DIESEL PARTICULATE MATTER HEALTH RISK ASSESSMENT FOR THE WEST OAKLAND COMMUNITY

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DIESEL PARTICULATE MATTER HEALTH RISK ASSESSMENT
FOR THE WEST OAKLAND COMMUNITY

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I. INTRODUCTION, KEY FINDINGS, and RECOMMENDATIONS

A. Introduction

The California Air Resources Board (ARB or Board) has completed a health risk assessment (HRA or study) for the West Oakland community. The study was designed to evaluate the emissions impacts and the potential public health risk to both residents of West Oakland and the broader Bay Area from exposures to diesel particulate matter (diesel PM). The sources of diesel PM include activities at the Maritime Port of Oakland, the Union Pacific Railyard, and other significant diesel PM sources in and near the West Oakland community such as local freeways and marine vessels in the San Francisco Bay.

The West Oakland community is located in Oakland, California. It is bounded by the Maritime Port of Oakland (the Port), the Union Pacific (UP) Oakland Railyard, and the I-580, I-880, and I-980 freeways. Approximately 22,000 people reside in West Oakland. As trade through the Port has increased, many residents have voiced concerns about the health impacts from exposures to diesel PM. An aerial photograph of the West Oakland community is provided in Figure 1. The study was conducted in response to those concerns and was a cooperative effort between ARB and the Bay Area Air Quality Management District (BAAQMD). Both the Port and UP assisted by providing information on their local marine and rail operations allocated near the West Oakland community.

Figure 1: Aerial Map of the West Oakland Community

The study helps identify sources that have the greatest impact on potential cancer risks to nearby residents and provides a tool that can help identify the impacts of measures adopted, planned, and under development to reduce diesel PM emissions. In addition, the information from this study is being used to satisfy UP and ARB's commitment under the Statewide Railroad Agreement (CARB, 2005) wherein health risk assessments are required for each major railyard. This HRA fulfills that commitment for the UP's Oakland Railyard. The key findings from the study are provided below. In subsequent chapters, we provide a more in-depth discussion on the health risk assessment.

B. Key Findings

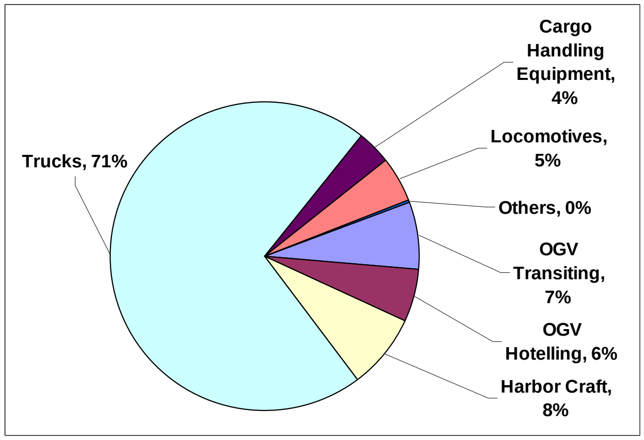
For this study, the diesel PM emission sources were allocated to three Parts. Part I included the diesel PM emissions from Port operations; Part II encompassed activities at the UP's Oakland Railyard; and Part III included other diesel PM emissions from activities not included either in Part I or Part II. These sources included ocean-going vessels (OGV) destined for San Francisco Bay ports other than the Port of Oakland, on-road heavy-duty trucks not transporting goods to and from the Port, harbor craft such as the commercial ferries used to transport passengers across the bay, and local distribution centers in and near the West Oakland community.

The key findings from the study are presented below.

