar national standards that will affect trucks accessing California ports and distribution centers from other states. To ensure ongoing compliance with the emission standards in-use, ARB in 2004 and 2005 adopted rules requiring increasingly comprehensive on-board engine diagnostic systems, beginning with model year 2007 trucks. During 2006, ARB staff plans to bring a regulation to the Board establishing a manufacturer-run program to monitor in-use compliance with the 2007 emission standards by testing the diesel truck engine in place during normal vehicle operation, at various mileage intervals.

- ✓ <u>Vehicle Replacement Incentives</u>. Each year since 1998, the State of California's Carl Moyer Program has been offering monetary incentives to reduce NOx emissions from diesel engines below the levels required by current standards, agreements, and regulations. The most common action has been to replace an older diesel truck with a cleaner diesel or alternative fuel model, resulting in lower NOx and PM emissions. Recent changes to Moyer program guidelines specifically target "vehicles that move goods in and out of ports." The changes also include a longer project life for owners of trucks serving the ports (five years instead of three) to assist truck owners in qualifying for Moyer funds. Several air districts, including those in the Sacramento Region, South Coast, and San Joaquin Valley, have supplemented Moyer incentives to clean up truck fleets with monies from other funding programs.

- ✓ <u>Low Sulfur Diesel Fuel</u>. In 2003, ARB adopted a statewide sulfur limit of 15 ppm for diesel fuel. The standard takes effect statewide in 2006. New 2007 and later trucks will meet the PM standard with the aid of diesel particulate filters that trap the particles before exhaust leaves the vehicle. This technology only works when sulfur levels in fuel are low.

- ✓ <u>Smoke Inspections for Trucks in Communities</u>. In 2003, ARB shifted its enforcement emphasis from truck weigh stations along freeways to communities heavily impacted by truck traffic. ARB regulations require that diesel trucks and buses not smoke. In 2006, ARB will expand its Environmental Justice Strike Forces by adding more smoke inspectors for trucks serving the Ports of Los Angeles and Long Beach, and operating in the California-Mexico border region.

- ✓ Truck Idling Limits. In 2002, ARB adopted a rule to prohibit trucks from idling within 100 feet of schools. In 2004, ARB adopted a rule to limit engine idling of heavy-duty diesel trucks in California – at ports and elsewhere – to five minutes. This was followed in 2005 by ARB adopting a rule to require trucks equipped with sleeper berths to meet the five-minute limit or use equipment with very low emissions in idle mode.

- ✓ Community Reporting of Violators. ARB maintains a hotline for community members to report excessive idling and smoking vehicles: 1-800-ENDSMOG, as well as a website, http://www.arb.ca.gov/enf/complaints/complaints.htm.

- ✓ Clean Transport Refrigeration Units. In 2004, ARB adopted a rule to cut emissions from transport refrigeration units. The ARB rule requires all of the units operating in the State (including those registered outside California) to meet progressively more stringent PM standards starting in 2008.

- ✓ Low NOx Software Upgrade. In 2005, ARB adopted a regulation that requires the installation of low NOx software (also called chip reflash) in heavy-duty diesel vehicles with 1993 - 1998 model year engines operating in California, including those registered out-of-state. In the 1990's, engine manufacturers installed computer software on engines that activated emission controls during certification testing to show compliance with the required emission limits, but essentially deactivated the NOx controls during sustained highway driving to increase fuel economy.

Table III-11 shows that adopted ARB regulations and other existing programs will reduce current emissions of all pollutants from trucks by 60 to 80 percent by 2020.

Table III-11
Statewide Emissions from Trucks
with Benefits of All Measures Adopted as of October 2005
(tons per day)

Pollutant	Year				
	2001	2005	2010	2015	2020
Diesel PM	37.7	30.6	19.4	11.1	6.2
NOx	654.5	684.3	517.4	359.5	254.9
ROG	56.0	54.5	42.8	31.3	23.3
SOx	4.9	5.3	0.6	0.7	0.8

3. Strategies to Further Reduce Emissions

This section discusses additional strategies needed to cut emissions from existing heavy-duty trucks in the short-haul fleet, at ports and elsewhere. We have revised the port truck modernization program the draft plan based on new information, and added a new strategy to address the rest of the much larger fleet of existing short-haul trucks involved in general goods movement. ARB's has already adopted a rule for transport refrigeration units that addresses that aspect of truck emissions.

Approaches to Upgrade or Modernize Heavy Truck Fleets. Before we describe the proposed strategies to upgrade heavy truck fleets moving goods in California, it's useful to understand the options available, including their benefits, costs and limitations. We briefly review the technical feasibility, relative emission control, and relative cost of several approaches that could be applied.

- Retire and Replace – Completely replace an old truck with a newer, cleaner truck powered by a diesel, natural gas, or advanced technology engine. This option works for any vintage of existing truck.

  Replacement can potentially reduce all three pollutants of concern – diesel PM, NOx, and ROG – depending on the age of the vehicle being retired and its replacement (see Table III-9 above). In 2010, we estimate that a seven-year old replacement truck will cost about $43,000. Though expensive, this option delivers substantial emission reductions while eliminating out of service time for the trucker.

- Repower – Keep the truck itself, but replace the existing diesel engine with a brand new, cleaner diesel engine. Depending on the year of the engine being replaced, repowering can reduce all three pollutants of concern – diesel PM, NOx, and ROG. We estimate that purchasing and installing a new engine (if technically feasible) would cost about $40,000 in 2010. Other considerations in repower decisions are the remaining life of the truck chassis and the days or weeks the truck would be lost from service.

  Both technical and economic considerations apply to the repower option. First, because the more sophisticated control technologies used to comply with 2007+ standards may be more integrated with the truck chassis and other components as a single system, engines meeting those standards may be unavailable as stand-alone units to replace older truck engines. In addition, because the cost of a new engine represents a substantial portion of truck value – operators would also lose truck availability during periods of repower service – the repower option may be economically unattractive relative to truck replacement. These factors would be more fully considered as modernization and outreach programs are developed.

- Retrofit – Keep the existing truck and engine, but add an ARB-verified diesel emissions control system, such as a bolt-on device (like a filter or catalyst) and/or a lower-emission fuel (like a diesel blend or other alternative fuel). Verified emission control systems reduce diesel PM, or diesel PM plus other pollutants. ARB has established requirements for system performance, durability, and warranties to ensure that the equipment works as expected on the road. This is typically the least expensive option. There are verified technologies available for some makes and model years of trucks, but not all. Some of the retrofit devices can provide highly efficient control, but may also require additional maintenance to achieve those levels. Most retrofits can be done in about a day, and can usually be performed while the truck is in the shop for regular maintenance, minimizing time out of service.

Diesel particulate filters (DPFs or filters) contain a semi-porous material that permits gases in the exhaust to pass through but traps the diesel soot, with a PM control efficiency of 85 percent or more. These filters are widely available for 1994 and later trucks; retrofit devices are not generally available for pre-1994 trucks. There are two kinds of filters available for diesel trucks: – passive and active. Passive filters must be periodically maintained to remove the residual material collected on the filter. These filters cost approximately $8500; additional costs include one-time custom installation and annual maintenance of about $200. Active filters clean themselves at the end of the day or shift when plugged into an electrical outlet. These filters cost about $14,000 for purchase and installation; there are no annual maintenance costs.

Diesel oxidation catalysts (catalysts) use a catalyst material and oxygen in the air to trigger a chemical reaction that converts a portion of diesel PM and ROG into carbon dioxide and water. These catalysts can be installed on trucks older than 1994, but their diesel PM control efficiency is limited to about 30 percent. These catalysts cost about $1,000 - $1,500 to purchase, plus the cost of installation; there are no annual maintenance costs.

NOx catalysts use a catalytic coating and chemicals in the exhaust to convert NOx to atmospheric nitrogen. They can be used in combination with diesel particulate filters on 1994 - 2003 diesel engines to achieve a 25 percent NOx reduction (in addition to the 85 percent diesel PM reduction). The cost of this combination technology is about $20,000 per truck including installation, plus about $2,000 in maintenance costs over the 10-year life of the system.

Exhaust gas recirculation technologies, verified for certain 1998 - 2002 truck engines, achieve NOx reductions of 40 percent or more, in addition to 85 percent PM and ROG reduction when used in combination with filters.

Selective catalytic reduction technologies reduce NOx to nitrogen and water through the use of a catalyst and a reducing agent (e.g., urea solution). They have achieved NOx reductions of up to 80 percent, but their verification is currently limited to off-road applications. Within several years these technologies are expected to become more proven and available.

a. *Implementation Possible by 2010*

i. ARB Private Truck Fleets Rule

In the *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-fueled Engines and Vehicles* (adopted in 2000), ARB established statewide goals to cut emissions and risk from all categories of diesel engines under its regulatory authority. That plan listed a series of anticipated measures that staff would develop for Board consideration. For on-road vehicles, we started these rulemakings with urban transit buses, followed by refuse trucks, and then truck fleets owned by public agencies and utilities (adopted in December 2005). With school buses covered by a special incentive program, the final on-road category to be addressed is private truck fleets.

ARB staff will begin the extensive public process to develop a rule for private truck fleets with workshops scheduled for April 2006. This public process will enrich our understanding of the private truck fleet, including: the numbers of trucks, how and when and where they are operated, their ages and emissions, the range of fleet sizes, and the variation in profitability within these operations. We will also be doing a technical evaluation of emission reduction options for the existing fleet, building on the best available control technology approaches established for public truck fleets and other diesel rules. The need for further emission reductions, the understanding of private fleets, our technical evaluation, and public input will all guide the specific proposal that staff ultimately brings to the Board for adoption, anticipated in 2007.

Concurrently, ARB staff will be working on State Implementation Plans (SIPs) with local air districts and other stakeholders to define the emission targets and strategies needed to attain the federal 8-hour ozone and fine particulate (PM2.5) standards by the applicable deadlines in each affected region of California. The planning effort will involve extensive analysis of diesel truck emissions to understand what kind of focused actions are needed for attainment, especially in the San Joaquin Valley and South Coast that experience the most severe PM2.5 and ozone pollution. Depending on the nature of the fleets in each SIP area, it may be appropriate to incorporate such actions into the statewide private fleets rule or it may be more effective to pursue additional strategies (beyond the fleet rule) tailored to each region that requires them.

While it is premature to define the provisions of the private fleets rule or the outcome of the SIP development process, we must outline a strategy in this plan to address the additional emissions associated with older trucks that move goods but would not be included in efforts to upgrade port trucks. The description below relies on the technology-based approach for fleet replacement, retrofit, or cleaner fuels that ARB staff used in prior diesel risk reduction rulemakings.

This strategy would reduce diesel PM, NOx, and possibly ROG emissions from approximately 250,000 heavy-duty trucks under private ownership by companies or individuals in California. A "fleet" may include hundreds of trucks or a single truck. Many of these private fleets are engaged in goods movement and include long and short haul truck-tractors, port transload hauling trucks, wholesale and retail goods transport trucks, tanker trucks, and package and household goods transport trucks. The subset of port trucks could be included in this rulemaking or dealt with separately in the port truck modernization program described in the next strategy. To avoid double-counting benefits, we removed the trucks that directly access a port from the population of trucks analyzed for this private fleet rule strategy.

ARB is currently considering a strategy that makes use of best available control technology, including replacement, repowers, and retrofits. We anticipate that the requirements would be designed for trucks by age group, based on the most feasible and cost-effective approach for that group (replacement, repower, or retrofit). Rule implementation would likely begin in about 2008. If the potential benefits of the private truck fleets rule are combined with the benefits of the existing control program, the effect would be to reduce total emissions from all heavy trucks (including those outside the scope of the new rule) by the following amounts, relative to 2005 levels:

- 50 percent for diesel PM and 30 percent for NOx in 2010
- 75 percent for diesel PM and 50 percent for NOx in 2015
- 85 percent for diesel PM and 65 percent for NOx in 2020

Status: ARB has scheduled public workshops in April to kick off rule development.

ii. Port Truck Modernization

After considering the options for the subset of older, privately-owned port trucks, ARB staff has redesigned its draft strategy to reduce diesel PM and NOx emissions from the existing port truck fleet, as well to concurrently regulate additional trucks entering port service. The strategy below completely replaces the approach described in the December 2005 draft plan. The new strategy would hasten reductions in diesel PM and achieve NOx reductions more cost-effectively. Port truck modernization would take place in three phases:

Phase 1: By 2010, all trucks in regular port service would be retrofitted with diesel particulate filters to reduce diesel PM by 85 percent or more. Retrofits that achieve concurrent NOx reductions would be used to the greatest extent feasible. To maximize risk reduction in communities that are adjacent to ports, distribution centers, intermodal rail facilities, heavily traveled roads, the entire fleet of 11,700 trucks in routine port service would be retrofitted. To enable these retrofits, the 6,000 pre-1994 trucks in port service in 2010 would also need to be replaced with roadworthy 1998-2002 trucks with fully effective original equipment engines.[15] 1998 and later trucks would be retrofit with devices to reduce both diesel PM and NOx.

Most port trucks are driven by owner/operators who may lack sufficient capital to absorb the resulting costs up front. We envision that these costs would be heavily supported by incentive dollars. Guaranteed loans would be offered as a financing mechanism; drivers would receive credits with each pick-up or drop-off to retire these loans. Payments would be metered over an extended period to ensure that upgraded trucks have sufficient financial incentive to remain in port trucking through at least 2015. The source of loan funds could be State bond monies, contributions or fees generated by container terminal operators, or funds provided by the ports.

<u>Phase 2: Between 2007 and 2020, trucks *entering* port service for the first time would be required to meet 2003 or later emissions standards.</u> Through 2011, only trucks with original equipment engines meeting at least the 2003 standards *and* fitted with diesel particulate filters would be permitted to enter port service.[16] Between 2013 and 2015, the newer trucks would need to minimally meet 2007 engine standards.[17] After 2015 all new entries would need to meet 2010 standards.[18] We envision that the costs would be borne primarily by the private sector operators choosing to enter port service.

<u>Phase 3: By 2020, all trucks in port service would be required to meet 2007 or later emission standards.</u> Pre-2003 trucks would need to be retired or replaced by trucks meeting 2010+ standards by 2017. Remaining pre-2007 trucks would be retired and replaced by 2010 or newer trucks by 2019. As in Phase 2, we envision that the cost of truck upgrades would covered through private sector funding.

Key to implementation of the above strategy would be requirements by the ports to restrict entry of trucks new to port service unless equipped with diesel PM controls. After each final milestone date, the port terminal would be responsible for ensuring only compliant vehicles are allowed access to drop off or pick up cargo.

Status. ARB staff is releasing a detailed analysis in the March 2006 report, *Evaluation of Port Trucks and Possible Mitigation Strategies.*

iii. <u>Enhanced Enforcement of Truck Idling Limits</u>

ARB adopted statewide truck idling limits to immediately reduce emissions, especially in communities with high levels of truck activity. ARB's regulations that limit non-essential idling to five minutes and ban idling within 100 feet of schools provide the regulatory tools to address the problem, but compliance with the limit can be enhanced through partnerships with local governments.

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[15] These engines would meet at least the 4.0 gram/brake-horsepower-hour certification standard for NOx.
[16] 2.5 gram/brake-horsepower-hour certification standard for NOx+HC.
[17] Expected to average 1.1 gram/brake-horsepower-hour certification for NOx+HC, 0.01 for PM.
[18] 0.2 gram/brake-horsepower-hour certification for NOx+HC, 0.01 for PM

ARB is working to increase compliance with the idling limits, especially in communities heavily-impacted by truck traffic like those around ports, distribution centers, and the U.S. – Mexico border. ARB's truck inspection teams currently enforce the idling limits. Other government representatives can also enforce the regulation and issue notices of violation, including peace officers in the California Highway Patrol, and police and sheriff's departments, as well as local air district inspectors.

- We are targeting enforcement with environmental justice strike forces that focus on highly-impacted areas, including areas with a large number of resident complaints. Inspectors inform truck drivers about the advantages of shutting their engines when the vehicles are not in use. Newer engines using modern diesel fuels don't need to idle between stops to prevent poor operation as older vehicles once needed. When a truck is inspected, we also check to see if it is complying with all other applicable requirements, including: no excessive smoke, no engine tampering, use of compliant fuel, and completion of required software upgrades. For out-of-state or out-of-country trucks, we check to make sure they meet U.S. emission requirements.

- We have worked with the California Highway Patrol, local peace officers, and air district personnel to help train them to respond to excess idling complaints.

- We have developed educational materials for distribution to truck drivers and for the general public. A fact sheet on the idling regulation is available at: http://www.arb.ca.gov/toxics/idling/outreach/factsheet.pdf.

- We have publicized ARB's telephone complaint line, 1-800-END-SMOG, and website, http://www.arb.ca.gov/enf/complaints/complaints.htm, that the public can use to inform ARB inspectors about trucks that are not complying with the truck idling limitations.

ARB staff will expand its work with local governments to increase enforcement, which will decrease the pollution and nuisance from idling trucks.

Since the benefits of the idling limits are already included in the emission estimates in this plan, we do not quantify any additional emission reductions from this strategy.

iv. ARB Rule for International Trucks (Adopted January 2006)

ARB adopted new regulations in January 2006 to ensure that trucks from outside the U.S. that operate in California meet the applicable U.S. emission standards, beginning in 2006. The regulations implement AB 1009 (Pavley, Statutes of 2004), which addressed an anticipated increase in travel by Mexican commercial vehicles in California upon implementation of the transportation provisions of the North American Free Trade Agreement (NAFTA). Mexican trucks are currently limited to operating within 20 miles of the U.S.- Mexican border.

We have little emissions data for Mexican trucks. It is likely that the fleet as a whole pollutes more than the U.S. fleet – Mexican truck emission standards were aligned with the U.S. standards from 1993 through 2003, but do not reflect the tightening of U.S. standards for 2004 and later engines, or the even more stringent U.S. standards for model year 2007 and newer engines.

The benefits of this rule for trucks serving the ports are not reflected in this plan because the potential excess emissions are not included in the goods movement inventory. Once the travel restrictions are lifted and we begin to gain some objective data on Mexican truck travel, ARB plans to include the appropriate emissions changes in the inventory.

b. Implementation Possible by 2015

Implementation of the ARB private truck fleets rule would be completed during this period.

Phase 2 of the port truck modernization program will extend through this period to ensure that trucks newly entering port service have effective controls. In this timeframe, Phase 2 would focus on PM and NOx retrofits for an estimated 5,000 additional 2003-2006 trucks as they move into port service. As we are designing the port truck modernization program, this effort may require a regulation or port policies to ensure that upgraded trucks are kept in port service and that new entrants use the cleanest trucks. A regulation or policy adopted by port authorities would limit port access to compliant vehicles.

c. Implementation Possible by 2020

Phase 3 of the port truck program would ensure that all trucks added to port service after 2015 would meet 2010 certification standards. By 2017 pre-2003 trucks, and by 2019 pre-2007 trucks, would be replaced by trucks meeting the 2010 standards.

4. Emission Reductions

Key Assumptions. We estimated the benefits for each of the two truck strategies that generate new emission reductions, the ARB private fleets rule and the port truck modernization program. Since the private fleets rule is just beginning the extensive public process on rule development, we had to make a number of assumptions to create a potential scenario for truck upgrades to generate the potential benefits in this plan. However, the specific provisions of the rule ultimately proposed for Board consideration may differ significantly from the scenario assumptions. The port truck program is still under development and will be specifically detailed in ARB staff's March 2006 report on that topic.

ARB Private Truck Fleets Rule

For use in this plan, we constructed a possible scenario to approximate the emission reductions that could be achieved with the strategy. Trucks would be retrofitted, repowered, or replaced, depending on their age. The specific details are illustrative only and should not be considered as binding on the requirements ultimately developed for the statewide private fleets rule or any supplemental SIP measures.

- The truck population was grouped by model year to prioritize and target appropriate strategies: Group 1 is about 10,400 pre-1988 trucks, Group 2 is about 8900 1988-90 trucks, Group 3 is about 9400 1991-93 trucks, and Group 4 is about 65,600 1994-2006 trucks. We assumed that Group 1 trucks, being the oldest, would be subject to replacement and repower strategies. Thirty-five percent of Groups 2 and 3 trucks would be replaced or repowered, while the balance would be retrofitted. We assumed Group 4 trucks (about 70 percent of the whole fleet) would be subject to retrofits only.

- There are three levels of retrofit, each associated with specific applicable control technologies. Level 1 is assumed to reduce PM emissions by 25%, Level 2 reduces PM emissions by 50% and is also assumed to include technology to reduce NOx emissions by 7%, and Level 3 reduces PM emissions by 85% and NOx emissions by 25%. The retrofit benefits were estimated by applying the appropriate level of emission reductions to the fraction of trucks in each group that would be retrofitted.

- Repower or replacement with a used 1994+ truck is assumed to reduce PM emissions between 90% and 98%, and NOx emissions between 25% and 50%, depending on the age of the truck being repowered or replaced. Replacement with a brand new truck is assumed to reduce PM emissions between 90% and 98%, and NOx emissions between 84% and 97%, depending on the age of the truck being replaced. The repower/replacement benefits were estimated by applying the appropriate percent reduction to the fraction of trucks in each group that would be repowered or replaced.

- To avoid double-counting reductions from the same vehicles, we adjusted the estimated benefits of the private truck fleets rule to exclude the benefits from trucks that would be covered by the port truck modernization strategy.

Port Truck Modernization Program

- For emissions calculations, staff limited the fleet to trucks with a gross vehicle weight of 33,000 lbs. or more. We assumed that port trucks are older, on average, than the fleet as a whole (age distribution was based on a 2002 study by Starcrest International). We projected that the number of trucks in regular port service would grow from approximately 12,000 in 2005 to 15,000 in 2010, 18,000 in 2015 and 21,000 in 2020.

- We assumed that port trucks make trips of lower average speed (35 mph), owing to short hauls to distribution centers and congested conditions near the ports of Los Angeles, Long Beach and Oakland. We used updated emission factors based on the latest truck testing data.

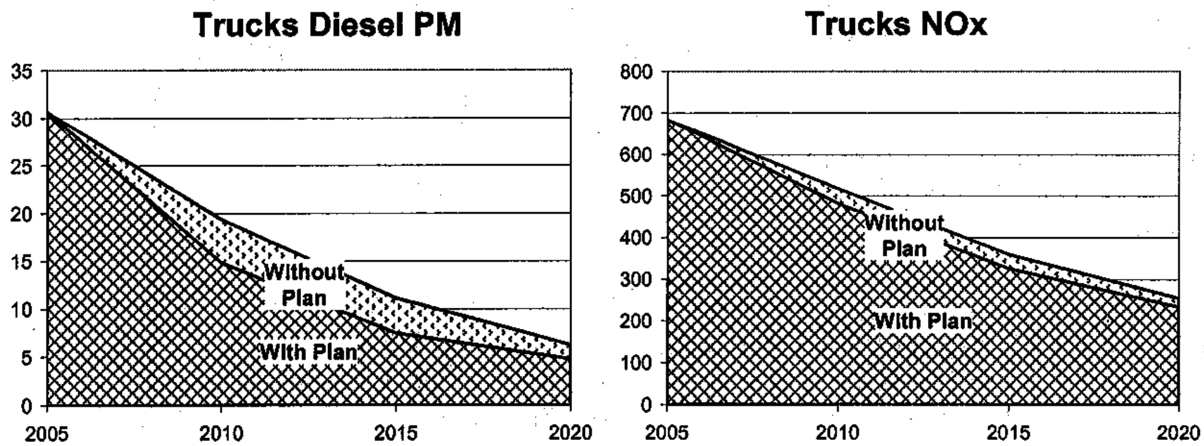
- The description of the strategy provides sufficient detail on the specifics of how the port truck fleet would be modernized to understand the key inputs for our emission reduction calculations.

Results. Table III-12 shows how the new strategies described in this section will further reduce emissions. Figure III-4 shows the impact on truck emissions with and without the plan's strategies.

Table III-12
Statewide Emission Reductions from Trucks with Full Implementation of Plan Strategies
(tons per day)

Pollutant	Year				
	2001	2005	2010	2015	2020
Diesel PM					
Emissions with Existing Program	37.7	30.6	19.4	11.1	6.2
New Reductions – ARB Private Truck Fleets Rule			-4.0	-3.29	-1.22
New Reductions - Port Truck Modernization			-0.49	-0.38	-0.26
New Reductions – Enhanced Enforcement of Truck Idling Limits			Not applicable		
New Reductions - ARB Rule for International Trucks			Not applicable		
New Reductions – Total			-4.5	-3.7	-1.5
Emissions with Plan	37.7	30.6	14.9	7.4	4.7
NOx					
Emissions with Existing Program	654.5	684.3	517.4	359.5	254.9
New Reductions – ARB Private Truck Fleets Rule			-32.0	-32.3	-12.4
New Reductions - Port Truck Modernization			-4.1	-1.9	-8.9
New Reductions – Enhanced Enforcement of Truck Idling Limits			Not applicable		
New Reductions – ARB Rule for International Trucks			Not applicable		
New Reductions – Total			-36.1	-34.2	-21.3
Emissions with Plan	654.5	684.3	481.3	325.3	233.6
ROG					
Emissions with Existing Program	56.0	54.5	42.8	31.3	23.3
New Reductions – ARB Private Truck Fleets Rule					
New Reductions - Port Truck Modernization			Not quantified		
New Reductions – Enhanced Enforcement of Truck Idling Limits					
New Reductions – ARB Rule for International Trucks					
New Reductions – Total					
Emissions with Plan	56.0	54.5	42.8	31.3	23.3
SOx					
Emissions with Existing Program	4.9	5.3	0.6	0.7	0.8
New Reductions – ARB Private Truck Fleets Rule					
New Reductions - Port Truck Modernization			No SOx reductions assumed to result from new strategies		
New Reductions – Enhanced Enforcement of Truck Idling Limits					
New Reductions - ARB Rule for International Trucks					
New Reductions – Total					
Emissions with Plan	4.9	5.3	0.6	0.7	0.8

Figure III-4
Impact of Plan Strategies on Statewide Truck Emissions
(tons per day)



5. Costs

Key Assumptions. We estimated the potential cost for each of the two new truck strategies that were credited in the emission reduction calculations.

ARB Private Truck Fleets Rule. Costs for the private fleets rule were estimated for a scenario that assumed application of a range of strategies targeted by model year. Trucks would be retrofitted, repowered, or replaced between 2008 and 2012, depending on their age.

- The truck population was grouped by model year to prioritize and target appropriate strategies:

	Model Year(s)	Number of Trucks	Action Assumed
Group 1	pre-1988	10,400	Replace or repower
Group 2	1988-1990	8,900	35% replace or repower 65% retrofit
Group 3	1991-1993	9,400	
Group 4	1994-2006	65,600	Retrofit

- There are three levels of retrofit, with cost ranging from $3,000 for Level 1 up to $10,000 for Level 3. Repower or replacement with a used 1994+ truck is assumed to cost $50,000. Replacement with a new 2010 truck is assumed to cost $110,000. These costs are drawn from past fleet modernization experience and current market expectations. Applying these costs to the distribution of strategies assumed above results in a total cost of about $2.5 billion.

Port Truck Modernization. ARB staff assumed the port truck fleet modernization would be carried out in three phases:

- Phase 1 costs include replacing all pre-1994 trucks with 1998 or newer trucks and retrofitting all trucks in port service. We are assuming that 6000 pre-1994 trucks would be replaced with a 10 year old truck that costs $16,000, for a total cost of $96 million. We are assuming that 1200 1994-1997 model year trucks would be retrofitted with diesel particulate filters costing $10,000 and that 10,500 model year 1998 and newer trucks would be retrofitted with combination diesel particulate filter and NOx reduction devices costing $20,000. Total cost for the retrofits is $222 million.

- Phase 2 costs are based on ensuring that trucks that enter port service between 2007 and 2020 meet 2003 or later standards. Between 2007 and 2011, 2,400 pre-2003 trucks would be replaced by 2003 model year trucks. The incremental cost for these trucks--$22,000--is assumed to be the difference between purchasing a 6 year old truck that costs $38,000 and a ten year old truck that costs $16,000. The differential cost of $22,000 times 2,400 trucks is $52.8 million. Also, 3500 2003 and newer trucks would be retrofitted with $10,000 diesel particulate filters for a cost of $35 million.

- Then, between 2012 and 2014 1,300 pre-2007 trucks would be replaced with 2007 MY trucks. The incremental cost for these trucks is assumed to be the difference between purchasing a 6 year old truck that costs $38,000 and a ten year old truck that costs $16,000. The differential cost of $22,000 times 1,300 trucks is $28.6 million. Between 2016 and 2020 2,000 pre-2010 trucks would be replaced with 2010 MY trucks. The incremental cost for these trucks is assumed to be the difference between purchasing a 7 year old truck that costs $30,000 and a ten year old truck that costs $16,000. The differential cost of $14,000 times 2,000 trucks is $28 million. Total cost for phase 2 is $144.4 million.

- Phase 3 costs are based on replacing 3,900 pre-2003 trucks by 2017 with a six year old truck costing $38,000 and replacing 5,300 2003-2006 trucks by 2019 with an eight year old truck costing $25,000, for a total cost of $280.7 million.

Results. The combined cumulative cost to fully implement the strategies for the truck sector are given below. Each time period is cumulative, thus the 2007-2020 value is the total cost (stated in 2005 dollars) of implementing the strategies for this sector. In subsequent chapters we convert these amounts to present value.

	Cumulative Costs 2007-2010 (In millions)	**Cumulative Costs 2007-2015 (In millions)**	**Cumulative Costs 2007-2020 (In millions)**
Trucks	$1,888	$2,904	$3,213

F. LOCOMOTIVES

Strategy "Snapshot." The plan proposes to reduce locomotive emissions primarily by: upgrading switching locomotives to diesel-electric hybrid or equivalent technology in the near-term, securing new national Tier 3 emission standards to make available cleaner engines with 90 percent control of both NOx and PM, and concentrating these cleaner locomotives in California.

1. Introduction

Trains have long been considered an efficient way to move goods for long distances. The locomotives that pull trains have powerful, long-lasting engines that typically run on diesel fuel. Trains are an integral part of California's goods movement system, as each container train can replace up to an estimated 250 truck trips.

At this time, moving goods with locomotives generates less pollution than with trucks, but this will not be true in the future unless locomotive engines become significantly cleaner to keep pace with the improvements to truck engines. The average locomotive in 2000 generated less than half of the NOx and PM emissions that the average truck would have generated to move the same ton of cargo the same distance. However, emissions from trucks are being reduced at a faster rate than emissions from locomotives as a result of more stringent truck regulations. We estimate that diesel PM emissions per ton-mile of goods moved by rail will equal or exceed comparable truck emissions by 2015, as new trucks meeting 2007 emission standards start to reduce truck fleet emissions.

Locomotives emit all of the pollutants we are targeting in this plan – diesel PM, NOx, ROG, and SOx. Switching locomotives account for about five percent of all rail emissions in California, but can have a significant impact on the air quality and health risks in the communities near large yard operations. ARB's 2004 assessment of diesel PM risk levels near the Roseville Rail Yard in Placer County showed that there were localized risks in excess of 500 potential cancer cases per million people exposed, and that over 155,000 people living in the vicinity of the Rail Yard faced an elevated cancer risk due to the rail operations. In contrast, line haul locomotives that travel throughout California emit over 95 percent of statewide rail emissions, but have emissions that are less concentrated and distributed over a much larger area. In California, two freight railroad companies, the Union Pacific Railroad (UP) and the Burlington Northern and Santa Fe Railway (BNSF), account for approximately 95 percent of all railroad emissions, and 99 percent of all goods movement rail emissions.

Federal law limits the abilities of states and local jurisdictions to control locomotive emissions, or to enforce rules that affect national railroad transportation. Due to these statutory restrictions, states and local agencies have limited authority to require the reduction or mitigation of emissions from locomotives. Rules have to be narrowly and carefully crafted to survive federal preemption, limiting the emission reductions that can be obtained. Attempts to adopt broader regulatory requirements would likely be subject to court challenges that could delay or eliminate the emission benefits. Voluntary agreements with the railroads are a part of the State's strategy because they avoid these delays.

The goods movement industry uses two types of locomotives: "line-haul" locomotives, which move large amounts of goods over long distances, and "switching" locomotives, which move rail cars within a facility to set them up for line haul trips or to prepare them for local delivery. Although emissions from each of these two types of locomotive operations differ, all new locomotives, regardless of type, must comply with the same set of emission standards.

Locomotives last a very long time (30 to 40 years) and railroads generally remanufacture them every seven years. Remanufacturing typically involves rebuilding the locomotive engine back to its original operating specifications. In 1998, U.S. EPA established national emission standards for 1973 and later locomotives. The applicability of these emission standards is based on the original manufacture date for the locomotive, and follows a tiered system similar to those discussed for other sectors.

The most stringent existing standards – Tier 2 – provide a significant reduction in locomotive emissions, but the long life of locomotive engines means that without additional action we would not see the full benefits of these standards until 2030. Tables III-13 and III-14 show the existing levels of control required for locomotives.

Table III-13
National NOx+ROG Emission Standards
for Locomotives

Type	Tier	Date of Original Manufacture	Percent Control When Engine Is New or Remanufactured
Line-haul locomotives	Tier 0	1973 - 2001	33%
	Tier 1	2002 - 2004	47%
	Tier 2	2005 and later	61%
Switcher locomotives	Tier 0	1973 - 2001	26%
	Tier 1	2002 - 2004	41%
	Tier 2	2005 and later	58%

* Relative to uncontrolled equipment

Table III-14
National PM Emission Standards
for Locomotives

Type	Tier	Date of Original Manufacture	Percent Control When Engine is New or Remanufactured
Line-haul locomotives	Tier 0	1973 - 2001	0%
	Tier 1	2002 - 2004	0%
	Tier 2	2005 and later	47%
Switcher locomotives	Tier 0	1973 - 2001	0%
	Tier 1	2002 - 2004	0%
	Tier 2	2005 and later	52%

* Relative to uncontrolled equipment

To accelerate the introduction of these cleaner Tier 2 locomotives in the South Coast to help meet the former 2010 deadline for ozone attainment, ARB and U.S. EPA entered into an enforceable agreement in 1998 (1998 Agreement) with the two major freight railroads in California, UP and BNSF. The 1998 Agreement requires the railroads to concentrate their cleanest locomotives in the South Coast to achieve a 65 percent reduction in NOx emissions by 2010 (20 years earlier than would have resulted from typical fleet turnover). Since these same cleaner locomotives will travel in other areas of the State, the 1998 Agreement will also significantly reduce NOx emissions statewide.

2. Actions Taken – 2001 Through October 2005

✓ Low Sulfur Diesel Fuel Rule. In 2004, ARB adopted a regulation requiring locomotives that operate solely within the State to use California low-sulfur diesel fuel, beginning in January 2007 statewide. When implemented in 2007, this regulation will reduce the allowable sulfur levels in the diesel fuel used by switcher locomotives from 500 ppm to 15 ppm of sulfur.

✓ Statewide Railroad Agreement. In 2005, ARB entered into a statewide pollution reduction agreement (2005 Agreement) with the UP and BNSF railroads. The 2005 Agreement is expected to achieve an additional 20 percent reduction in diesel PM emissions at rail yards within three years.

To accomplish this, UP and BNSF have agreed to: phase out non-essential idling and install idling reduction devices, identify and expeditiously repair locomotives with excessive smoke, ensure that at least 99 percent of the locomotives operating in California pass smoke inspections, maximize the use of low sulfur fuel (15 ppm), prepare health risk assessments for 17 major rail yards, work with the local air districts and neighboring communities to identify risk reduction measures, and annually report their plans to implement feasible measures beginning January 2006. The 2005 Agreement establishes enforcement penalties that increase with the number of violations cited against an individual locomotive anywhere in the State. It also provides for significant penalties against the railroads should the railroads fail to implement the agreement.

✓ Idle Reduction Training. In early 2006, ARB staff began training its own inspectors and those from local air districts to enforce the locomotive idle reduction provisions of the Agreement. Staff from the railroads also attended the first training sessions, which were held in Sacramento and San Bernardino. Interested community members have also been invited to participate in additional training sessions planned within the next month for the Bay Area and South Coast air districts.

As shown in Table III-15, the existing control program (both national emission standards and enforceable agreements) will reduce NOx emissions by about 30 percent.

Table III-15
Statewide Emissions from Locomotives
with Benefits of All Measures Adopted Through October 2005
(tons per day)

Pollutant	Year				
	2001	2005	2010	2015	2020
Diesel PM	4.7	4.7	4.2	4.3	4.4
NOx	203.1	158.6	116.9	129.0	139.5
ROG	12.2	11.7	11.3	11.7	12.2
SOx	7.8	7.4	0.8	0.1	0.1

Line haul operations account for the vast majority of diesel PM and NOx emissions statewide, as shown in Chapter II. Emissions from switching operations amount to about five percent of all locomotive emissions statewide, but they are concentrated in a few locations and must be reduced to improve air quality in nearby communities.

3. Strategies to Further Reduce Emissions

Despite the existing federal requirements for locomotive engines and California's voluntary agreements, we must further reduce emissions from locomotives to meet our air quality goals. This section discusses the most promising strategies available for achieving these reductions. They include the use of new technologies, better operating procedures, and retrofits. Some of these actions can be taken on a statewide level, and others are needed at a national level to promote a unified approach to reducing locomotive emissions.

a. Implementation Possible by 2010

There are several technologies available now to reduce emissions from the existing fleet of locomotives. We describe three approaches below that can achieve additional emission reductions by 2010.

i. Upgrade Engines in Switcher Locomotives

The engines used in locomotives – like those used in other diesel applications – can be rebuilt or replaced several times over the locomotive's lifetime. The goal is to upgrade the entire switcher locomotive fleet to cleaner engines with 95 percent diesel PM and ROG control, and 70 percent or better NOx control, by 2010.

Two alternative technologies have been developed that are likely to provide emission reductions by 2010: diesel-electric hybrid locomotives and the locomotives comprised of multiple off-road diesel engines designed to meet more stringent emission standards than locomotive engines. These are not drop-in technologies; a locomotive is completely rebuilt from the frame up to use these technologies.

Diesel-electric hybrid switch locomotives (e.g. Green Goats) are a proven technology that is already in use at some California rail yards. These engines use the same basic concept as a gas-electric hybrid automobile – a battery pack powers the locomotive, while a small diesel engine runs as needed to keep the batteries charged. Hybrid switch locomotives have significantly reduced diesel PM and NOx emissions, idling time, and fuel use compared to conventional switchers.

Remanufactured switchers are also being powered with two or three (700 hp) Tier 3 non-road diesel engines called gen-sets instead of conventional diesel locomotive engines. The multiple engine design has the flexibility to operate on a single generator for most operations, but engage additional engines for added horsepower when needed. The gen-sets are high-speed engines similar to truck engines that accelerate quickly, while typical locomotives have low to medium speed engines. The lifetime engine activity is distributed equally over all of the gen-sets to prevent one engine from wearing out sooner than the rest. The gen-sets are easily repaired or replaced. Engine replacement occurs roughly every 5 to 10 years depending on the work load which would also allow operators to upgrade to more advanced emission control technologies as they become available in the future. Gen-set locomotive manufacturers report that these locomotives can reduce fuel consumption by 20 to 35 percent.

Texas has recently provided $81 million to fund the replacement of 98 switch locomotives with new locomotives powered by multiple off-road engines. The Sacramento Metropolitan Air Quality Management District and Placer County Air Pollution Control District are helping to fund the purchase of one of these switch locomotives to replace a traditional model at the Roseville Rail Yard.

Each of these options can reduce current PM and NOx emissions generated by a switcher locomotive by up to 80 percent, at a cost of approximately $1 million per locomotive. The speed at which this concept can be implemented will be limited by industry's capacity to build the engines and convert locomotives to use them. While the pilot projects being implemented are using multiple off-road engines, we believe that even lower-emission on-road diesel engine technology could be applied to projects in the near future to achieve even better NOx control.

ii. Retrofit Diesel PM Control Devices on Existing Engines

Two options for add-on parts to existing locomotives are diesel particulate filters and diesel oxidation catalysts. Diesel particulate filters contain a semi-porous material that permits gases in the exhaust to pass through but traps the diesel soot, with a PM control efficiency of 85 percent or more. They have been successfully demonstrated in the laboratory on U.S. locomotives, where they reduced diesel PM emissions by up to 80 percent. Diesel oxidation catalysts use a catalyst material and oxygen in the air to trigger a chemical reaction that converts a portion of diesel PM and ROG into carbon dioxide and water. These catalysts have been shown to reduce diesel PM emissions by 20 to 50 percent. While diesel particulate filters typically need a low-sulfur content fuel to operate effectively, diesel oxidation catalysts are tolerant of higher fuel sulfur contents.

Although a number of projects have been proposed throughout the country, diesel particulate filters and diesel oxidation catalysts have not yet been tested or used in rail yard applications in the U.S. A key question to be addressed is whether the filters can maintain the anticipated level of control and necessary durability over time, particularly in rail yard applications. BNSF and UP will be testing two to four locomotives equipped with diesel particulate filters in California rail yard service in 2006.

iii. Use of Alternative Fuels

Cleaner fuels, including ARB's low-sulfur diesel and alternative fuels, are another option to reduce emissions from locomotives (especially older engines), but there are challenges to cost-effective implementation. The alternative fuels are available, but locomotive engines will need to be altered or retrofitted to use some of them. The infrastructure necessary to supply these fuels on a large scale (in California or throughout the U.S.) could present a significant cost. A partial list of these fuels includes:

- *Alternative Diesel.* There are a number of alternative diesel fuels currently available. These include emulsified diesel fuel and biodiesel. The use of these fuels does not typically require any modifications to the locomotive engine, but would likely require the installation of a separate fueling infrastructure.

  Emulsified diesel is a diesel blend that contains diesel fuel, water and other additives that reduce PM emissions. Biodiesel is derived from vegetable oils or recycled restaurant grease, and can be mixed with diesel fuel or used straight. Pure biodiesel can reduce PM emissions by over 50 percent but generally results in a NOx increase. For this reason, biodiesel is best used in combination with NOx control strategies. Biodiesel manufacturers are also working on additives that can be used to prevent increases in NOx emissions.

- *Natural Gas.* Locomotive engines would require modification to be able to use this fuel, and there are concerns about the storage and safe handling of natural gas. The installation of a separate rail yard fueling infrastructure would also be required. Natural gas has a lower energy content per unit of fuel than diesel, which would increase fuel consumption, fuel cost, and reduce the locomotive's range between refueling.

- *Fisher-Tropsch Diesel.* Made from converting synthetic gas to a liquid hydrocarbon diesel, this synthetic diesel fuel contains less than 10 ppm sulfur, which directly reduces diesel PM and SOx emissions.

b. Implementation Possible by 2015

The key to significant additional reductions from locomotives is to get new locomotives built with the best available control systems and to induce the railroads to put these engines into service much faster than would ordinarily occur. By 2012, we believe a clean new locomotive can be equipped with advanced emission control technologies capable of controlling diesel PM and NOx emissions by 90 percent (relative to uncontrolled engines). Based on accelerated replacement of the existing locomotive fleet in California (at a rate of 10 percent per year), we believe these clean locomotives can comprise 30 percent of the California fleet by 2015. To realize the benefits from this concept, California needs more stringent national standards and a program to concentrate the cleanest locomotives here. This section discusses each element.

i. More Stringent National Requirements

U.S. EPA is developing new locomotive emission standards, with the formal proposal due in mid-2006 and final rulemaking in mid-2007. ARB has advocated in formal comments[19] to U.S. EPA that any new national locomotive emission reduction program must address both: (1) new locomotives through aftertreatment based standards, anti-idling devices, and on-board diagnostics, and (2) existing locomotives through aggressive rebuild and remanufacture requirements, as well as installation of anti-idling devices on the national locomotive fleet. Because of federal preemptions, the establishment of aggressive national locomotive emission standards is essential. This strategy includes all of the elements that we believe must be part of the federal rulemaking.

- Tier 3 Emission Standards. U.S. EPA is developing new locomotive emission standards, commonly referred to as Tier 3, modeled after the 2007/2010 highway and Tier 4 off-road diesel engine programs. These standards would likely apply to new locomotives manufactured in 2011 and beyond. This technology, based on high-efficiency catalytic aftertreatment, will be enabled by the use of 15 ppm sulfur diesel fuel in the national locomotive fleet beginning in 2012. The application of

[19] Letter from Catherine Witherspoon, Executive Officer, ARB, to Margo Oge, Director, U.S. EPA Office of Transportation and Air Quality, August 26, 2004.

exhaust emission control technologies in new locomotives could achieve 90 percent control of both NOx and PM emissions.

- On-Board Diagnostics (OBD). U.S. EPA should adopt an on-board diagnostics requirement for locomotives similar to that used in new cars and trucks. The diagnostics system monitors engine performance, notifies the operator of malfunctions that could increase emissions, and helps ensure proper maintenance.

- Rebuild Tier 0, and Tier 1, and Tier 2 Engines to More Stringent Emission Standards. We also believe U.S. EPA should adopt tougher requirements to reduce emissions from existing engines. The Tier 0 and Tier 1 standards implemented in 2000 and 2002 still apply when locomotives originally built to meet those standards are remanufactured. Engines originally built before 1973 are not required to have any emissions control. U.S. EPA should revise the Tier 0 and Tier 1 standards to ensure that the rebuilt engines reflect the technological improvements that have taken place since the locomotive was manufactured. Engine modifications that are already in use, such as changing the compression ratio, optimizing the turbochargers, modifying fuel injectors, and altering injection timing, could provide cost-effective emission reductions from these older engine configurations. U.S. EPA should also revise the Tier 2 standards to include aftertreatment based retrofit controls on these locomotives when they are remanufactured. More stringent "Tier 2.5" rebuild requirements could potentially achieve a 25 percent NOx reduction and 60 percent diesel PM reduction from the existing fleet.

- Idle Limiting Devices on New and Rebuilt Engines. Idle limiting devices are already being installed on virtually all new locomotives, and can be retrofitted onto existing engines. They are electronic monitoring devices that monitor engine parameters, temperatures, and other conditions for practical opportunities to shut down. Locomotives using these devices are expected to save enough fuel in 5-6 years to pay for the device and installation. The nationwide adoption of idling restrictions would meet both the industry's needs for regulatory certainty and the states' needs for lower emissions. The application of idle limiting devices on locomotives could reduce locomotive idling emissions by 40 percent.

ii. Concentrate Tier 3 Locomotives in California

Normally the benefits of a new locomotive standard – such as the Tier 3 standards discussed above – would be seen over time as older locomotives are retired and replaced with new locomotives. However, California could develop a voluntary agreement with the railroads in 2007 to accelerate the use of Tier 3 or equivalent locomotives in California, beginning in 2012. This is the same approach used in the 1998 Agreement to reduce emissions in the South Coast, which accelerated the emission benefit of U.S. EPA's Tier 2 locomotive engine standards by two decades.

c. *Implementation Possible by 2020*

We are relying on U.S. EPA to adopt the necessary Tier 3 locomotive engine standards to achieve 90 percent control of diesel PM and NOx. California would continue to implement a program to accelerate replacement of the existing locomotive fleet (at the same rate of 10 percent per year) with new engines meeting Tier 3 standards, such that these clean locomotives comprise 90 percent of the California fleet by 2020. The reductions from this program from continuation of the strategies in the prior sections.

4. Emission Reductions

Key Inputs. For the locomotive sector, the tonnage of cargo carried via rail is projected to more than double between 2001 and 2020.

- We split the rail category into two engine functions: line haul and switcher locomotives. About 96 percent of total rail emissions are from line haul locomotives and 4 percent of total rail emissions are from switchers. These were further split by idling and movement emissions.

- The starting inventory already accounts for ARB low-sulfur diesel fuel requirements for intrastate locomotives and the benefits of the 1998 Agreement for South Coast (including benefits outside the South Coast as complying locomotives travel to and from that area). We adjusted this inventory to reflect the 2005 Statewide Agreement that reduces idle emissions from switcher and line haul locomotives by 20%.

- Beginning 2010, we assumed the entire fleet of statewide switchers has completely been turned over to gen-sets, Green Goats, or the equivalent. This cleaner fleet of switchers would be equipped with 95% diesel PM control and over 70% NOx control.

- In 2015, we applied the benefits of anticipated Tier 3 locomotive standards (at 90% diesel PM and NOx control) and enhanced rebuild standards for Tier 2 locomotives (at 65% NOx control) to "Tier 2.5" (at 75% NOx control). These more stringent control levels apply to line haul locomotives, and to switcher locomotives (that would be upgraded a second time to take advantage of the lower NOx standards with Tier 3 engines). We assumed a 10% penetration of Tier 3 engines each year beginning in 2012, with a concurrent 5% penetration of upgraded Tier 2 to Tier 2.5 engines.

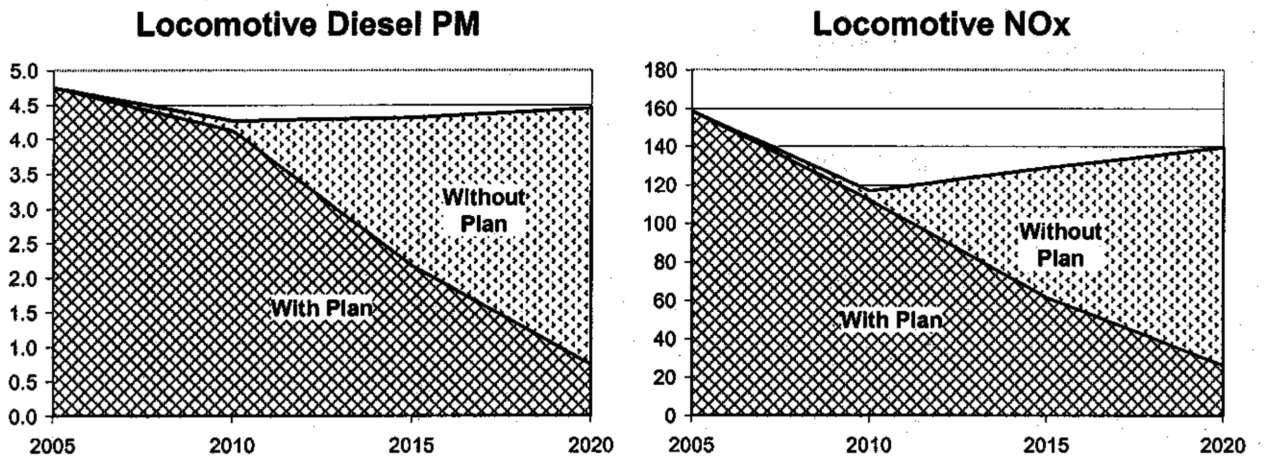
	Percent of California Fleet	
	2015	2020
Rebuilt to Tier 2.5	20%	10%
New Tier 3	40%	90%
Total cleaner locomotives	60%	100%

Results. As shown in Table III-16, implementing this plan would reduce total statewide locomotive emissions by nearly 90 percent between 2001 and 2020. Figure III-5 shows the impact on locomotive emissions with and without the plan's strategies.

Table III-16
Statewide Emissions from Locomotives with Benefits of Plan
(tons per day)

Pollutant	Year				
	2001	2005	2010	2015	2020
Diesel PM					
Emissions with Existing Program	4.7	4.7	4.2	4.3	4.4
New Reductions - 2010 Strategies			-0.15		
New Reductions - 2015 Strategies				-2.14	
New Reductions – 2020 Strategy					-3.71
New Reductions - Total			-0.1	-2.1	-3.7
Emissions with Plan	4.7	4.7	4.1	2.2	0.7
NOx					
Emissions with Existing Program	203.1	158.6	116.9	129.0	139.5
New Reductions - 2010 Strategies			-4.6		
New Reductions - 2015 Strategies				-67.4	
New Reductions – 2020 Strategy					-113.2
New Reductions - Total			-4.6	-67.4	-113.2
Emissions with Plan	203.1	158.6	112.3	61.6	26.3
ROG					
Emissions with Existing Program	12.2	11.7	11.3	11.7	12.2
New Reductions - 2010 Strategies			-0.5		
New Reductions - 2015 Strategies				-5.6	
New Reductions – 2020 Strategy					-10.3
New Reductions - Total			-0.5	-5.6	-10.3
Emissions with Plan	12.2	11.7	10.8	6.1	1.9
SOx					
Emissions with Existing Program	7.8	7.4	0.8	0.1	0.1
New Reductions - 2010 Strategies			Not quantified		
New Reductions - 2015 Strategies					
New Reductions – 2020 Strategy					
New Reductions - Total					
Emissions with Plan	7.8	7.4	0.8	0.1	0.1

Figure III-5
Impact of Plan Strategies on Statewide Locomotive Emissions
(tons per day)



5. Costs

- Since the locomotive strategies may involve a combination of technology and fuels to achieve the desired control levels, we used a general approach to develop the cost estimates. We applied a cost effectiveness number based on other ARB programs to the total amount of emission reductions expected from these strategies. We projected cost-effectiveness in the range of $6,500 to $18,000 per ton of NOx + diesel PM reduced. The lower end is based on approximately 150 percent of the average current cost-effectiveness of the Carl Moyer program. The upper end reflects our estimate of how costs may escalate in the future, as sources get cleaner and it becomes more difficult and costly to get additional emission reductions.

- We then estimated the emission reductions from these locomotive strategies for each year from 2007 through 2020, interpolating between the years for which we projected emission reductions in the prior section. We multiplied the cost-effectiveness range by the tons of NOx + diesel PM reductions in each year from the combined strategies to calculate the total cost per year in 2005 dollars. Finally, we summed up the annual costs from 2007 through 2020 to project the cumulative cost to implement the plan strategies for this sector.

Results. The cumulative costs to fully implement the strategies for the locomotive sector are given below. Each time period is cumulative, thus the 2007-2020 value is the total cost (stated in 2005 dollars) of implementing the strategies for this sector. In subsequent chapters we convert these amounts to present value.

