Appendix G

Emissions Analysis Methodology and Results

Medium-Heavy Duty Diesel Trucks, Heavy-Heavy Duty Diesel Trucks, and Regulated Bus Categories

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List of Acronyms

AADTT	Annual Average Daily Truck Traffic
ARB	Air Resources Board
BACT	Best Available Control Technology
BEA	Bureau of Economic Analysis
BLS	Bureau of Labor Statistics
BOE	Board of Equalization
BTS	Bureau of Transportation Statistics
Caltrans	California Department of Transportation
CBA	California Bus Association
CPUC	California Public Utilities Commission
CY	Calendar Year
DMV	Department of Motor Vehicles
DOF	Department of Finance
DPF	Diesel Particulate Filter
EDA	Equipment Data Associates
FHWA	Federal Highway Administration
GDP	Gross Domestic Product
GVWR	Gross Vehicle Weight Rating
HDT	Heavy-Duty Truck
HHDDT	Heavy Heavy-Duty Diesel Trucks
IFTA	International Fuel Tax Agreement
IRP	International Registration Plan
LP	License plate
MHDDT	Medium Heavy-Duty Diesel Trucks
MVSTAFF	California Motor Vehicle Stock, Travel and Fuel Forecast
MY	Model Year
NAAQS	National Ambient Air Quality Standards
NOOS	Neighboring out-of-state
NO_x	Nitrogen Oxides
NNOOS	Non-neighboring out-of-state
OD	Origin-Destination
OOS	Out-of-state
PM	Particulate Matter
POAK	Port of Oakland
POLA	Ports of Los Angeles and Long Beach
PTO	Power Take Off
SCAG	Southern California Association of Governments
SIP	State Implementation Plan
TEU	Twenty-foot equivalent unit
UCC	Uniform Commercial Code
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VIUS	Vehicle Inventory and Use Survey
VMT	Vehicle Miles Traveled

A. Introduction

Commercial heavy-duty diesel trucks and buses (commercial diesel buses and trucks exceeding 14,000 lbs gross vehicle weight rating (GVWR)) are currently the single largest source of nitrogen oxide (NO_x) emissions in California, accounting for 30 percent of statewide NO_x emissions (ARB, 2008). These same trucks and buses are also the largest source of diesel particulate matter (diesel PM) in California, representing about 40 percent of statewide diesel PM emissions.

In December 2008, the Air Resources Board (ARB or Board) adopted the Statewide Truck and Bus Rule (regulation). That regulation was designed to achieve emissions reductions by requiring truck and bus fleet owners to modernize their fleets and install exhaust retrofits. As part of that regulatory development, staff developed a statewide emissions analysis that quantified emissions from different types of trucks and buses separated by registration type, body type and/or vocation as well as mileage thresholds. The assumptions used in development of that emissions analysis were published in Appendix G of the technical support document (TSD) for the 2008 rulemaking, and the results of the inventory were published in an on-line database (ARB, 2008).

In December 2008, the National Bureau of Economic Research declared that the United States had entered an economic recession. That recession turned out to be the most severe in the United States since the Great Depression. In December 2009, staff reported its statewide estimate of the impact of the economic recession on truck and bus emissions. Results suggested that emissions in 2009 across all trucks and buses operating in California were approximately 20 percent lower than estimates provided in the 2008 Rule staff report (ARB, 2009). As a result of the recession, the Board directed staff to develop regulatory amendments to the Rule that provide economic relief while ensuring air quality goals would still be attained.

The emissions inventory developed to support the proposed regulatory amendments builds upon the 2008 and 2009 work. We revised the inventory methodology to improve the quality and accuracy of emissions estimates. We revised growth rates and forecasted vehicle age distributions to reflect the impact of the economic recession both today and in the future. We developed a new procedure for allocating statewide emissions to each air basin in California so the impact of the Rule could be evaluated regionally. Finally, we assessed the impact of the proposed regulatory amendments on emissions from Trucks and Buses on a statewide and regional basis. This appendix provides the fundamental analysis behind updates to the emissions analysis, regional emissions estimates, the impact of the economy on emissions, and the emissions impact of new regulatory amendments.

B. Methodology

Emissions are calculated as the product of a population of vehicles, the number of miles each vehicle travels, and emission rates per mile. Beneath this simple equation lies a series of data and assumptions about the population, miles traveled, and emission rates per vehicle model year in a given calendar year, growth and attrition estimates, deterioration, and other factors that affect emissions estimates, all of which were discussed in the 2008 Rulemaking. We applied the concept separately for each analysis category of trucks that shares similar travel, service, size, age or other characteristics.

$$\sum_{MY,\,C} \left(POP_{MY,\,C} \times AC_{MY,\,C} \times ER_{MY,\,C} \right) = EMS_{CY}, \qquad \textbf{Equation 1}$$

where: $POP_{MY,\,C}$ is the population of trucks for model year MY within each analysis category C for a given calendar year;
$AC_{MY,\,C}$ is the accrual rate (miles traveled per year) per truck by model year MY and analysis category C in a given calendar year;
$ER_{MY,\,C}$ is the calculated emission rate, in grams pollutant per mile driven, assuming statewide speed travel distributions in EMFAC2007 and fleet specific cumulative mileage accrual over the life of the truck, by model year MY and analysis category C;
EMS_{CY} is the emissions calculated in tons per day for a given calendar year.

The basic calculation methodology is unchanged from that described in Appendix G of the Rule Initial Statement of Reasons published in ARB (2008). Emissions analysis updates described in this document relate to changes in inputs to the methodology.

The emissions analysis methodology published in 2008 involved applying annual average growth rates that are independent of the economic cycle. In 2009 staff developed a scaling model that was designed to assess the impact of multiple potential economic forecast scenarios on emissions (ARB, 2009). For this rulemaking, staff are using an emissions forecast that reflects the average of a fast recovery and slow recovery bounding scenario. This emissions forecast scenario is input directly to the emissions model for the analysis described in this document.

C. Statewide Emissions Analysis Updates

1) Construction Trucks
In the emissions analysis presented to the Board in December, 2008, ARB staff categorized the medium heavy-duty diesel trucks (MHDDT) and heavy heavy-duty diesel trucks (HHDDT)[1] into different fleet categories that differentiated trucks and buses by registration type (in-state vs. interstate), body type (tractor, single-unit, etc.),

[1] Heavy-duty diesel trucks include MHDDT with a GVWR above 14,000 lbs and up to 33,000 lbs, and HHDDT with GVWR above 33,000 lbs.

and vocation (agricultural, construction, drayage, etc.). Over the past year staff listened to stakeholder comments and evaluated the impact of the recession on the construction sector. Our analysis suggested that trucks involved in construction have been impacted more severely by the recession than other trucking sectors. In order to reflect this finding, staff separated trucks owned by construction firms from other trucking categories in the inventory, and then developed an alternate economic forecast reflecting the economic downturn on construction trucking.

Like other vocational trucking categories, trucks owned by construction firms cannot be easily identified through the California Department of Motor Vehicles (DMV) registration database. To identify a population of construction trucks, staff analyzed data in the Vehicle Inventory and Use Survey (VIUS), (VIUS, 2002). Construction trucks were identified in the survey by selecting "construction" as the industry in which the vehicle was most used. Based on the survey, staff estimated the fractions of trucks in the construction industry relative to the population in the inventory fleet category and the results are shown in Table 1.

Table 1. Percentage of Construction Trucks by Inventory Category

MHDDT instate	21
HHDDT tractor	20
HHDDT single-unit	40
HHDDT CAIRP[2]	6

Next, staff evaluated the age distribution of construction trucks in VIUS and compared that to all trucks in VIUS. Results suggested that construction trucks have roughly the same average age profile as other trucking categories, and as a result staff decided to assume that construction trucks by body type have the same age distribution as non-construction trucks of the same body type and registration status. Table 2 compares the average age of construction trucks against non-construction trucks by inventory category.

Table 2. Construction vs. Non-Construction Truck Average Age (VIUS, 2002)[3]

	Construction	General
Tractor	8.0	7.4
Single Unit (non-tractor)	7.6	7.2

[2] CAIRP: California registered International Registration Plan (IRP) trucks
[3] VIUS grouped all age 16 and older into one category and only trucks age 15 or newer in VIUS were included in the analysis.

Staff assumed that all in-state registered tractors and single-unit construction trucks followed the in-state single unit accrual schedule as documented (ARB, 2008).

The emission factors remain unchanged; as a result HHDDT single-unit emission rates are used for HHDDT construction single-unit trucks, HHDDT tractor emission rates for HHDDT construction tractors, HHDDT IRP truck emission rates for HHDDT construction IRP trucks, and MHDDT emission rates for MHDDT construction trucks.

To estimate the impact of the recession on construction activity in California, staff reviewed a variety of economic indicators. Surrogates for construction emissions such as employment, gross domestic product, building permits, value of equipment financed, and fuel consumption indicate that construction activity decreased between 30 percent and 80 percent in California between 2006 and 2009, as shown in Table 3.

Table 3. Impact of Recession on Economic Metrics

Data Type	Change Relative to Peak	Data Source
CA Construction Employment (2006-2009)	-30%	US Bureau of Labor Statistics (BLS, 2010)
CA Construction GDP (2005-2008)	-30%	US Bureau of Economic Analysis; (BEA, 2009)
CA Construction Taxable Fuel Refunds (2006-2008)	-40%	CA Board of Equalization; (BOE, 2008)
CA Construction Valuation (2005-2009)	-65%	CA Dept of Finance; (DOF, 2010)
CA New Building Permits (2004-2009)	-80%	CA Dept of Finance; (DOF, 2010)
CA New Equipment Sales Financed (2005-2009)	-80%	Equipment Data Associates; (EDA, 2010)

Based on above reviews, staff estimated a 50 percent reduction in activity from 2006 to 2009. Staff generated an estimation of average recovery using bounding fast and slow recovery scenarios to represent both vehicle miles traveled (VMT) growth assumptions, as shown in Figure 1, and vehicle sales in the construction sector, as shown in Figure 2. Construction vehicle sales trends were estimated using the relationship between vehicle sales and economic trends documented in the staff report for the 2008 Truck and Bus rulemaking (ARB, 2008).

Figure 1. Construction Vehicle Miles Travelled (VMT) Growth Assumption

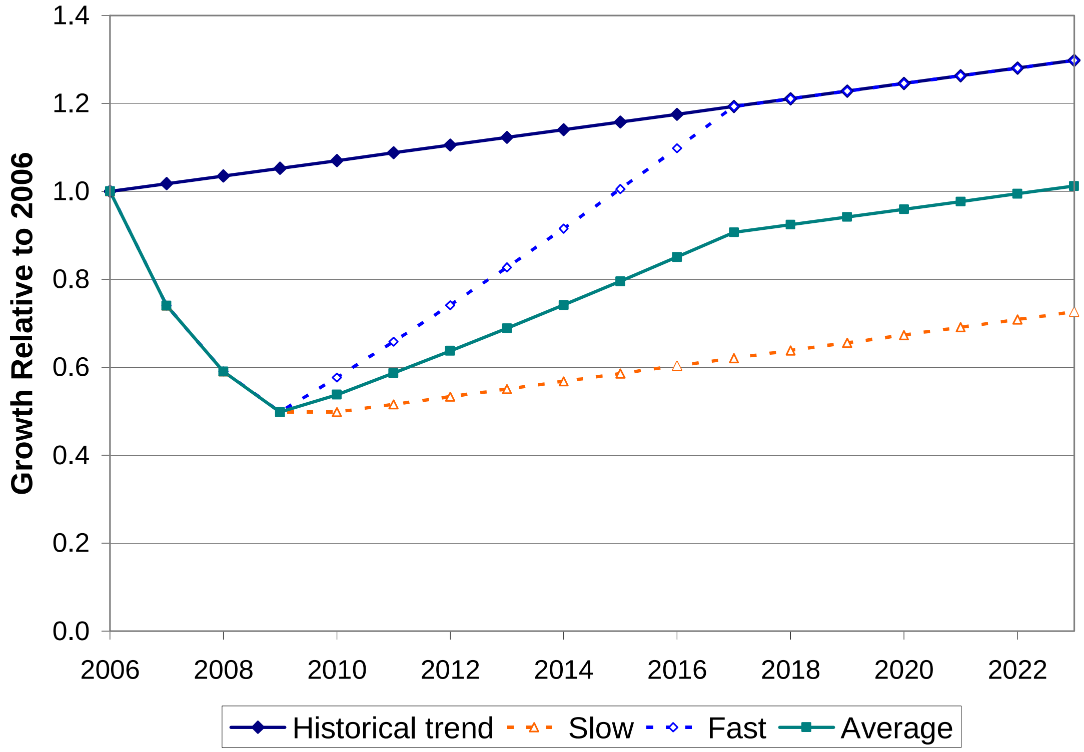
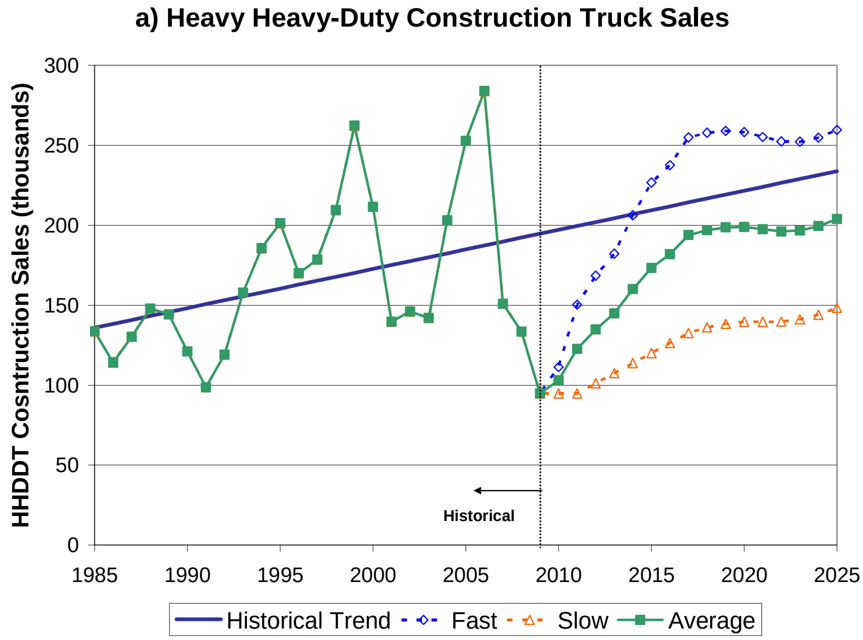
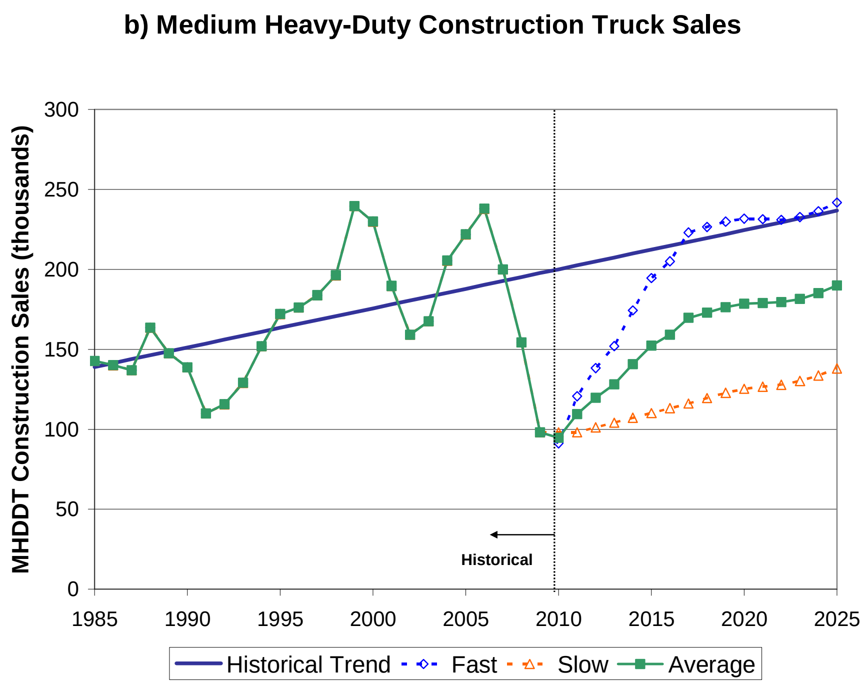


Figure 2. Construction Truck Sales Trend and Estimated Recovery

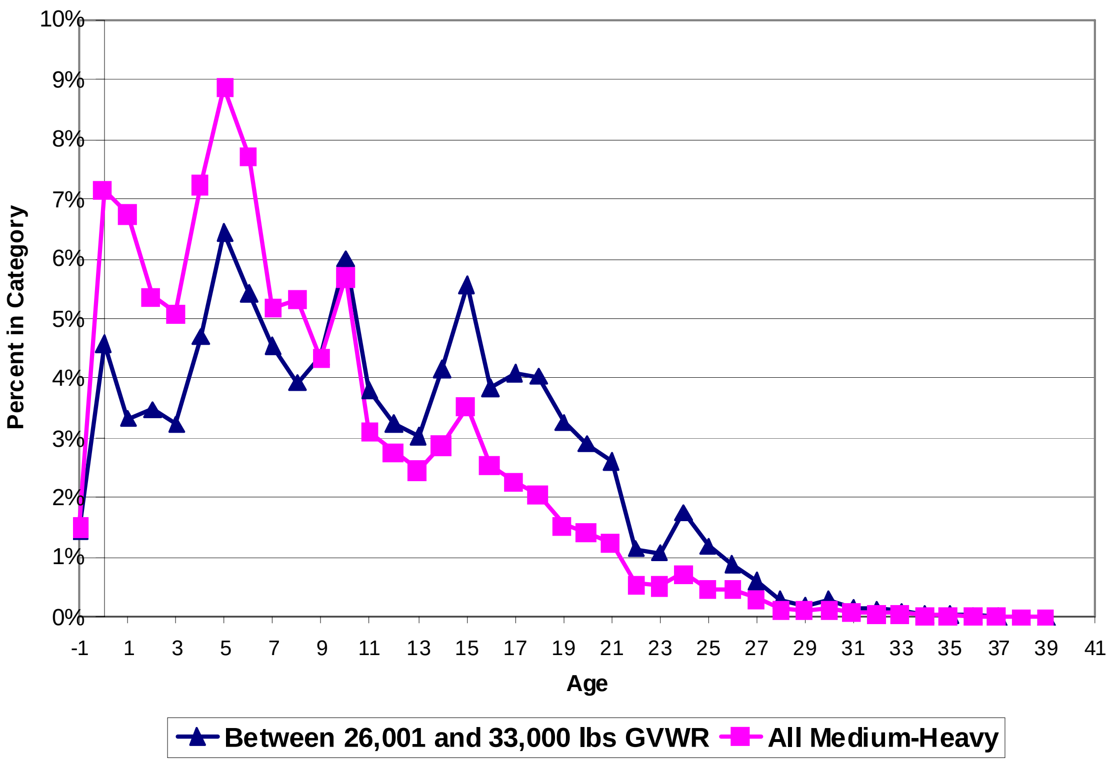




2) Medium Heavy-Duty Diesel Truck Population Split

Diesel fueled trucks with a GVWR between 14,000 and 33,000 lbs GVWR are considered to be MHDDT. The proposed amended regulation would exempt vehicles with a GVWR less than 26,000 lbs from meeting PM filter requirements. To estimate the population of vehicles that are above 26,000 lbs within the MHDDT category staff analyzed the GVWR code of MHDDT in the DMV registration data (DMV, 2005). Results suggest that about 30 percent of the MHDDTs statewide are above 26,000 lbs and they have different age distribution than the overall medium heavy-duty diesel trucks as shown in Figure 3.