West Oakland Community

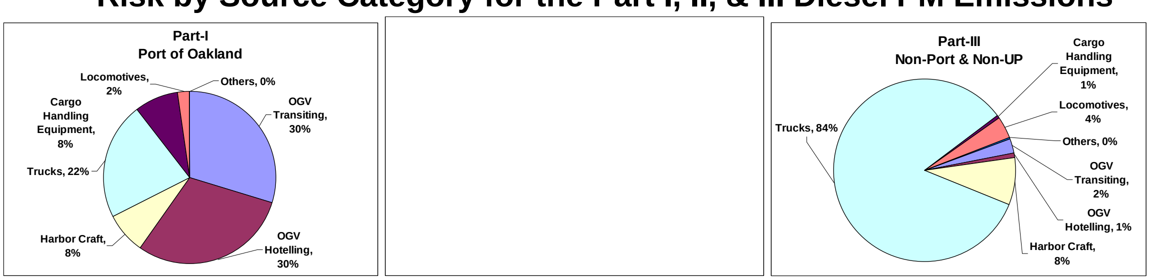
- The potential health risks in the West Oakland community from exposures to diesel PM emissions are of significant concern.
- The West Oakland community is exposed to diesel PM ambient concentrations that are almost three times the average background diesel PM ambient concentrations in the BAAQMD.
- The estimated lifetime potential cancer risk for residents of West Oakland from exposure to diesel PM emissions from all sources is about 1,200 excess cancers per million. This estimate assumes residents are exposed to the year 2005 levels of diesel PM emissions (Port and UP operations, and non-Port/non-UP marine and land-based diesel sources) continuously for 70 years.
- Diesel PM emissions from Port operations result in an estimated lifetime potential cancer risk of 200 excess cancers per million in West Oakland. Diesel PM emissions from the UP Railyard result in potential cancer risks of about 40 excess cancers per million and emissions from non-Port and non-UP sources result in a risk of about 950 excess cancers per million.
- As shown in Figure 2, the emissions from on-road heavy-duty trucks result in the largest contribution to the overall potential cancer risks levels in the West Oakland community, followed by OGV (combined transiting, maneuvering, anchoring, and hotelling emissions), harbor craft, locomotives, and cargo handling equipment.

Figure 2: Percent Contribution to the West Oakland Community Potential Cancer Risk by Source Category for the Combined Part I, II, & III Diesel PM Emissions



- The contribution to the potential cancer risk in the West Oakland community from the different Parts varies. As shown in Figure 3 for the Port diesel PM emission sources, the OGV transiting (includes maneuvering and anchoring) and hotelling emissions are responsible for the largest contribution to the potential cancer risks in the West Oakland community followed by on-road trucks and cargo handling equipment. Cargo handling equipment at the UP Railyard (Part II)is responsible for the largest contribution from the UP activities followed by locomotives. The Part III sources are those sources in or near the West Oakland community that are not associated with either the Port or the UP Railyard. For these sources, the on-road trucks are responsible for over 80 percent of the contribution to the potential cancer risks in the West Oakland community.

Figure 3: Percent Contribution to the West Oakland Community Potential Cancer Risk by Source Category for the Part I, II, & III Diesel PM Emissions



Part I: 265 tons per year (T/Y) Part II: 11 T/Y Part III: 568 T/Y
Total Diesel PM Emissions Part I + Part II + Part III = 845 T/Y

- The impact of emissions on potential cancer risk also varies by source category. With respect to activities at the Port of Oakland, reducing truck emissions will have the greatest impact on reducing potential cancer risk in the West Oakland community, followed by locomotives and OGV emissions.
- Diesel PM emissions and the associated cancer and non-cancer health risk will be reduced in the West Oakland community by about 80 percent by 2015 due to ARB's

actions. However, even with these actions, the remaining cancer risk will be greater than 200 in a million in the West Oakland community.

Broader Bay Area Region

- On a regional basis, diesel PM emissions from Port operations impact a very large area, about 550,000 acres. More than 3 million people live in this area. As a result of the diesel PM emissions from the Port, the area has potential elevated cancer risks of more than 10 chances in a million. Overall, the Port emissions result in a regional population-weighted potential cancer risk of about 30 in a million. OGV emissions are the largest contributor to the regional risk due to Port-related activities, responsible for about 85 percent of overall average potential cancer risks.
- On a regional basis, Port diesel PM emissions also result in non-cancer health impacts. Due to diesel PM from Port operations, there are an estimated 18 premature deaths per year, 8 hospital admissions for respiratory and cardiovascular problems, about 290 cases of asthma-related and other lower respiratory symptoms, and 15,000 minor restricted activity days.[1]
- Goods movement related on-road heavy-duty trucks that travel throughout the Bay Area and OGV from the Port and Part III are responsible for about 130 premature deaths. This represents about 80% of the regional non-cancer health impacts due to directly emitted diesel PM in the broader Bay Area. Of this, OGVs are responsible for about 35 premature deaths and trucks about 95 premature deaths.

C. Recommendations

The findings described above demonstrate that people living in the West Oakland community are exposed to unhealthful levels of diesel PM emissions and that these emissions will decline as ARB's emission reduction programs are implemented. However, even with the benefits from these programs, the residual risks are unacceptable and much more needs to be done to ensure that the potential cancer risks are reduced quickly and that programs are developed to offset the expected growth in emissions as global trade expands. Achieving emission reductions from the myriad of diesel PM emission sources is a challenging task and success depends on collective and innovative efforts at the community, local, State, federal and international levels. It is not possible to meet this challenge alone. There also isn't one approach that can be used to reduce emissions from the ships, locomotives, trucks, and other diesel-fueled vehicles and equipment. A variety of strategies are needed including regulatory efforts, voluntary and incentive programs, careful land-use decisions, and cooperative agreements.