	Cumulative Costs 2007-2010 (in millions)	**Cumulative Costs 2007-2015** (in millions)	**Cumulative Costs 2007-2020** (in millions)
Locomotives	$28 to $77	$545 to $1,509	$1,707 to $4,726

G. OPERATIONAL EFFICIENCIES

There are many efforts underway to identify, evaluate and implement operational efficiencies to increase the speed and capacity of the goods movement system in California. We discuss some examples in this section that may improve efficiency and reduce air pollution. Our growth and emission projections in this plan do not assume any benefits from system changes.

1. Efficiency Improvements

Improving the efficiency of the systems and equipment designed to move cargo can reduce the need for infrastructure improvements, lower the emissions per unit of cargo, and decrease the cost of delivery. We discuss a few examples of approaches to increase port efficiency that may warrant further study. Another approach to decrease the need for infrastructure at the major ports is to shift some of the expected growth to underutilized smaller ports that have excess capacity.

a. Empty Container Logistics for Trucks

Only an estimated two percent of the empty import containers handled by local short haul truckers are reloaded with outbound cargo ("street turned"). For a variety of reasons only a small portion of the empty containers can ever be reused for export loads. The potential for expanded reuse may be roughly 5-10 percent. While an increase from 2 percent to 5 percent or 10 percent does not appear dramatic, the large number of containers at stake can create a substantial impact.

Chassis logistics are a major limiting factor in empty container logistics. Even when an ocean carrier operator has no immediate need for a specific empty container to be returned to the port, it may have a pressing need to use the attached chassis for another shipment.

Two options to reduce truck trips involving empty containers are:

- Increasing the current two percent reuse (i.e., using emptied import containers to transport export-bound goods back to the port).

- Implementation of depot-direct off-hiring where all local trucks would be directed to an off-port container depot rather than directly to the port. The container depot would match incoming and outgoing containers to reduce the number of empty container trips into the port. A Southern California Association of Governments study found that such a truck depot would reduce truck trips, overall. However, the benefits of reduced "empty container" trips may be somewhat offset by the shift of truck traffic from the port to the off-port depot.

Use of the Internet is essential to provide more information and help match containers and increase efficiency. The Port of Oakland has launched an Internet-based, container logistics service to reduce the congestion and emissions associated with empty container trips.

Container logistics are complex, however, and successful implementation requires considerable coordination and agreement among multiple parties such as motor carriers, ocean carriers, leasing companies, and chassis pool operators.

b. Speed Loading and Unloading of Vessels

Cargo ships emit substantial emissions from their auxiliary engines while hotelling at the terminal during loading and unloading. A decrease in hotelling times through faster, more efficient cargo handling strategies can also reduce emissions. Terminal delays can be reduced through the use of advanced information technologies, expanded operating hours and "destination loading" on ships from the far east to reduce unloading and hotelling times at California's ports.

c. Automated Cargo Handling

Yard trucks are used to move containers from one location to another in the port. Containers are moved multiple times while they are on terminal property. The fewer times a container is moved, the lower the emissions associated with its transit through the port. Container moves can be reduced through:

- Technology-dependent options, such as installing automated and electrified container-moving equipment on a rail system within the container storage areas.

- Computerized tracking and management practices that allow containers to move from the ship directly onto the trains or trucks that move them from the port.

The ports may want to explore automated cargo handling systems as a way to increase efficiency and throughput. However the emission reductions associated with reduced cargo handling efforts may be minimal after 2015 due to current emission standards and ARB's proposed cargo handling equipment rule, which accelerates the replacement of older engines with newer, cleaner engines.

2. Transport Mode Shifts

Shifting the mode of transport of containers from trucks to trains can realize emission reductions through 2012. However trucks will become the cleaner option starting in 2015, when a majority of the truck fleet will meet 2007 emission standards, unless more stringent emission standards are implemented for trains as proposed in this plan. Examples of mode shift projects that are in place or have been suggested are:

a. *Port of Oakland*

The Joint Intermodal Terminal at the Port of Oakland provides railroads direct access to the port. This access reduces the number of short truck trips over local roads to the rail yard and from the rail yard to the port. The Bay Area Metropolitan Transportation Commission's December 2004 *Regional Goods Movement Study for the San Francisco Bay Area* states that there is growing interest in using the rail network as an alternative connection to the San Joaquin Valley.

b. *City of Shafter Inland Intermodal Center*

Under this proposal, goods moved from the Port of Oakland to Southern California would be diverted to an inland route utilizing a train shuttle service from the Port of Oakland to the City of Shafter (near Bakersfield), and transferred to trucks for the remainder of the journey to Southern California destinations. Empty containers located in warehousing facilities in the southern Central Valley would be re-used for moving agricultural products bound for the Port of Oakland. This project would require some capital investment to complete connections, but by-and-large the rail lines already exist.

Project proponents estimate that some 80,000 truck trips annually would be eliminated by shuttling goods to the Shafter Intermodal Center. They identify environmental benefits associated with reduced truck congestion during loading and unloading operations at the Port, reduced shipping delays and queuing of marine vessels awaiting berthing at the Port, reduced emissions from trucks that would otherwise operate on congested freeways, and reduced emissions from more efficient management of containers returning to the Port.

c. *Ports of Los Angeles and Long Beach*

Approximately 18 percent of all containers moving through the Ports of Los Angeles and Long Beach are transferred to and from trains at rail yards that are located on or very near the marine terminal. Other containers are transferred by truck to trains at rail yards that are located four to twenty miles from the ports. The truck traffic to and from these off-port rail yards can be reduced by increasing the use of on-dock rail yards. In the long run, major infrastructure improvements would be required to accommodate increases in on-dock transfers to trains; however in the short term, ports are looking to increase the amount of containers loaded onto trains at the dock by:

- Working with railroads to assure timely availability of loading equipment and crews.
- Working to improve the productivity of loading and unloading of rail cars.
- Maximizing the number of rail cars loaded on dock.
- Preventing storage of containers on rail lines at on-dock terminals.[20]

[20] Southern California Association of Governments, *Southern California Regional Goods Movement Policy Paper*, pp. 17-18.

d. Shifting from Trucks to Barges

An option that is often discussed to reduce the need for more infrastructure and to help absorb the anticipated growth in container shipping is to utilize California's smaller and inland ports as distribution satellite centers for the larger ports. These ports are often underutilized or are experiencing a declining customer base as the trend moves toward larger container ships. In a process referred to as "short-sea shipping, containers would be brought to these ports by barges that are loaded at the larger ports. The distance that would have been covered by trucks (or rail) carrying containers traveling in the direction of these smaller or inland ports would be covered by the barges. The containers would then be loaded onto trucks for further distribution throughout the state at the smaller satellite ports. To provide an air quality benefit, these barges would need to be equipped with effective emission controls.

H. LAND USE DECISION-MAKING

Land use decisions are a local government responsibility, and we believe local government has a role in preventing avoidable air pollution exposures that pose a health risk. People who live close to major sources of pollution are exposed to greater concentrations of harmful emissions, and therefore are at greater health risk. Recent studies have shown that public exposure to air pollution can be substantially elevated near some sources of pollution, but health risks are greatly reduced with distance.

Goods movement-related facilities like ports, rail yards, and freeways are major sources of harmful air pollution, and land use decision makers should use caution when considering siting sensitive land uses such as new residences, schools, day care centers, playgrounds and medical facilities near these types of sources. Community members who live close to goods movement facilities have emphasized that it is important not only to have cleaner ships, trains, and trucks, but also to apply other exposure-reducing safeguards such as buffer zones that keep people away from the greatest concentrations of pollutants. There are also other opportunities for local government to play a positive role, such as limiting the routing of trucks through neighborhoods.

To assist local land use decision makers, the Board approved the *Air Quality and Land Use Handbook: A Community Health Perspective* in 2005. The purpose of the document is to highlight the potential health impacts associated with proximity to air pollution sources so local government can explicitly consider this issue in permitting and planning processes. The Handbook includes specific recommendations regarding the siting of new sensitive land uses near freeways, distribution centers, rail yards, ports, refineries, chrome plating facilities, dry cleaners, and gasoline dispensing facilities. In addition to source specific recommendations, the Handbook encourages land use agencies to use their planning processes to ensure the appropriate separation of polluting sources and sensitive land uses. While the Handbook provides suggestions, the decision as to how best to achieve that goal is a local issue.

The Handbook was developed with extensive input from community and environmental groups, business organizations, local air districts and other State and local agencies involved in the land use planning process. It is now beginning to be used by consultants, developers, neighborhood groups, and planners to design projects that rely on separation and other protective measures to reduce health risks caused by nearby pollution sources.

Land use agencies can use each of their existing planning, zoning, and permitting authorities to address the potential health risk associated with new projects such as residential development near ports related facilities. Local agencies can help address localized and cumulative impacts of port related facilities on communities by using their authority to separate residential or other sensitive land uses from sources of air pollution or to require mitigation where separation is not feasible.

Under this strategy, we recommend that land use agencies do the following:

- In developing of General Plans, consider land use compatibility and the cumulative impacts of multiple polluting sources specifically those that are port-related.
- In developing zoning ordinances, ensure that private development takes place such that land uses are compatible. For example, do not locate truck support facilities such as refueling stations or other truck services in residential areas. Seek ways to keep trucks from driving through communities for services.
- In the siting decisions, consider strategies to separate new sensitive land use projects, such as residences, from major goods movement facilities and avoid siting new sensitive land uses immediately downwind of ports or rail yards in the most heavily impacted zones.

Combined with the emission reductions from regulations and incentive programs, planning decisions are critical in helping to reduce community exposure to port related emissions.

I. PROJECT AND COMMUNITY SPECIFIC MITIGATION

The primary strategies in this plan reflect the authorities and responsibilities of ARB and U.S. EPA to reduce emissions from trucks, locomotives, ships, harbor craft, and cargo handling equipment. The main mechanism for achieving these reductions is regulatory action and incentive programs. These comprehensive strategies will provide statewide public health benefits. Implementation of the plan will help regions meet air quality standards, and provide relatively greater benefits in communities near ports and rail yards where the emissions are now concentrated.

It is also important to recognize that other government agencies and those in the goods movement industry have roles to play in terms of mitigating environmental and other community impacts. As new infrastructure projects to support goods movement are developed, environmental mitigation is an essential component. Environmental review provisions of State and federal law provide the legal framework for development of environmental mitigation where government approvals are required for a project. These processes provide an opportunity for public input from communities. Community input is also important where formal environmental review and government approval is not required. For communities already impacted by nearby air pollution sources, community consultation is especially important where new projects or expansions would significantly increase environmental impacts.

At the project level, it will be important to mitigate the impacts of new infrastructure and other projects. Early consultation with communities can help identify potential mitigation measures of most importance in a particular location. For major expansions related to goods movement, communities may choose to consider development of a community benefits agreement as a mechanism to address environmental and other community impacts.

Mitigation efforts tailored to specific communities or projects are an important complement to ARB's statewide strategies. The general concepts outlined in the plan for statewide application – especially the use of cleaner diesel engines and cleaner fuels – may be feasible earlier in targeted situations. This provides opportunities for site-specific mitigation prior to full implementation of the strategies on a statewide basis. This would help mitigate community impacts as quickly as possible with a priority on the most impacted areas. Mitigation of existing impacts near individual rail yards is an example of the need to address health risk in specific communities. Project oriented mitigation is essential to address impacts of any new infrastructure projects. Linking appropriate mitigation to such projects is especially critical in areas where emissions are already concentrated.

As California looks at expanding its goods movement infrastructure, it will be essential to mitigate the temporary emissions from the (usually diesel) heavy equipment used to build new infrastructure. To help address the issue, ARB staff is developing a new rule that will clean up existing fleets of diesel construction equipment statewide. ARB's fleet rule is designed to accelerate the retrofit and replacement of existing heavy-duty diesel engines used in off-road equipment, including construction equipment. ARB staff plans to bring this rule to the Board in early 2007.

J. <u>PORT PROGRAMS TO REDUCE EMISSIONS</u>

Each of California's three major ports is undertaking initiatives to help reduce emissions in and around the ports. ARB staff has not calculated emission benefits for each port program, nor are these programs specifically credited in the plan's assumptions. However, such programs are important contributors to achieving the emission reductions identified for each sector in this plan.

Port of Los Angeles

Environmental Policy and *Community Advisory Committee* – In October 2001, the Port of Los Angeles's Board of Harbor Commissioners created a Port Community Advisory Committee and announced a new environmental policy "that there will be no net increase in air emissions or traffic impact from future port operations." Over the past five years, the Port has undertaken several initiatives to reduce air pollution, including the installation of diesel oxidation catalysts on yard tractors, the use of emulsified diesel fuel, accelerated replacement of yard equipment, use of shore-based electrical power while ships and tugs are at dock, use of cleaner alternate fuels in port equipment, and investment in operational efficiencies.

China Shipping Terminal Settlement – In 2004, the Natural Resources Defense Council negotiated a settlement with China Shipping to use low-emission technologies in the company's new terminal at the Port of Los Angeles, as well as other community mitigation actions. These technologies include use of shore-based electrical power for 70 percent of ships at the terminal and use of alternative fuel yard tractors at the terminal.

Comprehensive Leasing Policy – In February 2006, the Board of Harbor Commissioners announced a new, comprehensive leasing policy that includes clean air requirements in all new and revised port leases. Lease provisions will include shore-side power requirements, the use of low-sulfur fuel in main and auxiliary ship engines, the use of alternative fuels in all new yard tractors, and the use of low-emission truck and locomotives used within terminal facilities.

Port of Long Beach

Green Port Policy – In August 2005, the Port of Long Beach launched its Green Port Policy that aims at reducing air emissions per ton of cargo handled. Programs outlined in this policy include: a voluntary vessel speed reduction program, a goal to provide shore power at all container terminals, various clean fuel and clean engine efforts, and clean switcher locomotive programs. The Port has added catalysts to over 600 pieces of cargo handling equipment, 300 of those pieces using emulsified fuel, and another 100 pieces using ethanol blended diesel fuel.

Green Flags Incentive Program – In January 2006, the Port began a program to provide financial incentives to ship and harbor craft owners by reducing dock fees when the ships comply with the vessel speed reduction program. The goal is to get 100 percent compliance with the program.

Smoke Stack Emissions Reduction Program – The Long Beach Harbor Patrol staff is trained to report ships and harbor craft that emit black smoke from their smoke stacks.

Joint Port of Los Angeles and Port of Long Beach Programs

Vessel Speed Reduction. In May 2001, the Ports of Los Angeles and Long Beach began implementing a voluntary speed reduction program for ocean-going vessels entering or leaving the ports.

Gateway Cities Clean Air Program – This program provides financial incentives to reduce diesel emissions in Southern California. It includes funding from ARB, U.S. EPA, the South Coast Air District's Mobile Source Review Committee, and the Ports of Los Angeles and Long Beach.

PierPass Program – The marine terminal operators at the Ports of Los Angeles and Long Beach formed a not-for-profit organization and launched the PierPass program for trucks serving these ports in July 2005. With PierPass, a "traffic mitigation fee" is charged based on container size. The fee is refunded if the shipping company moves the container during off-peak hours. Expanding port hours helps to reduce truck congestion on nearby freeways and at the terminal.

Switcher Locomotive Program – This program will upgrade 18 harbor locomotive engines with various emission reduction techniques. These techniques include: replacing the engines with cleaner Tier 2 models, using liquefied natural gas engines, using emulsified diesel fuel, and installing diesel oxidation catalysts. All of the engines will include a device that limits idling to 15 minutes.

Port of Oakland

Vision 2000 Maritime Development Program – In 2000, the Port of Oakland released the *Vision 2000 Maritime Development Program* which included the expansion plan for the port including new marine terminals, roadways, a rail yard park, and associated facilities. The Port also developed an Air Quality Mitigation Program for the expansion. The Program calls for reducing emissions from many port sources. The approaches include: emulsified diesel fuel for transport trucks, repowering tugboats and local transit buses, and replacement, repowering, or retrofitting of diesel truck and cargo equipment that operate at the Oakland facility. The Port's new truck replacement program will provide up to $2 million in total funding to truck owners to replace approximately 80 trucks.

Port of San Diego

Working with the San Diego Air District, the Port of San Diego recently received a $90,000 U.S. EPA grant to retrofit port trucks and possibly 15 Dole yard tractors to reduce diesel emissions. The port has also hired a consultant to examine cold ironing options at its terminals. In 2003, the Port of San Diego spent $2.3 million for the construction of the Dole refrigerated container facility with cold-ironing capability. Containers are off-loaded from Dole vessels and plugged into shore power at one of over 500 power poles located on the refrigerated container facility. With this on-terminal power source, the refrigeration units on the containers operate on diesel for less than 20 minutes before they are hitched to a truck and leave the Tenth Avenue Marine Terminal.

K. SUMMARY OF STRATEGIES

This section presents summary information on all of the emission reduction strategies discussed in this plan, including a complete listing of strategies and the emission reductions that would result from implementation.

1. List of Strategies and Implementation Timeframes

Table III-17 lists the measures adopted since 2001 plus new strategies described in this plan to reduce emissions from ports and goods movement. The table also shows the time period when each adopted measure is scheduled for implementation and the period when each new strategy could begin implementation.

Table III-17
List of Strategies to Reduce Emissions from Ports and Goods Movement

Strategy	Status (Adopted or New Strategy)	Implementation Could Begin		
		2006-2010	2011-2015	2016-2020
SHIPS				
Vessel Speed Reduction Agreement for Southern California	2001	✓		
U.S. EPA Main Engine Emission Standards	2003	✓		
U.S. EPA Non-Road Diesel Fuel Rule	2004	✓		
ARB Rule for Ship Auxiliary Engine Fuel	New (2005)	✓		
Cleaner Marine Fuels	New	✓	✓	✓
Emulsified Fuels	New	✓	✓	✓
Expanded Vessel Speed Reduction Programs	New	✓	✓	✓
Install Engines with Emissions Lower than IMO Standards in New Vessels	New	✓	✓	✓
Dedicate the Cleanest Vessels to California Service	New	✓		
Shore Based Electrical Power	New	✓		
Extensive Retrofit of Existing Engines	New		✓	✓
Highly Effective Controls on Main and Existing Engines	New		✓	✓
Sulfur Emission Control Area (SECA) or Alternative	New		✓	
Expanded Use of Cleanest Vessels in California Service	New		✓	
Expanded Shore Power and Alternative Controls	New		✓	
Full Use of Cleanest Vessels in California Service	New			✓
Maximum Use of Shore Power or Alternative Controls	New			✓
COMMERCIAL HARBOR CRAFT				
Incentives for Cleaner Engines	2001-2005	✓		
ARB Low Sulfur Diesel Fuel Rule	2004	✓		
ARB Rule to Clean Up Existing Engines	New	✓		
Shore Based Electrical Power	New	✓		
U.S. EPA or ARB New Engine Emission Standards	New		✓	
CARGO HANDLING EQUIPMENT				
ARB Low Sulfur Diesel Fuel Rule	2003	✓		
ARB/U.S. EPA Tier 4 Emission Standards	2004	✓		
ARB Stationary Diesel Engine Rule	2004	✓		
ARB Portable Diesel Equipment Rule	2004	✓		
Incentives for Cleaner Fuels	2001-2005	✓		

Strategy	Status (Adopted or New Strategy)	Implementation Could Begin By		
		2010	2105	2020
CARGO HANDLING EQUIPMENT, continued				
ARB Rule for Diesel Cargo Handling Equipment	New (2005)	✓		
ARB Rule for Gas Industrial Equipment	New	✓		
Upgrade to 85 Percent Diesel PM Control or Better	New		✓	
Zero or Near Zero Emission Equipment	New			✓
TRUCKS				
ARB/U.S. EPA 2007 New Truck Emission Standards	2001	✓		
Vehicle Replacement Incentives	2001-2005	✓		
ARB Low Sulfur Diesel Fuel Rule	2003	✓		
ARB Smoke Inspections for Trucks in Communities	2003	✓		
Community Reporting of Violators	2005	✓		
ARB Truck Idling Limits	2002-2005	✓		
ARB Low NOx Software Upgrade Rule	2005	✓		
ARB International Trucks Rule	New (2006)	✓		
ARB Private Truck Fleets Rule	New	✓	✓	
Port Truck Modernization	New	✓	✓	✓
Enhanced Enforcement of Truck Idling Limits	New	✓		
LOCOMOTIVES				
ARB Low Sulfur Diesel Fuel Rule	2004	✓		
ARB 2005 Agreement with Railroads to Cut PM Statewide	2005	✓		
Idle Enforcement Training	2006	✓		
Upgrade Engines in Switcher Locomotives	New	✓		
Retrofit Diesel PM Control Devices on Existing Engines	New	✓		
Use of Alternative Fuels	New	✓		
More Stringent National Requirements	New		✓	
Concentrate Tier 3 Locomotives in California	New		✓	✓
OPERATIONAL EFFICIENCY				
Efficiency Improvements	New	✓	✓	✓
Transport Mode Shifts	New	✓	✓	✓
LAND USE DECISIONS	New	✓	✓	✓
PROJECT AND COMMUNITY SPECIFIC MITIGATION	New	✓	✓	✓
PORT AND LOCAL PROGRAMS TO REDUCE EMISSIONS	Ongoing/New	✓	✓	✓

2. Emission Reductions with Plan Strategies

This section summarizes the statewide reductions and resulting emissions after implementation of the strategies in this plan for 2010, 2015, and 2020. Tables III-18 through III-21 show the emissions for each pollutant and each source sector after implementation of the strategies in this plan.

Diesel PM. Table III-18 shows the remaining diesel PM emissions by source sector after plan implementation. Between 2001 and 2005, ship emissions grow due to increased trade, while other sectors stay fairly constant. After 2005, we begin to see substantial decreases from all sectors in response to the effectiveness of controls in place or anticipated as part of this plan. Programs to clean up trucks cut diesel PM emissions from this sector in half between 2005 and 2010, while ships begin to achieve a net reduction in this period due primarily to cleaner auxiliary engine fuel and use of shore power. After 2010, the continued fleet turnover to cleaner trucks, locomotives, ships, and harbor craft drives the progress in reducing diesel PM emissions.

Table III-18
Statewide
Diesel PM Emissions from Ports and Goods Movement
with Full Implementation of Plan Strategies
(tons per day)

Diesel PM	Year				
	2001	2005	2010	2015	2020
Ships	7.8	10.6	8.8	5.0	5.7
Harbor Craft	3.8	3.7	2.1	1.4	1.0
Cargo Handling Equipment	0.8	0.7	0.3	0.1	0.0
Trucks	37.7	30.6	14.9	7.4	4.7
Transport Refrigeration Units	2.5	2.6	1.6	0.6	0.2
Locomotives	4.7	4.7	4.1	2.2	0.7
Total	57.3	52.9	31.8	16.7	12.3

NOx. Table III-19 shows the NOx emissions by source sector after full implementation of the plan strategies. For this pollutant, the introduction of cleaner locomotives between 2001 and 2005 minimizes the effect of increasing ship and truck emissions due to growth in activity over the same period. Between 2005 and 2010, NOx emissions from ships continue to increase with more activity, while emissions from trucks, locomotives, harbor craft, and cargo handling equipment all significantly decline in response to more stringent requirements for cleaner engines. After 2010, we begin to see the ship strategies overcome the effects of growth to reduce the emissions from this sector. By 2020, locomotive and truck emissions decrease to less than half of their 2010 levels as the entire fleets are converted to cleaner technologies.

Table III-19
Statewide
NOx Emissions from Ports and Goods Movement
with Full Implementation of Plan Strategies
(tons per day)

NOx	Year				
	2001	**2005**	**2010**	**2015**	**2020**
Ships	94.7	124.9	133.2	93.7	79.5
Harbor Craft	75.4	69.2	41.3	29.4	22.3
Cargo Handling Equipment	21.1	18.9	12.3	6.0	3.1
Trucks	654.5	684.3	481.3	325.3	233.6
Transport Refrigeration Units	21.5	23.6	26.8	27.8	28.3
Locomotives	203.1	158.6	112.3	61.6	26.3
Total	1,070.3	1,079.5	807.2	543.8	393.1

The emission trends in this version of the plan are generally consistent with those in the December 1 draft plan, with the exception of NOx emissions from heavy trucks. This plan shows a net increase in truck NOx emissions between 2001 and 2005, and a decline from 2005 to 2010. The December 1 draft plan showed a minor decrease by 2005 and a more dramatic decline by 2010. The main reason is our use of updated emission factors based on testing of current technology trucks. This testing indicates a less significant decline in per truck emissions from newer trucks than we had previously anticipated (based on estimates made before the complying technology was introduced). The result is that turnover of the fleet to the early 2000s truck still reduces NOx emissions, but not enough to overcome the effect of growth in trucks and miles traveled in the early years. With the addition of the private truck fleets strategy to this plan, the percent reduction in NOx emissions from trucks catches up with the draft plan by 2020.

ROG. Table III-20 shows the impact of plan strategies on ROG emissions. Although ROG emissions from ships increase over time, all of the other sectors generally show a steady decline in ROG emissions between 2001 and 2020.

There are likely to be additional ROG reductions, beyond those shown above, from implementation of the plan strategies for trucks. One of the uncertainties is the portion of trucks that will be replaced with a newer model versus retrofit with a diesel PM filter. The current filters that are most effective in reducing diesel PM emissions do not typically reduce ROG emissions, but if an older truck is replaced with a newer model designed to meet a lower ROG emission standard there would be a reduction in diesel PM. We have not quantified this potential benefit of the two new strategies to accelerate clean up of the existing truck fleet.

Table III-20
Statewide
ROG Emissions from Ports and Goods Movement
with Full Implementation of Plan Strategies
(tons per day)

ROG	Year				
	2001	2005	2010	2015	2020
Ships	2.4	3.2	4.2	5.3	6.8
Harbor Craft	7.6	7.0	4.4	3.1	2.4
Cargo Handling Equipment	2.5	1.9	1.2	0.8	0.5
Trucks	56.0	54.5	42.8	31.3	23.3
Transport Refrigeration Units	12.8	11.4	7.2	3.8	3.9
Locomotives	12.2	11.7	10.8	6.1	1.9
Total	93.5	89.7	70.6	50.4	38.8

SOx. Table III-21 shows the expected change in SOx emissions with full implementation of the plan strategies. SOx generally increases between 2001 and 2005 due to growth. The sharp decline in SOx emissions after 2005 is due to more stringent controls coming on line: existing ARB requirements for lower sulfur fuel in trucks and land-based equipment statewide in 2006, followed by harbor craft in 2007; national requirements for lower sulfur locomotive fuel; and the plan strategies to cut sulfur levels in ship fuels. The plan strategies would cut current levels of SOx emissions by half in 2010 and by more than three-fourths in 2020. As new information emerges about the contribution of sulfates to the health impacts from ambient levels of fine particles, it may be necessary to accelerate implementation of these strategies.

Table III-21
Statewide
SOx Emissions from Ports and Goods Movement
with Full Implementation of Plan Strategies
(tons per day)

SOx	Year				
	2001	2005	2010	2015	2020
Ships	59.6	81.1	40.7	14.6	15.1
Harbor Craft	0.4	0.4	0.1	0.1	0.1
Cargo Handling Equipment	<0.05	<0.05	0.1	0.1	<0.05
Trucks	4.9	5.3	0.6	0.7	0.8
Transport Refrigeration Units	0.2	0.3	<0.05	<0.05	0.1
Locomotives	7.8	7.4	0.8	0.1	0.1
Total	72.9	94.5	42.3	15.6	16.2

Table III-22 summarizes the declining emission trends that would result from existing air quality programs plus full implementation of plan strategies, despite growth. The declining trends by pollutant show the effect of adding emissions from all goods movement sectors together. Generally, trucks are the biggest contributor to emission reductions between 2005 and 2010 (supplemented by locomotives, harbor craft, and cargo handling equipment), while trucks, ships and locomotives all provide significant emission reductions in later years as the new strategies ramp up. The exception is SOx emissions, where ARB's lower sulfur fuel requirements for ship auxiliary engines are driving the notable decrease from ships (and total SOx emissions) between 2005 and 2010.

Table III-22
Statewide
Trends in Emissions from Ports and Goods Movement with Full Implementation of Plan Strategies
(tons per day)

Pollutant	Year				
	2001	2005	2010	2015	2020
Diesel PM	57	53	32	17	12
NOx	1,070	1,080	807	544	393
ROG	94	90	71	50	39
SOx	73	94	42	16	16

Table III-23 focuses on the emission reductions that would be achieved by fully implementing the new strategies in this plan, beyond the benefits of the existing control program. The plan strategies would reduce statewide diesel PM emissions by over 10 tons per day in the year 2010, a 24 percent decrease from projected levels in that year with the existing control program. In 2020, diesel PM would be reduced by two-thirds, NOx would be cut nearly in half, and SOx would be decreased over 90 percent.

Table III-23
Statewide
Emission Reductions from Ports and Goods Movement with Full Implementation of Plan Strategies
(tons per day)

Pollutant		Year		
		2010	2015	2020
Diesel PM	Emissions with Existing Program*	42	36	36
	Reductions from New Strategies*	-10	-19	-24
	Emissions with Plan	32	17	12
	Percent Reduction in Same Year	24%	53%	67%
NOx	Emissions with Existing Program	892	771	721
	Reductions from New Strategies	-85	-227	-328
	Emissions with Plan	807	544	393
	Percent Reduction in Same Year	10%	29%	45%
ROG	Emissions with Existing Program	72	57	51
	Reductions from New Strategies	-2	-7	-12
	Emissions with Plan	70	50	39
	Percent Reduction in Same Year	1%	12%	24%
SOx	Emissions with Existing Program	108	138	182
	Reductions from New Strategies	-66	-122	-166
	Emissions with Plan	42	16	16
	Percent Reduction in Same Year	61%	88%	91%

- "Existing program" includes measures adopted as of October 2005. Rules adopted after that date or proposed approaches are considered "new strategies."

CHAPTER IV

BENEFITS AND COSTS

A. SUMMARY OF BENEFITS

Chapter III summarizes the emission reductions from the plan strategies. Here, ARB staff has used those benefits to assess how far the strategies take us toward the quantitative goals of this plan. Next, we estimate the adverse health impacts that would be avoided with full implementation of the plan strategies.

1. Emission Reduction Goals

Statewide Goal for 2010. *Reduce projected 2010 statewide emissions of diesel PM, NOx, SOx, and ROG from ports and goods movement to 2001 levels or below to mitigate the impacts of growth.*

With the expansion of this plan to include domestic as well as international goods movement, we applied the same goal to an increased emissions base. As a result, the targeted emission reductions have increased. The plan more than meets the new emissions target for each pollutant. Table IV-1 below shows that the emission reduction strategies proposed in the plan would exceed this goal by about 25-40 percent depending upon the pollutant.

Table IV-1
Statewide
By 2010, Reduce Emissions from
Ports and Goods Movement to 2001 Levels
(tons per day)

	Emissions Target (2001 Levels)	**2010 Emissions with Plan Strategies**	**Percent Below 2001 Levels by 2010**
Diesel PM	57	32	44%
NOx	1,070	807	25%
ROG	94	71	24%
SOx	73	42	42%

Statewide Goal for 2020. *Reduce health risk from diesel PM from ports and goods movement by 85 percent, compared to 2000 levels.*

As shown in Table IV-2 the plan meets this goal with an overall diesel PM risk reduction of 86 percent. This compares to 64 percent risk reduction in the draft plan. In order to calculate health risk, public exposure as well as emissions must be taken into account. We have done so for each emissions category based on location of the emissions relative to communities. For example, reducing diesel PM emissions from ships while at dock produces a far greater risk reduction than the same emission reduction when a ship is traveling to or from port. The methodology and inputs used for this exposure adjustment are described in Appendix C.

Table IV-2
Statewide
Relative Diesel PM Risk Reduction from Ports and Goods Movement with Full Implementation of Plan Strategies
(tons per day)

Category	**2001 Emissions (Exposure Adjusted)**	**2020 Emissions (Exposure Adjusted)**	**Percent Risk Reduction**
Ships-Underway	0.45	0.43	2%
Ships-Hotelling	0.77	0.12	84%
Cargo Equipment	0.34	0.02	94%
Harbor Craft	0.91	0.47	48%
On-Port Trucks and Locomotives	0.10	0.02	80%
Off-Port Trucks and Locomotives and Transport Refrigeration Units	44.7	5.60	87%
Total	47.27	6.66	**86%**

As discussed in Appendix A, the location (within a specific air basin, at a port or at sea), and emission conditions (such as exhaust temperature and stack height) have a significant impact on population exposure. Ships and harbor craft release a significant portion of their emissions at sea. In addition, ships have high stacks that disperse emissions. Some of these emissions do not reach land; all of the emissions are diluted by the time they do. Similarly, sources confined to the port (like ships at berth or cargo handling equipment) have a smaller impact than the sources that move into and through the community (like trucks and trains).

As a result, the community exposure per ton of diesel PM emissions released at sea or on port property is lower than the exposure from a ton of diesel PM released on land within the community. Trucks and locomotives operating in the community have the highest ratio of exposure per ton of diesel PM emitted. Because of this variation in exposure impact and different relative degrees of control by source sector, the diesel PM risk reduction will be greater than the mass emission reduction.

Ideally, the impact of diesel PM emission sources in each region would be estimated using sophisticated air quality models that account for all significant factors that affect both emissions and the population exposed. Such an analysis is currently available only for those emissions from sources within the Ports of Los Angeles and Long Beach and from vessels using those two ports. The impact of all other emission sources, including off-port trucks and locomotives, vessels in other parts of the State and offshore, and on-port emissions at other major ports, must be estimated using an emission based methodology.

This approach recognizes that emissions from ground level sources that typically operate within highly populated urban areas result in greater exposure per ton released than sources that emit either some distance offshore or within port facilities where a portion of the emissions are dispersed over water.

Our risk reduction analysis employs exposure adjustment factors developed from ARB staff's risk assessment performed for the Ports of Los Angeles and Long Beach, together with the health impacts analysis detailed in Appendix A. Table IV-3 shows these exposure adjustment factors. These are the same factors used in the draft plan, but now expressed as the percentage of emissions remaining after adjustment. The impact of off-port trucks and locomotives that operate in the community are represented at 100 percent of estimated emissions, while other categories are represented by a lesser percent of emissions (from ships underway at 8 percent, to harbor craft at 24 percent, to on-port trucks and locomotives at 50 percent).

Table IV-3
Diesel PM Exposure Factor by Category

Category	Relative Exposure
Ships-Underway	8%
Ships-Hotelling	35%
Harbor Craft	24%
Cargo Handling Equipment	43%
Trucks-On Port	50%
Trucks-Off Port	100%
Transport Refrigeration Units	100%
Locomotives-On Port	50%
Locomotives-Off Port	100%

Table IV-4 shows the unadjusted diesel PM emissions used to calculate the health risk reduction from implementation of plan measures. The overall emission reduction is 79 percent from the 2001 base year. This compares to a 44 percent overall emission reduction in the draft plan. For all categories, the percent reduction is greater in this plan compared to the draft plan.

Table IV-4
Statewide
Diesel PM Emissions from Ports and Goods Movement
with Full Implementation of Plan Strategies
(tons per day)

Diesel PM	2001 Emissions	2020 Emissions with Plan Strategies	Percent Mass Reduction
Ships	7.8	5.7	27%
Harbor Craft	3.8	1.0	74%
Cargo Handling Equipment	0.8	<0.05	>95%
Trucks	37.7	4.7	88%
Transport Refrigeration Units	2.5	0.2	92%
Locomotives	4.7	0.7	85%
Total	**57.3**	**12.3**	**79%**

Statewide Goals for 2015 and 2020. *Apply the strategies in the plan on a statewide basis to achieve NOx reductions to aid in attainment of federal and State air quality standards.*

The benefits of the statewide strategies in the plan will be most significant in the South Coast, San Joaquin Valley, Sacramento, the Bay Area, and San Diego – urban areas where goods movement emissions are a significant portion of the emissions inventory. In the draft plan, we established quantified targets specific to South Coast because of the magnitude of the air quality problem and the concentration of port-related emissions.

However, the San Joaquin Valley faces a similar air quality challenge. While we did not set specific targets in the draft plan, our quantification of the plan benefits shows that the percent reductions from 2001- 2020 are greater in the San Joaquin Valley than in the South Coast (see Tables IV-5 and IV-6 below). Similar percentage reductions will occur in the other regions as well. We have added this new goal to explicitly recognize the statewide need for the strategies in this plan. See Appendix B for additional regional analyses of emissions and plan benefits.

Table IV-5
San Joaquin Valley
Emissions from Ports and Goods Movement
with Full Implementation of Plan Strategies
(tons per day)

Pollutant	Year					Percent Reduction 2001-2020
	2001	2005	2010	2015	2020	
Diesel PM	11	9	4	2	1	91%
NOx	218	216	149	97	70	68%
ROG	18	17	13	9	7	61%
SOx	2	2	0.2	0.3	0.2	90%

Table IV-6
South Coast
Emissions from Ports and Goods Movement
with Full Implementation of Plan Strategies
(tons per day)

Pollutant	Year					Percent Reduction 2001-2020
	2001	2005	2010	2015	2020	
Diesel PM	14	14	8	4	3	79%
NOx	256	268	207	145	99	61%
ROG	23	22	18	13	10	57%
SOx	22	35	12	4	4	82%

The coastal areas in Santa Barbara and Ventura Counties experience significant air pollution emitted offshore from ships in transit. Implementing the plan strategies for cleaner ships and marine fuels would fully mitigate the projected diesel PM and NOx emission increases between 2001 and 2020 due to shipping growth in each area. The plan strategies would reverse the SOx increases after 2005, achieving a declining emissions trend from ships over time. By 2020, SOx emissions from ships would be reduced to less than half of 2001 levels in each area.

South Coast Goal for 2015. *Reduce the projected 2015 emissions of NOx from ports and international goods movement in the South Coast by 30 percent to aid attainment of the federal PM2.5 standards.*

The draft plan showed about a 50 percent reduction in NOx emissions from ports and international goods movement in 2015. Table IV-7 shows that this plan would achieve a 48 percent NOx reduction in 2015, exceeding the 2015 goal for a 30 percent reduction from ports and international goods movement in that region. If we were to apply this goal to all goods movement in the South Coast the baseline emissions and the reduction target almost double due to non-port fleet truck emissions. Rather than expand the original goal beyond international goods movement, we are maintaining this regional goal as originally stated until attainment targets are developed as part of the 2007 SIP as discussed in the draft plan.

Table IV-7
South Coast
Reduce 2015 NOx Emissions
from Ports and International Goods Movement by 30 Percent
(tons per day)

Pollutant	Emissions Target (30% Below 2015 Levels)	2015 Emissions with Plan Strategies	Percent Reduction with Plan in 2015
NOx	82	61	48%

South Coast Goal for 2020. *Reduce projected 2020 emissions of NOx from ports and international goods movement in the South Coast by 50 percent to aid attainment of the federal 8-hour ozone standard.*

The draft plan showed about a 60 percent reduction in NOx emissions from ports and international goods movement in 2020. Table IV-8 shows that this plan would achieve a 67 percent NOx reduction in 2020, exceeding the 2020 goal for a 50 percent reduction from ports and international goods movement in that region. If we apply that goal to overall goods movement emissions, we would also meet the 50 percent target. As with the 2015 target, the 2020 goal is intended to be a preliminary step in the attainment planning process. Once the South Coast region has an ozone attainment target and firm attainment date, the goods movement emission target can be revisited.

Table IV-8
South Coast
Reduce 2020 NOx Emissions
from Ports and International Goods Movement by 50 Percent
(tons per day)

Pollutant	**Emissions Target** (50% Below 2020 Levels)	**2020 Emissions with Plan Strategies**	**Percent Reduction with Plan in 2020**
NOx	63	42	67%

2. Statewide Health Impacts Avoided with Plan Implementation

By reducing emissions from ports and goods movement, all Californians will benefit from decreased exposure to diesel PM, with resultant decreases in incidences of cancer, PM-related cardiovascular effects, chronic bronchitis, asthma, and hospital admissions from respiratory illness. Additional health benefits are expected from reductions in NOx emissions that are precursors to PM2.5 and ozone, and ROG emissions that are also precursors to ozone.

For each increment of emissions reduced, there is an incremental reduction in the ambient levels of the pollutant emitted or its atmospheric products. (For example, reducing NOx emissions typically lowers atmospheric PM2.5 and ozone levels.) Then for each incremental reduction in ambient PM2.5 or ozone levels, there are associated benefits from the avoided health impacts that would otherwise have occurred from release of those emissions. As described in Appendix A, ARB has established relationships between the tons of emissions reduced through its control programs and the estimated health impacts avoided by those reductions. Table IV-9 shows that the emission reductions achieved from plan implementation would help avoid over 800 premature deaths in year 2020 alone.

Table IV-9
Statewide
Health Benefits[1] of Full Implementation of Plan Strategies in Year 2020

Health Outcome	Cases Avoided in 2020	Uncertainty Range[2] (cases per year)
Premature Death	820	240 to 1,400
Hospital Admissions (respiratory causes)	530	310 to 740
Hospital Admissions (cardiovascular causes)	300	190 to 460
Asthma and Other Lower Respiratory Symptoms	21,000	8,300 to 34,000
Acute Bronchitis	1,800	-420 to 3,800
Work Loss Days	130,000	110,000 to 150,000
Minor Restricted Activity Days	1,200,000	720,000 to 1,700,000
School Absence Days	270,000	110,000 to 440,000

[1] Does not include the reduction in contributions from particle sulfate formed from SOx emissions, which is being evaluated with several ongoing emissions, measurement, and modeling studies.
[2] Range reflects uncertainty in health concentration-response functions, but not in emissions or exposure estimates. A negative value as a lower bound of the uncertainty range is not meant to imply that exposure to pollutants is beneficial; rather, it is a reflection of the adequacy of the data used to develop these uncertainty range estimates.

3. Economic Value of Statewide Health Benefits

There is an economic value associated with each of the adverse impacts avoided by implementation of the plan strategies shown above. Table IV-10 presents the dollar value of the adverse impacts that would be avoided by reduced emissions in 2020.

Table IV-10
Statewide
Economic Value of Full Implementation of Plan Strategies in Year 2020
(present value)

[corrected]

Health Outcome	Value in 2020 (in millions)	Uncertainty Range[1] (in millions)
Premature Death	$3,700	$850 to $8,800
Hospital Admissions (respiratory causes)	$11	$5 to $20
Hospital Admissions (cardiovascular causes)	$8	$4 to $15
Asthma and Other Lower Respiratory Symptoms	$0.2	$0.1 to $0.4
Acute Bronchitis	$0.4	-$0.1 to $1.1
Work Loss Days	$15	$10 to $22
Minor Restricted Activity Days	$39	$18 to $70
School Absence Days	$16	$5 to $32
Total	**$4,000**	**$900 to $9,000**

[1] Range reflects statistically combined uncertainty in concentration-response functions and economic values, but not in emissions or exposure estimates.

B. COSTS TO IMPLEMENT PLAN STRATEGIES

We have estimated the range of potential costs to implement the new strategies described in this plan. These costs may be borne by a combination of the affected businesses, governments, and consumers.

1. Methodology

Chapter III now includes a brief description at the end of each sector about how we estimated costs for the new strategies. The two approaches are summarized below.

Bottom Up Approach. ARB staff has projected costs for the new strategies affecting trucks and harbor craft, based on estimates of the costs of control, (i.e., the costs for replacement, repower, retrofit, fuel changes, and other technologies times the number of units affected). Where ARB has recently adopted a new regulation (i.e., cargo handling equipment and auxiliary ship engine fuels), we are using the costs detailed in the staff reports for those rulemakings. We have also relied on the analyses in a new March 2005 ARB report for the costs to prepare both ships and terminals to use shore-based power.

Top Down Approach. For the remaining strategies, it is not yet clear what combination of technologies and approaches will be used to achieve the emission reductions. For estimating the costs of these strategies, we used a "top-down" approach based on a projected cost-effectiveness range of $6,500 to $18,000 per ton of NOx + diesel PM reduced. The lower end of this range is based on approximately 150 percent of the average current cost-effectiveness of the Carl Moyer program. The upper end reflects our estimate of how costs may escalate in the future, as sources get cleaner and it becomes more difficult and costly to get additional emission reductions. Multiplying this cost range by the tons of NOx + diesel PM reductions that we are projecting each year from the combined strategies gives the total cost per year.

Cumulative Cost. ARB staff has estimated the emission reductions for these strategies in 2010, 2015, and 2020. We have used linear interpolation and extrapolation to project the reductions for each year between 2007 and 2020. We have calculated cumulative cost as of 2010, 2015, and 2020 by summing the costs for all of the prior years. The cumulative costs for both the "bottom-up" estimates and the "top-down" estimates are summed to arrive at total cumulative cost as of 2010, 2015, and 2020. All of the costs generated for the strategies are in constant 2005 dollars. We estimate the cumulative cost to fully implement the plan strategies for ports and goods movement would be $9.7 - $16.5 billion (in 2005 dollars) between 2007 and 2020. For subsequent analyses and comparison to the economic value of plan benefits, we converted these costs to present value dollars.

2. Results

Table IV-11 shows the range of cumulative costs as of 2010, 2015, and 2020, converted to present value. We estimate that the mid-range cost to implement the new strategies (in present value dollars) in this plan would be about $2 billion in 2010, rising to $5 billion by 2015, and reaching a total cumulative cost of about $8 billion by 2020.

Table IV-11
Cumulative Costs to Implement Plan Strategies
(present value)

Year	Range of Cumulative Cost (in billions)	
	Low End	High End
2007 - 2010	$2	$2
2007 - 2015	$4	$6
2007 - 2020	$6	$10

To derive a benefit-cost ratio, we looked at the cumulative benefits from all health impacts avoided (premature deaths and other quantified health endpoints) and the economic value of those benefits over the timeframe of the plan, in present value dollars. Table IV-12 shows the key inputs to this calculation.

Table IV-12
Benefit-Cost Ratio for Plan Strategies Through 2020
(present value)

	Cumulative Benefits and Costs
Cumulative Premature Deaths Avoided by Plan Strategies	7,200
Cumulative Economic Value of All Health Effects Avoided	$34 – $47 billion
Cumulative Costs to Implement Plan Strategies	$6 - $10 billion
Benefit-Cost Ratio	**3-8 to 1**

Thus, for every $1 invested to implement these strategies, $3 to $8 in economic benefits are realized by avoided health effects, including premature death, hospitalization due to respiratory and cardiovascular causes, asthma and other lower respiratory symptoms, and acute bronchitis. Premature deaths avoided account for over 95 percent of the estimated economic value of all health benefits of the plan.

For purposes of comparison with estimated cumulative costs, Table IV-12 provides a range of estimates for the economic value of adverse health effects avoided by plan strategies from implementation through 2020. The range has been estimated using accepted U.S. EPA methodology and discount rates. Both ends of the range are based on the ARB's mean estimate for the health effects avoided in present value dollars (see

Table IV-10). Discounting the economic value of health effects avoided at a rate of 7 percent yields the lower end of the range: a value of $34 billion. Discounting the economic value of health effects avoided at a rate of 3 percent yields the upper end of the benefit range: a value of $47 billion.

We divided the low end of the benefit range by the high end of the projected cost range to compute the worst-case benefit-cost ratio, (3 to 1). In addition, we divided the high end of the benefit range by the low end of the cost range to compute the best-case benefit-cost ratio, (8 to 1). Even under the worst-case scenario, more than three dollars of economic benefits are realized for every dollar invested to implement the plan strategies.

C. ECONOMIC IMPACTS

ARB staff assessed the overall impact of the plan strategies on California's economy. Staff used E-DRAM, a model of the California economy, developed by UC Berkeley, to estimate impacts of potential control strategies on California's personal income and employment. ARB has used E-DRAM to assess economic impacts of major regulations including the State Implementation Plan for ozone and the motor vehicle greenhouse gas regulations developed in response to AB 1493 (Pavley, 2002). The Department of Finance has used it in the past for policy and revenue analysis. The model has been updated as industrial data becomes available. The current version is based on the latest 2003 industrial data.

1. Annualized Compliance Cost Estimates

Table IV-11 shows the estimated present value of the cumulative cost in 2010, 2015, and 2020 to implement the plan strategies. These costs cover the purchase of complying equipment with an expected average life of 20 years. Staff annualized the capital costs for a five percent discount rate, which is the real rate of return on a risk-free investment.

Staff assigned all of these costs to the transportation sector of E-DRAM. The sector includes several sub–sectors such as ships, trucks, railroad, inland water transport, buses, airline transport, taxis and limousines, pipelines, postal service, warehousing, and others. According to the model, the transportation sector is an $80 billion portion of the California economy in 2020, roughly two percent of State gross product.

The cost increases are expected to be at least partly passed on to consumers gradually over several years according to financial rules of cost apportionment and market conditions. An annualized cost pass-through is used for E-DRAM modeling because the cost of the control must be spread over the number of years that benefits accrue from the controls. We assumed a 20-year life for the controls over which the equipment and other compliance expenditures occur. Table IV-13 shows the annualized costs for an analysis of impacts on the California economy.

Table IV-13
Annual Costs of the New Plan Strategies
(in 2005 dollars)

Year	Annualized Costs to Transportation Sector (millions)
2010	$211 - 228
2015	$478 - 663
2020	$779 - 1,323

2. Economic Impacts

The changes caused by the proposed plan would affect industries both negatively and positively. Using E-DRAM to model the California economy, staff estimated the net effects of these activities on the overall economy.

Higher goods movement costs provide a means to estimate the direct expenditures that would be incurred by California businesses to meet the goals of the proposed plan. These expenditures would in turn bring about additional (indirect) changes in the California economy that may change the overall impacts of the plan on the economy. Increased goods movement costs, if passed on to the consumer as a price increase, may result in a reduction of demand for other goods and services as consumers use more of their money to pay for the increased cost of goods movement. California firms may respond by cutting back future production and employment growth.

Tables IV-14, IV-15, and IV-16 summarize the impacts of the new plan strategies on the California economy for years 2010, 2015, and 2020. Since the E-DRAM model is built to reproduce the economic conditions of 2003, we first extrapolated the model out to 2010, 2015 and 2020 based on State population, personal income, and industry-specific forecasts.

The results of the E-DRAM simulation show that the changes caused by the proposed plan would reduce the California Personal Income by roughly $3 - $5 billion (0.1-0.2 percent) in 2020. As a result, California net employment due to the proposed plan would also be reduced by 10,000 to 17,000 (less than 0.1 percent) in 2020. However, E-DRAM projects California personal income to grow by more than $700 billion, and employment to rise by 3.5 million, between 2006 and 2020. Thus, the impacts of the new plan strategies are small compared to the growth in personal income and employment expected to occur in California over the next 14 years.

Many of the goods imported into California pass through the state on the way to a destination beyond California. Likewise, some of the exports from California ports have originated outside of California and have traveled across the State. The E-DRAM results displayed in the tables do not capture any of the out-of-state economic impacts, but only the in-state impacts.

Table IV-14
Economic Impacts of the Plan Strategies on the California Economy in 2010

California Economy	Without Plan	With Plan	Difference	Percent of Total
Impacts if annualized cost is $211 million:				
Personal Income (billions of 2005 dollars)	1,533	1,532	-1	-0.07%
Employment (thousands of jobs)	16,951	16,948	-3	-0.02%
Impacts if annualized cost is $228 million:				
Personal Income (billions of 2005 dollars)	1,533	1,532	-1	-0.07%
Employment (thousands of jobs)	16,951	16,948	-3	-0.02%

Table IV-15
Economic Impacts of the Plan Strategies on the California Economy in 2015

California Economy	Without Plan	With Plan	Difference	Percent of Total
Impacts if annualized cost is $478 million:				
Personal Income (billions of 2005 dollars)	1,810	1,808	-2	-0.11%
Employment (thousands of jobs)	18,196	18,189	-7	-0.04%
Impacts if annualized cost is $663 million:				
Personal Income (billions of 2005 dollars)	1,810	1,807	-3	-0.17%
Employment (thousands of jobs)	18,196	18,187	-9	-0.05%

Table IV-16
Economic Impacts of the Plan Strategies on the California Economy in 2020

California Economy	Without Plan	With Plan	Difference	Percent of Total
Impacts if annualized cost is $779 million:				
Personal Income (billions of 2005 dollars)	2,136	2,133	-3	-0.14%
Employment (thousands of jobs)	19,532	19,522	-10	-0.05%
Impacts if annualized cost is $1,323 million:				
Personal Income (billions of 2005 dollars)	2,136	2,131	-5	-0.23%
Employment (thousands of jobs)	19,532	19,515	-17	-0.09%

These results indicate that higher goods movement costs result in consumers redirecting other expenditures. Consumers would pay more on the purchase of transported goods, thus having less money to spend on the purchase of other goods and services. The increased consumer payments for transported goods affect the rest of the California economy. It is important to note that the three tables show a negative change in personal income and employment. However, because of growth in both personal income and employment expected to continue in California, the impact of the strategies is to modestly reduce the growth rather than resulting in a net reduction in personal income or jobs.

E-DRAM is a macroeconomic model. Its transportation sector is aggregated and does not distinguish between several transportation-related industries such as trucking, shipping, and rail. The model is very useful for demonstrating the overall economic impacts of major proposals on the California economy. For this analysis, the costs of the plan were allocated to E-DRAM's aggregated transportation sector, which treats the economic impact of strategies to reduce ship emissions, for example, the same way as strategies to reduce emissions from locomotives or trucks. Therefore, our analysis shows the overall impact of strategies in the plan at a high level of aggregation and the total impact on the State economy as a whole.

A source of uncertainty for the model results is the industry data. The model uses the data for 2003, provided by Professor Peter Berck of UC Berkeley. The data were extrapolated to future years by assuming 3.4 percent annual income growth and annual 1.4 percent job growth, based on the UCLA Anderson School of Business Forecast. These growth rates apply to all E-DRAM sectors including the sectors that are involved in goods movement. If the goods movement sector grows faster than the rates applied to E-DRAM, our current analysis would overstate the relative impact of the strategies.

