

**Appendix B:  
Emissions Estimation Methodology for On-Road Diesel-Fueled Heavy-Duty  
Drayage Trucks at California Ports and Intermodal Rail Yards**

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**CALIFORNIA AIR RESOURCES BOARD**

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## EXECUTIVE SUMMARY

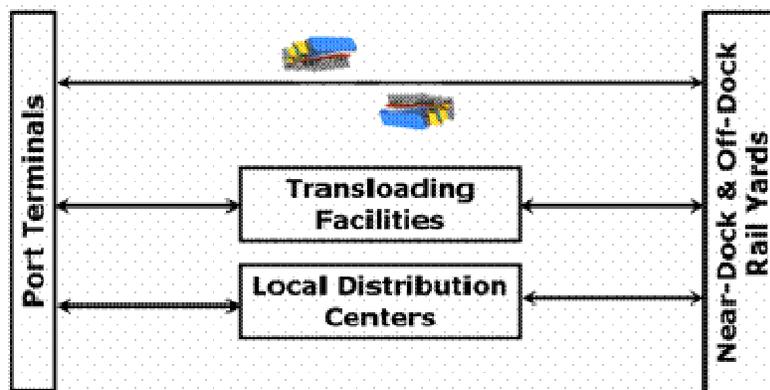
The California Air Resources Board (ARB) has developed a proposed regulation to reduce diesel PM and NOx emissions from drayage trucks servicing ports and intermodal rail yards in California. The regulation is expected to significantly reduce diesel PM emissions, which is necessary for reducing premature mortality, cancer risk, and other adverse health effects from exposure to diesel PM. The regulation would also reduce NOx emissions which contribute to violations of ozone air quality standards in California.

This technical report describes methodologies used to develop drayage truck emissions inventories and provides estimates of emissions reductions to support regulatory development. Staff chose 2005 as the base year for this emissions inventory because 2005 was the most recent year in which complete container lift data and trip origin and destination data were available to estimate truck trips and travel miles. The objectives in developing this emissions inventory were to estimate:

- the trips, trip lengths, and vehicle miles traveled associated with trucks servicing California's major ports and intermodal rail yards;
- the emissions associated with these drayage trucks; and
- the benefits of the proposed regulation.

This drayage truck emissions inventory was developed using a step-wise approach. The first step was to obtain container lift data from major ports and intermodal rail yards. These data were used in a "container balancing" approach to estimate truck trips and destinations of those trips, as shown in Figure ES-1. Port container lift data were used as baseline information to estimate the total number of import, export, and empty containers moved between terminals, to rail yards, to local distribution centers, and on longer hauls.

**Figure ES-1: Containerized Cargo Movements by Truck**



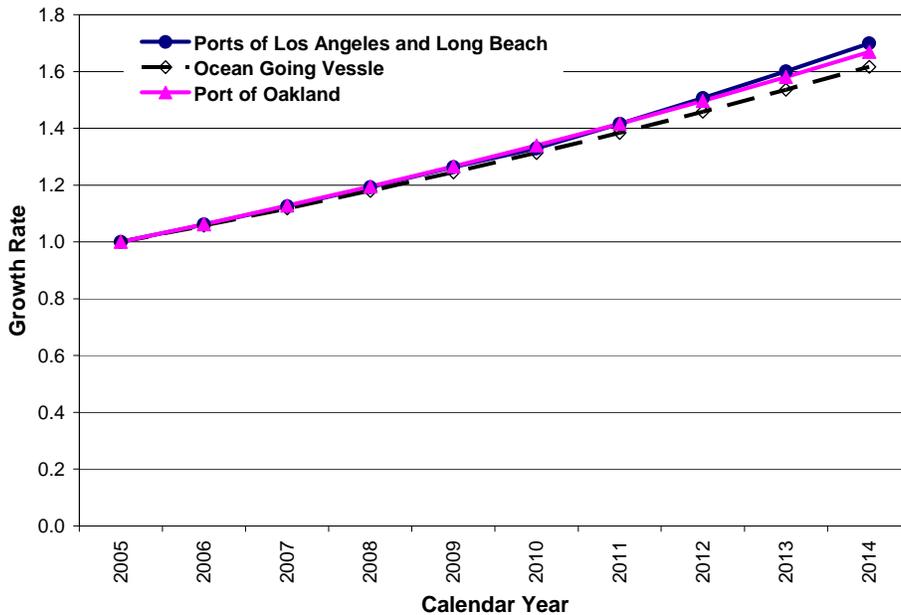
In the second step to develop this emissions inventory, staff estimated fleet average travel miles per trip by analyzing drayage truck activity studies and data collected in 2004 to 2007. With truck trips and travel miles per trip, we estimated drayage truck travel miles (VMT). Next, we estimated base year emissions by coupling emission rates to VMT. Equation ES-1 describes our method for estimating emissions by calendar year.

$$EM_y = Trip_y * Mile * ER_y * DFG_y \tag{ES-1}$$

- Where,  $EM$  = emissions (tons/year)
- $y$  = calendar year
- $Trip$  = the number of trips (trips/year)
- $Mile$  = truck travel miles (miles/year)
- $ER$  = emissions rates (g/mile)
- $DFG$  = drayage truck activity growth rate

Future year emissions, 2007 to 2014, were forecasted with the projected drayage fleet growth rate. These growth rates were based on container vessel installed power growth rates previously developed for ARB’s Goods Movement Emissions Reduction Plan and adjusted with rail facility growth rates at the ports of Los Angeles/Long Beach and Oakland. Truck activity is anticipated to grow approximately 5% per year between 2005 and 2014 as shown in Figure ES-2.

**Figure ES-2: Drayage Truck Activity Growth Rates at Ports in California**



Using the emissions inventory approach described above, staff estimated total drayage truck VMT by year in California. VMT is projected to grow every year, consistent with

increasing international trade and economic growth, and is projected to 50% grow statewide by 2014.

Finally, in the process of emissions inventory development, staff conducted extensive emissions inventory model validation studies by collecting drayage truck traffic information, surveying truck trip origins and destinations (O-D), interviewing port terminal and intermodal rail yard operators, and communicating with drayage truck trip generation / travel demand model developers / modelers. Validation studies were very important in developing this emissions inventory, because these studies led to a more complete understanding of drayage truck behavior and therefore key assumptions affecting activity and emissions estimates.

Truck activity data were not available for the Ports of Stockton, Hueneme, and San Diego, and smaller Bay Area ports, which complicated emissions estimates. To estimate emissions, staff scaled emissions from the Port of Oakland to other smaller ports using non-petroleum related throughput tonnage. This approach assumed that operations at other ports are similar to operations at the Port of Oakland. This assumption is simplistic but necessary given the limited information available for these ports.

For future projection we estimated truck activity growth based upon container vessel installed power growth rates developed for ARB's Goods Movement Emissions Reduction Plan and adjusted with rail facility growth rates at the ports of Los Angeles / Long Beach and Oakland. Truck activity is anticipated to grow approximately 5% per year between 2005 and 2014 as shown in Figure ES-2.

Figure ES-3 provides baseline and with regulation NOx emissions estimates. Results show the regulation is projected to generate 61% reductions in NOx through the turnover of the fleet to 2007 emission standard trucks by 2014.

**Figure ES-3: Statewide Drayage Truck NOx Emissions with and without the Proposed Regulation**

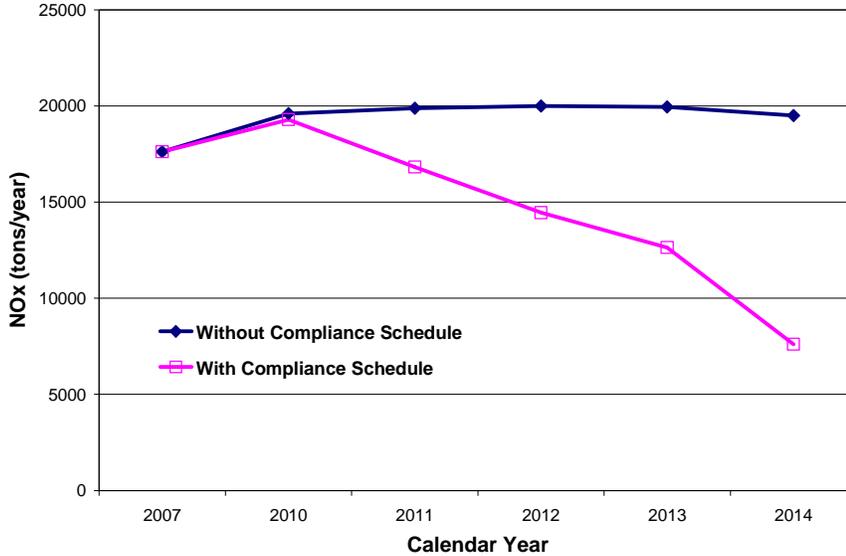
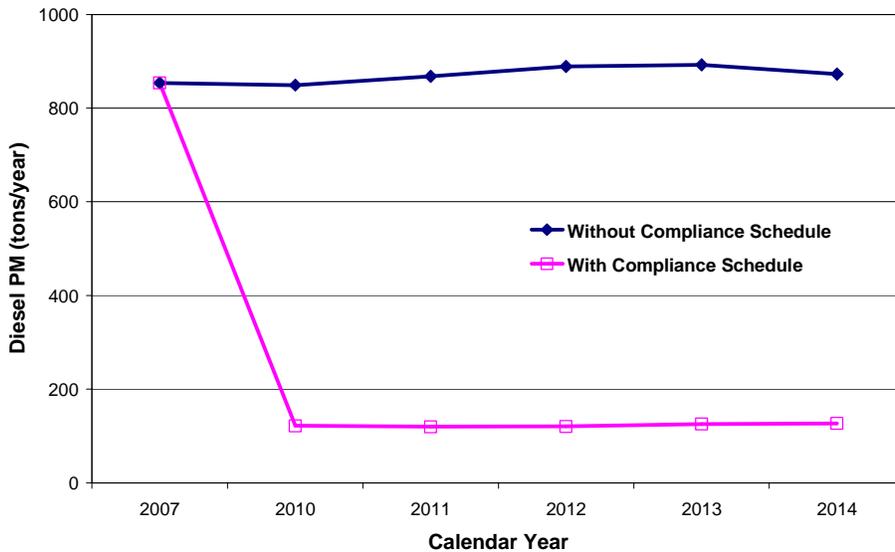


Figure ES-4 displays baseline and with regulation statewide diesel PM exhaust emissions. Results show the regulation is projected to generate 85% reductions in diesel PM with the integration of particulate filters and the turnover of the fleet to 2007 emission standard trucks by 2014.

**Figure ES-4: Statewide Drayage Truck Diesel PM Emissions with and without the Proposed Regulation**



## I. INTRODUCTION

This section provides background on the drayage truck emissions inventory, the purpose and goals in preparing this emissions inventory, and a general overview of the methodology used to estimate emissions from drayage trucks servicing ports and intermodal rail yards in California.

### A. Background

In 1998, the California Air Resources Board (ARB) identified diesel particulate matter (diesel PM) as a toxic air contaminant. A needs assessment for diesel PM was conducted between 1998 and 2000, which resulted in ARB staff developing and the Board approving the *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles* (Diesel RRP) in 2000 (ARB, 2000). The Diesel RRP presented information on the available options for reducing diesel PM and recommended regulations to achieve these reductions. The scope of the Diesel RRP was broad, addressing all categories of engines both mobile and stationary, and included control measures for diesel sources, such as those covered by the proposed regulation. The ultimate goal of the Diesel RRP is to reduce California's diesel PM emissions and associated cancer risks by 85 percent from the 2000 baseline levels by 2020.

In January 2005, a Goods Movement Cabinet Workgroup, created by Governor Schwarzenegger and led by the California Environmental Protection Agency and the Business, Transportation and Housing Agency, established a policy for goods movement and ports to improve and expand California's goods movement industry and infrastructure while improving air quality and protecting public health. The workgroup worked collaboratively with the logistics industry, local and regional governments, neighboring communities, business, labor, environmental groups, and other interested stakeholders to create a two-phased Goods Movement Action Plan, which outlines a comprehensive strategy to address the economic and environmental issues associated with moving goods via the state's highways, railways, and ports (ARB, 2007a). In April 2006, the Board approved the Emissions Reduction Plan for Ports and Goods Movement (GMERP) in California (ARB, 2006a). Drayage trucks servicing ports and intermodal rail yards are one of the key contributors to goods movement-related emissions as defined in the GMERP.

ARB staff has proposed a regulation to reduce diesel PM and the oxides of nitrogen (NO<sub>x</sub>) emissions from drayage trucks. Drayage trucks are the on-road heavy-duty diesel-powered vehicles that access ports and intermodal rail yards in California. The regulation is expected to significantly reduce diesel PM emissions. The reduction of diesel PM is needed to reduce premature mortality, cancer risk, and other adverse health effects from exposure to this diesel PM. The regulation would also reduce NO<sub>x</sub>

emissions which contribute to violations of ozone ambient air quality standards throughout the State.

## **B. Purpose and Overview**

The objectives in developing this emissions inventory were to estimate:

- the trips, trip lengths, and vehicle miles traveled associated with trucks servicing California's major ports and intermodal rail yards;
- the emissions associated with these drayage trucks; and
- the benefits of the proposed regulation.

This inventory provides estimates of NO<sub>x</sub> and diesel PM emissions from drayage trucks servicing ports and intermodal rail yards in California. This inventory covers 14 ports including Benicia, Crockett, Hueneme, Humboldt Bay, Long Beach, Los Angeles, Oakland, Pittsburgh, Redwood City, Richmond, Sacramento, San Diego, San Francisco, and Stockton. Rail yards include Burlington Northern Santa Fe (BNSF) Oakland, BNSF Commerce Eastern, Union Pacific (UP) Commerce, UP ICTF, UP LATC, UP Lathrop, BNSF Hobart, BNSF Richmond, BNSF San Bernardino, BNSF Stockton, and UP Oakland.

We chose the year 2005 as the base year of this emissions inventory because that was the most recent year for which container lift data and trip origin and destination data were available to estimate truck trips and travel miles, respectively. Future year emissions (2007-2014) were forecasted based on projected drayage fleet growth.

## **C. Public Process**

Allowing stakeholders and the general public to review and comment on a product associated with a rulemaking process is a critical element of that rulemaking process. ARB staff worked directly with Port of Los Angeles/Long Beach staff and consultants in developing and validating this emissions inventory. ARB staff also interviewed many drayage truck operators to better understand their business operations. In addition, inventory drafts were presented at several workshops attended by various organizations including the California Trucking Association, American Trucking Association, environmental groups, local air pollution control and air quality management districts, ports, intermodal rail yards, and port terminals operators. We also met directly with trucking associations and environmental groups, and provided spreadsheet inventory summaries on request and on our web site. We received comments through these public review processes, and considered these comments when reviewing and updating the inventory.

## **II. EMISSION ESTIMATION METHODOLOGY**

The drayage truck emissions inventory was developed using a step-wise approach. Container lift data and other information was used to estimate the number of truck trips to various destinations, origin/destination data were used to estimate trip lengths, survey data were used to estimate truck population and age distribution, and future growth trends were estimated using container vessel growth rates and other information.

### **A. Emission Inventory Inputs**

Data required for estimating drayage truck emissions include:

- Truck trips at ports and intermodal rail yards
- Travel distances from ports to intermodal rail yards, transloading / distribution facilities and container depots
- Future drayage truck activity growth rate
- Model year distribution and fleet specific emissions rates
- Drayage truck mileage accrual rate for emissions rates
- Engine control module reflash adjustment factors

A container balancing-based methodology was used to estimate trips, VMT and emissions for the Ports of Los Angeles, Long Beach, and Oakland. Other smaller ports and rail yards not covered by the above three Port-specific estimates were scaled from the Port of Oakland estimates.

#### **1. Container Balancing**

Imported containerized cargo is transported to ports by ocean-going vessels. Once at berth containers are lifted by cranes onto the docks, moved to container yards by cargo handling equipment, and then transported by trucks and locomotives to their intermediate and/or final destinations. A truck can transport one 40-foot container or up to two 20-foot containers for a single trip. Exported and empty containers return to Ports via trucks and rail. Because containerized cargo can be measured by twenty foot equivalent units (TEU), ports develop factors to convert TEU to the number of container lifts to measure container moves. These conversion factors are 1.81 for the Ports of Los Angeles and Long Beach, and 1.76 for the Port of Oakland. Tables II-1 and II-2 show loaded container lifts by destination and transportation mode for the ports of Los Angeles / Long Beach and the port of Oakland, respectively.

**Table II-1: Container Lifts for the Ports of Los Angeles and Long Beach in 2005**

Destination	Transportation Mode	
	Import	Export
Rail Yards	1,734,925	890,592
Transloading / Distribution Facilities	2,258,103	431,314
All	3,993,028	1,321,906

**Table II-2: Container Lifts for the Port of Oakland in 2005**

Destination	Transportation Mode	
	Import	Export
All	475,232	481,097

## **2. Truck Trips**

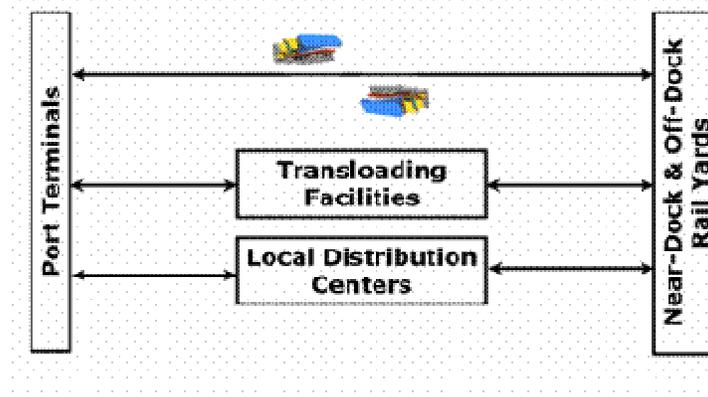
Estimating truck trips from container movement data requires a detailed understanding of how drayage trucks operate. Based on container movement and trip generation studies (Cambridge, 2005), as well as discussions with Port staff, one container lift is equivalent to one truck trip. When operating efficiently, a drayage truck will pick up an empty container, deliver that container to a Port, and pick up a full import container for transport to a rail yard or distribution center. This type of operation implies that one imported container entering a port may generate two trips: one trip from the port to a distribution center, and one trip from the distribution center to a port. The movement of containers destined for export is less efficient; generally a truck will pickup an empty container at a Port, return that container to a distribution center to be filled, and then transport that container to the Port for export. To increase drayage efficiency, fleet companies may reuse empty containers at distribution centers rather than transporting them back to the Port directly. However, studies show that only 2% of loaded containers from ports are reused and returned to ports as loaded containers in the South Coast (Tioga, 2002; Gladstein, 2007).

In reality, drayage truck trips are less efficient than is optimal. Our analysis suggests it is common for a truck to deliver an empty container to one terminal at a port, drive the tractor alone (bobtail) to another terminal to pick up a chassis, drive the chassis to another terminal to pickup a container, and then transport the container to its destination. A bobtail is a truck without a chassis. This process involves potentially long waiting times to complete. This analysis also suggests it is relatively common for a bobtail to travel to the Port from a distribution center.

We estimated truck trips based on container lifts at the ports of Los Angeles / Long Beach / Oakland and intermodal rail yards connected to the ports. Staff estimated total loaded container truck trips for import and export modes and added empty container truck trips by balancing the number of loaded container truck trips. Then staff

distributed container truck trips to trip origins and destinations from/to ports. The trip origins and destinations include near-dock rail, off-dock rail, transloading, container depot, and distribution facilities (Figure II-1).

**Figure II-1: Containerized Cargo Movement by Truck**



**a. Ports of Los Angeles and Long Beach**

**1) Container Truck Trips**

Container lift data were provided by Port of Long Beach transportation staff for the 2005 year (Carwright, 2006). These data contained detail about the transport mode (import/export/empty) and destination (on/near dock rail, off dock rail, and distribution center). After estimating total container truck trips using container lift data, staff split total truck trips by import and export modes. Then staff distributed truck trips to destinations including rail yards, transloading / distribution, and container depots using available data and several studies (Cambridge, 2006; Jones & Stokes, 2004). Table II-3 shows the number container truck trips by transportation mode and travel destinations at the ports of Los Angeles, Long Beach and associated intermodal rail yards.

**Table II-3: Container Truck Trips at the Ports of Los Angeles, Long Beach and Associated Intermodal Rail Yards in 2005**

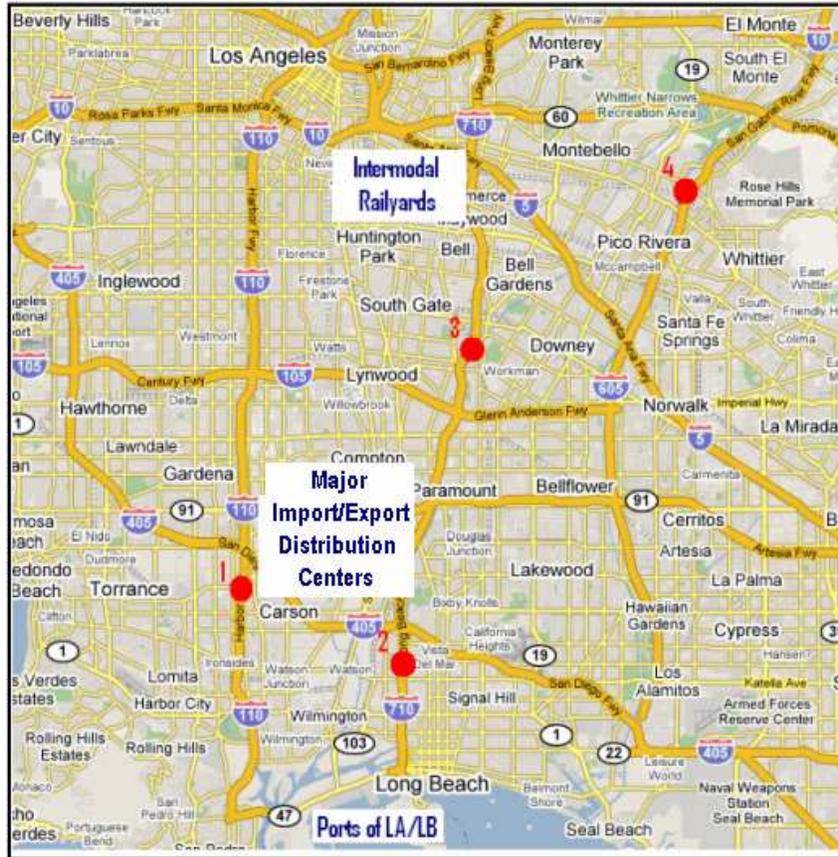
Mode	Travel Destinations	Trips
Import	Near-Dock Rail	339,188
	Off-Dock Rail	1,176,335
	Transloading / Distribution	2,565,320
Export	Near-Dock Rail	228,516
	Off-Dock Rail	851,193
	Transloading / Distribution	431,314
Empty	Near-Dock Rail	45,001
	Off-Dock Rail	68,076
	Transloading / Distribution	2,782,894
	Container Depot	495,506
All		8,983,342

2) Off-Port Truck Repositioning

Trucks make trips not only for transporting loaded and empty containers, but also for repositioning themselves to pick up containers or to leave after transporting containers. Drayage truck operators try to minimize repositioning for financial reasons, but a truck may need to reposition if a more efficient revenue move cannot be identified. Repositioning may involve bobtail traveling from one destination to another. A bobtail is a truck without a chassis which is pulling nothing. A drayage truck may also pull a chassis without an empty or loaded container. For modeling purposes, we identified two types of repositioning truck trips: off-port and inter-terminal truck trips.

Off-port repositioning truck trips include trips from/to ports to/from out of port boundaries including near/off-dock rail, container depot, transloading, and distribution facilities. To measure off-port repositioning truck trips, staff conducted a traffic count survey at four major freeway locations connecting to the ports of Los Angeles and Long Beach in June 2007. APPENDIX A shows the protocol of drayage truck traffic county survey. Four survey locations were chosen on the 710, 110 and 605 freeways. We selected these four locations because of significant drayage truck activity from the ports through these freeways to off-dock rail and local distribution facilities. Figure II-2 shows the four traffic survey locations to count off-port repositioning truck trips. Red dots indicate survey locations and the numbers are arbitrary location identifiers in Figure II-2.

**Figure II-2: Off-Port Repositioning Truck Trip Survey Locations**



At the four survey locations staff counted drayage trucks by configuration including container, bobtail and chassis moves for 40 minutes per hour from 7am to 6pm on a weekday. The survey results showed that daily average bobtail and chassis truck percentages were 18% and 7%, respectively. Daily average off-port repositioning truck trips were 24% of total drayage truck trips at the South Coast (Table II-4).