[1] In late October 2008, ARB released a new methodology for estimating premature deaths associated with long-term exposures to fine airborne particulate matter in California that increases the relative risk factor from 6% to 10% increase in premature death per $10 \mu g/m^3$ increase in PM2.5 exposures. Using the 10% relative risk factor increases the estimated premature deaths reported above by 67%.

With that in mind, we have the following recommendations.

- Maximize emissions and risk reduction as quickly and early as possible
  As this risk assessment shows, current health risks in the West Oakland community and the Bay Area region as a whole are too high. Even with ARB's emission reduction programs, further efforts are needed to achieve additional emissions reductions.

  - The ARB, BAAQMD, the Port and its tenants, UP, and the community should work cooperatively to identify, prioritize, and implement actions beyond those identified in the Statewide Goods Movement Emission Reduction Plan to reduce diesel PM and other air emissions as quickly as possible.
  - The ARB, BAAQMD, the Port and its tenants, UP, and the community should work cooperatively to encourage and support national and international efforts to reduce emissions from ocean-going vessels as well as national efforts to reduce emissions from locomotives.

- Build and leverage funding sources to ease transition to clean technologies
  Programs designed to reduce emissions from trucks, ocean-going vessels, commercial harbor craft, and cargo handling equipment are expensive. The State has established funding opportunities which need to be utilized to their fullest extent to help ease the transition. The Port of Oakland should work in concert with ARB, the BAAQMD, and other stakeholders to secure incentive funding and identify additional funding opportunities.

  - The Port should work with the ARB, the BAAQMD, and the terminal operators to secure any incentive funding that may be available through the Carl Moyer Memorial Air Quality Standards Attainment Program.
  - The Port should work with the ARB, the BAAQMD, the terminal operators, and trucking companies to take advantage of the Proposition 1B Goods Movement Emission Reduction Program funds. These funds directly support early and accelerated diesel PM emission reduction programs and can help ease the transition into compliance with adopted and proposed ARB regulations.
  - The Ports of Los Angeles and Long Beach are implementing an Infrastructure Cargo Fee designed to provide a large supplemental funding source for infrastructure and air quality improvements. The Port of Oakland should adopt such a program or similar mechanism to ensure sufficient funding is available to meet air quality goals.

- Ensure successful implementation of ARB regulations
  Achieving successful implementation of ARB regulations in the Bay Area will achieve major emissions reductions in the West Oakland community. Achieving these goals requires ARB, the Port of Oakland, UP, BNSF, and private industry to work together

and cooperate to ensure emissions reductions are achieved. Specific initiatives include the following:

- The Port of Oakland should expeditiously adopt a clean trucks plan by the end of 2008. Continued delays in the adoption and implementation of a plan will result in truck owners not being able to replace or retrofit their trucks by the regulatory deadlines. A critical element of the plan is the collection of container fees. Without additional funds, truck owners will not have the financial means to upgrade their trucks.
- The BAAQMD, the Port and its tenants, UP, and the community should actively support implementation of the regulations "*Fuel Sulfur and Other In-Use Operational Requirements for Ocean-Going Vessels within California Waters and 24 Nautical Miles of the California Baseline*" and adoption of the "*Regulation to Reduce Emissions of Diesel Particulate Matter, Oxides of Nitrogen and Other Criteria Pollutants, and Greenhouse Gases from In-Use Heavy-Duty Diesel-fueled Vehicles.*" These regulations are critical to reducing diesel PM emissions not only throughout the State but also in the West Oakland community.
- The Port should work with the terminal operators, the local electrical utilities, and vessel operators to comply with ARB's regulation to reduce hotelling emissions. This may include the installation of shore power infrastructure to support cold-ironing for ships that visit the Port, negotiating with the local electrical utilities for reduced tariffs, and encourage vessel modifications to reduce emissions.
- UP Railroad should continue to aggressively work to fulfill commitments made in the 2005 ARB/Railroad State Wide Agreement *"Particulate Emissions Reduction Program at California Rail Yards."* Key elements for the agreement between the ARB and the Railroads (UP and BNSF) include the identification and implementation of future feasible mitigation measures based on the results of the railyard HRA.