CHAPTER V

FUNDING NEEDS

The Californian's who live near near ports, rail yards, and along high traffic corridors bear a disproportionate share of the emission impacts from goods movement. In addition, the regional impacts of goods movement emissions affect millions of Californians. Chapter IV put the total price tag for this emission reduction plan at $6-10 billion over 15 years (in present value dollars) and the benefits at approximately $34-47 billion over the same period. This chapter discusses options for paying these costs including traditional regulations, taxpayer assistance in the form of incentives or other subsidies, user-based fees, and market-based strategies. ARB staff's intent is not to resolve the question in this document, but to lay out options and initiate a broader discussion.

In general, ARB staff presumes that traditional regulations (which place the costs of control on the owners and operators of polluting sources) will provide the lion's share of progress needed to protect public health and attain ambient air quality standards. But air pollution from ports and goods movement raises some special issues. The health impacts on nearby communities are highly concentrated and the need for mitigation is urgent. These effects are exacerbated by the pace of growth in trade from the Pacific Rim. Accordingly, ARB staff is examining whether new funding can expedite relief from the existing health threat and mitigate the anticipated impacts of future growth. Fee mechanisms may be needed to attract the cleanest ships and to provide alternative financing to secure emission reductions in and near impacted communities. The economic viability of some of the sources (like an owner with a single port truck or a single commercial fishing vessel) also creates a situation where financial assistance may be essential to support the needed upgrade to cleaner equipment.

A. REGULATIONS VERSUS INCENTIVES

Over the past 50 years, California has steadily improved air quality in the face of tremendous economic and population growth. The vast majority of that progress has come from effective regulations. Accordingly, ARB staff expects state and federal regulations to play the primary role in implementing this plan. In the regulatory paradigm, polluting sources pay for the necessary emission controls. Regulations are crafted so that industries can absorb the expense of installing pollution controls or upgrading technology as part of the cost of doing business. Regulated industries pass these costs on to consumers in the form of higher prices, although competition and other factors may prevent some companies from recouping all of their control costs. Low-interest loans with extended payment periods are available to aid smaller businesses that need upfront capital to comply.

In recent years regulatory programs have been supplemented with incentives to accelerate voluntary actions such as replacing older equipment. Incentive programs like the Carl Moyer Program are both popular and effective. They also help to demonstrate emerging technologies that then set a tougher emissions benchmark for regulatory requirements. Most of the existing incentive programs are designed to pay for the incremental cost between what is required and advanced technology that exceeds that level. The incentive programs are publicly funded by general fund taxes or by fees imposed on California drivers as part of their annual registrations, smog inspections or new tire purchases. California is currently investing up to $140 million per year to clean up older, higher emission sources. Ten percent of the Carl Moyer funds that flow through the state budget are reserved, by ARB, for projects of statewide significance, including goods movement-related clean up. The U.S. Congress recently authorized a similar diesel emissions reduction program at the national level for $200 million per year over five years, but has not yet appropriated funds for that purpose.

The question has arisen – should the Carl Moyer Program (or similar programs) be expanded to address goods movement emissions? The answer is yes. But while all of the private sector would appreciate financial support in reducing emissions, ARB staff believes that such incentives should be targeted to those owner/operators that are least able to help themselves. In that regard, ARB staff has identified a need for approximately $1 billion to subsidize the clean-up of older, high emitting port trucks. These vehicles are owned predominantly by single owner-operators who lack the resources to comply with a mandatory vehicle retirement program. State subsidies would enable a rapid turnover of these vehicles to newer models, newer engines, and/or the application of highly effective retrofit devices. Moreover, making this happen as quickly as possible is imperative given the disproportionate impact emissions from these trucks have on nearby communities.

How should that money be raised? There are several options. Motor vehicle revenues could be set aside for this purpose, either as an expansion of the Carl Moyer Program or as a new subsidy. Alternatively, state or local general obligation bonds could be issued to generate revenues for a special port-related incentive program. In January, Governor Schwarzenegger proposed a $1 billion bond, with a $1 billion match from other sources, to help reduce air pollution from goods movement as part of his Strategic Growth Plan. The State Legislature is considering several bond measures, including transportation infrastructure and associated environmental mitigation. Finally, the private sector might be induced to pay for port truck turn-over, in exchange for greater regulatory flexibility elsewhere.

There is also a need to co-fund focused demonstration projects to test special fuels in the marine environment, and to evaluate the transferability of stationary or mobile emission controls to marine vessel engines. These projects are not eligible for Carl Moyer funds since they generally do not result in permanent emission reductions and do not utilize "verified" devices. However, they are vital to evaluating technological feasibility and overcoming owner/operator reluctance to shift to unproven emission control techniques. ARB staff believes a special fund should be created for this purpose, ideally on the order of at least $5 million per year.

B. FEDERAL FUNDING

The federal government has a responsibility to reduce goods movement related emissions for two reasons. First, U.S. EPA is legally obligated to reduce emissions from interstate transportation sources to the levels needed to protect public health everywhere in the U.S., including in California with its severe air pollution problems. Second, because California ports are a gateway to the U.S. market, the federal government must help mitigate the disproportionate impacts in California communities that are conduits for movement of imported goods to other states.

U.S. EPA has taken effective action to make new trucks substantially cleaner in the future. It has done the same for new, off-road diesel equipment, although over a much longer timeframe. The federal government has yet to deal effectively with the more challenging emission sources. It needs to take aggressive action to push tougher emission standards for ships; to set more stringent national emission standards for locomotives or marine vessels (those regulations are currently pending); and to help clean up the millions of *existing* diesel engines in interstate trucks, off-road equipment, locomotives and ships.

Where federal regulations cannot reach, the national government must step forward, as California did, with sufficient incentive funding to fill the gap. For example, a federal version of California's Moyer Program would be highly cost-effective. U.S. EPA has provided several small grants thus far, contributing $960,000 to California goods movement-related projects under the West Coast Clean Diesel Collaborative. Congress also took a step in the right direction last year by authorizing up to $200 million a year for five years for the National Clean Diesel Campaign – now it must follow through with the allocation of actual funding.

C. USER FEES

User-based fees are another approach that could be used to mitigate goods movement emissions and their impact on California residents. The hard part is figuring out who would collect such fees, under what authority, in what amount, and for what purpose. The most successful fees thus far have included some degree of industry buy-in and an element of voluntary participation. Once designed and implemented, fee revenues could be used to directly reduce emissions and support the strategies outlined in this plan. They could also be used to help support needed infrastructure improvements or security. There are other fee options that could be used to provide needed emission reductions. For example, port authorities could develop a fund as part of a port-wide declining emission bubble that would allow the entire port to achieve emissions reductions in the most effective manner available to the particular port. Enforceable agreements with railroads, shipping and cargo companies could include provisions for the companies to fund environmental mitigation projects.

D. OTHER MARKET-BASED APPROACHES

ARB staff has been approached by a least one coalition that proposes to use a market-based incentive program to accomplish most, if not all of the emission reductions envisioned in this plan. The Maritime Goods Movement Coalition submitted a conceptual proposal that is included as Appendix G to this plan for reference. Market-based programs are very attractive where regulatory authority is limited by either legal or practical constraints. When designed properly, market incentives unleash the creativity and efficiency of multiple actors, getting to the desired outcome more quickly or less expensively than otherwise might be the case. However, for all their virtues, market-based approaches raise significant environmental concerns, particularly in nearby communities concerned about toxics trading, lack of control at proximate sources, other environmental justice impacts, and overall enforceability. ARB staff believes that it is important to keep the market-based trading option on the table for goods movement, but has not endorsed any particular approach at this time.

CHAPTER VI

FEDERAL RESPONSIBILITY

California is experiencing explosive growth in goods movement because Pacific Rim countries are using California's ports as the gateway to consumers across the country. Approximately fifty percent of the goods reaching the State's shores are destined for endpoints beyond its borders, and contribute to the economic vitality of the nation. Yet despite our vital role in national and international trade, the diseconomies of transborder shipments are generally borne by our State alone. California's ports are clearly the nation's ports and need to receive corresponding national attention. As noted in Cal/EPA & BT&H's Phase 1 Goods Movement Action Plan, federal responsibility for goods movement encompasses a wide range of security, transportation and environmental concerns. This plan focuses on the air quality issues that need the federal government's active involvement to resolve.

Some federal efforts are very promising. U.S. EPA has helped to reduce goods movement emissions through its national fuel quality standards and emission standards for new interstate trucks, new and rebuilt locomotive engines, new off-road engines and domestically flagged vessels. Additional regulations are pending for harbor craft and for the next round of marine and locomotive engines (Tier 3). However, the emissions from unregulated and under-regulated sources such as foreign vessels and the "legacy" fleet of older vehicles and equipment is overwhelming progress in other sectors. Additional efforts are needed to stem the tide.

On the global scene, U.S. EPA, members of the State Department and national diplomats are California's representatives in the international bodies that govern maritime operations. California needs continuing proactive and aggressive action by these entities to ensure that its environmental needs are addressed via international laws, standards and trade agreements.

The federal government has a role to play in financing air quality clean up as well. The cost of environmental mitigation rests largely on the private sector due to the long established principle that polluters pay. However, there is a significant government role in providing incentives for the rapid conversion to cleaner technologies. Also, certain economic actors in the goods movement sector – such as individual drayage truckers – lack the access to capital necessary to undertake expensive environmental controls. For the latter, progress can only occur if government steps in with some form of subsidies or market mechanisms to make capital available. The federal government should assist California in this regard, due to the major contribution of our ports to the national economy.

California intends to do everything in its power to reduce goods movement emissions. ARB has already adopted more stringent requirements for several goods movement categories, including marine auxiliary engine fuels and cargo handling equipment. However, the State cannot complete the job on its own due to the limitations set forth in national and international laws and the practicalities of global trade movements. Accordingly, this emission reduction plan calls for federal action in the following areas:

A. ACCELERATED REGULATION

U.S. EPA is developing emission standards for several goods movement sources including trains, off-road equipment, marine auxiliary engines and harborcraft. Most of these will apply to new engines only. The diesel engines used in goods movement tend to be very long lived. Also, the effectiveness of emission controls can degrade over time. With that in mind, it is essential that U.S. EPA incorporate the advanced diesel controls that are being developed for on-road trucks and land-based off-road equipment, including after-treatment technologies, into its emission standards for new engines wherever possible to ensure the greatest possible emission reductions.

Specifically, U.S. EPA should facilitate the transfer of state-of-the-art emission controls such as high-efficiency catalytic aftertreatment to locomotives, marine engines, auxiliary engines, and harbor craft. U.S. EPA should also craft its regulations to require the use of the cleanest possible retrofit technologies when engines in sources under its control are replaced or rebuilt, including modifications that would allow these engines to use cleaner fuels. U.S. EPA should include on-board diagnostics and idle limiting device requirements as part of its upcoming emission standards for locomotives. In addition, U.S. EPA should require rebuilt locomotive engines to reflect current technologies, including after-treatment retrofit controls, rather than the standards in effect when the locomotive was first built.

B. LEADERSHIP ON INTERNATIONAL EMISSION SOURCES

California must rely on U.S. EPA to represent its interests before foreign or international regulatory bodies that have the ability to reduce emissions from international goods movement sources. In this role, U.S. EPA should advocate for the adoption of cleaner ship emission standards and less polluting practices by the International Maritime Organization. U.S. EPA should also continue to work with the Mexican government to harmonize the two countries' diesel truck emission standards and diesel fuel quality standards.

C. SULFUR EMISSION CONTROL AREA DESIGNATION

ARB has begun working with U.S. EPA to establish a sulfur emission control area (SECA) off California's coast (or beyond) under the provisions of the International

Maritime Organization, similar to the program already in place in parts of Europe. California needs U.S. EPA to actively support this request, which would reduce PM emissions from ships by about 18 percent and SOx emissions by about 40 percent. In addition, it is essential that the U.S. Congress ratify MARPOL Annex 6 at the earliest possible date, to enable the U.S. to take advantage of the SECA designation option.

D. INCENTIVE FUNDING

This year alone, California will spend up to $140 million in Carl Moyer Program incentive funding to reduce emissions from existing diesel engines and other sources not subject to regulatory control. U.S. EPA has helped fund some pilot diesel retrofit programs at California ports and in the border area. But at present, the federal funding level does not reflect the excess emissions attributed to sources that are largely under federal control. U.S. EPA should assist in providing and developing financial incentives for the owners of older sources to retrofit or replace older, high-emitting engines.

APPENDIX A

QUANTIFICATION OF THE HEALTH IMPACTS AND ECONOMIC VALUATION OF AIR POLLUTION FROM PORTS AND GOODS MOVEMENT IN CALIFORNIA

March 21, 2006

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Appendix A Table of Contents

Appendix A Table of Contents (continued)

Executive Summary

The California Air Resources Board (CARB) staff assessed the potential health effects associated with exposure to air pollutants arising from ports and goods movement in the State. This health impacts assessment focused on particulate matter (PM) and ozone as they represent the majority of known risk associated with exposure to outdoor air pollution, and there have been sufficient studies performed to allow quantification of the health effects associated with emission sources. This assessment quantifies the premature deaths and increased cases of disease linked to exposure to PM and ozone from ports and goods movement, and provides an economic valuation of these health effects. Because of the uncertain nature of several key inputs and methodologies, these results will be refined over time.

Background

Port and goods movement-related emission sources, which are mostly diesel engines, emit PM directly (i.e., diesel PM) and form additional PM (i.e., particle nitrate, particle sulfate, secondary organic aerosols) through chemical reactions and physical processes in the atmosphere involving emitted nitrogen oxides (NO_X), sulfur oxides (SO_X), and reactive organic gases (ROG). Emissions of NO_X and ROG also contribute to ozone formation through atmospheric reactions.

Population-based studies in hundreds of cities in the U.S. and around the world demonstrate a strong link between elevated PM levels and premature deaths, increased hospitalizations for respiratory and cardiovascular causes, asthma and other lower respiratory symptoms, acute bronchitis, work loss days, and minor restricted activity days. Ozone is linked to premature death, hospital admissions for respiratory diseases, minor restricted activity days, and school absence days in other scientific studies. Attaining the California PM and ozone standards statewide air quality would annually prevent about 9,000 premature deaths[1] (4% of all deaths)[2] with an uncertainty range of 3,000 to 15,000 based on 1999-2000 PM and 2001-2003 ozone monitoring data. This is greater than the number of deaths (4,200 to 7,400) linked to second-hand smoke in the year 2000. In comparison, motor vehicle crashes caused 3,200 deaths and there were 2,000 homicides.

Air pollution has a serious impact on the State's economy. An annual value of about $2.3 ($1.5 to 2.8 uncertainty range) billion is associated with hospitalizations and the treatment of major and minor illnesses related to air pollution exposure in California. In addition, the value of preventing premature deaths resulting from exposure to air pollution in excess of the State's PM and ozone standards is estimated to be $70 ($22 to 131 uncertainty range) billion.

Methodology

The methodology used to quantify the adverse health effects of PM and ozone is based on concentration-response functions – relationships between adverse health outcomes (for a population group) and air pollution levels. The fraction of PM and ozone pollution attributable to ports and goods movement was estimated from scaling factors (based on measurements and air quality modeling) linking air basin-wide emission inventories of diesel PM, other PM2.5 sources (e.g., ship boilers, truck brake

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[1] Calculated using concentration-response function for PM2.5 and premature death from Pope et al. 2002, which resulted in a 25% increase over estimates based on Krewski et al. 2000. The U.S. EPA also uses this study (e.g., see http://www.epa.gov/interstateairquality/pdfs/finaltech08.pdf).

[2] According to the Department of Health Services, there are about 235,000 annual deaths due to all causes in California (based on 2001-2003 data)

and tire wear), NO_X, and ROG to outdoor levels of PM components (diesel exhaust, particle nitrate, secondary organic aerosols) and ozone. A similar analysis for particle sulfate formed from SO_X emissions was also attempted, as described below. 184

Results

Table A-1 displays the estimated premature deaths and other health outcomes that can be associated with PM and ozone exposure from port-related goods movement and other port activities for the current year (2005). The estimated economic value of eliminating these adverse health effects, due mostly to avoided premature deaths but also to savings in health care expenditures, is also shown. Primary diesel PM accounts for 50% of the risk, followed by nitrate particles. Since it takes several hours to form nitrate particles from NO_X emission sources, risks are more uniformly distributed over an air basin than from diesel PM, which is highest for those living closest to the sources. The South Coast Air Basin dominates the risk (50% of goods movement-related deaths statewide), followed by other coastal air basins – San Francisco Bay Area, San Diego County, and South Central Coast. Not one source type dominates the risk and all contribute at least 5 to 10% to the total. Valuations are in year 2005 dollars and should be interpreted as the economic value of avoiding these adverse health impacts. They are not the costs of implementing the reduction strategies, which are presented in the main report.

Table A-1 Annual (2005) Statewide PM and Ozone Health Effects Associated with Ports and Goods Movement in California[1] .

Health Outcome	Cases per Year	Uncertainty Range[2] (Cases per Year)	Valuation (million)	Uncertainty Range[3] (Valuation - million)
Premature Death	2,400	720 to 4,100	$19,000	$5,900 to $36,000
Hospital Admissions (respiratory causes)	2,000	1,200 to 2,800	$67	$40 to $94
Hospital Admissions (cardiovascular causes)	830	530 to 1,300	$34	$22 to $53
Asthma and Other Lower Respiratory Symptoms	62,000	24,000 to 99,000	$1.1	$0.44 to $1.8
Acute Bronchitis	5,100	-1,200 to 11,000	$2.2	$-0.52 to $4.7
Work Loss Days	360,000	310,000 to 420,000	$65	$55 to $75
Minor Restricted Activity Days	3,900,000	2,200,000 to 5,800,000	$230	$130 to $350
School Absence Days	1,100,000	460,000 to 1,800,000	$100	$41 to $160
TOTAL VALUATION	NA	NA	$19,000	$6,000 to $36,000

[1]Does not include the contributions from particle sulfate formed from SO_X emissions, which is being addressed with several ongoing emissions, measurement, and modeling studies.

[2]Range reflects uncertainty in health concentration-response functions, but not in emissions or exposure estimates. A negative value as a lower bound of the uncertainty range is not meant to imply that exposure to pollutants is beneficial; rather, it is a reflection of the adequacy of the data used to develop these uncertainty range estimates. Additional details on the methodology and the studies used in this analysis are given in later sections of this Appendix.

[3]Range reflects uncertainty in health concentration-response functions for morbidity endpoints and combined uncertainty in concentration-response functions and economic values for premature death, but not in emissions or exposure estimates.

Projecting future population and ports and goods movement emissions growth and control (for already adopted measures outside of the proposed plan) to the year 2020 results in 1,700 (500 to 2,800 uncertainty range) remaining deaths per year (Table A-15), with an estimated annual value (in 2005 dollars) of $5.5 to 9.4 ($2 to 18) billion. The contribution of PM outweighs that of ozone by tenfold. Primary diesel PM is presently the major contributor to the total estimated premature deaths attributable to ports and goods movement, but, in 2020, secondary diesel PM (i.e., particle nitrate) becomes the most significant contributor as measures are already in place to be effective in controlling primary diesel PM emissions in the long run.

The proposed year 2020 mitigation strategies presented in the main report are expected to result in a reduction of 820 (240 to 1400) deaths annually, with an estimated value of $2.7 to 4.7 ($0.9 to 8.8) billion. Without the implementation of the proposed mitigation strategies, cumulative deaths due to ports and goods movement emissions from 2005 to 2020 are estimated to be 7,200 (2,100 to 12,000 uncertainty range) with an economic value of $33 to 46 ($10 to 87) billion. Further discussions of the benefits and costs of the proposed mitigation strategies can be found in Chapter IV in the main body of the report.

Peer and Public Review

All the concentration-response functions originate from peer-reviewed scientific journals, and several key components of this assessment (i.e., diesel PM exposure estimates, PM and ozone health benefit methodology, economic valuation) have previously undergone peer reviews conducted by the California EPA's Scientific Review Panel, the University of California Office of the President, or the U.S. EPA's Scientific Advisory Board. Several university and government agency scientists commented on the calculation methodology proposed for the assessment in November 2005. Ten scientists reviewed the December 1, 2005 draft report in parallel with the public review. Their comments are presented in Section F of the Technical Supplement and, to the extent possible, incorporated into the revised assessment. Public comments are summarized in Section G of the Technical Supplement and were also incorporated into the revised assessment to the extent possible.

Recent Studies of Premature Death

A recent study (Jerrett et al. 2005) which analyzed PM exposure for Los Angeles found a 2.5 times higher estimate for premature death than the 51-city national study by Pope et al. (2002), but greater uncertainty. The 2.5-times higher result appears to be due to better exposure characterization techniques rather than higher toxicity of the PM mixture in Los Angeles. Several additional studies that have either just been published or will be in the next few months will help resolve this issue. CARB staff intends to review all of these studies and will solicit the advice of the study authors and other experts in the field and U.S. EPA to determine how to best incorporate these new results into future versions of health assessments for ports and goods movement.

Particle Sulfate

The December 2005 draft of this report did not include a quantitative health assessment of particle sulfate formed from goods movement-related emissions of SO_X. Any analysis is complicated by the fact that, in addition to sulfate formed from fossil fuel use in California, there are three other sources of atmospheric sulfate in California – natural "background" sulfate formed over the ocean by biologic activity, global "background" sulfate that is distributed throughout the Northern Hemisphere by the upper air westerly winds, and sulfate blown into Southern California from combustion in Mexico. New analyses of air quality and emissions data conducted in the intervening period indicate that uncontrolled SO_X emissions from ships increase the estimates of total goods movement-related health effects by about one quarter.

However, this preliminary estimate contains several uncertainties and a fully quantitative analysis must await the completion (by end of 2006) of research being jointly conducted by CARB staff, five university groups, the U.S. EPA and its contractors, and Environment Canada as part of a feasibility study for establishing a SO_X Emission Control Area (SECA) to reduce sulfur emissions from West Coast shipping. The research includes a refined inventory of ship activity and ship emissions, analysis of historical PM data from sites along the West Coast to look for evidence of ship emissions, development of new monitoring methods that can distinguish fossil fuel sulfate from that due to biologic activity in the ocean, and model development to allow simulation of sulfate formation and transport over the ocean and land areas of coastal California. 186

Other Uncertainties

There are significant uncertainties involved in quantitatively estimating the health effects of exposure to outdoor air pollution. Uncertain elements include emission and exposure estimates, concentration-response functions, baseline rates of death and disease, occurrence of additional unquantified adverse health effects, and economic values. Many of these elements have a factor-of-two uncertainty, but, over time, some of these will be reduced as new research is completed. However, significant uncertainty will remain in any estimate made over the foreseeable future.

It was not possible to quantify all possible health benefits that could be associated with reducing port-related goods movement emissions. Unquantified health effects due to PM exposures include myocardial infarction (heart attack), chronic bronchitis, onset of asthma, and asthma attacks, as there is some overlap between these and the quantified effects such as lower respiratory symptoms and all respiratory and all cardiovascular hospitalizations. In addition, estimates of the effects of PM on premature birth, low birth weight, and reduced lung function growth in children are not presented. While these outcomes can be significant in any assessment of the public health impacts of air pollution, there are currently few published investigations on these topics, or baseline disease rates for California air basins are not available for some endpoints. In other cases, the results of the studies that are available are not entirely consistent. Nevertheless, there are some data supporting a relationship between PM exposure and these effects, and there is ongoing research in these areas that should help to clarify the role of PM on these health outcomes.

Ongoing Studies

CARB and others fund and conduct studies that will improve our understanding of the emissions, exposure, and health and economic risks of port-related goods movement, especially in the communities closest to the port and associated rail and truck traffic. For example, emission testing of ships, trucks, and trains being conducted now and over the next two years will provide improved activity estimates and chemical speciation profiles. Beginning in fall 2006, the Wilmington Exposure Study will measure air pollution hotspots downwind of the ports, refineries, rail yards, freeways, and local roads. Air quality measurement and modeling to support the State Implementation Plan and a possible SECA designation for North America will improve estimates for particle nitrate, particle sulfate, and ozone during 2006. Over the next 30 months, CARB staff will conduct risk assessments for the 16 largest rail yards in California. As each project is completed, results will be made available to the public.

I. Introduction

The Goods Movement Action Plan: Phase I (BTH and Cal/EPA 2005) identified several elements that will guide efforts to develop a strategic plan for goods movement. One of these elements: "(to) acknowledge the environmental impacts and identify needed resources and strategies to help mitigate those impacts", was the genesis for this current effort.

A. Overview of the Environmental Challenge

The Phase I Report provided a general discussion of the extent of environmental and community impacts of goods movement based on preliminary reports and CARB estimates of port emissions in the South Coast Air Basin (SoCAB). One goal of this report is to provide a more detailed assessment of these environmental impacts, including health impacts, to properly identify potential mitigation strategies. This health impact assessment focuses on the health and attendant economic impacts of air pollution resulting from port-related goods movement throughout the state. Other environmental impacts discussed in Phase I, such as noise and light pollution, traffic-safety concerns, or blight are not within the scope of this analysis.

Emissions from goods movement activities, especially port-related goods movement, have been found to be a significant and growing contributor to regional and community air pollution. Unless further mitigation actions are taken, these emissions will increase with the rapid increase in trade. For instance, according to Phase I and other preliminary environmental assessments, it was estimated that without new pollution prevention interventions, a tripling in trade at the Ports of Los Angeles and Long Beach between the years 2005 and 2020 would result in a 50% increase in nitrogen oxide (NO_X) emissions and a 60% increase in diesel particulate matter (PM) from trade-related activities, during a time when overall air pollution will decrease (CARB 2005a).

A number of air pollutants are associated with goods movement related emissions; however, PM components (diesel exhaust, particle nitrate, particle sulfate, secondary organic aerosol) and ozone are considered to have the greatest impacts on human health. The most severe consequence of increasing emissions of these pollutants would be an increase in the prevalence of diseases such as asthma and heart disease and an increase in the number of premature deaths from cardiopulmonary disease or lung cancer. Increased health care costs, lost work days, and school absenteeism are some of the economic impacts that could result from an increase in disease rates.

B. Community Concerns

This health impact analysis uses air-basin-level emission inventories to evaluate port-related goods movement health impacts for the entire state, but it does not focus on near-source emissions and their potential impacts. Residents in neighborhoods in the vicinity of ports, rail yards or inter-modal transfer facilities, or those along major transportation corridors, are more likely to face greater health risks related to goods movement. Wilmington, City of Commerce, San Francisco's East Bay, and Roseville are examples of communities that may be more affected by port-related activities in comparison to those living elsewhere within an air basin. Many of these communities are made up of people from economically disadvantaged groups who would be the least able to sustain the personal and financial impacts related to increased disease burden. Several community-based air pollution studies and risk assessments have been performed by CARB, the South Coast Air Quality Management District (SCAQMD), and others to evaluate the impact of increased emissions on these populations (i.e., SCAQMD 2000). Many CARB research projects, aimed at increasing our understanding of these impacts are also currently underway. A brief summary of these studies is provided in Section V-C.

Vulnerable populations in impacted communities throughout the state, including the elderly and children or those with existing health problems, are also likely to suffer more from an increase in air pollutants. Additional CARB projects are being conducted to understand these impacts and descriptions of these studies are also provided in section V-C.

II. Background

The Goods Movement Action Plan: Phase I (BTH and Cal/EPA 2005) provided an example of the environmental impacts associated with goods movement emissions in the SoCAB by examining the potential impacts of two major pollutants: diesel PM and NO_X. In that analysis, emissions from on-road heavy-duty trucks (diesel-fueled), gasoline vehicles, off-road equipment and industrial sources were viewed in comparison to port-related goods movement emissions. Port-related emissions for NO_X were significant in relation to the other emission categories in 2005 and the increase due to growth in the industry by the year 2020 makes them the most important source category by that time. Port-related emissions are expected to account for 20% of the SoCAB's NO_X emissions in 2020. Port emissions of diesel PM, which are now nearly equal to those of off-road equipment, will be over three times higher than off-road equipment in 2020 and at least 14 times that of on-road trucks. The Phase I Report concluded that "extensive actions" would be needed to bring port emissions under control to prevent them from becoming the single largest source of air pollution in the SoCAB.

A. Sources of Concern

Ships, railroads, diesel trucks, and cargo handling equipment are the most important port and goods movement-related emission categories. At the ports, ship emissions dominate and will continue to dominate in terms of the tonnage of emissions for diesel PM and NO_X. This is largely due to the cleaner diesel engines that will be required over time for the other source categories. However, in terms of risk resulting from diesel PM, the near-source emissions – those from sources operating from within the ports and by neighborhoods – will have a greater health impact than emissions further off-shore.

B. Emissions

Vehicles and equipment which move international and domestic goods through California are an important source of emissions. Table A-2 presents estimated statewide emissions related to goods movement in 2001, the base year for this study. On a typical day, we estimate more than 1000 tons per day of NO_X are emitted from statewide goods movement activities in California. NO_X emissions from statewide goods movement lead directly to formation of ozone and secondary particulate, and represent about 30% of the total statewide NO_X emissions inventory. More than seventy tons per day of SO_X were generated by goods movement related activities in 2001.

Emissions of diesel particulate, a known carcinogen, are particularly important; in 2001 diesel particulate emissions generated by ports and international goods movement were estimated to be about 57 tons per day of PM and represented about 75% of the statewide diesel particulate inventory.

Table A-2 2001 Statewide Pollutant Emissions by Goods Movement Source Type
(Tons per Day)

Pollutant	Ships	Harbor Craft	Cargo Handling Equipment	Trucks	TRU	Trains	Total
Diesel PM	7.8	3.8	0.8	37.7	2.5	4.7	**57.3**
NO_X	95	75	21	655	22	203	**1070**
ROG	2	8	3	56	13	12	**93**
SO_X	60	0.4	<0.1	5	0.2	8	**73**

Predicting growth in goods movement activities is a key element of the emissions inventory development process. Based on recent data, it is clear that California is experiencing a major increase in the amount of goods imported to our ports. Between 2000 and 2004, the number of containers measured as twenty-foot equivalent units (TEU) increased by 40% at the Ports of Los Angeles and Long Beach.[3] Between 1990 and 2004 traffic doubled from one to two million TEU per year at the Port of Oakland.[2.] The Southern California Association of Governments (SCAG) believes freight volumes will double or triple in the Los Angeles region over the next two decades[4]. The Bay Area Metropolitan Transportation Commission believes total cargo tonnage will double at the Port of Oakland between 2002 and 2020.[5]

The draft goods movement emission inventory released in December 2005 included growth estimates for international goods movement. With the inclusion of domestic goods movement, we needed to develop estimates of growth for domestic goods separate from the international goods. We also took this opportunity to refine our growth estimates for international goods movement activities. Below we briefly describe our refinements to the international goods movement growth estimates and our approach for determining the expected growth in domestic goods movement activities.

Staff has revised international goods movement growth estimates by making the growth rates of trucks and trains that transport goods to and from ports, consistent with the growth rates applied to ships. These growth estimates are based upon the change in number and capacity of container ships that occurred in the years 1997-2003. Specifically, the change in total installed power of container ships was used to estimate growth. Total installed power is a function of the number and the total size of container ships visiting California between 1997 and 2003. These growth rates agree well with container forecasts projected for the Ports of Los Angeles for the No Net Increase Report[6], Long Beach, and Oakland[5]. This plan assumes the numbers of containers processed by ports in California will nearly double by 2010 and nearly quadruple by 2020 relative to the number of containers processed in 2001.

Trucks and trains not involved in port-related goods movement are expected to grow at slower rates that those transporting goods to and from ports. The fraction of trucks and trains involved in goods movement was estimated, and this fraction was grown using the container ship growth rate described above. The remaining fraction of trucks and trains were grown at slower rates specific for these categories. VMT growth for trucks is largely provided by local planning organizations, and locomotive growth was based on national trend data. Domestic growth rates are projected to be much lower than international growth rates. For example, we expect total truck VMT in South Coast will increase about 80% between 2001 and 2025. At the same time, this plan assumes international truck VMT in South Coast will increase by 170%.

Figure A-1 provides all goods movement and Figure A-2 provides ports and international goods movement emission estimates by pollutant and by year for 2001-2025. While the SO_X emissions for all goods movement are projected to triple, the emissions for other pollutants are projected to decrease by 30 to 45% by 2025, The

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[3] American Association of Port Authorities (2005). US / Canada Container Traffic in TEUs. Available at: http://www.aapa-ports.org/industryinfo/statistics.htm.

[4] Southern California Association of Government (2004), Southern California Regional Strategy for Goods Movement, A Plan for Action. Available at: http://www.scag.ca.gov/goodsmove/pdf/GoodsmovePaper0305.pdf.

[5] San Francisco Bay Conservation and Development Commission and Metropolitan Transportation Commission (2003), San Francisco Bay Area Seaport Plan.

[6] Report to Mayor Hahn and Councilwoman Hahn by the No Net Increase Task Force: June 24, 2005. Available at: http://www.portoflosangeles.org/DOC/NNI_Final_Report.pdf.

emissions from ports and international goods movement increase with the dramatic 191
growth in imported goods. By 2025 diesel particulate emissions are projected to more than double and SO_X emissions are projected to quadruple. NO_X emissions are projected to increase more than 70% by 2025, primarily in areas that are currently not in attainment with air quality standards.

Figure A-1 Statewide Goods Movement Emissions

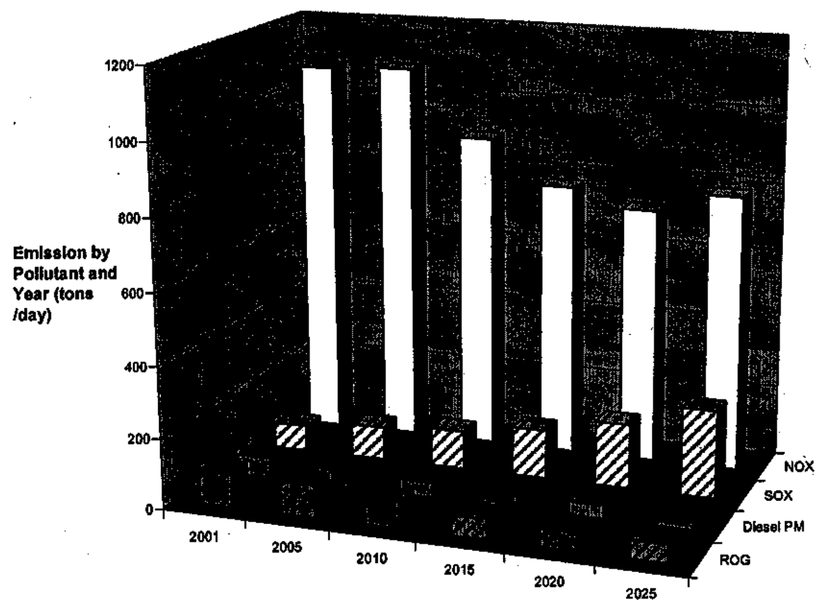
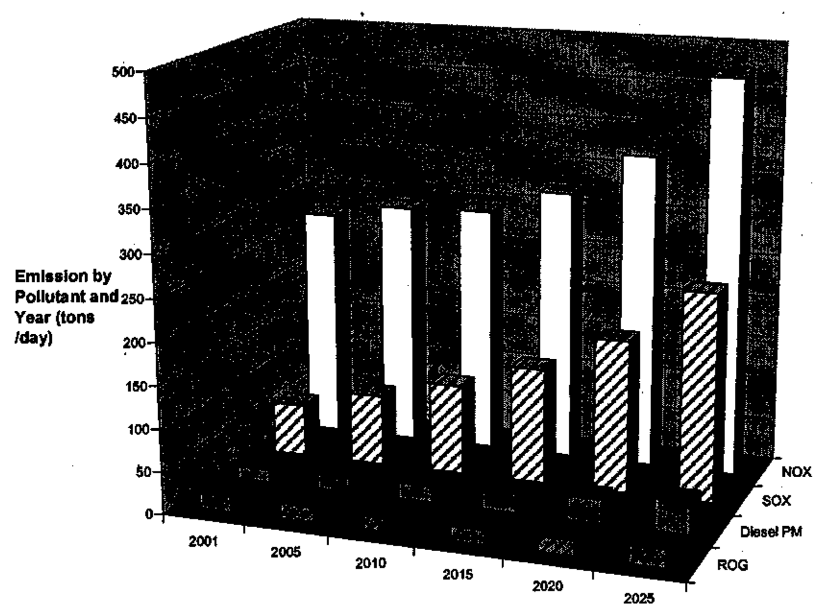


Figure A-2 Port and International Goods Movement Emissions



California has four major goods movement corridors: (1) the South Coast Region, (2) the San Francisco Bay Area Region, (3) the San Diego Region, (4), the San Joaquin Valley Region, and (5) the Sacramento Valley Region. Regions like the South Coast and the San Francisco Bay Area are major centers of goods movement because they contain the largest ports in California. In particular, the South Coast region contains the largest container cargo ports in the U.S. and southern California's economy and transportation infrastructure has developed around these ports. The San Joaquin Valley and Sacramento Valley are major corridors for transport of goods by truck and rail, and also contains the Ports of Stockton and Sacramento. Table A-3 provides 2001 emissions estimates for each of these five regions. 192

Table A-3 2001 Goods Movement Emissions by Region (tons/day)

Region	ROG	Diesel particulate	NO_X	SO_X
South Coast	23	14	256	23
San Francisco	12	6	120	11
San Diego	5	3	48	5
San Joaquin Valley	18	11	218	2
Sacramento Valley	5	2	51	1

C. Previous Risk Assessments

In October 2005, CARB staff released a draft risk assessment for the Ports of Los Angeles and Long Beach (CARB 2005a). These ports are located adjacent to each other on San Pedro Bay about 20 miles south of downtown Los Angeles. The purpose of the study was to increase understanding of the port-related diesel PM emissions impacts and how emissions from different source types affect cancer risk and other health outcomes. This study focused on the on-port emissions from ships, locomotives, on-road heavy-duty trucks, and cargo handling equipment. Cargo handling equipment is used to move containerized and bulk cargo, and includes forklifts, yard trucks, rubber tire gantry cranes, and many other equipment types.

Diesel PM emissions from the two ports were estimated to be 1,760 tons per year in 2002. This represents about 20% of the total diesel PM emissions in the SoCAB. About 73% of the emissions were related to ship activities in the California Coastal Waters (CCW), which is the region extending 14 to 100 miles offshore, depending on location. Commercial harbor craft vessel emissions were estimated at 14% of the total, followed by cargo handling equipment (10%), in-port heavy duty trucks (2%), and in-port locomotives (1%).

Locomotives are another source of goods movement related pollutants. In October 2004, CARB staff published the Roseville Rail Yard Study; a health risk assessment of particulate emissions from diesel-powered locomotives at the Union Pacific J.R. Davis Yard in Roseville, California. Diesel PM emissions from the rail yard were estimated to be about 25 tons per year, with moving locomotives accounting for about 50% of the emissions total, idling locomotives 45%, and engine testing 5% (CARB 2004).

The Roseville Rail Yard Study and the SoCAB port risk assessment both used an emission inventory and air dispersion modeling program to estimate the ambient concentrations to which nearby residents would be exposed, and both quantified cancer and non-cancer risk related to diesel PM. Risk assessment is a process with four inter-related steps: identifying the hazard, or in this case, the air pollutant of concern; determining how human health would be affected by the pollutant; determining the air pollution concentration to which an average person in the affected area would be exposed; and finally, assessing the rate of increased illness or premature death that would result from the exposure. These types of risk assessments are generally performed to determine the magnitude of health impacts from the sources and guide the design of activities to reduce the health hazard. Risk assessments are used routinely to guide development of regulations that focus on reducing (mitigating) pollutants from the most important sources. In risk assessments performed to help design control measures, the estimate of the inhaled concentration of the pollutant (dose) is multiplied by the OEHHA cancer potency factor (response rate) and multiplied by one million to arrive at the number of additional cancer cases estimated per one million population. In the case of non-cancer health effects, CARB and OEHHA use concentration-response functions derived from published epidemiologic studies to relate the changes in predicted concentrations to various health endpoints, the population affected, and the baseline incidence rates (CARB 1998c, Lloyd and Cackette 2000).

Based on the modeling analysis for the communities surrounding the ports in the SoCAB, potential cancer risk associated with on-port and vessel emissions was estimated to exceed 500 in a million. A 50 per million cancer risk still existed more than 15 miles from the ports. CARB staff's assessment of diesel PM health impacts of the Ports of Los Angeles and Long Beach characterized the increased risk of cancer and non-cancer health effects to nearby neighborhoods. The study determined these non-cancer health effects in the study area in year 2005 as follows: 67 premature deaths, 41 hospital admissions for respiratory or cardiovascular causes, 2,100 cases of lower respiratory symptoms, 170 cases of acute bronchitis, 12,000 days of work loss, and 71,000 restricted activity days. In the health assessment for this plan, CARB staff updated the analysis of the non-cancer health effects in three ways. First, the impact of the two ports was calculated for the entire area surrounding the ports (40 mile by 50 mile), not the smaller study area near the ports. Second, the updated methodology, using Pope et al. (2002) for calculating premature death associated with particulate pollution was used. Third, the emissions inventory was updated from 2002 to 2005. In the Roseville Rail Yard Study, the risk assessment showed elevated concentrations of diesel PM contributing to cancer risks of 500 per million population on the rail yard property (an area between 10 to 40 acres). Elevated cancer risks between 100 and 500 million cases per million were estimated for the 700 to 1,600 acres surrounding the rail yard where 14,000 to 26,000 people live. And risk levels between 10 and 100 cases per million were estimated for a 46,000 to 56,000 acre area with a population of 140,000 to 155,000.

Movement of goods to and from port facilities, rail yards, distribution centers, and inter-modal transfer facilities will also result in increased exposure to nearby residents. Residents living in near major transportation corridors for goods movement will also experience elevated exposure and health risk in comparison to the average resident in the region. CARB staff have determined that living very near a large distribution center where hundreds of trucks operate could increase the cancer risk by as much as 750 cases per million (CARB 2004). A number of monitoring studies have concluded that PM and other traffic-related exposures are elevated in the vicinity of freeways (Zhu et al. 2002). Recently published epidemiologic studies estimate an increased risk for respiratory symptoms and asthma for those living near roads with heavy traffic (Kim et al. 2004, Gauderman et al. 2005).

The increasing on-road diesel truck traffic from expanding port cargo handling volumes is not only a concern due to its effect on community exposure and ambient air quality, but also adds to in-vehicle exposures. CARB studies indicate that non-smoking Los Angeles residents receive from 30% to 50% of their total diesel PM exposures during their 90 minute-per-day average drive time (Rodes et al. 1998, Fruin et al. 2004a). Some pollutants (e.g., ultrafine particles) show even higher in-vehicle percentages (Fruin et al. 2004b). Analyses of in-vehicle monitoring measurements have found that the high concentrations of black carbon (indicating diesel PM), NO, ultrafine particles, and particle-bound polycyclic aromatic hydrocarbons (PAHs) are primarily driven by diesel truck traffic volumes (Fruin et al. 2005, Westerdahl et al. 2005). Quantifying the increased in-vehicle exposures due to increased goods movement traffic emissions is beyond the scope of this report, but needs to be taken into account before total exposure impacts can be considered fully quantified. Nonetheless, in our exposure estimation for secondary PM, interpolations were first performed at the census tract level, which addresses some of the concerns regarding exposures at a smaller scale. The census-tract interpolated values were then weighted by census populations to arrive at population-weighted exposures for each county or air basin, which is consistent with how concentration-response functions are typically derived in epidemiological studies.

D. Air Pollutants of Concern

The air pollutants of concern related to goods movement are largely those associated with diesel-fueled engines, which cover nearly all of the trucks, locomotives, off-road equipment, and ships that move international goods. Diesel engine emissions are highly complex mixtures consisting of a wide range of organic and inorganic compounds including directly emitted organic (or elemental) and black carbon (EC and BC), toxic metals, nitrogen oxides (NO_X), particulate matter (PM), volatile organic compounds, gases such as formaldehyde and acrolein, and PAHs. Diesel exhaust includes over 40 substances that are listed as hazardous air pollutants by the U.S. EPA and by the CARB as hazardous air pollutants (HAPs). In 1998, CARB (CARB 1998b, 1998c) identified diesel PM as a toxic air contaminant (TAC). Increases in lung cancer have been identified in most studies of groups occupationally exposed to diesel exhaust. Population-based case control studies identified statistically significant increases in lung cancer risk for truck drivers, railroad workers, heavy equipment operators, and others. On average, these studies found that long-term occupational exposures to diesel exhaust were associated with a 40% increase in the relative risk of lung cancer (OEHHA 1998). These results were largely confirmed in a recent analysis of lung cancer in a cohort of railroad workers (Garschick et al. 2004). Based on these studies and an estimated ambient concentration of diesel PM for which most Californians are exposed (1.54 $\mu g/m^3$), OEHHA estimated a annual range of additional cancer cases of 200 to 3600 for every one million residents over a 70-year lifetime (OEHHA 1998).

In addition to the long term cancer effects of diesel exhaust, short term effects have been observed. There are a number of indications in the occupational epidemiology literature (Delfino et al. 2002) and animal studies that some air toxics are associated with induction and exacerbation of asthma. These include chemicals that are products of fuel combustion, such as formaldehyde and acrolein. It has been shown in numerous studies that diesel exhaust particulate matter can enhance allergic asthma (Nel et al. 1998, Diaz-Sanchez et al. 1999, 2000, Saxon and Diaz-Sanchez 2000). Similar results have been obtained in animal models (Maejima et al. 2001). In addition, immune suppression (Burchiel et al. 2004) has been observed in experimental animals exposed to diesel exhaust resulting in increased susceptibility to respiratory infection (Castranova et al. 2001).

A major pollutant of concern is PM which can be either directly emitted into the atmosphere (primary particles) or formed there by chemical reactions of gases (secondary particles) from natural or man-made sources such as sulfur oxides (SO_X) and NO_X, and certain organic compounds. Ambient ozone pollution is formed from primary emissions of NO_X and other precursor compounds. We've focused primarily on PM and ozone, because these are the two pollutants for which there is sufficient evidence of adverse health effects.

The great majority of epidemiological studies reporting associations between PM and adverse health effects have used as their measure of PM either $PM_{2.5}$ (particles less than 2.5 µm in diameter) or PM_{10} (particles less than 10 µm in diameter). The particles in diesel emissions are very small (90% are less than 1 µm by mass). However, because there are very few studies that used $PM_{1.0}$ as the measure of particulate matter, we've primarily relied upon studies that used ambient $PM_{2.5}$ concentrations as the measure of particulate matter exposure. We did, however, include some studies that used ambient PM_{10} concentrations, because of other advantages these studies offered.

Ozone is regulated in California as a criteria air pollutant. In April of 2005, through collaboration with OEHHA, the CARB approved the nation's most health protective ozone standard with special consideration toward children's health. A new 8-hour-average standard for ozone was established as 0.070 parts per million (ppm), and a 1-hour-average ozone standard was set at 0.09 ppm. Ozone is a powerful oxidant that can damage the respiratory tract, causing inflammation and irritation.

1. Health Effects Associated with PM and/or Ozone

Many studies have investigated the relationship between PM and/or ozone and a variety of adverse health effects. For some health effects, concentration-response functions have been estimated in the epidemiological literature, and the "weight of evidence" argues in favor of their inclusion in a quantitative analysis. For other health effects, there is as yet an insufficient basis for inclusion in a quantitative analysis. The health effects that have been identified to be associated with PM and/or ozone, including those that are included in the quantitative analysis and those that are not, are given in Exhibit 1.

Exhibit 1. Summary of the Health Effects Associated with PM and Ozone

Health Effect	Identified		Included In Quantitative Analysis	
	PM	*Ozone*	*PM*	*Ozone*
Mortality				
All-cause mortality in adults	X	X	X	X
Cardiopulmonary mortality in adults	X	X	*	*
Lung cancer mortality in adults[1]	X	--	*	--
Infant mortality	X	--	†	--
Respiratory Hospital Admissions				
Hospital admissions for all pulmonary illnesses	X	X	X	X
Hospital admissions for chronic obstructive pulmonary disease	X	X	**	**
Hospital admissions for pneumonia	X	X	**	**
Hospital admissions for asthma	X	X	**	**
Cardiovascular Hospital Admissions				
Hospital admissions for all cardiovascular illnesses	X	--	X	--
Emergency Room Visits				
Emergency room visits for asthma	X	X	†	†
Other Morbidity Effects				
Myocardial infarction (heart attack)	X	--	†	--
Chronic bronchitis	X	--	†	--
Acute bronchitis	X	--	X	--
Asthma and lower respiratory symptoms	X	--	X	--
Minor restricted activity days	X	X	X	X
Work loss days	X	--	X	--
School absences	--	X	--	X
Asthma onset	--	X	--	†
Low birth weight, pre-term birth	X	--	†	--
Respiratory Symptoms in Asthmatics				
Exacerbation of asthma	X	X	†	†
Respiratory symptoms (e.g., bronchitis, phlegm, cough)	X	X	X	†
Asthma attacks	X	X	†	†

1 Lung cancer mortality associated with exposure to ambient PM, and lung cancer risk associated with diesel particulates.

X These endpoints have been identified and, if sufficient data available, were quantified.

* These endpoints were not included in the quantitative analysis because they are subsets of all-cause mortality, which is included.

** These endpoints are a subset of all-respiratory hospital admissions.

† These endpoints were not quantified due to insufficient information to perform a quantitative analysis. Please see Appendix A for more detail.

-- These pollutants have not been identified as associated with these health endpoints in this document.

2. Selection Concentration-Response Functions for Quantified Analysis

There are many C-R functions available for estimating the reduced health risks associated with reductions in the levels of ozone and $PM_{2.5}$, as well as a variety of sources of uncertainty surrounding any such risk reduction estimates. When we conduct benefits analyses, we have to decide which health endpoints to include in the analysis and which epidemiological studies (reporting estimated C-R functions for those health endpoints) to use.

In its recent particulate matter risk assessment, U.S. EPA's Office of Air Quality Planning and Standards (OAQPS) included only those health endpoints "for which the overall weight of the evidence from the collective body of studies supports the CD [Criteria Document] conclusion that there is likely to be a causal relationship or that the scientific evidence is sufficiently suggestive of a causal relationship that OAQPS staff judges the effects to be likely causal between PM and the effects category" (Abt Associates Inc., 2005). In addition, EPA considered only those health endpoint categories for which there are C-R functions based on either directly measured $PM_{2.5}$ or $PM_{2.1}$, or concentrations of fine particles estimated using nepholometry data.

U.S. EPA is using this same "weight of the evidence" approach in selecting appropriate health endpoints in its current ozone risk assessment, and we used a similar approach in selecting health endpoints to include in this analysis.

In selecting C-R functions to use from among the many that are available in the epidemiological literature, we were guided by the following considerations:

- The geographic specificity of the study. A common study selection criterion for a benefits analysis that is specific to a given location (e.g., Los Angeles or California) is that the study was conducted at or near that location. The relationship between a pollutant and the population health response to that pollutant is likely to vary to some extent from one location to another, because of (1) differences among populations (for example, if the population in one location has a higher percentage of older and more vulnerable people than in another location) and, (2) for a pollutant such as $PM_{2.5}$, which is itself a mix of other "pollutant species," differences in the pollutant.

- Single-city versus multi-city C-R functions. All else being equal, a C-R function estimated in the assessment location is preferable to a function estimated elsewhere since it avoids uncertainties related to potential differences due to geographic location. There are several advantages, however, to using estimates from multi-city studies versus studies carried out in single cities. Multi-city studies are applicable to a variety of settings, since they estimate a central tendency across multiple locations. When they are estimating a single C-R function based on several cities, multi-city studies also tend to have more statistical power and provide effect estimates with relatively greater precision than single city studies due to larger sample sizes, reducing the uncertainty around the estimated coefficient. In addition, there is less likelihood of publication bias or exclusion of reporting of negative findings or findings that are not statistically significant with multi-city studies. Because single-city and multi-city studies have different advantages, if a single-city C-R function has been estimated in an assessment location and a multi-city study that includes that location is also available for the same health endpoint, one approach is to use the results from both. We have used that approach in this benefits analysis.

- Studies of the relationship between mortality and short-term vs. long-term exposure to $PM_{2.5}$. There is evidence suggesting that there are effects of long-term exposure to $PM_{2.5}$ that are not captured in the short-term studies. Several well-regarded studies of the relationship between mortality and long-term exposure to $PM_{2.5}$ are available, and have been used in recent EPA risk assessments and benefits analyses. Because using both studies of long-term exposure and studies of short-term exposure would result in double counting of mortality impacts, long-term studies are considered preferable to short-term mortality studies.[7]

- The year of publication of the study. If more than one study for a health endpoint is available, more recent studies are preferable to older studies because the statistical techniques for estimating concentration-response functions have become substantially more sophisticated over time. There are several ways in which techniques have improved, among which are improved methods for taking weather variables into account and better specification of lag structures (for example, several of the more recent studies of short-term effects have specified distributed lag models which may be superior to single-lag models). The exact publication date before which to exclude studies from consideration is obviously somewhat arbitrary. We considered 1990 a reasonable choice, however, since some of the more sophisticated techniques were first applied in the 1990s, and many studies were published after that date.

- $PM_{2.5}$ as the measure of particulate matter vs. PM_{10}. While it is still unclear exactly what components of particulate matter have adverse effects on health, most recent research suggests that adverse health effects are most associated with the fine portion of particulate matter, $PM_{2.5}$. In addition, as noted above, 90% of the particles in diesel emissions are less than 1 μm by mass.

- C-R functions estimated using GAMs in the software package S-Plus that have not been re-estimated. Many time-series studies, especially those carried out in recent years, involved use of generalized additive models (GAMs). In late May 2002, EPA was informed by the Health Effects Institute (HEI) of a generally unappreciated aspect in the use of S-Plus statistical software often employed to fit these models. Using appropriate modifications of the default convergence criteria code in the S-Plus software and a correct approach to estimating the variance of estimators will change the estimated C-R functions and could change the results of tests of significance of estimates, although it is not possible to predict a priori how estimates and significance tests will change. Many but not all of the C-R functions that were originally estimated using the S-Plus software for fitting GAMs have since been re-estimated using revised methods. In May 2003, HEI published a special peer-reviewed panel report describing the issues involved and presenting the results of the re-analyzed studies (Health Effects Institute, 2003). In its particulate matter risk assessment, EPA used as one of its selection criteria that a C-R function that had been estimated using GAMs S-Plus and had not been re-estimating using revised methods was excluded from consideration.