Figure 3. Medium Heavy-Duty Diesel Truck Age Distributions



The average age of diesel trucks with GVWR between 26,000 and 33,000 lbs is about 11 years old while the overall medium heavy-duty diesel is about 8 years old. To reflect the differences in age distribution and population fraction, staff assumed that 30 percent of MHDDTs between age 9 and 13, 58 percent of the older than 13 years and 20 percent of vehicles newer than nine years old are MHDDT above 26,000 lbs. This assumption is applied to MHDDT instate and interstate trucks.

3) Impact of Recession and Growth by Category

As described in ARB (2009), the recession has had a major impact on the trucking industry. In order to develop the updated emissions analysis, staff revisited fuel and economic truck activity indicators to estimate the impact of the recession on truck and bus operations in California. Using the same methodology as described in ARB (2009) staff developed an estimate for an average recovery forecast based on fast and slow bounding recovery scenarios.

Staff's previous analysis identified a relationship between overall economic trends and truck sales. The impact of this relationship is that as the economy has deteriorated as a result of the recession, national new truck sales have decreased and fewer new vehicles are registered in California (ARB, 2009). Because of this relationship, staff has developed both forecasts for the impact of the reduced total vehicle activity caused by the recession on emissions by truck category, and forecasts for the impact of reduced vehicle sales on emissions by truck category. Detailed assumptions by category are presented in Section F.

4) Motorcoach/Buses

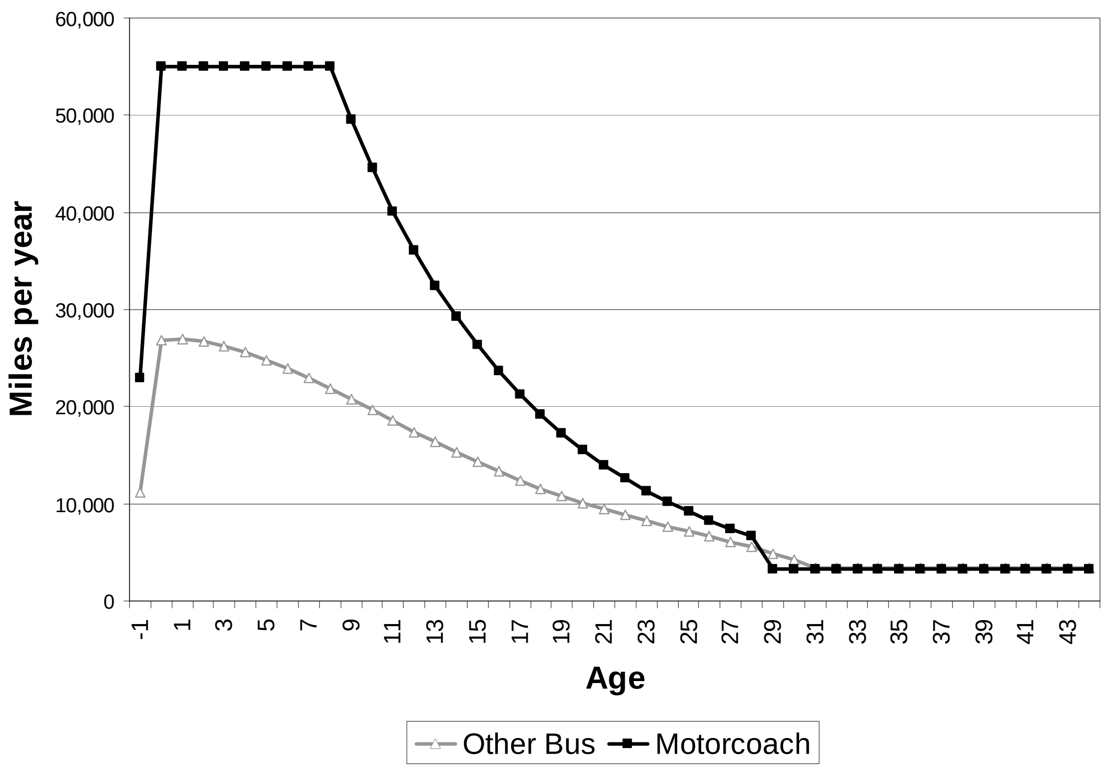
In the December 2008 Board Hearing, the Board adopted specific regulatory provisions for motorcoaches. In order to reflect these regulatory provisions, staff consulted with the California Bus Association (CBA) to obtain information to assist in estimating the population, mileage accrual rates, and other assumptions for the motorcoach inventory category. The CBA provided population estimates from the California Public Utility Commission (CPUC, 2009), and results of a survey (CBA, 2010) that could be used to assess mileage accrual. The age distribution was assessed by matching registered motorcoach companies against the buses those firms registered in the DMV database. Staff subtracted the motorcoach population by age from the other bus category, and assumed a 1.75 percent growth rate per year in the absence of the recession. Staff used HHDDT emission rates because motorcoaches are rated in excess of 33,000 lbs GVWR, and emission rates for the other bus category from which motorcoaches were extracted are based on a weighted average of heavier and lighter buses.

To estimate the impact of the recession, staff used CBA provided population estimates in 2000 (3376), 2008 (3589), and 2009 (3125). Age distributions were forecasted by assuming heavy heavy-duty vehicle sales forecasts developed using the fast and slow recovery bounding scenarios. Table 4 provides assumed motorcoach populations and VMT, while Figure 4 shows the assumed accrual schedule.

Table 4. Motorcoach Population and VMT

2000	3320	3320	147	147
2005	3670	3670	160	160
2007	3760	3451	166	153
2008	3914	3294	169	143
2009	4042	3125	172	133
2010	4113	3240	175	137
2014	4374	3775	187	158
2020	4834	4375	208	183

Figure 4. Motorcoach Mileage Accrual



5) Out-of-State Vehicle Miles Traveled

The 2008 inventory analysis assumed a set amount of VMT by out-of-state (OOS) trucks in California in 2005, based on information from the International Fuel Tax Agreement (IFTA) program provided by email from the California State Board of Equalization (BOE, 2010a). After the 2008 inventory was developed BOE provided 2007 calendar year estimated out-of-state truck VMT and fuel usage in California. This number was substantially lower than what had been provided in 2005. In 2010, staff received 2008 and 2009 estimated out-of-state truck VMT and fuel usage in California. Overall, data representing California registered trucks in the IFTA program appears plausible, with a 20 percent increase between 2005 and 2007, and then a 20 percent decrease due to the recession from 2007 to 2009. Out-of-state VMT data shown in Table 6 are not consistent between 2005 and 2007-2009. For example, the 2005 data provided by BOE are much higher than any of the 2007-2009 data, and the 2008 data are higher than 2007 data. These trends are not consistent with either economic surrogates or overall on-road fuel trends. Because of these anomalies in the IFTA data, staff decided to adjust the IFTA numbers for out-of-state trucks to reflect our best estimate of what out-of-state truck VMT in California should be given the totality of available data. To adjust the data, staff calculated the average annual truck VMT between 2007 and 2009 for OOS and for CA registered IFTA respectively, and then back-casted 2005 out-of-state IFTA miles based on the ratio of the two averages and 2005 CA registered IFTA truck miles. Staff then applied the impact of the recession as measured by the BOE data for on-road fuel trends. The BOE IFTA data, as well as staff assumptions based on the data are shown in Table 5.

Table 5. Reported and Estimate Interstate VMT (million miles/year) in California: 2005-2009

Year	CA Registered IFTA Truck Miles in CA	Reported OOS Truck Miles in CA	Modeled OOS Truck Miles in CA no recession	Modeled OOS Truck Miles in CA with recession
2005	2,189	4,398	3,144	**3,144**
2007	2,660	2,943	3,419	**3,397**
2008	2,213	3,761	3,601	**3,115**
2009	2,134	3,358	3,654	**2,843**

6) Odometer Capping

Truck emission rates are a function of cumulative mileage on the vehicle through an emissions process called deterioration. The cumulative lifetime mileage on a vehicle can be measured using the vehicle's odometer. Previous analyses, as well as the EMFAC2007 model, assumed that odometer is a function of the year by year mileage accrual. To evaluate this assumption, staff collected truck "for-sale" records from truckpaper.com that contained odometer readings, as well as odometer records from the Goods Movement Bond Program and data in VIUS (2002). Results demonstrated that odometer is not simply a function of the year by year mileage accrual, and instead odometer readings tend to level off depending on engine design life. This concept is shown in Figure 5.

Figure 5. Schematic Representation of Difference between Current and Revised Method for Estimating Vehicle Odometer

The reason for the difference is that when a truck or vehicle is young, the average odometer is a function of some high accruing and some low accruing vehicles. As vehicles age higher mileage vehicles are scrapped more quickly than lower mileage vehicles. So, surviving older vehicles are more likely to have accrued fewer miles than average when those vehicles were younger. The net result is that odometer is a function of both accrual rates and vehicle survival rates, and observed odometer readings in practice tend to level out to a constant level for older vehicles. Staff decided to cap odometer readings at a specific value for each truck category and used capped odometer-age relation to generate emission rates by age. The choice of the cap depends on the data sources evaluated; in this case staff decided to cap odometer levels at 800,000 for HHDDTs, and at 400,000 for MHDDTs, as shown in Table 6. Overall, the change in odometer led to less than a 5 percent change in the inventory for any calendar year.

Table 6. Odometer Cap by Inventory Category

Inventory Category	Survival Rate Based Odometer Reading Cap Value
MHDDT Ag	400,000
MHDDT CAIRP	400,000
MHDDT instate	400,000
MHDDT OOS	400,000
HHDDT Ag	800,000
HHDDT CAIRP	800,000
HHDDT NNOOS	800,000
HHDDT NOOS	800,000
HHDDT other port	800,000
HHDDT POAK	800,000
HHDDT POLA	800,000
HHDDT single	No change from ARB (2008)
HHDDT tractor	800,000
MHDDT utility	No change from ARB (2008)
HHDDT utility	No change from ARB (2008)
MHDDT instate construction	400,000
HHDDT single construction	No change from ARB (2008)
HHDDT tractor construction	800,000
HHDDT CAIRP construction	800,000

D. 2008 Truck Field Data Collection

1) Study Design and Data Collection Locations

In 2008 ARB staff implemented a large-scale field data collection effort. The primary objective of this effort was to obtain information to improve regional allocation estimates of heavy-duty truck (HDT) activity. The data collection effort consisted of two components: license plate (LP) surveys and origin-destination (OD) surveys. License plate surveys consisted of time-stamped digital photographs at each location, and provided the mixture of trucks by registration type at 15 weigh stations and 15 roadside locations[4]. OD surveys were collected by intercepting and talking with truck drivers to obtain information on the truck and on the current trip. OD surveys provided trip information which helped to allocate the trip VMT into geographic areas, and were

[4] The license plate data collection effort obtained data from 16 weigh stations and 30 roadside locations. However, given the time required to process data, staff prioritized the list of locations to be processed so that most weigh stations and major representative roadside locations in the South Coast, the San Joaquin Valley and the San Fransisco Bay Area are included in the analysis.

collected at 18 weigh stations and 3 roadside locations. Attachment A provides the OD survey instrument. A total of 54,570 license plates and 6,215 OD surveys were collected and processed for the regional allocation analysis. Most of the data were collected during the daytime and in the middle of the week.

The survey was designed to capture both inter-regional and local trips. Two types of survey sites were considered: locations on major freeways at the border of an air basin and locations inside a particular region or air basin. Locations near state borders were omitted from this study to focus on intra-state truck traffic. Interstate truck traffic data collected by UC Davis (Lutsey, 2008) were used to inform and supplement data collected through the ARB field data collection; that collection effort was focused on roadways near California's border with Mexico, Nevada, Arizona, and Oregon.

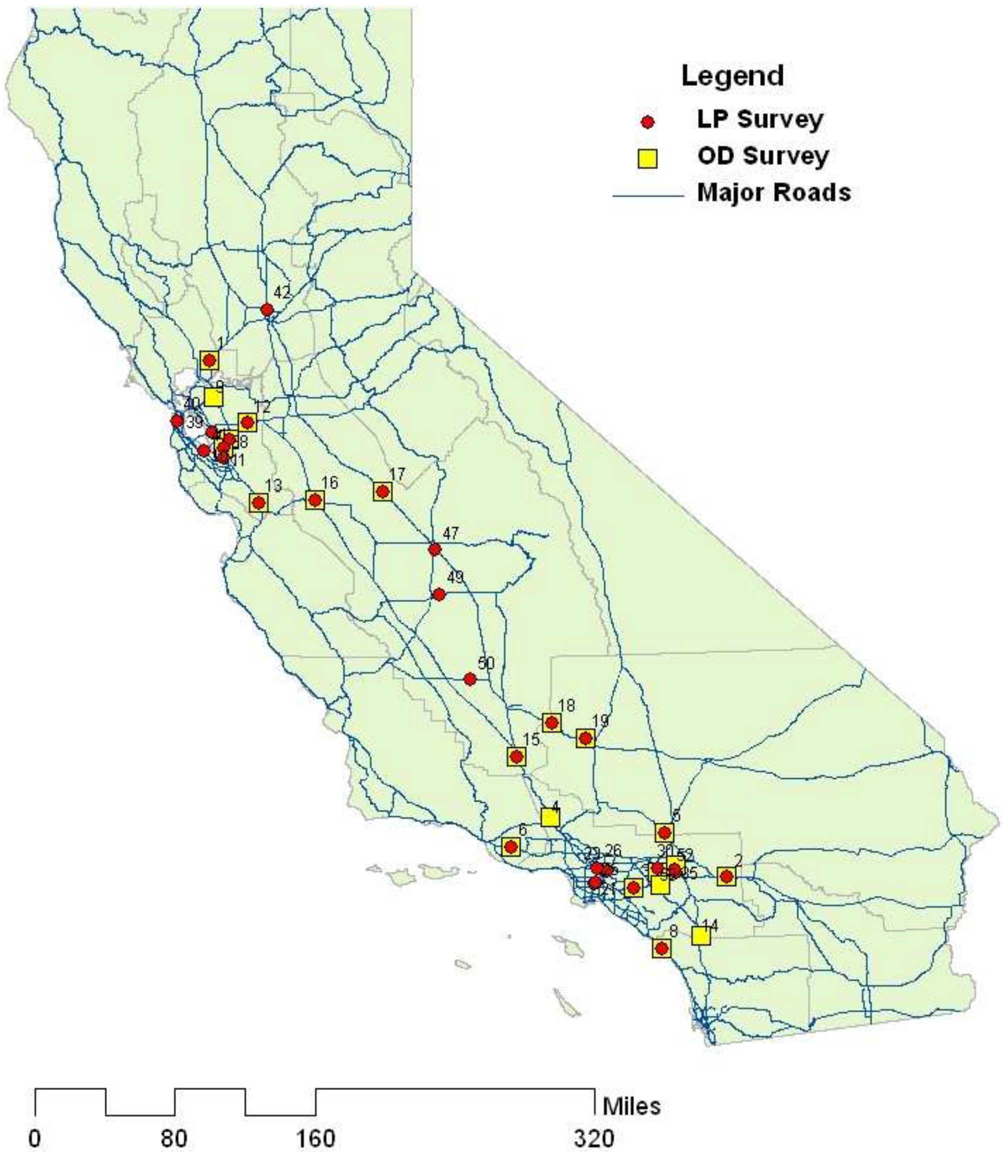
Data collection covered all major portions of the California state highway system, but a higher concentration of data was collected in the South Coast Air Basin and San Joaquin Valley Air Basin. OD surveys were conducted primarily at weigh stations for safety purposes, and tended to be biased towards inter-regional trips because weigh stations are typically located between rather than within regions. License plate collection sites were focused on assessing the mix of different types of vehicles operating within a region, and selected locations were located across a region of interest. Table 7 and Figure 6 show survey locations.

Table 7. ARB 2008 Statewide HDT LP and OD Survey Plan

Site ID#	Route	County	Name/Description	Direction*	Hours of work per day	Number of days per direction	
						LP	OD
Weigh Stations							
1	I-80	Solano	Cordelia	EB/WB	24	2	3
2	I-10	Riverside	Desert Hills	EB/WB	24	3	3
3	CA-91	Orange	Peralta	EB/WB	9	2	3
4	I-5	Los Angeles	Castaic	NB	9		3
5	I-15	San Bernardino	Cajon	NB/SB	9	2	3
6	US-101	Ventura	Conejo	NB/SB	9	2	3
8	I-5	San Diego	San Onofre	NB/SB	9	2	3
9	I-680	Contra Costa	Walnut Creek	NB/SB	9		3
10	I-680	Alameda	Mission Grade	NB	9	2	3
11	I-880	Alameda	Nimitz	NB/SB	9	2	3
12	I-580	Alameda	Livermore	EB/WB	9	2	3
13	US-101	Santa Clara	Gilroy	NB/SB	9	2	3
14	I-15	San Diego	Rainbow	NB/SB	9		3
15	5	Kern	Grapevine	SB	9	2	3
16	5	Merced	Santa Nella	NB/SB	9	2	3
17	99	Merced	Chowchilla River	NB	9	2	3
18	58	Kern	Keene	EB	9	2	3
19	58	Kern	Cache Creek	WB	9	2	3
Roadside/overpass Survey Sites							
21	I-710	Los Angeles	Near Jct 105	NB/SB	9	2	
23	I-605	Los Angeles	Near Jct. 5	NB/SB	9	2	
25	I-105	Los Angeles	Near Jct 19	EB/WB	9	2	
26	CA-60	Los Angeles	Near Jct 710	EB/WB	9	2	
30	I-15	San Bernardino	South of Jct CA 60	NB/SB	9	2	
34	CA-91	Riverside	Near Jct 215	EB/WB	9	1	
35	CA-60	Riverside	Near Jct 91	EB/WB	9	1	
38	CA-237	Santa Clara	Near Great America Parkway	EB/WB	9	1	
39	I-880	Alameda	Near Oakland/Jct Rte 77	NB/SB	9	1	
40	I-280	San Mateo	Near Daly City/Ocean Ave	NB/SB	9	1	
41	US-101	Alameda	Near Jct 84	NB/SB	9	1	
42	I-5	Sacramento	at Arena Blvd	NB/SB	9	1	
47	CA-99	Fresno	Fowler	NB/SB	9	1	
49	CA-198	Kings	Near Jct 41	EB/WB	9	1	
50	CA-46	Kern	Near Jct 43	EB/WB	9	1	
51	Etiwanda and the 60				9		1
52	Riverside and Agua Mansa (colton)				9		1
53	91 Fwy and the 15 Fwy (Corona)				9		1

* Direction: NB-northbound; SB-southbound; EB-eastbound; WB-westbound

Figure 6. ARB 2008 HDT Field Study Survey Locations



Information from OD surveys and collected license plates were annotated and integrated into a database. License plate data were evaluated and cross referenced to the DMV database to obtain state of registration from all trucks, model year and GVWR from California-registered trucks.