- <u>Continue to study trucking operations at the Port and in West Oakland</u>
  As discussed in this assessment, trucking emissions are the largest single source of health risk to the West Oakland community. We propose actions be taken to provide additional data on the impact of trucking operations on the broader Bay Area region and the West Oakland community.

  - The BAAQMD should continue working with the community and the Port to implement its studies of trucking operations in the West Oakland community
  - The Port of Oakland should conduct a port truck survey and origin/destination study that investigates where Port truck trips begin, how Port trucks travel through the local community, and where Port trucks ultimately deliver their cargo.
  - The BAAQMD and ARB should consider revisiting findings from this risk assessment if new information about trucking operations in West Oakland deviates significantly from findings developed in this assessment.

II. BACKGROUND AND STUDY OVERVIEW

Diesel engines emit a complex mixture of air pollutants, composed of gaseous and solid material. The visible emissions in diesel exhaust are known as particulate matter or PM, which includes carbon particles or "soot." In 1998, following a 10-year scientific assessment process, ARB identified diesel PM as a toxic air contaminant based on its potential to cause cancer and other health problems, including respiratory illnesses, and increased risk of heart disease. Subsequent to this action, research has shown that diesel PM also contributes to premature deaths (ARB, 2002). Health risks from diesel PM are highest in areas of concentrated emissions, such as near ports, railyards, freeways, or warehouse distribution centers. Exposure to diesel PM is a health hazard, particularly to children whose lungs are still developing and the elderly who may have other serious health problems.

Diesel PM is a significant component of particulate matter in many cities. Diesel PM is composed of carbonaceous particles (soot) and particles that can form from nitrogen oxides (NO_X) and oxides of sulfur (SOx) emitted by diesel engines. The health impacts of particulate matter (PM10 and PM2.5) have been studied in epidemiological studies conducted in many different cities. These studies have found an increase of one to two percent in daily mortality associated with each 10 $\mu g/m^3$ increase in PM10 exposure. The most vulnerable subpopulations are those with preexisting respiratory or cardiovascular disease, especially the elderly. In addition, increased hospital admissions and illnesses from respiratory disease have been associated with particulate matter exposure in adults and children. Numerous epidemiological studies have also found an association between exposures to diesel PM and an increased risk of lung cancer.

> *A **risk assessment** is a tool used to evaluate the potential for a chemical or pollutant to cause cancer and other illnesses.*

Health risk assessments are a useful tool for comparing the potential health impacts of various sources of air pollution. In a risk assessment, the amount of diesel PM emitted from each source (e.g., truck or ship) is estimated. An air modeling computer program uses local meteorological data (e. g. wind speed and direction) to estimate the annual average ground level concentrations of diesel PM in the communities around the facility. The increased risk of developing lung cancer from exposure to a particular level of diesel PM can be estimated using the Office of Environmental Health Hazard Assessment's (OEHHA) cancer potency factor for diesel PM. The non-cancer health impacts of diesel PM exposure can also be quantified if the expected concentrations of a pollutant are high enough and there is enough population exposed to predict a result.

> *For **cancer** health effects, the risk is expressed as the number of chances in a population of a million people who might be expected to get cancer over a 70-year lifetime. The number may be stated as "10 in a million" or "10 chances per million". Often, scientific notation is used and you may see it expressed as 1×10^{-5} or 10^{-5}. Therefore, if you have a potential cancer risk of 10 in a million, that means if one million people were exposed to a certain level of a pollutant or chemical there is a chance that 10 of them may develop cancer over their 70-year lifetime. This would be 10 new cases of cancer above the expected rate of cancer in the population. The expected rate of cancer for all causes, including smoking, is about 200,000 to 250,000 chances in a million (one in four to five people).*

These non-cancer impacts include premature death, hospital admissions, respiratory illnesses/asthma, and lost school/work days. However, the cancer health impacts have more commonly been used as the yardstick with which to compare the impacts of various diesel sources. Risk assessments have various uncertainties in the methodology and risk assessments are therefore deliberately designed so that risks are not under predicted. Risk assessments are best understood as a tool for comparing risks from various sources, usually for purposes of prioritizing risk reduction, rather than as a literal prediction of the incidence of disease in the exposed population.