**Table II-4: Off-Port Repositioning Truck Survey Results in the South Coast**

ID	Location	Miles from the Ports	Truck Count (%)	
			Bobtail / Chassis	Container
1	I110 at Carson St.	10	25	75
2	I710 at Willow St.	3	19	81
3	I710 at Imperial St.	13	29	71
4	I605 at Beverly Blvd.	21	31	69
All (Average)			24	76

Given staff limitations, we were not able to survey all arterials and local roads where off-port repositioning trips may occur. We estimated an additional 5% of all trips may reposition on arterials and local roads not covered by the survey. As a result, we

concluded that about 30% of total drayage truck trips were off-port repositioning truck trips.

### 3) Inter-Terminal Truck Repositioning

Drayage trucks reposition their locations between port terminals and generate inter-terminal truck trips. For example, a truck transports a container to one terminal and leaves the terminal without a container to another terminal to pick up a container. To measure inter-terminal truck trips staff conducted a truck traffic count survey at two major public road sites connecting port terminals and four entrance and exit gates of five port terminals at the ports of Los Angeles and Long Beach in July 2007 (Figure II-3). The three pink dots indicate roadside survey locations and the four red dots indicate port terminal entrance / exit gate locations in Figure II-3. The two pink dots on the West Ocean Blvd indicate one survey location for different directions.

**Figure II-3: Inter-Terminal Repositioning Truck Trip Survey Locations**



During the survey, staff counted drayage trucks at the six locations by their configurations including containers, bobtails and chasses for 40 minutes per hour from 7am to 6:30pm on a weekday. Daily average bobtail and chassis trip percentages ranged from 37% to 52% at the locations. Hourly bobtail and chassis trip percentages ranged from 37% to 51% at the six locations. Table II-5 shows daily average bobtail and chassis truck trip percentages at the two roadside and the four entrance/exit gate survey locations.

**Table II-5: Inter-Terminal Repositioning Truck Survey Results in the South Coast**

Survey	Location	Truck Trip (%)		
		Container	Bobtail	Chassis
Roadside	W Ocean Blvd	63	29	8
Roadside	Terminal Island Freeway	48	43	9
Gate	Maersk Terminal	59	38	3
Gate	APL Terminal	57	32	11
Gate	PCT and ITS Terminals	51	40	8
Gate	LBCT Terminal	58	40	2
All (Average)		55	37	8

From the inter-terminal repositioning truck survey, staff found that the daily average bobtail and chassis truck trip percentage was about 45% at the ports. The finding of the 45% bobtail and chassis truck trips at the ports is consistent with the bobtail and chassis trip percentage of 47% that the ports of Los Angeles and Long Beach trip generation mode suggested (POLA, 2007; POLB, 2007). Because staff counted all trucks passing the survey locations, the 45% bobtail and chassis truck trips included not only inter-terminal repositioning trucks, but also off-port repositioning trucks. As a result, we assumed that 30% of total truck trips were off-port repositioning trucks, and an additional 15% of total truck trips represent inter-terminal repositioning from one terminal to another.

#### 4) Non-Containerized Truck Trips

For non-containerized truck trips, staff used trip generation modeling results provided directly by the ports of Los Angeles and Long Beach. The ports estimated 6,536 non-containerized port truck trips per day in 2005 (ITERIS, 2007). We estimated yearly total truck trips by applying 287 port operation days (POLA, 2007; POLB, 2007) to the provided daily truck trips.

### b. Port of Oakland

#### 1) Container Truck Trips

Staff estimated container truck trips using the container balance method. After developing total container truck trip estimates, we split total truck trips to travel destination using the results of a goods movement flow study in the Bay Area (MTC, 2003). Table II-6 shows the number container truck trips by transportation mode and travel destination at the ports of Oakland and the intermodal rail yards connected to the ports.

**Table II-6: Container Truck Trips at the Port of Oakland and Associated Intermodal Rail Yards in 2005**

Mode	From / To the Ports	Trips
Import	Near-Dock Rail	213,106
	Local Transloading / Distribution	199,472
	Regional Transloading / Distribution	62,654
Export	Near-Dock Rail	127,864
	Local Transloading / Distribution	240,865
	Regional Transloading / Distribution	112,369
Empty	Near-Dock Rail	85,243
	Local Transloading / Distribution	436,347
	Regional Transloading / Distribution	176,276
All		1,654,194

2) Off-Port Truck Repositioning

Since no transportation studies or activity data were available to estimate off-port truck repositioning at the Port of Oakland, staff collected field information from port terminal and near-dock rail yard operators. The terminal operators informed us that a significant percentage of truck trips are bobtails; however, terminal operators could not provide a quantitative estimate. Near-dock rail yard operators informed us that approximately 25% of total truck trips are bobtails at their rail yards. The 25% bobtail trip percentage was consistent with the bobtail trip percentages at the intermodal rail yards in the South Coast. As a result, we assumed that 30% of total truck trips are off-port truck repositioning trips conducted as either bobtail and chassis moves.

3) Inter-Terminal Truck Repositioning

Since no transportation study or activity data were available representing inter-terminal truck repositioning at the Port of Oakland, we assumed 15% of total truck trips are inter-terminal truck repositioning trips, based on the assumption that port operations are similar to operations at the Ports of Los Angeles and Long Beach.

**3. Travel Miles**

To estimate VMT it is necessary to estimate trip lengths by trip type. Our estimates were based on available survey data, published reports, and surveys conducted by ARB staff for this inventory development. Generally, travel distances were easily estimated for trips between ports and rail yards because the location of both the origin and destination was known. Travel distances were estimated for distribution centers based on weighted trip average travel distances derived from origin/destination studies and geographic information system (GIS) analysis and published reports. We also estimated travel distances to regional destinations outside of air basin boundaries.

## **a. Ports of Los Angeles and Long Beach**

### **1) Within South Coast**

For trip origin/destinations in the South Coast, we used GIS to estimate travel distances between intermodal rail facility physical locations and the Ports of Los Angeles and Long Beach. Drayage trucks travel 5 miles and 20 miles from the ports to near-dock and off-dock intermodal rail facilities, respectively, based on a trip-weighted GIS-based travel analysis.

Estimating travel distances to/from the Ports of Los Angeles and Long Beach to distribution and transloading facilities is more complicated. There are thousands of transloading and local distribution facilities, and the number of trips to each facility, or even the location of individual facilities is unknown. To estimate distribution center travel distances we started with fleet average travel miles using the truck trip origin and destination (O-D) survey provided by the Ports of Los Angeles and Long Beach. The ports conducted an O-D survey for more than 3,700 drayage trucks servicing the ports in 2004 and geocoded truck trip origin and destination locations (POLA, 2007; POLB, 2007). Because trip origins and destinations were geocoded, we could calculate travel miles by GIS network analysis by assuming the shortest path. Since we knew intermodal rail facility travel miles, we excluded intermodal rail facility trips from the trip O-D survey and estimated average truck travel miles to transloading and local distribution facilities. The estimated average travel miles were 30.2 miles per trip for containers and 20.6 miles for bobtails and chasses in the South Coast.

To validate this estimate, we conducted a truck trip origin and destination survey at five locations around the port terminal entrance and exit gates in July 2007. The survey day was the same day as the roadside and gate truck traffic survey conducted. The five O-D survey locations included:

- Queens Way & Harbor Plaza
- Navy Way & Reeves St.
- Seaside Ave. & Ferry St.
- Terminal Way & Navy Way
- Terminal Way & Ferry St.

With cooperation for the California Highway Patrol (CHP), ARB staff randomly selected trucks exiting and entering terminal gates and asked their trip origins and destinations from 7am to 5pm. See APPENDICES B and C for the protocol of the O-D survey and the survey form staff used. Staff surveyed a total 342 trucks at the survey locations. From the survey, using GIS shortest path estimates, we calculated that the average travel miles to transloading / local distribution centers was 29.9 miles for import/export/empty containers, and 10.3 miles for bobtails/chasses. The container travel miles from the ARB O-D survey was almost identical to the miles of 30.2 from the ports O-D survey. To compensate for the fact that under congested conditions trucks

might not travel a shortest path, we added an additional 10% of travel miles and 4 miles per container distribution center trips.

Bobtail/chassis travel miles estimated using the ARB survey was shorter than estimates derived from the Ports' O-D data. Given the relatively small sample size from the one-day ARB survey for chasses/bobtail trips, we decided to use the Port's travel estimates. We assumed trucks travel on average 3 miles per inter-terminal trip, based on the distance between the center of the Ports of Los Angeles and Long Beach. Table II-7 shows the drayage truck average travel miles per trip from the Ports of Los Angeles and Long Beach in the South Coast Air Basin.

**Table II-7: Drayage Truck Average Travel Miles from the Ports**

Truck	Destination from the Ports Terminals	Average Travel Miles per Trip
Bobtail and Chassis	Inter-Terminal	3
	Off-Terminal	20.6
Container	Near-Dock Rail Facilities	5
	Off-Dock Rail Facilities	20
	Transloading / Local Distribution Facilities	33.2
	Container Deport Facilities	4

For non-containerized truck travel miles, staff used the non-containerized truck travel mile of 36.9 for the South Coast provided by the ports of Los Angeles and Long Beach (ITERIS, 2007).

2) Out of South Coast

A portion of drayage trucks servicing the ports of Los Angeles and Long Beach travel outside of the South Coast air basin boundaries. The O-D survey provided by the ports of Los Angeles and Long Beach showed that 10% of the truck trips which we assumed to travel to transloading / local distribution facilities actually left the South Coast air basin. We estimated travel miles for these trips based on the assumption that trucks travel to major business hubs outside the air basin boundaries. Table II-8 shows travel destinations and miles from the South Coast air basin boundaries.

**Table II-8: Travel Destinations from the South Coast Boundaries**

Destination	Air Basin Trucks Travel	Travel Miles from the South Coast Boundary
Ventura	South Central Coast	32
Fresno	San Joaquin Valley	150
Las Vegas	Mojave Desert	164
Phoenix	Mojave Desert	82
Phoenix	Salton Sea	98
San Diego	San Diego	61

**b. Port of Oakland**

1) Within Bay Area

Based on the goods movement study by MTC (2003) we estimated travel miles from the Port of Oakland to the air basin boundary. For the travel miles from the port to local transloading / distribution facilities we used EMFAC default heavy heavy-duty diesel truck (HHDDT) average travel miles in the Bay Area. Table II-9 shows the average travel miles from the Port of Oakland to destinations in the Bay Area.

**Table II-9: Drayage Truck Average Travel Miles from the Ports**

Truck	Destination from the Ports Terminals	Average Travel Miles per Trip
Bobtail and Chassis	Inter-Terminal	1.5
	Off-Terminal	Same as Containers
Container	Near-Dock Rail Facilities	1.5
	Transloading / Local Distribution Facilities	31
	Regional Distribution Facilities	45* <sup>1)</sup> 50* <sup>2)</sup> 75* <sup>3)</sup>

\*<sup>1)</sup> To Sacramento, CA and Reno, NV

\*<sup>2)</sup> To Fresno, CA

\*<sup>3)</sup> To Salinas, CA

2) Out of Bay Area

Because no trip O-D survey data were available for the Bay Area, we used MTC (2003) to identify truck travel directions and to estimate travel miles from the Bay Area air basin boundary to regional destinations. Based on the statistics from the MTC study, we estimated 18% of total truck trips generated by the Port of Oakland traveled to neighboring regional destinations. Table II-10 shows travel destinations and miles from the Bay Area air basin boundary.

**Table II-10: Drayage Truck Travel Destinations from the Bay Area Boundaries**

Destination	Air Basin Trucks Travel	Travel Miles from the Bay Area Boundary
Sacramento	Sacramento Valley	32
Reno	Sacramento Valley	150
Reno	Mountain County	164
Fresno	San Joaquin Valley	82
Salinas	North Central Coast	98

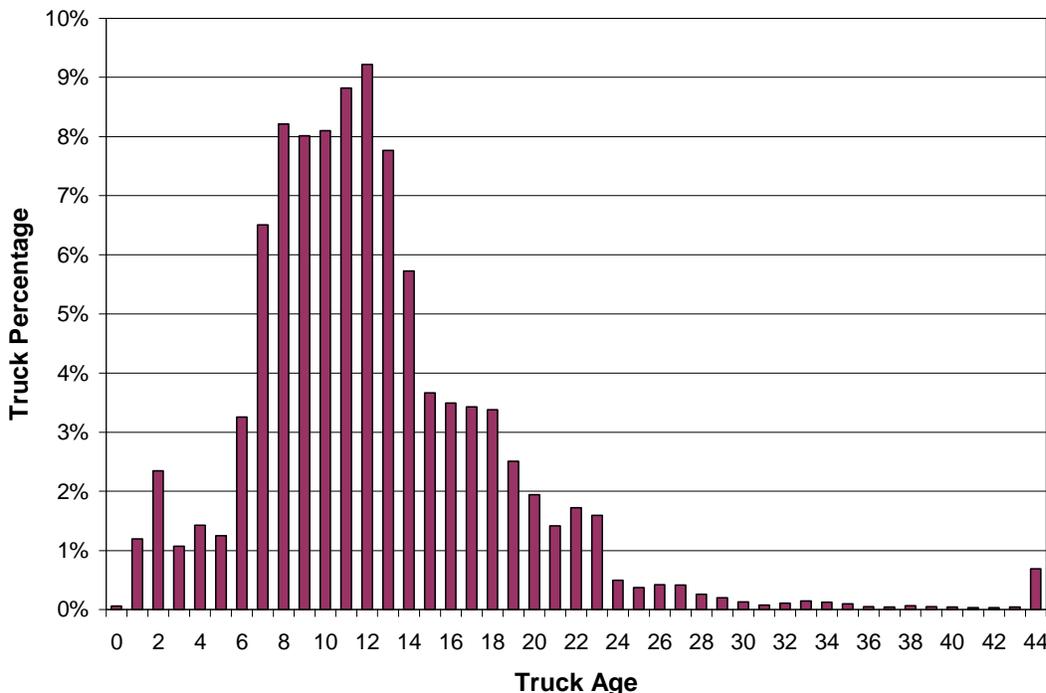
**4. Model Year Distribution**

Younger trucks emit less pollution than older trucks based on improved pollution control technologies and less mileage and engine deterioration. As a result, understanding the drayage truck fleet model year distribution is critical for estimating emissions as well as regulatory benefits. To estimate model year distribution, we relied on estimates provided by the Ports of Los Angeles, Long Beach, and Oakland, which were derived from license plate surveys.

**a. Ports of Los Angeles and Long Beach**

To develop the age distribution for the Ports of Los Angeles and Long Beach, we used HHDDT license plate data provided by the ports. The Ports collected the license plate data using optical character reorganization devices at 7 terminals in 2006. These data are summarized in Figure II-4.

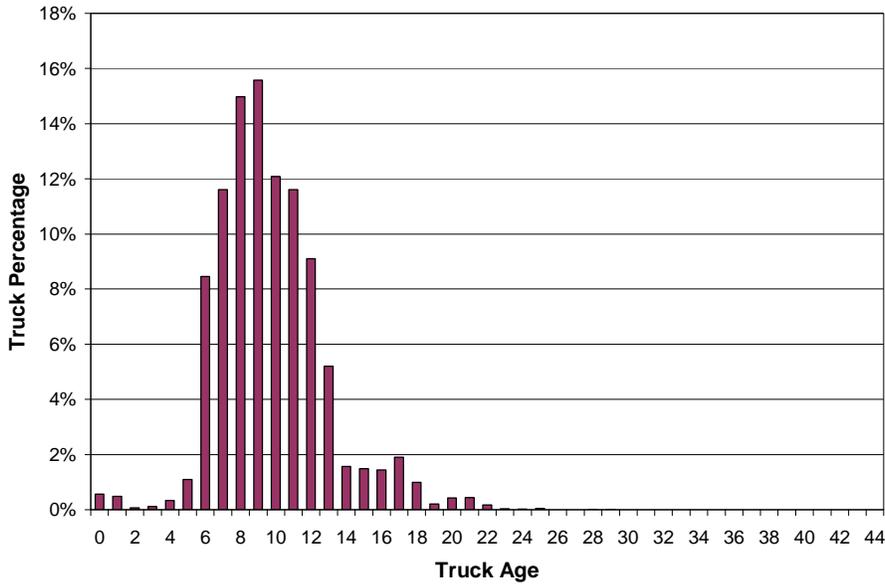
**Figure II-4: Drayage Truck Age Distribution at the Ports of Los Angeles and Long Beach**



**b. Port of Oakland**

To develop the model year age distribution for the Port of Oakland, we used HHDDT license plate data collected at the major entrance / exit gates to the port by the Port of Oakland in 2006. Figure II-5 provides the resulting model year distribution.

**Figure II-5: Drayage Truck Age Distribution at the Port of Oakland**



**5. Emissions Rate**

Emissions rates are inputs to the EMFAC model and are composed of a zero-mile or base emissions rate and a deterioration rate. The zero-mile emissions rate represents a vehicle’s emission factor when new. As a vehicle travels the more miles, the vehicle emits more emissions (Equation II-1). These excess emissions are due to deterioration, which in diesel engines is based on tampering, mal-maintenance, and malfunction of engine components and engine controls (ARB, 2006b).

$$ER = ZER + DR \tag{Equation II-1}$$

Where, *ER* = emissions rate (g/mi)  
*ZER* = Zero-mile emissions rate (g/mi)  
*DR* = Deterioration rate (g/mi)

The deterioration rate is a function of lifetime mileage accrual and varies by truck model year. Through an extensive analysis of truck age distributions and mileage accrual data, staff developed a combined annual mileage accrual rate for use in the

deterioration rate calculation. To understand the impact of deterioration, staff conducted an assessment of mileage accrual for California-domiciled trucks not engaged in interstate commerce.

Some heavy-duty diesel truck engines in the fleet are subjected to reflash electronic control models (ECM) to meet the consent decree settlement. Based on the settlement, ARB required engines of model years 1993 to 1998 to reflash ECM. To review the emissions benefits of reflashing ECM for those engines, ARB conducted emissions tests and developed the adjustment factors of ECM reflash. With the ECM reflash adjustment factors, staff adjusted emissions rates with a combined annual mileage accrual rate. These adjustments are described below.

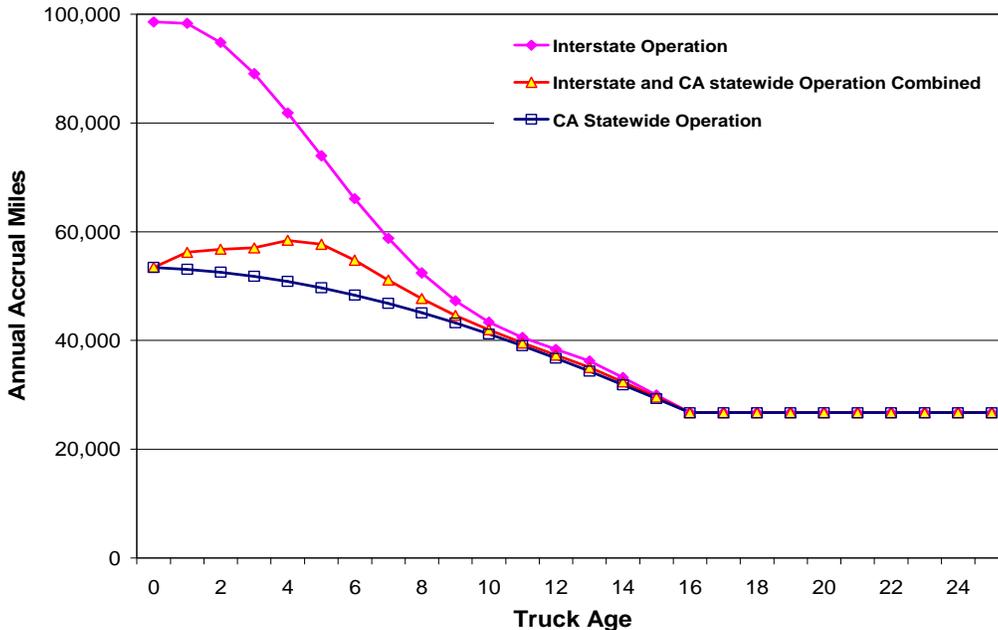
**a. Combined Annual Mileage Accrual**

Analysis of Registration and International Registration Plan data provided by the California Department of Motor Vehicles reveals that trucks engaged in interstate commerce are much younger than trucks operating solely in California. We believe drayage trucks are a subset of the in-state registered legacy fleet of older trucks operating in California.

Overall, we have found that like drayage truck model year distributions above, the in-state truck fleet contains relatively few new trucks. As a result, the age distribution of in-state legacy trucks strongly suggest that interstate truck fleets are sold used to the California legacy fleet for local operations such as drayage trucking. This transfer implies that trucks operating in drayage service probably traveled much more than EMFAC accrual rate estimates in their first few years of operation, and the same or less than EMFAC accrual estimates in later years of operation. Because mileage accrual is a factor in determining the amount of deterioration in emission factors for the fleet, we conducted an analysis of census data to develop a new accrual schedule for drayage and other in-state trucks.

Figure II-6 shows the results of our accrual rate analysis. We developed two HHDDT annual mileage accrual rates by analyzing the 2002 Vehicle Inventory and Use Survey (VIUS) data (CENSUS, 2002). One of the two annual mileage accrual rates is for the interstate truck operation, and another is for the California statewide operation. Trucks operating interstate annually accrue up to 100,000 miles at the ages of 0 to 3, and their annual travel miles sharply decrease after age 3 (Figure II-6).

**Figure II-6: Interstate and California Statewide Operation Combined Accrual**



Trucks operating only within California annually accrue about 55,000 miles at age 0, and their annual mileage accrual rates gradually decrease (Figure I-6). At age 10 trucks operating interstate and California statewide accrue almost the same miles per year.

For the emissions rates of drayage trucks migrated from the interstate operations, we developed an interstate and CA statewide operation combined accrual rate by weighting populations for the both operations (Figure II-6). This combined accrual rate was used to estimate model year specific drayage truck deterioration and emission rates for calendar years 2007 to 2020.

**b. ECM Reflash Adjustment**

To account for emissions benefits by reflashing ECM, staff developed ECM adjustment factors for selected engine model years 1993 to 1998 and applied the factors to emissions rate calculated with the combined accrual rate. Table II-11 shows ECM reflash adjustment factors. Emissions rates decrease with the adjustment factors, except diesel PM emissions at the high speed cruise.

**Table II-11: ECM Reflash Adjustment Factors**

Pollutant	Activity	Engine Model Year					
		1993	1994	1995	1996	1997	1998
NOX	Off-Terminal/Off-Rail Run	0.96	0.9	0.9	0.89	0.89	0.89
	On-Terminal Run	0.99	0.98	0.98	0.97	0.97	0.97
	On-Rail Run	0.99	0.97	0.97	0.96	0.96	0.96
Diesel PM	Off-Terminal/Off-Rail Run	1.02	1.05	1.05	1.05	1.05	1.05
	On-Terminal Run	0.99	0.97	0.97	0.97	0.97	0.97
	On-Rail Run	0.99	0.97	0.97	0.97	0.97	0.97

**c. Emission Rates**

Staff generated calendar year specific emissions rates by applying drayage truck age distributions to the model year specific emissions rates. Staff tabulated drayage truck fleet average emissions rates for calendar years 2007 to 2020 for the South Coast and the Bay Area, respectively (Table II-12 and Table II-13).