OD surveys were generally conducted during daytime hours, with the exception of the Desert Hills weigh stations where additional surveys were collected through the night. Survey teams invited truck drivers to complete a survey while the trucks were weighed and inspected. The surveyor inspected the truck and engine to obtain basic truck information and asked truck drivers questions verbally to help fill out the OD survey questionnaire. The questionnaire was prepared in both English and Spanish. Staff manually input OD survey data from each paper survey into a database. Using Arc GIS tools, each OD trip, including its origin, destination and route, was mapped onto the roadway system. Trips were parsed into segment by county boundary. Therefore, total trip distance and miles traveled in each air basin were generated for each trip. VMT were summarized by each truck category, survey location, trip type, and air basin.

License plate images were collected from trucks pulling through a weigh station or traveling on the roadway network at normal speeds using high performance digital cameras between February and May 2008. At each direction-specific survey location, license plate images were collected during daylight hours on weekdays for one to two days, except for the Desert Hills weigh station. At the Desert Hills weigh station, additional license plate images were also collected during night hours and on Saturday in both directions. LP pictures were manually input from each digital photograph into a database, and cross-referenced against the DMV registration database to obtain model year, body type, and other characteristics. Table 8 shows the data collection period, the number of OD records and the number of LP records collected and analyzed at each site.

Table 8. ARB 2008 Statewide HDT LP and OD Data Summary

Site ID #	Route	Name/Description	Direction	Date	Hour Start	Hour End	Number of OD Survey	Number of LP Survey
Weigh Stations								
1	I-80	Cordelia	WB	12/17/2007	14	23		519
			WB	12/18/2007	0	9		746
				4/15/2008	6	15	132	
				4/16/2008	6	16	137	
				4/17/2008	x	x	133	
2	I-10	Desert Hills	EB/WB	3/4/2008	2	16	71	691
				3/5/2008	1	23	82	62
				3/6/2008	0	12	85	513
				3/8/2008	6	13	51	
				3/19/2008	8	15	128	562
				3/20/2008	7	12	130	361
3	CA-91	Peralta	EB/WB	4/21/2008	6	14	59	
				4/22/2008	6	14	64	
				4/23/2008	6	14	56	
				4/24/2008	6	13	69	
				4/28/2008	6	15	62	
				4/29/2008	6	14	76	
				5/12/2008	8	11		284
				5/13/2008	7	15		1570
4	I-5	Castaic	NB	4/2/2008	8	12	46	
				4/3/2008	7	12	70	
				4/7/2008	7	17	70	
				4/9/2008	7	12	42	
				4/10/2008	8	13	70	
5	I-15	Cajon	NB/SB	3/17/2008	7	14	28	163
				3/18/2008	7	14	26	207
				4/2/2008	7	14	33	249
				4/3/2008	8	12	14	
				4/7/2008	9	13	60	
				4/28/2008	8	15	127	
				4/29/2008	7	15	124	
				4/30/2008	7	10	34	
6	US-101	Conejo	NB	x	7	17	212	
				4/15/2008	8	15	83	
				4/16/2008	6	15	20	333
				4/17/2008	7	14	52	
				4/30/2008	6	10	54	
8	I-5	San Onofre	NB/SB	4/21/2008	7	15	141	1206
				4/22/2008	7	15	141	
				4/23/2008	7	15	143	1004
9	I-680	Walnut Creek	NB/SB	4/28/2008	7	13	80	
				4/30/2008	7	9	36	
				5/15/2008	6	15	53	
10	I-680	Mission Grade	NB	4/28/2008	6	13	64	576
				4/29/2008	7	14	112	557
				4/30/2008	x	x	25	
11	I-880	Nimitz	NB	5/19/2008	6	16	70	903
				5/20/2008	6	16	136	431
				5/21/2008	6	15	55	
12	I-580	Livermore	EB/WB	5/12/2008	6	16	132	584
				5/13/2008	6	16	134	134
				5/14/2008	6	16	135	
				5/22/2008	7	7	1	
13	US-101	Gilroy	SB	5/7/2008	7	15	201	544
				5/8/2008	9	13	200	411
14	I-15	Rainbow	NB/SB	4/28/2008	7	16	144	
				4/29/2008	7	15	138	
				4/30/2008	7	15	133	
15	5	Grapevine	SB	4/8/2008	7	15	50	695
				4/9/2008	7	15	71	384
				4/10/2008	7	14	75	1014
16	5	Santa Nella	NB / SB	5/4/2008	7	9		168
				5/5/2008	7	7	201	199
				5/6/2008	6	7	161	199

(continued)

Site ID #	Route	Name/Description	Direction	Date	Hour Start	Hour End	Number of OD Survey	Number of LP Survey
17	99	Chowchilla River	NB	4/15/2008	7	14	34	444
				4/16/2008	7	14	43	521
				4/17/2008	7	14	46	454
18	58	Keene	EB	4/21/2008	12	13		80
				4/22/2008	9	9		18
				4/23/2008	10	12		46
				5/19/2008	9	16	71	263
				5/20/2008	6	15	85	524
				5/21/2008	7	12	74	
19	58	Cache Creek	WB	4/21/2008	9	16	67	349
				4/22/2008	7	15	90	482
				4/23/2008	7	14	70	
Roadside/overpass Survey Sites								
21	I-710	Near Jct 105	NB/SB	2/26/2008	8	12		1543
				2/27/2008	6	11		3163
				2/28/2008	5	10		2044
23	I-605	Near Jct. 5	NB/SB	3/4/2008	6	13		1972
				3/5/2008	5	13		4823
				3/6/2008	8	14		3848
25	I-105	Near Jct 19	EB/WB	3/12/2008	8	13		1269
				3/13/2008	8	13		1854
26	CA-60	Near Jct 710	EB/WB	3/17/2008	8	13		1153
30	I-15	South of Jct CA 60	NB/SB	4/1/2008	9	15		863
34	CA-91	Near Jct 215	EB/WB	4/7/2008	9	9		87
				4/9/2008	8	13		459
35	CA-60	Near Jct 91	EB/WB	4/8/2008	8	14		1293
				4/9/2008	14	14		1
38	CA-237	Near Great America Parkway	EB/WB	4/13/2008	9	15		241
				4/14/2008	9	15		133
39	I-880	Near Oakland/Jct Rte 77	NB/SB	4/15/2008	8	14		2892
40	I-280	Near Daly City/Ocean Ave	NB/SB	4/16/2008	8	15		679
41	US-101	Near Jct 84	NB/SB	4/17/2008	8	15		1521
42	I-5	At Arena Bl (95834)	NB/SB	4/21/2008	8	16		2644
47	CA-99	Fowler	NB/SB	4/29/2008	8	23		2814
49	CA-198	Near Jct 41	EB/WB	4/30/2008	13	24		419
50	CA-46	Near Jct 43	EB/WB	5/8/2008	8	14		405
51	Etiwanda and the 60			4/15/2008	6	13	162	
52	Riverside and Agua Mansa (colton)			4/16/2008	6	12	106	
53	91 Fwy and the 15 Fwy (Corona)			4/17/2008	6	9	35	
Total							6215	54570

2) Regional Allocation Based on OD Survey Data

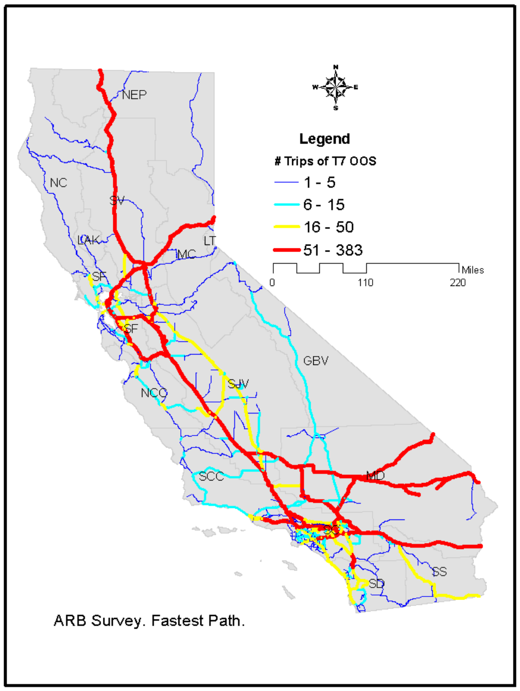
To analyze OD data staff used the NORTAD (BTS, 1998) roadway network, which is comprised of the North American Transportation Atlas, as well as highway networks representing Mexico and Canada. This roadway network included an estimate of the congested speed and length of each roadway link. The United States Geological Survey Geographic Names Information System (USGS, 2009) and other internet sources were used to assign GIS coordinates for each origin and destination in the OD database. Using ArcGIS Network Analyst and congested speeds for each link staff estimated the route traveled for each origin-destination pair in the OD database using both a fastest path and a shortest path algorithm. Results were assessed visually using GIS, and quantitatively by calculating VMT by truck category and air basin. Because the number of samples collected at each survey location is not proportional to the number of trips passing the specific location, staff scaled up the trip-VMT based on the Average Annual Daily Truck Traffic (AADTT) at the locations where the trips were observed. Staff used Caltrans reported AADTT for location on state highways[5] (Caltrans, 2009) and FAF2 AADTT for off-highway locations (FHWA, 2008).

Results showed that many trucks traveling in California are also participating in trucking activities across the United States. More importantly, results suggested interstate trucks have a different travel pattern from trucks that do not travel outside of California, and that California registered single-unit trucks have a different travel pattern from California-registered tractors. While this finding is relatively intuitive, the field study data represent the first attempt at a quantitative study to assess differences in travel patterns across different types of trucking. Figure 7 compares the OD results visually across four inventory categories.

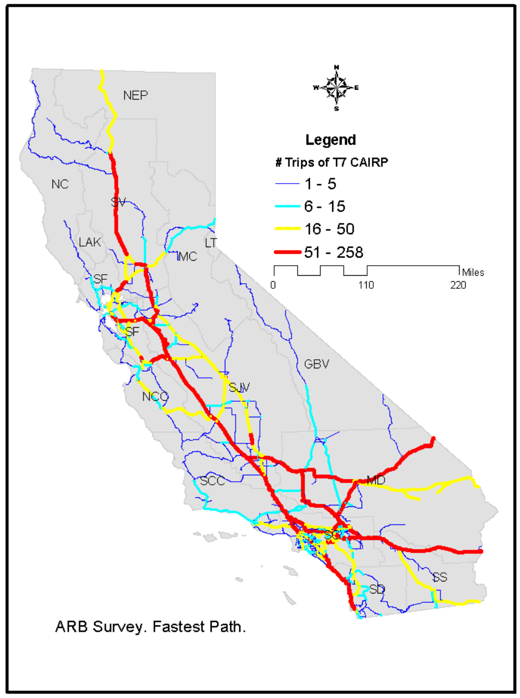
[5] Caltrans Truck Traffic report only provides AADTT on California State Highways.

Figure 7. Estimated Travel Pattern by Inventory Category

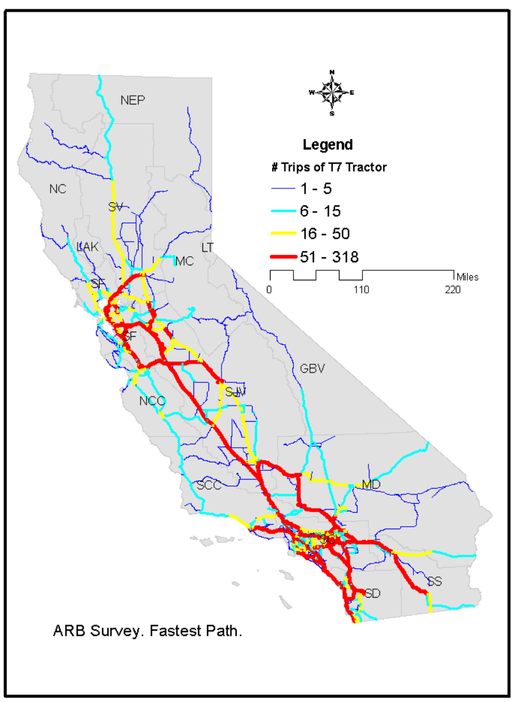
HHDDT Out-of-State



HHDDT CAIRP



HHDDT Tractor



MHDDT

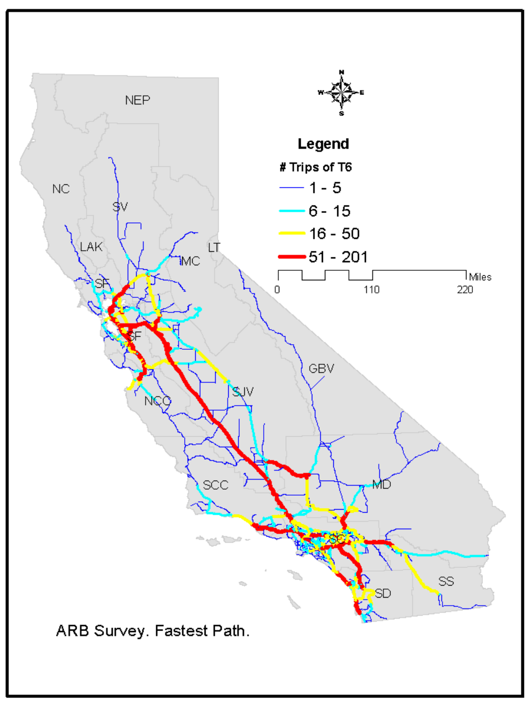


Figure 8 compares results from all trucking categories in the OD data to results generated through the US Freight Analysis Framework (FAF2), (FHWA, 2008). Results are generally similar, and reflect differences between the various approaches and mix of vehicles contained in each study. Table 9 presents the percentage of travel by air basin estimated using the OD data by inventory category.

Figure 8. Heavy Duty Truck Travel Patterns: ARB OD Survey Results vs. FAF2

ARB OD Survey ***FAF2 Truck Flow***

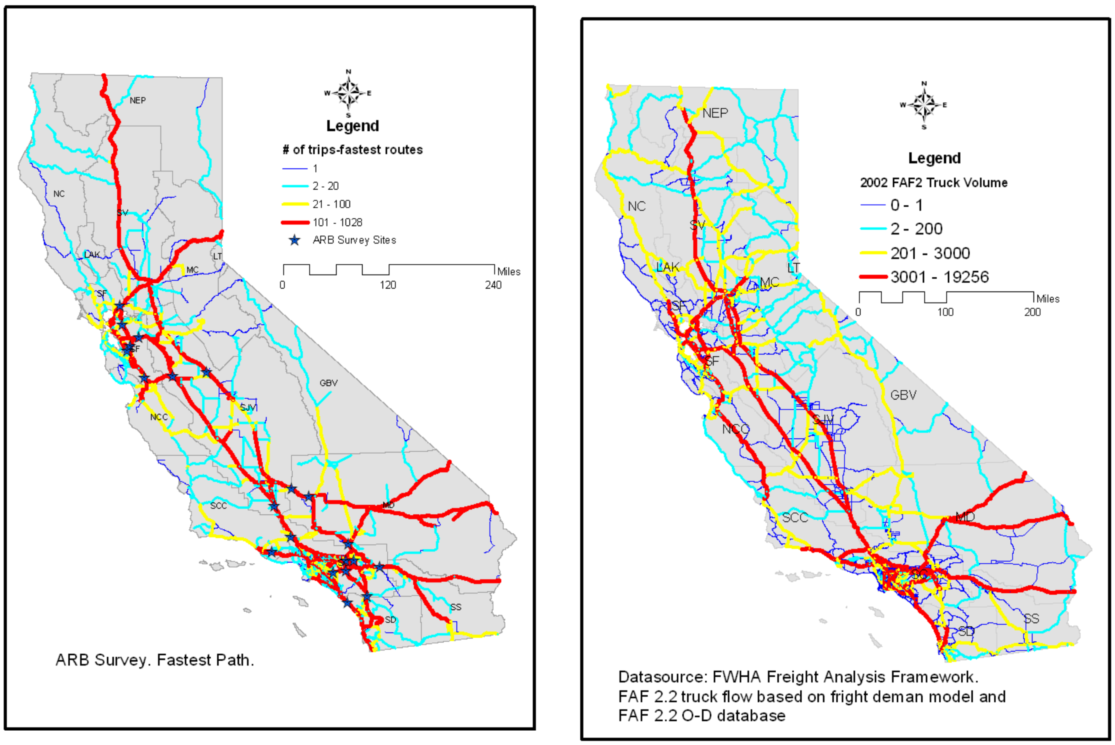


Table 9. Truck VMT Regional Allocation Factors by Fleet Based on OD Analysis

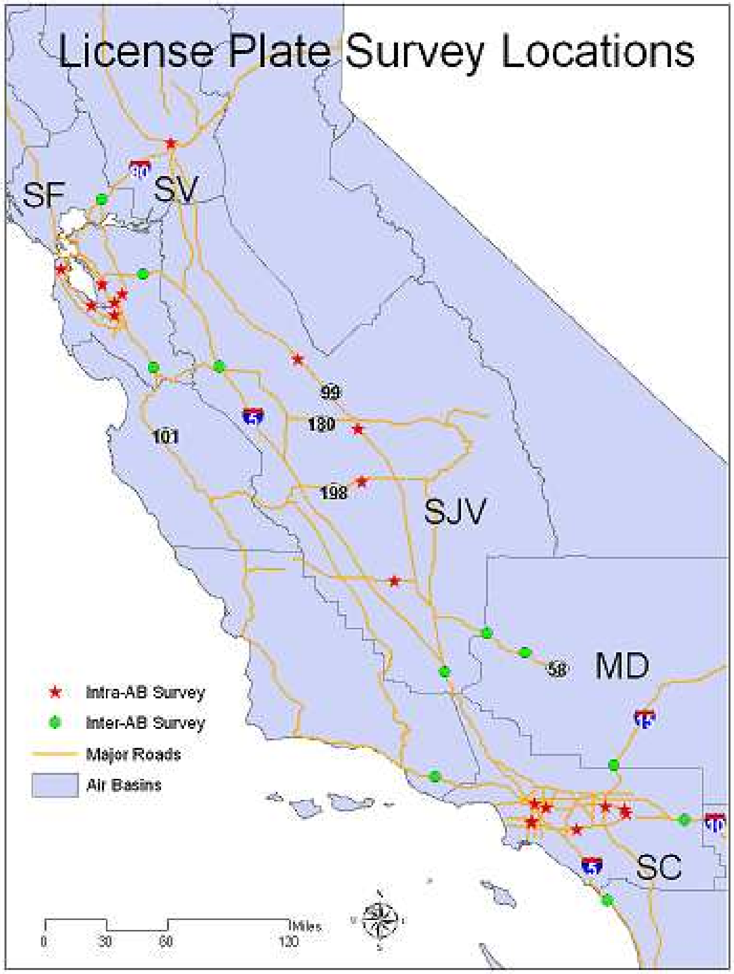
Air Basin	HHDDT OOS	HHDDT CA IRP	HHDDT Tractor	HHDDT Single	HHDDT All	MHDDT All
Great Basins Valley	0.3%	0.6%	0.2%	0.2%	0.3%	0.4%
Lake County	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Lake Tahoe	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mountain Counties	2.6%	0.9%	0.6%	0.6%	1.6%	0.9%
Mojave Desert	27.7%	19.3%	5.8%	10.4%	19.1%	11.7%
North Coast	0.4%	0.3%	0.4%	0.7%	0.4%	0.8%
North Central Coast	0.4%	0.5%	0.8%	0.9%	0.6%	0.9%
Northeast Plateau	3.2%	2.6%	0.4%	0.0%	2.2%	0.1%
South Coast	14.3%	21.1%	28.6%	24.9%	20.2%	26.2%
South Central Coast	0.5%	0.6%	1.0%	2.2%	0.7%	1.8%
San Diego County	1.3%	2.9%	6.7%	3.9%	3.2%	5.0%
San Francisco Bay	4.5%	4.0%	10.8%	15.1%	6.4%	12.3%
San Joaquin Valley	29.2%	33.1%	37.9%	36.9%	32.8%	30.7%
Salton Sea	2.8%	3.8%	3.1%	2.6%	3.1%	4.8%
Sacramento Valley	12.8%	10.4%	3.7%	1.6%	9.3%	4.4%
Total	100%	100%	100%	100%	100%	100%

3) OD and LP Survey Data Analysis

In addition to evaluating the OD analysis results, staff developed an alternative analysis using both the LP and OD data. The general approach was to estimate the number of inter air basin trips and intra air basin trips by inventory category and air basin, and to multiply those trip estimates by an assumed trip length within each air basin to estimate VMT by air basin for each inventory truck category. These results could then be used to develop a percent VMT allocation by inventory truck category.