A. West Oakland Community Health Risk Assessment Study Overview

West Oakland is bounded to the west and southwest by the Maritime Port of Oakland, the Union Pacific Railyard, and the I-880 freeway. The I-580 freeway traverses along the northern edge of the neighborhood, the I-980 freeway to the east and the I-880 freeway to the south. West Oakland covers about a three square mile area and is a diverse neighborhood. It is not uncommon to find light industrial, commercial, and residential areas intermixed within the same block. As mentioned earlier, to investigate the potential health impacts from exposures to diesel PM emissions, a health risk assessment was conducted. Below we provide brief summaries of the key elements for the HRA.

Study (Modeling) Domain

The study or modeling domain is the area in which the concentrations of diesel PM emissions in the atmosphere are to be determined. In this study, the modeling domain includes the Port, the ocean to the west of the Golden Gate Bridge out to the outer buoys, the inner bay waterway between Golden Gate Bridge and the Port, and the nearby communities. The size of the modeling domain was selected to ensure that the modeling effort would take into consideration all the diesel PM emissions. These emissions include all of the ship travel routes in the nearby ocean and the inner waterways to and from the Port, the Port property, and other land-based areas that could result in diesel PM emissions that would be expected to have risks level of 10 per million or greater. The modeling domain for the study is shown in Figure 4. It covers a 100 kilometer (km) by 100 km area (about 3,800 square miles).

For computer modeling purposes, the domain needs to be broken up into smaller areas referred to as grid cells. Selection of grid cell size reflected a compromise between the desire to define meteorological and geophysical variations on a very small scale, and the computer time and resources necessary to run the model. Given the complex terrain (sea-land, rolling mountains, etc.), non-uniform land-use characteristics, and the water bodies large enough to cause strong local-scale flows, we decided to use a grid cell size of 500 meters (m) x 500 m (about a third of a mile by a third of a mile) for the modeling effort. To provide a more detailed estimate of localized impacts of the emissions on the nearby community of the Port (West Oakland community), we used a grid cell size of 250 m x 250 m for the areas bordering the Port.

The meteorological grid was defined by 10 vertical layers. Cell heights were set at 20, 60, 80, 100, 300, 600, 1000, 1500, 2200, and 3000 meters above-ground level (AGL).

Figure 4: Modeling Domain for the West Oakland Community Health Risk Assessment

Air Pollutants Evaluated

The study focused on the impacts from diesel PM. As mentioned earlier, diesel PM is a toxic air contaminant and exposure to diesel PM emissions can result in serious health impacts. Previous studies have shown that diesel PM is responsible for over 70 percent of the potential cancer risk from all toxic air contaminants in California. (DDRP, 2000) Because the health impacts from diesel PM are so large and exceed the health impacts from other air toxics on a community and regional basis, we limited the study to diesel PM emissions and did not evaluate the impact of other toxic air contaminants on West Oakland or the region.

Sources and Locations of Diesel PM Investigated

There are many sources of diesel PM emissions within the study domain. Diesel PM emission inventories were prepared for all local sources of diesel PM that were expected to impact the West Oakland community. To help manage the development of the emissions inventory and to interpret the results, the study domain was segregated into three parts. Part I included the diesel PM activities associated with the Maritime Port of Oakland. Part II addressed diesel PM sources at the Union Pacific (UP) Railyard. Part III examined the other sources of diesel PM in the Bay (over-water) and those located in and near the West Oakland community. Both Parts I and III included emission sources that were located overwater such as ships, ferries and tug boats. Figures 5 and 6 provide aerial overviews of the land-based portions and the water-based regions for Parts I, II, and III. These are the areas in which we estimated the diesel PM emissions.