- Multi-pollutant C-R functions vs. single-pollutant C-R functions. Some epidemiological studies focusing on a given pollutant estimate C-R functions in

[7] For C-R functions of ozone and mortality, only short-term exposure studies are available.

which only that pollutant is entered into the health effects model (single pollutant models), while other studies include one or more co-pollutants in their models (multi-pollutant models). To the extent that any of the co-pollutants present in the ambient air may have contributed to the health effects attributed to the targeted pollutant (i.e., the pollutant of interest) in single pollutant models, risks attributed to that pollutant might be overestimated where C-R functions are based on single pollutant models. On the other hand, inclusion of pollutants that are highly correlated with one another in a multi-pollutant model can lead to misleading conclusions in identifying a specific causal pollutant. When collinearity exists, inclusion of multiple pollutants in models often produces unstable and statistically insignificant effect estimates for the targeted pollutant and the co-pollutants. Neither single-pollutant nor multi-pollutant models is clearly preferable.

There is a stated or implied "all else equal" in most criteria, but in practice all else is often not equal. While any set of C-R function selection criteria can be used as a guide, they generally cannot by themselves determine which C-R functions to select, because the criteria may conflict with each other in the selection process. For example, one C-R function may have been estimated in the assessment location (e.g., Los Angeles) but used PM_{10} as the measure of particulate matter, while another C-R function may have been estimated in a different location but used $PM_{2.5}$ as the measure. By one selection criterion, we would select the first C-R function, but by another we would select the second. We therefore sometimes had to make "judgment calls," in which we weighed the particular strengths of one C-R function against those of another for the same health endpoint. In some cases, we used two different C-R functions for the same health endpoint, each of which offered specific advantages and disadvantages, and presented two alternative sets of results.

In its PM health risk assessment, staff at EPA's Office of Air Quality Planning and Standards (OAQPS) reviewed the evidence evaluated in the 2004 PM Criteria Document (CD) (see Chapter 3 of the 2005 PM Staff Paper) in selecting what it considered appropriate health endpoints to include. Given the large number of endpoints and studies addressing PM effects, OAQPS included in the quantitative PM risk assessment only:

- More severe and better understood (in terms of health consequences) health endpoint categories.
- Health endpoints for which the overall weight of the evidence from the collective body of studies supports the CD conclusion that there is likely to be a causal relationship or that the scientific evidence is sufficiently suggestive of a causal relationship that the effects would be judged to be likely causal between PM and the effects category.
- Health endpoint categories for which there were studies that satisfied their study selection criteria.

For the primary analysis, we used the same broad health endpoint categories for $PM_{2.5}$ that were selected by OAQPS. This includes:

- Non-accidental premature mortality associated with long-term exposures;
- Respiratory hospital admissions associated with short-term exposures;
- Cardiovascular hospital admissions associated with short-term exposures; and
- Respiratory symptoms not requiring hospitalization associated with short-term exposures.

Non-accidental, cardiovascular, and respiratory mortality due to short-term exposure, as well as cardiopulmonary and lung cancer mortality due to long-term exposure were also included in EPA's $PM_{2.5}$ risk assessment, because health risk reductions were not monetized, and so overlapping categories of health effects could be shown separately. For a benefits analysis, however, in which there is a final monetized benefit, this would not be appropriate.

Some health endpoints, such as chronic bronchitis, were *not* included in the EPA's $PM_{2.5}$ risk assessment because it was judged that there is as yet insufficient weight of evidence for them. However, EPA set fairly stringent criteria for inclusion in the risk assessment. For example, the PM Criteria Document notes that there is a reasonably significant relationship between long-term PM exposure and non-mortal respiratory effects.[8] As a result, we included some additional endpoints, such as acute bronchitis, minor restricted activity days (MRADs), and work loss days (WLDs).

In the primary analysis for ozone, we used those health endpoint categories that OAQPS staff selected for the ozone health risk assessment. This includes:

- Premature mortality associated with short-term exposures;
- Respiratory hospital admissions associated with short-term exposures.

In addition, we included two health endpoints, school loss days and MRADs, within the category of "minor effects."

Exhibits 2 and 3 below list the studies that were considered for use in the analysis for PM and ozone, respectively. Most of these studies were either conducted in California or are multi-city studies contained in U.S. EPA's Final Particulate Matter Criteria Document (2004) or its Second External Review Draft of the Ozone Criteria Document (2005). A few additional studies that are not included in the CDs because they were published too late to be included are also included in these Exhibits. Those studies that we used in the primary analysis are noted in the Exhibits.

[8] "For respiratory effects, notable new evidence from epidemiological studies substantiates positive associations between ambient PM concentrations and not only respiratory mortality, but (a) increased respiratory-related hospital admissions, emergency department, and other medical visits; (b) increased incidence of asthma and other respiratory symptoms; and (c) decrements in pulmonary functions" (EPA 2004, p. 9-79).

Exhibit 2. Studies Reviewed for Health Effects Related to Particulate Matter

Health Endpoint Category	*Health Endpoint*	*Study Location*	**Study**	**Notes**	**Used in Primary Analysis**
Mortality associated with long-term exposures	Mortality; ages 30+	61 U.S. cities	Pope et al. (2002)		X
	Mortality; ages 30+	61 U.S. cities	Pope et al. (1995), reanalyzed by Krewski et al. (2000)		
	Mortality; ages 25+	6 U.S. cities	Dockery et al. (1993)		
	Mortality; ages 25+	6 U.S. cities	Laden et al. (2006), reanalysis of the Six Cities data		
	Mortality; ages 30+	Los Angeles	Jerrett et al. (2005)	*Extremely large effect estimate. Use in sensitivity discussion.*	
	Mortality; ages 65+	California	Enstrom (2005)	*Size of cohort about one tenth that of Pope* et al. *(2002), but all in California*	
	Infant mortality	86 U.S. Cities	Woodruff et al. (1997)		
	Infant mortality	California	Woodruff et al. (2006)		
Respiratory hospital admissions	HA, COPD, age 20-64	Los Angeles	Moolgavkar (2000a)		X
	HA, COPD, age 65+	Los Angeles	Moolgavkar (2000a), reanalyzed in Moolgavkar (2003a)		X
	HA, COPD; ages 65+	14 U.S. Cities (not including L.A.)	Samet et al. (2000), reanalyzed by Zanobetti and Schwartz (2003)	PM_{10} based.	X
	HA, pneumonia; ages 65+	14 U.S. Cities (not including L.A.)	Samet et al. (2000), reanalyzed by Zanobetti and Schwartz (2003)	PM_{10} based.	X
	HA, pulmonary, ages 30+	Los Angeles	Linn et al. (2000)	PM_{10} based.	
	HA, emergency and urgent asthma-related	Los Angeles	Nauenberg and Basu (1999)	PM_{10} based. Wet season only (Nov. 15 – March 1)	
Cardiovascular hospital admissions	HA, Cardiovascular, age 20-64	*Los Angeles*	Moolgavkar (2000b)		X

Health Endpoint Category	*Health Endpoint*	*Study Location*	**Study**	**Notes**	**Used in Primary Analysis**
	HA, Cardiovascular, age 65+	*Los Angeles*	Moolgavkar (2000b), reanalyzed in Moolgavkar (2003a)		X
	HA, Cardiovascular, age 65+	14 U.S. Cities (not including L.A.)	Samet et al. (2000), reanalyzed by Zanobetti and Schwartz (2003)	PM_{10} based.	X
Emergency room visits for asthma	ER visits for asthma	Santa Clara Co., CA	Lipsett et al. (1997)	Based on winter-time observations with strong contribution from residential wood smoke.	
	ER visits for asthma	Seattle, WA	Norris et al. (1999)		
Other effects	Myocardial infarction		Peters et al. (2001)		
	Chronic bronchitis		Abbey et al. (1995)		
	Acute bronchitis	24 communities in the U.S. and Canada	Dockery et al. (1996)		X
	Lower respiratory symptoms	6 U.S. cities	Schwartz and Neas (2000)		X
	MRADs	Nationwide; workers aged 18-65.	Ostro and Rothschild (1989)	Fine particulate concentrations were estimated by regression from airport visibility data.	X
	WLDs		Ostro (1987)	Fine particulate concentrations were estimated by regression from airport visibility data.	X
Respiratory symptoms among asthmatics	Asthma symptom scores for asthmatics	So. CA community	Delfino et al. (1998b)		
	Exacerbation of asthma in African-American children	Los Angeles	Ostro et al. (2001)	Both PM_{10} and ozone in the model	
	Chronic airway disease determined by pulmonary function tests	CA communities	Berglund et al. (1999)		
	Asthma, bronchitis, cough, wheeze	12 southern CA communities	Peters et al. (1999)	Acid aerosols and NO2 linked to respiratory morbidity in children,	

Health Endpoint Category	*Health Endpoint*	*Study Location*	**Study**	**Notes**	**Used in Primary Analysis**
	Bronchitis, phlegm, cough among asthmatic children	12 southern CA communities	McConnell et al. (1999; 2003)	Looked at a variety of measures of particulate matter, including and organic carbon, $PM_{2.5}$, and PM_{10}.	
	Asthma attacks	Santa Monica, Anaheim, Glendora, Garden Grove, Thousand Oaks, and Covina, CA	Whittemore and Korn (1980)	This study was published in 1980, and uses data from the early 1970s. It measured TSP instead of PM_{10} or $PM_{2.5}$.	
Birth outcomes	Low birth weight	California	Parker et al. (2005)		
	Preterm births	California	Ritz et al. (2000)		

Exhibit 3. Studies Reviewed for Health Effects Related to Ozone

Health Endpoint Category	*Health Endpoint*	*Study Location*	**Study**	**Notes**	**Used in Primary Analysis**
Mortality associated with short-term exposures	Mortality (non-accidental, all ages)	*95 U.S. cities*	Bell et al. (2004)		X
	Mortality (non-accidental, all ages)	*Multiple U.S. cities*	Bell et al. (2005)	Meta-analysis of 39 studies. Found significant impact as well as publication bias.	X
	Mortality (non-accidental, all ages)	*Multiple U.S. cities*	Ito et al. (2005)	Meta-analysis	X
	Mortality (non-accidental, all ages)	*Multiple U.S. cities*	Levy et al. (2005)	Empiric Bayes meta-regression of 28 studies.	X
	Mortality (non-accidental, all ages)	*15 European cities*	Anderson et al. (2004)	World Health Organization	X
	Mortality (non-accidental, all ages)	*Multiple U.S. cities*	Levy et al. (2001)	Meta-analysis.	X
	Mortality (non-accidental, all ages)	*Multiple cities*	Stieb et al. (2002)	Meta-analysis.	X
	Mortality (non-accidental, all ages)	*Multiple cities*	Thurston and Ito (2001)		X
	Mortality (non-accidental, all ages)	*23 European cities*	Gryparis et al. (2004)		X
	Mortality (non-accidental, all ages)	*80 U.S. cities*	Samet et al. (2000), reanalyzed by Dominici et al. (2003)		
	Mortality (non-accidental, all ages)	*14 U.S. cities*	Schwartz et al. (2005)		
	Mortality (non-accidental, all ages)	*Los Angeles Co., CA*	Kinney et al. (1995)		
	Mortality (non-accidental, all ages)	*San Bernardino and Riverside Counties, CA*	Ostro (1995)		
	Mortality (non-accidental, all ages)	*Coachella Valley, CA*	Ostro et al. (2000)		
	Mortality (non-accidental, all ages)	*Santa Clara Co., CA*	Fairley (1999), reanalyzed by Fairley (2003)		

Health Endpoint Category	*Health Endpoint*	*Study Location*	**Study**	**Notes**	**Used in Primary Analysis**
	Mortality (non-accidental, all ages)	*Los Angeles Co., CA*	Moolgavkar (2003a)		
Mortality associated with long-term exposures	Mortality	*Three California air basins (San Francisco, South Coast, San Diego)*	Abbey et al. (1999) Beeson et al. (1998)	This study had only 6,338 subjects, all white non-Hispanic non-smoking.	
Respiratory hospital admissions	HA, asthma	CA	Neidell (2004)		
	HA, pulmonary	Los Angeles	Linn et al. (2000)	C-R functions for age < 30 and age 30+ estimated separately. Ozone significant single pollutant model, however, unstable to inclusion of other pollutants, notably CO.	
	HA, asthma	Los Angeles	Nauenberg and Basu (1999)	Ozone not related to asthma admissions.	
	HA, all-respiratory (all ages)	3 previous studies on Canadian cities	Thurston and Ito (1999)	Meta-analysis.	X
	HA, all-respiratory (all ages)	16 Canadian cities	Burnett et al. (1997)	Ozone result significant and stable with inclusion of other pollutants. Soiling index used as a surrogate for particulate matter.	
	HA, all-respiratory	3 cities in New York State	Thurston et al. (1992)		
Effects not requiring hospitalization	School absences	12 southern CA communities	Gilliland et al. (2001)		X
	MRADs	Nationwide; workers aged 18-65.	Ostro and Rothschild (1989)		X
Respiratory symptoms among asthmatics	Morning symptoms in inner city asthmatic children	8 U.S. cities	Mortimer et al. (2002)	The study has a high percent of children from poor households and is thus not a representative sample of all asthmatic children.	
	Exacerbation of asthma in African-American children	Los Angeles	Ostro et al. (2001)	Both PM_{10} and ozone in the model. Ozone not significant.	

Health Endpoint Category	*Health Endpoint*	*Study Location*	**Study**	**Notes**	**Used in Primary Analysis**
	Symptoms interfering with daily activity among Hispanic asthmatic children	Los Angeles	Delfino et al. (2003)		
	Asthma symptoms	Alpine, CA	Delfino et al. (2004)		
	Respiratory symptoms	12 southern CA communities	Peters et al. (1999)		
	Phlegm	12 southern CA communities	McConnell et al. (1999; 2003)		
	Asthma attacks	Santa Monica, Anaheim, Glendora, Garden Grove, Thousand Oaks, and Covina, CA	Whittemore and Korn (1980)	This study was published in 1980, and uses data from the early 1970s. It measured photochemical oxidant (O_x) instead of ozone (O_3).	
Asthma onset (due to long-term exposure)	Asthma onset	California	Greer et al. (1993)		
	Asthma onset	California	McDonnell et al. (1999) (cont'd work of Greer et al. (1993))		
	Asthma onset	12 southern CA communities	McConnell et al. (2002)		
Birth outcomes	Low birth weight	California	Parker et al. (2005)		
	Preterm birth	California	Ritz et al. (2005)		

a) Mortality

There is evidence for independent effects of both PM and ozone on the risk of premature mortality. We discuss each separately.

PM-related Mortality. There is a large literature examining a linkage between particulate matter and premature mortality. A number of recent studies in California (Jerrett et al. 2005; Ostro et al. 2006; Ostro et al. 2003; Fairley, 2003) have reported a significant impact; on the other hand, some (Enstrom, 2005; Moolgavkar, 2003b) have questioned this relationship. Enstrom 2005 found only a small effect on mortality with PM2.5 exposure in the early years of exposure to a cohort of elderly Californians with no effect from more recent exposures. However, this study has generated a great deal of controversy and may have a number of potential uncontrolled confounders including second hand smoke exposure. Nevertheless, the weight of the evidence in the literature points to a significant relationship.

As we discussed above, we gave preference to studies of long-term exposure, rather than short-term exposure to PM. Among the long-term exposure studies, U.S. EPA used a C-R function from Pope et al. (2002). This study extended the follow-up period for the American Cancer Society (ACS) cohort to sixteen years and published findings on the relationship of long-term exposure to $PM_{2.5}$ and all-cause mortality (as well as cardiopulmonary and lung cancer mortality). This 2002 study has a number of advantages over previous analyses, including: doubling the follow-up time and tripling the number of deaths, expanding the ambient air pollution data to include two recent years of $PM_{2.5}$ data, improving the statistical adjustment for occupational exposure, incorporating data on dietary factors believed to be related to mortality, and using more recent developments in nonparametric spatial smoothing and random effects modeling.

Recently, the Health Effects Subcommittee (HES) of the Science Advisory Board's (SAB) Clean Air Act Compliance Council indicated its preference that U.S. EPA use the results from this study rather than the results from the Krewski et al. (2000) ACS and/or Six Cities analyses to represent base case estimates for long-term exposure mortality associated with $PM_{2.5}$ concentrations for the purposes of benefits analyses (Science Advisory Board (SAB), 2004). Two periods of $PM_{2.5}$ measurements were considered in the ACS-extended study. The first, from 1979 through 1983, was the period considered in the original ACS study as well as in the Krewski reanalysis. The second was 1999-2000. The authors also report results based on an average of the two periods. The HES recommended that U.S. EPA use the results based on the average of the two periods from this study as representing the best estimates. The HES stated that this choice "may serve to reduce measurement error" (Science Advisory Board (SAB), 2004). For our benefits analysis, we used the corresponding C-R function based on $PM_{2.5}$ measurements averaging the air quality data from the two periods.

In a sensitivity discussion, we used a recent study by Jerrett et al. (2005) that examined the relationship between air pollution and mortality with small-area exposure measures in Los Angeles. This is a cohort study based on a subset of the American Cancer Society cohort used in the Pope et al. (2002) analysis. Jerrett et al. concluded that measurement error due to estimating exposure for a metropolitan area can lead to a large downward bias in the estimated impact, and that chronic impacts associated with intra-city gradients appear much larger than previously reported across metropolitan areas. This study also suggests that these effects are closely related to traffic exposure. The authors cite confirmation of the traffic effects in a Dutch study that found a doubling of cardiopulmonary mortality for subjects living near major roads (Hoek et al. 2002). Jerrett et al. estimated a 17% increase in all-cause mortality per 10 ug/m^3 change in $PM_{2.5}$ – nearly three times larger than that seen in Pope et al. (2002). Although both the importance of intra-city gradients and the suggested relation of the effects to traffic exposure have been seen in other studies (Hoek et al. 2002), given the magnitude of the estimate and other possible models presented by Jerrett et al. (with estimated increase ranging from 11% to 17%) we elected to use this study in a sensitivity discussion, until additional work can confirm this effect.

Laden et al. (2006) extends the original Harvard Six Cities study (Dockery et al. 1993). We considered using this study as a supplementary source of a C-R function for mortality and long-term exposure to $PM_{2.5}$, because it focuses on essentially the same geographical area in which we are interested. We chose not to use it, however, for several reasons. First, $PM_{2.5}$ concentrations, while *measured* in the years from 1979 through 1988, were *estimated* in the subsequent years in the study. This introduces additional uncertainty into the resulting C-R function estimates. Second, the number of cities is relatively small, the cities are located outside of California, and the cohort is all white. Third, the reported relative risks were sufficiently high as to give us pause. This was true for the original Harvard Six Cities study and the reanalysis of that study (Krewski et al. 2000) as well. For example, Laden et al. (2006) reports a relative risk for (all cause) mortality of 1.16 – i.e., a 16% increase in mortality – associated with an increase in long-term $PM_{2.5}$ of 10 $\mu g/m^3$. The corresponding relative risk from the Krewski reanalysis of the original Harvard Six Cities study was 1.13 – a 13% increase in mortality. Both of these percent increases are over twice the percent increases that would be predicted to be associated with an increase in $PM_{2.5}$ of 10 $\mu g/m^3$ by either the reanalysis of the ACS study (Krewski et al. 2000) or the extended ACS study (Pope et al. 2002), which would predict increases of 4.7% and 6%, respectively. Nonetheless, the Laden results are in line with Jerrett et al. (2005).

Chen et al. 2005 found a greater risk of fatal coronary heart disease in females, but not males, exposed to PM2.5, PM coarse and PM10. This study is not representative of all of California since the study subjects were all white non-Hispanic. However, since the subjects are all non-smoking and detailed information was available on environmental tobacco smoke exposure in the cohort, and could be adjusted for, a large potential confounder is accounted for in the study. In addition, the majority of the cohort resides in the large urban centers of California.

Ozone-related Mortality. A number of studies have tested the significance of a relationship between ozone and premature mortality, with a number of these studies conducted in California ((Kinney and Ozkayank, 1991; Kinney et al. 1995; Moolgavkar, 2003b; Fairley, 2003). In addition, there have been a number of studies conducted in other parts of the country, including several meta-analyses (Bell et al. 2005; Ito et al. 2005; Levy et al. 2005)and a multi-city study (Bell et al. 2004)

The evidence from California is somewhat mixed. Moolgavkar (2003b) did not find a significant effect, while Kinney et al. (1995; 1991) reported a significant effect, though the effect was sensitive to inclusion of PM; Fairley (2003) reported a significant impact even when controlling for fine PM.

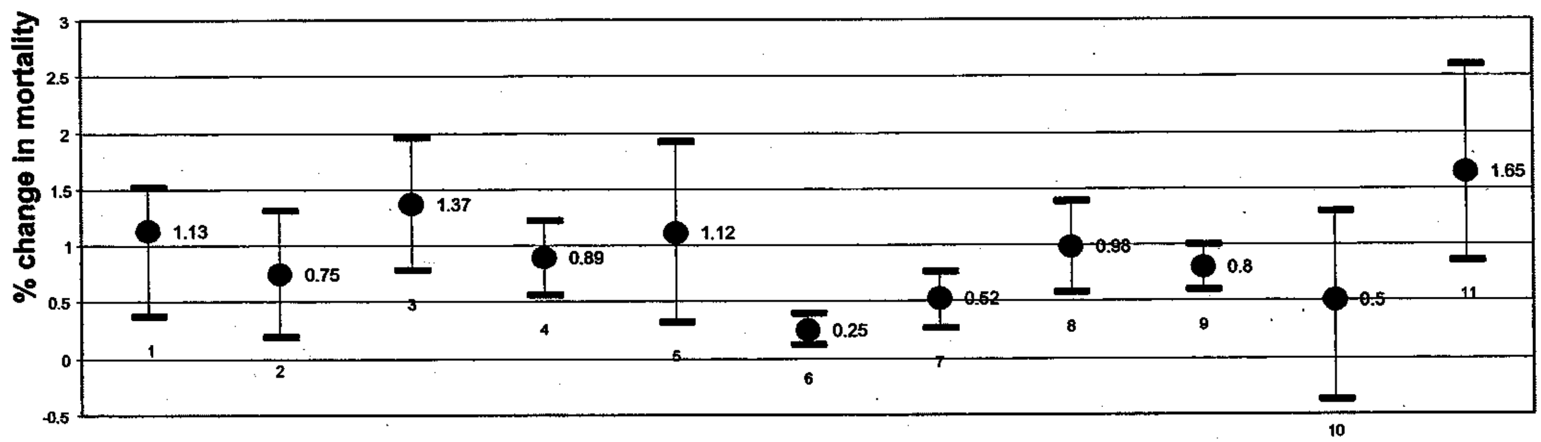
The World Health Organization (WHO) conducted a meta-analysis of the 15 cities in Europe (Anderson et al. 2004). Their meta-estimates indicate a relative risk of 1.003 (95% CI = 1.001 – 1.004) for a 10 μg/m^3 change in 8-hour ozone. For standard pressure (1 atmosphere) and temperature (25° C), 1 ppb ozone equals 1.96 μg/m^3. We have assumed the ratio between 1-hour and 8-hour ozone of 1.33 and between 1-hour and 24-hour of 2.5 (Schwartz 1997). Making the conversions, the WHO estimate implies a 1.13% change (95% CI = 0.38 - 1.51) in daily mortality per 10 ppb change in 24-hour ozone. The WHO also provided an estimate correcting for possible publication bias using a trim and fill technique. Under an assumption that bias was present, the adjusted estimate is 0.75 % (95% CI = 0.19 – 1.32) per 10-ppb change in 24-hour ozone.

This estimate is very similar to that produced by Levy et al. (2001). In their meta-analysis they began with 50 time-series analyses from 39 published articles. A set of very strict inclusion criteria was applied, which eliminated all but four studies. Reasons for exclusion included: studies outside the U.S., use of linear temperature terms (versus non-linear and better modeled temperature), lack of quantitative estimates, and failure to include particulate matter (PM) in the regression models. Ultimately, their analysis generated an estimate of 0.98% (95% CI = 0.59 – 1.38) per 10 ppb change in 24-hour average ozone. If the criteria are loosened to include eleven more studies, the pooled estimate decreases to 0.80 (0.60 – 1.00). Stieb et al. (2002) also reported a similar effect estimate based on 109 previous studies (including those with single- and multi-pollutant models) of 1.12 (0.32 – 1.92). Thurston and Ito (2001) reviewed studies published prior to the year 2000. When the authors focused on seven studies that more carefully specified the effect of a possible confounder, daily temperature, by using non-linear functional forms, the resulting meta-estimate was 1.37% (95% CI = 0.78 – 1.96). Relaxing this constraint to include all 19 available studies, the resulting risk estimate was 0.89% (95% CI = 0.56 – 1.22) per 10-ppb change in 24-hour ozone.

Two more recent meta-analyses have been published that provide lower effect estimates. Gryparis et al. (2004) is an analysis of 23 European cities from the APEHA2 study. The study controlled for potential confounders by including average daily temperature and humidity, respiratory epidemics, day of week in the regression model. The overall full-year estimate was 0.5% (95% CI = -0.38 – 1.30) per 10-ppb change in 24-hour ozone. A meta-analysis was also conducted using summer-only data. Presumably this estimate will be less confounded by seasonality and also represent a time when the population would be spending more time outdoors. The summer-only estimate was 1.65% (95% CI = 0.85 – 2.60) per 10-ppb change in 24-hour ozone. This summer-specific estimate might be particularly relevant for California due to its milder climate. A meta-analysis of the 95 largest U.S. cities from the National Morbidity, Mortality, and Air Pollution Study (NMMAPS) data base provided estimates using a similar natural spline model for every city (Bell et al. 2004). Ultimately, the model suggested an effect of 0.25% (95% CI = 0.12 – 0.39) per 10-ppb change in 24-hour ozone. The NMMAPS study may generate an underestimate of the impact of mortality due to the modeling methodology used to control weather factors. Specifically, this effort included four different controls for temperature and dewpoint, where most other times-series analyses used only two or modeled extreme weather events more carefully and used city-specific models to ensure the best fits. In comparing the results for particulate matter (PM) for a given city with studies of individual cities by other researchers, the NMMAPS results are usually lower (Samet et al. 2000). This estimate was based on a lag consisting of today's and yesterday's ozone concentrations. When a longer period 7-day lag was used the estimate increased to 0.52% (95% CI = 0.27 – 0.77) per 10-ppb change in 24-hour ozone.

Our estimates for the effects of ozone on mortality attempt to reflect the range provided in the above cited studies. Figure A-3 provides a graphical summary of the range of effect estimates and our suggested central, low and high estimates. A low estimate of 0.5% per 10 ppb, 24-hour ozone, corresponds to the best estimates from the NMMAPS (using a one-week cumulative lag) and the APEHA2 European study, but is below most of the other central estimates. A central estimates of 1% per 10 ppb is very similar to the

Figure A-3: Percent Change in Mortality Associated with Ozone (per 10 ppb 24-hour average)



Study #	Author	# of studies	Comment
1	Anderson (2004)	15	European
2	Anderson (2004)	20	Euro, corrected for possible publication bias
3	Thurston+Ito (2001)	7	Studies using non-linear temp
4	Thurston+Ito (2001)	19	All studes
5	Stieb et al. (2003)	109	All studies
6	Bell et. al. (2004)	95	NMMAPS, lag(01)
7	Bell et. al. (2004)	95	NMMAPS,lag(06)
8	Levy et al. (2001)	4	Strict criteria
9	Levy et al. (2001)	15	Less strict criteria
10	Gryparis et al. (2004)	23	all year Europe
11	Gryparis et al. (2004)	23	summer Europe

central estimates generated by Anderson (2004), Levy et al. (2001), and Stieb (2003). Finally, as a high estimate, we use 1.5% per 10 ppb which reflects the central estimates of Thurston and Ito (using non-linear functions for temperature) and the summer-only estimates of Gryparis et al. (2004). Our range of estimates is applied to all age groups. On the 1-hour scale, a 1% change per 10 ppb of 24-hour ozone is about 0.4% per 10 ppb change in 1-hour daily maximum ozone based on an assumed the ratio between 1-hour and 8-hour ozone of 1.33 and between 1-hour and 24-hour of 2.5 (Schwartz 1997).

A more recent study (Bell et al. 2006) explores the evidence for a threshold in the ozone/mortality relationship and concludes "all results indicate that any threshold would exist at very low concentrations, far below current U.S. and international regulations and nearing background levels (Bell et al. 2006). A variety of percent increases in mortality associated with a 10 ppb increase in ozone are reported in this study, depending on the underlying model and air quality dataset being used.

In 2005, U.S. EPA funded three independent groups of researchers to assess the strength of the relationship between short-term exposures to ozone and premature death. These three recent meta-analyses (Bell et al. 2005; Ito et al. 2005; Levy et al. 2005) independently found consistent results on the association, and the results are in fair agreement with our chosen estimates.

To summarize, for ozone-related premature death, we used the following for the central estimate:

- Anderson (2004), Levy et al. (2001), and Stieb (2003)
- Bell et al. (2005); Ito et al. (2005) and Levy et al. (2005)

a) Infant Effects

A number of studies in California have associated air pollution with low birth weight, preterm delivery, and cardiovascular birth defects (Wilhelm and Ritz, 2005; Salam et al. 2005; Parker et al. 2005; Kaiser et al. 2004; Wilhelm and Ritz, 2003; Ritz et al. 2002; Ritz et al. 2000; Woodruff et al. 1997). These results have been replicated in a number of other locations both in the U.S. and around the world (Sagiv et al. 2005; Bobak, 2000; Loomis et al. 1999; Bobak et al. 2001; Ha et al. 2001; Liu et al. 2003; Yang et al. 2003a; Yang et al. 2003b; Gouveia et al. 2004; Maisonet et al. 2001). In addition, a number of studies have linked particulate air pollution to infant mortality (Ha et al. 2003; Kaiser et al. 2004; Loomis et al. 1999; Woodruff et al. 1997; Bobak and Leon, 1999; 1992).

The weight of the evidence points to air pollution, especially particulate matter, as having a significant impact on infants. In particular, we estimate the impact on infant mortality using by Woodruff et al. (1997). However, not all of the available evidence supports this conclusion, notably the work by Lipfert (2000), which examined infant mortality in the United States. As a result, we consider the infant mortality estimate in a sensitivity discussion.

The impact of air pollution on low birth weight was estimated by Parker et al. (2005). This study is California specific and examined an association with PM2.5. Ritz et al. (2000) estimated the impact of PM10 air pollution on preterm birth in southern California. Both of these estimations could not be used in a sensitivity discussion due to the many potential confounders with extrapolating their results to a California-wide estimation, and the uncertainties remaining on the association between these birth outcomes and particulate pollution exposure.

b) Hospital Admissions

For <u>respiratory hospital admissions</u> associated with exposure to particulate matter, we used:

- Linn et al. (2000), hospital admissions for pulmonary illness;
- Samet et al. (2000), reanalyzed by Zanobetti and Schwartz (2003), hospital admissions for COPD and hospital admissions for pneumonia; and
- Moolgavkar (2000a; 2003a).

Moolgavkar (2000a; 2003a), has the advantages of having been conducted in Los Angeles and using $PM_{2.5}$ as the measure of particulate matter, in addition, it includes ages 20 to 64 as well as ages 65 and older. Linn et al. (2000) used PM_{10} as the measure of particulate matter; however it was also conducted in Los Angeles and covers a broader range of respiratory hospital admissions. Samet et al. (2000) also used PM_{10} as the measure of particulate matter, but it has the advantage of being a 14-city study, and thus having substantially more statistical power to detect small effects over a lot of "noise." Because there is substantial overlap in the endpoints of these studies, their results (for ages 65 and older) cannot be summed. As a result, we pooled the Moolgavkar age 65+ estimare for COPD hospital admissions with the Zanobetti & Schwartz age 65+ COPD, added this to the 65+ Zanobetti & Schwartz estimate for pneumonia, and later added the result to the Moolgavkar estimate for COPD hospital admissions applied to age group 18+. This would give one central estimate of age 18+ respiratory hospital admissions. For sensitivity, Linn et al. (2000) for age 30+ could be used. However, due to the limited age range, the estimate would be viewed as an underestimate. Hence, we present the pooled estimate for age 18+ in our primary analysis.

For <u>cardiovascular hospital admissions</u> associated with exposure to particulate matter, we used:

- Moolgavkar (2003a; 2000b), hospital admissions for cardiovascular illness;
- Samet et al. (2000), reanalyzed by Zanobetti and Schwartz (2003), hospital admissions for cardiovascular illness.

Moolgavkar (2003a; 2000b) has the advantages of having been conducted in Los Angeles and of using $PM_{2.5}$ as the measure of particulate matter; in addition, it covered ages 20-64 as well as ages 65 and older. The advantages (and disadvantages) of Samet et al. (2000) are noted above. For ages 65 and older, we pooled the estimates based on Moolgavkar (2003a; 2000b) and Zanobetti and Schwartz (2003), and added this to the estimate for ages 18 to 64 based on Moolgavkar (2003a; 2000b) to arrive at an estimate for age 18+.

Studies of a possible ozone-hospitalization relationship have been conducted for a number of locations in the United States, including California. These studies use a daily time-series design and focus on hospitalizations with a first-listed discharge diagnosis attributed to diseases of the circulatory system (ICD9-CM codes 390-459) or diseases associated with the respiratory system (ICD9-CM codes 460-519). Various age groups are also considered which vary across studies.

For ozone, we included only respiratory hospital admissions, because the evidence for an association between cardiovascular hospital admissions and ozone is weak. For respiratory hospital admissions, the overall weight of the evidence suggests that the effect of ozone on respiratory hospital admissions is robust to the inclusion of particulate matter. To estimate ozone-related hospital admissions, we initially considered Linn et al. (2000) because it was conducted in Los Angeles; however, they reported only the results of a single-pollutant model and noted that this result was not stable with the inclusion of other pollutants, notably carbon moNOXide. The relatively small sample-size of this study is a concern.

For this estimate, we rely on the meta-analysis by Thurston and Ito (1999). These authors used a random effects model using three studies from North America. The studies were Burnett et al. (1994), Thurston et al. (1994), and Burnett et al. (1997). The category of all respiratory admissions for all ages yielded an estimate of relative risk of 1.18 (95% CI= 1.10 – 1.26) per 100 ppb change in daily 1-hour maximum ozone. This category includes hospital admissions for asthma and bronchitis, so separate estimates of these outcomes are not necessary. The estimate converts to a 1.65% change in hospital admissions (95% CI = 0.95 – 2.31%) per 10 ppb change in 1-hour daily maximum ozone. This estimate was applied to all age groups. Additional studies of respiratory admissions for specific diseases or subpopulations provide additional support for the above relationship, but are not quantified to avoid double counting. For example, Anderson et al. (1997) reported a relative risk of 1.04 (95% CI= 1.02-1.07) for hospital admissions for COPD for all ages for a 50 μ/m change in ozone. This converts to 2.05% per 10 ppb change in 1-hour maximum ozone. Burnett et al. (2001) investigated respiratory hospitalizations in children under age 2, and reported a relative risk of 1.348 (95% CI= 1.193 – 1.523), which converts to a 6.6% increase in hospital admissions per 10 ppb change in 1-hour daily maximum ozone.

To summarize, for respiratory hospital admissions due to ozone, we used:

- Thurston and Ito (1999), hospital admissions for all respiratory symptoms.

c) Emergency Room Visits

A range of studies conducted in the United States have examined the association between air pollution and respiratory and cardiovascular emergency room visits (Peel et al. 2005; Slaughter et al. 2004; Metzger et al. 2004; Jaffe et al. 2003; Tolbert et al. 2000; Fauroux et al. 2000; Norris et al. 1999; Atkinson et al. 1999; Lipsett et al. 1997; Weisel et al. 1995; Schwartz et al. 1993; Cody et al. 1992). And there are a number of studies from Canada, Spain, United Kingdom, and other countries (Pande et al. 2002; Stieb et al. 2000; Tobias et al. 1999; Ilabaca et al. 1999; Tenias et al. 1998; Delfino et al. 1998a; Delfino et al. 1997a; Stieb et al. 1996).

Two studies by Norris et al. (1999) and Lipsett et al. (1997) were initially chosen to estimate the effect of particulate matter on emergency room visits for asthma. The Lipsett et al. study was conducted in California; however, it focused on just the winter season in a region with a lot of residential wood smoke. Moreover, it used PM_{10} as its measure of particulate matter and used interaction terms between PM_{10} and temperature when specifying the model (thus requiring temperature data to properly use the results). For these various reasons, this study was subsequently discarded. Instead, the Norris et al. study was used because it used $PM_{2.5}$ as its measure of pollution and covered the full year. However, we consider this endpoint as a potential endpoint only, since it is single-city study conducted in Seattle, Washington, and thus outside the area of interest.

Regarding ozone, the U.S. EPA (2005) Criteria Document for ozone cited both significant and non-significant results from a range of studies, and then concluded that the evidence is inconclusive regarding an association between ozone and emergency room visits. This conclusion coupled with the lack of studies from California informed the choice not to estimate ozone-related emergency room visits.

d) Effects not Requiring Hospitalization

A variety of respiratory symptoms and illnesses not requiring hospitalization were included in the analysis. For particulate matter, the endpoints and the studies reporting C-R functions for those endpoints are as follows:

- Lower respiratory symptoms – Schwartz and Neas (2000);
- Acute bronchitis – Dockery et al. (1996);
- Minor restricted activity days (MRADs) – Ostro and Rothschild (1989);
- Work loss days (WLDs) – Ostro (1987).

For ozone, we used:

- School loss days – Gilliland et al. (2001);
- MRADs – Ostro and Rothschild (1989).

Restricted activity day estimates are derived from a sample of an adult working population by Ostro and Rothschild (1989). This study is the same as that used for estimating this health effect for PM (see above).

School absence estimates are derived from analysis of 1,933 grade school students enrolled in the Children's Health Study (Gilliland *et al.* 2001). Illness-related absences were verified through telephone contact for respiratory-related illness including runny nose or sneeze, sore throat, cough, earache, wheezing, or asthma attack. Associations were observed between 8-hour average ozone and school absenteeism due to these respiratory illnesses. The results from this study were applied to all school-aged children.

e) Asthma-Related Effects

Particulate matter has been more closely associated with asthma-related effects, such as wheeze, cough, and other symptoms. Children appear to be particularly at risk. Ostro et al. (2001) could be used to estimate asthma-related effects (wheeze, cough, shortness of breath) and McConnell et al. (1999) to estimate acute bronchitis and chronic phlegm among asthmatic children. However, because lower respiratory symptoms (including asthma-related symptoms), acute bronchitis, and school loss days are already being estimated, there are concerns of double-counting effects in children. As a result, the asthma exacerbations are not treated separately.

Regarding ozone, the evidence suggests that asthmatic children may be at risk, though the evidence is somewhat mixed. An 8-city study by Mortimer et al. (2002) reported a significant effect for ozone on morning asthmatic symptoms in a single-pollutant model; however, the confidence bounds for this result increased with the inclusion of other pollutants and often left the estimate statistically insignificant. Studies conducted in California are mixed. In an analysis in 12 Southern California communities, McConnell et al. (1999; 2003) reported little effect for ozone on asthmatic symptoms, though they reported that children playing sports may be more likely to develop asthma (McConnell et al. 2002). Ostro et al. (2001) reported no association found between ozone and new episodes of cough or wheeze, but found some evidence that ozone is associated related asthma medication use. Similarly, Delfino et al. (2002; 2004; 1996; 1997b) have reported some significant associations between ozone and asthma; however, the results are not definitive. As a result, we have not estimated asthma-related effects associated with ozone.

The health endpoints and studies that were selected from among those considered are summarized in Exhibits 4 and 5 for PM and ozone. Endpoints and/or studies that are used only in a sensitivity discussion are shown in italics.

Exhibit 4. $PM_{2.5}$ Concentration-Response Functions

Endpoint	Location	Age	Author	Notes
Mortality, All Cause	51 U.S. cities	30+	Pope et al. (2002)	
	Los Angeles	*30+*	*Jerrett* et al. *(2005)*	*Sensitivity discussion (very large effect coefficient)*
	86 U.S. cities	*<1*	*Woodruff* et al. *(1997)*	*Sensitivity discussion*
	California	*<1*	*Woodruff* et al. *(2006)*	*Sensitivity discussion*
Hospital Admissions, All Cardiovascular	14 U.S. cities	65+	Zanobetti and Schwartz (2003)	The two 65+ estimates are pooled using fixed/random effects approach. Result summed with Moolgavkar estimate for ages 18-64.
	Los Angeles, CA	65+	Moolgavkar (2003a)	
	Los Angeles, CA	18-64	Moolgavkar (2000b)	
Hospital Admissions, Chronic Lung Disease	14 U.S. cities	65+	Zanobetti and Schwartz (2003)	Moolgavkar 65+ COPD with the Zanobetti & Schwartz 65+ COPD, add this to the 65+ Zanobetti & Schwartz Pneumonia are pooled. Result added to the 18-64 Moolgavkar COPD estimate.
Hospital Admissions, Pneumonia	14 U.S. cities	65+	Zanobetti and Schwartz (2003)	
Hospital Admissions, Chronic Lung Disease	Los Angeles, CA	18-64	Moolgavkar (2000a)	
Hospital Admissions, Chronic Lung Disease	Los Angeles, CA	65+	Moolgavkar (2003a)	
Hospital Admissions, All Respiratory	*Los Angeles, CA*	*30+*	*Linn* et al. (2000)	*Sensitivity discussion*
Lower Respiratory Symptoms (including asthma related effects)	6 U.S. cities	7-14	Schwartz and Neas (2000)	
Acute Bronchitis	24 communities	8-12	Dockery et al. (1996)	
Minor Restricted Activity Days	Nationwide	18-64	Ostro and Rothschild (1989)	
Work Loss Days	Nationwide	18-64	Ostro (1987)	
Asthma Exacerbation, Cough	*Los Angeles, CA*	*8-13*	*Ostro* et al. *(2001)*	*Sensitivity discussion (potential overlap with other endpoints, such as lower respiratory symptoms. Asthma exacerbation estimates presented separately.)*
Asthma Exacerbation, Shortness of Breath	*Los Angeles, CA*	*8-13*	*Ostro* et al. *(2001)*	
Asthma Exacerbation, Wheeze	*Los Angeles, CA*	*8-13*	*Ostro* et al. *(2001)*	
Acute Bronchitis, among asthmatics	*Southern California*	*9-15*	*McConnell* et al. *(1999)*	
Chronic Phlegm, among asthmatics	*Southern California*	*9-15*	*McConnell* et al. *(1999)*	

Exhibit 5. Ozone Concentration-Response Functions

Endpoint	Location	Age	Author	Notes
Mortality, Non-Accidental	95 U.S. cities	All ages	Bell et al. (2004)	
	15 European cities	All ages	Anderson et al. 2004	
	Multiple U.S. cities	All ages	Levy et al. (2001)	
	Multiple cities	All ages	Stieb et al. (2002)	Used in combination to develop low, central and high estimate for coefficient expressing the strength of association.
	Multiple cities	All ages	Thurston and Ito (2001)	
	23 European cities	All ages	Gryparis et al. (2004)	
	Multiple U.S. cities	All ages	Bell et al. (2005)	
	Multiple U.S. cities	All ages	Ito et al. (2005)	
	Multiple U.S. cities	All ages	Levy et al. (2005)	
Hospital Admissions, All Respiratory	Toronto, Canada	All ages	Thurston and Ito (1999)	
School Loss Days, All Cause	Southern California	6-18	Gilliland et al. (2001)	
Minor Restricted Activity Days	Nationwide	18-64	Ostro and Rothschild (1989)	

3. Unquantified Adverse Effects

As shown in Exhibit 1, there are a number of adverse health effects that have been associated with PM and/or ozone that were not included in the quantified benefits analysis. In some cases, health endpoints were excluded because they are subsets of a larger health endpoint category that is included. Cardiopulmonary mortality and lung cancer mortality were excluded, for example, because they are subsets of all-cause mortality. To include them would have resulted in double counting of benefits.

In some cases, while there is quantitative evidence of a relationship between an adverse health effect and one or both of the pollutants of concern, that evidence comes from one or more single-city studies, none of which were in California. For example, several single-city studies (Weisel, 2002; Tolbert et al. 2000; Cody et al. 1992) found a significant relationship between ozone and ER visits for asthma. However, none of these studies was in California. Moreover, the incidence of ER visits is believed to be particularly variable across locations; this argued against applying one of the statistically significant C-R functions from another location to locations within California.

For some health endpoints, although there is substantial evidence of a relationship between one of the pollutants and the health effect, there are no epidemiologically estimated concentration-response functions available.

We recognize a multitude of endpoints that may contribute to impacting health. However, the weight of evidence to date was deemed insufficient to warrant quantification in our report. These include but are not limited to: chronic bronchitis, onset of asthma, low birth weight, preterm birth, reduced lung function growth in children, psychosocial factors (stress), noise (including cardiovascular effects), light and its effects on sleep, major occupational issues including workplace exposures and injuries, traffic accidents and associated morbidity/mortality, other transportation related issues, and environmental consequences, quality of life, morbidity over extended periods of time, neurological disease, and developmental effects.

Finally, there are other adverse health effects that overlap with endpoints already included in our quantified analysis. They include myocardial infarction (heart attack) and asthma attacks.

4. Community Health Impacts

Vulnerable populations of individuals shown to be particularly susceptible to air pollution-related disease and people living in communities with high pollution burdens are two groups that are of particular concern when assessing the impacts of goods movement-related emissions. Sensitive groups, including children and infants, the elderly, and people with heart or lung disease, can be at increased risk of experiencing harmful effects from exposure to air pollution. People living in communities close to the source of goods movement-related emissions, such as ports, rail yards and inter-modal transfer facilities are likely to suffer greater health impacts and these impacts will likely add to an existing health burden.

Air pollution has been directly associated with low birth weight, preterm delivery, and cardiovascular birth defects (Maisonet et al. 2001, Ritz *et al.* 2000, Ritz et al. 2002, Ha et al. 2001, Gilboa et al. 2005, Wilhelm and Ritz 2003, 2005). Preterm delivery and low birth weight are risk factors for infant mortality and life-long disability. Also, a number of studies have linked particulate air pollution to infant mortality (Woodruff et al. 1997, Ha et al. 2003, Bobak and Leon 1999) from respiratory causes. There is not enough information at this time to identify the levels of exposure that pose a significant risk of these adverse effects.

The health impacts of air pollution on children are of particular concern. Studies have shown associations between traffic-related pollution and effects in children, including chronic bronchitis symptoms, wheeze, cough, allergic rhinitis, asthma induction, and upper and lower respiratory tract infections (Jaakkola *et al.* 1991, Osterlee *et al.* 1996, Wjst *et al.* 1993, van Vliet *et al.* 1997, Venn et al. 2001, Kim *et al.* 2004). Recent evidence (Gauderman et al. 2004, Kunzli et al. 2004) indicates that air pollution exposure can impair lung function growth in children. The long-term consequences of lower lung function can include shorter lifespan, as lung function peaks in young adulthood and declines thereafter; lung function is the most significant predictor of mortality in the elderly (Schuneman *et al.* 2000, Hole *et al.* 1996).

For those with underlying heart disease or diabetes, increased exposure to air pollutants can compound the effects and increase the rate of adverse events. In one study, individuals with existing cardiac disease were found to be in a potentially life-threatening situation when exposed to high-levels of ultrafine air pollution (Peters *et al.* 2001). Fine particles can penetrate the lungs and may cause the heart to beat irregularly or can cause inflammation, which could lead to a heart attack. Fine particulate matter exposure in vehicles was associate with changes in heart rhythm and blood inflammatory and clotting factors in young health males (Riediker 2004). For persons with a tendency toward hyperlipidemia or diabetes, PM exposure has been found to increase their risk of underlying CVD (Kunzli *et al.* 2005). Understanding the relationships between existing disease and increased exposure is extremely important in quantifying the detrimental health effects of air pollution.

Communities surrounding many goods movement-related facilities where there may be a disproportionate exposure to air pollutants are often economically disadvantaged or ethnically or culturally diverse. People in these communities often have poor access to health care or carry a disease burden that may make them more susceptible to excess exposure. Their housing characteristics may contribute to this susceptibility. Many new areas of research are attempting to understand just how pollutant burdens, low educational attainment, poverty and access to health care, and other factors are interrelated and how these relationships might lead to increased health effects.

Several mortality studies have examined whether socioeconomic status (SES) and related factors such as education and race/ethnicity affect the magnitude of PM-mortality associations. These studies help address the question of whether factors linked with poverty or educational attainment render individuals more susceptible to the adverse effects of exposure to air pollution. To date, the findings have been mixed. The prospective cohort studies investigating the potential impacts of longer-term exposure appear to find consistent effect modification by education, whereas the acute exposure studies do not demonstrate much, if any, modification of these relationships. In their re-examination of the ACS data set originally analyzed by Pope *et al.* (1995), Krewski *et al.* (2000) conducted an exhaustive set of sensitivity analyses. They considered a wide range of alternative specifications; their findings largely corroborated those of the original study, however, the relative risk estimates varied significantly when the analysis was stratified by educational attainment.

Zanobetti and Schwartz (2000) tested for effect modification by income or education in four large cities with daily PM10 data during the study period of 1986 to 1993 (Chicago, Detroit, Minneapolis-St. Paul, Pittsburgh). They used individual-level educational status from the death records of the National Center for Health Statistics. In three of the four cities, the PM10 effect for the cohort members with less than 12 years of education was larger than that for those with more than 12 years of education. In two of the cities, the PM effect for those in the low-education group was more than twice the other cohort. In contrast, in a study of air pollution and mortality in 10 U.S. cities, Schwartz (2000) examined whether the city-specific mortality effect was modified by several city-wide factors. No effect modification of the pollution effect was found from unemployment, living in poverty, college degree or the proportion of the population that is nonwhite, although sample size limited the ability for detection.

Some evidence exists that living near a major roadway with simultaneous exposure to traffic-related air pollution shortens life expectancy (Finkelstein et al. 2004, Hoek *et al.* 2002). A recent study (Lipfert 2006) found an association between traffic density and mortality. The investigators feel that the results of this study indicate that environmental factors other that traffic emissions, such as traffic noise, stress and socioeconomic factors that are linked to increased traffic may be having an impact as well. One study showed that myocardial infarction is triggered following short-term exposure to elevated traffic pollution in cars, public transit, or on motorcycles or bikes (Peters *et al.* 2004). Risk assessments that utilize air dispersion models to estimate "average" concentrations in a specific area may underestimate risk if that area is surrounded by major roadways. The short-term cardiovascular effects associated with traffic density are not yet quantifiable.

Cumulative impacts are very likely to be experience by communities living in close proximity to goods movement-related activity. Airborne pollutants can deposit onto surfaces and waterways, providing another source of exposure. For example, goods movement activities contribute to non-point source runoff that contaminates coastal and bay waters with a number of toxicants, including PAHs, dioxins, and metals. Exposures to pollutants that were originally emitted into the air can also occur as a result of dermal contact, ingestion of contaminated produce, and ingestion of fish that have taken up contaminants from water bodies. These exposures can all contribute to an individual's health risk. In some cases, the risks from these kinds of exposure can be greater than the risks from inhalation of the airborne chemicals. An assessment of cumulative impacts is beyond the scope of this analysis.

In most risk assessments, chemicals are evaluated without consideration of other pollutants that may add to the risks posed by the chemicals being assessed. The typical risk assessment does consider cumulative impacts on a specific organ of the body for multiple chemicals that originate from a single source. However, there generally are no methods at present for evaluating cumulative impacts posed by exposures to multiple pollutants. For these reasons, it is often not possible to fully evaluate the health risks in a community that is impacted by multiple sources of pollution.

III. Methodology

A. Air Pollutant Emissions from Goods Movement-Related Sources

Below we describe the methodologies used to develop emissions estimates for each source category - the ships, trucks, trains, cargo handling equipment and harbor craft – associated with goods movement. In each case we built upon and refined estimates for these source categories that historically have been included in the statewide emissions inventory as either a discrete and independent category (i.e., ships and harbor craft) or combined in a more generalized category (i.e., on-road trucks) in the statewide emissions inventory. In the development of the goods movement emission inventory we took steps to ensure the inventory reflected the most up-to-date information on emission rates, activity patterns, expected growth rates and current control measures. In the following sections we provide a brief overview of how these inventories were calculated. Additional details are also provided in the Emission Inventory Technical Supplement.

1. Ocean-going Ships

Ocean-going ships can be classified into many different categories, including container ships that move goods in containers, tankers that move liquids like oil, bulk material transports, and others. Some vessel types, like container ships, directly move imported goods into the State. Other vessel types, like passenger ships, are not engaged in goods movement, but do contribute emissions to the overall port-wide total. All types of ocean-going vessels are included in this analysis, out to 24 nautical miles from shore.

The ocean-going ship category is defined by size; the category includes all ships exceeding 400 feet in length or 10,000 gross tons in weight. These ships are typically powered by diesel and residual oil fueled marine engines. Ocean-going ships have two types of engines. The main engine is a very large engine used mainly to propel the vessel at sea. Auxiliary engines are engines that in general provide power for uses other than propulsion, such as electrical power for ship navigation and crew support. Passenger vessels use diesel electric engines, where a diesel or residual oil fueled engine act as a power plant, providing power both for propulsion and general ship operations. For this reason, CARB considers engines on passenger vessels to be part of the auxiliary engine category.

ARB staff recently developed an improved emissions inventory that accounts for emissions based on a variety of factors including type of vessel, transit locations, various ship engine sizes and loads, and other factors. This inventory covers three modes of ship operation: in-transit emissions generated as a ship travels at cruising speeds, generally in between ports of call; maneuvering emissions generated as a ship slows down in anticipation of arriving, moving within or departing a port; and hoteling emissions generated by auxiliary engines as a ship is docked at port. This inventory was incorporated into the draft plan. Since that time we have further refined the ocean-going ship inventory. Specifically, the emission factor associated with maneuvering was adjusted for low-load conditions, and emissions generated by boilers operating on ships and barges were added to the inventory.