The first step in this process was to separate LP data collection sites into two types: inter-regional sites and intra-regional sites. Inter-regional sites are located near the border of one air basin and were likely to capture inter-regional truck trips, while intra-regional sites were located in the middle of air basins and were likely to capture trips within a single air basin. Interregional site are marked with circles and intra-regional sites are marked with stars as shown in Figure 9.

Figure 9. License Plate Survey Locations by Trip Type



License plates surveyed were then cross-referenced to the California DMV registration database to obtain vehicle registration information. Based on the location of vehicle registration, staff separated data at each site into trucks traveling inside or outside of the air basin in which they were registered. Since the survey was conducted in selected urban areas (South Coast and Bay area) and rural areas (Mojave Desert and San Joaquin Valley) in California, we also grouped the LPs into urban and rural groups. The average fractions of trips by trucks registered inside vs. outside of an air basin observed at inter-air basin locations and intra-air basin locations, respectively, are shown in Table 10, where "inAB" refers to trucks traveling within their air basin of registration and "outAB" refers to trucks traveling outside their air basin of registration.

Table 10. Average Percentages of Truck License Plates by Registered Air Basin for Intra and Inter Air Basin Survey Location Groups

Air Basin Group	Survey Location	T7CAIRP		T7Tractor		T7Single		T6	
		inAB	outAB	inAB	outAB	inAB	outAB	inAB	outAB
SC	Inter	0.34	0.66	0.37	0.63	0.43	0.57	0.39	0.61
SC	Intra	0.76	0.24	0.89	0.11	0.92	0.08	0.90	0.10
SF	Inter	0.20	0.80	0.40	0.60	0.48	0.52	0.46	0.54
SF	Intra	0.27	0.73	0.56	0.44	0.70	0.30	0.76	0.24
MD	Inter	0.15	0.85	0.09	0.91	0.06	0.94	0.10	0.90
SJV	Inter	0.25	0.75	0.32	0.68	0.40	0.70	0.22	0.81
SJV	Intra	0.52	0.48	0.71	0.29	0.82	0.18	0.66	0.34
URBAN	Inter	0.28	0.72	0.38	0.62	0.45	0.55	0.41	0.59
URBAN	Intra	0.63	0.37	0.80	0.20	0.86	0.14	0.86	0.14
RURAL	Inter	0.22	0.78	0.25	0.75	0.26	0.74	0.17	0.83
RURAL	Intra	0.52	0.48	0.71	0.29	0.82	0.18	0.66	0.34

Staff categorized three types of trips for each area basin and inventory category: trips within an air basin by local trucks (trucks registered in that air basin), inter-air basin trips by local trucks, and inter-air basin trips by non-local trucks (trucks registered outside of the air basin of travel). Staff assumed that the distribution of the number of trips is consistent with the distribution of the overall truck population, and that at intra-regional sites the observed ratio of trips between local trucks and non-local trucks represented the real ratio of population of trucks registered in vs. out of the specific air basin. The population of trucks registered in each air basin was obtained from analyzing DMV truck registration data.

The non-local truck population was estimated using the local truck population and the ratio of non-local to local trips observed at intra-regional sites (Equation 2). Next, staff assumed that at inter-regional sites, the observed ratio of trips by local trucks vs. non-local trucks represented the ratio of population between local trucks making inter-regional trips and non-local trucks making inter-regional trips. Thus the population of local trucks making inter-regional trips was derived using the population of non-local trucks and the ratio of trips observed at inter-regional sites (Equation 3). Finally, the population of local-trucks that make inter-regional trips is estimated as the difference between total registered population in the air basin and the population of local trucks making inter-regional trips (Equation 4). Staff also assumed that the existence of non-local trucks traveling completely within an air basin is insignificant and distributed evenly statewide, and therefore will not affect the analysis.

$$PIO_{ab,fl} = P_{ab,fl} * (RAO_{ab,fl} / RAI_{ab,fl})$$ **Equation 2**

$$PII_{ab,fl} = PIO_{ab,fl} * (RII_{ab.fl} / RIO_{ab,fl})$$ **Equation 3**

$$PIR_{ab,fl} = P_{ab,fl} - PII_{ab,fl}$$ **Equation 4**

where,
PIO = the population of trucks traveling in and out of an air basin other than the air basin in which they are registered.
ab = air basin
fl = inventory category
P = truck population registered in an air basin by inventory category
RAO = the average fraction of trucks traveling in an air basin other than their registration air basin, seen at an intra-air basin survey location
RAI = the average fraction of trucks traveling in their registration air basin, seen at an intra-air basin survey location.
PII = the population of trucks traveling in and out of their registration air basin, seen at an inter-air basin survey location
RII = the average fraction of trucks traveling in an air basin where they are registered, seen at an inter-air basin survey location
RIO = the average fraction of trucks traveling in an air basin other than their registration air basin, seen at an inter-air basin survey location
PIR = the population of trucks traveling completely in their registration air basin

The relative ratio between the above populations reflected the relative ratio of trips by corresponding population. It should be noted that it is the relative ratio, not the absolute value that impacts the regional allocation. Table 11, Table 12, and Table 13 display estimated truck population (surrogate for trips) by trip type and inventory category.

Table 11. Intra Air Basin Truck Population by Trucks Registered in the Air Basin

Air Basin	HHDDT CA IRP	HHDDT In-State Tractor	HHDDT In-State Single	MHDDT All
South Coast	168,447	240,514	112,619	2,471,067
San Francisco	6,829	34,336	30,360	828,013
Mojave Desert	16,845	10,110	8,409	106,131
San Joaquin Valley	51,421	102,215	45,940	667,300
Great Basins Valley	255	316	462	3,894
Lake County	44	462	673	6,368
Lake Tahoe	444	21	131	3,468
Mountain Counties	2,585	4,281	7,811	69,687
North Coast	1,548	4,057	6,914	38,309
North Central Coast	6,047	7,450	7,051	90,369
Northeast Plateau	1,535	1,069	1,357	9,917
Sacramento Valley	25,513	33,221	28,210	354,499
South Central Coast	3,963	13,572	14,200	243,396
San Diego County	12,124	34,952	21,444	419,807
Salton Sea	4,613	10,455	5,494	76,899

Table 12. Inter Air Basin Truck Population by Trucks Registered in the Air Basin

Air Basin	HHDDT CA IRP	HHDDT In-State Tractor	HHDDT In-State Single	MHDDT All
South Coast	32,887	20,005	8,320	193,157
San Francisco	15,872	37,841	20,264	307,155
Mojave Desert	3,406	411	124	6,541
San Joaquin Valley	22,772	24,695	6,798	110,492
Great Basins Valley	151	111	105	2,250
Lake County	26	161	153	3,680
Lake Tahoe	263	7	30	2,004
Mountain Counties	439	598	1,002	7,753
North Coast	916	1,417	1,577	22,139
North Central Coast	3,578	2,602	1,608	52,223
Northeast Plateau	908	373	309	5,731
Sacramento Valley	15,094	11,600	6,433	204,861
South Central Coast	1,371	2,185	1,214	30,172
San Diego County	2,282	3,107	1,271	15,297
Salton Sea	1,596	1,683	470	9,533

Table 13. Inter Air Basin Truck Population by Trucks Registered out of the Air Basin

Air Basin	HHDDT OOS	HHDDT CA IRP	HHDDT Tractor	HHDDT Single	MHDDT All
South Coast	1,319,639	64,380	33,720	10,997	299,380
San Francisco	257,693	62,613	56,087	21,777	367,524
Mojave Desert	153,728	19,005	4,358	1,927	58,710
San Joaquin Valley	728,206	69,627	52,563	11,909	405,282
Great Basins Valley	3,341	381	177	128	3,201
Lake County	3,625	66	258	187	5,236
Lake Tahoe	2,139	663	12	36	2,851
Mountain Counties	39,897	1,108	956	1,218	11,031
North Coast	39,212	2,312	2,267	1,917	31,498
North Central Coast	67,631	9,033	4,163	1,955	74,300
Northeast Plateau	13,249	2,293	597	376	8,154
Sacramento Valley	286,578	38,108	18,564	7,823	291,464
South Central Coast	87,128	5,006	6,526	3,481	142,547
San Diego County	167,315	8,329	9,280	3,643	72,270
Salton Sea	58,024	5,827	5,027	1,347	45,037

Next staff converted the estimated population of trucks by trip type, air basin and fleet category to VMT by trip type, air basin and fleet category. This required estimation of average travel distance within each air basin for each trip type. Average travel distances per trip were estimated using the OD data. Each OD record was cross-referenced to the DMV database to identify the air basin in which each truck was registered. Using these data, staff calculated the average travel miles by travel air basin, trip type and inventory category. In evaluating the OD data, staff found that intra-air basin trips were under-represented. This was a consequence of conducting surveys at weigh stations which tend to be located in between air basins and capture inter-regional travel. As a result, staff estimated an average intra-air basin trip distance based on travel demand model output developed by SCAG and the San Joaquin Valley transportation agencies in their heavy-duty truck models. Average travel miles of intra-air basin trips by HHDDT and MHDDT were estimated to be 25 and 20 miles, respectively, in San Joaquin Valley air basin (Cambridge Systematics, 2008), and 15 and 13 miles, respectively, in South Coast air basin (SCAG, 1999). For inter-air basin trips, that is, trips traversing multiple air basins, staff divided trips into segments in each air basin and compiled the average travel miles in each air basin by trip type. For interstate trips, only travel miles accrued within California were used. Table 14 and Table 15 show average travel miles within a specific air basin for inter air basin truck trips by local trucks and those by non-local trucks, respectively.

Table 14. Average Travel Miles for Inter Air Basin Truck Trips by Trucks Registered in the Air Basin

Air Basin	HHDDT CA IRP	HHDDT In-State Tractor	HHDDT In-State Single	MHDDT All
South Coast	97	85	59	67
San Francisco	62	53	61	61
Mojave Desert	104	56	28	40
San Joaquin Valley	182	138	70	77
Great Basins Valley	115	74	39	54
Lake County	99	74	39	54
Lake Tahoe	99	74	39	54
Mountain Counties	99	74	39	33
North Coast	99	74	39	54
North Central Coast	55	52	28	39
Northeast Plateau	82	74	39	54
Sacramento Valley	100	58	44	46
South Central Coast	48	40	46	33
San Diego County	75	77	65	47
Salton Sea	107	102	17	107

Table 15. Average Travel Miles for Inter Air Basin Truck Trips by Trucks Not Registered in the Air Basin

Air Basin	HHDDT OOS	HHDDT CA IRP	HHDDT In-State Tractor	HHDDT In-State Single	MHDDT All
South Coast	88	108	97	70	75
San Francisco	66	56	56	56	56
Mojave Desert	169	135	91	68	80
San Joaquin Valley	207	190	149	189	163
Great Basins Valley	160	127	68	131	118
Lake County	97	100	66	76	77
Lake Tahoe	13	100	2	76	77
Mountain Counties	65	47	36	61	38
North Coast	72	114	65	65	82
North Central Coast	53	57	45	33	38
Northeast Plateau	83	81	83	76	82
Sacramento Valley	136	129	75	52	66
South Central Coast	45	48	40	48	41
San Diego County	55	64	61	59	53
Salton Sea	66	73	69	40	61

To calculate regional allocation factors by inventory category using the LP and OD study data, staff multiplied the estimated trips per air basin by inventory category by the assumed average travel miles per trip by air basin by inventory category. Results are shown in Table 16.

Table 16. Truck VMT Regional Allocation Factors by Fleet Based on OD/LP Analysis

Air Basin	HHDDT OOS	HHDDT CAIRP	HHDDT In-State Tractor	HHDDT In-State Single	HHDDT All	MHDDT All
South Coast	30.4%	24.9%	24.1%	21.1%	26.9%	23.2%
San Francisco	4.3%	10.5%	15.9%	20.7%	9.9%	17.2%
Mojave Desert	7.2%	6.6%	1.9%	2.5%	5.3%	2.4%
San Joaquin Valley	40.4%	36.6%	38.7%	27.8%	38.0%	30.1%
Great Basins Valley	0.1%	0.1%	0.1%	0.2%	0.1%	0.2%
Lake County	0.1%	0.0%	0.1%	0.3%	0.1%	0.2%
Lake Tahoe	0.0%	0.2%	0.0%	0.1%	0.0%	0.1%
Mountain Counties	0.7%	0.3%	0.5%	2.2%	0.7%	0.7%
North Coast	0.7%	0.8%	1.0%	2.6%	1.0%	1.6%
North Central Coast	1.0%	1.7%	1.4%	2.1%	1.3%	2.3%
Northeast Plateau	0.3%	0.6%	0.3%	0.5%	0.4%	0.4%
Sacramento Valley	10.3%	13.9%	8.1%	10.0%	10.5%	12.3%
South Central Coast	1.0%	0.8%	1.9%	4.1%	1.5%	4.0%
San Diego County	2.4%	1.7%	3.7%	4.4%	2.8%	3.4%
Salton Sea	1.0%	1.4%	2.2%	1.4%	1.4%	1.8%
Total	100%	100%	100%	100%	100%	100%

4) Discussion of Field Study Results

The ARB field study is the most comprehensive study of its kind that has been conducted to date on truck travel in California. Results show significant differences in truck travel between broad types of trucking operations in California that are important to consider when developing an emissions inventory representing heavy duty trucks. Despite the large amount of data collected there are still some limitations to consider. For example, it was necessary to obtain OD data primarily at weigh stations. This was done for practical purposes as conducting OD surveys at most roadside locations is disruptive to traffic and places survey staff unacceptably close to traffic. However most weigh stations are located on roadways on the outskirts of urban areas and as a result will see more inter-regional than intra-regional trips. As was observed in the LP data, most trips at roadside locations were intra-air basin trips traveled by trucks that are also registered in the air basin – local trips for which OD data were limited. In another example, while many sites were sampled, some regions, especially rural areas such as the northern portion of the state were not well covered by the field study due to staffing limitations on data collection. Regional allocation factors developed to represent these areas may be more uncertain as a result.

In light of these limitations, staff evaluated field study results along with other corroborative data on an inventory category specific basis to decide on regional allocation factors for each category.

E. Regional Allocation of Activity and Emissions

Staff derived a regional allocation for each truck category by analyzing relevant field study results and corroborative data sources specific to the trucking type or vocation.

1) Interstate Trucks

Table 17 compares the regional distribution factors developed using the OD and OD/LP approaches to regional distribution assumptions in EMFAC2002 and EMFAC2007.

Table 17. Comparison of CA Interstate Truck VMT Regional Allocations

Air Basin	OD	LP/OD	EMFAC2002	EMFAC2007	Assumed
Great Basins Valley	0.6%	0.1%	0.2%	0.6%	0.6%
Lake County	0.0%	0.0%	0.1%	0.0%	0.0%
Lake Tahoe	0.0%	0.2%	0.1%	0.1%	0.1%
Mountain Counties	0.9%	0.3%	1.1%	1.8%	1.8%
Mojave Desert	19.3%	6.7%	1.5%	15.1%	15.1%
North Coast	0.3%	0.8%	1.3%	1.4%	1.4%
North Central Coast	0.5%	1.7%	2.5%	1.8%	1.8%
Northeast Plateau	2.6%	0.6%	0.3%	1.5%	1.5%
South Coast	21.1%	25.2%	36.9%	20.0%	20.0%
South Central Coast	0.6%	0.8%	2.6%	1.3%	1.3%
San Diego County	2.9%	1.8%	7.5%	3.8%	3.8%
San Francisco Bay	4.0%	9.1%	17.3%	7.8%	7.8%
San Joaquin Valley	33.1%	37.2%	17.6%	28.9%	28.9%
Salton Sea	3.8%	1.4%	1.8%	6.5%	6.5%
Sacramento Valley	10.4%	14.1%	9.3%	9.6%	9.6%
Total	100%	100%	100%	100%	100%

ARB staff revised the VMT distribution for HHDDT in EMFAC2007, as documented in ARB (2006a). The document described the redistribution of HHDDT VMT from a registration to a travel basis. The travel based VMT distribution was estimated using a combination of data from a survey conducted by California Department of Transportation (Caltrans) in 1999, and modeled information from MVSTAFF, an annual report developed by Caltrans. Detailed descriptions of the methodologies in developing the VMT redistribution can be found in the Technical Memo. Although the distribution was applied to the entire HHDDT fleet in EMFAC2007, the underlying Caltrans survey was geared toward long-haul trucks since the survey data were collected at weigh stations, agricultural inspection stations and rest areas.

The ARB 2008 field study was designed to focus on intra-California trips. Compared to the Caltrans 1999 study, the ARB field study captured more intra-state trips and local trips in both origin-destination and license plate data. In particular, two thirds of the license plate data were collected at roadside locations where intra-state trips were more likely to be captured. As a result, regional allocations based on the OD and LP analysis is not appropriate for distributing inter-state trip VMT. Staff chose to use the regional allocation developed for HHDDT VMT redistribution in EMFAC2007 for all interstate trucks, including out-of-state registered trucks and California registered inter-state trucks. The "assumed" allocations in the table were used for interstate fleets.