Figure 5: Land-based Emissions Domain for Parts I, II, and III

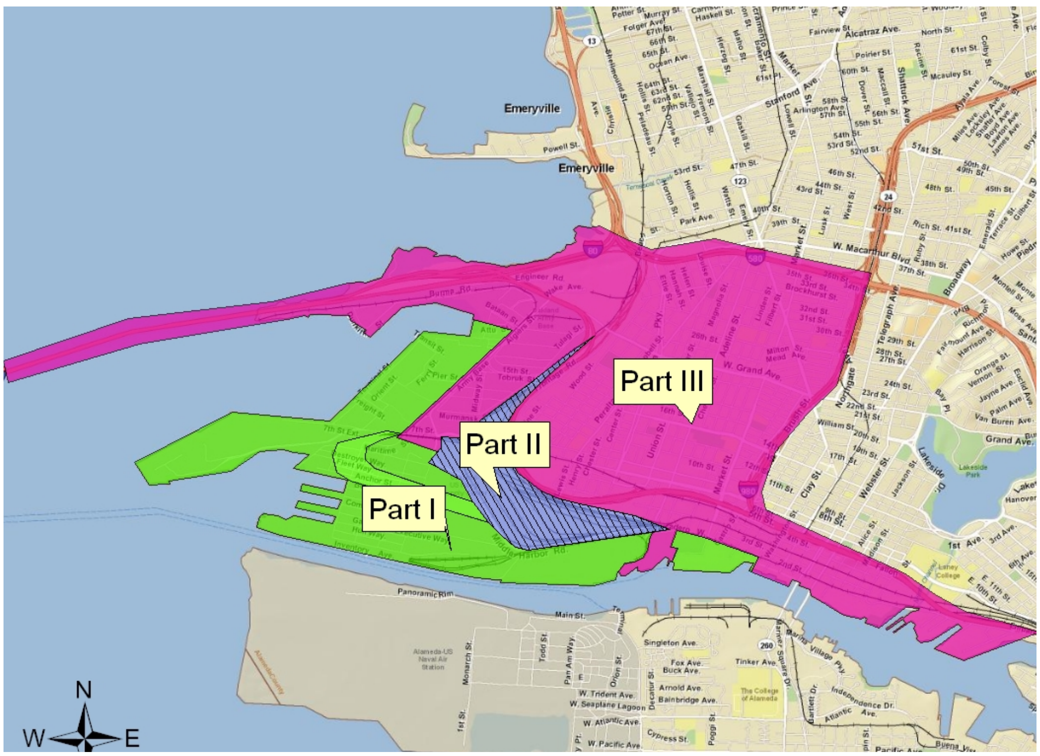
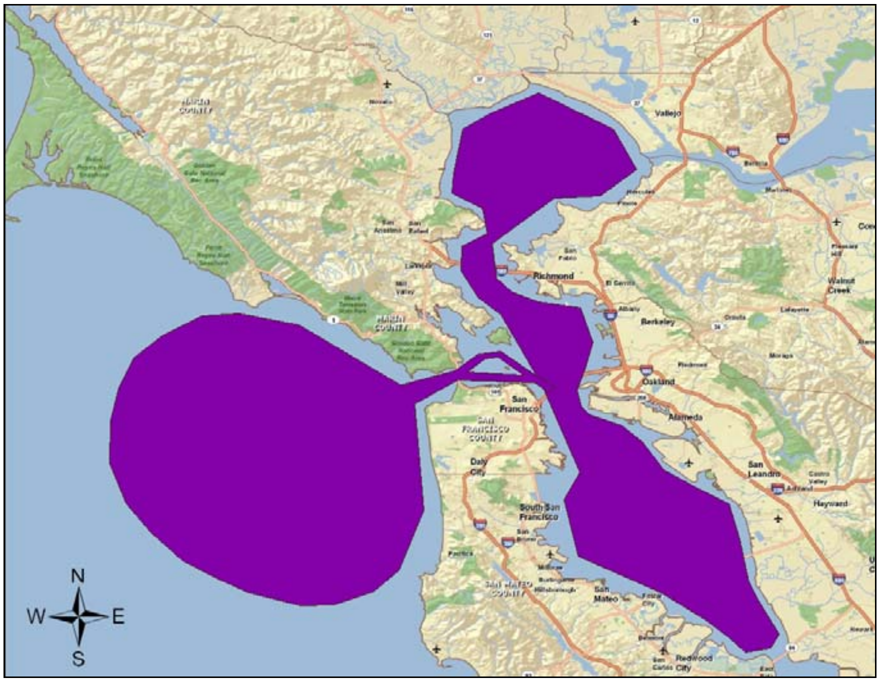


Figure 6: Overwater-based Emissions Domain for Parts I and III



In each area, there were a wide variety of operations and activities that resulted in emissions of diesel PM. In Table 1 below, we provide a summary of the various diesel PM emission sources inventoried in each Part.

Table 1: Sources of Diesel PM Evaluated in the HRA

Area	Description	Emission Sources Inventoried
Part I	Maritime Port of Oakland	ocean-going vessels, commercial harbor craft, cargo handling equipment, port drayage trucks operating on Port property, in West Oakland and on local freeways, on-port locomotives
Part II	Union Pacific Railyard	locomotives, cargo handling equipment, truck refrigeration units and reefer cars, drayage trucks
Part III	Non-port and non-Union Pacific Railyard areas in and adjacent to the West Oakland Community	on-road trucks, ocean-going vessels,* commercial harbor craft, cargo handling equipment, locomotives, Amtrak Maintenance facility, major construction projects, stationary point sources, truck-based businesses and distribution centers