Emissions are calculated on a statewide basis for each port in California. Emissions are also calculated for hoteling and maneuvering operating modes that occur within ports and transit emissions as ships move up and down the California coastline. Emissions calculated within 24 nautical miles of the shore are included in this emissions inventory. For emissions inventory tracking purposes, emissions are allocated to a port when they occur within three miles of shore. Emissions outside of three miles are allocated to the outer continental shelf air basin.

Estimating growth of ocean-going vessel emissions is a important issue. For this inventory, CARB staff worked with experts at the University of Delaware to compile data on the number and size of main engines visiting each port in California over time. These data account for any increase in the number of ships visiting each port over time as well as the increasing size of these ships. Using data collected representing the years 1997-2003, we developed growth rate estimates for each port. For emissions at the Ports of Los Angeles and Long Beach, we used the growth rates developed for the Port of Los Angeles' No Net Increase Report,[1] which agree with CARB growth projections based on main engine size. As a result, growth rate estimates for 2025 used in this plan are consistent with the No Net Increase report. Our estimates for container growth at the Port of Oakland were also consistent with previous estimates.[2]

Table A-4-a presents statewide emissions by pollutant and ship type from 2001-2020. Container ships are the dominant ship type, although major growth is also forecast for passenger ships, which has a significant on emissions in the San Diego air basin. Table A-4-b presents those same emissions by mode: hoteling, maneuvering, and transit.

Table A-4-a
Statewide Ship Emissions to 24 Miles from Shore by Ship Type*
(tons per day)

	NO_X				Diesel PM				SO_X			
Ship Type	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**
Container Ship	59	102	127	156	4.8	8.7	11.0	13.9	37	66	84	106
Tanker	10	15	18	22	0.8	1.3	1.6	1.9	6	10	12	15
Passenger Ship	7	18	29	48	0.7	1.8	2.9	4.9	5	14	23	39
Other Cargo Ships	18	22	25	28	1.5	1.9	2.2	2.6	11	15	17	21
Sum	**95**	**158**	**200**	**254**	**7.8**	**13.8**	**17.8**	**23.4**	**60**	**106**	**137**	**180**

** Includes benefits of regulations passed through October 2005; does not include Auxiliary Engine regulation.*

[1] Report to Mayor Hahn and Councilwoman Hahn by the No Net Increase Task Force: June 24, 2005. Available at: http://www.portoflosangeles.org/DOC/NNI_Final_Report.pdf

[2] Metropolitan Transportation Commission, Regional Goods Movement Study for the San Francisco Bay Area: Final Summary Report. Available at: http://www.mtc.ca.gov/pdf/rgm.pdf

Table A-4-b
Statewide Ship Emissions to 24 Miles from Shore by Operating Mode
(tons per day)

	NO_X				Diesel PM				SO_X			
Operating Mode	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**
Hoteling	15	33	40	49	1.3	3.0	3.7	4.6	10	25	31	38
Maneuvering	2	5	7	8	0.2	0.4	0.5	0.6	1	3	4	5
Transit	77	120	153	197	6.4	10.5	13.6	18.2	48	79	103	137
Sum	**95**	**158**	**200**	**254**	**7.8**	**13.8**	**17.8**	**23.4**	**60**	**106**	**137**	**180**

** Includes benefits of regulations passed through October 2005; does not include Auxiliary Engine ATCM*

2. Commercial Harbor Craft

Harbor craft are commercial boats that operate generally within or near harbors, or are smaller vessels that support a commercial or public purpose. The harbor craft category includes many types of vessels including crew and supply vessels, pilot vessels, tug and workboats, fishing vessels and ferries. This category does not include recreational vessels used for private use.

ARB staff recently developed an improved statewide emissions inventory for the harbor craft category. This emissions inventory was developed using the statewide population of harbor craft, in conjunction with information about the size and activity of propulsion engines by vessel type obtained by survey to estimate emissions. Harbor craft have both propulsion and auxiliary engines; both are generally powered by diesel fuel. For most commercial harbor craft, the propulsion engines are the primary engines and move the vessel through the water. The auxiliary engines generally provide power to the vessels electrical systems and can also provide additional power to unique, essential vessel equipment (e.g., refrigeration units) during the normal day-to-day operation of the vessel.

Growth in harbor craft emissions was assessed by vessel category. Growth in tug boat emissions were assumed proportional to growth in the number of visits to each port by ocean-going ships in each year, which is not projected to increase with time. No growth was assumed in other harbor craft ship types unless location specific information was provided by local authorities.

For the goods movement inventory, we are using the statewide inventory for harbor craft. However, since the release of the draft plan we have refined our estimates. Specifically, to be consistent with the ocean-going ship inventory, only emissions released within 24 nautical miles of shore are now included in the goods movement inventory. In addition, emission factors were updated to account for fleet turnover, current engine standards, and the increase in emission factors with engine age. The combined effect of these assumptions is to reduce future year emissions. Table A-5-a provides emissions by harbor craft type by pollutant for 2001-2020.

Table A-5-a
Statewide Harbor Craft Emissions to 24 Miles from Shore by Ship Type
(tons per day)

	NO_X				Diesel PM			
Ship Type	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**
Fishing Vessels	19	14	11	10	1.0	0.8	0.5	0.5
Tug Boats	15	11	8	7	0.8	0.6	0.4	0.4
Ferry/Excursion	35	26	20	18	1.6	1.3	0.9	0.8
All Others	6	5	4	4	0.3	0.3	0.2	0.2
Sum	**75**	**56**	**44**	**39**	**3.8**	**2.9**	**2.1**	**1.8**

3. Cargo Handling Equipment

The cargo handling equipment category includes many different types of off-road vehicles that are used to move goods through California's ports and intermodal facilities. CARB staff recently developed a new statewide emissions inventory representing cargo handling equipment that estimates the emissions from cranes, forklifts, container handling equipment such as yard hostlers, top picks and side picks, bulk handling equipment such as excavators, tractors, and loaders used at ports and intermodal rail yards.

The goods movement inventory provides emissions by equipment type and for each port and major intermodal facility in California. The inventory reflects updated population and activity data for cargo handling equipment statewide by equipment type based on a survey conducted by CARB in early 2004 and recent emission inventories prepared for the ports of Los Angeles and Long Beach. Growth rates were developed by equipment type from survey responses. The cargo handling equipment inventory in the draft plan has not changed. Table A-5-b presents cargo handling equipment emissions estimated for 2001 and 2025 by pollutant and equipment type.

Table A-5-b
2001 Statewide Cargo Handling Equipment Emissions (tons per day)

	NO_X				Diesel PM			
Equipment Type	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**
Yard Tractor	15	10	7	3	0.6	0.3	0.2	0.1
Material Handling Equip	3	3	3	2	0.1	0.1	0.1	0.1
Crane	2	2	2	1	0.1	0.1	0.05	0.04
All Others	1	1	1	0	0.1	0.03	0.02	0.01
Sum	**21**	**16**	**11**	**6**	**0.8**	**0.5**	**0.4**	**0.2**

** Includes benefits of regulations passed through October 2005; it does not reflect the Cargo Handling Equipment regulation adopted by the CARB in December 2005.*

4. Trucks

Trucks are an integral and important component of California's goods movement transportation system. Nearly all goods moved through California are moved by a truck at some time during their transport. Emissions released by trucks are a substantial component of statewide, regional, and goods movement emissions inventories.

The calculation of emissions from trucks is not a simple process. Estimating emissions requires some knowledge about population / engine characteristics, travel activity, and emission factors for individual types of trucks. Engine characteristics include engine model year, manufacturer and technologies. Travel activity includes not just an assessment of the number of trucks and the distance each truck travels in an area, but also the distribution of speeds at which trucks travel and the number of miles the average truck travels per year. Both fleet characteristics and travel activity are typically provided by local and state governments to CARB.

Emission factors relate a given activity level to emissions of each pollutant. These data are obtained by conducting controlled tests of many individual vehicles and then analyzing resulting data to extract average emission factors and trends for different types and ages of engines. Emission factors also include estimates of how emissions change at different speeds, and how emissions increase as engines in trucks become older. All of this information is integrated across a predicted fleet of trucks in a region to calculate emissions. CARB's motor vehicle emissions model, EMFAC, incorporates these factors for the calculation of vehicle emissions.

Truck emissions estimates have changed substantially since the draft goods movement plan was released in December, due to a number of different changes. Most significantly, the inclusion of domestic goods movement has led to a major increase in emissions for the category. Two additional changes led to major changes in the inventory.

- **This plan includes new information regarding motor vehicle emissions.**

ARB staff is currently in the process of developing a new version of EMFAC. This model has not yet been completed, but staff has developed draft emissions calculation methods that include new information about engine populations and characteristics; travel activity; and emission factors. To ensure truck emissions estimates are as accurate as possible in this plan, staff included the new data and assumptions into the goods movement truck emissions inventory. Incorporating new data and assumptions increased emissions estimates and changed the statewide spatial allocation of truck emissions. The current version of the EMFAC model allocates heavy duty truck emissions spatially based upon where vehicles are registered. For this plan, staff allocated emissions based on where trucks are expected to travel. This change results in travel decreases in areas like South Coast and the Bay Area where most trucks in California are registered, and travel increases in areas like the San Joaquin Valley and Mojave Desert where trucks tend to travel on longer routes. Second, truck emission factors in the current version of EMFAC are based upon an extremely limited set of data representing tested trucks. Over the past several years CARB and other organizations have funded new studies to test emissions from trucks. These data, representing chassis dynamometer tests on more than 30 trucks, were integrated into truck emissions estimates for this plan. Generally truck emission factors for NO_X and diesel exhaust particulate matter increased substantially, leading to a significant increase in emissions relative to the current EMFAC model.

- **This plan includes significant revisions to methods for estimating truck emissions associated with international goods movement.**

The EMFAC model provides emission estimates by vehicle class and by county. It does not provide emission estimates for a specific industry or sector of the economy, such as goods movement. As a result, estimating emissions associated with international goods movement required the development of new methods. The goal of these new methods was to estimate the VMT associated with trucks that haul international goods. The fraction of total truck VMT attributable to international goods movement in a region is then multiplied by emissions in that region to estimate international goods movement emissions. This section describes the development of those methods, which have changed significantly since the release of the draft plan. Our new method is based on the concept of balancing the number of inbound containers to California, outbound containers from California, and empty containers moved out of California. Our assumption is that the number of containers should be balanced; and the flow of containers on ships needs to be consistent with the number of containers moved by trucks and trains.

To illustrate this assumption, it is useful to consider how international goods move in California. Imported goods enter California through the Ports of Los Angeles, Long Beach, Oakland, and others. These goods arrive on ocean-going ships, much of which are packaged in containers. Once at port containers are removed from the ship and staged for land-side transportation. Containers may be moved directly on to a train without the assistance of a truck. This is referred to as "on-dock" rail. Containers may also be moved by a truck to a rail yard, such as the Intermodal Container Transfer Facility in Long Beach, only a few miles away from the port. This is referred to as "near-dock" rail. Containers may also be moved by a truck to a more distant rail yard, such as the Hobart yard in Los Angeles. This is referred to as "off-dock" rail. Rail transportation is most cost-effective over long distances and most containers loaded on to rail at California's ports are moved out of California.

Other containers are moved by truck directly to their destination, which is most often a distribution center. When trucks carry containers to a distribution center, several things may happen. In many cases the container contents are distributed to smaller trucks for local delivery. Emissions associated with these local deliveries are not included in this plan. In other cases a container may be picked up by a long-haul trucking firm and the container may be moved out of state. In some cases the container is transloaded. Transloading is the practice of repacking generally 40 foot containers into 53 foot containers. Since the cost to move a container is about the same regardless of container size it is more cost effective to move larger containers by truck of rail than smaller containers. Over longer distances transloading can be a cost-effective and efficient method to transport goods.

Our container balancing method was first applied to the South Coast region. Staff collected data from the Ports and local government agencies in the South Coast region. Based on these data staff developed an estimate of the number of containers moving into the region's ports, and projected these numbers into the future. The total number of containers in each year was then allocated to different travel modes. Table A-5-c presents our estimate of the number of containers in 2001 and 2025 moved by each travel mode. The data indicate more than 50% of containers passing through the Ports of Los Angeles and Long Beach travel by rail.

Table A-5-c
Container Balance by Travel Mode: South Coast
(number of containers)

Mode		Containers		
		Year 2000	Year 2010	Year 2025
Rail	On-Dock	933,476	2,624,477	3,118,943
Truck	Near-Dock (ICTF)	375,899	1,286,991	1,976,471
	Off-Dock (Hobart)	658,070	1,164,786	2,513,832
	Transload	1,568,539	2,018,570	5,947,318
	Local	1,730,801	2,227,388	6,562,559
Total		5,266,785	9,322,212	20,119,123

About 10,000 trucks are estimated to service the Ports by moving containers on short routes to and from rail yards and distribution centers. These trucks, called Port Trucks in this plan, are generally older than other truck fleets in the South Coast region[1]. Because trucks emit more as they get older, the port truck fleet is dirtier than the regional average fleet.

To estimate port truck emissions in South Coast, staff estimated an average distance traveled per container for each travel mode. The number of containers was then multiplied by the average distance traveled by truck in each mode to calculate VMT. Staff calculated a ratio of port truck VMT to total VMT in South Coast, and adjusted this ratio to account for the higher emission rate of port trucks based on model year distribution. This ratio was then multiplied by truck total truck emissions in South Coast to estimate emissions generated by port trucks.

A fraction of goods transported to distribution centers, primarily transloaded containers, are moved by truck through and potentially out of California to other regional destinations such as Oregon, Utah, Nevada, and other states. Using technical reports generated by local transit agencies in the Los Angeles region, we estimated an additional amount of heavy-duty truck miles traveled in each air basin in California as a result of these secondary transload trips. We adjusted the ratio of transload VMT to air basin total VMT to account for the fact that trucks pulling transloads likely involve national fleets that are much cleaner than the air basin average. This adjusted ratio was also multiplied by emissions in each air basin to calculate emissions associated with transloaded containers originating from the Ports of Los Angeles and Long Beach.

[1] Port of Los Angeles (2004). Port of Los Angeles Baseline Air Emissions Inventory – 2001. Available at: http://www.portoflosangeles.org/DOC/POLA_Final_BAEI.pdf

To estimate the fraction of port truck and transload truck emissions associated with other ports in California we applied the method used for South Coast to the Bay Area. Port trucks servicing the Port of Oakland were assumed to travel in the Bay Area and San Joaquin Valley, and transload VMT generated for containers originating in Oakland was estimated in each air basin of California. For ports outside of the Bay Area, we scaled port truck VMT by the total non-petroleum related tonnage throughput at each port. Only Oakland and the San Pedro Bay ports were assumed to generate transload long-haul truck trips.

Table A-6-a presents domestic truck, port truck, and transload truck emissions projected on a statewide basis between 2001 and 2020. International emissions decreased from the draft plan because we used the container balance method. We believe current emissions more accurately reflect international goods movement, and projections in the draft plan were over-estimated. One might expect port truck emissions to increase with projected to container growth, but as Table A-6-a shows it does not. Container growth is accounted for in the calculation; however existing controls on the truck fleet are projected to reduce emissions more quickly than container growth would increase emissions. Overall, the inclusion of all goods has led to a dramatic increase in total diesel PM and NO_X emissions attributable to goods movement from the draft plan. NO_X emissions are five times higher, and diesel PM estimates ten times higher than estimates in the previous draft plan.

Table A-6-a
Statewide Truck Emissions (tons per day)

	NO_X				Diesel PM			
Truck Type	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**
Domestic Trucks	623	492	336	234	36.0	18.5	10.4	5.7
Port Trucks	19	20	21	18	1.4	0.7	0.6	0.4
International Long Haul Trucks	13	5	3	3	0.3	0.2	0.1	0.1
Sum	**655**	**517**	**359**	**255**	**37.7**	**19.4**	**11.1**	**6.22**

Emissions in the South Coast and Bay Area reflect container balancing, as shown in Tables A-6-a and A-6-c. Table A-6-d provides results for the San Joaquin Valley. While the San Joaquin Valley has significant transload traffic, these trucks are relatively cleaner than domestic truck fleets that are likely to be generally older and dirtier.

Table A-6-b
Truck Emissions in the South Coast Region (tons per day)

	NO_X				Diesel PM			
Truck Type	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**
Domestic Trucks	120	104	68	44	7.0	4.0	2.2	1.1
Port Trucks	16	17	17	15	1.2	0.6	0.5	0.4
International Long Haul Trucks	4	2	1	1	0.1	0.0	0.0	0.0
Sum	**140**	**122**	**87**	**60**	**8.2**	**4.6**	**2.7**	**1.50**

Table A-6-c
Truck Emissions in the Bay Area (tons per day)

	NOx				Diesel PM			
Truck Type	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**
Domestic Trucks	49	37	23	16	2.4	1.2	0.6	0.3
Port Trucks	3	3	3	2	0.2	0.1	0.1	0.1
International Long Haul Trucks	1	0	0	0	0.0	0.0	0.0	0.0
Sum	**52**	**40**	**26**	**18**	**2.5**	**1.3**	**0.7**	**0.39**

Table A-6-d
Truck Emissions in the San Joaquin Valley (tons per day)

	NOx				Diesel PM			
Truck Type	**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**
Domestic Trucks	179	133	92	64	9.9	4.7	2.7	1.5
Port Trucks	0	0	0	0	0.0	0.0	0.0	0.0
International Long Haul Trucks	4	2	1	1	0.1	0.0	0.0	0.0
Sum	**183**	**135**	**93**	**65**	**10.0**	**4.8**	**2.7**	**1.49**

5. Locomotives

Trains, and the diesel-fueled locomotives that power them, travel throughout California. The vast majority of trains in California move freight; a fraction of this freight is imported into and through California from overseas, while the balance represents freight generated in California that is bound for export, and freight generated and consumed within California.

ARB's inventory of emissions from locomotives was first developed in 1987 and has been updated periodically since that time. The inventory accounts for generalized locomotive activity patterns over broad geographical regions. The inventory covers two types of train locomotives. Line-haul locomotives are larger, more modern locomotives that are used to move trains over long distances. Switchers are smaller, older locomotives used to transport trains within a rail yard or over short distances. Line-haul locomotives operate in rail yards as they travel through to their final destination.

To estimate both domestic and international locomotive emissions generated in California CARB staff updated the statewide locomotive inventory. The statewide inventory accounts for several types of line haul trains, all of which are pulled by the same fleet of locomotives. These types include intermodal trains that haul containers; mixed trains that haul bulk materials and other goods such as wood products, agricultural products and petroleum products; and local trains that operate on privately owned local runs. This inventory also includes passenger trains. To update the inventory we reassessed the fraction of intermodal trains operating in each air basin. We then estimated the fraction of international intermodal trains operating in each air basin based on rail yard specific data provided to CARB by class I rail companies. We then reassessed growth to be consistent with expected growth in the number of containers that will be moving through each air basin in California. These estimates were calibrated using the container balancing method developed for trucks, as discussed above. Switching associated with international intermodal trains was considered international; all other switching emissions were considered domestic. Table A-6-e presents international line haul, international switching, domestic line haul, and domestic switching by pollutant for the years 2001 and 2025.

Table A-6-e
Projected Locomotive Emissions: Baseline Projections 2001-2020
(tons per day)

		Diesel PM				NO_X			
Train Type		**2001**	**2010**	**2015**	**2020**	**2001**	**2010**	**2015**	**2020**
Line Haul									
	International	1.2	1.4	1.6	1.8	49	34	42	51
	Domestic	3.3	2.7	2.6	2.5	144	76	81	82
Switching									
	International	0.04	0.03	0.03	0.03	2	1	1	1
	Domestic	0.2	0.1	0.1	0.1	9	6	5	5
Sum		**4.7**	**4.3**	**4.3**	**4.4**	**203**	**116**	**128**	**139**

B. Adjustment Factor for Ship Emissions

Diesel PM emissions released off-shore do not result in nearly as much population exposure as occurs when the emissions are released on-shore within populated regions. There are two reasons for this. First, diesel PM emissions released off-shore are diluted before they reach shore. As a result, there is no near-source population exposure where pollutant levels are highest. Second, a portion of off-shore diesel PM emissions never reaches the shore, depending on wind direction and over-water deposition rates.

To account for the differing impact of diesel PM emission from off-shore sources, CARB staff developed a South Coast and a statewide diesel PM emissions impact adjustment factor. For the South Coast, the adjustment factor for ship diesel PM emissions release off-shore was estimated to be 0.1, based on dispersion modeling. That is, 100 tons per year of emissions from ships released off-shore would have the same populated-weighted diesel PM concentration (and health impacts) as 10 tons per year of diesel PM emissions released in residential areas near the ports. For the rest of the state, the adjustment factor was estimated to be 0.25.

In calculating the impact of off-shore emissions, the mass of directly emitted diesel PM associated from ships operating off-shore was multiplied by 0.1 for the South Coast Air Basin and by 0.25 for the rest of the State. The resulting emissions were then assigned to the appropriate coastal county. No adjustment was made for secondary PM formation from NO_X, SO_X, and ROG emissions, since these pollutants require at least several hours to form particle nitrate, particle sulfate, and secondary organic aerosol. For the same reason, offshore sources of NO_X and VOC that contribute to ozone formation were also not adjusted. This latter assumption probably overestimates the impact of offshore emissions, as there will be some losses due to offshore winds and over-water deposition; however, there is the possibility that this could be offset by enhanced chemical conversion rates due to the chlorine radicals (from sea salt spray) and the humid conditions encountered over the ocean. These issues are being studied as part of the technical analysis for a possible North American SO_X Emissions Control Area, described in Section V-C.

The 0.1 adjustment factor for the South Coast Air Basin was derived from dispersion modeling results for the Ports of Los Angels and Long Beach (CARB 2005a) and from modeling results for off-port truck and rail activity that was conducted as part of this report.

Diesel PM emissions from transiting and maneuvering ships associated with the Ports of Los Angels and Long Beach were estimated to be 942 tons per year. Modeling analysis results estimated the annual average population-weighted diesel PM concentration within the study area (20 miles by 20 miles) from these emissions to be 0.11 microgram per meter cubed ($\mu g/m^3$). This would result in an annual average population-weighted diesel PM concentration of 0.0117 $\mu g/m^3$ per 100 tons per year emissions from ships operating offshore. Since this concentration only represents the emissions impact within the study domain, the value was adjusted to account for the impact of ship emissions that extend beyond the study area. As discussed elsewhere in this report, CARB staff estimated that about 40% of the impact from ships operating offshore were outside the study area. Taking this into consideration, the population-weighted diesel PM concentration was adjusted to 0.0164 $\mu g/m^3$ per 100 tons per year emissions from ships operating offshore.

The population-weighted diesel PM concentrations from truck and rail activity within the study area, but off the port property, were estimated to be 0.18 $\mu g/m^3$ resulting from 114 tons per year of diesel PM emissions. Normalized to 100 tons of emissions, the annual average population-weighted concentration would be 0.158 $\mu g/m^3$ per 100 tons of diesel PM emissions off the port property. Comparing the ratios of the population-weighted concentration per 100 tons of diesel PM emissions from offshore ships to off-port truck and rail source (0.0164/0.158), results in a value of about 0.1. This is the value used to adjust the impact of ship emission released offshore the South Coast Air Basin.

The adjustment factor selected for the remainder of the State was 0.25. There is insufficient information to develop adjustment factors for other areas using the same approach as used for the South Coast Air Basin. Given the resulting uncertainty, a more conservative (health protective) adjustment factor of 0.25 was selected for use until additional analyses can be performed. For the San Francisco Bay, it seems reasonable to use a greater adjustment factor than used for the South Coast Air Basin because once a ship enters the Bay the emissions are likely to impact urbanized area regardless of the wind direction. CARB staff will continue work to refine these estimates using region-specific models.

C. Exposure Estimates

1. Diesel PM

In 1998 CARB identified diesel particulate exhaust as a toxic air contaminant (CARB 1998). As part of the identification process, 3 staff estimated the ambient PM10 concentrations of diesel exhaust throughout California. In this estimation, CARB staff used receptor modeling techniques, which includes chemical mass balance model results from several studies, ambient 1990 PM10 monitoring network data, and 1990 PM10 emissions inventory data. The staff used the 1990 PM10 inventory and monitoring data because it would best represent the emission sources in the years when the ambient data were collected for the studies used to estimate 1990 diesel exhaust PM10 outdoor concentrations. The staff has also estimated outdoor exposure concentrations for 1995 and 2000 based on linear extrapolations from the base year 1990 to the respective emissions inventories (CARB 1998).

2. Particle Nitrate and Particle Sulfate

This section provides information on the population-weighted exposure calculation of annual geometric means for particle nitrate and particle sulfate to which people in different parts of California are potentially exposed. The term "potentially" is used because daily activity patterns influence a person's exposure. For example, being inside a building will decrease a person's exposure to outdoor nitrate and sulfate concentrations in their vicinity. However, any person who is outdoors will be exposed to a variable concentration. Furthermore, the exposures presented here provide an integrated regional perspective rather than an indication of exposure at any individual location. This exposure analysis is based solely on "outdoor" nitrate and sulfate data, as measured by the Statewide Routine Monitoring Network and additional special monitoring networks IMPROVE and Children's Health Study.

a) PM Data Description

Airborne particulate matter (PM) is not a single pollutant, but rather a mixture of primary and secondary particles. Particles vary widely in size, shape, and chemical composition, and may contain inorganic ions, metallic compounds, elemental carbon (EC), organic carbon (OC), and compounds from the earth's crust. A large variety of emission source types, both natural and man-made, are responsible for atmospheric levels of PM. These emission sources directly emit PM ("primary" particles), which then, over time, become coated with the low-vapor-pressure products of atmospheric chemical reactions ("secondary" particles) involving ozone and other oxidants, oxides of sulfur (SO_X), oxides of nitrogen (NO_X), ammonia (NH_3), and volatile organic compounds (VOC). In California, the proximity of a location to a variety of sources, in addition to the diurnal and seasonal variations in meteorological conditions, causes the size, composition, and concentration of particulate matter to vary in space and time.

In urban areas of California, nitrate represents a larger fraction of PM mass compared to the rest of the nation due to wide use of low-sulfur fuels for mobile and stationary sources. The formation of secondary ammonium nitrate (NH_4NO_3) begins with the oxidation of oxides of nitrogen (NO_X) into nitric acid (HNO_3). The nitric acid then reacts with gaseous ammonia to form NH_4NO_3. The sea influences the chemical composition of aerosols in the coastal zone. Sodium chloride (NaCl) is always present in aerosols in the form of large particles originating from seawater. Several studies have indicated the importance of HNO_3 reaction on the sea salt particles, leading to thermally stable sodium nitrate ($NaNO_3$) production in the particle phase accompanied by liberation of gaseous hydrochloric acid (HCl) from the particles. This reaction may be the principal source of coarse (2.5 to 10 µm) nitrate, and plays an important role in atmospheric chemistry because it is a permanent sink for gas-phase nitrogen oxide species.

Sulfur dioxide emissions result almost exclusively from the combustion of sulfur-containing fuels. Other sulfur compounds, such as sulfur trioxide (SO_3), sulfuric acid (H_2SO_4), and sulfate, may also be directly emitted during combustion of sulfur-containing fuels, although usually only in small amounts. In the atmosphere, sulfur dioxide is chemically transformed to sulfuric acid, which can be partially or completely neutralized by ammonia and other alkaline substances in the air to form sulfate salts. Sulfate concentrations in the SoCAB are much greater than other areas. However, nationwide, large reductions in ambient SO_2 concentrations have resulted in reductions in sulfate formation that would have been manifest in PM2.5 concentrations on the regional scale.

b) Nitrate and Sulfate Population-weighted Exposures

This analysis is based on the Inverse Distance Weighting method from the Geostatistical Analyst 9.0 software. For this discussion, the nitrate and sulfate annual geometic mean values and population counts were associated by census tract group block and merged to assemble a distribution of exposures across a range of concentrations. Concentrations of many air pollutants, including nitrate and sulfate, may change substantially from place to place. Accordingly, population exposure estimates tend to be more accurate when the population data and air quality data on which they are based are highly resolved, geographically. Population counts by census tract group block provide a convenient source of highly resolved population data. A typical census tract group block contains several thousand people. As a result, densely populated areas have many census tract group blocks, while sparsely populated areas have very few.

The interpolated nitrate and sulfate concentrations from the Statewide Routine Monitoring Network plus the special monitoring networks, IMPROVE and Children's Health Study, were assigned to a census tract group block. The interpolation was a weighted-average of the concentrations measured at the monitors. The weight assigned to each monitor was a function of its distance from the point in space within the state, using an inverse distance weighting function (1/distance to a power). In this way, close monitors are more influential than are distant monitors to the point. Using a weighting factor of 1/distance squared is a common practice. So it was used by staff in this assessment. In addition for the weighting factor, a minimum of 3 monitoring stations were used even if those sites were beyond the search radius of 50 kilometers. Up to a total of 15 could be used within the radius. Geographical barriers such as mountain ranges that may impede the movement of emissions and pollutants were not considered in the exposure calculations, but this omission had little impact on the results since monitors typically collect data in populated areas on both sides of such barriers.

c) Nitrate and Sulfate Monitored Data

The PM nitrate and sulfate data used for the interpolated exposure have been derived from a variety of routine and special monitoring programs and databases. 1998 provide the best data availability with maximum spatial resolution for both routine monitoring network and special study PM network, so this study used mean annual sulfate and nitrate concentrations based on the 1998 data. The PM data that were used in this study generally met U.S. EPA's minimum data completeness criterion, i.e., 11 of 15 samples per calendar quarter. Three different data sets for 1998 were used to provide the ambient nitrate and sulfate concentrations.

- PM10 nitrate and sulfate data from Size Selective Inlet (SSI) monitors. In 1998 the SSI sampling network consisted of 91 sites, however the data completeness criterion reduced the number of sites used in this analysis to 60. Compositional analysis in a laboratory provides the mass of certain ions, including nitrate and sulfate, present in the SSI samples.
- PM2.5 sulfate and nitrate data from Two-Week Samplers (TWS) used in the Children's Health Study. The TWS network was deployed to provide information for an on-going study of the chronic respiratory effects in children from long-term exposure to air pollution in southern California. Because estimates of long-term average concentrations (seasonal and annual) of vapor-phase acids and PM2.5 mass and inorganic ions were needed, it was decided that two-week integrated sampling would be more appropriate than every 6^{th} day sampling.
- PM2.5 nitrate and sulfate data from the Interagency Monitoring of Protected Visual Environments (IMPROVE) program. The IMPROVE program monitoring sites are located in federally protected Class 1 areas and are outside of urban areas. Data from 11 California sites are used in this study.

The concentrations used are a mixture of both PM10 and PM2.5. For annual averages, we believe that mixing PM2.5 and PM10 sulfate and nitrate data is reasonable because most sulfate and nitrate occur in the PM2.5 fraction. To confirm this, we have estimated ratio of PM10 sulfate to PM2.5 sulfate using PTEP data at six monitoring sites in southern California. In general, the annual mean fine PM-sulfate fraction at these sites ranges between 0.8 to 0.9. A similar relationship between PM10 nitrate and PM2.5 nitrate has also been observed at several heavily populated urban locations in California.

Two additional set of data provided information used in estimating background sulfate concentrations. They were:

- The dichotomous (dichot) sulfur data. Dichot sampler uses a low-volume PM10 inlet followed by a virtual impactor which separates the particles into the PM2.5 and PM10-2.5 fractions. The sum of PM2.5 and PM10-2.5 provides a measure of PM10. With the routine monitoring program, samples of PM10 are collected over a 24-hour period using a PM10-SSI) sampler and Dichot sampler. Samples are usually collected from midnight to midnight every sixth day.
- PM2.5 and PM10 sulfate data from the PM Technical Enhancement Program (PTEP 1995). A one-year PM10 Technical Enhancement Program (PTEP)

monitoring was conducted at six sites: downtown Los Angeles, Anaheim, Diamond Bar, Rubidoux, Fontana, and San Nicolas Island. At each location, the sampling equipment was deployed to collect fine and coarse particulate fractions for speciation.

Since the annual California ambient air quality standard for PM is based on the geometric mean (useful for characterizing lognormal data), the geometric means of SSI-PM10 nitrate and sulfate and IMPROVE nitrate and sulfate mass concentrations were calculated for this study. However, the annual arithmetic mean was calculated for the PM2.5 sulfate and nitrate data from Two-Week Samplers. Because the two-week sampler provides an integrated two-week average measurement at each air monitoring station.

Since nitrate and sulfate measurements represent only the mass of the anion, the concentration data need to be adjusted to represent the total mass of the collected particulate molecules, i.e., including the anion, cations, and associated water. The ammonium cation (NH_4^+) is expected to be the major cation for nitrate and sulfate ions in California. There is considerable uncertainty regarding the amount of water associated with ammonium nitrate and ammonium sulfate, but ambient conditions are relatively dry in California for most of the year. In this data analysis, the mass associated with dry ammoniated nitrate and sulfate (i.e., zero molecule of water per XNO_3 or XSO_4 molecule) can be estimated by multiplying the nitrate values by the ratio of the molecular weight of ammonium nitrate to the molecular weight of nitrate, a factor of 1.29, and multiplying the sulfate values by a factor of 1.38.

d) Background Estimation for Particle Sulfate

At the time of release of the December 2005 draft, this report did not specifically address population exposure due to secondary sulfate due to goods movement emissions. Analyses of ambient air quality data conducted in the intervening period now permit an estimate of sulfate effects (see Section A of the Technical Supplement).

Stringent regulations on the sulfur content of fuels have minimized sulfur emissions from most California sources, but despite low sulfur content, the large volume of motor fuel used in California still results in significant statewide SO_X emissions, of which goods movement sources such as locomotives, trucks, etc. are a significant fraction. The largest uncontrolled fossil fuel sulfur source in California is the burning of residual oil as fuel in ocean-going vessels.

Sulfate analysis is complicated by the fact that, in addition to sulfate formed from fossil fuel use in California, there are three other sources of atmospheric sulfate in California – natural "background" sulfate formed over the ocean, global "background" sulfate that is distributed throughout the Northern Hemisphere by the upper air westerly winds, and sulfate blown into Southern California from combustion in Mexico.

Estimating the public exposure to goods movement sulfate is a step-wise process. First, measured ambient sulfate levels must be partitioned among three general source categories (natural, transported, and local), and the "local" fraction must be further subdivided between goods movement sulfate and that from all other emissions. Next, population-weighted exposure due to goods movement sulfate is computed by overlaying the geographic distributions of goods movement sulfate and population. Finally, health effects are computed by applying appropriate risk factors to the population exposure data.

Natural sulfate concentrations from the ocean were estimated from a review of open ocean measurements and California-specific shore-line and offshore island monitoring data. Sulfate carried by the sea breeze will be reduced by deposition and diluted by dispersion as the air moves inland. Concentrations inland from the shoreline were estimated from the residuals of regressions between fossil fuel emissions and measured sulfate over the period 1985-2000, and found to agree with expected fall-off going inland.

Particle sulfate in the upper air from sources throughout the Northern Hemisphere have been detected at multiple mountain locations in North America, and California-specific data are available from studies in northern California. Since this sulfate is widely distributed over the mid-latitudes, a single upper air "background" level was assigned to all high altitude sites.

Annual average "local" source sulfate at most California monitoring sites was estimated by subtracting site-specific estimates of oceanic and Northern Hemisphere sulfate from the observed values. In extreme southern California (San Diego and Salton Sea Air Basins), where transport from Mexico adds significantly to the measured sulfate, additional adjustments were made based on regression analyses and comparison of ambient sulfate concentrations with analogous population centers farther north.

Population-weighted sulfate exposure was computed by estimating local sulfate concentrations at the census block level using spatial interpolation of the monitoring data. Finally, aggregated Air Basin health effects were estimated from the population-exposure data and the fraction of those effects due to GM emissions determined based on local emission inventories.

New analyses of air quality and emissions data conducted since December 2005 indicate that uncontrolled SO_X emissions from ships increase the estimates of total goods movement-related health effects by about one quarter. However, this preliminary estimate contains several uncertainties and a fully quantitative analysis must await the completion (by end of 2006) of research being jointly conducted by CARB staff, five university groups, the U.S. EPA, and Environment Canada as part of a feasibility study for establishing a SO_X Emission Control Area (SECA) to reduce sulfur emissions from West Coast shipping. The research includes a refined inventory of ship activity and ship emissions, analysis of historical PM data from sites along the West Coast to look for evidence of ship emissions, development of new monitoring methods that can distinguish fossil fuel sulfate from that due to biologic activity in the ocean, and model development to allow simulation of sulfate formation and transport over the ocean and land areas of coastal California.

e) Uncertainties

Secondary nitrate and sulfate particle formation are influenced by a combination of precursor pollutant concentrations and weather conditions. Conversion of SO_X to sulfate aerosols is accelerated by the presence of oxidants in the air (as during ozone episodes) and is accelerated even more under humid conditions when the conversion can occur inside water droplets. NO_X conversion to nitrate is even more sensitive to weather conditions, as formation rates must compete with dissociation back to gases, so that nitrate is generally a cool-wet (e.g., winter) weather phenomenon. Due to the influences of these factors, the same emissions can result in high PM concentrations on one occasion, and low concentrations on another.

There is uncertainty in these estimates of the secondary fraction of PM2.5 mass. For example, limited ambient speciated data in many areas, particularly rural areas, and forced us to rely on a very limited data in the same region of the air basin. Additionally, these estimates do not account for the volatilization of NO_3 from the particulate filters during sampling and before analysis. Volatilization could be as high as 50%. Overall, it seems that our relatively simple method provides reasonable estimates of the contribution of secondary PM in most of the heavily populated air basins.

To partially assess the uncertainty associated with the interpolation methods, we compared the actual measurements and the interpolated values at the monitoring stations. The mean-squared errors were 0.28 $\mu g/m^3$ and 0.08 $\mu g/m^3$ for nitrate and sulfate calculations, respectively.

3. Secondary Organic Aerosols

Atmospheric particulate carbon consists of both elemental carbon (EC) and organic carbon (OC). Elemental carbon has a chemical structure similar to impure graphite and is emitted directly by sources. Organic carbon can either be emitted directly by sources (primary OC) or can be the result of the condensation of gas-phase oxidation products of volatile organic compounds (VOCs) in the air, here after is referred to secondary organic aerosol (SOA). The initial PM analysis for goods movement only addressed primary carbonaceous material. To complete the assessment of goods movement, PM effects on the contribution to SOA must also be obtained.

Routine OC measurements do not distinguish the primary and secondary components of OC. Even detailed laboratory molecular analyses of organic species in PM can not differentiate properly all of the primary and secondary organic aerosols.

Because direct chemical determination of SOA requires more detailed analysis than is available in routine PM data, the ratio of OC to EC can be used to estimate the amount of SOA in a given sample [Strader at al 1999; Turpin and Huntzicker (1991) Turpin and Lim (2001)]. If an OC/EC ratio that is both characteristic of primary emissions and relatively constant within the period of interest can be determined, then additional OC that drives the ambient ratio above this base level can be assumed to be secondary.

The OC/EC method was used to determine the contribution of SOA at PM monitoring sites in California in 2000. Using this ratio, the contribution of SOA at about 50 sites in California range from 0.15 $\mu g/m^3$ to 2.40 $\mu g/m^3$. Population-weighted SOA exposure was computed by estimating local SOA concentrations at the census block level using spatial interpolation of the monitoring data, based on a methodology similar to that used for particle nitrate and particle sulfate. Finally, aggregated air basin health effects were estimated from the population-exposure data and the fraction of those effects due to goods movement emissions determined based on local emission inventories. The effects of the uncontrolled ship emissions on port-area air quality show up in these calculations: roughly less than 1% of the health effects due to goods movement (i.e., shipping and port operations) are due to SOA.

4. Ozone

For ozone, California has a monitoring network of approximately 175 monitors located throughout the State. In our ozone staff report (CARB/OEHHA 2005b), hourly observations were input into the estimation of the health impacts of ozone exposures above the standard. Several scenarios of characterizing the ozone exposures were considered: averaging monitored values across each county, assigning portions of populations to monitored concentrations within each county, and interpolating exposures for each census tract. All three options led to very similar results.

D. Health Impacts Methodology

A number of adverse health impacts have been associated with the increase in pollutant emissions associated with goods movement-related emissions. For many of these impacts there is insufficient scientific information to estimate the number of new cases that could result from increased ambient concentrations of the respective pollutant. For this analysis, staff used the same basic methodology and peer-reviewed epidemiologic studies discussed in the Particulate Matter and Ozone Standards reviews (CARB/OEHHA 2002, 2005b) to determine concentration-response functions for several health endpoints, with one exception. An updated study on PM mortality effects was substituted to determine premature deaths associated with diesel PM.

The following goods movement-related health impacts were quantified in this analysis:

Particulate Matter

- Premature deaths
- Hospital admissions for respiratory diseases
- Hospital admissions for cardiovascular diseases
- Acute bronchitis
- Asthma and other lower respiratory symptoms
- Work Loss Days
- Minor Restricted Activity Days

Ozone

- Premature deaths
- Hospital admissions for respiratory diseases
- Minor Restricted Activity Days
- School Absence Days

In a sensitivity discussion, we address premature deaths and respiratory hospital admissions using other studies, infant mortality, and other potential health endpoints.

Concentration-response functions are equations using coefficients derived from epidemiologic studies that relate the change in the number of adverse health effect incidences in a population to a change in pollutant concentration experienced by that population. Due to the form of the models used in many epidemiologic studies, a logarithmic function is usually needed to characterize the non-linear relationship between changes in pollution concentration and occurrences of adverse health outcomes as follows:

$$\Delta y = y_0 (e^{-\beta \Delta conc} - 1) \times pop$$

where:

Δy= changes in the number of occurrences of a health endpoint corresponding to a particular change in concentration;

y_0 = baseline incidence rate per person;

β= coefficient; usually derived from the percent change in the health endpoint extracted from an epidemiologic study or meta-analysis;

Δconc = change in PM or ozone concentration; and

pop= population being exposed to the change in concentration.

Baseline incidence rates for these functions are determined using data available from a variety of databases assembled by California state health agencies. These include the California Office of Statewide Health Planning and Development and the Department of Health Services.

1. Particulate Matter

To determine concentration estimates for each pollutant related to goods movement an emissions inventory approach was used. It is not possible to estimate total diesel PM-related concentrations based on emissions estimates alone—because not all PM is directly emitted. Primary diesel PM, or directly emitted diesel PM, can be estimated directly from the emissions inventory. Secondary diesel-related PM is formed in the atmosphere from the precursors: SO_2, NO_X and other organic compounds. An estimate of the particle nitrate formed from goods movement-related NO_X must be calculated to derive secondary diesel PM estimates; similarly, diesel PM formed from goods movement-related ROG must also be estimated to address secondary organic aerosols (SOA). Details on how each of the pollutant concentrations was derived are provided above and in the Technical Supplement. To quantify the health impacts of diesel PM, four basic steps are required:

1. Estimate the basin-specific PM2.5 concentrations attributed to diesel sources.
2. Calculate the health impacts for the base year 2000 by applying a concentration-response (C-R) function to the exposed population for each basin; details on the selection of health endpoints and C-R functions are discussed earlier in Section II.D above. Without available studies addressing the relative toxicity of diesel PM compared to PM2.5, we assumed it's equally toxic. In reality, diesel PM may be more toxic than other components of PM2.5; hence, our assessment may underestimate the true effects.

3. Associate the health impacts with the related emission inventory in the base year (diesel PM, NO_X and ROG for primary diesel PM, particle nitrate, and SOA respectively) to determine the specific factors of tons per annual case of health endpoint.
4. Apply factors to the Goods Movement emission inventory (adjusted to reflect lower impacts from emissions over the oceans and bays) to estimate the average annual impacts for each health endpoint (with population growth adjustment) for years 2005, 2010, 2015, and 2020.

Sources such as tire wear, brake wear, and ship boilers emit PM2.5, which are not captured by primary diesel PM. To address these sources, health impacts for total PM2.5 and primary diesel PM were calculated based on diesel PM factors. Since diesel PM emissions come from a PM10 inventory, and about 92% are PM25, the health impacts due to non-diesel PM2.5 sources were estimated as: PM2.5 impacts – 0.92 * diesel PM impacts. Note that the concentration-response functions between PM and mortality were based on PM2.5, so this is a reasonable approximation of the non-diesel PM2.5 effect.

A critical issue here is the categorization of volatile organic compounds (VOC) emissions, and how that relates to formation of SOA. Many different types of VOCs are emitted into the atmosphere, where they can affect SOA formation at different rates. One of the major uncertainties is the assumption of all ROG emissions have equal propensity for form SOA. Diesel emissions are supposed to contain a high fraction of high molecular weight compounds (especially from ships), which could also influence SOA production.

Currently, the details of SOA formation are not well known, and the implications for needs related to the development of emission factors and other emissions estimation tools to characterize the precursor emissions remain uncertain. Large carbon number organic compounds that have an affinity to stick together could contribute significantly to these processes. Future development efforts may need to be directed to expand VOC speciation profiles to include compounds that improve the methods for characterizing SOA formation. Additional uncertainties are associated with lack of proper time and spatial resolution in ambient measurements of both primary and secondary organic species. These detailed measurements are critical in evaluating influence of meteorology and diurnal and seasonal changes in emissions.

2. Ozone

For health effects due to goods movement-related ozone concentrations, staff followed the same basic procedure outlined in the CARB and OEHHA's Review of the Ozone Standards (CARB/OEHHA 2005b), which itself was based on methods developed by the U.S. EPA for assessment of health benefits (Hubbell *et al.* 2005). The basic approach is the same as that for PM discussed above. However, concentrations by basin are based on the actual 2001-2003 daily measurements, used to calculate the health impacts due to exposures above the newly approved State 8-hour standard of 0.070 ppm. In that calculation, staff estimated the daily concentrations that would result in a hypothetical setting of attainment of the 8-hour standard. The difference between the two sets of measurements, considered at the daily level to account for day-of-week variation in ozone measurements (the "weekend" effect), was used to quantify the health impacts. As detailed in the Ozone Standard Staff Report (CARB/OEHHA 2005b), ozone concentrations in the SoCAB, where a majority of the population reside, have declined at a consistent rate throughout the distribution of the ozone levels. Consequently, strategies to control both ROG and NO_X are considered to be equally effective. The basin-specific health impacts due to ozone exposures above the 8-hour standard are associated with total emissions from reactive organic gas (ROG) and NO_X emissions that would need to be reduced to attain the standard to determine health impact factors. These factors are then applied to the Goods Movement total inventories of ROG and NO_X to determine the health impacts. Further details on the peer-reviewed studies used to derive coefficients for ozone health impacts can be found in the Ozone Standard Staff Report (CARB/OEHHA 2005b) and in Ostro et al. 2006.

3. Port-Specific Modeling

To estimate potential non-cancer health impacts associated with exposures to directly emitted diesel PM from the Ports of Los Angeles and Long Beach, we used air dispersion modeling of ambient directly emitted diesel PM (primary diesel PM). The detailed methodology for this analysis is presented in the October 2005 draft report "Diesel PM Exposure Assessment Study for the Ports of Los Angeles (POLA) and Long Beach (POLB)" (CARB 2005a). The non-cancer health effects evaluated include premature death, hospital admissions, asthma and other lower respiratory symptoms, acute bronchitis, work loss days, and minor restricted activity days – as was done for PM in the rest of the state.

To estimate the ambient concentration levels of primary diesel PM resulting from port operations, CARB staff conducted air dispersion modeling. We evaluated the impacts from the 2002 estimated on-port property and over-water emissions for five categories of emission sources at the ports: cargo handling equipment, on-road heavy-duty trucks, locomotives, ocean-going vessels, and commercial harbor craft. Meteorological data from Wilmington was used for this study. The Wilmington site is about one mile away from the ports, and the measurements were collected in 2001. The U.S. EPA's ISCST3 air dispersion model was used to estimate the annual average offsite concentration of diesel PM in the area surrounding the two ports. The modeling domain (study area) spans a 20 x 20 mile area, which includes both the ports, the ocean surrounding the ports, and nearby residential areas in which about 2 million people live. The land-based portion of the modeling domain, excluding the property of the ports, comprises about 65% of the modeling domain. A Cartesian grid receptor network (160 x 160 grids) with 200 x 200 meter resolution was used in this study.

The annual average above ambient diesel PM concentration in each grid cell was calculated using the U.S. EPA ISCST3. The population within each grid cell was determined from U.S. Census Bureau year 2000 census data. Using the methodology peer-reviewed and published in the Staff Report: Public Hearing to Consider Amendments to the Ambient Air Quality Standards for Particulate Matter and Sulfates, (PM Staff Report) (CARB, 2002), we calculated the number of annual cases of death and other health effects associated with exposure to the above ambient PM concentrations modeled for each of the grid cells. For each grid cell, each health effect was estimated based on concentration-response functions derived from published epidemiological studies relating changes in ambient concentrations to changes in health endpoints, the population affected, and the baseline incidence rates. The total impacts for the affected population in the modeling domain were obtained by summing the results from each grid cell.

To estimate the non-cancer health effects in areas outside the modeling domain, we interpolated the diesel PM concentrations from the modeling domain (20 mile x 20 mile) into an area of 40 mile x 30 mile in the north direction and another area of 20 mile x 20 mile in the east direction of the modeling domain. Concentrations into the south and west directions of the modeling domain were not interpolated because these areas are located over the ocean. The expanded model receptor domain covers an area of 40 mile (east-west) and 50 mile (north-south) and includes a population of about 10 million people. The non-cancer health effects presented in this report are derived from the expanded modeling domain, i.e., 40 mile x 50 mile.

E. Economic Valuation of Health Effects

This section describes the methodology for monetizing the value of avoiding the adverse impacts associated with goods movement-related emissions as discussed in the previous section. The most significant inputs into the analysis are the incident rates as previously discussed and the valuations associated with each endpoint (e.g., premature death). In addition, the discount rates that are chosen for valuing the avoidance of the adverse impacts are also discussed.

The U.S. EPA has established $4.8 million in 1990 dollars at the 1990 income level as the mean value of avoiding one premature death (U.S. EPA, 1999, pages 70-72). This value is the mean estimate from five contingent valuation studies and 21 wage-risk studies, with estimates ranging from $0.6 million to $13.5 million in 1990 dollars, (or $0.9 million to $20.1 million in 2005 dollars).

Contingent valuation and wage-risk studies examine the willingness to pay (or accept) for a minor decrease (or increase) in mortality risk. For example, if 10,000 people are willing to pay $800 apiece for risk reduction of 1/10,000 then collectively the willingness-to-pay for avoiding a premature death, in this example, would be $8 million. This is also known as the "value of a statistical life" or VSL.

Contingent valuation studies provide stated preference data about willingness-to-pay for decreased levels of risk. Such studies pose a market situation to survey respondents who are asked how much they would be willing to pay. The approach is useful for getting estimates on willingness-to-pay (WTP) for policies that have not yet been implemented. The earliest techniques involved asking people directly how much they value incremental risk avoidance. Today, the more effective referendum format suggests a specific dollar amount and then asks respondents whether they would be willing to pay that amount to decrease the probability of experiencing a well-defined adverse health outcome (Freeman, 2003).

Wage-risk studies provide revealed preference data about willingness to accept increased levels of risk. Willingness-to-pay and willingness-to-accept result in very close estimates when the change in risk is small. Such studies look at comparisons between different jobs in terms of wages and risks of death on the job. The comparisons focus on risk by controlling for other differences in job attributes. The compensating wage approach may underestimate the value of preventing premature mortality, because people who are willing to be paid to accept increased risk may value risk reduction less than the average person (Freeman 2003).

Table A-7 provides some information about the 26 studies that U.S. EPA used to calculate its estimate for the value of avoiding a premature death, or VSL. U.S. EPA averaged the 26 estimates to get a value of 4.8 million in 1990 dollars. This value applies to both adult and infant mortality.

Table A-7 Collected Valuations of Premature Deaths Prevented

Authors	Year	Type of Estimate	Valuation (millions 1990$)	Annual risk reduction	Implied compensating wage (1990$/year)
Kneisner and Leeth	1991	Wage-risk	0.6	0.0004	240
Smith and Gilbert	1984	Wage-risk	0.7		
Dillingham	1985	Wage-risk	0.9		
Butler	1983	Wage-risk	1.1	0.00005	60
Miller and Guria	1991	Cont. Valu.	1.2		
Moore and Viscusi	1988	Wage-risk	2.5		
Viscusi, Magat, and Huber	1991	Cont. Valu.	2.7		
Gegax et al.	1985	Cont. Valu.	3.3		
Marin and Psacharopoulos	1982	Wage-risk	2.8		
Kneisner and Leeth	1991	Wage-risk	3.3		
Gerking, de Haan, and Schulze	1988	Cont. Valu.	3.4		
Cousineau, Lacroix, and Girard	1988	Wage-risk	3.6		
Jones-Lee	1989	Cont. Valu.	3.8		
Dillingham	1985	Wage-risk	3.9		
Viscusi	1979	Wage-risk	4.1	0.0001	410
Smith	1976	Wage-risk	4.6	0.0001	460
Smith	1976	Wage-risk	4.7	0.0001	470
Olson	1981	Wage-risk	5.2	0.0001	520
Viscusi	1981	Wage-risk	6.5	0.0001	650
Smith	1974	Wage-risk	7.2	0.000125	900
Moore and Viscusi	1988	Wage-risk	7.3	0.00006	440
Kneisner and Leeth	1991	Wage-risk	7.6		
Herzog and Schlottman	1987	Wage-risk	9.1	0.000097	880
Leigh and Folson	1984	Wage-risk	9.7	0.0001	970
Leigh	1987	Wage-risk	10.4		
Garen	1988	Wage-risk	13.5	0.000108	1,460

U.S. EPA's most recent regulatory impact analyses, (U.S. EPA 2004, 2005), apply a different estimate of the value of avoiding one premature death, ($5.5 million in 1999 dollars). This revised value is based on more recent meta-analytical literature, and has not yet been assessed or endorsed by the Environmental Economics Advisory Committee (EEAC) of U.S. EPA's Science Advisory Board (SAB). Unless and until U.S. EPA's SAB reviews and endorses the revised estimate, CARB staff will continue to use the last VSL estimate approved for use by the SAB, i.e., $4.8 million in 1990 dollars.