**Table II-12: Fleet Average Emissions Rates for South Coast Drayage Trucks (g/mi for Run and g/hr for Idle)**

Pollutant	Activity	Calendar Year			
		2007	2010	2012	2014
NOX	Off-Terminal/Rail yard Run	20.2	18.8	12.2	5.1
	On-Terminal Run	28.4	27.0	18.1	9.1
	On-Rail yard Run	28.3	26.7	18.0	9.1
	On-Terminal/Rail yard Idle	105.1	116.2	120.5	123.5
Diesel PM	Off-Terminal/Rail yard Run	1.08	0.13	0.12	0.11
	On-Terminal Run	2.28	0.25	0.17	0.08
	On-Rail yard Run	2.28	0.25	0.17	0.08
	On-Terminal/Rail yard Idle	2.31	0.25	0.19	0.14

**Table II-13: Fleet Average Emissions Rates for Bay Area Drayage Trucks (g/mi for Run and g/hr for Idle)**

Pollutant	Activity	Calendar Year			
		2007	2010	2012	2014
NOX	Off-Terminal/Rail yard Run	20.2	19.2	12.4	4.6
	On-Terminal/Rail yard Run	28.1	27.1	18.3	8.7
	On-Terminal/Rail yard Idle	112.6	115.5	119.5	122.6
Diesel PM	Off-Terminal/Rail yard Run	0.58	0.08	0.08	0.08
	On-Terminal/Rail yard Run	1.72	0.24	0.16	0.07
	On-Terminal/Rail yard Idle	1.71	0.23	0.17	0.12

**B. Base Year Emissions**

Staff estimated 2005 base year emissions with truck tips, travel miles and emissions rates for the Ports of Los Angeles / Long Beach and the Port of Oakland. To do so, we

estimated drayage truck VMT as the product of truck tips and travel miles. We also estimated drayage truck idle hours at the ports using the number of truck trips and idle minutes per truck visit derived from studies conducted by the Ports of Los Angeles, Long Beach, and Oakland. We assumed 45 and 30 minutes of idling time per truck for the ports of Los Angeles / Long Beach and the Port of Oakland, respectively. We then applied VMT and idle hours to emissions rates to estimate base year NOX and diesel PM emissions (Equation II-2 and Equation II-3)

$$EM = VMT * ER \quad \text{(Equation II-2)}$$

$$EM = IHR * ER \quad \text{(Equation II-3)}$$

Where, *EM* = emissions (tons/year)  
*VMT* = vehicle travel miles  
*ER* = emissions rates (g/mi)  
*IHR* = idling hours (hour)

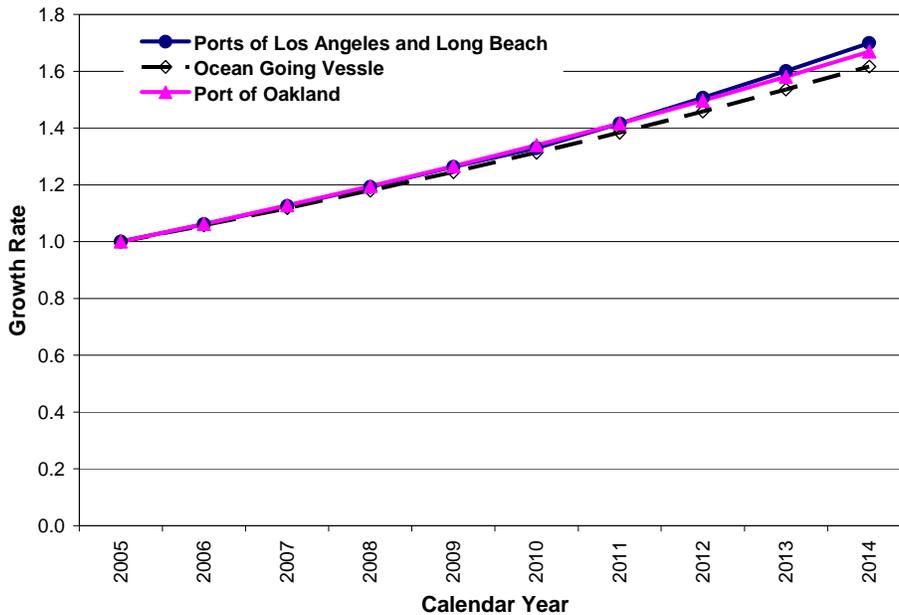
## C. Future Year Emissions

### 1. Drayage Truck Activity Growth

Growth is an important factor to consider when estimating future truck activity (truck trips and VMT). In this case, the demand for drayage truck activity is driven by a combination of projected increases in trade and the projected growth in rail traffic (which competes with trucks for container movement). Our growth estimates are based upon container vessel installed power growth rates developed for ARB's Goods Movement Emissions Reduction Plan (ARB, 2006a) and adjusted with rail facility growth rates at the Ports of Los Angeles and Long Beach. We estimated rail facility capacity growth rates from the study results that Ports in California published (Jones & Stokes, 2004; SCAG, 2005; Parsons, 2004). We found that rail facility growth rates in the South Coast were slightly lower than the container vessel growth rate, indicating a slight increasing utilization of trucks over rail in the future. Truck traffic is anticipated to grow approximately 5% per year between 2005 and 2014 at the Ports of Los Angeles and Long Beach.

In the Bay Area, we did not find any documented assessment of future rail capacity growth at the Port of Oakland and near-dock rail facilities. As a result, we assumed no future rail facility growth at the Port of Oakland. We project truck activity to grow approximately 5% every year from 2005 to 2014 at the Port of Oakland, as shown in Figure II-7.

**Figure II-7: Drayage Truck Activity Growth Rates at Ports in California**



## 2. Future Drayage Truck Age Distributions

Estimating the benefits of the proposed Drayage Truck Rule requires an assessment of how trucks will be replaced to meet regulatory requirements in 2010 and 2014. This type of assessment is particularly complicated in this case due to the projected interplay between the proposed Drayage Truck Rule and SIP commitments. Developing this assessment requires making several specific assumptions about the future behavior of truck owners as this regulation and others are implemented.

By the end of 2013, the proposed Drayage Truck Rule requires drayage truck operators who are driving a pre-2004 truck to upgrade their truck either to a 2004-2006 model year truck, or to a 2007 or better model year truck. On its face one might expect a truck owner to upgrade to a 2004 truck because that truck will cost less on the used truck market than a 2007 truck. However, we anticipate (as documented in recent SIP commitments) that 2004 trucks will be regulated under the future Private Fleet Rule and that either 2004-2006 trucks will be required to be replaced or retrofit for consistency with 2007 engine standards. Therefore, we assumed drayage truck owners in possession of trucks 2003 model year or older would upgrade to a 2007 or better truck by 2014. 2004-2006 trucks would effectively be replaced with a 2007 or better truck in 2014 as a result of the future Private Fleet Rule.

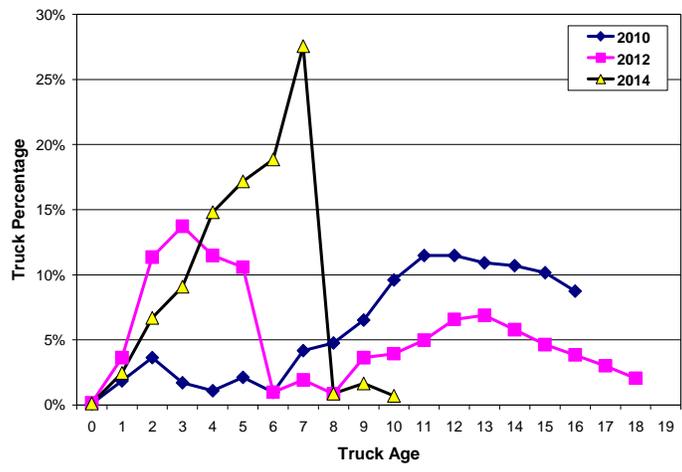
Based on the above assumption and the proposed Drayage Truck Rule, truck operators will generally replace their trucks with 2007 or better model years by 2014. We assume many truck owners will choose to replace their non-compliant truck by 2014 with a 2007 truck, and we assume some truck owners will replace with a newer model year vehicle

or even a new vehicle. These assumptions are based on baseline port truck age distributions, which are port specific and described below.

**a. Ports of Los Angeles and Long Beach**

Based on the proposed rule compliance schedule, all pre-1994 model year engines should be replaced with 1994 to 2003 model year engines with DPF by December 31, 2009. We distributed the pre-1994 engines to 1994 to 2003 engines by the current age distribution with corresponding ages in 2010. As described above, we assume by December 31, 2013 all drayage trucks should meet or exceed 2007 truck emission rates except for a few legacy 2004-2006 trucks. As a result, we distributed all pre-2004 model year trucks to 2007 and newer trucks by 2014. We distributed new trucks to drayage service across compliant model years in each of the calendar years 2010 to 2014, effectively assuming for example that a new truck in 2014 will be a 2007 or better vehicle. Figure II-8 shows future drayage truck age distributions at the Ports of Los Angeles and Long Beach. As can be seen in the 2014 age distribution, we assume that 2004-2006 trucks will remain in the fleet only if they were originally in the drayage fleet, and that no additional 2004-2006 trucks will enter the fleet over time. We also assume that about 30% of trucks replaced under the regulation will contain engines with 2010 or better emission rates, even though the rule does not require it.

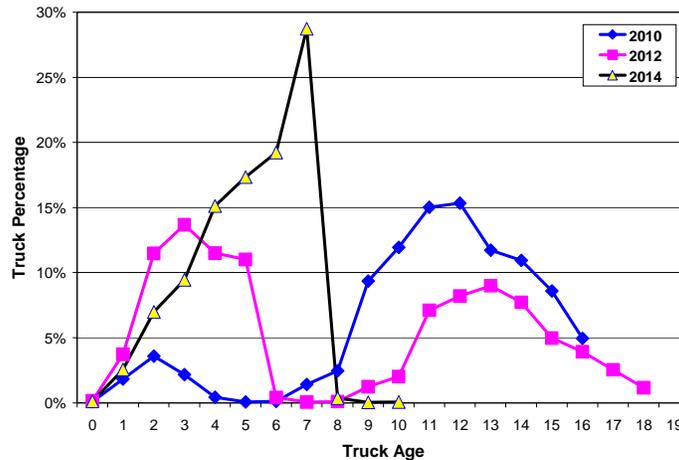
**Figure II-8: Future Drayage Truck Age Distributions at the Ports of Los Angeles and Long Beach**



## b. Port of Oakland

We distributed the pre-1994 model year engines to 1994 to 2003 engines using the current Port of Oakland age distribution with corresponding ages in 2010. To distribute new trucks entering to the drayage service and the pre-2003 model year engines in 2014, we assumed ~30% would be 2010 or better – the same assumption as for the Ports of Los Angeles and Long Beach. Figure II-9 shows future drayage truck age distributions at the Port of Oakland.

**Figure II-9: Future Drayage Truck Age Distributions at the Port of Oakland**



## D. Extrapolating Emissions to Smaller Ports

Information was not available to conduct a full container balancing assessment of truck trips for smaller ports. To estimate emissions at these ports, we scaled truck activity and emissions from the Port of Oakland to other ports using port-specific throughput tonnages. Based on the assumption that the operation at other ports is similar to the operation at the Port of Oakland, the scalars represent the ratios of other port truck activity to the truck activity at the Port of Oakland. Table II-14 shows emissions scalars used for the extrapolation of other port emissions in 2005.

**Table II-14: Emissions Scalars for the Extrapolation of Other Port Emissions in 2005**

Area	Port	Emissions Scalar
Bay Area	San Francisco, Redwood City, Crockett, Pittsburg, and Benicia	0.094
San Diego	San Diego	0.110
South Central Coast	Hueneme	0.038
North Coast	Humboldt Bay	0.011
San Joaquin Valley	Stockton	0.059
Sacramento Valley	Sacramento	0.013

### III. EMISSIONS INVENTORY RESULTS

#### A. Ports of Los Angeles / Long Beach and Associated Intermodal Rail Yards

##### 1. Truck Trips

Staff estimated future year drayage truck trips for years 2007 to 2014 with the drayage truck activity growth rate. Trucks trips at the Ports of Los Angeles and Long Beach including associated intermodal rail yards are projected to increase about 5% every year. The ports are projected to generate about 20 million drayage truck trips in 2007 and about 29 million trips in 2014. Table III-1 shows all drayage truck trips at the Ports of Los Angeles / Long Beach and associated intermodal rail yards.

**Table III-1: Drayage Truck Trips at the Ports of Los Angeles, Long Beach and Associated Intermodal Rail Yards**

Activity	Calendar Year			
	2007	2010	2012	2014
Trips/yr	20,172,773	23,279,027	25,958,082	28,889,595

##### 2. VMT and Idle Hours

Staff estimated drayage truck VMT for years 2007 to 2014 using estimated truck trips, and estimated travel miles by destination. We estimate the ports generate 502 million miles traveled in 2007 and 719 million miles traveled in 2014. Drayage trucks are projected to idle 7 million hours in 2007 and 10 million hours in 2014 at the Ports of Los Angeles and Long Beach. Table III-2 shows all drayage truck VMT and idle hours at the ports of Los Angeles / Long Beach and associated intermodal rail yards.

**Table III-2: Drayage Truck VMT and Idle Hour at the Ports of Los Angeles, Long Beach and Associated Intermodal Rail Yards**

Activity	Calendar Year			
	2007	2010	2012	2014
VMT/yr	501,848,835	578,738,442	645,497,309	718,547,111
Idle Hours/yr	7,187,642	8,280,930	9,231,236	10,271,092

##### 3. Emissions

Emissions are calculated as the product of VMT and emission rates as described above. We project that drayage trucks servicing Ports and Rail yards in the South Coast region will emit 12,144 tons of NOx and 634 tons of diesel PM in 2007. Between 2007 and 2014 we project NOx emissions will increase from 2007 levels because of the significant percentage of older trucks in the fleet. Table III-3 shows drayage truck emissions representing southern California ports and rail yards.

**Table III-3: Drayage Truck Emissions (Tons/Year) At The Port Of Los Angeles, Port Of Long Beach, And Associated Intermodal Rail Yards**

Emissions (tons/yr)	Calendar Year			
	2007	2010	2012	2014
NOx	12,144	13,500	13,991	13,915
Diesel PM	634	622	645	634

#### 4. Out of South Coast

A portion of truck trips generated from the Ports of Los Angeles and Long Beach are extended out of the South Coast. Staff estimated VMT and emissions generated by drayage trucks traveling out of the South Coast Tables III-4, III-5 and III-6 show VMT, NOX emissions and diesel PM emissions, respectively, generated by drayage truck traveling out of the South Coast.

**Table III-4: Drayage Truck VMT Out Of The South Coast**

Air Basin	Calendar Year			
	2007	2010	2012	2014
South Central Coast	802,272	926,169	1,033,469	1,150,881
San Joaquin Valley	53,943,460	62,274,122	69,488,841	77,383,430
Mojave Desert	26,595,676	30,702,932	34,259,996	38,152,255
Salton Sea	22,597,706	26,087,543	29,109,894	32,417,053
San Diego	8,570,895	9,894,525	11,040,848	12,295,192
Total	112,510,009	129,885,291	144,933,048	161,398,812

**Table III-5: Drayage Truck NOX (Tons/Year) Out Of The South Coast**

Air Basin	Calendar Year			
	2007	2010	2012	2014
South Central Coast	18	20	20	20
San Joaquin Valley	1,202	1,328	1,364	1,338
Mojave Desert	592	655	672	660
Salton Sea	503	556	571	560
San Diego	191	211	217	213
Total	2,506	2,769	2,845	2,791

**Table III-6: Drayage Truck Diesel PM (Tons/Year) Out Of The South Coast**

Air Basin	Calendar Year			
	2007	2010	2012	2014
South Central Coast	1	1	1	1
San Joaquin Valley	64	63	66	65
Mojave Desert	32	31	33	32
Salton Sea	27	26	28	27
San Diego	10	10	11	10
Total	134	132	138	137

**B. Port of Oakland and Associated Intermodal Rail Yards**

**1. Truck Trips**

Based on our container balancing methodology, we estimate the ports will generate about 3.3 million drayage truck trips in 2007 and about 4.7 million truck trips in 2014. Table III-7 provides drayage truck trip estimates representing the Port of Oakland and associated intermodal rail yards.

**Table III-7: Drayage Truck Trips At The Port Of Oakland And The Intermodal Rail Yards Connected To The Port**

Activity	Calendar Year			
	2007	2010	2012	2014
Trips/yr	3,345,546	3,880,553	4,261,129	4,667,580

**2. VMT and Idle Hours**

We project the Port of Oakland will generate 66 million drayage truck miles traveled in 2007 and 98 million drayage truck miles traveled in 2014. We estimate drayage trucks will idle 1 million hours in 2007 and 1.5 million hours in 2014 at the Port of Oakland. Table III-8 shows all drayage truck VMT and idle hours at the Port of Oakland and associated intermodal rail yards.

**Table III-8: Drayage Truck VMT And Idle Hour At The Port Of Oakland And The Intermodal Rail Yards Connected To The Port**

Activity	Calendar Year			
	2007	2010	2012	2014
VMT/yr	66,100,809	79,212,013	88,496,934	98,389,467
Idle Hours/yr	1,021,733	1,200,430	1,333,024	1,478,113

### 3. Emissions

Based on VMT and model year distribution estimates, we project drayage trucks will emit 1,611 tons of NOx and 47 tons of diesel PM in 2007. Based on anticipated fleet growth and fleet turnover we estimate drayage trucks will emit 1,564 tons of NOx and 55 tons of diesel PM in 2014 (Table III-9).

**Table III-9: Drayage Truck Emissions (Tons/Year) At The Port Of Oakland And Associated Intermodal Rail Yards**

Emissions (tons/yr)	Calendar Year			
	2007	2010	2012	2014
NOx	1,611	1,821	1,743	1,564
Diesel PM	47	52	57	55

### 4. Out of Bay Area

A portion of truck trips generated from the Port of Oakland are extended out of the Bay Area. Staff estimated VMT and emissions generated by drayage trucks traveling out of the Bay Area. Tables III-10, III-11 and III-12 show VMT, NOX emissions and diesel PM emissions, respectively, generated by drayage truck traveling out of the Bay Area.

**Table III-10: Drayage Truck VMT Out Of The Bay Area**

Air Basin	Calendar Year			
	2007	2010	2012	2014
Sacramento Valley	5,127,960	6,166,411	6,900,176	7,680,993
Mountain County	2,074,166	2,491,642	2,787,311	3,102,337
San Joaquin Valley	29,441,976	35,431,183	39,652,061	44,138,442
North Central Coast	1,815,598	2,180,890	2,439,646	2,715,368
Total	38,459,700	46,270,126	51,779,194	57,637,140

**Table III-11: Drayage Truck NOX (Tons/Year) Out Of The Bay Area**

Air Basin	Calendar Year			
	2007	2010	2012	2014
Sacramento Valley	114	128	121	105
Mountain County	46	52	49	42
San Joaquin Valley	654	737	694	604
North Central Coast	40	45	43	37
Total	854	963	906	789

**Table III-12: Drayage Truck Diesel PM (tons/year) out of the Bay Area**

Air Basin	Calendar Year			
	2007	2010	2012	2014
Sacramento Valley	3	4	4	4
Mountain County	1	2	2	2
San Joaquin Valley	19	21	24	24
North Central Coast	1	1	1	1
<b>Total</b>	<b>25</b>	<b>28</b>	<b>32</b>	<b>31</b>

**C. Other Ports**

We estimated VMT and emissions at other ports not associated with the Ports of Los Angeles, Long Beach, and Oakland using emissions scaling factors discussed in section II-D. Tables III-13, III-14 and III-15 provide VMT, NOx emissions and diesel PM emissions at these ports and rail yards.

**Table III-13: Annual Drayage Truck VMT At Other Ports And Intermodal Rail Yards**

Air Basin	Calendar Year			
	2007	2010	2012	2014
San Francisco Bay Area	4,050,041	4,658,581	5,057,843	5,461,632
San Diego	4,773,524	5,490,771	5,961,356	6,437,276
South Central Coast	1,624,205	1,868,250	2,028,368	2,190,301
North Coast	486,542	559,647	607,612	656,120
San Joaquin Valley	2,573,230	2,959,871	3,213,546	3,470,097
Sacramento Valley	545,898	627,922	681,738	736,164
<b>Total</b>	<b>14,053,439</b>	<b>16,165,042</b>	<b>17,550,463</b>	<b>18,951,590</b>

**Table III-14: Annual Drayage Truck NOx (Tons/Year) At Other Ports And Intermodal Rail Yards**

Air Basin	Calendar Year			
	2007	2010	2012	2014
San Francisco Bay Area	146	158	147	128
San Diego	173	187	174	151
South Central Coast	59	64	59	51
North Coast	18	19	18	15
San Joaquin Valley	93	101	94	81
Sacramento Valley	20	21	20	17
<b>Total</b>	<b>508</b>	<b>549</b>	<b>511</b>	<b>445</b>

**Table III-15: Annual Drayage Truck Diesel PM (tons/year) at Other Ports**

Air Basin	Calendar Year			
	2007	2010	2012	2014
San Francisco Bay Area	4	4	5	5
San Diego	5	5	6	5
South Central Coast	2	2	2	2
North Coast	1	1	1	1
San Joaquin Valley	3	3	3	3
Sacramento Valley	1	1	1	1
Total	15	16	17	16

#### **IV. EMISSIONS BENEFITS WITH THE PROPOSED REGULATION**

The proposed regulation is designed to achieve substantial early reductions of diesel PM while obtaining NOx emissions reductions to meet attainment goals. The compliance schedule is designed to retire older vehicles earlier and to retrofit with diesel particulate filters (DPF) to reduced NOx and diesel PM emissions. Under the proposed regulation, existing trucks in drayage service older than the 2004 model year should be replaced or retrofitted with diesel particulate filters by December 2009, and should meet 2007 engine standards by the end of 2013.

##### **A. Statewide**

Under the proposed compliance schedule we assumed no natural fleet turnover would occur for the drayage truck fleet within two years (2008-2009) before the rule implementation. Assuming no natural fleet turnover is a conservative assumption because existing drayage trucks may remain in the fleet to get possible financial benefits proposed by the Goods Movement Emission Reduction Program (ARB, 2007b). After Phase 1 compliance we assumed natural turnover would resume. With the compliance schedule NOx and diesel PM emissions are projected to decrease significantly. Initially, we project NOx emissions in 2010 will increase slightly due to fleet turnover assumptions. As the regulation is implemented, we project statewide drayage truck NOx emissions will decrease by 2% in 2010 to 61% in 2014. We project statewide drayage truck diesel PM emissions will decrease by 86% in 2010 to 85% in 2014. After the Phase 1 compliance statewide drayage truck diesel PM emissions are projected to gradually increase due to deterioration. Figures IV-1 and IV-2 show statewide drayage truck NOX and Diesel PM emission benefits, respectively.