2) Heavy-Heavy Duty In-State Tractors

Table 18 compares regional distribution factors developed using the OD and OD/LP approaches to assumptions in EMFAC2002 and EMFAC2007.

Table 18. Comparison of CA In-State Tractor HHDT VMT Regional Allocations

Air Basin	OD	LP/OD	EMFAC2002	EMFAC2007	Assumed
Great Basins Valley	0.2%	0.1%	0.2%	0.6%	0.16%
Lake County	0.0%	0.1%	0.1%	0.0%	0.06%
Lake Tahoe	0.0%	0.0%	0.1%	0.1%	0.00%
Mountain Counties	0.6%	0.5%	1.1%	1.8%	0.56%
Mojave Desert	5.8%	1.9%	1.5%	15.1%	3.83%
North Coast	0.4%	1.0%	1.3%	1.4%	0.71%
North Central Coast	0.8%	1.4%	2.5%	1.8%	1.13%
Northeast Plateau	0.4%	0.3%	0.3%	1.5%	0.32%
South Coast	28.6%	24.1%	36.9%	20.0%	26.34%
South Central Coast	1.0%	1.9%	2.6%	1.3%	1.49%
San Diego County	6.7%	3.7%	7.5%	3.8%	5.20%
San Francisco Bay	10.8%	15.9%	17.3%	7.8%	13.34%
San Joaquin Valley	37.9%	38.7%	17.6%	28.9%	38.32%
Salton Sea	3.1%	2.2%	1.8%	6.5%	2.61%
Sacramento Valley	3.7%	8.1%	9.3%	9.6%	5.93%
Total	100%	100%	100%	100%	100%

The HHDDT in-state tractor fleet category is a mix of vocational trucks that are dedicated to specific industries/services and travel mostly in California close to their base of operations, and trucking companies that regularly travel across California. Therefore neither a travel based nor a registration based allocation would fully describe the HHDDT tractor travel. ARB field study results are particularly relevant to this category.

Although the scale of OD survey conducted by ARB in 2008 was smaller than Caltrans survey in 1999, it was designed to capture both inter-regional and local trips by different inventory categories, and was supplemented by the large-scale LP survey. Staff used the average of the results from OD survey, and OD/LP survey for the regional allocation as shown in Table 18.

3) Heavy-Heavy Duty In-State Single-Unit Trucks

Staff believes the vast majority of single-unit trucks make short haul trips because the trucks are generally used for local delivery or vocational applications such as street sweeping, liquids transport, drilling and other uses. These types of trips were under-represented in both the Caltrans 1999 study and the ARB field study. The degree to which local trips were under-estimated is highly uncertain and depends on the selection of survey locations. Therefore, regional allocations developed based on these survey data are not appropriate for allocating single-unit truck VMT. Staff assumed that single-unit trucks travel mostly in their registered air basin and applied a registration-based regional allocation method. This assumption was supported by our observations in the ARB field study. Staff developed registration populations by air basin from DMV data after excluding specific fleets including agricultural trucks and construction trucks, and multiplied populations with age-specific accrual rates to derive VMT by registration area basin. Table 19 presents regional distribution factors developed using the OD and OD/LP approaches, regional distribution assumptions in EMFAC2002 and EMFAC2007 and the one developed in this analysis.

Table 19. Comparison of CA In-state Single-Unit HHDT VMT Regional Allocations

Air Basin	OD	LP/OD	EMFAC2002	EMFAC2007	Assumed
Great Basins Valley	0.2%	0.2%	0.2%	0.6%	0.1%
Lake County	0.0%	0.3%	0.1%	0.0%	0.1%
Lake Tahoe	0.0%	0.1%	0.1%	0.1%	0.1%
Mountain Counties	0.6%	2.2%	1.1%	1.8%	2.5%
Mojave Desert	10.4%	2.5%	1.5%	15.1%	1.6%
North Coast	0.7%	2.6%	1.3%	1.4%	2.4%
North Central Coast	0.9%	2.1%	2.5%	1.8%	2.3%
Northeast Plateau	0.0%	0.5%	0.3%	1.5%	0.0%
South Coast	24.9%	21.1%	36.9%	20.0%	40.7%
South Central Coast	2.2%	4.1%	2.6%	1.3%	4.3%
San Diego County	3.9%	4.4%	7.5%	3.8%	7.7%
San Francisco Bay	15.1%	20.7%	17.3%	7.8%	18.0%
San Joaquin Valley	36.9%	27.8%	17.6%	28.9%	10.1%
Salton Sea	2.6%	1.4%	1.8%	6.5%	1.1%
Sacramento Valley	1.6%	10.0%	9.3%	9.6%	9.0%
Total	100%	100%	100%	100%	100%

4) Medium-Heavy Duty In-State Trucks

Like HHDDT single-unit trucks, MHDDT instate trucks mostly make local delivery or vocational trips that were under-represented in both the Caltrans 1999 and ARB 2008 OD surveys. Staff applied the registration-based regional allocation method to medium-heavy duty in-state trucks, including both GVWR above and below 26,000 lbs. Table 20 compares regional distribution factors developed using the OD and OD/LP approaches, regional distribution assumptions in EMFAC2002 and EMFAC2007 and the one developed in this analysis.

Table 20. Comparison of CA In-State MHDDT VMT Regional Allocations

Air Basin	OD	LP/OD	EMFAC2002	EMFAC2007	Assumed
Great Basins Valley	0.4%	0.2%	0.2%	0.1%	0.1%
Lake County	0.0%	0.2%	0.1%	0.1%	0.1%
Lake Tahoe	0.0%	0.1%	0.1%	0.1%	0.1%
Mountain Counties	0.9%	0.7%	1.1%	0.9%	1.1%
Mojave Desert	11.7%	2.4%	1.5%	2.2%	1.4%
North Coast	0.8%	1.6%	1.3%	0.7%	0.8%
North Central Coast	0.9%	2.3%	2.5%	2.6%	2.0%
Northeast Plateau	0.1%	0.4%	0.3%	0.2%	0.0%
South Coast	26.2%	23.2%	36.9%	42.5%	44.5%
South Central Coast	1.8%	4.0%	2.6%	3.5%	4.1%
San Diego County	5.0%	3.4%	7.5%	7.9%	7.3%
San Francisco Bay	12.3%	17.2%	17.3%	17.1%	19.0%
San Joaquin Valley	30.7%	30.1%	17.6%	12.1%	9.9%
Salton Sea	4.8%	1.8%	1.8%	1.3%	1.0%
Sacramento Valley	4.4%	12.3%	9.3%	8.7%	8.6%
Total	100%	100%	100%	100%	100%

5) Drayage Trucks

Drayage trucks were not identified during the 2008 field study and as a result were not specifically analyzed as part of that study. The regional allocation of drayage truck emissions is based upon the emissions analysis developed for ARB's Drayage Truck Regulation (ARB, 2007a). As described in Appendix B of the Technical Support Document for the Drayage Truck Regulation, the regional allocations were based on OD surveys conducted by Ports of Los Angles and Long Beach and a study done by the Metropolitan Transportation Commission in the Bay Area. Using the study results, staff estimated VMT in each air basin by the drayage trucks serving the ports and developed the regional allocations. These are shown in Table 21.

Table 21. Comparison of CA Drayage Truck Regional Allocations

Air Basin	Los Angeles Ports/Railyards	Bay Are Ports/Railyards	Other Drayage Trucks
Great Basins Valley	0.0%	0.0%	0.0%
Lake County	0.0%	0.0%	0.0%
Lake Tahoe	0.0%	0.0%	0.0%
Mountain Counties	0.0%	2.0%	0.0%
Mojave Desert	4.3%	0.0%	0.0%
North Coast	0.0%	0.0%	3.5%
North Central Coast	0.0%	1.7%	0.0%
Northeast Plateau	0.0%	0.0%	0.0%
South Coast	81.7%	0.0%	0.0%
South Central Coast	0.1%	0.0%	11.6%
San Diego County	1.4%	0.0%	34.0%
San Francisco Bay	0.0%	63.6%	28.8%
San Joaquin Valley	8.8%	28.2%	18.3%
Salton Sea	3.7%	0.0%	0.0%
Sacramento Valley	0.0%	4.5%	3.9%
Total	100%	100%	100%

6) Construction Trucks

For construction fleets, staff assumed that the regional allocation is proportional to the regional rate of population growth. This surrogate is designed to reflect where populations are growing and therefore where construction is more likely to be focused. The Demographic Research Unit of California Department of Finance (DOF, 2009) provides population estimates and projections by county. The populations within counties were then distributed into air basins based on census data. Staff calculated the year to year increase in population within each air basin and used the fraction of the population growth in air basin versus statewide growth as a surrogate for construction fleets regional allocation. The resulting allocations are shown in Table 22 for calendar year 2008, and projected for 2020 and 2030 where DOF provided a population forecast. Staff interpolated regional allocation factors linearly between forecast years.

Table 22. Regional Allocation for Construction Fleets

Air Basin	Calendar Year		
	2008	2020	2030
Great Basin Valleys	0.0%	0.1%	0.1%
Lake County	0.1%	0.2%	0.2%
Lake Tahoe	0.2%	0.2%	0.2%
Mountain Counties	0.3%	1.5%	1.2%
Mohave Desert	2.4%	3.4%	3.2%
North Coast	0.3%	0.7%	0.6%
North Central Coast	1.7%	1.6%	1.7%
Northeast Plateau	0.0%	0.3%	0.2%
South Coast	35.4%	37.7%	31.9%
South Central Coast	3.0%	3.0%	2.8%
San Diego	10.7%	6.5%	7.8%
San Francisco Bay	22.0%	10.1%	13.7%
San Joaquin Valley	13.1%	21.7%	23.3%
Salton Sea	3.0%	3.8%	3.3%
Sacramento Valley	7.7%	9.3%	9.7%
Total	100%	100%	100%

7) Agricultural Trucks

ARB staff, in conjunction with agricultural trade associations, administered a survey to farmers, ranchers, and other agricultural businesses designed to identify and characterize trucks serving the agricultural sector. The results were used to develop population, age distribution and accrual rates as described in the Appendix G of the Technical Support Document (ARB, 2008). In addition to the characteristics in Appendix G, the survey also collected information regarding where the trucks had traveled. The results indicated that although most of the agricultural trucks traveled within one air basin boundary, about 30 percent of them did travel across air basins. The results, shown in Table 23 are generally consistent with the distribution of irrigated acreage given the 30 percent of agricultural trucks that travel across multiple regions. In this analysis, staff used the agricultural survey-based regional allocation factors.

Table 23. Regional Allocation for Agricultural Activities

Air Basin	Irrigated Acreage	Agricultural Truck Survey	Assumed
Great Basins Valley	0.3%	0.3%	0.3%
Lake County	0.8%	1.6%	1.6%
Lake Tahoe	0.0%	0.0%	0.0%
Mountain Counties	1.1%	2.1%	2.1%
Mojave Desert	5.3%	0.7%	0.7%
North Coast	0.6%	5.3%	5.3%
North Central Coast	4.2%	3.9%	3.9%
Northeast Plateau	5.0%	2.3%	2.3%
South Coast	0.5%	2.4%	2.4%
South Central Coast	4.1%	4.6%	4.6%
San Diego County	1.1%	2.1%	2.1%
San Francisco Bay	2.1%	6.5%	6.5%
San Joaquin Valley	49.3%	45.1%	45.1%
Salton Sea	5.5%	3.7%	3.7%
Sacramento Valley	20.0%	19.3%	19.3%
Total	100%	100%	100%

8) Utility Trucks

A utility company is defined in the fleet rule for public agencies and utilities as a privately-owned company that provides water, natural gas, and electricity (ARB, 2006b). Some of the large utility companies that operate throughout California register all their trucks at their corporate office making it infeasible to use the actual registration data to allocate utility fleet VMT. However, staff believes most utility trucks are used to service the general population and would have similar allocation as MHDDTs. As a result, staff assumed the same MHDDT spatial allocation in EMFAC 2007 for utility trucks, as shown in Table 24.

Table 24. Regional Allocation for Utility Trucks

Air Basin	MHDDT Utility	HHDDT Utility	MHDDT EMFAC 2007	HHDDT EMFAC 2007
Great Basins Valley	0.1%	0.1%	0.1%	0.6%
Lake County	0.1%	0.1%	0.1%	0.0%
Lake Tahoe	0.1%	0.1%	0.1%	0.1%
Mountain Counties	0.9%	0.9%	0.9%	1.8%
Mojave Desert	2.2%	2.2%	2.2%	15.1%
North Coast	0.7%	0.7%	0.7%	1.4%
North Central Coast	2.6%	2.6%	2.6%	1.8%
Northeast Plateau	0.2%	0.2%	0.2%	1.5%
South Coast	42.5%	42.5%	42.5%	20.0%
South Central Coast	3.5%	3.5%	3.5%	1.3%
San Diego County	7.9%	7.9%	7.9%	3.8%
San Francisco Bay	17.1%	17.1%	17.1%	7.8%
San Joaquin Valley	12.1%	12.1%	12.1%	28.9%
Salton Sea	1.3%	1.3%	1.3%	6.5%
Sacramento Valley	8.7%	8.7%	8.7%	9.6%
Total	100%	100%	100%	100%

9) Regional Allocation Results

Using the regional allocation described in the previous section, staff estimated the MHDDT and HHDDT VMT for each air basin and calendar year. Table 25 shows the VMT results for selected air basin by fleet category in 2008.

Table 25. VMT by Fleet Category in Selected Air Basins, 2008

Fleet Category	2008 Air Basin VMT, Thousand Miles/Day			
	SCAB	SFBAB	SJVAB	SVAB
MHDDT Ag	7	20	139	59
MHDDT CAIRP	13	5	19	6
MHDDT instate	3,577	1,878	959	832
MHDDT instate construction	530	329	196	115
MHDDT OOS	8	3	11	4
MHDDT utility	19	9	7	5
HHDDT Ag	18	49	343	146
HHDDT CAIRP	1,341	524	1,936	641
HHDDT CAIRP construction	102	63	38	22
HHDDT NNOOS	1,508	590	2,178	721
HHDDT NOOS	488	191	705	233
HHDDT other port	-	59	37	8
HHDDT POAK	-	205	91	14
HHDDT POLA	1,514	-	163	-
HHDDT single	721	318	178	160
HHDDT single construction	264	164	98	57
HHDDT tractor	1,891	958	2,752	426
HHDDT tractor construction	197	122	73	43
HHDDT utility	11	5	4	3

F. Impact of the Recession on VMT and Vehicle Sales

The recession impacts the emissions inventory both in terms of reduced activity and in terms of aging fleets due to reduced new truck sales. Staff developed assumptions for the impact of the recession and future year forecasts for both VMT and vehicle sales by inventory category. These assumptions were fundamentally based on the approach described in previous documentation (ARB, 2008 and ARB, 2009), where staff defined a fast recovery scenario and a slow recovery scenario. The chosen forecast is the average of the two bounding scenarios. This section provides assumptions on activity and new truck sales for each inventory category in graphical format.

To forecast VMT by model year staff followed a multi-step process. To forecast future year VMT, staff multiplied base year VMT by the revised growth factor reflecting the recession for each calendar year for each inventory category. Staff used the methodology described (ARB, 2008 and ARB, 2009) to forecast a model year distribution in each future year based on the assumed sales fraction for each category.

Next, staff multiplied the age-accrual rate schedule by the assumed age distribution in each calendar year for each category to estimate the population-weighted mileage accrual rates for each calendar year and category. To estimate population by model year, staff divided total calendar year VMT by weighted accrual rates in each calendar year.

This approach is a simplification because it assumes the total population in each category will fluctuate with the recession. In reality, to respond to the recession some fleets will downsize or park vehicles, and some fleets will continue to operate most if not all of their vehicles with less mileage accrual per year.

1) Drayage Trucks

Drayage truck activity is developed based on Twenty-foot equivalent unit (TEU) throughput at ports of Los Angeles, Long Beach, and Oakland. Staff estimates that drayage truck VMT in southern California decreased 25 percent between 2006 and 2009 as shown in Figure 10; and in northern California decreased by 14 percent based on container throughput, as shown in Figure 11. The Drayage Truck category was not adjusted for sales during the recession because of the impacts of the Drayage Truck Rule.

Figure 10. Drayage Truck VMT Projection for Ports of Los Angeles and Long Beach and Intermodal Railyards

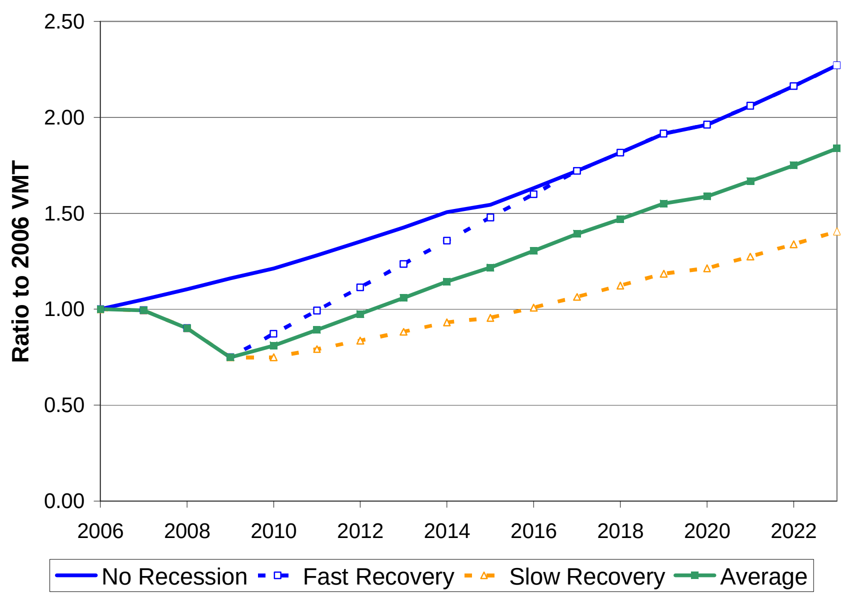
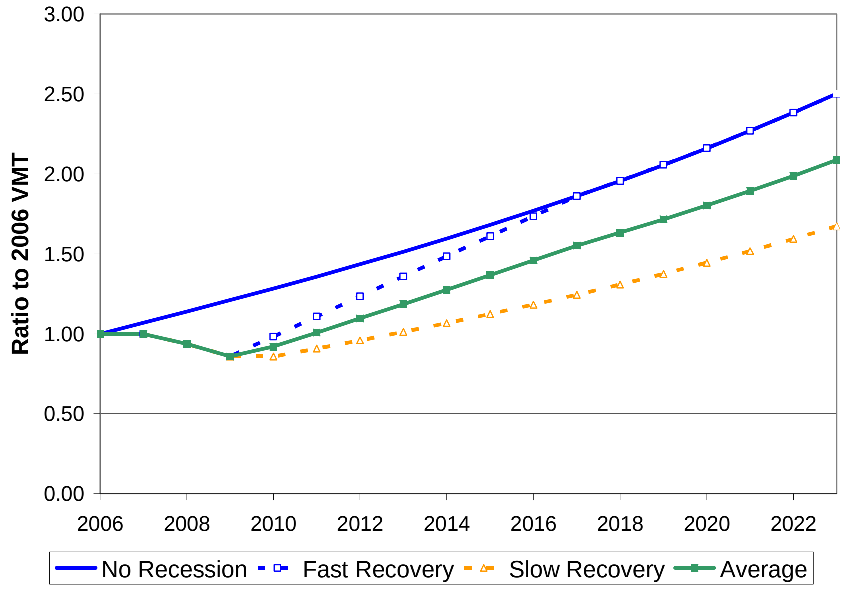


Figure 11. Drayage Truck VMT Projection for the Port of Oakland and Intermodal Railyards



2) Construction Trucks

Assumptions for this category are described in Section C-1.