As real income increases, people are willing to pay more to prevent premature death. U.S. EPA adjusts the 1990 value of avoiding a premature death by a factor of 1.201[1] to account for real income growth from 1990 through 2020, (U.S. EPA, 2004, page 9-121). Assuming that real income grows at a constant rate from 1990 until 2020, we adjusted VSL for real income growth, increasing it at a rate of approximately 0.6% per year. We also updated the value to 2005 dollars. After these adjustments, the value of avoiding one premature death is $7.9 million in 2005, $8.1 million in 2010 and $8.6 million in 2020, all expressed in 2005 dollars.

The U.S. EPA also uses WTP methodology for some non-fatal health endpoints, including lower respiratory symptoms, acute bronchitis and minor restricted activity days. WTP values for these minor illnesses are also adjusted for anticipated income growth through 2020, although at a lower rate, (1.066 in lieu of 1.201).

For school absences and work-loss days, the U.S. EPA uses an estimate of the parent's lost wages, (U.S. EPA, 2004), which CARB adjusts for projected real income growth.

"The Economic Value of Respiratory and Cardiovascular Hospitalizations," (ARB, 2003), calculated the cost of both respiratory and cardiovascular hospital admissions in California as the cost of illness plus associated costs such as loss of time for work, recreation and household production. CARB adjusts these COI values by the amount that annual medical care price increases for hospitalization exceed "all-item" price increases (CPI).

Table A-8 lists the valuation of avoiding various health effects, compiled from CARB and U.S. EPA publications, updated to 2005 dollars. The valuations based on WTP, as well as those based on wages, are adjusted for anticipated growth in real income.

[1] U.S. EPA's real income growth adjustment factor for premature death incorporates an elasticity estimate of 0.4.

Table A-8 Undiscounted Unit Values for Health Effects (in 2005 Dollars and current income levels) [1]

Health Endpoint	2005	2010	2020	References
Mortality				
Premature death ($ million)	7.9	8.1	8.6	U.S. EPA (1999), (2000), (2004)
Hospital Admissions				
Cardiovascular ($ thousands)	41	44	49	CARB (2003), p.63
Respiratory ($ thousands)	34	36	40	CARB (2003), p.63
Minor Illnesses				
Acute Bronchitis	422	440	450	U.S. EPA (2004), 9-158
Lower Respiratory Symptoms	19	19	20	U.S. EPA (2004), 9-158
Work loss day	180	195	227	2002 California wage data, U.S. Department of Labor
Minor restricted activity day (MRAD)	60	62	64	U.S. EPA (2004), 9-159
School absence day	88	95	111	U.S. EPA (2004), 9-159

[1]The value for premature death is adjusted for projected real income growth, net of 0.4 elasticity. Wage-based values (School absences, Work Loss Days) are adjusted for projected real income growth, as are WTP-derived values, (Lower Respiratory Symptoms, Acute Bronchitis, and MRADs). Health endpoint values based on cost-of-illness, (Cardiovascular and Respiratory Hospitalizations), are adjusted for the amount by which projected CPI for Medical Care (hospitalization) exceeds all-item CPI.

F. Uncertainty Calculations

Health impacts, (the number of cases), were estimated with a range that reflects the uncertainty of the underlying concentration-response functions. Per-case economic valuations of health impacts also reflect the uncertainty of the economic estimation. For estimates of the value of premature death, or VSL, this uncertainty is considerable.

Calculating an economic value for any health endpoint entails multiplying the health impacts (number of cases) by the per-case economic valuations. To calculate the uncertainty of the economic value of premature deaths, staff used standard statistical analysis to combine the uncertainty of the concentration-response function (used to derive the number of cases) with the uncertainty of the per-case economic valuation. Based on this method,[1] staff estimated the upper and lower bounds of the 95-percent

[1] The valuation of premature death is the product of multiplying two quantities together: the number of premature deaths times the value of statistical life (VSL). The uncertainty in the valuation depends on the uncertainties in these two quantities. The number of premature deaths appears to have a normal

confidence interval for the economic value of premature deaths avoided by the regulation.

The uncertainty range of our estimates for GM-related premature mortality impacts far exceeds the total uncertainty from all non-mortality health impacts combined. For non-mortality health endpoints, therefore, we did not develop procedures for combining health impact uncertainty with economic valuation uncertainty. For all non-mortality health endpoints our estimates of economic impact reflect only the uncertainty of underlying concentration-response functions.

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distribution. VSL has a lognormal distribution. Because their product does not have a recognized statistical distribution, we calculate it by numerical integration. From numerical integration, we obtained: 2.5th percentile = 0.31; and 97.5th percentile = 1.88. Therefore the lower bound of the 95% CI equals 0.31 of the calculated mean and the upper bound equals 1.88 times the calculated mean. We used these factors to calculate the upper and lower 95% CI for our dollar estimate of premature mortality impacts.

IV. Results

A. Emissions Estimates

The mass-based calculation of health impacts requires a statewide emissions inventory, and an emissions inventory representing goods movement. Both of these inventories are adjusted to account for the dispersion of emissions generated by ocean-going ships and harbor craft, as described above.

Table A-9 provides ports and goods movement emissions, by pollutant, that have been adjusted to reflect the dispersion adjustment factor for diesel PM. To adjust for dispersion, all emissions over water were discounted by 90% except for emissions within 3 miles of the San Diego and San Francisco Bay Area Air Basins, which were discounted by 75%. Diesel PM emissions associated with the health risk assessment of the Port of Los Angeles and Long Beach are excluded from Table A-9. Those emissions are excluded because they are not used to calculate health impacts; instead, the Ports' health risk assessment is used to calculate health impacts.

Table A-9 Dispersion-Adjusted Goods Movement Emissions Inventory

Pollutant	2005	2010	2015	2020
Diesel PM	42	30	21	17
NO_X	1,079	892	771	721
ROG	90	72	57	51
SO_X	95	108	138	182

Table A-10 provides a summary of the dispersion-adjusted draft 2006 statewide emissions inventory, including ocean-going ships out to 24 nautical miles from shore. To adjust for dispersion, all emissions over water were discounted by 90% except for emissions within 3 miles of the San Diego and San Francisco Bay Area air basins, which were discounted by 75%.

Table A-10 Dispersion-Adjusted Statewide Emissions[1]

Pollutant	1998	2000	2005	2010	2015	2020
Diesel PM	74	71	67	57	48	43
NO_X	3,865	3,787	3,161	2,651	2,226	2,021
ROG	3,340	3,126	2,424	2,155	2,031	1,985
SO_X	228	265	264	290	329	381

[1]Biogenic, geogenic, wildfires, windblown dust are included for NO_X and SO_X, but not for other pollutants.

B. Exposure Estimates

Table A-11 summarizes the exposure estimates used in the analysis of the health impacts. These are estimated population-weighted concentrations for each air basin of California using the methodology described in the previous section. They provide an integrated regional perspective rather than an indication of exposure at any individual location, but are consistent with how the concentration-response functions are derived in the epidemiological studies.

Table A-11 Exposure Estimates by Air Basin.

Base Year	1998	1998	2000	2000	2003
AIR BASIN	Nitrate[1] ($\mu g/m^3$)	Sulfate[2] ($\mu g/m^3$)	SOA[3] ($\mu g/m^3$)	DPM[4] ($\mu g/m^3$)	O_3[5] (ppm)
Great Basin Valleys	0.77	0.49	0.40	0.10	0.084
Lake County	0.80	0.39	0.51	0.20	0.071
Lake Tahoe	0.32	0.19	0.30	0.40	0.081
Mojave Desert	2.71	0.95	0.61	0.40	0.117
Mountain Counties	1.00	0.63	0.70	0.40	0.122
North Central Coast	1.00	0.43	0.61	0.80	0.089
North Coast	0.55	0.30	0.34	0.80	0.068
Northeast Plateau	0.32	0.20	0.32	0.70	0.072
Sacramento Valley	1.13	0.62	0.98	1.20	0.111
Salton Sea	2.32	1.29	0.32	1.50	0.119
San Diego	2.64	0.82	0.63	1.40	0.101
San Francisco Bay	1.05	0.52	0.73	1.60	0.098
San Joaquin Valley	1.79	1.31	0.73	1.30	0.122
South Central Coast	1.58	1.07	0.62	1.10	0.103
South Coast	4.63	1.16	1.11	2.40	0.146
CALIFORNIA	2.87	0.94	0.88	1.80	N/A

[1] Particle nitrate exposure based on inverse-distance-weighted and population-weighted annual geometric means for particle nitrate.

[2] Particle sulfate exposure based inverse-distance-weighted and population-weighted annual geometric mean for particle sulfate. Although it is presented here, particle sulfate was not part of our health impacts assessment in this report.

[3] Secondary organic aerosol (SOA) exposure based on inverse-distance-weighted and population-weighted annual arithmetic means for secondary organic aerosols.

[4] Diesel PM (DPM) is derived from receptor modeling results, emissions, and monitoring data.

[5] Ozone 1-hour peak indicator is based on 2001-2003 data and provides the basis for the assessment of the health impacts of exposures above the ozone ambient air quality standards. For details, see Appendix B of the ozone standard staff report (CARB/OEHHA 2005b).

C. Health Impacts Assessment

The next series of tables present the results of our health impacts assessment. Tables A-12 through A-15 present results that include those modeled for the SoCAB ports. In other words, information from Table A-16 is already incorporated into Tables A-12 through A-15. All results have been rounded to two significant figures; hence, the totals may not add up exactly.

1. Statewide Impacts

Shown in Table A-12-a is a summary of the combined statewide health effects from PM and ozone exposure linked with goods movement. We estimate that 2,400 premature deaths (720 – 4,100, 95% confidence interval (95%CI)) can be associated with goods movement emissions, annually on a statewide basis. Table A-12-b shows the statewide valuation of health effects associated with goods movement within California. The values reported in this table result from multiplying number of health effects cases reported in Table A-12-a by the unit valuations of Table A-8, discounted at 3% and 7% per year, using the discount rates recommended by U.S. EPA's guidance on social discounting (U.S. EPA, 2000). A detailed discussion of the discount rates can be found in Section D.

2. Air Basin-Specific Impacts

Since the majority of the economic impact arises from the estimated number of premature death, more detailed analysis of this health endpoint was conducted. For example, the number of premature deaths was calculated for each air basin (Table A-13). Our analysis showed about 50% of the premature deaths associated with goods movement occur in the SoCAB, while the San Diego County, San Francisco Bay Area, and San Joaquin Valley Air Basins collectively accounted for 27%. Moreover, for the SoCAB, goods movement-related health impacts account for a large portion of the total impact of ozone and PM pollution from all sources.

Table A-12-a Statewide PM and Ozone Health Effects Associated with Ports and Goods Movement[1] (Uncertainty range in parentheses)

Health Outcome	2005	2010	2020
Premature Death	2,400 (720-4,100)	2,000 (610-3,400)	1,700 (500-2,800)
Hospital Admissions (respiratory causes)	2,000 (1,200-2,800)	1,700 (1,000-2,400)	1,500 (860-2,100)
Hospital Admissions (cardiovascular causes)	830 (530-1,300)	710 (450-1,100)	580 (360-890)
Asthma and Other Lower Respiratory Symptoms	62,000 (24,000-99,000)	52,000 (20,000-83,000)	42,000 (16,000-66,000)
Acute Bronchitis	5,100 (-1,200-11,000)	4,300 (-1,000-9,300)	3,400 (-820-7,500)
Work Loss Days	360,000 (310,000-420,000)	310,000 (260,000-350,000)	250,000 (210,000-290,000)
Minor Restricted Activity Day	3,900,000 (2,200,000-5,800,000)	3,300,000 (1,900,000-5,000,000)	2,800,00 (1,500,000-4,100,000)
School Absence Days	1,100,000 (460,000-1,800,000)	1,000,000 (410,000-1,600,000)	860,000 (350,000-1,400,000)

[1]Does not include the contributions from particle sulfate formed from SO_X emissions, which is being addressed with several ongoing emissions, measurement, and modeling studies. Range reflects uncertainty in health concentration-response functions, but not in emissions or exposure estimates. A negative value as a lower bound of the uncertainty range is not meant to imply that exposure to pollutants is beneficial; rather, it is a reflection of the adequacy of the data used to develop these uncertainty range estimates. Additional details on the methodology and the studies used in this analysis are given in earlier sections of the Appendix.

Table A-12-b Economic Valuation of Statewide PM and Ozone Health Effects Associated with Ports and Goods Movement in present value dollars[1]

(Uncertainty range in parentheses)

Health Outcome	2005 ($million)	2010 ($million)	2020 ($million)
Premature Death	$19,000 ($5,900-$36,000)	$13,000 to $15,000 ($3,900-$28,000)	$5,500 to $9,400 ($1,700-$18,000)
Hospital Admissions (respiratory causes)	$67 ($40-$93)	$47 to $55 ($28-$77)	$23 to $39 ($13-$55)
Hospital Admissions (cardiovascular causes)	$34 ($22-$53)	$23 to $27 ($15-$42)	$11 to $19 ($6.9-$29)
Asthma and Other Lower Respiratory Symptoms	$1.1 ($0.44-$1.8)	$0.77 to $0.89 ($0.30-$1.4)	$0.32 to $0.54 ($0.12-$0.87)
Acute Bronchitis	$2.2 ($-0.52-$4.7)	$1.4 to $1.7 ($-0.35-$3.7)	$0.60 to $1.0 ($-0.14-$2.2)
Work Loss Days	$65 ($55-$75)	$46 to $53 ($39-$61)	$22 to $37 ($19-$43)
Minor Restricted Activity Day	$230 ($130-$350)	$160 to $190 ($88-$280)	$69 to $120 ($38-$170)
School Absence Days	$100 ($41-$160)	$72 to $84 ($29-$140)	$37 to $63 ($15-$100)
Total	$19,000 ($6,000 - $36,000)	$13,000 to $15,000 ($4,000 - $28,000)	$5,700 to $9,700 ($2,000 - $18,000)

[1]Valuation in millions of 2005 dollars. @ 3% - discounted at 3% per year, @ 7% - discounted at 7% per year. The health impacts associated with the economic values in this table do not include the contributions from particle sulfate formed from SO_X emissions, which is being addressed with several ongoing emissions, measurement, and modeling studies. Range reflects uncertainty in health concentration-response functions for morbidity endpoints and combined uncertainty in concentration-response functions and economic values for premature death, but not in emissions or exposure estimates. A negative value as a lower bound of the uncertainty range is not meant to imply that exposure to pollutants is beneficial; rather, it is a reflection of the adequacy of the data used to develop these uncertainty range estimates. Additional details on the methodology and the studies used in this analysis are given in earlier sections of the Appendix.

Table A-13 Basin-Specific Mortality Effects Associated with Ports and Goods Movement[1]

Year	2005		2010		2020	
Air Basin	Mean Deaths	Uncertainty Range	Mean Deaths	Uncertainty Range	Mean Deaths	Uncertainty Range
Great Basin Valleys	<1	(<1)	<1	(<1)	<1	(<1)
Lake County	<1	(<1)	<1	(<1)	<1	(<1)
Lake Tahoe	1	(<1-1)	<1	(<1-1)	<1	(<1-1)
Mountain Counties	16	(5-27)	12	(4-20)	8	(3-14)
Mojave Desert	150	(54-250)	120	(43-200)	90	(31-140)
North Coast	2	(1-3)	2	(<1-3)	1	(<1-2)
North Central Coast	14	(4-24)	10	(3-17)	6	(2-11)
Northeast Plateau	5	(1-8)	3	(1-6)	2	(1-4)
South Coast	1,200	(360-2,100)	1100	(310-1,800)	800	(240-1,400)
South Central Coast	69	(21-120)	73	(22-120)	97	(30-160)
San Diego	150	(44-260)	140	(41-240)	200	(57-340)
San Francisco	220	(61-380)	190	(53-330)	180	(50-300)
San Joaquin Valley	270	(84-460)	200	(63-340)	120	(39-210)
Salton Sea	140	(43-230)	110	(36-190)	79	(25-130)
Sacramento Valley	140	(42-240)	110	(33-180)	75	(23-130)
Total	2,400	(720-4,100)	2,000	(610-3,400)	1,700	(500-2,800)

[1] Values are rounded. Mortality impacts do not include the contributions from particle sulfate formed from SO_X emissions, which is being addressed with several ongoing emissions, measurement, and modeling studies. Range reflects uncertainty in health concentration-response functions, but not in emissions or exposure estimates.

3. Source-Specific Impacts

We also investigated the contribution of specific goods movement-related sources to air pollution problems. We found that the source of air emissions most responsible for estimated the health impacts is trucking, with ocean going ships, rail and harbor craft as significant contributors (Table A-14). The relative ranking was similar for statewide estimates and for estimates of the health impacts in the major air basins (data not shown).

Table A-14 Mortality Effects Associated with Ports and Goods Movement: Contributions of Source Categories[1] (Uncertainty range in parentheses)

Source Category	2005 Number of deaths	2010 Number of deaths	2020 Number of deaths
Commercial Harbor Craft	140	120	85
	(41- 240)	(35-200)	(25-150)
Cargo Handling Equipment	43	38	16
	(13-73)	(11-64)	(5-28)
Ocean-Going Ships	210	290	540
	(63-360)	(86-490)	(160-910)
Rail (Locomotives)	270	230	290
	(84-460)	(69-380)	(89-490)
SoCAB Ports (modeled)	67	75	96
	(18-120)	(20-130)	26-170
Truck	1,500	1,200	580
	(460-2,600)	(360-2,000)	(180-990)
Transport Refrigeration Units	130	99	48
	(36-220)	(29-170)	(15-81)
STATEWIDE TOTAL	2,400	2,000	1,700
	(720-,4100)	(610-3400)	(500-2,800)

[1]Does not include the contributions from particle sulfate formed from SO_X emissions, which is being addressed with several ongoing emissions, measurement, and modeling studies. Range reflects uncertainty in health concentration-response functions, but not in emissions or exposure estimates.

4. Pollutant-Specific Impacts

The contribution of primary diesel PM, secondary particle nitrate, secondary organic aerosols, other primary PM2.5, and ozone to the mortality estimates are summarized in Table A-15.

Table A-15
Mortality Effects Associated with Goods Movement: Pollutant Contributions[1]
(Uncertainty range in parentheses)

Pollutant	Number of Deaths in Each Year		
	2005	2010	2020[2]
Primary Diesel PM	1,200 (330-2,000)	920 (260-1,600)	630 (170-1,100)
Secondary Diesel PM (Nitrate)	940 (260-1600)	850 (240-1,500)	790 (220-1,400)
Secondary Organic Aerosols	29 (8-50)	25 (7-43)	20 (5-34)
Other Primary PM2.5[3]	23 (6-39)	26 (7-44)	41 (11-71)
Ozone	240 (120-350)	210 (100-310)	180 (88-260)
Statewide Total	2,400 (720-4,100)	2,000 (610-3,400)	1,700 (500-2,800)

[1]Does not include the contributions from particle sulfate formed from SO_X emissions, which is being addressed with several ongoing emissions, measurement, and modeling studies. Range reflects uncertainty in health concentration-response functions, but not in emissions or exposure estimates.

[2]These values may overestimate the health impacts if the state ambient air quality standards for particulate matter and ozone are attained by the year 2020.

[3]PM2.5 includes truck tire wear and brake wear, and particles from ship boilers, which are not covered under primary diesel PM.

5. Cancer Risk

For diesel PM, the regional "background" risk in urban areas is 500-800 potential cancers per million people over a 70-year period. For areas in close proximity to major diesel sources, the increase in potential cancer risk can exceed 500 potential cancers per million people over a 70-year exposure period, effectively doubling the risks of those exposed. Since the concentration of diesel PM in the air declines with distance from the source, risks decrease the farther one moves away from goods movement activity centers. However, even several miles away, the elevated cancer risk can still exceed 10 expected cancers per million people exposed. To put these risk numbers into perspective, new stationary sources of air pollution, such as power plants and other industrial facilities are currently required to be designed to ensure that cancer risk from an individual source do not exceed 10 potential cancers per million persons exposed.

Based on CARB's preliminary work, cargo-handling equipment and ship hotelling activities are anticipated to be the largest contributors of toxic pollutants to neighboring communities. While ocean-going vessel transiting emissions contribute a substantial portion of the total port-related diesel PM, they do not produce a comparable cancer risk because those emissions are distributed over a very wide area. Most of the diesel PM emissions (90%) are emitted during transit in California Coastal Waters. In addition, the emission plume from ocean- going vessels has a much higher dispersion release height due to a higher physical stack height (about 50 meters) of the vessel. Cargo handling equipment and ship hotelling activities, on the other hand, occur in closer proximity to the affected communities and cargo handling equipment has a much lower dispersion release because of a relatively lower physical stack height (about 4-5 meters). CARB staff plans to have more detailed exposure assessments available in the future.

6. Port-Specific Impacts

Based on the methodology described above in section D-3, we estimated the non-cancer health effects, including premature death, hospital admissions, asthma and other lower respiratory symptoms, work loss days, and minor restricted activity days, for the Ports of Los Angeles (POLA) and Ports of Long Beach (POLB) and for five different years. The results for years 2005, 2010, and 2020 are summarized in Table A-16. Note that these results are derived from the POLA and POLB and cannot be applied to other ports. This is because that the non-cancer health effects depend on several factors: port activity pattern, emission spatial and temporal allocation, relations of the emission source versus receptor distance, the population density in the nearby communities, topographical feature in the ports and surrounding areas, and meteorological conditions. These results have been incorporated into Tables A-12 through A-15.

Table A-16 Non-Cancer Health Effects from Activities at the Ports of Los Angeles and Long Beach[1]

Health Outcome	2005	2010	2020
Premature Death	67 (18-120)	75 (20 – 130)	96 (30 – 170)
Hospital Admissions (respiratory causes)	14 (9 – 20)	16 (10- 22)	21 (13 – 29)
Hospital Admissions (cardiovascular causes)	27 (17-41)	30 (29-46)	38 (24 – 60)
Asthma and Other Lower Respiratory Symptoms	2,100 (780-3,300)	2,300 (880 – 3,700)	3,000 (1,100 – 4,800)
Acute Bronchitis	170 (-40 – 390)	190 (-150 – 430)	250 (-58 – 560)
Work Loss Days	12,000 (10,000 – 14,000)	14,000 (12,000 – 16,000)	18,000 (15,000 – 20,000)
Minor Restricted Activity Day	71,000 (58,000 – 84,000)	79,000 (64,000 – 94,000)	100,000 (83,000 – 120,000)

[1]Does not include the contributions from particle sulfate formed from SO_X emissions, which is being addressed with several ongoing emissions, measurement, and modeling studies. Range reflects uncertainty in health concentration-response functions, but not in emissions or exposure estimates. A negative value as a lower bound of the uncertainty range is not meant to imply that exposure to pollutants is beneficial; rather, it is a reflection of the adequacy of the data used to develop these uncertainty range estimates. Additional details on the methodology and the studies used in this analysis are given in earlier sections of the Appendix.

D. Economic Valuation of Health Effects

Table A-17 shows the value of health effects associated with goods movement within California. The estimates in this table result from multiplying the mean number of health effects cases, from Table A-12-a, by their undiscounted unit values, from Table A-8, and discounting the value of future health effects at both 3% and 7% per year, rates recommended by U.S. EPA's guidance on social discounting (U.S. EPA, 2000).

Table A-17 Value of Statewide Health Effects of Ozone and PM Associated with Goods Movement in California (Millions of current value dollars)

Health Outcome	2005 Value[1]	2010 Val. @ 3%	2010 Val. @ 7%	2020 Val. @ 3%	2020 Val. @ 7%
Premature Death	$19,000	$15,000	$13,000	$9,400	$5,500
Hospital Admissions (respiratory causes)	$67	$55	$47	$39	$23
Hospital Admissions (cardiovascular causes)	$34	$27	$23	$19	$11
Asthma and Other Lower Respiratory Symptoms	$1.1	$0.89	$0.77	$0.54	$0.32
Acute Bronchitis	$2.2	$1.7	$1.4	$1.0	$0.60
Work Loss Days	$65	$53	$46	$37	$22
Minor Restricted Activity Day	$230	$190	$160	$120	$69
School Absence Days	$100	$84	$72	$63	$37

[1]Values are expressed in millions of 2005 dollars. 2005 values are undiscounted. 2010 and 2020 values are discounted at 3% and 7% per year.

Table A-17 shows the sensitivity of health effects values to the choice of social discount rates. Social discounting represents society's preference for present benefits over future benefits. The value of future health impacts discounted to the present becomes smaller, and signals a preference for immediate impacts, putting more emphasis on programs with earlier air pollution reductions. Lower rates discount the value of future health impacts less, resulting in values closer to present, undiscounted values. The range of discount rates in Table A-17 shows that a 7- percent discount rate signals a higher preference for present health impacts than a 3 percent rate. For example, the present value of premature deaths associated with goods movement emissions in 2020 is much lower when discounted at 7 percent, ($5.5 billion), than at 3 percent ($9.4 billion).

V. Discussion

A. Health Impacts Assessment

1. Statewide Impacts

The California Air Resources Board assessed the potential health effects associated with exposure to air pollutants arising from port-related goods movement activities (port, rail, and truck) in the State. This analysis focused on particulate matter and ozone because they represent the majority of risk associated with exposure to outdoor air pollution, and there have been sufficient studies performed to allow quantification of the health effects associated with emission sources.

We estimate that 2,400 premature deaths (720 – 4,100, 95% confidence interval (95%CI)) can be associated with goods movement emissions, annually on a statewide basis. To put these mortality numbers into perspective, attaining the California PM and ozone standards statewide would annually prevent about 9,000 premature deaths (3,100 – 15,000) based on 1999-2000 PM and 2001-2003 ozone monitoring data, or 4% of all deaths[1]. This is greater than the number of deaths (4,200 – 7,400) linked to second-hand smoke in the year 2000. In comparison, motor vehicle crashes caused 3,200 deaths and homicides were responsible for 2,000 deaths. Other health endpoints quantified are hospital admissions for respiratory causes, hospital admissions for cardiovascular causes, asthma and other lower respiratory symptoms, acute bronchitis, work loss days, minor restricted activity days and school absences, ranging from hundreds, to hundreds of thousands of cases, annually. We also projected the annual numbers of cases of death and disease for the years 2010 and 2020.

Since the majority of the economic impact arises from the estimated number of premature death, more detailed analysis of this health endpoint was conducted. For example, the number of premature deaths was calculated for each air basin (Table A-13). Our analysis showed about 50% of the premature deaths associated with goods movement occur in the SoCAB, while the San Diego County, San Francisco Bay Area, and San Joaquin Valley Air Basins collectively accounted for 27%. Moreover, for the SoCAB, goods movement-related health impacts account for a large portion of the total impact of ozone and PM pollution from all sources.

We also investigated the contribution of specific goods movement-related sources to air pollution problems. We found that the source of air emissions most responsible for estimated the health impacts is trucking, with ocean going ships, rail, and harbor craft as significant contributors (Table A-14). The relative ranking was similar for statewide estimates and for estimates of the health impacts in the major air basins.

The relative contribution of primary diesel PM, secondary PM (nitrate produced from the atmospheric conversion of goods movement-related NO_X emissions), and ozone to our health impacts estimates was also assessed. While exposure to either PM or ozone is a serious public health issue, the current health impact of these pollutants are not equal.

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[1] According to the Department of Health Services, there are about 235,000 annual deaths due to all causes in California (based on 2001-2003 data)

For example, statewide, it is estimated that ozone exposure above the proposed California eight- hour ozone standard contributes to approximately 630 premature deaths annually (CARB/OEHHA 2005b, Ostro et al. 2006). In contrast, exposure to PM2.5 above the California annual average standard can be associated with 8,200 premature deaths annually. In our goods movement assessment, we also found that the contribution of PM outweighs that of ozone by tenfold (Table A-15). Primary diesel PM is presently the major contributor to the total estimated premature deaths attributable to ports and goods movement, but, in 2020, secondary diesel PM (i.e., particle nitrate) becomes the most significant contributor as measures are already in place to be effective in controlling primary diesel PM emissions in the long run.

It is possible that this relatively large contribution of secondary PM can be mostly attributed to exposures in the SoCAB, which possesses the unique characteristic of a relatively high ambient nitrate concentration and a high population density.

Ambient ozone levels frequently exceed federal and state health protective standards, especially in Central and Southern California. Ports and related goods movement are major sources of the NO_X emissions that react in the atmosphere on warm, sunny days to form ozone. Ozone is a powerful oxidant that can damage the respiratory tract, cause lung inflammation, and irritation, which can lead to breathing difficulties. Statewide, it is estimated that ozone exposure, above the proposed California eight-hour ozone standard, contributed to approximately 630 premature deaths (CARB/OEHHA 2005b, Ostro et al. 2006). It is estimated (Table A-15) that goods movement contributes to approximately 240 premature deaths per year. These statewide numbers can be broken down by air basin to estimate the contribution of various sources to ozone health effects. For example, in the SoCAB, ozone air pollution contributed to approximately 300 additional instances of premature death, and it is estimated that goods movement contributes to approximately 71 premature deaths per year in the SoCAB. CARB staff will examine these and other air basin estimates in its mitigation plan.

Table A-17 shows the total valuation of the current health impacts associated with port-related goods movement and other port activities in California to be about $19 billion (in year 2005 dollars), with an uncertainty range of $6 billion to $36 billion.

2. Sensitivity Discussion

Several new epidemiology studies have recently been published which may also be relevant to the health impacts analysis. In November 2005, a study which analyzed PM exposure and premature death for the SoCAB was published (Jerrett et al. 2005). It found a 2.5 times higher estimate for premature death than the national study by Pope et al. (2002), but greater uncertainty. The 2.5-times higher result appears to be due to better exposure characterization techniques rather than higher toxicity of the PM mixture in Los Angeles. U.S. EPA has not adopted this study in its core health impacts analysis. Several additional studies have either just been published or will be in the next few months. CARB staff intends to review all of these studies and will solicit the advice of the study authors and other experts in the field and U.S. EPA to determine how to best incorporate these new results into our future assessments.

In addition, infant mortality is surfacing as an additional health endpoint in this type of analysis. We calculated a mean of 7 (3 – 11, 95% CI) infant deaths statewide from exposure to current goods movement pollution sources using the Woodruff et al. (1997) study and a mean of 12 (-13 to 36, 95% CI) for the Woodruff et al. (2006) study. It is important to note that the Woodruff et al. (1997) study uses exposures from an earlier period and does not contain California data, while the Woodruff et al. (2006) study is specific to California and examines more current exposures.

For PM-related respiratory hospital admissions, using the Linn et al. (2000) study for age 30+ would lead to a lower estimate compared to our quantified estimate based on pooling Zanobetti and Schwartz (2003) and Moolgavkar (2000a; 2003a) for age 18+.

Based on Ostro et al. (2001), asthma exacerbations associated with goods movement emissions would be lower than total cases for asthma and other lower respiratory symptoms quantified in our analysis. To avoid double-counting, only estimates for asthma and other lower respiratory symptoms are presented.

Similarly, McConnell et al. (1999) could be used to estimate acute bronchitis and chronic phlegm among asthmatic children. However, because lower respiratory symptoms (including asthma-related symptoms), acute bronchitis, and school loss days are already being quantified, there are concerns of double-counting effects in children. As a result, the asthma-related effects among children are not treated separately.

3. Port-Specific Impacts

Results for port-specific impacts are presented in Table A-16. Below, we discuss two related assessments that address diesel PM health risks near ports and rail yards.

a) Diesel PM Health Risk Assessments

Goods movement related activities are a significant source of exposures to diesel PM. Approximately 70% of the potential cancer risk from toxic air contaminates in California is due to diesel PM. For diesel PM, the regional "background" risk in urban areas is about 500-800 potential cancers per million people over a 70-year period[1]. For areas in close proximity to major diesel sources, such as ports, rail yards and along major transportation corridors, the increase in potential cancer risk can exceed 500 potential cancers per million people over a 70-year exposure period, effectively doubling the risks of those exposed. Since the concentration of diesel PM in the air declines with distance from the source, risks decrease the farther one moves away from goods movement activity centers. However, even several miles away, the elevated cancer risk can still exceed 10 expected cancers per million people exposed.

The potential cancer risks are highly dependent on site specific variables such as the meteorological conditions, the types of activities occurring, the locations and emissions rates of the equipment, operating schedules and the actual location of where people live in relation to the goods movement operation. To better understand the potential health risks associated with living near a goods movement operation, CARB staff conducted

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[1]The cancer risk from known carcinogens is expressed as the incremental number of potential cancers that could develop per million people exposed assuming the affected population is exposed to the carcinogen at a defined concentration over a presumed 70-year lifetime. The ratio of potential number of cancers per million people can also be interpreted as the incremental likelihood of an individual exposed to the carcinogen developing cancer from continuous exposure over a lifetime.

two key health risk assessments.[1] One was on a major port complex, and the other on a large rail yard. These health risk assessments were developed in cooperation with the owners and operators of those facilities, and using appropriate meteorological information and modeling techniques.

Below is a summary of the two studies, one for the Ports of Los Angeles and Long Beach located in Southern California, and the other for the J.R. Davis Rail Yard in Roseville, California.

b) Exposure Assessment Study for the Ports of Los Angeles and Long Beach

On October 3, 2005, CARB released the draft results from a diesel PM exposure assessment study for the Ports of Los Angeles and Long Beach. The purpose of the study was to enhance our understanding of the port-related diesel PM emission impacts by evaluating the relative contributions of the various diesel PM emission sources at the ports to the potential cancer risks to people living in communities near the ports. The study focused on the on-port property emissions from locomotives, on-road heavy-duty trucks, and cargo handling equipment used to move containerized and bulk cargo such as yard trucks, side-picks, rubber tire gantry cranes, and forklifts. The study also evaluated the at-berth and over-water emissions impacts from ocean-going vessel main and auxiliary engine emissions as well as commercial harbor craft such as passenger ferries and tugboats. For the ocean-going vessel emissions, the study evaluated the hotelling emissions, i.e., those emissions from vessel auxiliary engines while at berth, separately from the maneuvering and transiting emissions. While there are locomotive and on-road heavy-duty truck emissions associated with the movement of goods through the ports that occur off the port boundaries, these were not evaluated in this study.

The results of the risk assessment show a very large area impacted by the diesel PM emissions associated with the operations and activities of the Ports. Overall, the emissions from the Ports impact areas extending several miles from the Ports. The computer model estimates the risk in a 20-mile by 20-mile area (the study area), with about a 10 to 15 mile boundary around the Ports depending on the direction. The areas with the greatest impact outside of the Ports' boundaries have an estimated potential cancer risk of over 500 in a million and affect about 2,500 acres where 53,000 people live. The area where the risk is predicted to exceed 200 in a million is also very large, covering an area of about 29,000 acres where over 400,000 people live. At the edge of the modeling study area, referred to as the modeling receptor domain, the potential cancer risk was as high as 100 chances in a million in some areas. The affected land area where the predicted cancer risk is expected to be greater than 100 in a million is

[1]A risk assessment is a tool that is used to evaluate the potential for a chemical to cause cancer or other illness. A risk assessment used mathematical models to evaluate the health impacts from exposure to certain concentrations of chemical or toxic air pollutants released from a facility or found in the air. For cancer health effects, the risk is expressed as the number of chances in a population of a million people who might be expected to get cancer over a 70-year lifetime.

estimated to be about 93,500 acres in the study area. Impacts likely extend beyond the study area but were outside of the modeling receptor domain for this study.

The study revealed that cargo-handling equipment and ship hotelling activities are the largest contributors of toxic pollutants to neighboring communities. While ocean-going vessel transiting emissions contribute a substantial portion of the total port-related diesel PM, they did not produce a comparable cancer risk because these emissions are released off-shore and impact a very wide area.

c) Exposure Assessment Study for the J.R. Davis Rail Yard

In October 2004, the CARB released the results from the Roseville Rail Yard Study. The health risk assessment evaluated the impacts from the diesel PM emissions from diesel-fueled locomotives at the Union Pacific J.R. Davis Yard located in Roseville, California. The J.R. Davis Rail Yard serves as a classification, maintenance, and repair facility for Union Pacific Railroad. During the study period, approximately 31,000 locomotives visited the yard resulting in about 25 tons of diesel PM emissions per year. About 50% of the emissions were from moving locomotives, 45% from idling locomotives, and 5% due to locomotive testing. The results from the study showed that the diesel PM emissions from the Yard impacted a large area. Risk levels between 100 and 500 in a million occur over a 700 to 1600 acre area in which about 14,000 to 26,000 people live. Risk levels between 10 and 100 in a million occur over a 46,000 to 56,000 acre area in which about 140,000 to 155,000 people live.

B. Uncertainties and Limitations

There are a number of uncertainties involved in quantitatively estimating the health impacts associated with exposures to outdoor air pollution. Over time, some of these will be reduced as new research is conducted. However, some uncertainty will remain in any estimate. Below, some of the major uncertainties and limitations of the estimated health benefits presented in this report are briefly discussed.

1. Uncertainty Associated with Emissions Estimation

Emissions inventories are complex data sets that represent quantitative estimations of pollutant releases from stationary and mobile sources. These inventories evolve over time as data are updated. As a result, an emissions inventory presented at any given time represents a "snap shot" of the inventory at the time it was generated.

When compiling an emissions inventory, CARB staff assembled the best emissions data that are currently available. These estimates are subject to both variability and uncertainty. Examples of variability include using an average emission factor to represent emissions factors that change with time or other parameters; or representing activity with a single estimate, such as annual hours of equipment operation, when annual hours will vary over time. Examples of uncertainty include assuming an average emission factor from a limited number of vehicle source tests accurately reflects the true emission factor for a population of vehicles in a given area; or assuming a single load factor to represent the average of a population of equipment's operating cycle, when the true average operating cycle is not well characterized.

CARB staff follows a rigorous quality control process during emissions inventory compilation which is designed to minimize error. At every stage of inventory development emissions estimates are evaluated for potential coding and transcription errors. Emissions inventory totals are compared against similar studies and inventories to ensure emissions estimates are reasonable.

2. Exposure Estimates and Populations

Use of the C-R function requires an input of the pollutant concentration to which the population is being exposed. For diesel PM, this calls for the population-weighted diesel PM concentration. For the calculations presented in this report we used basin-specific population-weighted average concentrations, which were estimated by CARB staff for the identification of diesel exhaust as an air toxic contaminant. The estimation procedure relied on many assumptions, the best available data sets at that time, and a variety of calculation techniques. In brief, the foundations of the estimates were results from three special studies – chemical mass balance (CMB) receptor modeling for the San Joaquin Valley (1988-89 data), the South Coast Air Basin (1986 data), and the San Jose area (1991-92 data). The CMB species considered in these studies were organic carbon and elemental carbon, or total carbon, and several elements, and the studies established overall motor vehicle contributions to PM10 at sampling locations (the base year was taken to be 1990). Diesel contributions to PM10 were estimated by scaling the CMB motor vehicle results with factors determined by a special PM10 emission inventory (constructed by CARB) that included separate estimates for diesel emissions. Then these diesel PM10 concentration estimates for sampling locations were used in interpolation algorithms to estimate regional concentrations; a linear rollback scaling was used to project the estimates forward in time to 1995, 2000 and 2010. Areas outside the special studies' regions were approximated by the San Joaquin Valley diesel PM10 estimates (which were scaled using local emission inventories). Finally, the spatial concentrations were averaged with population number weights to obtain a population weighted diesel PM10 estimate.

Despite the fact that a unique tracer for diesel particulate emissions has not been found, several recent receptor-based estimates of ambient diesel particulate concentrations, including that developed by CARB, show overall consistency in values. The results from such studies are outlined and compared below.

The CARB-funded Children's Health Study (CHS) contained a component in which source contributions to ambient particles were determined for the year 1995. In this work, Schauer et al. (2001) analyzed particulate matter collected at 12 sampling sites in the South Coast Air Basin for 96 organic compounds. A subset of these compounds was used in CMB receptor-based apportionment modeling studies. In contrast to the above CMB modeling for the special studies, this CMB modeling was able to directly estimate diesel particulate contributions to ambient PM (to achieve this separation, a diesel source profile and six other source profiles were utilized).

A third, more recent, CMB modeling study was conducted in the South Coast Air Basin: DOE/NREL's "Gasoline/Diesel PM Split Study." In this project, two preeminent practitioners of organic compound-based PM CMB source apportionment – University of Wisconsin, Madison (J. Schauer) and Desert Research Institute (E. Fujita) – collected side-by-side mobile source samples (light and heavy-duty vehicle dynamometer tests) and ambient samples. Using these parallel samples, each group carried out independent chemical analyses, profile construction, and CMB modeling. Because of the many differences in sample collection and analysis techniques, profile construction methodologies, and CMB species selection and modeling, each group obtained different estimates for the contribution of diesel exhaust to ambient PM2.5. The relative contributions of gasoline and diesel exhaust to PM2.5 also differed: diesel contributed more than gasoline vehicle exhaust to PM2.5 in E. Fujita's analysis, and the opposite conclusion was found in J. Schauer's analysis.

Several estimates of diesel PM from the above studies are given in the table below. Direct comparisons for location and year are not possible. However, projected estimates from the CARB Diesel PM TAC study compare well in general with CHS's 1995 diesel PM mass estimates and with Gasoline/Diesel PM Split Study's estimates of diesel contributions to total carbon (which are likely close to mass contributions). The exception is J. Schauer's estimates of diesel PM2.5 for the Gasoline/Diesel PM Split Study, which is lower than both CARB's projected estimates and E. Fujita's parallel estimate (and his earlier CHS estimate). Further work is needed to clarify this discrepancy.

Table A-18 Estimated Diesel PM Concentrations.

Diesel PM concentration (μg/m³)					
Study	**Location**	**1990**	**1995**	**2000**	**2010**
CARB Diesel PM TAC Id.	SoCAB statewide	3.6 (±1.4) 3.0 (±1.1)	2.7 2.2	2.4 1.8	2.4 1.7
CHS	Long Beach Riverside		2.9 (±.3)[1] 1.7 (±.2)[1]		
Gasoline/Diesel Split Study	(Schauer) (Fujita)			0.4-1.5[2] 1.2-3.4[2]	

[1]Average over the year
[2]L.A. North Main, concentration of total carbon from diesel exhaust (2001, summer)

To the extent that there is not a method for directly measuring outdoor diesel PM concentrations, the uncertainty behind primary diesel PM concentrations is unquantified in our analyses.

A related issue is whether small changes in diesel PM concentrations due to goods movement can have a measurable effect on health. It is important to emphasize that while a change may be small, it is an incremental change from a statewide population-weighted PM2.5 average concentration of 18.5 μg/m³ (based on 1999/2000 data). For secondary diesel PM, particle nitrate monitoring data were used to interpolate and derive the basin-specific population-weighted concentrations. A sensitivity check using county-specific population-weighted concentrations revealed less than 5% change in the health impacts due to secondary sources. Due to insufficient information on particle sulfate, the health impacts associated with secondary diesel PM due to sulfate have not been quantified in this report.

For ozone, California has a monitoring network of approximately 175 monitors located throughout the State. In our ozone staff report (CARB 2005), hourly observations were input into the estimation of the health impacts of ozone exposures above the standard. Several scenarios of characterizing the ozone exposures were considered: averaging monitored values across each county, assigning portions of populations to monitored concentrations within each county, and interpolating exposures for each census tract. All three options led to very similar results

Nonetheless, there are likely uncertainties in the statewide ozone exposure assessment, and in whether the existing monitoring network provides representative estimates of exposure for the general population. We have attempted to reproduce the same relationship between ozone monitor readings and exposure as in the original epidemiological studies. Most of these studies use population-oriented, background, fixed site monitors, often aggregated to the county level. The available epidemiological studies have used multiple pollutant averaging times, and we have proposed conversion ratios for 1-hour to 8-hour and 24- hour ozone concentrations based on national estimates. A preliminary examination of the California monitoring data indicates that the ratios are similar to those found in the highly populated areas of the State. However, uncertainty is added to the estimated impacts of ozone exposure to the extent the converted concentration bases differ from monitored concentrations (CARB/OEHHA 2005b).

There exists some concern on quantifying the health effects due to exposures to outdoor air pollution while people spend much of their time indoors. We recognize this fact. However, the epidemiological studies considered in our review, which led to the chosen the concentration-response functions, found strong links between outdoor air pollution levels and adverse health effects. As more studies are developed to address indoor/outdoor exposures to air pollution, future health impact assessments will take into account the new results.

Related to the issue of exposure estimation is population. In this analysis, staff used population forecasts developed by the Department of Finance (years 2010, 2020) to estimate the health impacts. Without officially quantified uncertainty estimates, we did not incorporate this source of uncertainty in our calculations.

3. Concentration-Response Functions

A primary uncertainty is the choice of the specific studies and the associated concentration-response (C-R) functions used for quantification. Epidemiological studies used for these estimates have undergone extensive peer review and include sophisticated statistical models that account for the confounding effects of other pollutants, meteorology, and other factors. The C-R function used for quantification of death associated with PM exposures is based on a publication by Pope et al. (2002). Vital status and cause of death data were collected by the American Cancer Society as part of an ongoing prospective mortality study, which enrolled approximately 1.2 million adults in 1982. The risk factor data for approximately 500,000 adults were linked with air pollution data for metropolitan areas throughout the United States and combined with vital status and cause of death data through 1998. Pope's analysis updates the large data set analyzed in 1995 (Pope 1995) and re-analyzed in 2000 (Krewski 2000) with additional follow-up time (doubling it to more than 16 years and tripling the number of deaths), substantially expands exposure data, including gaseous co-pollutant data and new PM2.5 data, improves control of occupational exposures, incorporates dietary variables that account for total fat consumption, and consumption of vegetables, citrus, and high-fiber grains, and uses recent advances in statistical modeling for incorporating random effects and non-parametric spatial smoothing components.

While there may be questions on whether C-R functions from the epidemiological studies are applicable to California, it should be noted that some of the cities considered by Pope *et al.* are in California. Also, numerous studies have shown that the mortality effects of PM in California are comparable to those found in other locations in the United States. Several new epidemiology studies have recently been published which may also be relevant to the health impacts analysis. In November 2005, a study which analyzed PM exposure and premature death was published (Jerrett et al. 2005). It found a 2.5 times higher estimate for premature death than the national study by Pope et al. (2002), but greater uncertainty. Several additional studies have either just been published or will be in the next few months. CARB staff intends to review all of these studies and will solicit the advice of the study authors and other experts in the field and U.S. EPA to determine how to best incorporate these new results into our future assessments.

In addition, many of the studies were conducted in areas having fairly low concentrations of ambient PM, with ranges in PM levels that covers California values. Thus, the extrapolation is within the range of the studies. Finally, the uncertainty in the C-R functions selected is reflected in the lower and upper estimates given in all the health impacts tables, which represent 95% confidence intervals. For premature death, this estimated error amounts to about a 50% difference from the mean value.

The C-R function used for quantification of death associated with ozone exposures is based on a review of all the published literature on the subject. As detailed in the CARB/OEHHA ozone standard staff report (CARB/OEHHA 2005b), the estimates for the effects of ozone on death reflect the range provided in several studies. Recently, three new meta-analyses conducted by three independent teams of researchers confirmed the validity of the chosen function (Levy 2005, Ito 2005, Bell 2005). Below, we detail some issues with choosing the C-R functions for ozone-related health impacts.

Potential confounding by daily variations in co-pollutants and weather is an analytical issue to be considered. With respect to co-pollutants, daily variations in ozone tends not to correlate highly with most other criteria pollutants (e.g., CO, NO_2, SO_2, PM10), but may be more correlated with secondary fine particulate matter (e.g., PM2.5) measured during the summer months. Assessing the independent health effects of two pollutants that are somewhat correlated over time is problematic. However, much can be learned from the classic approach of first estimating the effects of each pollutant individually, and then estimating their effects in a two-pollutant model. For this reason, we have emphasized use of ozone studies that have also controlled for PM.

The choice of the studies and concentration-response functions used for health impact assessment can affect the impact estimates. Because of differences, likely related to study location, subject population, study size and duration, and analytical methods, effect estimates differ somewhat between studies. We have addressed this issue by emphasizing meta-analyses and multi-city studies, and also by presenting estimates derived from several studies. For ozone deaths, studies of short-term exposure and mortality have been replicated in many cities throughout the world, under a wide range of exposure conditions, climates and covarying pollutants. As a result, the evidence of an effect of ozone on premature mortality is compelling, especially with the recently published meta-analyses of the effect. Nevertheless, uncertainty remains about the actual magnitude of the effect and the appropriate confidence interval.

Finally, on the question of relative toxicity of diesel PM compared to PM2.5, in this assessment, staff assumed diesel PM is equally toxic as PM2.5. Without definitive evidence to include otherwise, this approach may underestimate the true effects of diesel PM exposures on adverse health effects.

4. Baseline Rates of Mortality and Morbidity

Mortality and morbidity baseline rates are entered into the C-R functions in order to calculate the estimates presented in this report, and there is uncertainty in these baseline rates. Often, one must assume a baseline incidence level to be consistent throughout the city or country of interest. In addition, incidence can change over time as health habits, income and other factors change. For this analysis, we used baseline rates that are used by U.S. EPA. Some of the rates were collected from Department of Health Services and Office of Statewide Health Planning and Development. It is expected that incidence rates may change over time. However, without any peer-reviewed information on projections of mortality and morbidity rates into the future, we opted to assume the current rates would remain and only adjusted future estimates for population shifts.

5. Health Effects from Sulfate Exposure

Emissions of sulfur oxides (SO_X) contribute to particle sulfate formation (and PM-related health effects) through complex chemical reactions and physical processes in the atmosphere. Stringent regulations on the sulfur content of motor fuels and stationary source controls have minimized SO_X emissions from most California sources. The largest uncontrolled fossil fuel sulfur source in California is the burning of residual oil as fuel in ocean-going vessels.

The December 2005 draft of this report did not include a quantitative health assessment of particle sulfate formed from goods movement-related emissions of SO_X. Any analysis is complicated by the fact that, in addition to sulfate formed from fossil fuel use in California, there are three other sources of atmospheric sulfate in California – natural "background" sulfate formed over the ocean by biologic activity, global "background" sulfate that is distributed throughout the Northern Hemisphere by the upper air westerly winds, and sulfate blown into Southern California from combustion in Mexico. New analyses of air quality and emissions data conducted in the intervening period indicate that uncontrolled SO_X emissions from ships increase the estimates of total goods movement-related health effects by about one quarter. However, this preliminary estimate contains several uncertainties, e.g., a considerable uncertainty associated with estimating ship emissions, and proper characterization of transport of transoceanic pollutants. Thus, a fully quantitative analysis must await the completion (by end of 2006) of research being jointly conducted by CARB staff, five university groups, the U.S. EPA, and Environment Canada as part of a feasibility study for establishing a SO_X Emission Control Area (SECA) to reduce sulfur emissions from West Coast shipping. The research includes a refined inventory of ship activity and ship emissions, analysis of historical PM data from sites along the West Coast to look for evidence of ship emissions, development of new monitoring methods that can distinguish fossil fuel sulfate from that due to biologic activity in the ocean, and model development to allow simulation of sulfate formation and transport over the ocean and land areas of coastal California.

6. Unquantified Adverse Effects

An additional limitation in this analysis is that we did not quantify all possible health benefits that could be associated with reducing diesel PM and ozone exposure. Although the analysis illustrates that reduction in diesel PM and ozone exposure would confer health benefits to people living in California, we did not provide estimates for all endpoints for which there are C-R functions available. Unquantified health effects due to PM exposures include myocardial infarction (heart attack), chronic bronchitis, onset of asthma, and asthma attacks, as there is some overlap between these and the quantified effects such as lower respiratory symptoms and all respiratory and all cardiovascular hospitalizations. In addition, estimates of the effects of PM on premature births, and low birth weight, and reduced lung function growth in children are not presented. While these endpoints are significant in an assessment of the public health impacts of diesel exhaust emissions, there are currently few published investigations on these topics. Also, the results of the studies that are available are not entirely consistent. Nevertheless, there are some data supporting a relationship between PM exposure and these effects, and there is ongoing research in these areas that should help to clarify the role of diesel exhaust PM on these endpoints.

We recognize a multitude of endpoints that may contribute to impacting health. However, the weight of evidence to date was deemed insufficient to warrant quantification in our report. These include but are not limited to: psychosocial factors (stress), noise (including cardiovascular effects), light and its effects on sleep, major occupational issues including workplace exposures and injuries, traffic accidents and associated morbidity/mortality, other transportation related issues, and environmental consequences, quality of life, morbidity over extended periods of time, neurological disease, and developmental effects.

There is also evidence for other non-cancer health effects that are attributable to diesel exhaust PM exposure. For example, diesel PM apparently can act as an adjuvant in allergic responses and possibly asthma. However, additional research is needed at diesel exhaust concentrations that more closely approximate current ambient levels before the effect of diesel PM exposure on allergy and asthma rates is established. Also, because these endpoints have been investigated only in controlled exposure studies, population level C-R functions are not available for making estimates of the population-wide impacts of exposure.

Taken as a whole, the results of our limited analysis support the conclusion that reduction in emissions from Goods Movement will confer health benefits to the exposed population. However, since we did not make estimates for all possible endpoints, it is likely that we have underestimated the health benefits in this analysis. Also, since we have been able to quantify all sources of uncertainty, the range behind our estimates is likely smaller than they should be.

7. Uncertainty Associated with Economic Valuation

The unit valuation for premature mortality, often referred to as the "value of a statistical life", is based on 26 studies (U.S. EPA, 1999). The estimates from these 26 studies fit a lognormal distribution with shape parameter, leading to an estimate of uncertainty. Similar data were available for Minor Restricted Activity Days. For the other health effects, we do not have a range in the unit valuation, so we were not able to calculate a quantitative estimate of the uncertainty in the unit valuation. Since the economic valuation of premature mortality, and uncertainty thereof, overwhelms the economic values of non-mortality effects, it was deemed appropriate to quantify the uncertainty associated with economic valuation behind mortality valuations only.