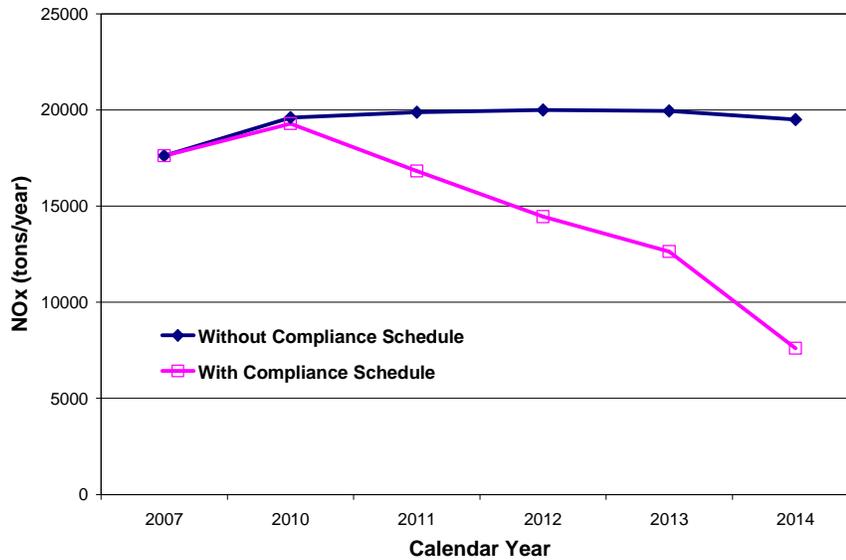
**Table IV-1: Statewide Drayage Truck NOx Emissions (tons/year) with the Proposed Regulation**

Air Basin	Calendar Year		
	2010	2012	2014
South Coast	13,215	9,997	5,494
San Francisco Bay Area	2,002	1,514	771
San Diego	394	287	138
San Joaquin Valley	2,142	1,548	695
South Central Coast	83	61	30
North Central Coast	46	33	14
Mojave Desert	637	460	213
Sacramento Valley	152	110	47
Salton Sea	541	390	181
North Coast	19	14	7
Mountain County	53	38	16
<b>Total</b>	<b>19,286</b>	<b>14,452</b>	<b>7,606</b>

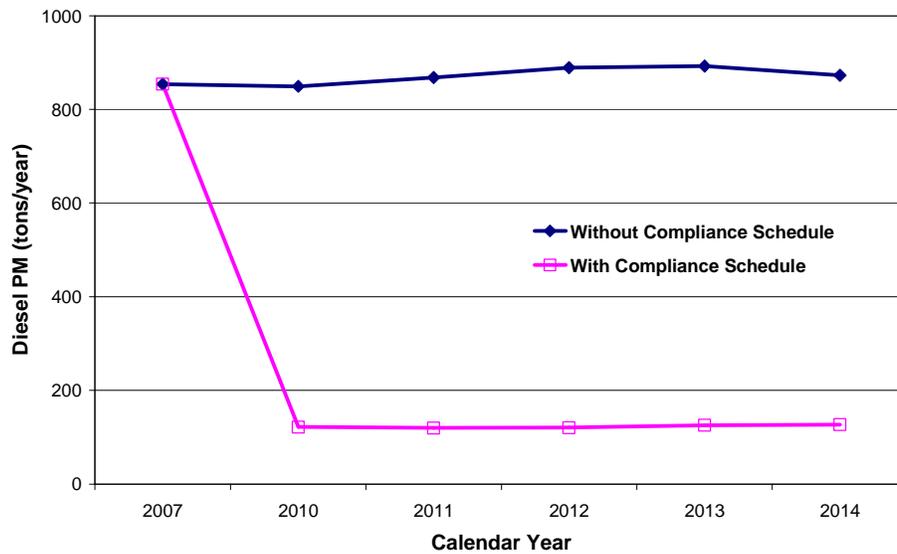
**Table IV-2: Statewide Drayage Truck Diesel PM Emissions (tons/year) with the Proposed Regulation**

Air Basin	Calendar Year		
	2010	2012	2014
South Coast	88.3	87.1	90.9
San Francisco Bay Area	8.7	8.6	9.2
San Diego	2.2	2.2	2.4
San Joaquin Valley	12.7	12.8	13.8
South Central Coast	0.4	0.4	0.4
North Central Coast	0.2	0.2	0.2
Mojave Desert	4.4	4.5	4.8
Sacramento Valley	0.7	0.7	0.7
Salton Sea	3.8	3.8	4.1
North Coast	0.1	0.1	0.1
Mountain County	0.2	0.2	0.3
<b>Total</b>	<b>121.7</b>	<b>120.6</b>	<b>126.8</b>

**Figure IV-1: Statewide Drayage Truck NOx Emissions with and without the Proposed Regulation**



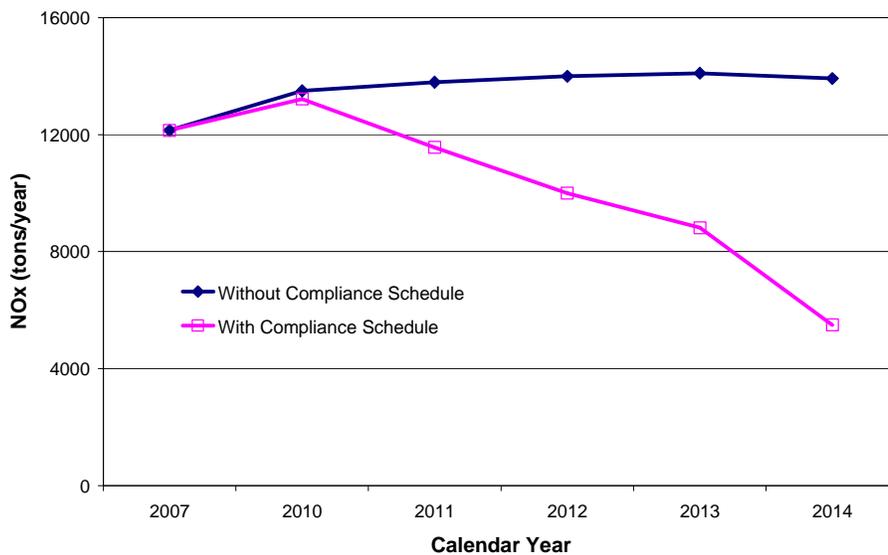
**Figure IV-2: Statewide Drayage Truck Diesel PM Emissions with and without the Proposed Regulation**



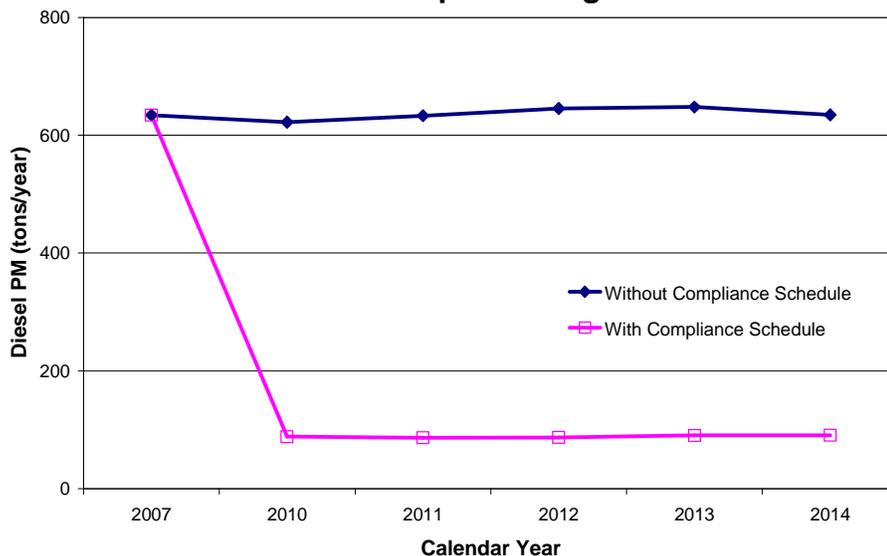
## B. Ports of Los Angeles / Long Beach and Intermodal Rail Yards

Because emissions related to the Port of Los Angeles, Port of Long Beach, and associated rail yards comprise such a large fraction of statewide emissions, we project trends in the South Coast region will mirror statewide trends. Figures IV-3 and IV-4 show drayage truck NOx and diesel PM emission benefits, respectively, at the Ports of Los Angeles / Long Beach and associated intermodal rail yards.

**Figure IV-3: South Coast Drayage Truck NOx Emissions with and without the Proposed Regulation**



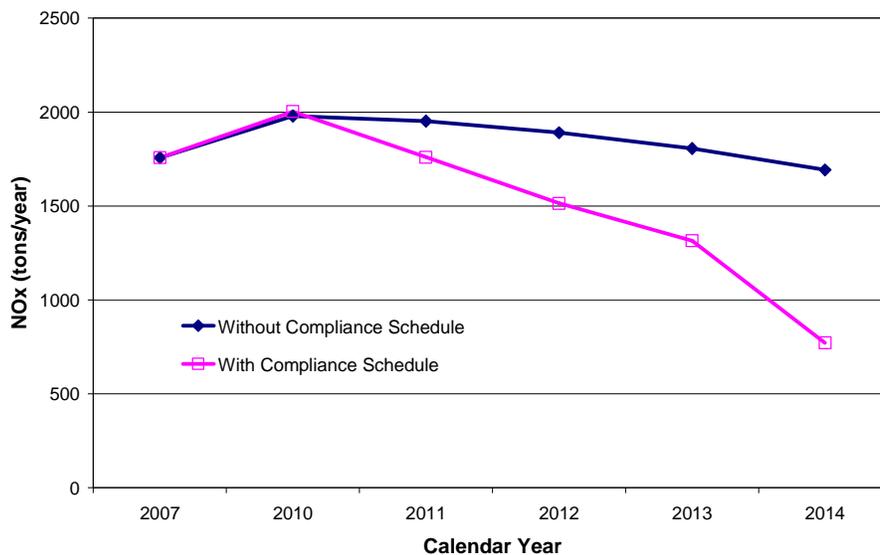
**Figure IV-4: South Coast Drayage Truck Diesel PM Emissions with and without the Proposed Regulation**



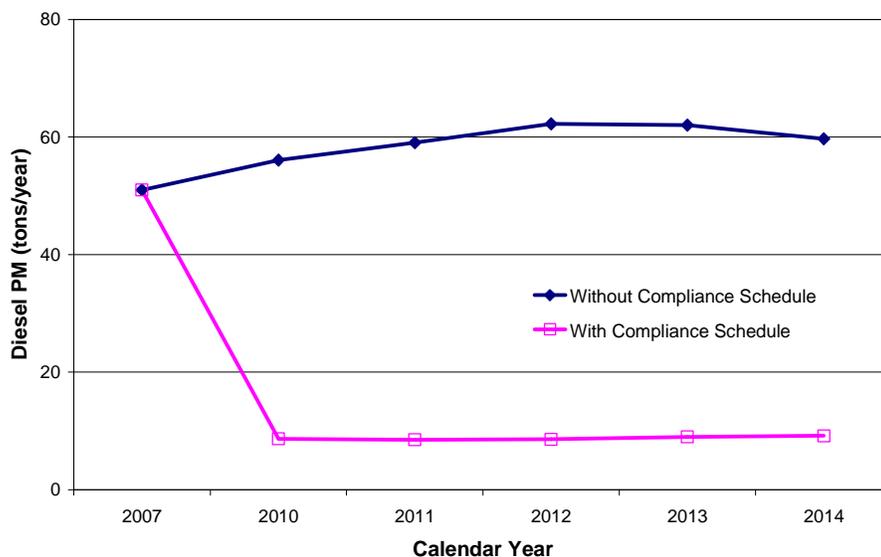
### C. Port of Oakland and Associated Intermodal Rail Yards

Overall, trends associated with the Port of Oakland and related rail yards are similar to statewide trends. However, because we predict drayage trucks servicing these ports and rail yards are newer than in South Coast, emissions reductions are reduced relative to those in South Coast. Figures IV-5 and IV-6 show drayage truck NO<sub>x</sub> and diesel PM emission benefits, respectively, at the Port of Oakland and associated rail yards.

**Figure IV-5: Port of Oakland and Associated Rail Yard Drayage Truck NO<sub>x</sub> Emissions with and without the Proposed Regulation**



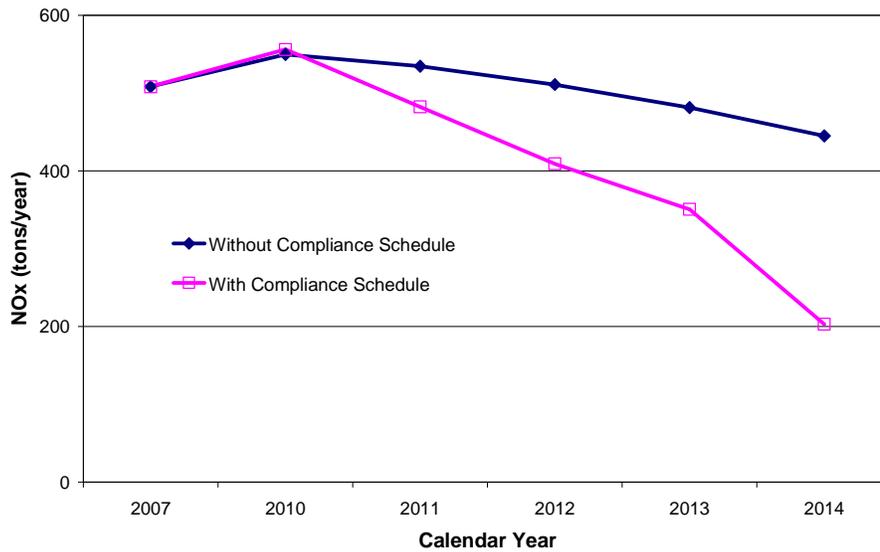
**Figure IV-6: Port of Oakland and Associated Rail Yard Drayage Truck Diesel PM Emissions with and without the Proposed Regulation**



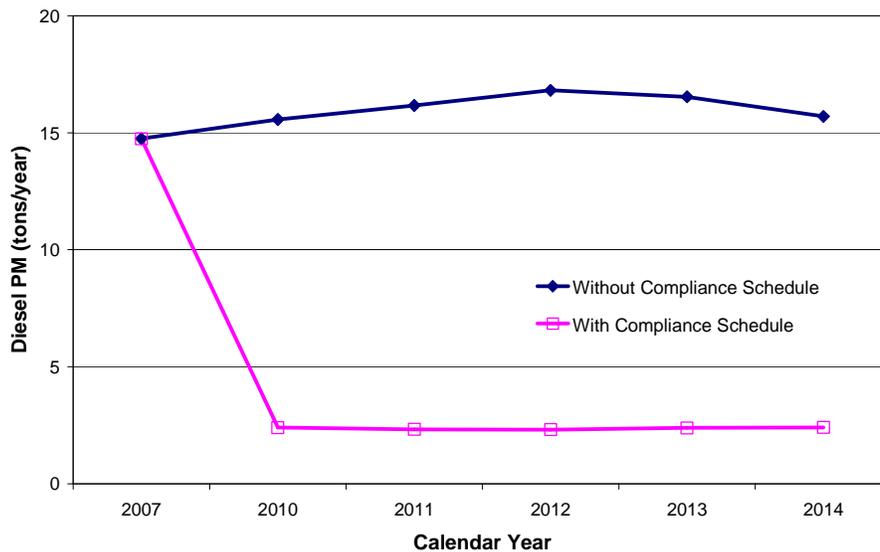
## D. Other Ports and Intermodal Rail Yards

Because emissions associated with all other Ports (other than Los Angeles, Long Beach, and Oakland) are scaled based on the Port of Oakland, trends follow those of the Port of Oakland. Figures IV-7 and IV-8 show projected drayage truck NOx and diesel PM emission benefits, respectively, at these other ports.

**Figure IV-7: Drayage Truck NOx Emissions with the Proposed Compliance Schedule at Other Ports**



**Figure IV-8: Drayage Truck Diesel PM Emissions with the Proposed Compliance Schedule at Other Ports and Intermodal Rail Yards**



## REFERENCES

- ARB (2000). Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles, California Air Resources Board.
- ARB (2006a). Emissions Reduction Plan for Ports and Goods Movement in California, California Air Resources Board.
- ARB (2006b). Revision of Heavy Heavy-Duty Diesel Truck Emission Factors and Speed Correction Factors, California Air Resources Board.
- ARB (2007a). Goods Movement Action Plan, California Air Resources Board.
- ARB (2007b). Goods Movement Emission Reduction Program – Staff Draft Concepts for Implementation, California Air Resources Board.
- Cambridge (2006). Port Truck Trip Reduction Strategies, Cambridge Systematics, Inc.
- Carwright (2006). Ports of Los Angeles and Long Beach Container Lift Data, received by email in February 2006.
- CENSUS (2002). Vehicle Inventory and Use Survey, U. S. Census Bureau.
- Gladstein C. (2007). Port Trucking, Faster Freight Cleaner Air; A Summit on North American Goods Movement and Air Quality.
- ITERIS (2007). Memorandum: Port Truck VMT Estimates, ITERIS, Inc.
- Jones & Stokes (2004). Port of Los Angeles Portwide Rail Synopsis.
- Parsons (2004). San Pedro Bay Poets Rail Market Study, Parsons Transportation Group.
- POLA (2007). Port of Los Angeles Inventory of Air Emissions-2005, Port of Los Angeles.
- POLB (2007). Port of Long Beach Inventory of Air Emissions-2005, Port of Long Beach.
- SCAG (2005). Southern California Regional Strategy for Goods Movement A Plan for Action, South Coast Association of Governments.
- Tioga (2002). Empty Ocean Container Logistics Study, The Tioga Group and Meyer, Mohaddes Associates.

**Appendix B – 1:  
Protocol of Port Truck Traffic Survey**

# APPENDIX B-1 PROTOCOL OF PORT TRUCK TRAFFIC SURVEY

## Protocol of Port Truck Traffic Survey

### 1. General guidance

Port truck traffic survey guidance is designed to collect categorized port truck traffic four freeway segments that port trucks travel most in the San Pedro Bay area. Port trucks can be categorized as bobtail (a power unit only), chassis (a power unit articulated with a chassis not carrying a container) and container trucks (a power unit articulated with a chassis carrying a container).

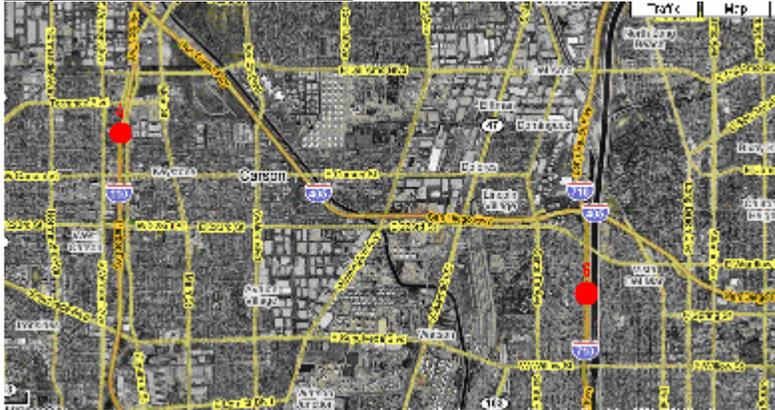
Two surveyors make one survey group for a selected survey location. One survey separately counts bobtail, chassis and container trucks for one direction (North or East bound), and another survey does for another direction (South or West bound). Survey composes two time periods, morning (7am to 12:20pm) and afternoon (12:40pm to 6:00pm). For each hour, surveyors should count trucks for 20 minutes continuously, take a 10 minute break, counts for another 20 minutes, and take another 10 minute break. As surveyors count port trucks, they should use attached survey forms (see pages 6 to 9).

### 2. Survey locations

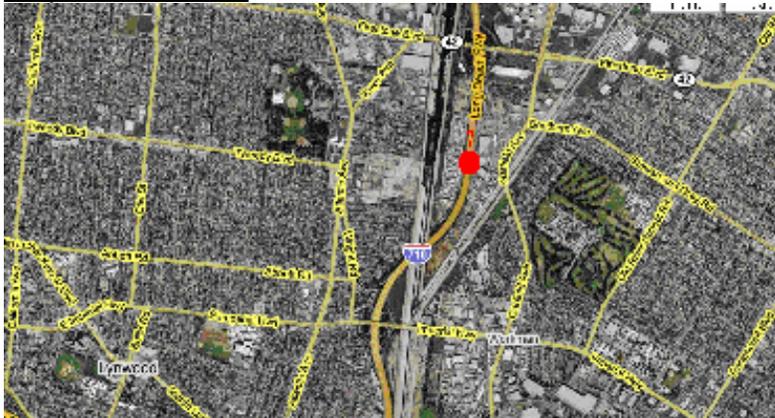
Surveyors are recommended to arrive at their designated survey locations 30 minutes earlier than the actual survey start hour. Before conducting the survey, surveyors should locate the **MOST SAFE** area that is the closest to their designated survey locations. If surveyors can not find safe areas for the survey, they may adjust their locations around the designated survey locations. Follow the table and pictures shown for the four survey locations. If you should encounter any events that you feel impact the survey (e.g. an accident blocking traffic) please makes notes of this on the back of the survey indicating which time period it impacts

ID	Survey Locations	Location Adjustment
4	I110 – Between W Carson St. and Torrance Blvd.	South of I405
6	I710 – Between W Willow St. and W Wardlow St.	South of I405
7	I710 – Between Imperial Hwy. and Firestone Blvd.	North of I105
8	I605 – Between Whittier Blvd. and Beverly Blvd.	

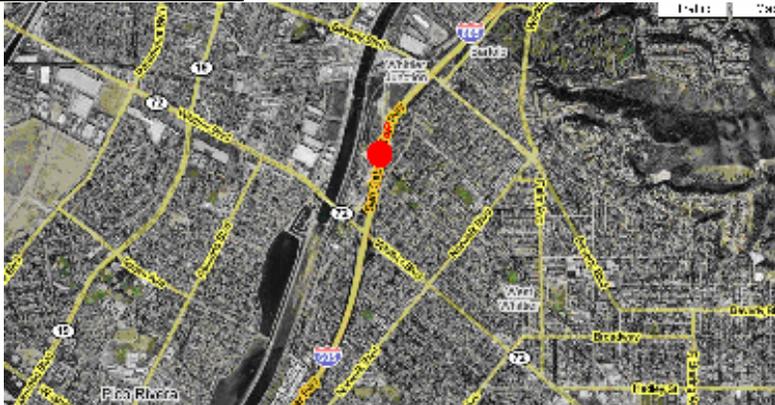
Map1: Locations 4 and 6



Map2: Location 7



Map3: Location 8



### 3. Port truck categories

Port trucks can be categorized into three types depending on tractor and trailer articulation with and without a container. The three types are bobtail, chassis and container trucks.

**Bobtail trucks – tractor without a trailer**



**Chassis truck – tractor with a flat bed chassis trailer**



**Container Trucks – tractor with a container loaded on a flat bed chassis trailer (the container length is typically 20' or 40'). Note Port Container trucks will be carrying a container with vertical ribs (see below).**

Example1 of Container Truck (**Containers have vertical ribs on their sides**)



Example2 of Container Truck (**Containers have vertical ribs on their sides**)



- \* **Caution:** Trucks pulling container trailers should not be counted as port trucks. A container trailer (typically 53' long) is a single unit and can not be separated into a chassis and container. The container is built on the chassis. Furthermore, the container will NOT have the vertical ribbing seen with port container trucks. **These trucks are NOT PORT TRUCKS and should NOT BE COUNTED.**

Example1 of Non-Port Trucks (Notice: No vertical ribbing on container)



Example2 of Non-Port Trucks (Notice: No vertical ribbing on container)



**Appendix B – 2:  
Protocol of Port Truck Origin and Destination Survey**

## **APPENDIX B-2 PROTOCOL OF PORT TRUCK ORIGIN AND DESTINATION SURVEY**

### **Port Truck Origin-Destination Survey Protocol**

#### **1. General guidance**

This survey is designed to collect data on origin and destination of port truck trips in and between the Port of Los Angeles and Port of Long Beach. To collect the data, surveyor will work with California Highway Patrol (CHP) officers to randomly sample port trucks on the surface street in the San Pedro Bay area.

With the assistance of CHP officers, surveyors will randomly pull port trucks over and conduct the survey using the attached form. Surveyors will ask the truck driver the following questions:

- Type of the truck: bobtail, chassis, or container (This can be determined visually by surveyors)
- If the truck is a container, is it empty or loaded?
- Where is the truck coming from?
- Where is the truck going to?
- What is the license plate number? (This can be observed by surveyors)

In collecting the original and destination location, the truck driver will be encouraged to answer the questions as completely as possible. If the location is a terminal, full name of the terminal should be provided. As an alternative, surveyor can use the map in the survey form to help the driver identify the approximate area. If the location is some place out of the port area, full address should be provided. At the minimum, the name of the city or zip code should be provided.

This survey targets only port trucks. There are three categories: bobtails, chassis and container trucks. A guide on how to identify and differentiate the port trucks is provided in section 5.

**Cautions:** In the case of chassis or container trucks, the license plate number should be the truck's license plate located at the front of the truck, not the chassis's plate at the back.

We estimate that each survey takes about three to five minutes.

## 2. Survey Sites

There are two preferred survey locations, one on the Ocean Blvd on the Terminal Island, near the ramp toward the Vincent Thomas Bridge, the other on Scenic Way, around the ramp toward Queensway Bridge (see Figure 1). The actual amount and exact locations of survey sites may depend on the availability of CHP officers and their work requirement.

**Figure 1: Preferred Survey Sites**



## 3. Contacts

Regarding to survey, please contact Zhen Dai (916-322-7455).

## 4. Survey Results Submittal

After completing survey, please return survey results to Violet Das (the secretary of Mobile Source Analysis Branch) by **Wednesday (8/1/2007) MORNING 9:00 am**. Violet's telephone number is (626) 575-6804. If surveyors can not reach Violet Das, fax survey results directly to Zhen Dai at (916) 327-8524.

## 5. Port Truck Types

Port trucks can be categorized into three types depending on tractor and trailer articulation with and without a container. The three types are bobtail, chassis and container trucks.

### **Bobtail trucks** – tractor without a trailer



### **Chassis truck** – tractor with a flat bed chassis trailer



**\*Caution :** Container chasses are “I”-Beam chasses (as in above pictures). A flatbed chassis is not a container chassis and should not be counted as a chassis in our survey. An example of flatbed chassis is below:



**Container Trucks** – tractor with a container loaded on a flat bed chassis trailer (the container length is typically 20' or 40'). Note Port Container trucks will be carrying a container with vertical ribs (see below).

Example 1 of Container Truck (**Containers have vertical ribs on their sides**)

Example 2 of Container Truck (**Containers have vertical ribs on their sides**)

\* **Caution:** Trucks pulling container trailers should not be counted as port trucks. A container trailer (typically 53' long) is a single unit and can not be separated into a chassis and container. The container is built on the chassis. Furthermore, the container will NOT have the vertical ribbing seen with port container trucks. **These trucks are NOT PORT TRUCKS and should NOT BE COUNTED.**

Example1 of Non-Port Trucks (Notice: No vertical ribbing on container)



Example2 of Non-Port Trucks (Notice: No vertical ribbing on container)



**Appendix B – 3:  
ARB Port Truck Origin and Destination Survey Form**

**APPENDIX B - 3  
ARB PORT TRUCK ORIGIN AND DESTINATION SURVEY FORM**

**Ports Truck Origin-Destination Survey**

To study the port truck activity for regulatory purpose, the California Air Resource Board is conducting a port truck origin-destination survey. You are RANDOMLY selected to participate in this short survey. Your response to Part A of this Survey would be highly appreciated. All surveys will be conducted anonymously. Any information about the truck such as license plate number will be kept confidential and used only for this analysis. The survey will take you less than five minutes. **THANK YOU VERY MUCH FOR YOUR ASSISTANCE.**

**Part A. Trip Original / Destinations:**

1. What type of truck is this? *(check one)*
- Bobtail (no chassis) .....
  - Tractor with : Chassis only .....
  - Empty Container .....
  - Loaded Container...