3) MHDDT

To estimate the impact of recession on MHDDTs, staff reviewed BOE diesel fuel sales data (BOE, 2010b) and estimated VMT growth using bounding scenarios as shown in Figure 12. To forecast MHDDT truck sales, staff used the same method documented (ARB, 2008 and ARB, 2009).

Figure 12. MHDDT VMT Growth Assumption

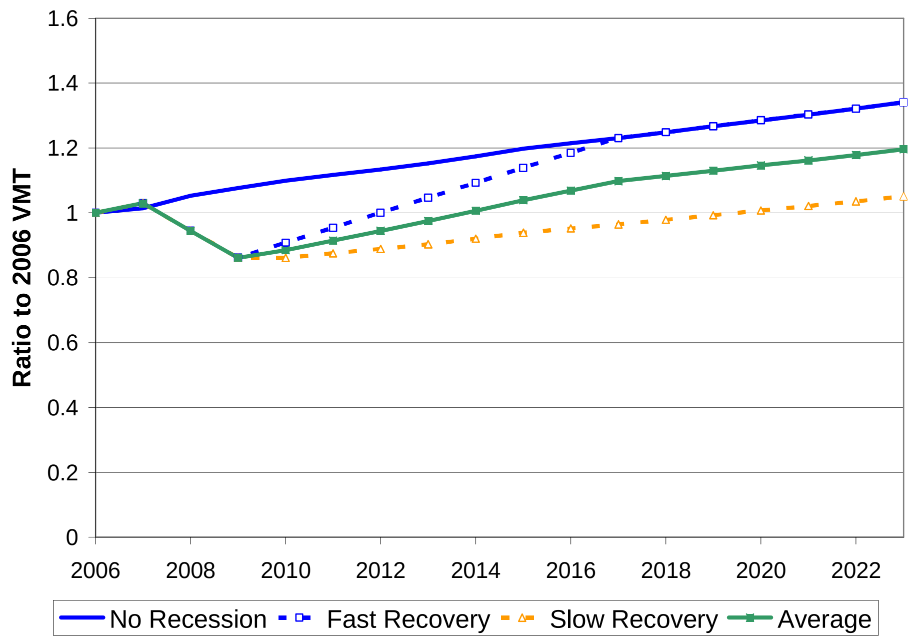
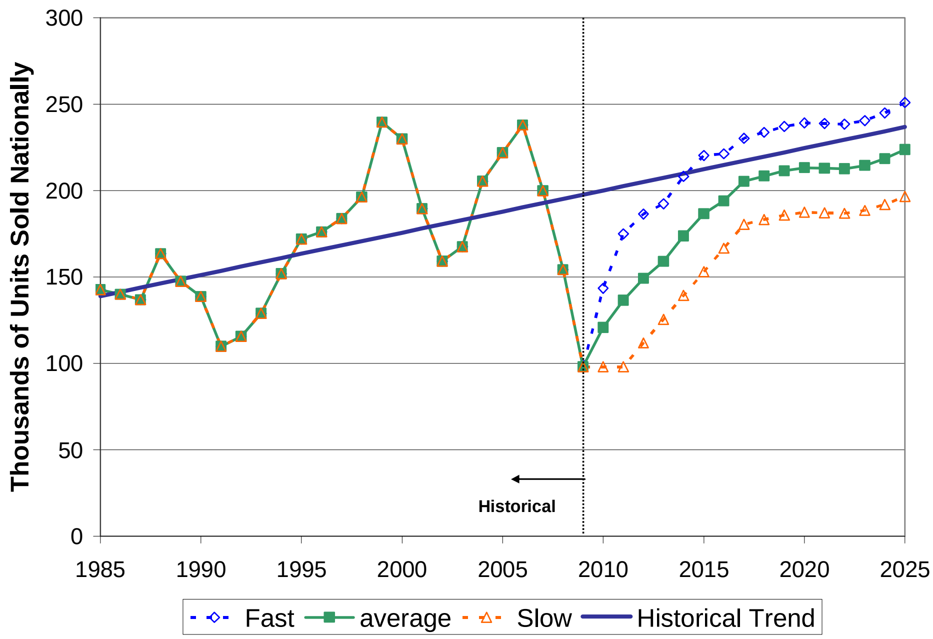


Figure 13. MHDDT Sales Forecast



4) HHDDT

To estimate the impact of recession on HHDDTs, staff reviewed BOE diesel fuel sales data (BOE, 2010b) and estimated VMT growth using bounding scenarios as shown in Figure 14. To forecast HHDDT truck sales, staff used the same method documented (ARB, 2008; ARB, 2009). VMT and sales assumptions apply to all HHDDT categories unless otherwise noted including interstate trucks.

Figure 14. HHDDT VMT Growth Assumption

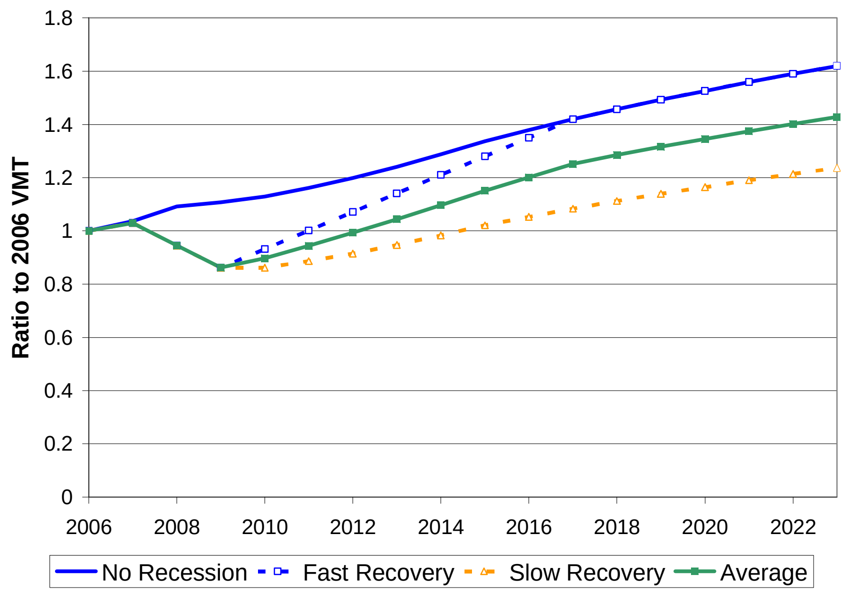
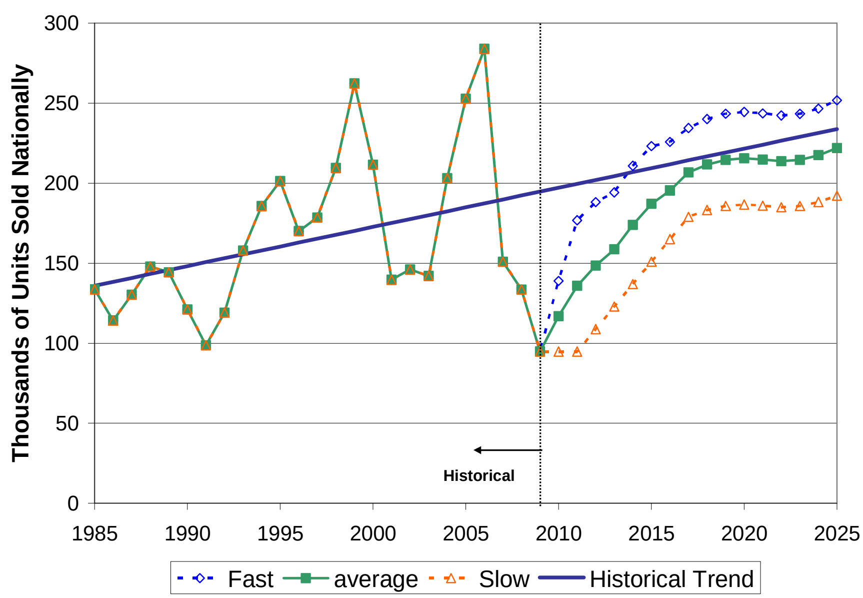


Figure 15. HHDDT Sales Forecast



G. Proposed Regulatory Scenarios and Compliance Assumptions

The proposed regulatory amendments provide substantial economic relief through the focusing of early PM requirements on vehicles that are most cost-effective to control, and on slowing the penetration of NO_x targets over time. To reflect these amendments, staff has made assumptions about how trucks in each category will respond to proposed regulatory requirements. Because of the impact of the recession and the increased life of retrofits before turnover is required in the Rule amendments, staff assumes that all vehicles subject to early PM requirements (2014 and prior) will install a Diesel Particulate Filter (DPF), and that turnover to comply with the regulation will generally occur only when explicitly required.

This section provides the assumptions used to calculate the emissions benefits of the proposed amended regulation for each inventory category for which regulatory requirements changed between the 2008 regulation and the proposed regulation. If the requirements did not change, the assumptions documented in ARB (2008) are still valid. The proposed rule provides specific compliance requirements for MHDDT fleets of truck GVWR of 26,000 lbs or less, regardless of their fleet size. Medium-heavy duty trucks with GVWR above 26,000 lbs are assumed to use the same compliance schedules as heavy-heavy duty trucks depending on their fleet size.

1) MHDDT Rule Compliance (<26,000 lbs GVWR)

This compliance schedule applies to all MHDDT with a GVWR less than 26,000 lbs. It also applies to MHDDT non-specialty agricultural trucks with a GVWR of 26,000 lbs or less and above first mileage threshold as described in ARB (2008).

Table 26. Turnover Assumptions for Medium Heavy Duty Truck Fleets GVWR<26,000 lbs

By Jan. 1	Model Year	Turn over to
2015	pre-1996	2010
2016	1996	2011
2017	1997	2012
2018	1998	2013
2019	1999	2014
2020	2000-2002	2015
2021	2003-2006	2016
2023	2007-2009	2017

2) Small Fleet Rule Compliance (>26,000 lbs GVWR)

The proposed amendments to the Regulation continue to provide flexibility for small fleets subject to early PM requirements. A small fleet is defined as a fleet that has three trucks or fewer. Staff assumes that small fleets will take advantage of these provisions. Amendments require the first truck in a small fleet to be DPF equipped by 2014, the second truck to be DPF equipped by 2015, and the third truck to by DPF equipped by 2016. Small fleets must then meet Best Available Control Technology (BACT) requirements starting in 2020.

Table 27 presents the revised assumptions for interstate trucks in small fleets, Table 28 presents the revised assumptions for single-unit trucks in small fleets, and Table 29 presents the revised assumptions for tractors in small fleets.

Table 27. Retrofit/Turnover Assumptions for >26,000 lbs GVWR Interstate Trucks in Small Fleets

Due Date January 1st of Calendar Year	Model Year Group	1st truck	2nd truck	3rd truck
2014	2003-2006	DPF		
2014	1998-2002	DPF	--	--
2015	2003-2006	DPF	DPF	
2015	1998-2002	DPF	1/3 DPF, 1/3 2008, 1/3 2010	--
2015	Pre-1994	2010	2010	--
2016	2003-2006	DPF	DPF	DPF
2016	1998-2002	DPF	1/3 DPF, 1/3 2008, 1/3 2010	2011
2016	Pre-1996	2010	2010	2010
2017	1996-1997	2010	2010	2010
2020	1998-2000	2013	2013	--
2021	2001-2004	2014	2014	2014
2022	2005-2006	2015	2015	2015
2023	all remaining	2015	2015	2015

Table 28. Retrofit/Turnover Assumptions for >26,000 lbs GVWR Single-Unit Trucks in Small Fleets

Due Date January 1st of Calendar Year	Model Year Group	1st truck	2nd truck	3rd truck
2014	1998-2006	DPF	--	--
2015	1998-2006	DPF	DPF	--
2015	Pre-1994	2010	2010	--
2016	1998-2006	DPF	DPF	DPF
2016	Pre-1996	2010	2010	2010
2017	1996-1997	2010	2010	2010
2020	1998-2000	2013	2013	2013
2021	2001-2004	2014	2014	2014
2022	2005-2006	2015	2015	2015
2023	all remaining	2015	2015	2015

Table 29. Retrofit/Turnover Assumptions for >26,000 lbs GVWR Tractor Trucks in Small Fleets

Due Date January 1st of Calendar Year	Model Year Group	1st truck	2nd truck	3rd truck
2014	2003-2006	DPF		
2014	1998-2002	DPF	--	--
2015	2003-2006	DPF	DPF	
2015	1998-2002	DPF	20% DPF, 60% 2008, 20% 2010	--
2015	Pre-1994	2010	2010	--
2016	2003-2006	DPF	DPF	DPF
2016	1998-2002	DPF	20% DPF, 60% 2008, 20% 2010	2011
2016	Pre-1996	2010	2010	2010
2017	1996-1997	2010	2010	2010
2020	1998-2000	2013	2013	--
2021	2001-2004	2014	2014	2014
2022	2005-2006	2015	2015	2015
2023	all remaining	2015	2015	2015

3) Large Fleet Rule Compliance (>26,000 lbs GVWR)

The proposed regulatory amendments provide relief to large fleet HHDDTs, because pre-1998 trucks would no longer be subject to early PM requirements. To reflect this change, staff updated compliance assumptions for large fleets. These assumptions are specific to each vehicle category because of differences in average miles traveled and vehicle dollar values between different categories. Table 30 presents compliance assumptions for >26,000 lbs GVWR tractors in large fleets; Table 31 presents compliance assumptions for >26,000 lbs GVWR single-unit trucks in large fleets. The proposed regulatory amendments contain a large fleet provision that allows fleets to install DPFs on 90% instead of 100% of their fleet. To reflect this provision, emissions benefits calculated using Tables 30 and 31 are multiplied by 0.9 to estimate the final benefit from large fleets. This assumption is also discussed in G8 below.

Table 30. Retrofit/Turnover Assumptions for >26,000 lbs GVWR Tractor Trucks in Large Fleets

Due Date January 1st of Calendar Year	Model Year Group	Assumed Compliance
2012	1998-2000	DPF
2013	2001-2002	DPF
2013	2003-2004	DPF
2014	2005-2006	DPF
2015	Pre-1994	2010
2016	1994-1995	2011
2017	1996-1997	2012
2020	1998-2000	2015
2021	2001-2002	2016
2021	2003-2004	2016
2022	2005-2006	2017
2023	all remaining	2017

Table 31. Retrofit/Turnover Assumptions for >26,000 lbs GVWR Single-Unit Trucks in Large Fleets

Due Date January 1st of Calendar Year	Model Year Group	Assumed Compliance
2012	1998-2000	DPF
2013	2001-2004	DPF
2014	2005-2006	DPF
2015	Pre-1994	2010
2016	1994-1995	2010
2017	1996-1997	2010
2020	1998-2000	2013
2021	2001-2004	2014
2022	2005-2006	2015
2023	all remaining	2015

4) Agricultural Truck Compliance Assumptions

The proposed regulatory amendments do not alter the fundamental compliance structure for agricultural trucks. However, because of changes to BACT requirements, compliance assumptions for specialty vehicles and some model year groups have been altered slightly, as shown in Table 32.

Table 32. Retrofit/Turnover Assumptions for Agriculture Trucks

Below 10,000 miles/yr and specialty agricultural trucks

Due Date January 1st of Calendar Year	Model Year	Turnover to
2023	pre-2010	2012

Above 10,000 miles/yr but below first mileage threshold

Due Date January 1st of Calendar Year	Model Year	Retrofit /Turnover to
2017	pre-1998	2010
2017	1998-2006	50% 2010 and 50% 2008
2023	2007-2009	2012

5) Utility Truck Compliance Assumptions

As a result of proposed regulatory amendments, the following assumptions in Table 33 are made for compliance for trucks owned by Utilities.

Table 33. Retrofit/Turnover Assumptions for Utility Trucks

	T6 Utility		T7 Utility	
Due Date January 1st of Calendar Year	**Model Year**	**Retrofit /Turnover to**	**Model Year**	**Retrofit /Turnover to**
2014	Pre-1998	2010	Pre-1998	2010
2014	1998-2006	DPF	1998-2006	DPF
2021	1998-2006	2013	1998-2004	2013
2022			2005-2006	2014
2023	2007-2009	2015	2007-2009	2015

6) Drayage Truck Compliance Assumptions

Proposed regulatory amendments would harmonize drayage truck and truck and bus regulatory requirements by removing the Phase II drayage truck requirement to turnover to a 2007 truck by 2014, while keeping Phase I retrofit requirements. Due to requirements imposed by the Ports of Los Angeles and Long Beach, all drayage trucks will meet 2007 standards in 2014; as a result regulatory amendments will have little effect in southern California. Drayage trucks in the Bay Area are not subject to this local requirement, and so benefits of the Drayage Truck Rule will be reduced by these amendments in that area. By 2017, drayage trucks will be required to follow truck and bus requirements, as shown in Table 34.

Table 34. Retrofit/Turnover Assumptions for Drayage Trucks

Assumptions for Southern California Drayage Trucks

	Calendar year					
Population distribution	**2010**	**2011**	**2012**	**2013**	**2014**	**2014-2016**
MY 1994-2003, DPF	4%	4%	4%	4%	4%	Trucks new to the drayage service would meet 2007 engine standard
MY 2004	10%	10%	0%	0%	0%	
MY 2004 DPF	0%	0%	6%	6%	6%	
MY 2005-2006	21%	21%	11%	0%	0%	
MY 2005-2006, DPF	0%	0%	0%	9%	9%	
MY 2007-2009	58%	58%	70%	72%	72%	
MY 2010 and newer	7%	7%	9%	9%	9%	

Approach for Drayage Trucks Outside of Southern California

Due Date January 1st of Calendar Year	**Model Year**	**Retrofit / Turnover to**
2010	Pre -1994	1994
2010	1994 - 2003	DPF
2012	2004	DPF
2013	2005-2006	DPF

Truck and Bus Regulation Assumptions starting in 2017

Due Date January 1st of Calendar Year	**Model Year**	**Turnover to**
2020	pre-1998	2010
2020	1998-2000	2012
2021	2001-2004	2012
2022	2005-2006	2012
2023	2007-2009	2012

7) School Bus Compliance Assumptions
Under the proposed regulation, school bus compliance requirements would be deferred for two years, as shown in Table 35.