C. Ongoing Studies to Reduce Uncertainties

1. Emissions

There are a number of studies underway or planned for the near future which will improve our estimates of the emissions associated with ports and goods movement. For ocean-going ships, emission factors will be refined based on emission test data for propulsion and auxiliary engines. Emission testing of both bunker and marine diesel oil fired auxiliary engines is underway to provide better emission factors for ship auxiliary engines, based on type of fuel used. Emissions from ship boilers will be added into emissions inventory and information on anchorage emissions will be assessed for inclusion into emission inventory efforts. Emission testing of locomotives and ocean-going ships will be used as the basis for developing updates to size/speciation profiles for modeling efforts. For cargo handling yard trucks, emission testing of in-use vehicles equipped with diesel fueled off-road, on-road, and propane fueled engines are being performed to provide additional emission factor data. Data logging programs are underway to obtain better load factor information used in estimating emissions. CARB is participating with Starcrest Consulting Group, LLC programs to update emissions inventories for the Port of Long Beach and Los Angeles. Updated information from these inventories, such as equipment populations, activity, and load factors, will be used to refine CARB statewide emission inventories.

CARB is also working with the U.S. EPA, Environment Canada, and the Mexico National Institute of Ecology to assess the benefits of a SO_X Emission Control Area (SECA) designation. The overall goals of that work are to improve our understanding (i.e., reduce uncertainties) in the modeling of offshore transport and transportation of commercial marine vessels (CMV) emissions and to quantify the health and welfare impacts of CMV emissions using modeling and observation-based approaches. Several SECA projects are underway, including improved CMV emission inventories, air quality modeling efforts in the SoCAB and Central California, PM source apportionment, and ambient isotope analysis.

Work to improve emission estimates for other transportation sectors will also take place. Under the new 2005 Railroad Agreement, risk assessments will be performed over the next 30 months at 16 rail yards throughout the state. CARB will receive detailed emission inventories (for both criteria pollutants and TACs) for all sources (mobile and stationary) at these facilities as part of this effort. The rail yards that will be included in this effort are identified in Attachment A of the Agreement, and generally represent the larger rail yards in the State. Another effort to improve the emission inventory for railroads will investigate the feasibility of using remote sensing technologies to measure emissions from locomotives. Assembly Bill 1222 requires CARB, in conjunction with the railroads, and the Sacramento Metropolitan and South Coast Air Quality Management Districts, to evaluate the feasibility of locomotive remote sensing. A report to the Legislature on the study will be prepared by December 31, 2006. Remote sensing, as it is being applied to locomotives, is a system that is designed to quantify in-use emissions as a locomotive passes a point along a track segment, and to ideally determine if that locomotive is operating within its emission certification levels. The intent would be to identify and tag for repair locomotives that have excessive emissions. The benefits of this program would be to reduce the number of "high polluting" locomotives in California service, but the anticipate emission reductions are unknown at this time as there is no estimate of what the population of high polluting locomotive baseline is. It is also unknown at this time if this technology will even work as described above, as it has not yet been demonstrated on locomotives.

Emissions from diesel trucks are a component of Goods Movement. Emissions associated with diesel engines are of great interest to CARB and for that reason, the Board co-funded an emissions test project, conducted under the auspices of the Coordinating Research Council (CRC). The project was recently completed. During this project, a total of 75 heavy-duty trucks (HDTs) were emissions tested over up to six test cycles. For a significant subset of these HDTs (about 30), two or three repeat tests of each test cycle were performed. In addition to mass emissions, a small subset also had chemical analyses performed, and a subset of these vehicles also had repeat emissions sampled for replicate chemical analyses. Analysis of these data will permit insights to be gained regarding the amount of variability or uncertainty associated with these emissions and chemistry data.

2. Exposure

Multiple studies are currently under way that will improve the characterization of emission sources related to Goods Movement and the associated the air quality impacts.

Regional air quality modeling is being conducted to address the 2007 Ozone SIP and the 2008 PM2.5 SIP. The best available emissions estimates from Goods Movement sources will be incorporated in these analyses. Under these SIP modeling projects, the impacts from these emissions can be evaluated on a regional basis throughout each of the SIP modeling domains.

Community Health Modeling is being conducted in the Wilmington region of Southern California using both regional and micro-scale modeling tools. These modeling studies include the best available emission estimates within and surrounding the Wilmington neighborhood, including the Ports of Los Angeles and Long Beach as well as emissions from trains and trucks. The dispersion of neighborhood-scale emissions within and surrounding Wilmington will be simulated with a Gaussian plume dispersion model to evaluate near field impacts (i.e., resolved within a scale of hundreds of meters). The CalPuff air quality model will also be used to evaluate the impacts from sources, including Goods Movement sources, on areas further downwind from Wilmington (e.g., Los Angeles and Riverside). In addition, regional modeling of toxics will be conducted using the CAMx photochemical model within the SoCAB that surrounds Wilmington. These regional simulations account for the impacts of regional sources on air quality within the Wilmington neighborhood. A saturation monitoring study within Wilmington, including the use of passive monitoring techniques, is in the early planning stages and may provide a sufficient data set by which to assess model performance and micro-scale emissions inventory characterization.

As mentioned early, several SECA projects, including source apportionment and ambient measurements, are planned or underway to assess the impacts of ship emissions. The objective of these two projects is to quantify the contribution of ship emissions to ambient coastal PM using an advanced statistical technique (Positive Matrix Factorization) and a suite of instrumentation, including Aerosol time-of-flight mass spectrometers (ATOFMS) and isotope measurements, respectively. The outcome of these projects is expected to improve our exposure estimates attributed from ship emissions.

Studies on diesel PM emission sources in the Port of Los Angeles and the Port of Long Beach are underway. In addition, an analysis for diesel PM emissions from the port rail yard provides a good assessment of impacts near the rail yards. These studies represent a good first step in characterizing the magnitude of air quality impacts from these two major ports. Initial modeling has been conducted using a Gaussian plume dispersion model. This can be enhanced with a more advanced modeling tool, such as CalPuff (also to be used in the Wilmington study described earlier), to assess air quality impacts on larger, regional scale.

The Community Air Risk Evaluation (CARE) program was initiated by the Bay Area District in July 2004 and its goal is to evaluate health risk from air toxics in the nine Bay Area counties. The program includes enhanced air monitoring and analysis that will better determine the relative contribution of air pollution sources including vehicular and stationary emissions with an emphasis on diesel exhaust.

3. Health and Environmental Justice

Several on-going research studies in the SoCAB and the San Francisco Bay Area will provide more detailed information on the exposure and health effects of pollutants associated with goods movement. These projects include epidemiologic investigations of the potential health effects of particle pollution on vulnerable subjects such as the elderly, those at risk for cardiovascular disease, and children; and a series of projects and studies aimed at understanding the differential effects of air pollution exposure that may be experienced by economically disadvantaged populations living in communities surrounding goods movement facilities—specifically, port facilities or railroads.

CARB is co-sponsoring a study, along with the National Institute of Environmental Health Sciences and the South Coast Air Quality Management District, to determine how exposures to ultrafine and fine particles may impact the health of the elderly living near traffic in Los Angeles. Investigators from the University of California at Irvine and Los Angeles as well as from the University of Southern California are monitoring heart function as well as biological markers of injury in elderly participants. Air quality measurements are being made both inside and outside the retirement homes under study. The elemental carbon content of local air is of special concern.

A study relating asthma to traffic-related pollution in Los Angeles neighborhoods will conduct NO_X and NO_2 monitoring at 200 locations within the Los Angeles (CARB 2005c). In the Los Angeles Family and Neighborhood Survey (L.A. FANS) study domain Land Use Regression models will be used to predict traffic pollutant (NO_X, NO and NO_2) exposures for all of the LA FANS subjects. These will be used to evaluate associations between traffic pollutant exposures and lung function and asthma (prevalence, exacerbation and possibly incidence) in children ages 0-17 years. This study will also use geostatistical models to estimate regional background concentrations of O_3 and $PM_{2.5}$ to evaluate whether concentrations of these more regionally distributed background pollutants confound or modify the effects of exposure (lung function and asthma) to the more heterogeneously distributed traffic-related pollutants (NO_X, NO, and NO_2). This study will provide information on respiratory impacts of motor vehicle emissions in a low socioeconomic status population and will aid in the development of air pollution exposure models that could be used in future epidemiological studies in L.A. County.

The "Teachers Cohort Study" (CARB 2005d) has the unique opportunity to use an existing dataset, the California Teachers' cohort, established by the Northern California Cancer Center and the California Department of Health Services. This cohort includes 133,479 current and former female public school teachers and administrators recruited in 1995. Investigators have followed this population for incidence of disease and mortality. The information gathered will allow the investigators to determine whether long-term exposure to PM (PM10 and PM2.5) or gaseous pollutants is associated with cardiovascular and cardiopulmonary disease incidence or mortality. Investigators will also determine whether exposure to traffic emissions, measured by residential proximity to busy roads, is related to cardiovascular disease incidence or mortality.

In order to assess community impacts of goods movement—the CARB has several projects underway that will build on recently completed emissions inventory and modeling studies conducted in the Wilmington port area. The primary studies are: *Investigation and Characterization of Pollution Concentrations Gradients in Wilmington, CA Using a Mobile Platform* (CARB 2005e), and, *Environmental Justice Saturation Monitoring of Selected Pollutants in Wilmington* (CARB 2005e).

The overall objective of the first study is to generate a vehicle-related pollutant gradient grid for Wilmington. The project will acquire a non-polluting vehicle and outfit it with a set of real-time instruments capable of measuring key variables and pollutants of interest. These pollutants include utrafine particles, PM2.5, CO and CO_2, oxides of nitrogen and black carbon. The main study phase of the project will conduct mobile platform measurements in the warm and cool seasons in and around Wilmington and investigate the identified pollution gradients as a function of traffic volume and composition, meteorological factors and weekday versus weekend influences. This information will be used to identify suitable locations for fixed site, passive monitors in the second study conducted by the Desert Research Institute (DRI). This DRI "saturation monitoring"study will investigate the previously identified pollution gradients in the Wilmington area and examine how such gradients are affected by key variables. Investigators will also obtain data relevant to resolving the relative importance of local point sources versus traffic-generated emissions versus transported background pollution. This study will also test the use of passive monitors for conducting field measurements. The pollutants to be measured will include, O_3, NO, NO_2, NO_X, SO_2, BTEX (benzene, toluene, ethylbenzene, xylenes), formaldehyde, acrolein and odor-causing sulfides. In the initial phase of this study the precision, accuracy, sampling rates and validity of passive sampling methods will be tested in the laboratory using a flow through chamber with known pollutant concentrations. Combined, these studies have as their objectives: to assess the Wilmington community's air quality concerns and identify "hot spots"; develop and test methods to validate existing air emissions inventory and pollutant concentration modeling, and, to develop tools for community-scale monitoring of pollutants for identification of exposure gradients.

Two recently approved research studies taking place in the Los Angeles area will provide additional information for assessing exposure to utrafine particle pollution: *Fine-Scale Spatial and Temporal Variability of Particle Number Concentrations within Communities and in the Vicinity of Freeway Sound Walls* and *Ultrafine Particle Concentrations in Schools and Homes* (CARB 2005g).

In the San Francisco Bay region CARB is sponsoring an investigation to determine whether socioeconomic variables are related to differential air pollution exposures. This study: *Air Pollution and Environmental Justice: Integrating Indicators of Cumulative Impact and Socioeconomic Vulnerability into Regulatory Decision Making* (CARB 2005i) has, as one of its primary objectives, to provide CARB staff with a "concrete tool" to integrate cumulative impact and risk measures with community vulnerability factors (socioeconomic measures). The study area for this project is the San Francisco East Bay, primarily the highway 880 corridor. This environmental justice study will also conduct a state-wide analysis of patterns of racial and ethnic disparities in cancer and other health risks associated with outdoor air pollution.

The project will integrate a wide range of data from federal, state, and air district sources, as well as a local-scale study to (a) address methodological challenges in assessing cumulative exposure, (b) develop and test a dual model which accounts for environmental and socio-economic conditions, (c) incorporate analysis of spatial auto-correlation to improve predictive power and experiment with differing scales of analysis, (d) incorporate community meetings and community-based participatory research in order to enhance community confidence, and (e) develop screening measures that can be used to guide regulatory action and community outreach. The local-scale study will incorporate community-based researchers utilizing geo-positioning devices to identify local air toxics emitters. A screening tool will be developed to identify communities that may be vulnerable due to SES and environmental conditions.

Many of the known biological responses associated with air pollution exposures could potentially alter an individual's risk of getting a disease or influence the way an existing disease progresses. For example, even though the evidence that air pollution causes asthma is only beginning to emerge (McConnell et al. 2002), air pollution is known to induce asthmatic episodes in people with the disease. Repeated episodes of asthma may damage or alter the respiratory tract of asthmatics, leading to worsening of the disease and a poorer quality of life. The Fresno Asthmatic Children's Environment Study (FACES) was designed to evaluate observations of elevated childhood asthma in Fresno. Fresno was selected because it is the largest population center in the San Joaquin Valley, with high 24-hour-average PM2.5 (160 $\mu g/m^3$) and PM10 (199 $\mu g/m^3$) concentrations and the second and third highest asthma hospitalization rates in California for black and Hispanic children, respectively. Health scientists have established that asthma sufferers have more breathing problems when PM is high and that children exhibit more asthma problems than adults do. Investigators at the University of California at Berkeley, the California Department of Health Services, private consultants, and the CARB developed an epidemiologic field investigation to determine how young children known to have asthma are affected by various environmental and lifestyle factors on a day to day and longer term basis. FACES includes 44% Hispanic, 14% black, 2% Asian, and 19% low-income families (less than $15,000 household income) among the approximately 300 participants. The study is anticipated to continue until 2007.

The Children's Health Study (CHS), which began in 1992, is a long-term epidemiologic study of the health effects of children's chronic exposures to southern California air pollution. About 5500 children in 12 communities have been enrolled in the study; two-thirds of them were enrolled as fourth-graders. The CHS includes 28% Hispanic, 5% black, and 5% Asian among its participants. Data on the children's health, their exposures to air pollution, and many factors that affect their responses to air pollution are gathered annually. Concentrations of pollutants have been measured in each community throughout the study and for brief periods in schools and some homes. In addition, each child's lung function is tested every spring. Annual questionnaires ask about the children's respiratory symptoms and diseases, such as chronic cough and asthma; level of physical activity; time spent outdoors; and many other factors known to influence children's responses to air pollution, such as parental smoking and mold and pets in the household.

4. Economics

Information on the health benefits of regulatory programs is necessary for accurate economic assessment. Currently, several adverse health outcomes associated with exposure to air pollution have been demonstrated. However, the economic benefits of reducing many adverse health outcomes have not been characterized. In response, the CARB is actively engaged in economic research that will improve its ability to accurately quantify the health benefits of reducing exposure to outdoor air pollution.

The last comprehensive assessment of health benefits of air pollution reductions in California was completed in 1986 and is outdated. Although South Coast and San Francisco Bay Area districts have quantified health benefits for their plans to meet air quality standards, many of the underlying health benefits studies that these analyses are based upon are more than a decade old. In addition, there are significant gaps in the economics literature that have not yet been addressed. Recent work funded by CARB to develop new estimates of economic value for reducing hospitalizations provides useful new information for such assessments, but there are several important remaining gaps in the literature.

Recent health effects research points toward air pollutants as risk factors for the onset of several chronic respiratory and cardiovascular illnesses. These include cardiovascular disease, asthma, and permanent lung function decrements. Willingness-to-pay (WTP) estimates are available in the economics literature only for reducing risks of onset of chronic bronchitis (Viscusi et al. 1991).

One CARB-supported study, "Economic Value of Reducing Cardiovascular Disease Morbidity Associated with Air Pollution" will make an important contribution to better quantifying the health benefits of air pollution control in California, because there are no WTP estimates, or even very good COI (cost-of-Illness) estimates, for lifetime cardiovascular disease (CVD) morbidity. The study team will design, implement and analyze a WTP survey that develops a monetary estimate of individual WTP to reduce the risk of developing cardiovascular disease.

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APPENDIX B

REGIONAL ANALYSES

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APPENDIX B

REGIONAL ANALYSES

Implementing the new strategies in the plan would benefit all regions of California, because virtually every area has emissions from at least one of the goods movement sectors and needs further reductions to ensure clean, healthful air every day. The areas with the highest ports and goods movement activity would realize the greatest benefits from this plan. Our third goal for this plan, to "continue reducing emissions until community impacts are mitigated and air quality standards are met," includes a regional element since compliance with air quality standards is determined region by region.

Most of California's urban areas need additional reductions over the next 5 to 15 years or so to meet the federal 8-hour ozone standard, while South Coast and San Joaquin Valley need further actions to comply with the federal PM2.5 standards as well. Large urban regions like the Bay Area and San Diego that are very close to the federal ozone standard will need further NOx and ROG reductions to meet the more health-protective State ozone and particulate standards. And all areas of California would experience benefits from reduced diesel PM emissions and the associated health risk.

ARB staff has estimated the emission and health benefits of implementing the strategies discussed in this plan in five metropolitan regions that are heavily-impacted by goods movement emissions.

- South Coast (Air Basin), home to the State's largest international ports.
- San Joaquin Valley (Air Basin), home to Interstate 5 and Highway 99 and a source of substantial export commodities.
- San Francisco Bay Area (Air Basin), home to the Ports of Oakland and San Francisco.
- San Diego County, which has overland border crossings and a growing seaport.
- Sacramento Region, home to the State's largest rail switchyard and major interstate highways.

Other regions may be highly impacted by some of the goods movement sectors. For example, Santa Barbara and Ventura Counties receive significant offshore pollution from ships in transit, while the eastern desert has extensive truck and locomotive through traffic to Phoenix, Las Vegas, and points beyond.

The tables in Appendix B show projected emissions from ports and goods movement in the five, heavily-impacted regions. For each region, we show the emissions from each sector, by pollutant, with the existing programs (measures adopted through October 2005) and with the benefits of full implementation of the plan strategies. The tables focus on the same set of analysis years as the rest of the plan – 2001, 2005, 2010, 2015, and 2020.

Following the emission tables, we show the benefits of full implementation of plan strategies in reducing the health impacts from ports and goods movement pollution, as well as the economic valuation of those health impacts avoided.

Please note that since these regional tables breakdown statewide emission values by sector, some of the resulting values are less than 0.05 tons per day. Since these values are rounded off to one decimal place, they appear as 0.0 on the tables.

Table B-1
South Coast
Emissions from Ports and Goods Movement
with Benefits of All Measures Adopted as of October, 2005
(tons per day)

Sector	Year				
	2001	2005	2010	2015	2020
Diesel PM					
Ships	2.4	4.0	5.2	6.3	7.8
Harbor Craft	1.0	1.0	0.8	0.5	0.5
Cargo Handling Equipment	0.6	0.5	0.4	0.3	0.1
Trucks	9.1	7.6	5.2	3.0	1.5
Locomotives	1.0	1.0	0.9	0.9	1.0
Total	14.1	14.1	12.5	11.0	10.9
NOx					
Ships	30.0	46.6	59.0	71.2	85.4
Harbor Craft	21.3	19.2	15.1	11.4	9.9
Cargo Handling Equipment	15.0	13.5	11.6	8.2	4.5
Trucks	147.0	154.7	131.0	96.0	69.9
Locomotives	42.7	34.2	21.0	24.7	27.4
Total	256.0	268.2	237.7	211.5	197.1
ROG					
Ships	0.6	1.1	1.4	1.7	2.0
Harbor Craft	2.1	1.9	1.6	1.2	1.0
Cargo Handling Equipment	1.8	1.4	0.8	0.6	0.5
Trucks	15.7	15.1	12.1	8.5	6.6
Locomotives	2.7	2.6	2.5	2.6	2.7
Total	22.9	22.1	18.4	14.6	12.8
SOx					
Ships	20.0	31.9	41.7	51.5	64.4
Harbor Craft	0.1	0.1	0.0	0.0	0.0
Cargo Handling Equipment	0.0	0.0	0.0	0.0	0.0
Trucks	1.0	1.1	0.2	0.2	0.2
Locomotives	1.3	1.4	0.2	0.0	0.0
Total	22.4	34.5	42.1	51.7	64.6

Table B-2
South Coast
Emissions from Ports and Goods Movement
with Full Implementation of Plan Strategies
(tons per day)

Sector	Year				
	2001	2005	2010	2015	2020
Diesel PM					
Ships	2.4	4.0	2.5	1.3	1.4
Harbor Craft	1.0	1.0	0.6	0.3	0.3
Cargo Handling Equipment	0.6	0.5	0.3	0.1	0.0
Trucks	9.1	7.6	4.1	2.2	1.2
Locomotives	1.0	1.0	0.8	0.4	0.2
Total	14.1	14.1	8.3	4.3	3.1
NOx					
Ships	30.0	46.6	46.5	28.3	22.8
Harbor Craft	21.3	19.2	11.0	7.7	5.7
Cargo Handling Equipment	15.0	13.5	8.8	4.3	2.2
Trucks	147.0	154.7	121.8	89.7	60.8
Locomotives	42.7	34.2	19.1	14.7	7.6
Total	256.0	268.2	207.2	144.7	99.1
ROG					
Ships	0.6	1.1	1.4	1.7	2.0
Harbor Craft	2.1	1.9	1.2	0.8	0.6
Cargo Handling Equipment	1.8	1.4	0.8	0.6	0.3
Trucks	15.7	15.1	12.1	8.5	6.6
Locomotives	2.7	2.6	2.2	1.3	0.5
Total	22.9	22.1	17.7	12.9	10.0
SOx					
Ships	20.0	31.9	11.9	4.2	4.3
Harbor Craft	0.1	0.1	0.0	0.0	0.0
Cargo Handling Equipment	0.0	0.0	0.0	0.0	0.0
Trucks	1.0	1.1	0.2	0.2	0.2
Locomotives	1.3	1.4	0.2	0.0	0.0
Total	22.5	34.5	12.3	4.4	4.5

Table B-3
South Coast
Emissions from Ports and Goods Movement
Plan Summary
(tons per day)

Pollutant		**Year**		
		2010	**2015**	**2020**
Diesel PM	Emissions with Existing Program	12.5	11.0	10.9
	Reductions from New Strategies	-4.2	-6.7	-7.8
	Emissions with Plan	8.3	4.3	3.1
	Percent Reduction	33.6	60.9	71.6
NOx	Emissions with Existing Program	237.7	211.5	197.1
	Reductions from New Strategies	-30.5	-66.8	-98.0
	Emissions with Plan	207.2	144.7	99.1
	Percent Reduction	12.8	31.6	49.7
ROG	Emissions with Existing Program	18.4	14.6	12.8
	Reductions from New Strategies	-0.7	-1.7	-2.8
	Emissions with Plan	17.7	12.9	10.0
	Percent Reduction	3.6	11.6	21.5
SOx	Emissions with Existing Program	42.1	51.7	64.6
	Reductions from New Strategies	-29.8	-47.3	-60.1
	Emissions with Plan	12.3	4.4	4.5
	Percent Reduction	70.8	91.4	93.1

Table B-4
South Coast
Emissions from Ports and Goods Movement with Full Implementation of Plan Strategies
(tons per day)

Pollutant	Year					Percent Reduction 2001-2020
	2001	2005	2010	2015	2020	
Diesel PM	14.1	14.0	8.3	4.3	3.1	78%
NOx	256.1	268.2	207.2	144.6	99.1	61%
ROG	22.9	22.1	17.7	12.9	10.0	56%
SOx	22.5	34.6	12.3	4.5	4.5	80%

Table B-5
South Coast
Health Benefits and Economic Value of Plan Strategies in Year 2020

Health Outcome	Cases Avoided in 2020	Uncertainty Range[2] (cases per year)	Value in 2020 (in millions)	Uncertainty Range[3] (in millions)
Premature Death	400	120 to 690	1,800	420 to 4,300
Hospital Admissions (respiratory causes)	210	120 to 290	4.4	1.9 to 7.7
Hospital Admissions (cardiovascular causes)	150	100 to 230	3.9	1.8 to 7.6
Asthma and Other Lower Respiratory Symptoms	12,000	4,500 to 18,000	0.12	0.03 to 0.24
Acute Bronchitis	950	-230 to 2,000	0.22	-0.04 to 0.61
Work Loss Days	68,000	58,000 to 79,000	8.1	5.1 to 12
Minor Restricted Activity Days	530,000	350,000 to 720,000	18	8.7 to 30
School Absence Days	94,000	38,000 to 150,000	5.5	1.6 to 11

[1] Does not include the reduction in contributions from particle sulfate formed from SOx emissions, which is being addressed with several ongoing emissions, measurement, and modeling studies.
[2] Range reflects uncertainty in health concentration-response functions, but not in emissions or exposure estimates. A negative value as a lower bound of the uncertainty range is not meant to imply that exposure to pollutants is beneficial; rather, it is a reflection of the adequacy of the data used to develop these uncertainty range estimates.
[3] Range reflects statistically combined uncertainty in concentration-response functions and economic values, but not in emissions or exposure estimates.

Table B-6
San Joaquin Valley
Emissions from Ports and Goods Movement
with Benefits of All Measures Adopted as of October, 2005
(tons per day)

Sector	**Year**				
	2001	**2005**	**2010**	**2015**	**2020**
Diesel PM					
Ships	0.0	0.0	0.1	0.1	0.1
Harbor Craft	0.0	0.0	0.0	0.0	0.0
Cargo Handling Equipment	0.0	0.0	0.0	0.0	0.0
Trucks	10.4	8.3	5.0	2.7	1.6
Locomotives	0.6	0.7	0.6	0.6	0.6
Total	11.0	9.0	5.7	3.4	2.3
NOx					
Ships	0.3	0.5	0.6	0.7	1.0
Harbor Craft	0.9	0.8	0.6	0.5	0.4
Cargo Handling Equipment	0.6	0.6	0.5	0.4	0.2
Trucks	185.9	190.8	138.5	96.5	69.1
Locomotives	29.9	23.1	19.6	20.3	21.0
Total	217.6	215.8	159.8	118.4	91.7
ROG					
Ships	0.0	0.0	0.0	0.0	0.0
Harbor Craft	0.1	0.1	0.1	0.0	0.0
Cargo Handling Equipment	0.1	0.1	0.0	0.0	0.0
Trucks	16.1	15.2	11.3	8.2	6.3
Locomotives	1.6	1.6	1.5	1.5	1.5
Total	17.9	17.0	12.9	9.7	7.8
SOx					
Ships	0.2	0.3	0.4	0.6	0.8
Harbor Craft	0.0	0.0	0.0	0.0	0.0
Cargo Handling Equipment	0.0	0.0	0.0	0.0	0.0
Trucks	1.5	1.5	0.2	0.2	0.2
Locomotives	0.8	0.7	0.1	0.0	0.0
Total	2.5	2.5	0.7	0.8	1.0

Table B-7
San Joaquin Valley
Emissions from Ports and Goods Movement
with Full Implementation of Plan Strategies
(tons per day)

Sector	Year				
	2001	2005	2010	2015	2020
Diesel PM					
Ships	0.0	0.0	0.1	0.0	0.0
Harbor Craft	0.0	0.0	0.0	0.0	0.0
Cargo Handling Equipment	0.0	0.0	0.0	0.0	0.0
Trucks	10.4	8.3	3.9	1.8	1.2
Locomotives	0.6	0.7	0.6	0.3	0.1
Total	11.0	9.0	4.6	2.1	1.3
NOx					
Ships	0.3	0.5	0.4	0.2	0.1
Harbor Craft	0.9	0.8	0.4	0.4	0.2
Cargo Handling Equipment	0.6	0.6	0.4	0.2	0.1
Trucks	185.9	190.8	129.6	87.0	65.2
Locomotives	29.9	23.1	18.4	9.5	4.0
Total	217.6	215.8	149.2	97.3	69.6
ROG					
Ships	0.0	0.0	0.0	0.0	0.0
Harbor Craft	0.1	0.1	0.1	0.0	0.0
Cargo Handling Equipment	0.1	0.1	0.0	0.0	0.0
Trucks	16.1	15.2	11.3	8.2	6.3
Locomotives	1.6	1.6	1.4	0.8	0.3
Total	17.9	17.0	12.8	9.0	6.6
SOx					
Ships	0.2	0.3	0.0	0.1	0.0
Harbor Craft	0.0	0.0	0.0	0.0	0.0
Cargo Handling Equipment	0.0	0.0	0.0	0.0	0.0
Trucks	1.5	1.5	0.2	0.2	0.2
Locomotives	0.8	0.7	0.1	0.0	0.0
Total	2.5	2.5	0.3	0.3	0.2

Table B-8
San Joaquin Valley
Emissions from Ports and Goods Movement
Plan Summary
(tons per day)

Pollutant		Year		
		2010	**2015**	**2020**
Diesel PM	Emissions with Existing Program	5.7	3.4	2.3
	Reductions from New Strategies	-1.1	-1.3	-1.0
	Emissions with Plan	4.6	2.1	1.3
	Percent Reduction	19.8	38.9	43.5
NOx	Emissions with Existing Program	159.8	118.4	91.7
	Reductions from New Strategies	-10.6	-21.1	-22.1
	Emissions with Plan	149.2	97.3	69.6
	Percent Reduction	6.6	17.8	24.1
ROG	Emissions with Existing Program	12.9	9.7	7.8
	Reductions from New Strategies	-0.1	-0.7	-1.2
	Emissions with Plan	12.8	9.0	6.6
	Percent Reduction	0.7	7.4	15.4
SOx	Emissions with Existing Program	0.7	0.8	1.0
	Reductions from New Strategies	-0.4	-0.5	-0.8
	Emissions with Plan	0.3	0.3	0.2
	Percent Reduction	55.1	58.9	79.0

Table B-9
San Joaquin Valley
Emissions from Ports and Goods Movement
with Full Implementation of Plan Strategies
(tons per day)

Pollutant	Year					Percent Reduction 2001-2020
	2001	2005	2010	2015	2020	
Diesel PM	11.1	9.1	4.5	2.1	1.2	89%
NOx	217.6	215.7	149.1	97.4	69.6	68%
ROG	17.9	16.9	12.8	9.0	6.6	63%
SOx	2.5	2.5	0.2	0.3	0.2	92%

Table B-10
San Joaquin Valley
Health Benefits and Economic Value of Plan Strategies in Year 2020

Health Outcome	Cases Avoided in 2020	Uncertainty Range[2] (cases per year)	Value in 2020 (in millions)	Uncertainty Range[3] (in millions)
Premature Death	30	10 to 60	170	39 to 400
Hospital Admissions (respiratory causes)	40	20 to 60	0.83	0.036 to 1.5
Hospital Admissions (cardiovascular causes)	10	7.0 to 20	0.29	0.13 to 0.56
Asthma and Other Lower Respiratory Symptoms	980	380 to 1,600	0.01	0.003 to 0.02
Acute Bronchitis	80	-20 to 180	0.02	-0.003 to 0.05
Work Loss Days	4,800	4,000 to 5,500	0.57	0.36 to 0.83
Minor Restricted Activity Days	73,000	34,000 to 120,000	2.4	0.84 to 4.9
School Absence Days	24,000	9,600 to 38,000	1.4	0.41 to 2.8

[1] Does not include the reduction in contributions from particle sulfate formed from SOx emissions, which is being addressed with several ongoing emissions, measurement, and modeling studies.

[2] Range reflects uncertainty in health concentration-response functions, but not in emissions or exposure estimates. A negative value as a lower bound of the uncertainty range is not meant to imply that exposure to pollutants is beneficial; rather, it is a reflection of the adequacy of the data used to develop these uncertainty range estimates.

[3] Range reflects statistically combined uncertainty in concentration-response functions and economic values, but not in emissions or exposure estimates.

Table B-11
San Francisco Bay Area
Emissions from Ports and Goods Movement
with Benefits of All Measures Adopted as of October, 2005
(tons per day)

Sector	Year				
	2001	**2005**	**2010**	**2015**	**2020**
Diesel PM					
Ships	1.4	1.7	2.2	2.9	3.8
Harbor Craft	1.3	1.4	1.1	0.8	0.7
Cargo Handling Equipment	0.1	0.1	0.1	0.1	0.0
Trucks	3.0	2.6	1.6	0.8	0.4
Locomotives	0.3	0.3	0.3	0.3	0.3
Total	6.1	6.1	5.3	4.9	5.2
NOx					
Ships	17.2	20.8	26.2	33.2	41.7
Harbor Craft	26.7	25.4	21.6	17.6	16.4
Cargo Handling Equipment	3.7	3.3	2.9	2.0	1.1
Trucks	56.2	60.1	45.3	31.7	23.8
Locomotives	16.1	13.0	10.7	12.2	12.9
Total	119.9	122.6	106.7	96.7	95.9
ROG					
Ships	0.5	0.6	0.7	0.9	1.2
Harbor Craft	2.7	2.6	2.3	1.8	1.7
Cargo Handling Equipment	0.4	0.3	0.2	0.1	0.1
Trucks	7.5	7.1	4.9	3.3	2.6
Locomotives	0.9	0.9	0.8	0.8	0.8
Total	12.0	11.5	8.9	6.9	6.4
SOx					
Ships	10.6	13.1	16.9	21.8	28.4
Harbor Craft	0.1	0.1	0.1	0.1	0.1
Cargo Handling Equipment	0.0	0.0	0.0	0.0	0.0
Trucks	0.4	0.5	0.1	0.1	0.1
Locomotives	0.3	0.2	0.0	0.0	0.0
Total	11.4	13.9	17.1	22.0	28.6

Table B-12
San Francisco Bay Area
Emissions from Ports and Goods Movement
with Full Implementation of Plan Strategies
(tons per day)

Sector	Year				
	2001	2005	2010	2015	2020
Diesel PM					
Ships	1.4	1.7	1.4	0.9	1.0
Harbor Craft	1.3	1.4	0.8	0.5	0.4
Cargo Handling Equipment	0.1	0.1	0.1	0.1	0.0
Trucks	3.0	2.6	1.3	0.6	0.3
Locomotives	0.3	0.3	0.3	0.1	0.0
Total	6.1	6.1	3.9	2.2	1.7
NOx					
Ships	17.2	20.8	22.3	16.1	13.6
Harbor Craft	26.7	25.4	15.8	11.8	9.5
Cargo Handling Equipment	3.7	3.3	2.2	1.1	0.6
Trucks	56.2	60.1	42.5	29.7	21.8
Locomotives	16.1	13.0	9.9	5.7	2.4
Total	119.9	122.6	92.7	64.4	47.9
ROG					
Ships	0.5	0.6	0.7	0.9	1.2
Harbor Craft	2.7	2.6	1.7	1.3	1.0
Cargo Handling Equipment	0.4	0.3	0.2	0.1	0.1
Trucks	7.5	7.1	4.9	3.3	2.6
Locomotives	0.9	0.9	0.7	0.4	0.1
Total	12.0	11.5	8.2	6.0	5.0
SOx					
Ships	10.6	13.1	6.6	2.4	2.5
Harbor Craft	0.1	0.1	0.1	0.1	0.1
Cargo Handling Equipment	0.0	0.0	0.0	0.0	0.0
Trucks	0.4	0.5	0.1	0.1	0.1
Locomotives	0.3	0.2	0.0	0.0	0.0
Total	11.4	13.9	6.8	2.6	2.7

Table B-13
San Francisco Bay Area
Emissions from Ports and Goods Movement
Plan Summary
(tons per day)

Pollutant		Year		
		2010	**2015**	**2020**
Diesel PM	Emissions with Existing Program	5.3	4.9	5.2
	Reductions from New Strategies	-1.4	-2.7	-3.5
	Emissions with Plan	3.9	2.2	1.7
	Percent Reduction	26.7	54.6	66.1
NOx	Emissions with Existing Program	106.7	96.7	95.9
	Reductions from New Strategies	-14.0	-32.3	-48.0
	Emissions with Plan	92.7	64.4	47.9
	Percent Reduction	13.1	33.4	50.0
ROG	Emissions with Existing Program	8.9	6.9	6.4
	Reductions from New Strategies	-0.7	-0.9	-1.4
	Emissions with Plan	8.2	6.0	5.0
	Percent Reduction	7.9	13.0	21.9
SOx	Emissions with Existing Program	17.1	22.0	28.6
	Reductions from New Strategies	-10.3	-19.4	-25.9
	Emissions with Plan	6.8	2.6	2.7
	Percent Reduction	60.3	88.3	90.5

Table B-14
San Francisco Bay Area
Emissions from Ports and Goods Movement
with Full Implementation of Plan Strategies
(tons per day)

Pollutant	Year					Percent Reduction 2001-2020
	2001	2005	2010	2015	2020	
Diesel PM	6.2	6.1	3.9	2.2	1.9	69%
NOx	119.9	122.7	92.7	64.4	48.0	60%
ROG	12.0	11.5	8.3	5.9	5.0	58%
SOx	11.5	13.9	6.8	2.6	2.7	77%

Table B-15
San Francisco Bay Area
Health Benefits and Economic Value of Plan Strategies in Year 2020

Health Outcome	Cases Avoided in 2020	Uncertainty Range[2] (cases per year)	Value in 2020 (in millions)	Uncertainty Range[3] (in millions)
Premature Death	100	30 to 170	460	100 to 1,100
Hospital Admissions (respiratory causes)	30	20 to 50	0.71	0.32 to 1.2
Hospital Admissions (cardiovascular causes)	40	30 to 60	1.0	0.48 to 2.0
Asthma and Other Lower Respiratory Symptoms	2,200	860 to 3,600	0.02	0.007 to 0.05
Acute Bronchitis	190	-40 to 410	0.04	-0.008 to 0.12
Work Loss Days	17,000	14,000 to 20,000	2.0	1.3 to 2.9
Minor Restricted Activity Days	110,000	83,000 to 130,000	3.6	2.0 to 5.6
School Absence Days	9,300	3,800 to 15,000	0.54	0.16 to 1.1

[1] Does not include the reduction in contributions from particle sulfate formed from SOx emissions, which is being addressed with several ongoing emissions, measurement, and modeling studies.
[2] Range reflects uncertainty in health concentration-response functions, but not in emissions or exposure estimates. A negative value as a lower bound of the uncertainty range is not meant to imply that exposure to pollutants is beneficial; rather, it is a reflection of the adequacy of the data used to develop these uncertainty range estimates.
[3] Range reflects statistically combined uncertainty in concentration-response functions and economic values, but not in emissions or exposure estimates.

Table B-16
San Diego County
Emissions from Ports and Goods Movement with Benefits of All Measures Adopted as of October, 2005
(tons per day)

Sector	Year				
	2001	2005	2010	2015	2020
Diesel PM					
Ships	0.7	0.9	1.4	2.2	3.6
Harbor Craft	0.5	0.5	0.4	0.3	0.2
Cargo Handling Equipment	0.0	0.0	0.0	0.0	0.0
Trucks	1.6	1.4	0.9	0.6	0.4
Locomotives	0.0	0.0	0.0	0.0	0.0
Total	2.8	2.8	2.7	3.1	4.2
NOx					
Ships	7.7	10.4	15.0	22.8	36.2
Harbor Craft	10.8	9.7	7.7	5.4	4.7
Cargo Handling Equipment	0.8	0.7	0.6	0.4	0.2
Trucks	27.5	29.1	23.1	18.4	16.0
Locomotives	1.4	1.4	1.2	1.7	1.8
Total	48.2	51.3	47.6	48.7	58.9
ROG					
Ships	0.2	0.3	0.4	0.6	1.0
Harbor Craft	1.1	1.0	0.8	0.6	0.5
Cargo Handling Equipment	0.1	0.1	0.0	0.0	0.0
Trucks	3.4	3.2	2.3	1.6	1.5
Locomotives	0.1	0.1	0.1	0.1	0.1
Total	4.9	4.7	3.6	2.9	3.1
SOx					
Ships	5.1	7.0	10.6	16.6	27.3
Harbor Craft	0.0	0.0	0.0	0.0	0.0
Cargo Handling Equipment	0.0	0.0	0.0	0.0	0.0
Trucks	0.2	0.2	0.0	0.0	0.0
Locomotives	0.0	0.0	0.0	0.0	0.0
Total	5.3	7.2	10.6	16.6	27.3

Table B-17
San Diego County
Emissions from Ports and Goods Movement
with Full Implementation of Plan Strategies
(tons per day)

Sector	Year				
	2001	**2005**	**2010**	**2015**	**2020**
Diesel PM					
Ships	0.7	0.9	0.5	0.3	0.4
Harbor Craft	0.5	0.5	0.3	0.2	0.1
Cargo Handling Equipment	0.0	0.0	0.0	0.0	0.0
Trucks	1.6	1.4	0.7	0.5	0.3
Locomotives	0.0	0.0	0.0	0.0	0.0
Total	2.8	2.8	1.5	1.0	0.8
NOx					
Ships	7.7	10.4	11.4	7.4	7.3
Harbor Craft	10.8	9.7	5.7	3.7	2.7
Cargo Handling Equipment	0.8	0.7	0.4	0.2	0.1
Trucks	27.5	29.1	21.7	17.1	15.5
Locomotives	1.4	1.4	1.2	0.8	0.3
Total	48.2	51.3	40.4	29.2	25.9
ROG					
Ships	0.2	0.3	0.4	0.6	1.0
Harbor Craft	1.1	1.0	0.6	0.4	0.3
Cargo Handling Equipment	0.1	0.1	0.0	0.0	0.0
Trucks	3.4	3.2	2.3	1.6	1.5
Locomotives	0.1	0.1	0.1	0.1	0.0
Total	4.9	4.7	3.4	2.7	2.8
SOx					
Ships	5.1	7.0	2.2	0.9	0.9
Harbor Craft	0.0	0.0	0.0	0.0	0.0
Cargo Handling Equipment	0.0	0.0	0.0	0.0	0.0
Trucks	0.2	0.2	0.0	0.0	0.0
Locomotives	0.0	0.0	0.0	0.0	0.0
Total	5.3	7.2	2.2	0.9	0.9

Table B-18
San Diego County
Emissions from Ports and Goods Movement
Plan Summary
(tons per day)

Pollutant		Year		
		2010	2015	2020
Diesel PM	Emissions with Existing Program	2.7	3.1	4.2
	Reductions from New Strategies	-1.2	-2.1	-3.4
	Emissions with Plan	1.5	1.0	0.8
	Percent Reduction	44.4	68.3	79.9
NOx	Emissions with Existing Program	47.6	48.7	58.9
	Reductions from New Strategies	-7.2	-19.5	-33.0
	Emissions with Plan	40.4	29.2	25.9
	Percent Reduction	15.1	40.0	56.0
ROG	Emissions with Existing Program	3.6	2.9	3.1
	Reductions from New Strategies	-0.2	-0.2	-0.3
	Emissions with Plan	3.4	2.7	2.8
	Percent Reduction	5.4	7.0	8.7
SOx	Emissions with Existing Program	10.6	16.6	27.3
	Reductions from New Strategies	-8.4	-15.7	-26.4
	Emissions with Plan	2.2	0.9	0.9
	Percent Reduction	79.1	94.4	96.7

Table B-19
San Diego County
Emissions from Ports and Goods Movement
with Full Implementation of Plan Strategies
(tons per day)

Pollutant	Year					Percent Reduction 2001-2020
	2001	2005	2010	2015	2020	
Diesel PM	2.9	2.8	1.6	0.9	0.9	69%
NOx	48.3	51.4	40.3	29.2	25.8	47%
ROG	4.9	4.6	3.4	2.8	2.7	45%
SOx	5.3	7.2	2.2	0.9	0.9	83%

Table B-20
San Diego County
Health Benefits and Economic Value of Plan Strategies in Year 2020

Health Outcome	Cases Avoided in 2020	Uncertainty Range[2] (cases per year)	Value in 2020 (in millions)	Uncertainty Range[3] (in millions)
Premature Death	120	40 to 210	560	130 to 1,300
Hospital Admissions (respiratory causes)	50	30 to 70	1.1	0.48 to 1.8
Hospital Admissions (cardiovascular causes)	50	30 to 70	1.2	0.58 to 2.4
Asthma and Other Lower Respiratory Symptoms	3,000	1,200 to 4,900	0.03	0.009 to 0.06
Acute Bronchitis	250	-60 to 550	0.06	-0.01 to 0.16
Work Loss Days	20,000	17,000 to 23,000	2.4	1.5 to 3.5
Minor Restricted Activity Days	140,000	100,000 to 180,000	4.7	2.5 to 7.5
School Absence Days	19,000	7,600 to 30,000	1.1	0.33 to 2.2

[1] Does not include the reduction in contributions from particle sulfate formed from SOx emissions, which is being addressed with several ongoing emissions, measurement, and modeling studies.
[2] Range reflects uncertainty in health concentration-response functions, but not in emissions or exposure estimates. A negative value as a lower bound of the uncertainty range is not meant to imply that exposure to pollutants is beneficial; rather, it is a reflection of the adequacy of the data used to develop these uncertainty range estimates.
[3] Range reflects statistically combined uncertainty in concentration-response functions and economic values, but not in emissions or exposure estimates.

Table B-21
Sacramento Region*
Emissions from Ports and Goods Movement
with Benefits of All Measures Adopted as of October, 2005
(tons per day)

Sector	Year				
	2001	2005	2010	2015	2020
Diesel PM					
Ships	0.0	0.0	0.0	0.0	0.0
Harbor Craft	0.1	0.1	0.1	0.1	0.0
Cargo Handling Equipment	0.0	0.0	0.0	0.0	0.0
Trucks	2.0	1.7	1.0	0.6	0.3
Locomotives	0.3	0.3	0.3	0.3	0.3
Total	2.4	2.1	1.4	1.0	0.6
NOx					
Ships	0.2	0.2	0.2	0.2	0.3
Harbor Craft	1.8	1.6	1.3	1.0	0.9
Cargo Handling Equipment	0.1	0.1	0.1	0.0	0.0
Trucks	35.4	37.8	27.7	19.8	14.7
Locomotives	13.4	10.4	8.6	9.3	9.7
Total	50.9	50.1	37.9	30.3	25.6
ROG					
Ships	0.0	0.0	0.0	0.0	0.0
Harbor Craft	0.2	0.2	0.1	0.1	0.1
Cargo Handling Equipment	0.0	0.0	0.0	0.0	0.0
Trucks	4.1	4.0	2.8	2.0	1.6
Locomotives	0.7	0.6	0.6	0.6	0.6
Total	5.0	4.8	3.5	2.7	2.3
SOx					
Ships	0.1	0.1	0.1	0.2	0.2
Harbor Craft	0.0	0.0	0.0	0.0	0.0
Cargo Handling Equipment	0.0	0.0	0.0	0.0	0.0
Trucks	0.3	0.3	0.0	0.0	0.0
Locomotives	0.5	0.5	0.1	0.0	0.0
Total	0.9	0.9	0.2	0.2	0.2

* All of Sacramento and Yolo Counties, plus Eastern Solano, Western Placer and Western El Dorado Counties. Does not include the portion of Southern Sutter County in the federal 8-hour ozone nonattainment area

Table B-22
Sacramento Region*
Emissions from Ports and Goods Movement with Full Implementation of Plan Strategies
(tons per day)

Sector	Year				
	2001	2005	2010	2015	2020
Diesel PM					
Ships	0.0	0.0	0.0	0.0	0.0
Harbor Craft	0.1	0.1	0.1	0.1	0.0
Cargo Handling Equipment	0.0	0.0	0.0	0.0	0.0
Trucks	2.0	1.7	0.8	0.4	0.3
Locomotives	0.3	0.3	0.3	0.2	0.1
Total	2.4	2.1	1.2	0.7	0.4
NOx					
Ships	0.2	0.2	0.1	0.0	0.1
Harbor Craft	1.8	1.6	0.9	0.6	0.5
Cargo Handling Equipment	0.1	0.1	0.1	0.0	0.0
Trucks	35.4	37.8	26.1	18.1	14.3
Locomotives	13.4	10.4	8.3	4.5	1.8
Total	50.9	50.1	35.5	23.2	16.7
ROG					
Ships	0.0	0.0	0.0	0.0	0.0
Harbor Craft	0.2	0.2	0.1	0.1	0.1
Cargo Handling Equipment	0.0	0.0	0.0	0.0	0.0
Trucks	4.1	4.0	2.8	2.0	1.6
Locomotives	0.7	0.6	0.6	0.3	0.1
Total	5.0	4.8	3.5	2.4	1.8
SOx					
Ships	0.1	0.1	0.0	0.1	0.1
Harbor Craft	0.0	0.0	0.0	0.0	0.0
Cargo Handling Equipment	0.0	0.0	0.0	0.0	0.0
Trucks	0.3	0.3	0.0	0.0	0.0
Locomotives	0.5	0.5	0.1	0.0	0.0
Total	0.9	0.9	0.1	0.1	0.1

* All of Sacramento and Yolo Counties, plus Eastern Solano, Western Placer and Western El Dorado Counties. Does not include the portion of Southern Sutter County in the federal 8-hour ozone nonattainment area

Table B-23
Sacramento Region*
Emissions from Ports and All Goods Movement
Plan Summary
(tons per day)

Pollutant		Year		
		2010	2015	2020
Diesel PM	Emissions with Existing Program	1.4	1.0	0.6
	Reductions from New Strategies	-0.2	-0.3	-0.2
	Emissions with Plan	1.2	0.7	0.4
	Percent Reduction	14.3	34.5	32.6
NOx	Emissions with Existing Program	37.9	30.3	25.6
	Reductions from New Strategies	-2.4	-7.1	-8.9
	Emissions with Plan	35.5	23.2	16.7
	Percent Reduction	6.3	23.4	34.9
ROG	Emissions with Existing Program	3.5	2.7	2.3
	Reductions from New Strategies	0.0	-0.3	-0.5
	Emissions with Plan	3.5	2.4	1.8
	Percent Reduction	0.0	12.4	21.6
SOx	Emissions with Existing Program	0.2	0.2	0.2
	Reductions from New Strategies	-0.1	-0.1	-0.1
	Emissions with Plan	0.1	0.1	0.1
	Percent Reduction	54.6	48.4	51.6

* All of Sacramento and Yolo Counties, plus Eastern Solano, Western Placer and Western El Dorado Counties. Does not include the portion of Southern Sutter County in the federal 8-hour ozone nonattainment area

Table B-24
Sacramento Region*
Emissions from Ports and Goods Movement with Full Implementation of Plan Strategies
(tons per day)

Pollutant	Year					Percent Reduction 2001-2020
	2001	2005	2010	2015	2020	
Diesel PM	2.3	2.1	1.2	0.7	0.4	83%
NOx	50.8	50.1	35.4	23.1	16.6	67%
ROG	5.0	4.7	3.5	2.3	1.7	66%
SOx	0.9	0.9	0.1	0.1	0.1	89%

* All of Sacramento and Yolo Counties, plus Eastern Solano, Western Placer and Western El Dorado Counties. Does not include the portion of Southern Sutter County in the federal 8-hour ozone nonattainment area.

Table B-25
Sacramento Region*
Health Benefits and Economic Value of Plan Strategies in Year 2020

Health Outcome	Cases Avoided in 2020	Uncertainty Range[2] (cases per year)	Value in 2020 (in millions)	Uncertainty Range[3] (in millions)
Premature Death	20	5 to 30	69	16 to 160
Hospital Admissions (respiratory causes)	10	8 to 20	0.30	0.13 to 0.52
Hospital Admissions (cardiovascular causes)	5	3 to 7	0.12	0.06 to 0.23
Asthma and Other Lower Respiratory Symptoms	300	120 to 480	0.003	0.0009 to 0.006
Acute Bronchitis	30	-6 to 60	0.006	-0.001 to 0.02
Work Loss Days	1,800	1,500 to 2,000	0.21	0.13 to 0.30
Minor Restricted Activity Days	22,000	12,000 to 33,000	0.74	0.29 to 1.4
School Absence Days	8,800	3,600 to 14,000	0.51	0.15 to 1.0

[1] Does not include the reduction in contributions from particle sulfate formed from SOx emissions, which is being addressed with several ongoing emissions, measurement, and modeling studies.
[2] Range reflects uncertainty in health concentration-response functions, but not in emissions or exposure estimates. A negative value as a lower bound of the uncertainty range is not meant to imply that exposure to pollutants is beneficial; rather, it is a reflection of the adequacy of the data used to develop these uncertainty range estimates.
[3] Range reflects statistically combined uncertainty in concentration-response functions and economic values, but not in emissions or exposure estimates.
* All of Sacramento and Yolo Counties, plus Eastern Solano, Western Placer and Western El Dorado Counties. Does not include the portion of Southern Sutter County in the federal 8-hour ozone nonattainment area

APPENDIX C

DIESEL PM RISK REDUCTION METHODOLOGY

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APPENDIX C

DIESEL PM RISK REDUCTION METHODOLOGY

Note: The factors applied to account for exposure in this plan appear to be different than the factors listed in the December 2005 draft. In fact, we did not change the methodology or exposure adjustment, we are simply expressing the factors in a different way as requested by public comments. For example, the draft plan identified an adjustment factor of "0.92" for Ships-Underway that was the discount applied to ship emissions (i.e., 92 percent of ship emissions underway were discounted, leaving 8 percent remaining as the exposure adjusted emissions). In this plan, we show that 8 percent (or 0.08) explicitly as the exposure factor.

1. Derivation of Exposure Adjustment Factors

Our risk reduction analysis employs exposure factors developed from ARB staff's risk assessment performed for the Ports of Los Angeles and Long Beach, described in Appendix A. This approach recognizes that diesel PM emissions from ground level sources that typically operate within highly populated urban areas result in greater exposure per ton released than sources that emit either some distance offshore or within port facilities where a portion of the emissions are dispersed over water.

The effect is to weight the diesel PM emissions according to the exposure impact for each category of source and operational location. By using the same approach for 2001 and 2020, we can then compare the results in each year to assess the relative reduction in health risk.