2. Where are you coming from? *(check one)*
- Another Terminal .....   
*(Please specify)*  
Terminal name: \_\_\_\_\_  
or,  
select a number in the map: \_\_\_\_\_
  - Out of the port area .....   
*(Please specify)*

\_\_\_\_\_  
*(address or intersection)*

\_\_\_\_\_  
*(city/state/zip code)*

3. Where are you going to? *(check one)*
- Another Terminal .....   
*(Please specify)*  
Terminal name: \_\_\_\_\_  
or,  
select a number in the map: \_\_\_\_\_
  - Out of the port area .....   
*(Please specify)*

\_\_\_\_\_  
*(address or intersection)*

\_\_\_\_\_  
*(city/state/zip code) (city/state/zip code)*

**THANK YOU!**

**Part B. FOR USE BY THE SURVEYOR ONLY**

Truck License Plate Number \_\_\_\_\_ *(please do not record tractor license plate)*  
 Surveyor \_\_\_\_\_ Time of Survey \_\_\_\_\_  
 Location of Survey \_\_\_\_\_

**Appendix C:  
Form 399 Summary**

## **APPENDIX C FORM 399 SUMMARY**

### **I. ECONOMIC IMPACT STATEMENT**

#### **Item A.1: Determination of Regulation Impact**

The proposed regulation to control emissions from in-use, on-road, heavy duty diesel-fueled drayage trucks is expected to have an impact on California small businesses, as well as a marginal impact on large businesses. However, it is not expected to hamper the ability of California businesses to compete with those of other States. The proposed regulation does impose recordkeeping requirements on all, and reporting requirements on most affected entities.

#### **Item A.2: Total Number and Type of Businesses Impacted**

The proposed regulation is expected to have a direct impact on the following businesses: independent truck owner-operators, licensed motor carriers (dispatching firms), dealerships engaged in the sale, and service of new and used on-highway, heavy duty diesel-fueled vehicles in California, and firms engaged in the sale and installation of emissions control after-treatment equipment (retrofits kits) for on-road, heavy duty, diesel-fueled vehicles. In addition, the proposed regulation is also expected to impact non-profit businesses such as local port and railroad authorities, and public and private shipping terminal operators.

The proposed regulation is expected to have an indirect or marginal impact on the following businesses: on-road heavy duty engine manufacturers, truck manufacturers, and manufacturers of after-treatment emissions control equipment.

Staff estimates that there are approximately 22,200 independent owner-operators (2009) who conduct drayage at California port and intermodal railyards on a frequent (mean 7 or more trips per week), or a semi-frequent (mean 3.5 – 7.0 trips per week) basis. These frequent and semi-frequent operators characterize approximately 80% of the drayage trips to the California ports and intermodal rail facilities. Staff estimates that the total number of drayage operators, which includes the frequent, semi-frequent, and infrequent visitors moving both containerized and non-containerized trucks could be between 55,000 -95,000 operators. Staff further estimates that if the efficiencies in drayage operations were to increase, with more semi-frequent operators capturing more of the drayage business, then there could be as many as 29,900 operators impacted by the proposed regulation.

In addition to the 22,200 – 29,900 independent truck owner-operators initially impacted by the proposed regulation, staff estimates that there could be an estimated ~ 1,800

licensed or primary motor carrier firms impacted by the proposed regulatory measure<sup>1</sup>. In addition to these businesses, staff expects the drayage business to grow by an additional 2,300 – 3,000 owner-operators between 2010 – 2013. Therefore, the total number of directly impacted businesses could range between 25,000 – 34,000 firms.

### **Items A.3: Determination of Number of Small Businesses Impacted**

Staff believes that of all the directly and indirectly impacted businesses mentioned above, a majority number of the businesses are small businesses. The State of California Department of General Services (DGS) considers a business to be a certified small business if the firm meets the following conditions; the firm must be independently owned and operated, the firm cannot be dominant in its field of operation, it must have principal offices located in California, and must have its officers domiciled in California. In addition, the firm must meet one of the following revenue and number of employees requirements: the firm must not have more than 100 employees, and average annual gross receipts of more than \$12 million for the previous three years, or if a manufacturing concern, then the firm may not have more than 100 employees.

Specifically, the proposed regulation is likely to impact the following small businesses that constitute more than 80 percent of all affected entities: independent truck owner-operators engaged in drayage, and licensed or primary motor carriers (dispatching firms).

Staff estimates that all independent owner-operators engaged in drayage business at the California ports and intermodal rail yards are considered to be small businesses. Independent research based on surveys has shown that the mean gross income (after deducting for diesel, insurance, and maintenance expenses) in 2006 for port drayage workers was approximately \$35,000 (Monaco, 2007). Staff has been able to corroborate the mean gross margin for drayage at the Ports of Los Angeles, Long Beach, and Oakland to be approximately \$37,700 or 50% (as a percentage of revenue) for the year 2007.

Staff also estimates that at least 80% of the motor carriers are considered to be small businesses. Staff assumes that motor carrier firms recognize only their gross margin on container receipts as revenue or income. In a survey of port truck operators at the Port of Long Beach (Monaco / Grobar, 2004), the authors of the study found that when the drivers were asked about the number of drivers working at the company (dispatching firm) they were contracting for, approximately 25% of them responded that their firm had less than 25 drivers, a majority of them (~60%) worked for firms with 25 – 99 drivers,

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<sup>1</sup> This estimate is based on the 800 – 1,200 licensed motor carriers providing drayage services at the San Pedro Bay Ports (Husing / Brightbill / Crosby, 2007). Staff estimated that there could be as many as 15,500 container and non-container trucks at the San Pedro Ports in frequent and semi-frequent service. Proportioning the number of trucks in frequent and semi-frequent service to the total number of trucks in frequent and semi-frequent service statewide, and applying the resultant ratio to the number of drayage firms serving the San Pedro Bay area, gives an approximation of the number of drayage firms statewide. This number was found to be ~1,800 firms (lower bound).

another 10% responded that their firms had 100 – 249 drivers, and the remaining 5% responded that their firms had over 250 drivers. Therefore, only 15% of the motor carrier firms employ more than 100 people. The mean and median firms contracted with 45 and 79 independent owner-operators, respectively. A quarter of the firms surveyed reported moving less than 25 containers per day, more than half reported moving less than 100 containers per day, and a fifth of the firms reported moving more than 150 containers per day. With estimated gross margins of 25-30% of harbor drayage revenues (Peoples / Talley, 2005), staff estimates that the mean and median primary or licensed motor carrier firms can be considered to be California-based small businesses.

In another survey of dispatching firms (Monaco / Grobar, 2004), about 13% of the respondents reported employing drivers. The remaining 87% exclusively contracted with owner-operators to haul freight. Staff estimates that most motor carrier firms that do not make more than 190 – 240 dispatches or container moves per average workday could be considered to be California-based small businesses (since their annual revenues are much less than \$12 million per year limit to qualify as a California small business). Staff estimates that in order to exceed the \$12 million California small business classification, motor carriers must move an estimated 1,100 containers per average workday. Based on this information, staff concludes that at least 80 percent of licensed motor carriers firms would fall under the classification of being a small business.

Staff does not believe that any of the heavy heavy-duty diesel engine manufacturers (for example, Cummins, Caterpillar, Detroit Diesel, International, Mack, and Volvo to name a few) are California-based, or considered to be small businesses. Also, the class 8 truck manufacturers, such as Paccar, International, Mack, Volvo, and Daimler are not California-based or considered to be small businesses. Both heavy duty engine manufacturers and the truck manufacturers are businesses likely to be beneficiaries from the regulation, as the rule will mandate replacements of some older heavy duty diesel-fueled drayage vehicles. Similarly, California-based new and used truck dealerships may also be beneficiaries from the proposed regulation as drayage operators seek truck replacements; due to the State DGS revenue qualifications, these businesses are not likely to be considered as small businesses. Some smaller truck service shops and used truck dealerships may qualify to be small businesses under the DGS classification.

Staff research indicates that one (Cleaire Advanced Emission Controls) of the major manufacturers of after-treatment emissions control equipment is California-based, but since it is not an independently operated company, it is not considered to be a small business. The other primary manufacturers of after-treatment emissions control equipment are not California-based either (for example, Johnson Matthey, Donaldson, 3M, and Corning), but are likely to be beneficiaries of the proposed regulation, as the regulation mandates retrofits of some in-use, on-road, heavy duty, diesel-fueled drayage trucks.

Staff expects that California firms engaged in the sale and installation of after-treatment emissions control products (such as diesel particulate filters / retrofit kits) may qualify to be considered as California small businesses and that these businesses are likely to benefit from the proposed regulation. However, some truck dealerships and manufacturers of after-treatment emissions control equipment are not likely to be considered as California based small businesses, but may benefit from the retrofit requirements of the proposed regulation.

#### **Item A.4: Potential Impact on Business Creation or Elimination**

Staff believes that the imposition of emissions reduction measures, may lead to some consolidation of independent owner-operators who conduct drayage at port and intermodal rail facilities infrequently (i.e., those operators who on average are making less than 3.5 visits to a port or intermodal rail facility per week) and for whom the expense of complying with the regulation is not economically justified. Staff estimates that the number of infrequent owner-operators impacted by the proposed regulation could be 33,000 – 65,000. Staff notes that short-haul drayage for infrequent operators is not their primary business or source of income, and correspondingly, staff expects that drayage operators in semi-frequent service (i.e., those making between 3.5 – 7 visits to a port or intermodal rail facility on a weekly basis) will increase their operating frequencies and capture more of the fixed drayage business. This is likely to increase the economic viability of frequent and semi-frequent drayage operators. As a probable scenario, staff further believes that the drayage business of infrequent operators is not likely to be eliminated entirely; they are likely to have their containers drayed off from the ports and intermodal rail facilities to an intermediate location such as a warehouse or public lot from where the containers can be picked up.

Staff expects the demand for drayage truck operators to continually be strong for the foreseeable future. This is due to the growth in container volume at the major California ports witnessed during the past 10 years and forecasts for overseas trade and container shipment activity to remain robust. In addition, the demand will be strengthened by the introduction of stricter legal programs such as the Truck Worker Identification Card (TWIC) at the California ports. Staff therefore expects there to be a net positive impact on business creation in the drayage industry and the overall impact of consolidation of infrequent operators in drayage to be minimal.

#### **Item A.5: Geographic Extent of Impacts**

The proposed regulation will impact all major California ports and surrounding intermodal railyard facilities within a radius of 80 miles from the port. The major California ports are scattered throughout the State and the proposed emissions control measure is primarily intended to mitigate local air quality impacts associated with the California goods movement. Therefore, staff expects the impacts to be statewide. Specifically, the regions that will likely be impacted are the following: Los Angeles (Port

of Los Angeles, Burlington Northern Santa Fe (BNSF) Hobart, LATC Union Pacific, Commerce UP, Commerce Eastern BNSF, ICTF UP), Long Beach (Port of Long Beach), Oakland & San Francisco (Port of Oakland, Union Pacific (UP) Oakland, BNSF Oakland, Ports of San Francisco, Richmond, Contra Costa, Benicia, and Redwood City, Richmond BNSF, San Bernardino, San Diego (Port of San Diego), Sacramento (Port of Sacramento), Stockton (Port of Stockton, Stockton Intermodal BNSF), Lathrop (Lathrop Intermodal UP), Hueneme (Port of Hueneme), and Eureka (Port of Humboldt Bay).

#### **Item A.6: Potential Impacts on Job Creation and Elimination**

Staff projects that without the proposed regulation, the employment in the truck transportation sector will grow by 9,000 jobs, between the years 2006 – 2013. With the proposed regulation, staff expects sector employment to be reduced 1,000 - 1,300 jobs by 2013 / 2014. Staff further believes that if the costs of compliance can be passed on to shipping companies and their customers, then the impact of the regulation on business elimination will be minimal. Staff cautions that in the absence of their ability to pass on the cost of compliance with the proposed regulation, many operators may leave the drayage profession altogether, or take their business elsewhere.

Staff believes that in order to meet the increased demand for the diesel emissions control systems and for new or late model on-road heavy duty diesel fueled vehicles, there would likely be marginal job creation or sustained employment in engine, truck, and after-treatment emissions control device manufacturing, and associated sales and service support as a result of this proposed regulation. However, staff notes that job creation, elimination, and occupational changes are also functions of the macroscopic economy and can be largely influenced by prevailing economic conditions, employment, interest rates, inventories, and business sentiment and outlook.

#### **Item A.7: Potential Impacts on California Business Competitiveness**

Staff does not believe that the proposed regulation will have any measurable impact on California competitiveness relative to companies operating out-of-state. This is because the proposed regulation primarily targets drayage at local California ports and intermodal rail facilities which serve as critical gateways for distributing goods to the rest of the country and the rest of the world. The California ports also have access to an intricate rail network, and regional and long-haul trucking companies that can economically and efficiently transport containerized and non-containerized bulk cargo to the far reaches of the country. So any impact (as measured by the increased cost of compliance) on the California drayage business will also impact businesses out of California equally (staff assumes that compliance costs can be passed on the supply chain).

Staff determined the equivalent cost of the proposed regulatory measure to a typical drayage operator at the Ports of Los Angeles and Long Beach, and the Port of Oakland.

Staff reported that the estimated Phase 1 replacement and retrofit costs represent, on average, a cost of \$3,700 per year to a drayage owner-operator between the years 2009 -2012. With the assumption that the drayage operator will make on average at least 2.4 container moves per day and work on average an estimated 250 days per year without impacting his or her quality of life, then the drayage operator is expected to make 2.4 x 250 or 600 container moves per year. When the annual cost of Phase 1 to the drayage operator is divided by the expected annual number of container moves per year, the impact of the cost of the regulation is determined to be approximately \$6 per container (2009 - 2012).

Similarly, staff previously reported that the estimated Phase 2 replacement costs represent, on average a cost of \$5,900 per year to a drayage owner-operator between the years 2013 -2027. When the annual cost of Phase 2 to the drayage operator is divided by the expected annual number of container moves per year (600), the impact of the cost of the regulation is determined to be approximately \$10 per container (2013 - 2027).

Therefore, staff determined that the annual cost of the proposed regulation to a typical drayage operator at the Ports of Los Angeles and Long Beach and the Port of Oakland is approximately \$6 per container move during the years 2009 -2012, and approximately \$10 per container move during the years 2013 -2027. This container fee can be assumed to be on average (weighted) \$9 per container move for the service life of the proposed regulation (2009 - 2027). Staff also determined that the \$9 average container fee represents less than 1 percent of standard sea-borne freight shipping rates applicable to containers (Air Parcel Express, 2005 and Maersk Sealand, 2005). This relevance is important when an assumption is made that the annual cost incurred by drayage operators for complying with the requirements of the proposed regulation can be passed on to the shipping companies, who may further pass on the costs to their customers.

Therefore, staff believes that the financial impact of the requirements of the proposed regulation on freight shipping rates is marginal, and correspondingly the ability of California business competitiveness with that of other states is minimal. With the potential impact on sea freight rates so low, staff does not envision California ports losing business to other states as a result of the proposed regulation. Staff does believe that if business is lost to other of State ports, then it is likely due to the fact that the largest ports in California and their supporting distribution systems are constrained in their capacities, and have to limit expansion.

Moreover, staff has shown that as a result of the proposed regulation, the economic impact of the highest year total annualized costs, which occur in the year 2013-2014, are relatively small and negligible on the California economy (see discussion on macro economic impact in the Technical Support Document). Staff projects that the California gross state product, employment, and personal income decrease by less than 0.1% in the years 2013-2014 (E-DRAM Model).

## Item B.1: Total Statewide Dollar Costs for Businesses and Individuals

Staff estimates that the total statewide costs for drayage trucks to comply with the proposed regulation requirements during the years (2009 – 2013), and for trucks entering drayage service between the years (2010 – 2013) is approximately between \$1.13 - \$1.53 billion. This estimate is based on a cash flow (CF) analysis of in-use, on-road, heavy duty diesel-fueled truck replacement and retrofit costs incurred by motor carriers and independent truck owner-operators. This estimate does not take into account any individual rebates or public grants / awards provided to the businesses or independent truck owner-operators. A detailed cost analysis for every phase of the regulation is presented in the Technical Support Document discussion section on Economic Impact Analysis. The total cost charges discussed above are related to two basic requirements: a drayage owner-operator must install a level 3 VDECs (DPF) if they own and operate a pre-2004 model year truck and they must replace all vehicles with a minimum model year 2007 California and federal compliant vehicle by 2013.

Since vehicle retrofit and replacement costs in the year incurred are primarily business expenses, the costs can be capitalized based on a capital recovery period (CRP) of 20 years of useful life for a new, heavy duty diesel-fueled drayage truck, and an interest rate of no less than 15% to reflect the higher risk of business with drayage truck owner-operators. Therefore, a truck being replaced with a used 6-year old model year 2007 California and federal compliant vehicle in 2013 can be capitalized for a period of (20 – 6) or 14 years. The higher discount rate reflects the higher risk that primarily stems from a lower credit worthiness of a lower income sub-group and a higher workforce and occupation turnover rate (Monaco, 2007). The initial cost of compliance based on the proposed schedule for drayage trucks results in average annualized cost of \$3,700 per independent owner-operator business for a period of 4 years. This includes vehicle upgrade costs (estimated to be approximately \$21,000 in 2006 dollars) for some pre-1994 owner-operators who must upgrade their trucks for retrofit and drayage entry requirements. Most operators may have initial retrofit compliance costs of approximately \$10,000 in 2006 dollars. In addition to these initial costs, owner operators then face vehicle net replacement costs of up to approximately \$33,000 in 2006 dollars. This cost is based on a trade-in allowance of approximately \$5,500 for pre-2004 model year trucks in 2013. This is equivalent to annualized costs of compliance in the amount of \$5,900 per business, for a period of 14 years beginning in the year 2014 (discount rate for drayage is assumed to be 15%). These annualized charges only reflect the cost of capital goods (retrofit product and / or replacement vehicle) and assume zero residual value of the truck at the end of 14 years. Staff estimates that annual O&M charges (which were factored into annualized expenses) associated with DPF maintenance<sup>2</sup> and wages lost due to ARB record keeping requirements could be \$550 (2006 dollars) per owner-operator per year. Estimated

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<sup>2</sup> Staff conversations with vendor (Ironman Parts, 2007); independent truck owner-operators may incur annual unadjusted maintenance expenses of approximately \$300 per year to service the retrofit product installed on their vehicles. This maintenance requirement is the annual de-ashing of diesel particulate filters.

annual costs are net of any sales taxes (~8.5%) and taxes owed on public grants for fleet modernization, fuel penalties associated with diesel PM and NOX emissions control devices (estimated to be ~2% (Emissions Advantage, 2005)), and differential vehicle insurance and registration rates stemming from the higher book value of replacement vehicles. In determining total costs of the regulation, staff did factor a credit for a portion of the residual value of the trade-in truck in 2013.

### **Item B.2: Share of Total Costs for Multiple Industries Impacted**

Analysis of business impacts of the proposed regulation on independent owner-operators indicates that as a result of the costs incurred by drayage truck owner-operators (100% of direct compliance costs), typical owner operator margins may decrease by 3% in 2009 and by 9% in 2013. Staff further established that independent owner-operator gross margins for typical drayage workers at the Ports of Oakland, Los Angeles, and Long Beach were on average \$37,700 per year. These workers therefore do have a limited ability in how much of the increase in compliance costs that result from the proposed regulation can be sustained in their business. Staff further believes that the increased compliance costs may be eventually passed on to shipping lines / companies who contract with motor carriers, who in-turn may pass on the costs to their customers in the form of increased shipping / freight rates. Staff also estimated the typical impact to be an increase in freight rates of less than 1% of the total sea-borne freight bill.

### **Item B.3: Costs of Compliance Associated With Reporting Requirements**

Staff believes that owner-operators will spend an estimated 12 hours per year performing the following tasks associated with complying with the proposed regulation: affix compliance sticker on vehicle, obtain retrofit device maintenance records for vehicle, registering with ARB Drayage Truck Registry (DTR) database, reading and understand the requirements of the regulation, and periodically inspecting emissions control device(s). Correspondingly, staff values lost wages as a result of trying to comply with the proposed regulation to be approximately \$250 per truck per year to the owner-operator.

However, staff further believes that some typical motor carriers that contract with a 50 - 100 owner-operators may incur greater costs of compliance with the proposed regulation every year. Staff has identified the following tasks associated with compliance requirements for such motor carriers: provide a copy of regulation to each drayage truck operator, ensure trucks being dispatched are registered and have affixed compliance sticker, and develop compliance strategy for firm. Staff estimated a total of 308 hours spent per year by secretarial / administrative personnel, and business manager level staff, and valued lost wages at \$4,400 per year per typical motor carrier firm (see Item A.3 for determination on motor carrier firm size). These costs are

estimated to be proportionately lower or higher for motor carrier firms that contract with fewer or greater than 50 -100 owner-operators.

In addition, motor carrier firms will be required to keep dispatch records for a period of five years and ensure that the drayage operator has motor carrier information in the vehicle. Staff believes that complying with these requirements are routine business tasks and therefore do not require special recordkeeping associated with the proposed regulation.

#### **Item B.4: Impact of Proposed Regulation on Housing Costs**

Staff does not believe that the proposed regulation will impact housing costs.

#### **Item B.5: Comparable Federal Regulations**

The applicability of the proposed regulation is extended to in-use, on-road, diesel-fueled, heavy duty drayage trucks. The comparable federal regulation is the new PM and NOx standards for new heavy-duty diesel-fueled on-highway engines promulgated for model year 2007. The proposed regulation seeks to ensure that the trucks entering drayage service at port and intermodal rail facilities meet California and federal 2007 standards for heavy duty diesel fueled engines by 2013.

#### **Item C.1: Estimated Benefits from Proposed Regulation**

The proposed emissions control measure is expected to reduce an estimated 750 tons of diesel particulate matter (diesel PM) by the year 2014 and further reduce 11,900 tons of oxides of nitrogen (NOx) emissions in the year 2014 from pre-regulatory baseline emissions levels (Environmental Impact Benefits). In addition to emissions reduction benefits, the proposed regulation is expected to partially mitigate the health effects caused by pollution from drayage trucks. All Californians and especially those citizens who live and work around affected port and intermodal rail yard facilities will benefit from reduced exposure to these pollutants and from reduced incidences of associated cancer and non-cancer health effects.

Staff estimates that approximately 580 premature deaths (160 – 990, 95 percent confidence interval or 95% CI) statewide will be avoided by the year 2014 from the implementation of the proposed drayage trucks regulation. Estimates of other health effects avoided statewide include:

- 120 hospital admissions due to respiratory causes (78 – 170, 95% CI)
- 230 hospital admissions due to cardiovascular causes (140 – 350, 95% CI)
- 17,000 cases of asthma-related and other lower respiratory symptoms (6,700 – 27,000, 95% CI)

- 1,400 cases of acute bronchitis (0 – 3,100, 95% CI)
- 100,000 work loss days (86,000 to 120,000, 95% CI)
- 580,000 minor restricted activity days (480,000 to 690,000, 95% CI)

### **Item C.2: Benefits as a Result of Goals Developed from Broad Statutory Authority**

Health and Safety Code (HSC) sections 43013(b) and 43018 provide broad authority for the Air Resources Board to adopt emission standards and other regulations to reduce emissions, including those from toxic air contaminants (TAC), and other air pollutant emissions from vehicular and other mobile sources. In addition, California's Air Toxic Program as set forth in HSC sections 39650 through 39675, mandates the identification and control of TAC in California.

### **Item C.3: Statewide Lifetime Benefits**

Staff estimates cumulative health benefits over the period from 2010 to 2014 to be nearly \$4.3 billion using a 3% discount rate, or nearly \$3.5 billion using a 7% discount rate. CARB follows U.S. EPA practice in reporting results using both 3% and 7% discount rates. Nearly all of the monetized benefits result from avoiding premature death. The estimated benefits from avoided morbidity are approximately \$64 million with a 3% discount rate and less than \$53 million with a 7% discount rate. Approximately 75% of the benefits are associated with reduced PM from direct sources, and the remaining 25% with reduced NOx.

Statewide lifetime benefits associated with the reduction in health impact cases were not quantified for the period beyond 2009 – 2014.

### **Item D.1-2: Alternatives to the Proposed Regulation & Cost Basis**

Staff considered the following two alternatives that would achieve an equivalent or greater reduction in diesel PM and NOx emissions from in-use, on-road, heavy-duty, diesel-fueled, drayage trucks. The first alternative considers replacing the entire existing in-use, on-road, heavy-duty diesel-fueled population of drayage trucks with new, heavy-duty, diesel-fueled drayage trucks that are compliant with Federal Heavy Duty Diesel Engine Standards for Model Year 2010 by the year 2013. For simplifying the cost of alternatives to the regulation, staff assumes that the entire fleet of an estimated 24,000 – 32,000 in-use, heavy-duty diesel-fueled trucks will be replaced with new Model Year 2010 compliant heavy duty diesel vehicles. Staff estimated costs for replacement with new heavy duty diesel vehicles due to not being able to guarantee supply of used model year 2010 vehicles in the market until the vehicles come of program leases (~ 4 to 5 years after model year introduction).