Table 35. Retrofit/Turnover Assumptions for School Buses

Due Date January 1st of Calendar Year	Model Year	Turnover to	Percent with DPF
2012	1987-2006		33%
2013	1987-2006		66%
2014	1987-2006		100%
2014	pre-1987	2007	

8) Regulatory Credit and Other Provisions - Not Modeled in the Inventory

The proposed regulatory amendments contain several provisions that are not modeled within the inventory, including reduced activity credits, early retrofit credits, alternative fuel credits, and large fleet phase-in. These provisions cannot be explicitly modeled because they are not mandatory, and the choice to exercise these provisions depends on many factors that are difficult to predict. Their impact on the margin is estimated, but other inventory charts shown in Section H do not include the impact of these provisions.

The reduced activity credits and alternative large fleet phase-in relief provisions in the regulation will likely reduce the number of filter equipped trucks, especially in the 2014 timeframe, from what is modeled directly in the inventory. Whether a fleet will choose to exercise reduced activity credits depends on how it has been impacted, and how it has responded to the recession. Some fleets will choose to take advantage of alternative fuel vehicle credits or early retrofits and others will not.

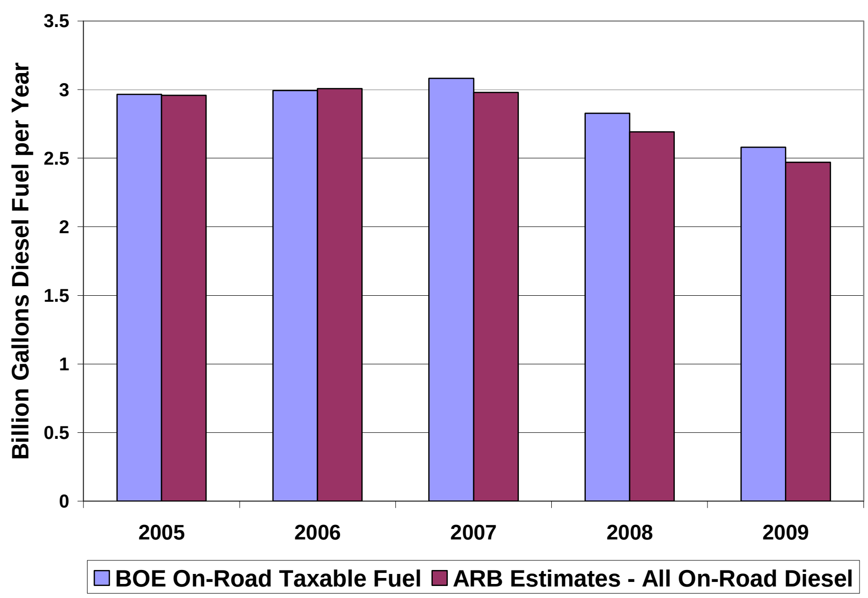
The reduced activity credits are designed to be self-correcting in that if the economy recovers more slowly more credits would be generated, and if the economy recovers more quickly fewer credits would be generated. For example, if the economy recovers more slowly than anticipated, more fleets would use reduced activity credits. This would reduce the benefits the Rule would achieve, but those disbenefits would be offset by reduced activity and emissions caused by the recession.

H. Emissions Results

1) Evaluation of Baseline Statewide Fuel Usage Estimates

The Truck and Bus Rule is not expected to have a significant impact on reducing statewide emissions of CO_2. However, comparing modeled fuel-use in the emissions analysis to the total amount of diesel fuel taxed in California annually is a valuable tool to ensure the emissions analysis is reasonably accurate. To develop this analysis, staff added annual CO_2 emissions estimates for diesel trucks and buses in this inventory to estimates of CO_2 emissions representing light-duty and light heavy-duty diesel vehicles. The combined total represents all on-road use of taxable diesel in California. Staff assumed 10,159 grams of CO_2 emissions per gallon diesel fuel to convert CO_2 emissions to gallons of diesel fuel. Figure 16 compares estimated fuel usage in the inventory analysis (including lighter duty vehicles from EMFAC2007) with on-road taxable diesel fuel provided by the BOE in their 10 year report (BOE, 2010b). Results show very good agreement, within 5 percent or less, between the inventory analysis and reported fuel data.

Figure 16. ARB Modeled Estimates of On-Road Diesel Fuel Use Based on the Emissions Analysis vs. BOE On-Road Taxable Fuel by Calendar Year



2) Estimating Statewide Emissions Benefits of the Proposed Regulation

When the Board adopted the regulation in 2008, the Rule was designed to achieve maximum reduction of diesel particulate matter emissions by 2014, and to ensure maximum NO_x emissions reductions by 2023. The rule was also designed to achieve sufficient NO_x reductions to achieve reductions in nitrate particulate to meet the particulate matter ambient air quality standard in both the South Coast Air Basin and the San Joaquin Valley.

The proposed amendments to the regulation are designed to ensure these overall benefits are achieved at a much lower cost. This is possible because the recession is projected to continue to reduce anticipated emissions levels well into the future. Overall, staff anticipates the amended regulation will reduce diesel PM emissions by 50 percent from currently anticipated levels in 2014, and that the regulation will ensure that by 2020 practically all trucks operating in California will be equipped with a diesel particulate filter. Figure 17 and Figure 18 compare anticipated baseline emissions (without the Rule) to emissions with the amended Rule if it is adopted. Staff anticipates the amended Rule will achieve a 15 percent reduction in NO_x emissions and a 50 percent reduction in $PM_{2.5}$ emissions from anticipated levels without the Rule in place between 2015 and 2023.

The emissions benefits shown in this section cover only BACT requirements and other major portions of the regulation that are modeled in the inventory. Credit provisions discussed in Section G8 of this document are covered quantitatively below in Section H4.

Figure 17. Statewide NO_X Emissions Estimates Baseline and with Regulation

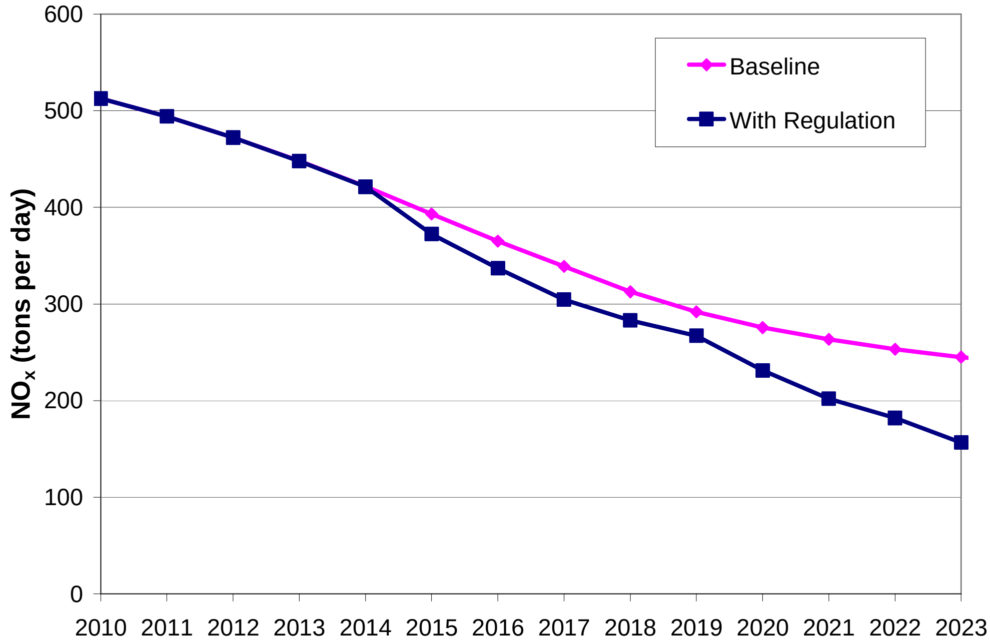


Figure 18. Statewide $PM_{2.5}$ Emissions Estimates Baseline and with Regulation

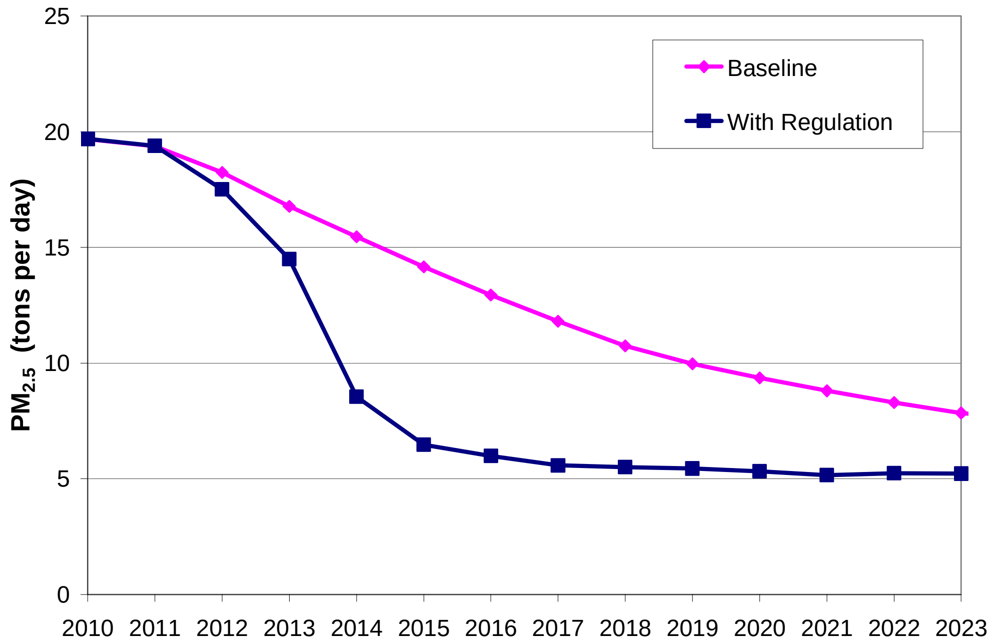


Figure 19 and Figure 20 compare anticipated emissions without the Rule to emissions with the amended Rule in the South Coast.

Figure 19. South Coast NO_X Emissions Estimates Baseline and with Regulation

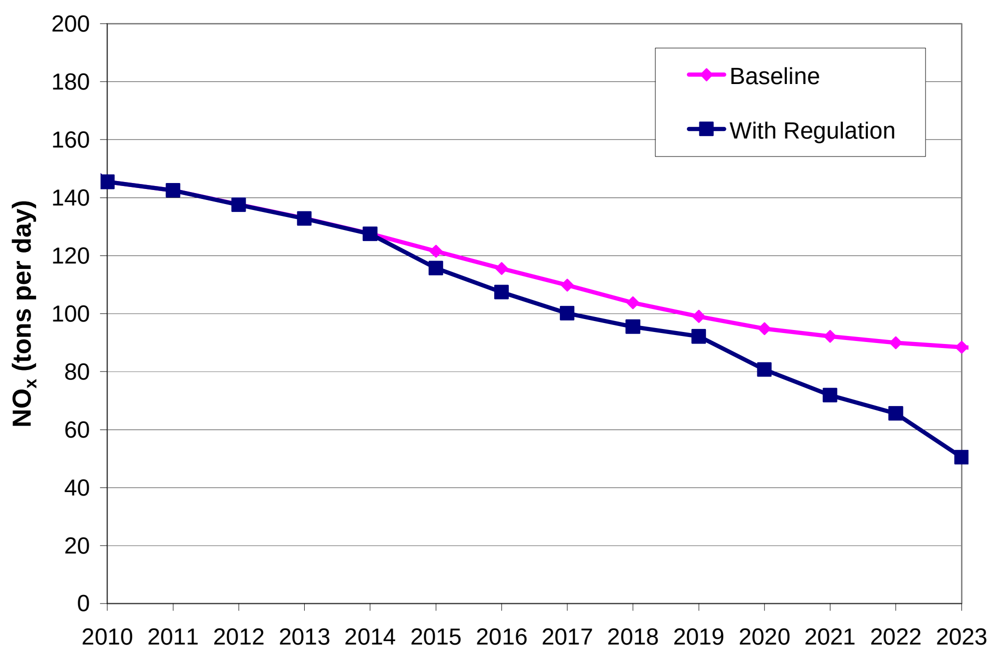


Figure 20. South Coast $PM_{2.5}$ Emissions Estimates Baseline and with Regulation

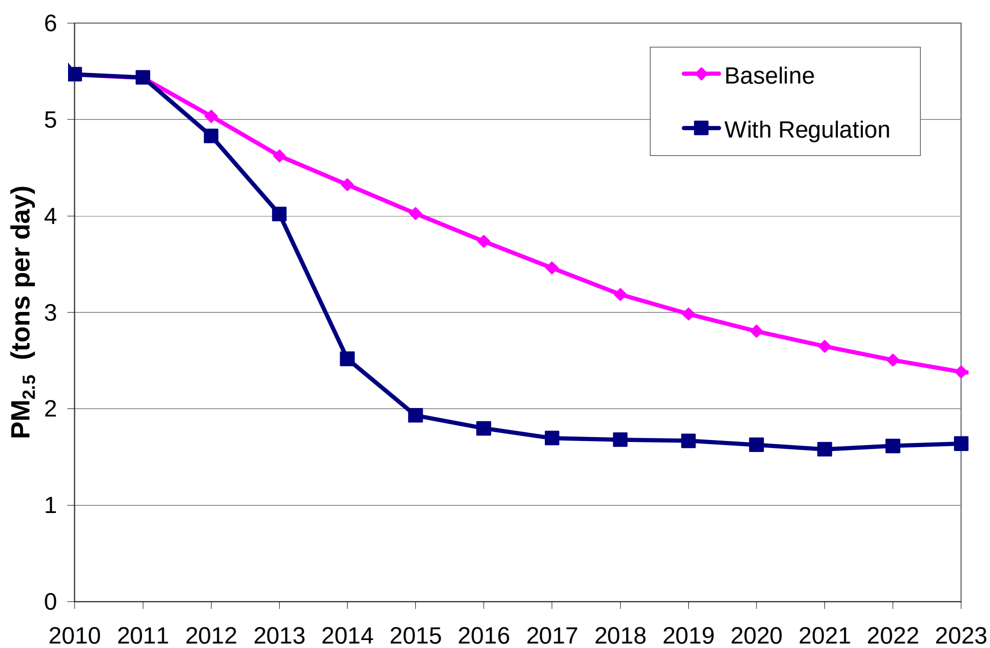


Figure 21 and Figure 22 compare anticipated emissions without the Rule to emissions with the amended Rule in the San Joaquin Valley.

Figure 21. San Joaquin Valley NO_X Emission Estimates Baseline and with Regulation

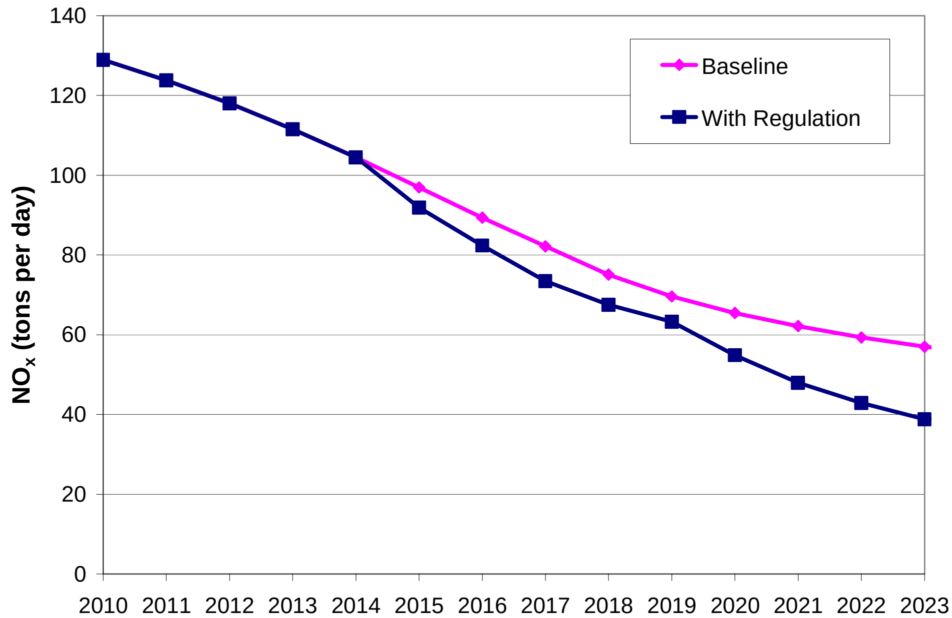
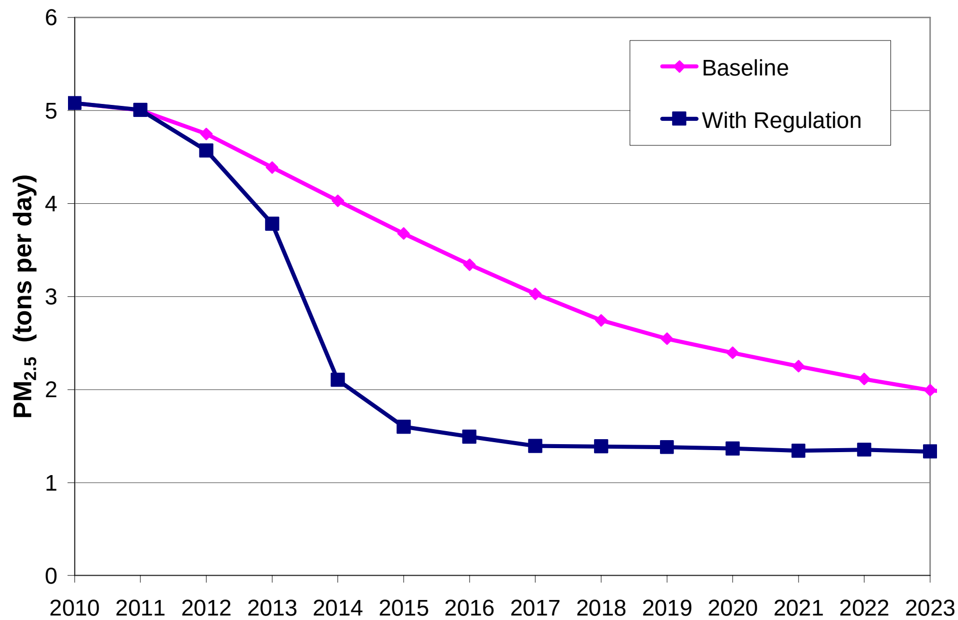


Figure 22. San Joaquin Valley $PM_{2.5}$ Emissions Estimates Baseline and with Regulation



3) PM and NO_x Emissions Benefits from both the Truck and Bus and In-Use Off-Road Rules are Preserved

Staff designed proposed regulatory amendments across both the Statewide Truck and Bus and In-Use Off-Road Rules to provide the maximum amount of economic relief possible while still preserving as much of the originally envisioned benefits as possible. Our estimates suggest that statewide the combined impact of the recession with amended regulations on both on-road and off-road inventories will provide essentially the same cumulative remaining emissions levels between 2011 and 2023 to what the adopted Rules would have achieved without the recession. This concept is shown in Figure 23 for $PM_{2.5}$ and Figure 24 for NO_x below.