* Included in Part III were only ocean-going vessels destined for ports and terminals in the Bay Area other than the Port of Oakland

2005 Baseline Emissions Inventory

We compiled a 2005 baseline emissions inventory representing emission sources in Part I, Part II, and Part III. Part I emissions inventories were developed by Environ International Corporation (Environ) for the Port of Oakland and reviewed by ARB and BAAQMD staff. Part II emissions inventories were developed by Union Pacific and reviewed by ARB staff. Part III emissions inventories were developed by ARB, Port, and BAAQMD staff. Because inventories were categorized into different Parts, we took care to ensure each Part was distinct so as to avoid double-counting of emissions. Table 2 provides summary emissions estimates by source category and Part. As shown in Table 2, the emissions of diesel PM from Port-related activities were estimated to be approximately 265 tons per year for the Port (Part I), 11 tons per year for the Union Pacific Railyard activities (Part II), and about 570 tons per year for the other sources (Part III). All combined, it was estimated that there were approximately 845 tons of diesel PM emissions in 2005 from the combined activities. A more detailed summary for the Parts I, II, and III emissions inventory is provided in Appendix A. Appendix A also provides the links to the more detailed emission inventory documents for each part.

It should be noted that the emissions totals for the various categories presented in Table 2 may be slightly different than the emissions presented in Appendix A. The emission inventory in Table 2 is the inventory used in the dispersion modeling. It differs slightly from the Appendix A inventory because, in some cases such as for Part III ocean-going vessels, the emissions inventory presented in Appendix A included emissions that were outside of the model domain. In addition, the Part I (port) heavy-duty diesel truck inventory used in the modeling exercise is different than that published in the Part I inventory prepared by the Environ for Port. The approximately 20 tons per year (T/Y) reported in Table 2 for Part I trucks includes approximately 2.8 T/Y emissions from port-truck activities on nearby freeways that was not within the scope of the inventory prepared for the Port. It also includes on-site truck emissions from the Oakland Maritime Support Services (OMSS) facility (1.4 T/Y).

Table 2: Summary of Modeled 2005 Diesel PM Emissions for the West Oakland HRA

Source Category	Port of Oakland (Part I)	Union Pacific Railyard (Part II)	Non-Port & Non-UP (Part III)	Combined
	2005 Diesel PM Emissions Tons/Year			
Ocean-going Vessels	209	-	218	428
Cargo Handling Equipment	21	2.2	4.3	27
Heavy-duty Diesel Trucks	20	1.9	90	112
Commercial Harbor Craft	13	-	238	251
Locomotives	2.0	3.9	1.3	7.2
TRUs & Reefer Cars	-	3.2	-	3.2
Amtrak Maintenance Facility	-	-	3.4	3.4
Major Construction Projects	-	-	13	13
Stationary Point Sources	-	-	0.2	0.2
Total	265	11	568	845

Notes: Modeled emissions are different than emissions reported in Appendix A and D due to the size of the modeling domain being slightly smaller than the overall region in which emissions were estimated. For Part III, the "Major Construction Projects" includes community construction projects. Approximately 10% or 1.2T/Y of the 13 T/Y is due to emissions from construction projects on Port property. Part III trucks include on-road truck emissions from activities at distribution centers.

The emission inventory presented in Table 2 represents the most comprehensive inventory of diesel PM emissions in the West Oakland area that has been done. The inventory was compiled from ARB developed category-specific emissions inventory models, and additional data where necessary to allocate emissions spatially within the modeling domain. The inventory was reviewed by several groups within ARB, and by the BAAQMD and the Port. Overall, there is general agreement that the inventory represents the best information available on each category of emissions source, and the magnitude of emissions in the modeling domain.

Early on in the inventory development process, ARB staff realized that information on trucking activity, both associated with the Port of Oakland and trucking operations in the West Oakland community as a whole, was quite limited. Staff used a transit network which provided the best available representation of truck activity in the West Oakland community to estimate emissions. However, that transit network also contained significantly more activity in the Bay Area as a whole than currently estimated in ARB's emissions inventory model, EMFAC. We believe because of this discrepancy that overall trucking activity and emissions in the modeling domain may be overestimated, which would result in an underestimate of the overall fraction of trucking emissions that are attributable to the Port of Oakland. The implications of this are discussed later in this document.