Staff cautions that model year 2010 or newer vehicle owner-operators may incur additional operating costs for trucks with urea equipped SCR systems used to control NOx emissions levels, but this is not a requirement of the regulation being proposed. While staff anticipates an additional cost of \$10,000 to the purchase price of a model year 2010 vehicle, staff believes that competing NOx control technologies being developed (for example, NOx adsorption catalysts) may dominate over urea-fed SCR systems in heavy duty diesel trucks and these additional costs may not be relevant. Life cycle operating costs for year 2010 compliant heavy duty diesel trucks with urea fed SCR systems was not determined as part of this regulatory comparison.

The second alternative to the regulation considers replacing and / or repowering one-half the entire existing estimated population of in-use, heavy duty diesel-fueled drayage vehicles in port and intermodal rail service with liquefied natural gas (LNG) fueled vehicles and the other half with new or used model year 2007 compliant heavy duty diesel-fueled vehicles. Staff assumes that one-half the entire fleet of an estimated 24,000 – 32,000 in-use, heavy-duty, diesel-fueled trucks will be replaced or repowered with LNG fueled vehicles at a cost of \$175,000 per vehicle (2006 dollars). This cost is based on a base diesel-fueled, Class 8 tractor cost of \$95,000 and a charge of \$80,000 to retrofit the tractor with a LNG fuel system (Cummins Westport, 2007). Costs for the other half of the estimated 24,000 – 32,000 drayage trucks in service were determined using the same methodology that was used in the proposed regulation.

LNG fuel dispensing infrastructure and fuel dispensing station annual operator costs were factored into the total cost determination as part of this regulatory comparison. LNG fuel dispensing station capital costs were based on a cost of \$800,000 / station. Staff was advised that approximately 4 stations are needed to fuel 1,000 trucks, which is equivalent to a cost of \$3,200,000 per 1,000 trucks. For an estimated 12,000 - 16,000 trucks, staff determined total capital (infrastructure) costs to be \$38.4 - \$51.2 million. When these costs are capitalized over a 20 year period (Plant, Property, and Equipment) at a discount rate of 7%, the annualized costs are expected to be \$3.6 million to \$4.8 million. Staff estimates that the LNG fuel dispensing facilities would incur additional annualized labor costs of \$5.2 million to \$6.9 million for operator assisted fuel dispensing at the LNG stations. These costs are based on an operator wage rate of \$21.65 per hour<sup>3</sup> and the assumption that the facility operates for 2 shifts per day, 6 days per week.

Staff notes that LNG fuel, on a per diesel gallon equivalent basis, is expected to be approximately 30% cheaper than diesel fuel between 2010 and 2014 (Tiax, 2005)<sup>4</sup>. This represents an incremental cost of approximately \$0.60 - \$0.70 per gallon of diesel over the cost of LNG fuel (with sensitivity analysis, the difference is expected to be

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<sup>3</sup> LNG Fuel Dispensing Station Operator Wage Rate Based on 2007 25th Percentile (Entry Level) Hourly Wage for Chemical Plant and System Operators in California (\$21.65) (<http://www.labormarketinfo.edd.ca.gov>).

<sup>4</sup> Tiax LLC, 2005, Figure 2-5: Incremental Cost of Diesel Over LNG, Comparative Costs of 2010 Heavy Duty Diesel and Natural Gas Technologies (Final Report).

\$0.40 - \$ 0.50 per gallon<sup>5</sup>). Life cycle operating costs for LNG trucks were not determined as part of this regulatory comparison.

### **Item D.3: Consideration of Performance Standards**

Requirements to comply with the provisions in the proposed regulation in 2009 – 2013 are based on performance standards and some prescriptive standards (such as compliance with truck model year requirements). The regulation does offer some flexibility to the drayage truck operator as long as both performance and prescriptive (model year) standards are met. The regulation allows retrofits, repowers, or replacements to meet both Phase 1 and Phase 2 requirements.

Emissions performance standards were also considered as an alternative strategy to the regulation. In particular, staff considered replacing all in-use, on-road, heavy-duty, diesel-fueled drayage trucks with new vehicles that at a minimum meet the EPA On-Highway Heavy Duty Diesel Engine Standards promulgated for 2007/2010 (PM Standard of 0.01 g/bhp-hr for 2007 and NOx Standard of 0.20 g/bhp-hr for 2010). Similarly, staff evaluated the feasibility of replacing all diesel fueled drayage trucks with LNG fueled trucks that meet the NOx performance standard of 0.6 g/bhp-hr and produce an equivalent or greater reduction in PM emissions.

### **Item E.1: Major Regulations – Cost of the Regulation**

If the estimated costs of the proposed regulation to California businesses exceeds \$10 million, then the regulation is classified as a major regulation. Since the proposed measure to reduce emissions from heavy duty, diesel-fueled drayage trucks is greater than \$10 million, the proposed measure is considered to be a major regulation. The total cost of the proposed regulation is estimated to be between \$1.13 - \$1.53 billion (2006 dollars) and includes costs for both Phase 1 and Phase 2 measures of the proposed regulation.

### **Item E.2-3: Major Regulations – Comparison of Cost Effectiveness**

Section E.2 describes the Alternative 1 and 2 strategies evaluated in Section D.1-2. In Section E.3, a comparison of the total cost and cost-effectiveness of the regulation to the regulation alternatives discussed in Items D.1-2 are presented. When compared to the proposed regulatory measure, the cost comparison shows that the alternatives to the regulation come at a much higher total cost (at least 2X) and a higher PM and NOx cost-effectiveness. While all three regulatory and regulatory alternatives produce the same reduction in PM emissions, the alternative regulatory measures are expected to

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<sup>5</sup> Tiax LLC, 2005, Figure 2-7: LNG Fuel Price Differential for Sensitivity Analysis, Comparative Costs of 2010 Heavy Duty Diesel and Natural Gas Technologies (Final Report).

produce far greater reduction in NOx emissions, at a far greater total cost. The cost effectiveness derivation for Alternative 1 and 2 strategies considered assumes that one-half of the total annualized costs are attributed to PM emissions control and the other half of the total annualized costs are attributed to NOx emissions control. A detailed derivation of the cost-effectiveness ratios for the regulation and the regulation alternatives considered is presented in the Technical Support Document for the proposed regulation.

## **II. FISCAL IMPACT STATEMENT**

### **Item A.6: Fiscal Effect on Local Government**

Local government agencies such as regional port authorities, district harbor commissions, public terminal operators, railroad commissions, and transit authorities may incur miscellaneous capital and labor costs associated with implementation of the proposed regulation. Such costs include but are not limited to the following: infrastructure and installation costs for electronic hardware (Optical Character Recognition (OCR) and / or Radio Frequency Identification (RFID) systems, video surveillance cameras, and / or computers) to collect, monitor, and record vehicle license plate data and operator / motor carrier information at the terminal gates and correspondingly provide ARB with same information as part of their quarterly reporting requirements, labor costs associated with terminal gate operator vehicular inspection and compliance training, one-time programming costs, and costs associated with conducting outreach to truck owner-operators and motor carrier firms.

Staff believes that these costs are likely to be absorbed by their respective agency budgets, since ARB does not endorse the use of any specific technology, nor does it require that any of the above mentioned technologies be used in order to comply with the proposed regulation. Moreover, staff also feels that these costs are part of their existing, ongoing efforts in modernizing port and intermodal facility entry, security, logistical improvements. Some of the affected local government agencies may have the ability to pass on these costs to the private companies (such as the port terminal operators, and the private railroad companies) conducting business on State and public grounds. Alternatively, some of the smaller local affected agencies may not have the automated electronic infrastructure in place and may have to collect the information manually. In this case, staff assumes that there will only be a few non-registered, non-compliant vehicles to deal with, and the local agency should easily be able to absorb the incorporate the function into their routine<sup>6</sup> and cost into their agency budget.

### **Item B.1-4: Fiscal Effect on State Government**

Staff anticipates that an additional four (4) staff members will be required at a total cost of \$400,000 per year (\$100,000 per staff member) in order to implement and enforce the provisions of the proposed regulation. The increase in State agency expenditure is anticipated for the 2009-2010 fiscal year.

Staff does anticipate that an additional \$110,000 will be required to conduct public outreach associated with the proposed regulation. These anticipated costs can be attributed to the following activities: Regulation Brochure Mail out to Affected Drayage Truck Owner-Operators (\$51,200), Trade Publication Advertisements (\$48,900), Motor

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<sup>6</sup> Staff has based this opinion on observations of port terminal / gate truck entry procedures, and estimated daily truck volumes at the Port of Humboldt Bay, Port of San Francisco, and Port of Sacramento.

Carrier / Truck Dealership Display Poster Distribution (\$9,600), and Two-Sided Multi-Lingual Regulation Card Distribution at Weigh Stations / Terminal Gates (\$3,200). The increase in State agency expenditure is anticipated for the 2008-2009 fiscal year.

Staff also believes that costs to program and administer the Database of Truck Registry (DTR), as required by the proposed regulation, will be absorbed by the State agency in their existing budget. Therefore, no fiscal impact of this requirement exists for FY 2007 – 2008, FY 2008 – 2009, and FY 2009 – 2010.

## REFERENCES

State of California Small Business Certification and Eligibility Requirements  
(<http://www.pd.dgs.ca.gov/smbus/sbcert.htm>)

Monaco, Kristen, The Economics of Port Drayage and the Implications for Clean Air, California State University Long Beach, February 2007.

Monaco & Grobar, A Study of Drayage at the Ports of Los Angeles and Long Beach, December 2004.

Air Parcel Express, Ocean Freight Transportation Charges (40-foot Container Shipped from Hong Kong to Seattle), April 2005.

Maersk Sealand, Ocean Freight Transportation Charges (20-foot Container Shipped from Tokyo to Los Angeles), May 2005.

Peoples / Talley, Owner-Operator Truck Driver Earnings and Employment: Port Cities and Deregulation, February 2005.

Husing / Brightbill / Crosby, Economic Analysis of the Clean Trucks Plan of the San Pedro Bay Ports Clean Air Action Plan, September 2007.

Emissions Advantage, LLC, WRAP Offroad Diesel Retrofit Guidance Document, 2005.

Tiax LLC, Comparative Costs of 2010 Heavy-Duty Diesel and Natural Gas Technologies, Final Report, July 2005.

Cummins Westport, 2007, Staff Converses with Gramm Williams, Director, Heavy Duty Vehicles, and Obtains Pricing Information for LNG Trucks / Conversion Systems on March 13, 2007.

**Appendix D:  
Methodologies for Economic Impact Assessment**

## **APPENDIX D METHODOLOGIES FOR ECONOMIC IMPACT ASSESSMENT**

This Appendix discusses the methodologies associated with developing total present value costs and calculating cost effectiveness of program measures for the proposed regulation to control emissions from in-use, on-road heavy duty diesel fueled drayage trucks.

The analysis begins with a discussion on the California on-road, used heavy duty diesel vehicle market and the price forecasting models developed to predict new and used truck replacement costs, when older model year drayage trucks are being replaced with newer model year vehicles. This discussion is presented in Section I. In addition to the development of the used truck price forecasting models, staff obtained vendor quotes for level 3 VDECS (diesel particulate filters), and utilized the price quotes as the basis for determining Phase 1 total retrofit costs. Vendor information on diesel particulate filters is presented in Section II.

Staff then presents total regulation cost and cost effectiveness estimation methodologies and a discussion on assumptions used to derive total present value costs for each phase of the proposed regulation (Section III). This section includes a discussion on discount rates and discounting mechanisms, capital recovery period (CRP) and factors (CRF), and annualized costs. Staff then illustrates how cost effectiveness for proposed measures was derived, including a short discussion on variation in cost effectiveness calculation methodology for the alternative strategies to the proposed regulation evaluated.

Section IV presents a brief discussion on the actual container growth rates at the Port of Los Angeles, Port of Long Beach and the Port of Oakland, and forecasts projected growth rates for the period 2009 – 2013. The total cost of the proposed regulation (2006 dollars) is then divided by the expected total volume of containers projected to be shipped to obtain an equivalent cost in terms of a container fee for a twenty-foot equivalent unit (TEU). This estimated fee was then compared to actual shipping freight rates to determine the magnitude of impact the container fee could potentially have on the shipping rates.

## I. California Used Truck Price Forecasting Models

In this section of the Appendix, used drayage truck prices are forecasted from parametric models developed from sample price data obtained by conducting market surveys. Staff primarily surveyed the internet site truckpaper.com where listings of heavy duty diesel vehicles for sale in California and the neighboring states are consolidated. Sample data points were qualified for Class 8 heavy duty diesel-fueled vehicles, with GVWR > 33,000 pounds, with or without sleeper cabins, and listed for sale in California and the neighboring States of Arizona and Nevada. Listed prices for vehicles obtained were for tractors only as trailers at California's ports and intermodal rail facilities are typically supplied or dropped off at the terminal. Staff notes that a majority of the listings of used trucks for sale were offerings from used truck dealerships. Since used truck dealerships maintain a margin on the sale of the used truck, prices quoted are often higher than private party listings. Lastly, staff notes that just like in the automobile industry where vehicles are seldom sold for the list price or MSRP, a certain amount of bargaining is expected even in the used heavy duty diesel truck market. Therefore, staff believes that the price curves developed are conservative estimates of probable used truck prices.

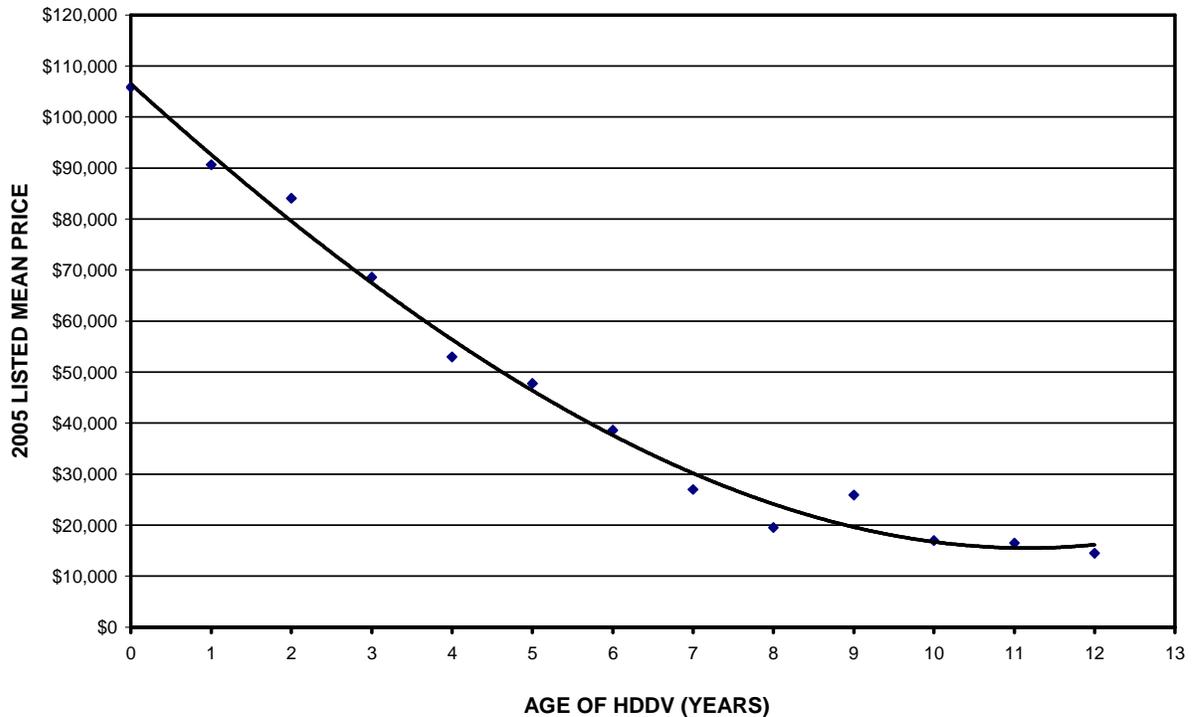
The survey did not include sample points for non-containerized trucks. Prices obtained from truckpaper.com were previously corroborated with other trade publications and internet websites, and staff determined that it was appropriate to rely on one particular source of data to survey, as long as the sample distributions did not change dramatically.

The first model<sup>7</sup> (Model 1) was developed from the used truck market survey conducted in 2005. To determine the drayage truck average value, price listings were grouped by model year, and a mean price for each model year was developed. Staff then used the mean price and model year data (which correspondingly correlates to the age of the vehicle) to develop a trend line for used heavy duty diesel fueled vehicles. Figure 1 below depicts this trend line developed from the staff survey. This trend line is backed by a third order parametric equation that predicts the value of the used truck based on its age. All forecasted used truck prices used for estimating replacement vehicle costs are assumed to be present value costs. In Model 1, the present value was determined to be 2005 dollars.

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<sup>7</sup> ARB, Preliminary Draft Report, Evaluation of Port Trucks and Possible Mitigation Strategies, April 2006.

**Figure 1: 2005 California Used Truck Price-Age Distribution Profile from Survey (Model 1)**



While the model has a high correlation coefficient, and can reasonably predict used truck values for vehicles up to 10 -12 years of age, price curves, in general, need to be developed for every year to reflect changes in base model new vehicle costs (which undeniably rise every year), advancement in technologies (for example, variable geometry turbo chargers, and common rail diesel fuel injection systems), standardization of equipment (for example, air conditioning, heating, and auxiliary power units), changes in market supply and demand conditions (for example, extraordinary demand for late model year used trucks), and inclusion of mandated devices (for example, equipping diesel trucks with diesel particulate filters as a result of the EPA 2007 heavy duty diesel engine standards<sup>8</sup>, or due to State requirement of anti-idling devices). Therefore, staff conducted additional used truck market surveys and developed additional truck price-age forecasting models to more accurately predict vehicle replacement costs for the proposed regulatory measures.

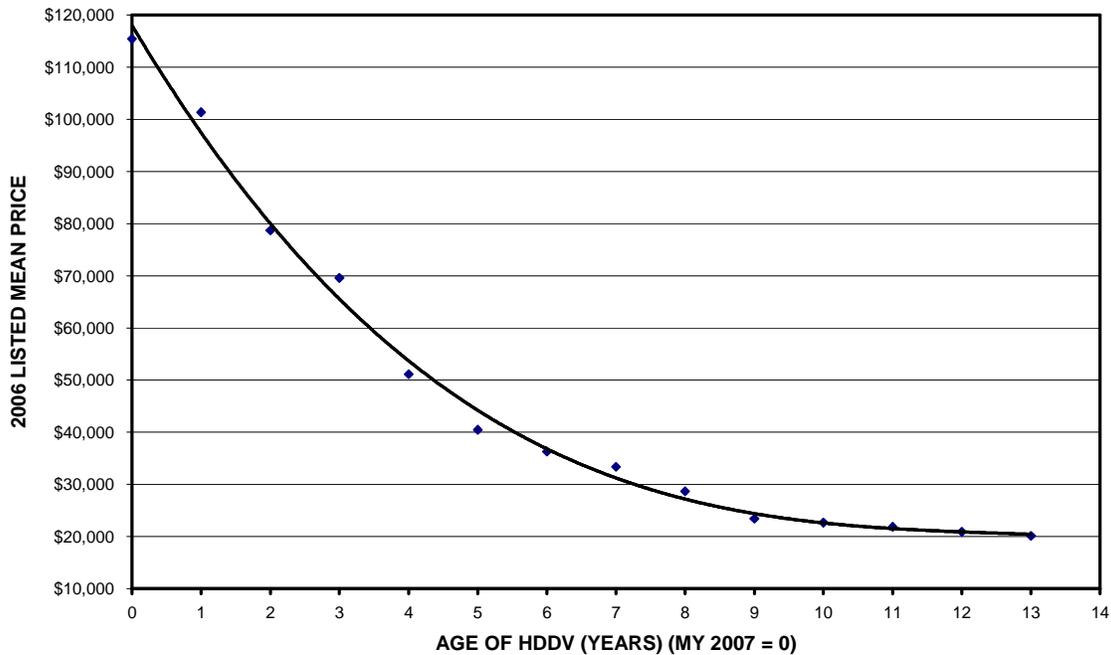
The second survey was conducted during October – December 2006 and included market prices for new model year 2007 heavy duty diesel trucks. Since

<sup>8</sup> USEPA Regulation for new on-highway, heavy duty diesel-fueled model year 2007 / 2010 engines promulgated in 2003.

the EPA federal standards for model year 2007 heavy duty diesel engines had not been implemented, and ultra low sulfur diesel fuel, as required by the new model year 2007 engines, was not widely available, staff believes that many of the data points for 2007 model year vehicles did not accurately reflect the true price of the vehicle. Staff assumes that some of those vehicles were either unequipped with diesel particulate filters, or would have to retroactively install DPF after the ultra low sulfur regulation would go into effect, or they could have claimed to be model year 2007 trucks with model year 2006 engines. As a result, staff conducted a third market survey in July 2007, and developed a third model to predict used truck prices. The third survey reflects the adoption of both the EPA standards for model year 2007 heavy duty diesel-fueled engines and the requirement to use ultra low sulfur diesel fuel for on-road diesel vehicles.

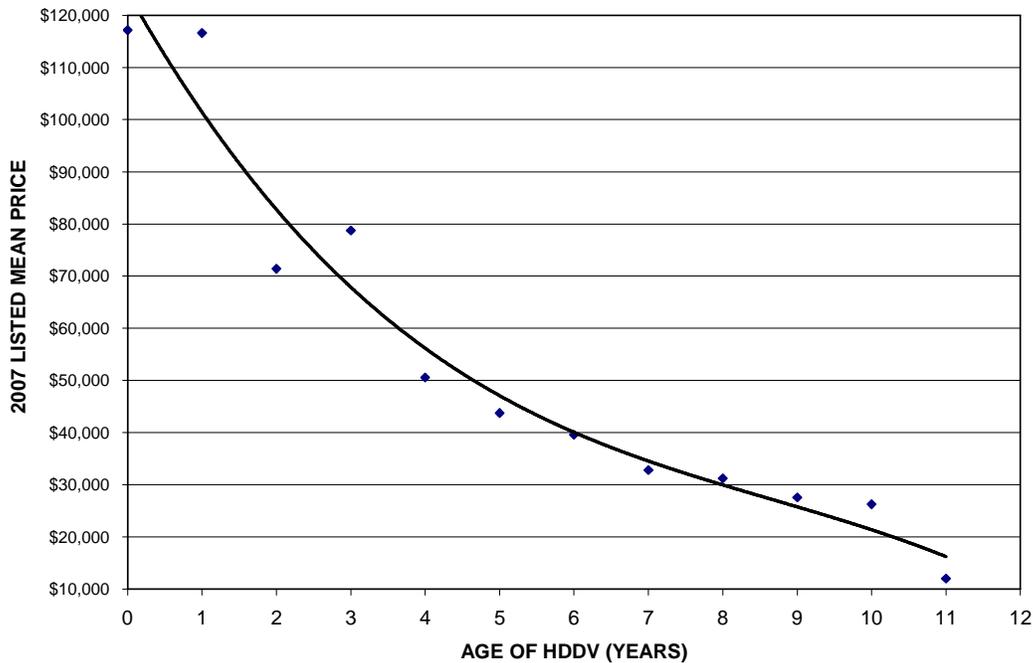
Staff expects the distribution profile of Model 3 to be different from Model 1 and Model 2, because of technological changes in emissions control technology and stricter truck emissions standards associated with model year 2007 trucks being implemented. Correspondingly, staff expects any increases in 2007 prices to have a downward effect on existing used truck prices, as the new technology would render the older technology obsolete. However, staff notes that this expectation did not materialize with the exception for aged trucks greater than 10 years old, and in general, used truck prices based on age of the vehicle were higher in 2007, than in 2006 and 2005. Similarly, staff expects the Model 3 distribution to change when EPA heavy duty diesel engine NOx standards are implemented in 2010; the imperative for the change being the introduction of a new NOx emissions control system. The trend lines for both Model 2 and Model 3 are presented in Figure 2 and Figure 3, respectively.

**Figure 2: 2006 California Used Truck Price-Age Distribution Profile from Survey (Model 2)**



The present value for the prices was determined to be 2006 dollars for Model 2 and 2007 dollars for Model 3. When used truck prices predicted by all three models are averaged, the mean used truck price reflects a value expressed in 2006 dollars, or the same present value basis that was used for the regulation total cost estimation. All three models were used to predict values for pre-2004 used drayage trucks. Only Model 2 and Model 3 were utilized to forecast used model year 2007 truck replacement costs as a result of the proposed regulatory requirement in 2013. Similarly, only Model 2 and Model 3 were utilized to predict new heavy duty diesel-fueled vehicle costs for new model year 2010 replacements (Regulation Alternative 1). Staff notes that in addition to the truck price forecasted for new 2010 model year trucks using Models 2 and 3, staff added a cost of \$10,000 for proposed compliance with the EPA 2010 NOx standards for heavy duty diesel fueled engines. This added cost is an approximation of expected costs for a urea based SCR system, or a new technology yet to be developed for controlling NOx emissions from heavy duty diesel engines (for example, a NOx adsorption catalyst, or NAC).