Table C-1 shows the base emissions inputs and resulting health impacts (cases of premature death) taken from the Ports of Los Angeles and Long Beach risk assessment, and the calculated "tons emitted per impact." The off-port trucks and locomotives operating in the community produced the greatest health impacts per ton of emissions (or conversely, requiring the least amount of tons – 6 -- emitted per impact). We assigned an exposure factor of 1.0 (or 100 percent) to those emissions. We then normalized the exposure impact for the other categories by the off-port trucks and locomotives, dividing the tons emitted per impact for each category by 6 to derive the exposure factor. Other categories are represented by an exposure factor less than 1.0, from ships underway at 0.08 (or 8 percent), to harbor craft at 0.24 (or 24 percent), to on-port trucks and locomotives at 0.50 (or 50 percent).

Table C-1
South Coast Air Basin Diesel PM Emissions in 2002
(tons per year)

Category	Base Emissions (tons per year)	Health Impacts	Tons Emitted Per Impact	Exposure Factor*
Ships-Underway	942	12.4	76.0	0.08
Ships-Hotelling	343	20	17.2	0.35
Cargo Equipment	172	12.4	13.9	0.43
Harbor Craft	244	9.8	24.9	0.24
On-Port Trucks	41	3.5	11.7	0.51
On-Port Locomotives	18	1.5	12.0	0.50
Total	1760	60	29.3	0.20
Off-Port Trucks and Locomotives	664	111	6.0	1.00

*Product of 6.0 divided by "ton emitted per impact" for category

This tells us the relative impact of each ton of diesel PM emitted from different sources and locations. We can then apply the exposure factor to other emission estimates using the same category and location indicators to assess the relative change in health risk attributable to reducing emissions from each sector.

2. Calculation of Exposure Adjusted Diesel PM Emissions and Risk

To estimate the change in health risk from reducing diesel PM emissions from ports and goods movement, between 2001 and 2020, with full implementation of the plan strategies, we applied the exposure factor to each emissions category and location. To simplify the calculations, we combined on-port truck and on-port locomotive emissions using the same 0.50 (or 50 percent) exposure factor. We also combined transport refrigeration units with off-port trucks and locomotives to capture the maximum impact of those emissions.

Table C-2 shows diesel PM emissions by category in 2001 and in 2020 with full implementation of the plan strategies, the application of the exposure factor, and the calculation of the exposure adjusted emissions in each year.

Table C-2
Statewide Diesel PM Emissions from Ports and Goods Movement with Exposure Adjustments and Full Implementation of Plan Strategies

Category	2001 Emissions (tons per day)	Exposure Factor	2001 Exposure Adjusted Emissions	2020 Emissions (tons per day)	Exposure Factor	2020 Exposure Adjusted Emissions
Ships-Underway	5.6	0.08	0.45	5.4	0.08	0.43
Ships-Hotelling	2.2	0.35	0.77	0.3	0.35	0.12
Cargo Equipment	0.8	0.43	0.34	<0.05	0.43	0.02
Harbor Craft	3.8	0.24	0.91	1.0	0.24	0.47
On-Port Trucks and Locomotives	0.2	0.50	0.10	0.03	0.50	0.02
Off-Port Trucks and Locomotives, plus Transport Refrigeration Units	44.7	1.00	44.7	5.6	1.00	5.60
Total	57.3		47.27	12.3		6.66

We then calculate the desired statistics using the totals – mass emissions of diesel PM are reduced by 79 percent, while exposure-adjusted emissions of diesel PM are reduced by 86 percent, correlating to an expected 86 percent reduction in health risk.

APPENDIX D

INTERNATIONAL GOODS MOVEMENT

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APPENDIX D

INTERNATIONAL GOODS MOVEMENT

The December 2005 *Draft Emission Reduction Plan for Ports and International Goods Movement in California* focused on emissions from all port-related operations and the transport of imported and exported goods in California. Since the scope of the plan was increased to include transport of domestic goods as well, all of the emissions and health statistics in the body of this revised plan cover the larger universe of sources. We have included this appendix to allow comparison to the December draft plan by identifying the emissions, benefits of plan strategies, and 2005 health impacts from the same universe of ports and international goods movement sources. Changes between the plan version for this group of sources are due to emission inventory improvements and minor changes to the emission reduction strategies.

1. Statewide Emissions

The international goods movement category includes all emissions from on-port sources, including all vessels and harbor craft, cargo handling equipment, and on-port trucks and rail. ARB staff also assigned a portion of emissions from off-port truck and rail sources to the "international goods movement" inventory. The Technical Supplement on Emission Inventory describes the methodology used to apportion emissions in detail.

The statewide emissions from ports and *international* goods movement in California are over 400 tons per day, combined, of the four pollutants we're most concerned about in this plan: diesel PM, NOx, ROG, and SOx. Table D-1 shows the emissions of each pollutant over time, with the benefits of air pollution controls already adopted by ARB, U.S. EPA, and other agencies as of October 2005.

Table D-1
Statewide
Emissions from Ports and International Goods Movement
With Measures Adopted Through October 2005
(tons per day)

Pollutant	Year				
	2001	2005	2010	2015	2020
Diesel PM	15.3	17.8	19.5	22.5	27.7
NOx	273	290	292	322	373
ROG	18	18	17	17	18
SOx	63	84	107	137	181

The distinction between international goods movement, and all goods movement, significantly impacts our estimates of the emissions from trucks, trains, and cargo handling equipment. Emission estimates for marine vessels and harbor craft are not affected, as those categories are included in their entirety in both the "all" goods movement and "international" goods movement inventories.

Table D-2 summarizes statewide emissions from ports and international goods movement by sector with measures adopted through October 2005.

Table D-2
Statewide
Emissions from Ports and International Goods Movement By Sector with Measures Adopted Through October 2005
(tons per day)

Sector	Year				
	2001	2005	2010	2015	2020
Diesel PM					
Ships	7.8	10.6	13.8	17.8	23.3
Harbor Craft	3.8	3.7	2.9	2.1	1.8
Cargo Handling Equipment	0.8	0.7	0.5	0.3	0.2
Trucks	1.6	1.3	0.8	0.7	0.5
Transport Refrigeration Units	0.1	0.1	0.1	0	0
Locomotives	1.2	1.4	1.4	1.6	1.9
Total	15.3	17.8	19.5	22.5	27.7
NOx					
Ships	94.7	124.9	158.2	199.6	253.6
Harbor Craft	75.4	69.2	56.4	43.6	38.6
Cargo Handling Equipment	20.5	18.4	15.7	11	6.1
Trucks	31.3	32.9	25.7	23.9	21.1
Transport Refrigeration Units	0.6	0.7	0.8	0.9	0.9
Locomotives	50.6	43.5	35.4	43	52.3
Total	273.1	289.6	292.2	322	372.6
ROG					
Ships	2.4	3.2	4.2	5.3	6.8
Harbor Craft	7.6	7	5.9	4.5	4
Cargo Handling Equipment	2.5	1.9	1.2	0.8	0.7
Trucks	2.3	2.2	1.7	1.7	1.7
Transport Refrigeration Units	0.4	0.3	0.2	0.1	0.1
Locomotives	3.1	3.3	3.7	4.3	5
Total	18.3	17.9	16.9	16.7	18.3
SOx					
Ships	59.6	81.1	106.1	136.9	180.4
Harbor Craft	0.4	0.4	0.1	0.1	0.1
Cargo Handling Equipment	<0.05	<0.05	0.1	0.1	<0.05
Trucks	0.2	0.2	0	0	0.1
Transport Refrigeration Units	<0.05	<0.05	<0.05	<0.05	<0.05
Locomotives	2.4	2.6	0.3	<0.05	0.1
Total	62.6	84.3	106.6	137.1	180.7

2. Emission Reductions from Plan Strategies

Table D-3 shows the emission reductions from ports and international goods movement that could be expected statewide from full implementation of the strategies discussed in this plan.

Table D-3
Statewide
Emission Reductions from Ports and International Goods Movement with Full Implementation of Plan Strategies
(tons per day)

Pollutant		Year		
		2010	2015	2020
Diesel PM	Emissions with Existing Program*	19.5	22.5	27.7
	Reductions from New Strategies*	-6.6	-15.1	-20.5
	Emissions with Plan	12.9	7.4	7.2
	Percent Reduction in Same Year	34	67	74
NOx	Emissions with Existing Program	292.2	322	372.6
	Reductions from New Strategies	-49.4	-150.4	-245.4
	Emissions with Plan	242.8	171.6	127.2
	Percent Reduction in Same Year	17	47	66
ROG	Emissions with Existing Program	16.9	16.7	18.3
	Reductions from New Strategies	-1.6	-3.4	-6.0
	Emissions with Plan	15.3	13.3	12.3
	Percent Reduction in Same Year	9	20	33
SOx	Emissions with Existing Program	106.6	137.1	180.7
	Reductions from New Strategies	-65.3	-122.2	-165.3
	Emissions with Plan	41.3	14.9	15.4
	Percent Reduction in Same Year	61	89	91

* "Existing program" includes measures adopted as of October 2005. Rules adopted after that date or proposed approaches are considered "new strategies."

3. 2005 Health Impacts

Chapter I discusses the health impacts associated will all goods movement in California, and provides an overview of how we estimate the number of premature deaths and other health effects associated with air pollution. Appendix A provides a more detailed discussion of this methodology. Table D-4 shows the estimated numbers of key health outcomes caused by 2005 levels of emissions from ports and international goods movement sources. The estimate of premature deaths from ports and international goods movement in the draft plan was 750 cases per year in 2005; the current estimate decreased slightly to 660 cases because we refined and reduced our estimates of truck and rail trips associated with the international portion of goods movement.

Table D-4
Annual 2005 Statewide PM and Ozone Health Effects Associated with Ports and International Goods Movement[1]

Health Outcome	Cases per Year	Uncertainty Range[2]	Valuation (in millions)	Uncertainty Range[3] (in millions)
Premature Death	660	190 to 1,100	$5,200	$1,600 to $9,800
Hospital Admissions (respiratory causes)	490	290 to 680	$16	$10 to $23
Hospital Admissions (cardiovascular causes)	240	150 to 370	$10	$6 to $15
Asthma and Other Lower Respiratory Symptoms	17,000	6,600 to 27,000	$0.3	$0.1 to $0.5
Acute Bronchitis	1,400	-340 to 3,000	$0.6	-$0.1 to $1
Work Loss Days	100,000	89,000 to 120,000	$19	$16 to $22
Minor Restricted Activity Days	1,000,000	600,000 to 1,400,000	$60	$36 to $86
School Absence Days	270,000	110,000 to 430,000	$24	$10 to $38
Total	Not applicable		$5,300	$1,700 to $10,000

[1] Does not include the reduction in contributions from particle sulfate formed from SOx emissions, which is being evaluated with several ongoing emissions, measurement, and modeling studies.
[2] Range reflects uncertainty in health concentration-response functions, but not in emissions or exposure estimates. A negative value as a lower bound of the uncertainty range is not meant to imply that exposure to pollutants is beneficial; rather, it is a reflection of the adequacy of the data used to develop these uncertainty range estimates.
[3] Range reflects statistically combined uncertainty in concentration-response functions and economic values, but not in emissions or exposure estimates.

APPENDIX E

COMPARISON OF PLAN TO PORT OF LOS ANGELES NO NET INCREASE MEASURES

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APPENDIX E

COMPARISON OF ARB EMISSION REDUCTION PLAN STRATEGIES AND THE PORT OF LOS ANGELES NO NET INCREASE (NNI) REPORT

In June 2005, the Port of Los Angeles released a No Net Increase (NNI) Report, which outlined 68 existing and potential strategies to mitigate emissions from growth in port operations. Although this report was not formally approved or implemented, many stakeholders have referenced the NNI strategies in their comments on ARB's Emission Reduction Plan. For that reason, we include a comparison of the strategies in each document.

The following five tables show the ARB plan strategies and the comparable NNI strategies for each of the five sectors associated with ports or the distribution of international cargo throughout California – ships, harbor craft, cargo handling equipment, trucks, and locomotives. The tables are meant for general comparison purposes only. The comparable strategies, in many cases, are not identical in scope. The ARB plan includes environmental goals beyond achieving 2001 emission levels, and therefore its strategies are often broader and more far-reaching than the comparable NNI measures.

Table E-1
ARB Emission Reduction Plan Strategies and Comparable NNI Strategies
Ships

Ships	
ARB Emission Reduction Plan Strategies	**Comparable No Net Increase (NNI) Strategies**
Actions Taken Since 2001	
Vessel Speed Reduction Agreement	OGV2 Vessel Speed Reduction MOU
U.S. EPA Main Engine Emission Standards	OGV1 New Engine Standards for Ships
U.S. EPA Non Road Diesel Fuel Requirements	No Comparable NNI Strategy
Implementation Possible By 2010	
ARB Rule for Ship Auxiliary Engine Fuel	OGV4 Auxiliary Engine Fuel Improvement Program OGV8 Cleaner Fuels for Ship Auxiliary Engines OGV11 Expanded Auxiliary Engine Fuel Improvement Program
Cleaner Marine Fuels	OGV9 Main Engine Fuel Improvement Program OGV12 Expanded Main Engine Fuel Improvement Program
Emulsified Fuels	OGV7 Low Emission Main Propulsion Engines
Expanded Vessel Speed Reduction Programs	OGV15 Expanded Vessel Speed Reduction Program
Install Engines in New Vessels that Exceed IMO Standards	OGV7 Low Emission Main Propulsion Engines
Dedicate the Cleanest Vessels to California Service	OGV6 Reroute Cleanest Ships
Shore Based Electrical Power	OGV3 Alternative Maritime Power OGV13 Additional Auxiliary Engine Reductions for Frequent Callers
Implementation Possible By 2015	
Extensive Retrofit of Existing Engines	OGV14 Retrofit/Repower Requirements for Infrequent Callers OGV13 Additional Auxiliary Engine Reductions for Frequent Callers
Highly Effective Emission Controls on Main Engines and Auxiliary Engines	OGV5 New Engine Standards for Category 3 Marine Engines OGV7 Low Emission Main Propulsion Engines
Sulfur Emission Control Area (SECA)	OGV10 Sulfur Emission Control Area SECA (EPA, ARB)
Expanded Use of Cleanest Vessels In California Service	OGV6 Reroute Cleanest Ships
Expanded Shore Power and Alternative Controls	OGV16 Expanded Alternative Maritime Power
Implementation Possible By 2020	
Full Use of the Cleanest Vessels in California Service	OGV6 Reroute Cleanest Ships OGV7 Low Emission Main Propulsion Engines
Maximum Use of Shore Power or Alternative Controls	OGV16 Expanded Alternative Maritime Power OGV17 Additional In-Use Measures for Ships

Table E-2
ARB Emission Reduction Plan Strategies and Comparable NNI Strategies
Commercial Harbor Craft

Commercial Harbor Craft	
ARB Emission Reduction Plan Strategies	**Comparable No Net Increase (NNI) Strategies**
Actions Taken Since 2001	
Incentives for Cleaner Engines	HC4 Dredging Activities HC5 TAC Harbor Craft Measures
Low Sulfur Diesel Fuel Rule	HC2 Clean Fuels for Harbor Craft HC3 Early Implementation of Ultra Low Sulfur Diesel
Implementation Possible By 2010	
ARB Rule to Clean Up Existing Engines - Cleaner Engines - Cleaner Fuels - Add-On Emission Control Devices	HC5 TAC Harbor Craft Measures HC6 New Engine Standards for Category 1 and 2 Marine Engines HC7 Emulsified Fuels HC8 In-Use Harbor Craft Emission Reduction Measure HC9 Repower Existing Harbor Craft HC10 Retrofit Existing Harbor Craft
Shore Based Electrical Power	HC11 AMP-Ready Staging Areas
Implementation Possible By 2015	
New Engine Emission Standards	HC6 New Engine Standards for Category 1 and 2 Marine Engines

Pre-2001 Actions	
U.S. EPA Standards for Harbor Craft (adopted in 1999)	HC1 New Engine Standards for Harbor Craft

Table E-3
ARB Emission Reduction Plan Strategies and Comparable NNI Strategies
Cargo Handling Equipment

Cargo Handling Equipment	
ARB Emission Reduction Plan Strategies	**Comparable No Net Increase (NNI) Strategies**
Actions Taken Since 2001	
Low Sulfur Diesel Fuel Rule	CHE2 Yard Tractor Modernization and ULSD Programs (2005 only for ULSD) CHE3 Early Implementation of ULSD for CHE other than yard tractors (2005 only)
EPA Tier 4 Emission Standards for New Off-road Engines	CHE1 Emission Standards for Heavy-Duty Nonroad Diesel Engines
Stationary Diesel Engine Rule	No Comparable NNI Strategy
Portable Equipment Rule	HC4 Dredging Activities (portable engines)
Incentives for Cleaner Fuels	CHE4 Alternative Fuel yard Tractor Resolution (new leases) CHE5 Emulsified Fuels CHE6 TAC Measures – cleaner fuels, retrofits and repowers of existing equipment
Implementation Possible By 2010	
ARB Rule for Diesel Cargo Handling Equipment	CHE2 Yard Tractor Modernization and ULSD Programs (2005 and 2006 ony) CHE6 TAC Measures – cleaner fuels, retrofits and repowers of existing equipment CHE7 Expanded Yard Tractor Modernization CHE8 Enhanced CHE Modernization other than yard tractor CHE9 Cargo Handling Equipment at Ports and Intermodal Rail Yards
ARB Rule for Gas Industrial Equipment	No Comparable NNI Strategy
Implementation Possible By 2015	
Upgrade to 85 Percent Diesel PM Control or Better	CHE7 Expanded Yard Tractor Modernization CHE8 Enhanced CHE Modernization other than yard tractor
Implementation Possible By 2020	
Zero or Near-Zero Emission Equipment	No Comparable NNI Strategy

Table E-4
ARB Emission Reduction Plan Strategies and Comparable NNI Strategies
Trucks

Trucks	
ARB Emission Reduction Plan Strategies	**Comparable No Net Increase (NNI) Strategies**
Actions Taken Since 2001	
2007 New Truck Emission Standards	HDV2 2007 On-Road Standards for Heavy-Duty Diesel Vehicles HDV16 On-Board Diagnostics for Heavy-Duty Trucks
Vehicle Replacement Incentives	HDV3 Gateway Cities Truck Modernization Program
Low Sulfur Diesel Fuel	HDV5 Ultra-Low Sulfur Diesel Fuel (15 ppm) HDV12 Early ULSD Implementation (through June 2006)
Smoke Inspections for Trucks in Communities	HDV6 Heavy-Duty Vehicle Inspection HDV7 Periodic Smoke Inspection Program HDV8 Augment Highway Inspections with Community-Based Inspections
Truck Idling Limits	HDV9 Reduced Truck Idling HDV19 Idling Reduction Measures HDV18 Electrified Truck Spaces
Community Reporting of Violators	No Comparable NNI Strategy
Clean Transport Refrigeration Units	HDV17 Transportation Refrigeration Units
Low NOx Software Upgrade Rule	HDV4 Engine Software Upgrade (or Low NOx Software Upgrade)
Implementation Possible By 2010	
Port Truck Modernization - Retire and Replace - Repower - Retrofit	HDV10 Expanded Truck Modernization Program HDV13 Retrofit with Diesel Oxidation Catalysts HDV14 Retrofit with Diesel Particulate Filters HDV15 PM In-Use Emission Control
Enhanced Enforcement of Truck Idling Limits	No Comparable NNI Strategy
ARB International Trucks Rule	HDV11 California Standards and Fleet Modernization for Mexican Trucks
ARB Private Truck Fleets Rule	HDV 10 Expanded Truck Modernization Program
Implementation Possible By 2015	
Continued Port Truck Modernization	See 2010 NNI comparable strategies for Port Truck Modernization above

Pre-2001 Actions	
2004 New Truck Emission Standards (adopted 2000)	HDV1 2004 On-Road Standards for Heavy-Duty Diesel Vehicles

Table E-5
ARB Emission Reduction Plan Strategies and Comparable NNI Strategies
Locomotives

Locomotives	
ARB Emission Reduction Plan Strategies	**Comparable No Net Increase (NNI) Strategies**
Actions Taken Since 2001	
Low Sulfur Diesel Fuel Rule	R2 ARB Diesel Fuel Used by Intrastate Locomotives R3 Standards for Nonroad Diesel Fuel
2005 Statewide Railroad Agreement	R10 Idling Controls for Switcher and Line Haul Locomotives R11 Efficiency Improvement on In-Use Class 1 Rail Equipment
Idle Enforcement Training	R10 Idling Controls for Switcher and Line Haul Locomotives
Implementation Possible By 2010	
Upgrade Engines in Switcher Locomotives	R5 PHL Switcher Locomotive Modernization and ULSD Programs R6 Ultra-Low Emission Switcher Locomotives: PHL R7 Ultra-Low Emission Switcher and Line Haul Locomotives: Class 1
Retrofit Diesel PM Control Devices on Existing Engines	R7 Ultra-Low Emission Switcher and Line Haul Locomotives: Class 1
Use of Alternative Fuels	R7 Ultra-Low Emission Switcher and Line Haul Locomotives: Class 1 R9 ARB Diesel Fuel for Class 1 Railroad Locomotives
* Implementation Possible By 2015	
More Stringent National Requirements - Tier 3 Emission Standards - On-board Diagnostics (OBD) - Rebuild Tier 0, Tier 1, and Tier 2 Engines to More Stringent Emission Standards - Idle Limiting Devices on New and Rebuilt Engines	R8 Tier 3 Standards for New and Remanufactured Locomotives and Engines
Concentrate Tier 3 Locomotives in California	R7 Ultra-Low Emission Switcher and Line Haul Locomotives: Class 1
Implementation Possible By 2020	
Continuation of 2015 Strategies	See "By 2015" NNI strategies above

Pre-2001 Actions	
Engine Standards for Locomotives (adopted 1998)	R1 Tier 0, 1, and 2 Engine Standards
1998 Memorandum of Understanding for South Coast Air Basin	R4 MOU in the South Coast Air Basin (1998)

* NNI strategy R12, *"Electrification of the Alameda Corridor,"* is not explicitly included in the ARB Emission Reduction Plan.

APPENDIX F

LIST OF PUBLIC AND PEER REVIEW COMMENTS

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APPENDIX F

LIST OF PUBLIC AND PEER REVIEW COMMENTS

This appendix lists the written comments we received on the December 2005 Draft Emission Reduction Plan for Ports and International Goods Movement through March 17, 2006. Each letter can be reviewed on our website at http://www.arb.ca.gov/planning/gmerp/gmerp.htm.

Public Comments

FROM	DATE
John E. Wilks, III	12/5/05
Tim Tyler, Pareto Energy LTD	12/13/05
Marcella McTaggart, El Dorado County AQMD Tom Christofk, Placer County APCD Mat Ehrhardt, Yolo-Solano AQMD Dave Valler, Feather River AQMD Larry Greene, Sacramento Metropolitan AQMD	12/15/05
Mike McKeever, Sacramento Area Council of Governments Larry Greene, Sacramento Metropolitan AQMD	12/15/05
Andrea Hricko, Southern California Environmental Health Sciences Center	12/28/05
Deborah Jordan, U.S. Environmental Protection Agency -- Region IX	1/9/06
James E. Enstrom, Ph.D., M.P.H., University of California, Los Angeles	1/9/06
Julie Masters, Natural Resources Defense Council Jesse Marquez, Coalition for a Safe Environment Andrea Samulon, Pacific Institute Noel Park, San Pedro and Peninsula Homeowners Coalition Martin Schlageter, Coalition for Clean Air Andrea Hricko, Southern California Environmental Health Sciences Center Margaret Gordon, West Oakland Environmental Indicators Project	1/10/06
The Goods Movement Subcommittee of the Bay Area Ditching Dirty Diesel Collaborative	1/10/06
The Modesta Avila Coalition	1/10/06
California State Senator George Runner	1/17/06
Manufacturers of Emission Controls Association	2/6/06
Richard Havenick, Air Quality Subcommittee of the Port of Los Angeles Community Advisory Committee	2/20/06
Seyed Sadredin, San Joaquin Valley APCD	2/22/06

FROM	DATE
Margaret Gordon, West Oakland Environmental Indicators Project Joy Williams, Environmental Health Coalition Jesse Marquez, Coalition for a Safe Environment Carolina Simunovic, Fresno Metropolitan Ministry Penny J. Newman, Center for Community Action and Environmental Justice Noel Park, San Pedro and Peninsula Homeowners Coalition	2/22/06
GTAT California	2/22/06
Bill Mueller, Cleaner Air Partnership	2/24/06
David Merk, Unified Port of San Diego	2/27/06
Becky L. Wood, Teichert Aggregates	2/27/06
David L. Modisette, California Electric Transportation Coalition	2/28/06
Larry Forester, Coalition for Practical Regulation	2/28/06
Catherine H. Reheis-Boyd, Western States Petroleum Association	2/28/06
Barry R. Wallerstein, D.Env., South Coast AQMD	2/28/06
Bill Carney, San Gabriel Valley Economic Partnership	2/28/06
Tom Plenys, Coalition for Clean Air Diane Bailey, Natural Resources Defense Council	2/28/06
Ralph G. Appy, Ph.D., Port of Los Angeles	2/28/06
Fran Inman, Majestic Realty Company	2/28/06
Mark A. Pisano, Southern California Association of Governments	2/28/06
Andrea Hricko, Southern California Environmental Health Sciences Center Julie Masters, Natural Resources Defense Council Andrea Samulon, Pacific Institute Angelo Logan, East Yard Communities for Environmental Justice Penny J. Newman, Center for Community Action and Environmental Justice Noel Park, San Pedro and Peninsula Homeowners Coalition Margaret Gordon, West Oakland Environmental Indicators Project Joy Williams, Environmental Health Coalition Jesse Marquez, Coalition for a Safe Environment	2/28/06
Teri Shore, Bluewater Network	2/28/06
T.L. Garrett, Pacific Merchants Shipping Association	2/28/06
Ernest Gutierrez, Alameda Corridor-East Construction Authority	2/28/06
Rusty Hammer, Los Angeles Area Chamber of Commerce	3/1/06
Julie Ruiz-Raber, City of Carson	3/7/06
David L. Modisette, California Electric Transportation Coalition	3/10/06

FROM	DATE
Bob Wyman, Maritime Goods Movement Coalition	3/10/06

Peer Review Comments on Health Impacts

FROM
Professor John Froines, University of California, Los Angeles
Professor Jane V. Hall, California State University, Fullerton
Dr. Aaron Hallberg, Abt Associates, Inc.
Professor Michael Jerret, University of Southern California
Dr. Melanie Marty, Office of Environmental Health Hazard Assessment
Dr. Bart Ostro, Office of Environmental Health Hazard Assessment
Professor Constantinos Sioutas, University of Southern California
Professor Akula Venkatram, University of California, Riverside

APPENDIX G

MARITIME GOODS MOVEMENT COALITION PROPOSAL

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APPENDIX G

November 23, 2005

Maritime Goods Movement Coalition

Goods Movement Attainment Plan (GMAP) – Key Elements

The Maritime Goods Movement (MGM) Coalition is a coalition of stakeholders in the maritime goods movement sector who have joined together to develop a long-term, comprehensive goods movement plan that will allow the region to attain national air quality standards and address local public health concerns while still protecting the region's economy and ensuring continued economic growth. Current members include representatives of the ports, terminal operators and fuel and energy providers.

The Coalition has prepared the following summary of its proposed Goods Movement Attainment Plan (GMAP). We present this summary as an outline of elements that would describe an ideal program, recognizing that there are several elements that cannot be implemented immediately. For example, the Coalition strongly supports the development of a long-term (e.g., 20-year) master plan for the goods movement sector, which would address the interrelationship among the goods movement system, the Southern California communities it impacts, the customers it serves, the jobs it provides and other relevant considerations. But we recognize that we should not wait for the completion of such a master plan to address air quality or public health needs or to make the infrastructure investments necessary to improve the efficiency of the goods movement sector and to permit continued economic growth. Therefore, we set forth the description below with the expectation that the many of the most important air quality and public health improvement strategies, as well as several of the most essential infrastructure investments, should proceed promptly even before the master plan is completed. We envision that the master plan would develop in parallel with these initial air quality, public health and infrastructure investments, so that in the relatively near term the interrelated elements of the goods movement system could be fully integrated within a goods movement master plan. Accordingly, although the description below sets forth a comprehensive goods movement strategy that will take some time to develop fully, our expectation is that certain components of the strategy would commence promptly.

In the summary that follows, references to the South Coast Air Quality Management District (SCAQMD) or to Southern California are for illustration only and should be read equally to refer to the Bay Area Air Quality Management District or to the Bay Area.[1]

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1 San Diego is currently in attainment of the National Ambient Air Quality Standards and therefore is not directly addressed in this outline.

Set forth below are the Coalition's recommendations regarding (1) a long-term master plan for the goods movement sector, (2) a market for the goods movement sector to reduce emissions, improve public health and invest in transportation improvements, and (3) a system of enforcement and monitoring to ensure goals are achieved.

Element	Description
GMAP Master Plan	Under the GMAP, a 20-year master plan would be developed for the goods movement sector in each region of the state. Its purposes would include the enhanced efficiency and performance of the goods movement system, the attainment of the ozone and fine particulate standards and the improvement of public health in communities impacted by the goods movement sector. It would: (1) contain strategies for the expeditious improvement of air quality and public health in local communities: (2) define the state implementation plan (SIP) elements for the goods movement sector; (3) establish a baseline emissions inventory and projected emissions levels for future years, which anticipate and address growth in the sector; and (4) establish transportation conformity benchmarks for the sector that would be incorporated in SCAG's Regional Transportation Plan and the SIP. As noted above, we anticipate that certain elements of the GMAP would proceed promptly (e.g., in pilot form) and would be integrated with the master plan as it is developed.
Master Programmatic EIR/EIS	The plan would be supported by a programmatic Environmental Impact Report/Environmental Impact Statement (EIR/EIS) under the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA), which would evaluate the potential environmental impacts of anticipated projects in the goods movement sector over the next 20 years. We recognize the sequencing challenge between the development of the goods movement master plan and the next SIP. Our expectation is that these two planning documents, and their respective environmental evaluation, would be integrated to the greatest extent possible.
Infrastructure Elements	The plan would identify those infrastructure investments that will be needed to reduce goods movement-related emissions and congestion in the region and to improve the efficiency of the goods movement system. It would identify potential public and private strategies for financing such projects, including the use of SIP credits, emissions

	credits and emissions fees as noted below. It also would include recommendations for process and operational improvements in the goods movement system that might increase efficiency and reduce emissions. We are developing a list of illustrations.
Administering Authority	At the outset, the GMAP would be initiated by existing state and regional authorities. However, as the master plan is developed and as activity associated with the plan increases, it seems appropriate that the GMAP be administered by a newly-established joint powers authority (the Goods Movement Authority (GMA)), consisting of representatives of agencies and entities with expertise in the goods movement sector, including, e.g., in Southern California, the Ports of Los Angeles and Long Beach and their respective Cities, the California Air Resources Board, the South Coast Air Quality Management District, and the Southern California Association of Governments, with an appropriate advisory role for the U.S. Environmental Protection Agency. An analogous organization would be established in Northern California, as appropriate.
Performance Targets and Timetables (i.e., the Schedule for Emission Reductions)	The GMAP would establish performance targets and timetables for the reduction of emissions from sources in the goods movement sector (e.g., cargo handling equipment, auxiliary and propulsion engines, harbor craft). These would be framed in terms of emissions per unit of output or other performance indicator. Performance targets and timetables would be contained in regulations adopted by appropriate regulatory agencies or the GMA, as part of the rulemaking process following properly noticed public workshops and hearings. Existing CARB regulations would be used as presumptive targets and timetables where they have already been adopted.
The GMAP Market	The GMAP would include as a primary element an emissions reduction market. This market could be designed either as an open or closed market, with specific characteristics noted below. 1. Assuring Environmental Performance. Both options are designed to ensure that the market will meet overall air quality and public health goals, including avoidance of creating excess, or "paper" credits, and mechanisms to ensure that the program will deliver local benefits notwithstanding credit trading. 2. Market Participation. Participation in the market would be required of some sources, while others would have the option of entering the market through an enforceable mechanism such as a memorandum of understanding (MOU), a lease provision or amendment, or other binding document. As noted below, **sources that do not meet the program's performance targets and timetables, either directly or**

	by obtaining sufficient credits to offset their emissions, would be required to pay an excess emissions fee into the GMAP investment fund as a condition of the use of the state's goods movement system. 3. Exclusion of Some Categories. In certain circumstances, it may be more appropriate to regulate one or more source categories outside of the GMAP market. Further analysis will be required to make this determination. 4. Market Transparency and Information. We recommend that, to provide clear price signals to market participants and to prevent errors due to misinformation regarding the supply of and demand for credits, the GMA would provide a web-accessible central data system reflecting all relevant market activity, including real-time information regarding credit supplies and the volume and price of credit transactions.
Allowances Under Option One – Open Market	No allowances issued. Credits are generated when the emissions *rate* of a regulated activity has been reduced early or beyond the applicable performance targets. The amount of credit in each case would equal the product of the degree of environmental improvement (e.g., the required emissions rate as specified in the performance standard less the actual or certified emissions rate) times the applicable activity level. Under the open market approach, the GMA would periodically adjust performance targets and timetables to ensure that the region's overall goods movement-related emissions remain on track.
Allowances Under Option Two – Closed Market	Allowances would be issued to existing sources subject to GMAP performance targets and timetables. We are currently evaluating options, but it may be appropriate to allocate allowances to terminal operators rather than to the specific vessels that visit the ports. Initial allowances would be based on current activity levels. Allowances for additional activity (i.e., growth) could be purchased from the market or the GMAP investment fund.
Eligible Credit Generators	Credits can be generated at any source that is subject to a performance target. We are currently analyzing options regarding the appropriate placement of emission reduction responsibility (i.e., whether responsibility should follow each source or be aggregated, e.g., at the terminal operator level). We envision that any person could invest in emission reductions at sources for which a performance target has been set and, through appropriate contract provisions or according to regulation, become a seller of credits.

Eligible Credit Users	Any source subject to a GMAP performance target, unless the source is located in a priority zone. Also, qualified sources outside of the GMAP (e.g., stationary sources) if the SCAQMD has determined that such sources are eligible to purchase credits for approved uses.
Approved Credit Uses	Regulated GMAP sources would be required to hold credits to offset any emissions in excess of GMAP performance targets. Qualified sources outside of the GMAP also could use credits as an alternative source of compliance with SCAQMD-designated rules, including select 1100-series rules (Source Specific Standards) and to meet the offset requirements of SCAQMD Regulation XIII (New Source Review). Sources could not purchase credits as an alternative means of complying with SCAQMD Regulation XIV (Toxic Air Contaminants).
Priority Zones and Priority Sources	Based on the continued air quality and public health studies conducted by the ARB, the SCAQMD and the California Office of Environmental Health and Hazard Assessment, the GMA would identify communities exposed to disproportionately high health risk from sources in the goods movement sector. These zones would be designated as priority zones for the purpose of accelerating investments to address air quality impacts. Sources that are identified as contributing significantly to the disproportionate risk in such zones also would be designated as priority sources for purposes of the GMAP program.
Special Investment Incentives and Trading Rules for Priority Sources Located in Priority Zones	Under the GMAP market, designated priority sources located in priority zones would be entitled to receive funding from the GMAP investment fund, from eligible credit users from within and without the goods movement sector (i.e., to accelerate investment in the priority zones). Priority sources located in priority zones **would not** be allowed to purchase credits from outside such zones for use within such zones (e.g., to defer or avoid emission reductions there). (We are considering whether and to what extent it might also be appropriate to accelerate investment in priority zones further by preferentially weighting credit generation in such zones. This element will require additional analysis.)
Special Targets and Tracking for Priority Zones	The **GMAP will establish accelerated emissions and risk reduction targets for priority zones.** The GMA will track program performance according to these targets on an annual basis and determine whether additional strategies are appropriate to ensure the reduction of risk and the improvement of public health in priority zones.

GMAP Investment Fund	Eligible sources would be entitled to purchase emission reduction credits from the GMAP investment fund. The GMAP investment fund would be used to finance the further reduction of emissions from the goods movement sector beyond otherwise applicable requirements, either by installing controls, converting fuels, improving the efficiency of the goods movement system or by investing in other appropriate emissions reduction or efficiency-enhancing measures.
Lease Provisions	The ports would continue to exercise their leasing authority; however, projects that participate in the GMAP market would satisfy the air quality-related conditions of any lease. Sources or projects that are not subject to the GMAP market would continue to be subject to project-specific air quality lease conditions.
Project-by-Project Review	Projects would continue to be evaluated under CEQA or NEPA to the extent previously required; however, participation in the GMAP market would be deemed to mitigate any project-related air quality impacts.
Excess Emission Fees	Sources that do not elect to participate in the GMAP market and that do not otherwise comply with the GMAP performance targets and timetables would be subject to an excess emissions fee as a condition of entry into the ports and participation in the goods movement system.
Fee Uses	Funds collected from the excess emissions fee would be used in the GMAP investment fund to improve the environmental, public health and transportation performance of the goods movement system. To the extent practicable, the funds would be used to mitigate directly the excess emissions of the source paying the fee (e.g., by financing surplus emission reductions through the construction and operation of controls or other emission reduction strategies).
Monitoring, Inspection, Reporting, Tracking and Other Accountability Mechanisms	Accounting would occur at several levels. At the source level, sources would be required to log and report their emitting activities when located within the goods movement zone (to be determined). These reports would be subject to periodic inspections. The GMA also would track and make publicly available data regarding overall sector activity and emissions in the region. Periodically, the GMA would compare program progress and performance, including analysis regarding the overall efficiency of the goods movement sector (e.g., by transit time), emissions and air quality improvement. The GMA also would publish promptly all relevant information regarding investments by the GMAP investment fund, including the cost of such investments and the emission reductions and other benefits achieved thereby. The GMAP market program would be subject to periodic independent audit by an appropriate authority.

Legal Authority and Enforcement Mechanisms	We are still evaluating the most appropriate means of assuring that the GMAP will be fully enforceable and effective in delivering the desired air quality and public health improvements and improvements in transportation efficiency. No determination has yet been made regarding the desirability or need for specific authorizing legislation at either the federal or state level. At the present time, however, we anticipate that the GMAP program can be implemented on the following basis. 1. Election to Binding Participation. Unless a source category is specifically excluded from participation in the GMAP market (see above), sources will be encouraged to elect binding participation. Material incentives include potential monetary gain through the generation and sale of credits, long-term certainty regarding the performance targets and timetables of the GMAP over the next 20 years, avoidance of unknown environmental mitigation measures as part of project-by-project lease review, higher confidence in the overall performance of a goods movement system that will be functioning in an integrated and well-planned manner. 2. Leasing Authority. To the extent that a source does not elect to binding participation in the GMAP market, it would continue to be subject to project-by-project standard setting as part of each port's leasing authority. 3. Excess Emissions Fee. Sources that do not comply with the GMAP performance targets or hold sufficient credits would be required to pay an excess emissions fee imposed by the port of entry as a condition of use of the port. 4. Inclusion in the SIP. By inclusion in the applicable SIP, performance commitments associated with the GMAP market and other program requirements would be subject to enforcement by EPA and citizens to the extent provided by the federal Clean Air Act.

November 22, 2005

Maritime Goods Movement Coalition

The Maritime Goods Movement Coalition has been formed to develop a long-term, comprehensive goods movement plan (the "Goods Movement Attainment Plan") that will allow the region to attain national air quality standards and address local public health concerns while still protecting the region's economy and ensuring continued economic growth.

There is consensus among policymakers that we must reduce emissions from the goods movement sector if we are ever to attain national health standards for ozone and fine particulate matter. Most other sources of emissions are already very heavily controlled. Not only are port and goods movement-related emissions relatively un- or undercontrolled, but total emissions from this sector will grow substantially as the sector experiences continued economic growth.

But regulating the goods movement sector is not a simple matter. To be effective, regulations must overcome unique legal obstacles, including the lack of legal authority to regulate certain major sources. Regulations also must be sufficiently integrated to avoid unintended consequences, such as increasing congestion or shifting goods from lower to higher emitting modes of transportation. They must be also be economically efficient if the region is to preserve the thousands of jobs related to the goods movement sector and to avoid wasting billions of dollars of scarce economic resources. The region's health and economic welfare are both at stake. Piecemeal regulation cannot possibly meet these multiple challenges. Instead, we will need an integrated, long-term strategy that can deliver clean air and reduce congestion while preserving the region's economic and employment opportunities.

The Maritime Goods Movement Coalition has been formed for the purpose of designing an integrated, market-based program that can best meet these multiple challenges. Properly designed, the program would dramatically and quickly improve both air quality and public health and encourage more efficient goods movement. By selectively using market tools, the proposal would significantly reduce the cost of achieving these objectives, provide greater flexibility to regulated sectors and allow the region to address activities that cannot be regulated in traditional ways.

A Comprehensive Air Quality Attainment Plan – the Goods Movement Attainment Plan

As initially envisioned, the Goods Movement Attainment Plan would set phased performance targets designed to enable the South Coast Air Basin to attain the national ozone standard as required by 2021 (or 2025) and the fine particulate standard by 2015. To achieve these air quality goals at the lowest cost, the plan would permit regulated sources to design solutions tailored to their own operations. The plan also would allow sources to generate and trade emission reduction credits to help finance emission reductions and to reward early actions. The plan would also include an investment fund financed by sources unable to meet the performance targets that would be invested in pollution control. A similar program could be developed for the Bay Area.

One important aspect of the plan is that it would incorporate anticipated growth in the volume of goods moved through the region and mitigate the air quality impacts of such growth through the plan's performance standards. This element would encourage conforming projects by streamlining CEQA review for such projects. Finally, the plan would provide significant near-term public health benefits, because it would preferentially credit the reduction of emissions that occur near communities and other sensitive receptors.

Plan Benefits

Relative to other plans that have been proposed, the Goods Movement Attainment Plan is designed to achieve the following benefits for the region in addition to achieving the targeted air quality objectives:

- ***Greater Flexibility*** – the plan would provide regulated entities with the flexibility to design solutions that are best suited to their own operations and that occur over a time frame commensurate with the national attainment deadlines (e.g., 2015 for particulate matter and 2021 (or 2025) for ozone);

- ***Greater Near Term Community Health Benefits*** – in the near term the plan could deliver greater public health benefits by attracting and accelerating investment in locations nearest to communities and other sensitive receptors.

- ***Lower Cost*** – the plan would reduce the cost of compliance by allowing sources involved in goods movement and in other sectors to generate and trade emission reduction credits;

- ***More Effective Regulation*** – by using market strategies, the plan can encourage emission reductions by sources that cannot be reached by traditional government regulation;

- ***Greater Economic Opportunities*** – the plan would protect reasonable economic growth at the ports by addressing conforming growth in the air quality plan and by ensuring a cost-effective means of meeting the plan's performance targets; and

- ***Fewer Future Project Hurdles*** – the plan would streamline approval of conforming projects at the ports by developing a master plan that incorporates mitigations into the plan's overall performance guidelines, thus reducing the uncertainties associated with project-specific CEQA review.

Questions and Answers

1. How would the Goods Movement Attainment Plan lower the overall cost of reducing emissions?

Answer: Under a market program, regulated sources can select the most cost-effective means of reducing emissions. They also can tailor controls to match their own unique operations in ways that often cannot be anticipated by regulators. Furthermore, under a market program, sources can time their expenditures to coincide with other investments. Historically, market programs implemented in the U.S. have demonstrated cost savings in the range of 25% or more.

As early as the 1970s the United States has used market strategies, such as emissions trading, to achieve emission reductions in the most cost-effective manner. One early program was the lead trading program, designed to remove lead from gasoline. More recent programs include the Regional Clean Air Incentives Market, or RECLAIM, which regulates large sources of oxides of sulfur and nitrogen in the South Coast Air Basin, and the acid rain program implemented nationally. Economic evaluations of such programs suggest that they achieve very substantial cost savings, lowering the cost relative to traditional command-and-control programs by as much as fifty percent (50%). *See*, *e.g.*, Ellerman, Jaskow and Harrison, "Emissions Trading in the U.S. – Experience, Lessons and Considerations for Greenhouse Gases," at 32 (Pew Center on Global Climate Change, May 2003).

2. How does a market program enhance environmental effectiveness?

Answer: A market program enhances environmental effectiveness by creating economic value for reducing emissions. In this circumstance, it also creates an opportunity to overcome potential legal impediments to regulation.

A well-designed market program enhances environmental effectiveness because it rewards conservation; it creates an economic incentive to accelerate investment in clean technologies; it provides a means of addressing economic hardship, which otherwise would serve to discourage, disable or diminish regulation; it aligns stakeholders and thus encourages consensus; and it creates rewards for innovation. Id. at 32-34. In this context, it also provides a means of overcoming otherwise formidable legal impediments to regulating emissions from sources such as rail engines and ocean-going vessels because such sources will have an incentive to participate in the market to realize economic opportunities. Furthermore, the fee mechanism is more likely to withstand legal challenge because it is tied directly to an activity's excess emissions, it can be avoided entirely if the source meets performance standards or provides offsets, and the funds would be directed to mitigate the activity's impact.

3. How can the plan prioritize public health benefits?

Answer: As currently envisioned, the plan will accelerate the reduction of emissions that pose the greatest risk to local communities. It will do this by establishing higher credit values for those investments that disproportionately benefit public health.

The proposed plan will create an economic incentive for those investments that yield the greatest health benefit. For example, the plan might pre-approve the generation of credits from reducing emissions that occur closest to local communities or to sensitive receptors or from reducing emissions that are considered the most toxic. The plan also may apply special weighting factors, or provide for expanded credit uses, so that such credits are valued more highly than other credits. The California Air Resources Board has recently evaluated health risk in local communities. The coalition intends to work with CARB, the SCAQMD and the local communities to identify those emission reductions that would deliver the greatest health benefits.

To ensure further that the desired emission reductions occur in local communities, we have crafted our proposal to prohibit sources from avoiding or deferring otherwise-required emission reductions by purchasing credits if their emissions significantly contribute to local risks in communities found by CARB or the SCAQMD to be exposed to disproportionately high risk. Of course, we want to encourage such sources to accelerate their emission reductions and, therefore, will recommend financial strategies to incentivize reductions beyond required levels. This can be achieved, among other means, by allowing them to generate credits for use outside of such higher-risk zones. This approach should further ensure that investments are attracted and accelerated in local communities that experience higher risk.

4. Wouldn't this program simply allow sources to "pay to pollute?"

Answer: For the first time, the plan will address all sectors of pollution in the ports, thus making all emissions sources accountable. Moreover, by creating financial value for emission reductions, the plan will make it possible to finance many otherwise orphan emission reductions (e.g., the existing truck fleets). Imposing accountability on all sectors will be necessary if the region is to attain the air standards.

The real problem under current law is that, in the goods movement sector, many polluters don't pay for their pollution, because, under current law, many port sources are not regulated at all. Even as government begins to regulate more goods movement sources, without using market strategies, it will be unable to address many if not most of the emissions, such as vessel emissions or emissions from the existing truck fleet.

The Goods Movement Attainment Plan is intended to address all of the sector's emissions either by imposing performance requirements on such sources or, in the case of existing vehicle fleets, by creating an efficient means of financing reductions from such fleets. The program thus ensures that all polluters are accountable, or in a sound bite, ensuring that "all polluters pay." Moreover, by establishing a new market for emission reductions in and around the ports, the program would create a powerful economic incentive for emission reductions wherever and whenever they can be found.

5. What are the deadlines for meeting EPA's ozone and fine particle air quality standards?

Answer: 2021 or 2025 for ozone and 2015 for PM2.5.

Under the Clean Air Act, EPA issues national ambient air quality standards (NAAQS) for various classes of pollutants. Exposure to levels higher than such standards is considered unhealthful. Among other categories, EPA has set NAAQS for ozone and fine particles. In California, the most difficult air quality challenges exist in the South Coast Air Basin, which consists of Los Angeles, Orange and portions of Riverside and San Bernardino Counties. The Basin currently fails to meet the NAAQS for ozone and fine particulates.

A. Ozone Standard:

Ground level ozone pollution, commonly referred to as "smog," is formed when volatile organic compounds (VOC) react with oxides of nitrogen (NOx) in the presence of sunlight. Although EPA had previously defined the ozone standard on the basis of peak one-hour readings, in 1997 EPA revised the NAAQS for ground-level ozone, setting it at 0.08 parts per million averaged over an 8-hour time frame. The current ozone standard is thus commonly referred to as the "8-hour ozone standard."

EPA designates areas that do not meet the NAAQS as "nonattainment" for that pollutant. Based on current ozone readings in the South Coast, EPA has designated the South Coast Air Basin as a "Severe-17" nonattainment area. Under EPA's regulations, the South Coast has until the year 2021 (or 17 years from the June 15, 2004 effective designation date) to attain the current ozone standard. *See* 69 Fed. Reg. 23858, 23863, 23882 (April 30, 2004); 40 CFR § 81.305. This deadline would become 2025 if the region were designated an "Extreme" area, as currently contemplated by the SCAQMD.

EPA has announced its intention to revoke the previous 1-hour ozone standard, which had an earlier attainment date of 2010. The 1-hour standard will be revoked effective June 15, 2005. See 69 Fed. Reg. 23951, 23954 (April 30, 2004, effective June 15, 2004)("We will revoke the 1-hour standard in full, including the associated designations and classifications, 1 year following the effective date of the designations for the 8-hour NAAQS.")

B. Fine Particle Standard:

Fine particle pollution is a mixture of microscopic solids and liquid droplets suspended in air. Fine particles can be emitted directly or formed in the atmosphere from a variety of combustion sources. EPA has determined that fine particles less than or equal to 2.5 micrometers (μm) pose the greatest risk. EPA's NAAQS for PM2.5 include both an annual standard (15 $\mu g/m^3$ based on a 3-year average of annual mean PM2.5

concentrations) and a 24-hour standard (65 μg/m^3 based on 3-year average of 98^{th} percentile of 24-hour concentrations).

EPA has designated the South Coast Air Basin as "nonattainment" for the PM2.5 NAAQS. Nonattainment areas that experience severe PM2.5 problems are eligible for a five-year extension beyond the initial 2010 attainment deadline, for a final compliance deadline of 2015. *See* 70 Fed. Reg. 944 (January 5, 2005, effective April 5, 2005).

The Goods Movement Attainment Plan would be designed to achieve gradually increasing emission reductions so as to enable the South Coast Air Basin to meet the 2021/2025 and 2015 final attainment deadlines for the ozone and fine particle standards.

6. How will the Goods Movement Attainment Plan set performance targets?

Answer: Sector-specific performance targets will be expressed as an expected emissions rate per unit of activity and will be phased in over time.

The coalition will evaluate each goods movement sector to determine the full range of strategies available to reduce emissions and improve air quality. For those strategies that are technologically feasible, cost-effective and clearly beneficial, the coalition will recommend their direct implementation over an appropriate time frame.

There will be many other areas for which significant uncertainties remain regarding the feasibility, cost or benefit associated with one or more strategies for certain sectors. In such cases, the coalition will recommend a sequence of phased emission reductions over the attainment period (i.e,. 16 or 20 years for ozone and 10 years for PM 2.5). Individual entities will retain the discretion to determine how to meet these reduction targets and will, in most cases, be encouraged to find approaches that are best suited to their own operations. Under the proposed market program, sources that do better than the phased emission reduction targets will generate emission reduction credits that can be traded and used in the market. Those who miss the targets will be required to hold sufficient offsetting credits or otherwise take mitigating action.

Example: Instead of mandating a particular approach for reducing ship emissions, the plan will establish phased emission reduction levels, probably expressed in terms of an emissions rate per unit of activity (e.g., pounds of emissions per unit of fuel consumed or power output). Under the plan, ships could use any means of meeting that target (e.g., exhaust treatment, barge control, sea water scrubbing, shore-side electrification).

7. How will the market work?

Answer: The market will allow sources to average their emissions to meet performance targets. Sources that act early or perform better than expected can generate tradable surplus emission reduction credits. Those that miss their targets will need to obtain offsetting credits or otherwise mitigate their excess emissions.

A. Credit Generation

Under the proposed plan, any source that is subject to a performance target will have the opportunity to generate tradable surplus emission reduction credits by achieving greater than expected reductions or by achieving reductions earlier than required.

B. Credit use

Under the proposed plan, any regulated source can purchase credits and use them as a means of demonstrating compliance with their own performance targets. Likewise, sources outside the goods movement sector can purchase credits from this program for their own compliance with air quality regulations or as a source of offsets for new business growth. One clear advantage of this proposal is to encourage investment in the goods movement sector from both within and outside the sector.

C. Targeted Mitigation Fee or Safety Valve

Under the proposed plan, regulated entities that fail to meet their performance targets and that have not otherwise demonstrated compliance (e.g., by purchasing credits), would be required to pay a mitigation fee for any excess emissions. This "safe harbor" mitigation fee would be applied either to port/goods movement infrastructure improvements or to other emissions mitigation strategies.

D. Ports/Goods Movement SIP and Periodic Adjustments

The plan can be designed as either a "closed" or "open" market (see other documents for a more detailed description of this design choice). If the plan is implemented as an "open" market that follows growth in the sector, it will be necessary periodically to evaluate whether the performance targets provide the desired level of progress towards attainment of the ozone and fine particle standards. Under the proposed plan, any necessary periodic adjustments would be made as part of a Ports/Goods Movement state implementation plan (SIP).

8. How will the plan address future growth?

Answer: The Ports/Goods Movement SIP will include projected emissions due to anticipated growth and will set performance targets accordingly.

Working with the Southern California Association of Governments and the air quality agencies, the Ports and Goods Movement participants would identify anticipated growth during the plan period (i.e., through the year 2021). The plan's performance targets would take such growth into account, subject to periodic adjustments as noted above. Because the plan would incorporate anticipated growth, provide performance expectations for all sources, and provide for mitigation of all material air quality impacts, the Goods Movement Action Plan would be designed to satisfy CEQA requirements for evaluating the air quality impacts of new projects. This would substantially streamline project-specific review for conforming projects.