Figure 23. Year by Year Comparison of $PM_{2.5}$ Emissions after On-Road and Off-Road Regulations are Applied: Adopted Rules without Recession vs. Amended Rules with Recession

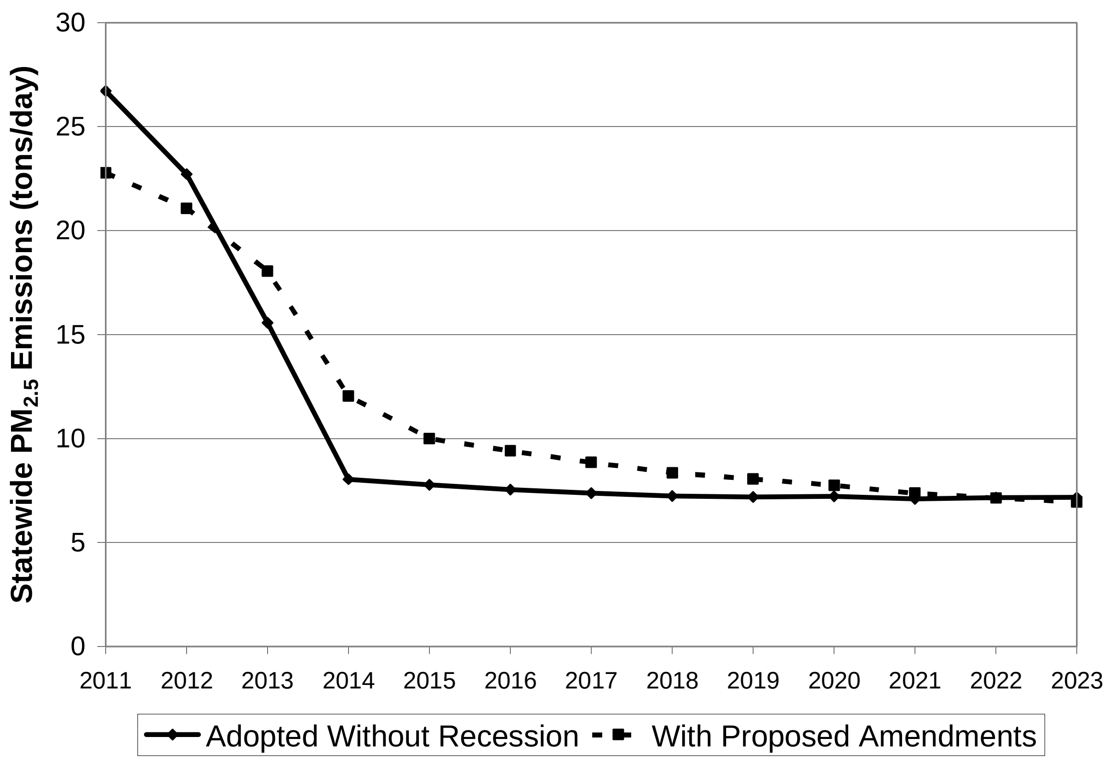
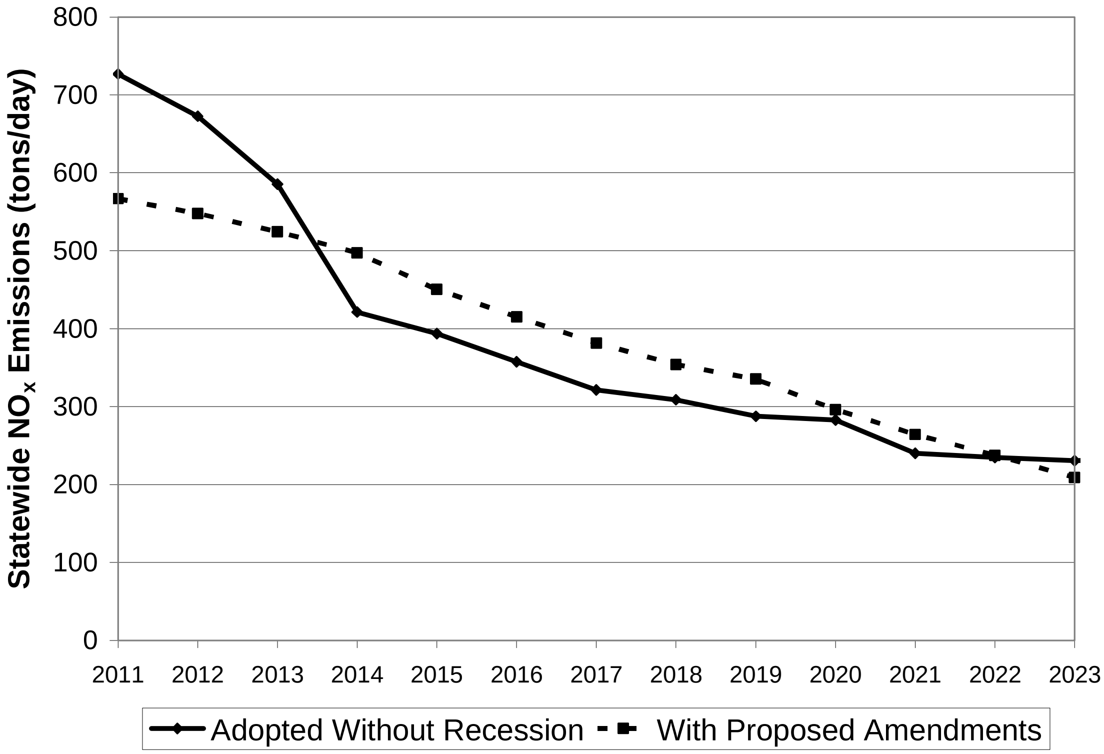


Figure 24. Year by Year Comparison of NO_X Emissions after On-Road and Off-Road Regulations are Applied: Adopted Rules without Recession vs. Amended Rules with Recession



4) Meeting SIP Targets

In September 2007, ARB adopted a State Implementation Plan (SIP) committing the State to develop measures to achieve emission reductions from sources under State regulatory authority. The reductions are needed to attain the Clean Air Act National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$ in 2014 and for ozone longer term. While multiple areas throughout the State exceed federal air quality standards, the air quality in the South Coast and the San Joaquin Valley poses the greatest challenge and defines the amount of reductions needed. Reductions are needed by 2014 to meet the $PM_{2.5}$ attainment deadline and by 2023 to meet the ozone attainment deadline for compliance with the NAAQS.

Staff decided to consider the impact of the recession and inventory changes on fleets affected by the truck and off-road regulations together in deciding how to provide regulatory relief so that emissions reductions could be targeted more cost effectively, and staff could ensure the combined emissions benefits achieved by the two rules would meet SIP legal requirements for the combined SIP categories.

To develop this comparison, remaining emissions anticipated after the application of the heavy-duty truck and in-use off-road regulatory concepts in the 2007 SIP were compared to anticipated remaining emissions from heavy-duty trucks and in-use off-road equipment in the updated rule inventories. The difference between the remaining emissions in the SIP and in the revised inventory is referred to as the margin. The margin defines how much relief can be provided under the truck and off-road rules while still meeting SIP legal requirements. The margin is compared in NO_x equivalent emissions which is a weighted combination of NO_x and $PM_{2.5}$. The $PM_{2.5}$ to NO_x ratio is 10:1 in South Coast and 9:1 in the San Joaquin Valley; these numbers were based on photochemical modeling in the 2007 SIP (ARB, 2007b).

Reduced activity credit provisions of the proposed regulatory amendments could not be accurately modeled within the inventory, but are expected to have a significant impact in reducing emissions benefits from strictly what BACT compliance would provide in 2014. This is because under the proposed credit provisions fleets that have downsized as a result of the recession can treat a retired vehicle as compliant, which reduced early PM compliance requirements for other vehicles in the fleet. This effect will be most significant in 2014 when SIP compliance is measured. The large-fleet phase-in requirements could lead to many large fleets meeting early PM requirements for 90 percent instead of 100 percent for vehicles subject to regulatory requirements.

Table 36 compares the 2014 margin in the San Joaquin Valley air basin for several inventory scenarios. The rules as currently adopted would provide a margin of 40 tons NO_x equivalent emissions. After modeling the major portions of the proposed Rule amendments without credit provisions, the remaining margin is estimated at 2.4 tons.

Table 36. Comparison of 2014 Remaining Emissions in the San Joaquin Valley Air Basin After Truck and Off-Road Rules Are Applied: SIP, Adopted Rule, With Rule Inventory (Not Including Credit Provisions)

		SIP	**Adopted***	**Proposed**
Off-Road	**NO_X**	29.1	12.1	13.4
	$PM_{2.5}$	0.7	0.4	0.6
Trucks	**NO_X**	88.6	75.2	101.8
	$PM_{2.5}$	1.9	1.1	2.0
NO_X Eq (pm*9)		141.1	101	138.7
Margin without Credit Provisions			40	2.4
Margin with Credit Provisions			n/a	0

* From August 2010 Workshop

Staff estimates that a maximum of 15 percent of the total NO_x equivalent benefits could be lost as a result of the reduced activity credit and large-fleet phase-in requirements of the proposed amended regulation. Staff believes that if the reduced activity credit and large-fleet phase-in requirements of the proposed regulation are considered, the remaining margin would be eliminated. This would represent a reduction in overall benefits of about 14 percent.

Table 37 compares the 2014 margin in the South Coast air basin for several inventory scenarios. The rules as currently adopted would provide a margin of 62 tons NO_x equivalent emissions. After modeling the major portions of the proposed Rule amendments, the remaining margin is estimated to be 7.4 tons. Staff estimates a maximum of 15 percent of the total NO_x equivalent benefits could be lost as a result of the reduced activity credit and large-fleet phase-in requirements of the proposed amended regulation. The total NOx equivalent benefit in the South Coast in 2014 is 18 tons/day. A 15% benefit loss would be equal to 2.7 tons; a 2.7 ton reduction from the 7.4 margin would leave a margin of 4.6 tons NOx equivalent emissions after all provisions of the Rule are considered.

Table 37. Comparison of 2014 Remaining Emissions in the South Coast Basin After Truck and Off-Road Rules Are Applied: SIP, Adopted Rule, Provisions Modeled in the Inventory, and All Regulatory Provisions

		SIP	Adopted*	Proposed
Off-Road	**NO_X**	85.6	24.9	27.6
	$PM_{2.5}$	2.3	0.9	1.3
Trucks	**NO_X**	55.1	81.5	117.6
	$PM_{2.5}$	2.3	0.9	2.1
NO_X Eq (pm*10)		186.7	124.4	179.3
Margin without Credit Provisions			62	7.4
Margin with Credit Provisions			n/a	4.6

* From August 2010 Workshop

With the proposed amendments the truck rules will continue to provide major diesel PM emissions reductions to protect public health and to ensure all trucks operating in 2023 are equipped with the cleanest engines available. The combined margin for trucks/buses and off-road equipment is minimized, providing maximum relief while still meeting SIP legal obligations.

I. Additional Documentation

As part of the Rulemaking package staff is providing the emissions inventory model and associated documentation. The following is a guide to the model files and documentation.

There are three folders in the inventory documentation package:

- EI models recession proposed – this folder contains the actual calculations of the emissions inventory for the proposed regulation and with the average of faster and slower growth scenarios
    - Baseline by fleet 10210.mdb – is the starting point of the inventory calculation. Population and VMT by fleet category, model year and air basin are calculated and forecasted. The impacts of Drayage Truck

regulation and Public and Utility Fleets regulation on drayage trucks and utility fleets are also estimated.
    - Base by sub cat 100810.mdb – is where the fleet categories in "Baseline by fleet 100810.mdb" were further divided into sub categories based on fleet size, annual mileage, etc.
    - Modeling assumptions.xls – documents the assumptions for fleet turnover and retrofit under the regulation.
    - XXXAB 102010.mdb – based on the population and VMT in "Base by sub cat 100810.mdb" and the assumptions in "modeling assumptions.xls", estimates the population and VMT results of fleet turnover and retrofit for each air basin.
    - Combined scenario 102010.mdb – combines the air basin results into one table and calculates the emissions under the proposed rule
- EI models no recession adopted rule – this folder contains the emissions inventory calculations for the adopted regulation without the recession.
    - Baseline by fleet no recession.mdb – is the starting point of the inventory calculation. Population and VMT by fleet category, model year and air basin are calculated and forecasted. The impacts of Drayage Truck regulation and Public and Utility Fleets regulation on drayage trucks and utility fleets are also estimated.
    - Base by sub cat no recession.mdb – is where the fleet categories in "Baseline by fleet no recession.mdb" were further divided into sub categories based on fleet size, annual mileage, etc.
    - XXXAB no recession adopted.mdb – based on the population and VMT in "Base by sub cat no recession.mdb" and the assumptions for the adopted rule, estimates the population and VMT results of fleet turnover and retrofit for each air basin.
    - Combined no recession adopted.mdb– combines the air basin results into one table and calculates emissions estimates with adopted rule and without recession.
- EI models with recession adopted rule – this folder contains the emissions inventory calculations for the adopted regulation with recession.
    - Baseline by fleet with recession.mdb – is the starting point of the inventory calculation. Population and VMT by fleet category, model year and air basin are calculated and forecasted. The impacts of Drayage Truck regulation and Public and Utility Fleets regulation on drayage trucks and utility fleets are also estimated.
    - Base by sub cat with recession.mdb – is where the fleet categories in "Baseline by fleet with recession.mdb" were further divided into sub categories based on fleet size, annual mileage, etc.
    - XXXAB with recession adopted.mdb – based on the population and VMT in "Base by sub cat with recession.mdb" and the assumptions for the adopted rule, estimates the population and VMT results of fleet turnover and retrofit for each air basin.

- Combined with recession adopted.mdb– combines the air basin results into one table and calculates emissions estimates with adopted rule and without recession.

- Supporting files – this folder contains supporting data/analysis for the inventory
  - Buses – Buses and motorcoach related files
    - Buses population accrual.xls – analysis of DMV data and data provided by CBA to estimate the population and accrual rates for all other buses and motorcoaches.
    - California Public Utilities Commissions.xls - provides the motorcoach population.
    - CBA survey.xls – provide mileage accrual by model year for motorcoaches.
    - EF for bus_PTO.xls – emission factors for buses and PTO.
  - Construction – construction fleets related files
    - BOE Construction Taxable Fuel Refunds.xls
    - Construction allocation pop growth by AB.xls – spatial allocation for construction fleet VMT based on DOF population forecast.
    - Construction Avg age&accrual in VIUS.xls – analysis of age and accrual rate of construction vehicles in VIUS 2002.
    - EDA UCC data analysis.xls – new construction equipment sales financed.
    - Percentage of Construction Trucks.xls – VIUS based analysis on construction population as percentages of HHDDT and MHDDT populations.
  - Emission Factor – emission factor related files
    - NOx adjustment details.xls – calculation to reflect engine manufacturer's compliance approaches for NOx standard.
    - HHDDT EF NOx adj cap 400_800K.xls – emission factors that reflect both the NO_x adjustment and odometer capping for HHDDT.
    - MHDDT EF NOx adj cap 400_800K.xls – emission factors that reflect both the NO_x adjustment and odometer capping for MHDDT.
    - EF cap 400_800K w NOx rev.xls – combines HH and MHDDT EF files for input to the Access models.
  - Field Study – field study related files
    - Cambridge 2008 trip length.pdf – for estimating the trip length in San Joaquin Valley Air Basin
    - SCAG 1999 trip length.pdf – for estimating the trip length in SCAG
    - Field study folder – documents released in 2010 regarding field study as part of California Public Records Act. Folder contains "Readme.xls" describing the content.
  - Growth & Sales – growth and sales forecasts
    - EIA sales VMT forecast.xls – the 2009 EIA forecast of VMT and new truck sales used for sales forecast
    - Growth w recession.xls – VMT growth trends that reflect recession recovery assumptions

    - Sales w recession.xls – Sales forecast reflecting the VMT growth trend with recession
- Misc
    - 2005 T6 GVW split.xls – analysis based on 2005 DMV to estimate the percent of MHDDTs that are above 26,000 lbs GVWR
    - Fuel comparion.xls – based on estimated CO_2 emissions, compare the estimated on-road fuel consumptions to the reported diesel taxable fuel from BOE
    - IFTA 2005~2009.xls - IFTA fuel/VMT from corresponding with BOE
    - Truck NOx_PM contribution to 2010_2020 STWD.xls – contains the analysis of the truck contribution to 2010 statewide mobile source emissions.
- Jan2010 folder – contains files released in 2010 as part of California Public Records Act. README.doc describes the content in the folder.

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K. Attachment – CARB Origin-Destination Survey Questionnaire

CARB HDT Origin-Destination Survey Questionnaire

Survey Location: ____________________ Direction______ Date: _________ Time:________
Surveyor __________________
Selection Reason: _X_ Random ___ Excess Smoke (____ %) ___ Other: ___________

Truck Information

1. Vehicle Type (circle one): Single Unit w/ trailer Tractor-Trailer (Trailer is 53' or longer? Y / N) Multiple-Trailer Tractor Dump truck Concrete mixer
   If a tractor-trailer, does the owner of the tractor also own the trailer? Yes___ No__ Don't Know_
2. Number of axles: Tractor _____, Trailer ______, Total: _____
3. Where is the home base of this vehicle? City ____________________ State ________
6. License Plates: US State _________ Number _______________
   Mexico _____________ Canada ______________
7. Make and Model Year of truck: __________ __________
8. Make and Model Year of engine: __________ __________
10. Has the engine been rebuilt or replaced?(circle one) Yes No Unknown
13. Odometer: ________________________
14. What is the current loaded weight of this truck? _______________ lb
15. What is the Gross Vehicle Weight Rating (GVWR or GCWR) of this truck? _______________ lb

Fueling Information

16. Total Fuel capacity of this truck: __________ gallons
17. Where did you last fuel up this truck? City ____________________ State ________
18. Where will you next fuel up this truck? City ____________________ State ________
19. Where do you usually buy fuel? CA Mexico Canada Other US State (specify): __________

Activity Information

20a. Where did your current trip begin? City______________________ State_______ Country_______
   Address____

21. What is the destination of your current trip?
   City____State________ Country______
   Address____

21a. How many tractors/trailers are there in your company? (OK if estimate) Tractors_____/Trailers____

Maintenance Information

34. In the past 12 months, has your truck had any downtime for repairs due to problems with the truck engine? Yes__ No__ Unknown__

35. During the past 12 months, which of the following malfunctions have you had on your truck? (Check all that apply):
   - Fuel Injection Problems: Mild _____ Medium _____ Severe _____
   - Engine Failure _____
   - Electronic Failure _____
   - Turbocharger Problems _____
   - Intercooler Problems _____
   - EGR Problems _____
   - Air/Fuel Ratio Control _____
   - Clogged Air Filter _____
   - Other Air Induction Problems _____
   - Excessive Engine Oil Consumption _____
   - PM Filter (DPF) Problems (if equipped) _____
   - Other ____

PrePass Program (skip this if survey conducted at weigh stations)

36. Is this truck currently enrolled in the Caltrans PrePass™ program? Yes___ No___ Unknown__

nments: ____

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