**Figure 3: 2007 California Used Truck Price-Age Distribution Profile from Survey (Model 3)**



Staff was able to corroborate that the distribution profiles established in Model 1 and Model 2 are more or less similar to the distribution profile developed in Model 3, with the exception of an anomaly detected for four year old trucks. The models were corroborated using the two-tail test hypothesis (central limit theorem) and the results of the test are presented in Table 1. Staff notes that Model 3 also shows more variance for late model year (up to 4 years old) trucks (see Figure 3) than either Model 1 or Model 2. Staff attributes this cause to the surge in demand for late model year trucks ahead of implementation of the EPA 2007 standards for heavy duty diesel-fueled engines. This extraordinary demand had the corresponding effect of raising listed used truck prices. Staff determined that many of the buyers who were in the market for a new trucks feared drastic price increases<sup>9</sup> (along with concerns of model year 2007 performance and reliability issues) ahead of the EPA rule, and pre-emptively rushed to purchase late model or model year 2006 trucks<sup>10</sup>. Staff believes that even if the predicted

<sup>9</sup> International Truck & Engine Corporation expected Class 8 Model Year 2007 compliant truck prices to increase \$7,000 - \$10,000. Volvo Trucks North America planned to add \$7,500 to the base sticker price of its 2007 model to cover the cost of emissions control technology (Fleetowner.com, June 2006).

<sup>10</sup> Lockridge, Deborah (Senior Editor), "The Pre-Buy Ride," Heavy Duty Trucking, August 2007 (<http://www.heavydutytrucking.com/2007/08/036a0708.asp>).

value in Model 3, was to be utilized, the variance would be less sensitive when averaged with values predicted using all three price forecasting models.

In conclusion, staff has been able to demonstrate that that the price forecasting models developed between 2005 and 2007, are reasonable models to forecast used truck prices for the purposes of regulatory cost analysis, with the exception of being able to accurately forecast the price of 4-year old vehicles. However, staff has been able to attribute the higher variance to a surge in used truck buying ahead of implementation of the EPA rule for 2007 model year heavy duty diesel engines. Staff further notes that this sensitivity is reduced when a mean predicted value based on averages from all three models developed is utilized for cost estimation purposes.



As an example of the application of the central limit theorem to the hypothesis being tested “Has the price forecast for 3-year old heavy duty diesel vehicles by Model 3 changed from that predicted by Model 1 and Model 2 ?” (see Item 2 in Table 1 above), staff observes that the price forecasted was found to be \$ 64,540 (Model 1) and \$ 65,544 (Model 2), respectively. The average price predicted for a 3-year old by Model 3 was found to be \$78,750 with a standard deviation of \$28,687 (Sample Size N = 7 Data Points). After computing the z-scores for Model 1 and Model 2 3-year old vehicle price forecasts, staff concludes with a 95% probability that the distribution, or price forecasted for 3-year old vehicle by Model 3 is similar to the distribution or price forecast obtained from Model 1 and Model 2. Similarly, the basic hypothesis test was applied to other model year price forecasts and the results presented in Table 1 above.

## **II. Diesel Particulate Filter Prices & Impact on Retrofit Costs**

Phase 1 requirements of the proposed regulation require the upgrade or replacement of some pre-1994 model year drayage vehicles and the simultaneous requirement to retrofit the vehicle with a level 3 (at least 85% pollutant emissions control) verified diesel emissions control system or VDECS. The retrofit device that is expected to meet the level 3 VDECS requirement by 2009 is a diesel particulate filter, or DPF. To estimate the total present value cost of the Phase 1 requirements, staff obtained multiple vendor quotes for various types of DPF products in February 2007. These vendor quotes along with the reference source, are provided in Table 2.

Staff cautions that not all DPF products are suitable for retrofitting model year 1994 to 2003 drayage trucks. The selection of the DPF, would in general be dependent upon the following factors: the engine size and horsepower of the engine, determining the duty cycle of the vehicle, whether a DPF is available for a particular model year engine and vehicle, whether the DPF meets ARB verification requirements, operator preference for active or passive DPF systems, access to electrical outlets / stations for active DPF regeneration, availability of public grants and rebates to lower net cost of retrofit, and any other compatibility issues that are specific to model year diesel engine.

Staff determined that the most suitable retrofit application for a Class 8 drayage truck would be to retrofit with a passive diesel particulate filter and diesel oxidation catalyst system. In basing this decision, staff assumed that access to electrical outlets for regeneration of the active DPF at the end of the shift might be a problem for some operators. Passive DPFs on the other hand are dependent upon the catalyst to lower the accumulated diesel PM ignition temperature and initiate a regeneration event.

**Table 2: Base Costs for Diesel Particulate Filters (Level 3 VDECS)**

PRODUCT NAME	UNIT PRICE RANGE	INSTALLATION COSTS RANGE	TOTAL COSTS (1)	CARB VERIFICATION	DPF VENDOR / DISTRIBUTOR
Cleaire Horizon-M Active DPF System (4)	\$11,250 - \$11,700	\$1,600 - \$2,100	\$13,325	Level 3 PM, Most On-Road Engines Through 2006 Model Year; Certain MY 2006 & 1993 or older engines with OEM DOC; CARB Diesel / Biodiesel.	IRONMAN PARTS, (CORONA CALIFORNIA)
Cleaire Horizon-M Active DPF System (2)	\$12,000	\$3,000 - \$5,000	\$16,000	Level 3 PM, Most On-Road Engines Through 2006 Model Year; Certain MY 2006 & 1993 or older engines with OEM DOC; CARB Diesel / Biodiesel.	CUMMINS EMISSIONS SOLUTION, COLUMBUS, IN
<b>Active DPF</b>			<b>\$14,663</b>		
Donaldson Passive DPF	\$7,600 - \$10,300	\$550 - \$950	\$9,700	Level 3 PM, 1993 - 2004 On-Road, CARB Diesel / Biodiesel.	IRONMAN PARTS, (CORONA CALIFORNIA)
Johnson Matthey Continuously Regenerating Technology (CRT & Catalyzed CRT) Passive DPF with DOC	\$7,800 - \$8,500	\$600	\$8,750	Level 3 PM, 1993 - 2004 On-Road, CARB Diesel / Biodiesel. The CRT / CCRT are also verified for a select few engines that employ EGR.	CUMMINS EMISSIONS SOLUTION, COLUMBUS, IN
Johnson Matthey Continuously Regenerating Technology (CRT) Passive DPF with DOC	\$9,800 - \$11,150	\$650 - \$1,050	\$11,325	Level 3 PM, 1993 - 2004 On-Road, CARB Diesel / Biodiesel. The CRT / CCRT are also verified for a select few engines that employ EGR.	IRONMAN PARTS, (CORONA CALIFORNIA)
<b>Passive DPF / with DOC</b>			<b>\$9,925</b>		
Cleaire Longview Passive DPF & NOx Reduction Catalyst (5)	\$16,200 - \$19,300	\$2,000 - \$2,600	\$20,050	Level 3 PM & Level 1 NOx	IRONMAN PARTS, (CORONA CALIFORNIA)
Cleaire Longview Passive DPF & NOx Reduction Catalyst (5)	\$19,000 - \$21,000	\$ -	\$20,000	Level 3 PM & Level 1 NOx	CUMMINS EMISSIONS SOLUTION, COLUMBUS, IN
<b>Passive DPF with NOx Catalyst</b>			<b>\$20,025</b>		

Passive DPFs can only be used on trucks meeting the 0.1 g/bhp-hr PM emissions standard, and also require that ultra low sulfur diesel be used only. Staff expects that all model year 1994 and newer trucks (up to 2003 and some 2004) could be successfully equipped with passive DPFs.

Price quotes were provided as a range for single units and included the cost of installation parts, backpressure monitor and remote display, estimated installation charges, but not inclusive of sales taxes (estimated to be ~ 8.5%)<sup>11</sup>. Staff was informed that the range of values obtained in the price quotes, corresponds to engines with horsepower below 350 hp (low) and engines with horsepower in the range 350 – 450 (middle or high). In determining total retrofit costs, staff therefore assumed that averaging the range of prices would be representative of actual conditions in drayage (350 - 425 hp engine). In addition, staff estimated that drayage operators will be subject to annual DPF maintenance (O&M) at an average cost of \$300 (DPF manufacturer /distributor requirements typically require de-ashing at least annually or at every 60,000 miles)<sup>12</sup>. Staff also expects the typical warranty period on the passive DPF to be for 5 years, or 150,000 miles. The vendor price quotes and the estimated installation costs for DPF products suitable for drayage truck retrofit applications are presented in Table 2. Staff notes that ARB does not endorse the product of any particular DPF manufacturer (as long as it meets ARB verification requirements), or recommend the service of any particular vendor for retrofit applications.

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<sup>11</sup> Staff obtained passive DPF price quotes primarily from two vendors, namely IronmanParts (Corona, CA), and Cummins Emissions Solutions (Columbus, IN).

<sup>12</sup> IronmanParts (Corona, CA), & Fleetguard Emissions Solution (Columbus, IN).

### **III. Total Present Value Cost & Cost Effectiveness Estimation Methodology for Proposed Regulatory Measures**

In this section, staff presents methodologies for total present value cost and cost effectiveness estimation for the proposed drayage truck regulatory measures and for the alternatives to the regulation considered. While the derivation of the total present value costs of the proposed regulation by phase is discussed in the report, underlying assumptions critical to the derivation of total present value costs and cost effectiveness are presented in this appendix.

#### **Total Present Value Program Costs**

Since future pollution control costs occur in a regulatory timeline, they must be discounted to the present value or time using the appropriate discount rate, which is usually the rate of inflation for a specific period, as measured by the Consumer Price Index (CPI), or is a rate used to reflect the opportunity cost of the investment plus the rate of inflation<sup>13</sup>, or is another rate that can be justified for the analysis (for example, the internal rate of return for a project, or a specific interest rate to reflect risk of the business). This type of analysis is called discounted cash flow (DCF) analysis and total costs are determined as net present value (NPV) of all cash flows occurring in the regulatory timeline. Alternatively, a cash flow (CF) analysis can be done in present value dollars and total present value costs determined can be adjusted at a later date to account for inflation and opportunity costs.

The CF analysis is the basis for determining the total costs of the proposed regulation. The present value date is determined to be a reference date in time to which all costs are normalized. For the purposes of this regulation, the reference date of December 31, 2006 was selected as the date for establishing net present value of all regulatory costs (outflows). Simply stated, the total cost estimation is based on new and used truck prices, and DPF retrofit product prices quoted in 2006 dollars. Installation costs are included in the determination of the total cost of the product. However, annual O&M costs are not included and where applicable are reported separately, or were included as part of the total annualized cost estimate.

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<sup>13</sup> This type of discount rate is the preferred rate for discounting cash flows to present value by the ARB Research Department. This rate typically hovers around 7% to reflect the core rate of inflation (~ 2.5%), plus the risk free rate (~ 4.5%, as measured by the yield on long term US treasuries).

## **Discount Rate**

As discussed previously, the discount rate is the interest rate that is applicable to the financial analysis. The discount rate is usually the rate of inflation for a specific period (for example, for the present decade), as measured by the Consumer Price Index (CPI), or is a rate used to reflect the opportunity cost of the investment plus the rate of inflation<sup>14</sup>, or is another rate that can be justified for the analysis (for example, the internal rate of return for a project, or a specific interest rate to reflect risk of the business).

The discount rate utilized by staff to annualize or amortize the total costs of the affected asset (in this case a new or used truck, or a DPF retrofit product) over its economically useful life, or over a period that can be justified (for example, a period of ownership) was 15%. This interest rate was selected to reflect the inherent business risk of the drayage profession, characterized by a higher workforce and occupation turnover rate (Monaco, 2007), and a higher risk that primarily stems from a lower credit worthiness of a lower income sub-group (independent owner-operator).

## **Capital Recovery Period**

The capital recovery period (CRP) is the period over which the capital asset (in this case a new or used truck selected for replacement, or a DPF product selected for a retrofit) is capitalized, or over which payments are amortized. The CRP is typically a period that is also justifiable to the business. For example, staff assumed that the economic or useful life of a new truck used in drayage or line haul is 20 years. Therefore, the CRP for this capital asset over which payments can be amortized is 20 years. Correspondingly, a 6-year old used truck which has a staff estimated 14 years of economic or useful life remaining, can be capitalized only for an additional 14 years.

Staff notes that CRP is not necessarily the same period as the period that a bank or financial institution is willing to make a loan over. For example, financial institutions may typically and only make a loan on a new or used truck for a period of 5-8 years<sup>15</sup>.

For estimating the annualized payments as a result of the requirement in the proposed regulation to have existing pre-2004 model year trucks in drayage service retrofitted with a level 3 VDECS by December 31, 2009, staff determined the CRP to be 4 years (Phase 1). Staff based this decision due to the second

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<sup>15</sup> Staff Conversation with Gregory Ingram, Manager Used Truck Center, International Truck & Engine Corporation, West Sacramento, CA, May 2006.

requirement in the proposed regulation to have all pre-2004 model year drayage trucks replaced with a model year 2007 compliant truck by December 31, 2013 (Phase 2). Staff assumes that drayage workers will dispose their pre-2004 trucks by the time they must comply with Phase 2 requirements. Therefore, the retrofit device could only be capitalized for a period of (2013 -2009), or 4 years, whereas the product or useful life could well exceed that term. Staff assumes that most drayage operators will trade-in their vehicles when seeking to replace with a 2007 model year compliant vehicle in 2013. Some may choose to sell their trucks outside California in 2013.

## Annualized Costs

When presented with total present value costs, staff must make a determination as to what is the equivalent cost on an annual or annualized basis. Since most businesses are levered firms, incremental costs to the firm are often evaluated on an annualized basis at a discount rate that reflects the firm's net cost of borrowing, or at an interest rate that can be justified to the business (for example, the firm's internal rate of return, or an interest rate to reflect the risk of the business venture or project). If the expenditure is a cost to acquire a capital asset such as a commercial vehicle, then the net annual costs (purchase price less residual value) are evaluated over the capital recovery period (see discussion on Capital Recovery Period). Therefore, annualized costs are determined from the following relationship:

Annualized Costs = Total Present Value Costs x Capital Recovery Factor

The capital recovery factor (CRF) can be derived from the following equation by assuming a discount rate, (i), per period, and the number of compounding periods, (n). The number of compounding periods (n) corresponds to the project life or the capital recovery period justified:

$$\text{Capital Recovery Factor (CRF)} = \frac{(i) * (1 + i)^n}{(1 + i)^n - 1}$$

Specifically, for the proposed drayage truck Phase 1 requirement (2009):

i = 15 percent discount rate

n = 4 year capital recovery period, and

CRF = 0.3503

Therefore, for a DPF retrofit that is expected to cost on average \$9,925 (2006 dollars), an independent owner-operator in the drayage business can expect to make annualized payments of \$9,925 x 0.3503, or \$3,476 per year for the next four (4) years.

Similarly, for the proposed drayage truck Phase 2 requirement (2013):

i = 15 percent discount rate  
n = 14 year capital recovery period, and  
CRF = 0.1747

Therefore, for a 2007 model year compliant vehicle that is expected to have a net cost on average of \$33,000 (2006 dollars) with a trade-in allowance included, an independent owner-operator in the drayage business can expect to make annualized payments of \$33,000 x 0.1747, or \$5,765 per year for the next fourteen (14) years.

Annualized costs are also utilized to determine the cost-effectiveness of the proposed regulatory measure. The derivation of cost-effectiveness is discussed in the following section.

### Cost Effectiveness

The cost effectiveness (CE) measure permits a direct comparison of the efficacy of the one proposed regulatory measure with another. ARB has utilized the cost-effectiveness to make a determination whether a regulatory measure should or should not be recommended when the value is compared to benchmarked values from other regulations that have been adopted by the ARB. Annualized costs play a role in the cost effectiveness when the costs are divided by the annual emissions reductions expected, as show by the following formula:

$$\text{Cost Effectiveness (\$/Ton)} = \frac{\text{Annualized costs (\$/Year)}}{\text{Annual Emission Reductions (Tons / Yr)}}$$

Since the proposed regulation expects to achieve reductions in both diesel PM and NOx emissions when fully implemented, the cost effectiveness is dependent upon whether the costs are attributed to diesel PM emissions control, or to NOx emissions control. For the Phase 1 proposed measure, cost attribution could easily be determined, since Phase 1 of the proposed measure which goes into effect December 31, 2009 primarily produces a reduction in diesel PM emissions. Cost effectiveness for Phase 1 is therefore the ratio of the average total annualized costs (2009 to 2013) to the annual amount of diesel PM expected to be reduced when the regulation is fully implemented.

Phase 1 Average Total Annualized Costs = \$84,465,233 to \$115,037,343  
Annual Reductions of Diesel PM Expected = 746 tons (2014)

Therefore,

Phase 1 Cost Effectiveness = (\$84,465,233 to \$115,037,343) / 746 tons  
Phase 1 Cost Effectiveness = (\$113,212 to \$154,189) per ton

Phase 1 Cost Effectiveness = (\$57 to \$77) per pound

Similarly,

For the Phase 2 proposed measure, cost attribution could easily be determined, since Phase 2 of the proposed measure which goes into effect December 31, 2013 primarily produces a reduction in NOx emissions. Cost effectiveness for Phase 2 is therefore the ratio of the total annualized costs (2013) to the annual amount of NOx expected to be reduced when the regulation is fully implemented.

Phase 2 Total Annualized Costs = \$137,885,091 to \$185,362,363

Annual Reductions of NOx Expected = 11,897 tons (2014)

Therefore,

Phase 2 Cost Effectiveness = (\$137,885,091 to \$185,362,363) / 11,897 tons

Phase 2 Cost Effectiveness = (\$11,590 to \$15,581) per ton

Phase 2 Cost Effectiveness = (\$6 to \$8) per pound

Cost attribution for the alternative strategies to the proposed regulation however, were different from the total cost attribution to PM and total cost attribution to NOx (2013) utilized in the proposed regulatory measure. Since both alternatives to the proposed regulation are implemented on December 31, 2013, and since both alternatives simultaneously produce a reduction in diesel PM and NOx emissions, only one-half of the annualized costs were attributed to diesel PM emissions control and the other-half of the annualized costs were attributed to NOx emissions control.

Therefore, for Regulation Alternative 1 (replace with new model year 2010 compliant vehicle) considered:

Regulation Alternative 1 Annualized Costs = \$495,545,410 to \$666,150,256

Regulation Alternative 1 Annual Diesel PM Emissions Reduction = 746 tons

Regulation Alternative 1 Annual NOx Emissions Reduction = 15,777 tons

Regulation Alternative 1 PM Cost Effectiveness = (\$495,545,410 to \$666,150,256) per ton x 0.5 (One-Half Cost Attribution) / 746 tons

Regulation Alternative 1 PM Cost Effectiveness = \$332,100 to \$446,435 per ton

Regulation Alternative 1 PM Cost Effectiveness = \$166 to \$223 per pound

and

Regulation Alternative 1 NOx Cost Effectiveness = (\$495,545,410 to \$666,150,256) per ton x 0.5 (One-Half Cost Attribution) / 15,777 tons

Regulation Alternative 1 NOx Cost Effectiveness = \$15,705 to \$21,112 per ton

Regulation Alternative 1 NOx Cost Effectiveness = \$8 to \$11 per pound

Similarly, for Regulation Alternative 2 (replace one-half with model year 2007 compliant truck and the other half with new LNG truck) considered:

Regulation Alternative 2 Annualized Costs = \$394,465,797 to \$530,174,827

Regulation Alternative 2 Annual Diesel PM Emissions Reduction = 746 tons

Regulation Alternative 2 Annual NOx Emissions Reduction = 12,843 tons

Regulation Alternative 2 PM Cost Effectiveness = (\$394,465,797 to \$530,174,827) per ton x 0.5 (One-Half Cost Attribution) / 746 tons

Regulation Alternative 2 PM Cost Effectiveness = \$264,360 to \$355,308 per ton

Regulation Alternative 2 PM Cost Effectiveness = \$132 to \$178 per pound

and

Regulation Alternative 2 NOx Cost Effectiveness = (\$394,465,797 to \$530,174,827) per ton x 0.5 (One-Half Cost Attribution) / 12,843 tons

Regulation Alternative 2 NOx Cost Effectiveness = \$15,357 to \$20,641 per ton

Regulation Alternative 2 NOx Cost Effectiveness = \$8 to \$10 per pound

## REFERENCES

Monaco, Kristen, The Economics of Port Drayage and the Implications for Clean Air, California State University Long Beach, February 2007.

**Appendix E:  
Record of Staff Conversation and Public Outreach**

## **APPENDIX E RECORD OF STAFF CONVERSATION AND PUBLIC OUTREACH**

### **ARB Staff Conversation Record and Public Outreach Efforts**

Since the inception of the proposed regulation to reduce emissions from in-use on-road heavy duty diesel-fueled drayage trucks in California, ARB staff members have actively conducted and participated in public outreach efforts to inform members of the community, affected entities such as motor carriers and independent truck owner-operators, port authorities and harbor commissions, shipping companies and port terminal operators, air quality management districts (districts), trade organizations, and collaborative interest groups about the impending requirements of the proposed regulation. Staff had conducted public workshops to keep the public informed about regulatory developments and direction and to stimulate regulatory discussions between participants. Staff also conducted workgroup meetings with special interest groups to shape the elements of the regulation and work out any differences in direction.

ARB Staff outreach efforts were conducted throughout the State of California. These public outreach efforts have included public workshops, public workgroup meetings, meetings with numerous trade associations, interest groups, community groups and stakeholders and proposed joint meetings with port authorities, district staff, and other interest groups.

### **ARB Sponsored Public Workshops and Workgroup Meetings (2006 – 2007)**

Public workshops were conducted throughout the State to present to all participants and entities affected by the regulation a synopsis of the proposed regulation, regulatory direction, status of the regulation, any development issues (for example, issues related to the development of the emissions inventory), and to stimulate discussions between the workshop participants and the regulatory staff. Staff notes that approximately 1,700 invitations to the public workshops were sent to members of the Port Trucks Listserve by email.

Public workgroup meetings are similar to public workshops in function, as their purpose is also to develop or formulate regulatory policy. Workgroup meetings generally have a smaller number of special interest participants who meet with ARB staff to discuss or resolve a regulatory development issue. The following public workshops were conducted by ARB staff:

- Public Consultation Meeting, Port of Los Angeles, San Pedro, CA, August 30, 2006.
- Public Consultation Meeting, Elihu M. Harris State Building, Oakland, CA, September 8, 2006.
- Public Workgroup Meeting, Cal EPA, Sacramento, CA, November 13, 2006.

- Public Workgroup Meeting, Port of Long Beach, Long Beach, CA, January 9, 2007.
- Public Workshop, Cal EPA, Sacramento, CA, July 9, 2007.
- Public Workshop, Port of Los Angeles, San Pedro, CA, July 10, 2007.
- Public Workshop, Port of San Diego, San Diego, CA, July 11, 2007.
- Public Workshop, West Oakland Senior Center, Oakland, CA, July 13, 2007.

### **Other Relevant ARB Sponsored Meetings**

The following other ARB sponsored meetings have direct relevance to the proposed port and intermodal rail yard drayage truck regulation. The outcomes of these meetings have provided an imperative for regulatory action and development.

- ARB Board Hearing to Consider Adoption of Goods Movement Emissions Reduction Plan, Sacramento, CA, April 20, 2006.
- ARB Board Hearing to Consider Adoption of San Pedro Bay Clean Air Action Plan (July 20, 2007)
- State Implementation Plan (SIP) Symposium, Sacramento, CA, October 12, 2006.

### **ARB Staff Meetings with Trade Associations, & Special Interest Groups**

ARB staff met with members of the following trade associations to discuss elements of the proposed regulation, regulatory direction, and listen to their concerns and organization views.

- Joint Meeting with CTA to Discuss Development of Proposed Port Trucks Emissions Control Measure, Cal EPA, Sacramento, CA, August 22, 2006.
- Joint Meeting of ARB / POLA / POLB / CTA to Discuss the SPBCAAP Clean Trucks Plan, Long Beach Hyatt, Long Beach, CA, June 1, 2007.

### **Proposed Joint Meetings with Port Authorities, Air Quality Management District (AQMD) Staff, and Other Public Interest Groups**

ARB management and staff conducted the following joint meetings with port authorities and district staff to discuss elements of the proposed regulation, or to determine regulatory direction and impact of measures proposed / adopted by their organization on ARB proposed legislation.

- Joint Meeting with Port of Oakland and BAAQMD Staff to Discuss Regulatory Development, Port of Oakland, CA May 24, 2006.

- Port of Oakland Facilities Tour for ARB Staff, Port of Oakland, CA May 24, 2006.
- Proposed Teleconference / Joint Meeting with Ports to Discuss Regulatory Development, Sacramento, CA, December 18, 2006.
- POLA Community Advisory Meeting Teleconference, Air Quality Subcommittee, Sacramento, CA, November 1, 2006.
- Presentation of ARB Goods Movement / Port Trucks Plan, Port of Long Beach, Long Beach, CA, September 12, 2006.
- Teleconference with San Pedro Bay Ports Clean Air Action Plan Technical Workgroup, Sacramento, CA, September 20, 2006.

### **ARB Consultation Meetings with Community Groups**

Staff actively represented the ARB in meetings with collaborative community groups such as the West Oakland Toxics Collaborative (WOTC). At the meetings, staff would typically provide a synopsis of the proposed regulation, solicit input and concerns from community members, and inform the public on any recent developments related to the regulation. The following consultation meetings were held with community groups:

- ARB Participation / Meeting with West Oakland Toxics Collaborative on August 29, 2006, September 20, 2006, October 17, 2006, November 27, 2006, January 10, 2007, February 13, 2007, and July 18, 2007.
- POLA Community Advisory Meeting Teleconference, Air Quality Subcommittee, November 1, 2006.
- ARB Goods Movement (Inc Port Trucks) Outreach Conducted at Port of Long Beach, September 12, 2006.
- Teleconference with San Pedro Bay Ports Clean Air Action Plan Technical Workgroup, September 20, 2006.
- Staff Telephone Conversation with Wilmington Coalition for a Safe Environment, November 28, 2006.

### **Distribution of Regulation Information Multilingual Flyers to Truck Drivers at Public Weigh Stations & Port Gate of Entry**

Staff distributed thousands of multilingual flyers in English, Spanish, Hindi, and Vietnamese that contained information about the proposed regulation, how it may impact truck owner-operators and motor carriers, and how individuals could be part of the regulatory development process. These flyers were distributed to truck operators primarily at public weigh station facilities in Los Angeles, Long Beach, and Oakland.

- Staff Distribute Regulation Information Flyers to Truck Driver / Owner / Operators at Public Weigh Scales in Oakland, Los Angeles, and Long Beach, on October 28, 2006, and January 9 – 18, 2007.

### **Staff Response to Public Comments**

ARB staff responded to public comments received after two critical staff reports were released by ARB for public comment. The first report was entitled the “Proposed Emissions Reduction Plan for Ports and Goods Movement in California” (March 2006). This measure was considered and subsequently ratified by the Board in April 2006. The second report that was published by ARB was the Preliminary Draft report entitled “Evaluation of Port Trucks and Possible Mitigation Strategies” (April 2006).

- Staff Compile Responses to 48 Public Comments Related to Ports & Goods Movement Emissions Reduction Plan, April 2006.
- Staff Compile Responses to 80 Public Comments Related to Preliminary Draft Report Entitled “Evaluation of Port Trucks and Possible Mitigation Strategies”, April 2006.

### **Staff Field Visits**

ARB staff visited 14 California Port and 11 California Intermodal facilities affected by the proposed regulation. The purpose of these visits were to conduct field inspections and primarily assess the amount of truck traffic on property, methods of compound entry and exit, truck data collection efforts at the gates, and to collect property specific information to develop a truck count and emissions inventory.

- Staff Field Visit to Port of Oakland to Assess Port Truck / Container Movement / Terminal Operator Operations, Oakland, CA, May 24, 2006.
- Staff Field Visit to Premises of AB Trucking to Assess PMC Operations Oakland, CA, October 17, 2006.
- Staff Field Visit to Premises of APL / Eagle Marine Terminal to Assess Terminal Operator Operations, Oakland, CA, October 17, 2006.
- Staff Field Visit to Premises of TRAPAC / Mitsui Terminal to Assess Terminal Operator Operations, Oakland, October 17, 2006.
- Staff Field Visit to Port of Long Beach (Seaside Tour) to Assess Port Operations, Long Beach, CA, October 25, 2006.
- Staff Port Visits / Terminal-Field Inspections
  - Ports of Benicia, Crockett, Hueneme, Humboldt Bay, Long Beach, Los Angeles, Oakland, Pittsburgh, Redwood City, Richmond, Sacramento, San Diego, San Francisco, and Stockton (2006 – 2007).
- Staff Intermodal Railyard Visits / Field Inspections

- Burlington, BNSF Oakland, Commerce Eastern BNSF, Commerce UP, ICTF UP, LATC UP, Lathrop Intermodal UP, Northern Santa Fe (BNSF) Hobart, Richmond BNSF, San Bernardino, Stockton Intermodal BNSF, and UP Oakland (2006 – 2007).

### **Public Surveys of Truck Owner-Operators**

Staff conducted three public surveys of independent truck owner-operators. Survey questions elicited voluntary responses from truck operators on mean age of their trucks, mean income earned, number of periodic trips made in port drayage, estimated distances traveled, etc.

- ARB & Port of Oakland Joint Public Survey of Independent Owner-Operators, Oakland, CA, July 1, 2006.
- ARB staff Survey of Independent Owner-Operators, Oakland, CA, July 1, 2006.
- ARB staff Survey of Independent Owner-Operators, Oakland, CA, July 1, 2006.

### **Staff Participation in Vendor / Technology Demonstrations**

ARB staff participated in numerous trade shows and vendor demonstrations to assess technological developments related to on-highway trucks, pollution control equipment, and after-treatment of vehicle emissions. The following events were attended by ARB staff:

- Presentation by STARTRAK (Wireless Monitoring & Control Service), Sacramento, CA, October 16, 2006.
- Presentation by CLEAIRE (Manufacturer of Electric Diesel Particulate Filters), Sacramento, CA, August 31, 2006.
- Presentation by FLIR Systems (Manufacturer of Thermal Imaging Systems Used in Hydrocarbon Leak Detection), Sacramento, CA, December 14, 2006.
- Clean Diesel Technology Tour & Conference (Multi-Vendor Clean Diesel Showcase), Sacramento, CA, April 19, 2007.
- International Trucking Show (Multi-Vendor Trade Show), Anaheim, CA, September 29, 2006.

### **Staff Participation in Public Consultation Meetings for the Proposed In-Use, On-Road, Private Fleets Regulation (2006 / 2007)**

Staff has been involved with the concurrent development of the in-use, on-road, heavy duty diesel private fleet regulation. This proposed measure aims to reduce emissions from medium heavy duty, and heavy-heavy duty diesel fueled

vehicles operating in the State of California. Staff participated in these public workshops in Sacramento and evaluated the proposals to corroborate regulatory development of the in-use, on-road, heavy duty diesel-fueled vehicle emissions control measures.

- Staff Participated in Public Workshops / Consultation Meetings held in Sacramento on April 5, 2006, July 18, 2006, October 5, 2006, April 11, 2007, and July 12, 2007.

### **ARB Staff Conversation Records**

The following conversations took place between ARB staff members and vendors. Information obtained from vendors was utilized for developing regulation policy, economic models, or technological assessments.

Alvarez, 2006, Staff Conversed with Mr. Alvarez (Port Truck Operator) and Responded to Concerns About Proposed Regulation on July 17, 2006.

Avila, Rafael, 2007, Staff Conversed with Mr. Avila (Port Truck Operator) and Responded to Concerns About Proposed Regulation on February 26, 2006.

BASF Catalysts / Engelhard, 2007, Staff Conversed with Barry Bambo, Manager (N.A), DPF Retrofit Section, and Inquired About Availability of DPF & SCR Systems on February 27, 2007.

Cummins Westport, 2007, Staff Conversed with Gramm Williams, Director, Heavy Duty Vehicles, and Obtained Pricing Information for LNG Trucks / Conversion Systems on March 13, 2007.

Fleetguard Emissions Solution, 2005, Cost Estimates and Warranty Information for DOC and DPF Emissions Control Products, Information Provided by Ms. Amy R. Boerger, Retrofit Business Leader, by Telephone Conversation with ARB Staff on September 14, 2005.

Fleetguard Emissions Solution / Cummins, 2007, Cost Estimates and Warranty Information for DOC, DPF, and Combined NOx/DPF Emissions Control Products, Information Provided by Mr. Bryan K. Perry, Retrofit Business, by Telephone Conversation and Email with ARB Staff on February 13, 2007.

International Truck, 2007, Staff Conversed with Jeff Jenkins and Inquired About Availability of Retrofit Kits for Heavy Duty Diesel Vehicles on February 27, 2007.

Ironman Parts & Service, 2007, Cost Estimates and Warranty Information for DOC, DPF, and Combined NOx/DPF Emissions Control Products Made by Donaldson, Johnson Matthey, Cleaire, & Huss. Information Provided by Peggy

Miller & Monica George, by Telephone Conversation & Email with ARB Staff on February 13, 2007.

Johnson Matthey, 2007, Staff Conversed with Ray Conway and Inquired About Pricing & Availability of SCR Systems for Heavy-Heavy Duty Diesel Vehicles on February 26, 2007.

Wilmington Coalition for Safe Environment, 2006, Staff Conversed with Jesse N. Marquez and Informed Coalition of ARB Interest to Conduct Outreach, Solicit Input, and Participate in Meetings with Member Affiliates on November 28, 2006.

**Appendix F:  
Health Impacts Assessment**

## **APPENDIX F HEALTH IMPACTS ASSESSMENT**

### **Health Impacts Assessment**

A substantial number of epidemiologic studies have found a strong association between exposure to ambient PM<sub>2.5</sub> and a number of adverse health effects (CARB, 2002). For this report, ARB staff quantified seven noncancer health impacts associated with the change in exposures to the diesel PM emissions. This analysis shows that the statewide cumulative health impacts of the emissions reduced through this regulation from year 2010 through 2014 are approximately:

- 580 premature deaths (160 – 990, 95% CI)
- 120 hospital admissions due to respiratory causes (78 – 170, 95% CI)
- 230 hospital admissions due to cardiovascular causes (140 – 350, 95% CI)
- 17,000 cases of asthma-related and other lower respiratory symptoms (6,700 – 27,000, 95% CI)
- 1,400 cases of acute bronchitis (0 – 3,100, 95% CI)
- 100,000 work loss days (86,000 to 120,000, 95% CI)
- 580,000 minor restricted activity days (480,000 to 690,000, 95% CI)

The table below lists the impacts associated with primary and secondary diesel emissions separately. The methodology for estimating these health impacts is described below and details can be found in Appendix A of the Emission Reduction Plan for Ports and Goods Movement in California (ARB, 2006) <sup>16</sup>.

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<sup>16</sup> [http://www.arb.ca.gov/planning/gmerp/march21plan/appendix\\_a.pdf](http://www.arb.ca.gov/planning/gmerp/march21plan/appendix_a.pdf)

**Table 1: Total Health Benefits Associated with  
Reductions in Emissions from Drayage Trucks  
(2009-2014)\***

Endpoint	Pollutant	# of Cases 95% C.I. (Low)	# of Cases (Mean)	# of Cases 95% C.I. (High)
Premature Death	PM	120	430	750
	NOx	40	140	250
	<i>Total</i>	<i>160</i>	<i>580</i>	<i>990</i>
Hospital admissions (Respiratory)	PM	59	92	130
	NOx	20	31	42
	<i>Total</i>	<i>78</i>	<i>120</i>	<i>170</i>
Hospital admissions (Cardiovascular)	PM	110	170	260
	NOx	36	57	88
	<i>Total</i>	<i>140</i>	<i>230</i>	<i>350</i>
Asthma & Lower Respiratory Symptoms	PM	5,000	13,000	21,000
	NOx	1,700	4,300	6,800
	<i>Total</i>	<i>6,700</i>	<i>17,000</i>	<i>27,000</i>
Acute Bronchitis	PM	0	1,100	2,300
	NOx	0	350	740
	<i>Total</i>	<i>0</i>	<i>1,400</i>	<i>3,100</i>
Work Loss Days	PM	65,000	76,000	88,000
	NOx	21,000	25,000	29,000
	<i>Total</i>	<i>86,000</i>	<i>100,000</i>	<i>120,000</i>
Minor Restricted Activity Days	PM	360,000	440,000	520,000
	NOx	120,000	140,000	170,000
	<i>Total</i>	<i>480,000</i>	<i>580,000</i>	<i>690,000</i>

\* Health effects from primary and secondary PM are labeled PM and NOx, respectively. The sum of PM and NOx impacts may not equal the total given due to rounding.

### Primary Diesel PM

Consistent with U.S. EPA (2004), ARB has been using the PM-premature death relationship from Pope et al. (2002) since the approval of the Ports and Goods Movement Emission Reduction Plan (ARB, 2006). Using the study by Pope et al. (2002), a statewide population-weighted average diesel PM<sub>2.5</sub> exposure of 1.8 µg/m<sup>3</sup> can be associated with a mean estimate of 2,200 premature deaths per year in California, about 10% higher than previous estimates (Lloyd and Cackette, 2001). The diesel PM<sub>2.5</sub> emissions corresponding to the diesel PM<sub>2.5</sub> concentration of 1.8 µg/m<sup>3</sup> is 36,000 tons for the year 2000 based on the emission inventory developed for this rule. Using this information, we estimate that for every reduction of 17 tons per year of diesel PM<sub>2.5</sub> emissions, one fewer premature death would result. This factor is derived by dividing 36,000 tons of diesel PM by 2,168 deaths (unrounded number of deaths described above). Although a single statewide factor (tons per death) is discussed in this example, staff actually developed basin-specific factors for the health impacts assessment of emissions from port trucks. These basin-specific factors were developed using basin-specific diesel PM concentrations and emissions for the year 2000. After adjusting for population changes between each future year and 2000, staff estimates that the cumulative total of approximately 3,760 tons of emissions from port trucks reduced through the implementation of this regulation in years 2010-2014 are associated with a reduction of approximately 430 deaths (120 – 750, 95% CI). Estimates of other health benefits, such as hospitalizations and asthma symptoms, were calculated using basin-specific factors developed from other health studies. Details on the methodology used to calculate these estimates can be found in Appendix A of the Emission Reduction Plan for Ports and Goods Movement in California (ARB, 2006).

### Secondary Diesel PM

In addition to directly emitted PM, diesel exhaust contains NO<sub>x</sub>, which is a precursor to nitrates, a secondary diesel-related PM formed in the atmosphere. Lloyd and Cackette (2001) estimated that secondary diesel PM<sub>2.5</sub> exposures from NO<sub>x</sub> emissions can lead to additional health impacts beyond those associated with directly emitted diesel PM<sub>2.5</sub>. To quantify such impacts, staff developed population-weighted nitrate concentrations for each air basin using data not only from the statewide routine monitoring network, which was used in Lloyd and Cackette (2001), but also from special monitoring programs such as IMPROVE and Children's Health Study (CHS) in year 1998. The IMPROVE network provided additional information in the rural areas, while the CHS added more data to southern California. Staff calculated the health impacts resulting from exposure to these concentrations of PM and then associated the impacts with the basin-specific NO<sub>x</sub> emissions to develop basin-specific factors (tons per case of health endpoint). Using an approach similar to that used for primary diesel PM and adjusting for population changes between each future year and 1998 (the year with the greatest geographic extent of nitrate monitoring), staff estimates

that the cumulative reduction of approximately 28,100 tons of emissions from port trucks in 2010-2014 are associated with the reduction of an estimated 140 premature deaths (40 – 250, 95% CI). Other health effects were also estimated as outlined above.

### **Assumptions and Limitations of Health Impacts Assessment**

Several assumptions were used in quantifying the health effects of PM exposure. They include the selection and applicability of the concentration-response functions, the exposure assessment, and the baseline incidence rates. These are briefly described below.

- For premature death, calculations were based on the concentration-response function of Pope et al. (2002). The ARB staff assumed that the concentration-response function for premature death in California is comparable to that developed by Pope and colleagues. This is supported by other studies (Dominici et al. 2005, Franklin et al. 2007) in California showing an association between PM<sub>2.5</sub> exposure and premature death similar to that reported by Pope et al. (2002). In addition, the Pope et al. (2002) study included subjects in several metropolitan areas of California. The U.S. EPA has been using the Pope et al. (2002) study for its regulatory impact analyses since 2004. For other health endpoints, the selection of the concentration-response functions was based on the most recent and relevant scientific literature. Details are in the Emission Reduction Plan for Ports and Goods Movement in California (ARB, 2006).
- The ARB staff assumed the model-predicted diesel PM exposure estimates published in the report titled “Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant” (ARB, 1998) could be applied to the entire population within each basin. That is, the entire population within the basin was assumed to be exposed uniformly to modeled concentration, an assumption typical of this type of assessment.
- The ARB staff assumed the baseline incidence rate for each health endpoint was uniform across each county and in many cases across each basin. This assumption is consistent with methods used by the U.S. EPA for its regulatory impact assessment and the incidence rates match those used by U.S. EPA.
- Although the analysis illustrates that reduction in diesel PM 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. Health effects such as myocardial infarction (heart attack), chronic bronchitis, and onset of asthma were unquantified due to the potential overlap with the quantified effects such as lower respiratory symptoms and hospitalizations. In addition, estimates of the effects of PM

on 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 and the results of the available studies are not entirely consistent (ARB, 2006). In summary, because only a subset of the total number of health outcomes is considered here, the estimates should be considered an underestimate of the total public health impact of diesel PM exposure.

## **Economic Valuation of Health Effects**

This section describes the methodology for monetizing the value of avoiding adverse health impacts.

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). This value is the mean estimate from five contingent valuation studies and 17 wage-risk studies. Contingent valuation and wage-risk studies examine the willingness to pay (or accept payment) for a minor decrease (or increase) in the risk of premature death. For example, if individuals are willing to pay \$800 to reduce their risk of mortality by 1/10,000, then collectively they are willing to pay \$8 million to avoid one certain death. This is also known as the “value of a statistical life” or VSL.<sup>17</sup>

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<sup>18</sup> to account for real income growth from 1990 through 2020, (U.S. EPA, 2004). 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 2006 dollars. After these adjustments, the value of avoiding one premature death is \$8.2 million in 2007, \$8.4 million in 2010 and \$8.6 million in 2014, all expressed in 2006 dollars. The U.S. EPA also uses the willingness-to-pay (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 2014, although at a lower rate (about 0.2% per year in lieu of 0.6% per year).

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<sup>17</sup> U.S. EPA’s most recent regulatory impact analyses, (U.S. EPA 2004, 2005), apply a different VSL estimate (\$5.5 million in 1999 dollars, with a 95 percent confidence interval between \$1 million and \$10 million). This revised value is based on more recent meta-analytical literature, and has not been endorsed by the Environmental Economics Advisory Committee (EEAC) of U.S. EPA’s Science Advisory Board (SAB). Until U.S. EPA’s SAB endorses a revised estimate, CARB staff continues to use the last VSL estimate endorsed by the SAB, i.e., \$4.8 million in 1990 dollars.

<sup>18</sup> U.S. EPA’s real income growth adjustment factor for premature death incorporates an elasticity estimate of 0.4.

For work-loss days, the U.S. EPA uses an estimate of an individual's lost wages, (U.S. EPA, 2004), which CARB adjusts for projected real income growth, at a rate of approximately 1.5% per year.

"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 (COI) plus associated costs such as loss of time for work, recreation and household production. When adjusting these COI values for inflation, CARB uses the Consumer Price Index (CPI) for medical care rather than the CPI for all items.

Table 2 lists the valuation of avoiding various health effects, compiled from CARB and U.S. EPA publications, updated to 2006 dollars. The valuations based on WTP, as well as those based on wages, are adjusted for anticipated growth in real income.

**Table 2: Undiscounted Unit Values for Health Effects  
(at Various Income Levels in 2006 Dollars)<sup>1</sup>**

<b>Health Endpoint</b>	<b>2007</b>	<b>2010</b>	<b>2014</b>	<b>References</b>
<b>Mortality</b>				
Premature death (\$ million)	8.2	8.4	8.6	U.S. EPA (1999, p. 70-72, 2000, 2004, p. 9-121)
<b>Hospital Admissions</b>				
Cardiovascular (\$ thousands)	44	45	47	CARB (2003), p. 63
Respiratory (\$ thousands)	36	37	39	CARB (2003), p. 63
<b>Minor Illnesses</b>				
Acute Bronchitis	452	455	458	U.S. EPA (2004), 9-158
Lower Respiratory Symptoms	20	20	20	U.S. EPA (2004), 9-158
Work loss day	192	201	213	2002 California wage data, U.S. Department of Labor
Minor restricted activity day (MRAD)	64	64	65	U.S. EPA (2004), 9-159

<sup>1</sup>The value for premature death is adjusted for projected real income growth, net of 0.4 elasticity. Wage-based values (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.

Benefits from the proposed Port Trucks Rule are substantial. CARB staff estimates cumulative benefits over the period from 2010 to 2014 to be nearly \$4.3 billion using a 3% discount rate or nearly \$3.5 billion using a 7% discount rate. CARB follows U.S. EPA practice in reporting results using both 3% and 7% discount rates. Nearly all of the monetized benefits result from avoiding premature death. The estimated benefits from avoided morbidity are approximately \$64 million with a 3% discount rate and less than \$53 million with a 7% discount rate. Approximately 75% of the benefits are associated with reduced PM from direct sources, and the remaining 25% with reduced NOx.

## **Conclusion**

The health benefits of implementing the proposed regulation are substantial. Staff estimates that the cumulative emissions reductions over the lifetime of the rule can be associated with approximately 580 fewer premature deaths, 120 fewer hospital admissions due to respiratory causes, 230 fewer hospital admissions due to cardiovascular causes, 17,000 fewer cases of asthma-related and other lower respiratory symptoms, 1,400 fewer cases of acute bronchitis, 100,000 fewer work loss days, and 580,000 fewer minor restricted activity days. The uncertainty behind each estimated benefit ranges from about 15% to 75% for most endpoints. The estimated statewide benefits over 2010 to 2014 from these reductions in adverse health effects is nearly \$3.5 billion using a 7% discount rate or about \$4.3 billion using a 3% discount rate.

## REFERENCES

ARB, 1998. Air Resources Board. April 1998. Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant. Appendix III, Part A, Exposure Assessment.

ARB, 2000. Air Resources Board. October 2000. Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles. <http://www.arb.ca.gov/diesel/documents/rrpapp.htm>

ARB, 2002. California Air Resources Board and Office of Environmental Health Hazard Assessment. Staff Report: Public Hearing to Consider Amendments to the Ambient Air Quality Standards for Particulate Matter and Sulfates, available at <http://www.arb.ca.gov/research/aaqs/std-rs/pm-final/pm-final.htm>.

ARB, 2003. Air Resources Board. May 2003. Final Research Report: The Economic Value of Respiratory and Cardiovascular Hospitalizations. <ftp://ftp.arb.ca.gov/carbis/research/apr/past/99-329.pdf>

ARB, 2006. California Air Resources Board. Emission Reduction Plan for Ports and Goods Movement, available at [http://www.arb.ca.gov/planning/gmerp/march21plan/appendix\\_a.pdf](http://www.arb.ca.gov/planning/gmerp/march21plan/appendix_a.pdf)

Dominici et al. 2005. Revised analyses of the National Morbidity, Mortality, and Air Pollution Study: mortality among residents of 90 cities. *J Toxicol Environ Health A*. Vol. 68(13-14):1071-92.

Franklin et al. 2007. Association between PM<sub>2.5</sub> and all-cause and specific-cause mortality in 27 US communities. *J Expo Sci Environ Epidemiol*. Vol. 17: 279-287.

Lloyd and Cackette. 2001. Lloyd, A.C.; Cackette, T.A.; Diesel Engines: Environmental Impact and Control; *J Air Waste Manage. Assoc.* 2001, 51: 809-847.  
<http://www.arb.ca.gov/research/seminars/lloyd/AWMA2001/JAWMADieselCriticalReview.pdf>

Pope CA 3<sup>rd</sup>, Burnett RT, Thun MJ, Calle EE, Krewski D, Ito K, Thurston GD. 2002. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. *Journal of the American Medical Association*. Vol. 287 (9): 1132-41.

U.S. EPA, 1999. United States Environmental Protection Agency. November 1999, *The Benefits and Costs of the Clean Air Act 1990 to 2010*. EPA-410-R-99-001 <http://www.epa.gov/air/sect812/copy99.html>

U.S. EPA, 2000. United States Environmental Protection Agency. September 2000, *Guidelines for Preparing Economic Analyses*. EPA240-R-00-003  
<http://www.epa.gov/opei/pubsinfo.htm>

U.S. EPA, 2004. United States Environmental Protection Agency. May, 2004. Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines. EPA-420-R-04-007. Office of Transportation and Air Quality.  
<http://www.epa.gov/otaq/regs/nonroad/equip-hd/2004fr.htm#ria>

U.S. EPA, 2005. Clean Air Interstate Rule: Regulatory Impact Analysis. March 2005: <http://www.epa.gov/interstateairquality/pdfs/finaltech08.pdf>