Because of these data limitations, ARB staff has worked with BAAQMD staff in their development and implementation of new studies focused on improving the quantification of Port and non-Port trucking operations in the West Oakland community. These studies are necessary, and will provide information that can be used in the future to update and refine truck inventory estimates provided in this report. ARB staff has also suggested that the Port of Oakland needs to conduct origin-destination truck surveys to better understand the location of trucking operations on both a regional basis, and within the West Oakland community. Without these studies, we cannot know with certainty the magnitude of trucking emissions that are attributable to the Port of Oakland that occur within the West Oakland community or on a regional basis. Nevertheless, it is clear that emissions from port drayage trucks and other heavy-duty trucks are a significant emissions source in the West Oakland community and they need to be reduced.

Future Emissions Inventory

One of the goals of this health risk assessment was to estimate both baseline and future health risks associated with emissions from the Port of Oakland, the Union Pacific Railyard, and other emissions sources. Evaluating the potential health impacts in future years requires the use of emission inventories for future years. Forecasting emissions requires estimating the future growth, and the impact of current and pending State and federal regulations on each emissions source. To accomplish this task, we used a scaling approach that was derived from ARB reports and published emissions estimates and designed to simulate the combined impact of both growth and regulatory control trends on each source category individually.

In general, the growth assumptions are consistent with the assumptions used in the Goods Movement Emission Reduction Plan (GMERP) approved by the ARB in 2006 and are about 4-5% per year for each category.[2] Even with substantial growth, emissions are expected to decrease in the future. These decreases are caused by regulations that the ARB and federal government have already adopted, such as ARB's Port Drayage Truck regulation requiring the clean-up of all trucks that service California's Ports. For the purposes of this forecast, we also assumed that two major ARB rules, which were either adopted or under development during the study period, will apply in 2015 and 2020. In July 2008 the Board approved a regulation which requires ocean-going ships to use cleaner fuels in their auxiliary and main engines and auxiliary boilers. A second regulation which will require the clean-up of private on-road heavy duty trucks (Private Fleet Regulation) will be considered by the ARB for adoption in December 2008. Overall, every emissions source covered in this assessment has been or will be controlled by local, state, and/or federal regulation. In particular, it is important to understand that with the adoption of ARB's Port Drayage Truck Regulation and the proposed Private Fleet Regulation every truck operating in West Oakland will be required to meet new, more stringent emissions standards.

Additional information on the control measures and regulations included in the forecasted inventory are provided in Table 8 found later in this report. In addition,

[2]Growth rates are subject to uncertainty. Given the recent economic slowdown in the U.S., some have argued that the growth rates projected in the GMERP cannot be sustained. However, it is not possible to know if this is a long-term trend or a short-term reaction to economic pressures. Based on the container throughput for the Port of Oakland between 1992 and 2007, the Port saw an average of 4.2% growth per year even with two or three years with negative growth.

information on the growth and control factors used to forecast the inventory is provided in Appendix I. Using this approach, emissions were forecasted to 2010, 2015, and 2020. Table 3 provides the future year emissions estimates for each Part and source category. As can be seen, even with growth, emissions are forecasted to decline due to the regulations that have been adopted or are planned to be adopted in 2008. Overall, the combined emissions are expected to decrease by about 50 percent in 2010 and 70 percent in 2020 relative to emissions levels in 2005.

Table 3: Summary of 2005 and Projected 2010, 2015, and 2020 Diesel PM Emissions for the West Oakland HRA

	Diesel PM Emissions Tons/Year															
	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020
Ocean-going Vessels	209	68	57	66	-	-	-	-	218	61	51	57	427	129	108	123
Cargo Handling Equipment	21	12	4.8	4.3	5.4	3	1.2	1.1	4.3	2.4	1	1	31	18	7	6.3
Heavy-duty Diesel Trucks	20	3.4	3.4	6.3	1.9	0.3	0.3	0.6	90	55	9	15	112	59	13	21
Commercial Harbor Craft	13	11	5.4	3.6	-	-	-	-	238	218	142	84	251	229	147	87
Locomotives	2	1.6	1.5	1.4	3.9	3.1	3	2.8	1.3	7.3	4.8	5	7.2	9	9	9.4
Total	265	96	72	82	11	6.4	6.5	4.5	556	342	208	162	832	445	285	248

Note: Emissions were forecasted only for locomotives, ships, trucks, harbor craft and cargo handling equipment. For Part II, emissions associated with TRUs and reefer cars were combined with cargo handling equipment emissions. Emissions were not forecasted for stationary point sources or construction projects. Therefore; 2005 emissions from Table 2 will differ than those presented in Table 3 for the year 2005. In addition, the totals may differ slightly due to rounding.

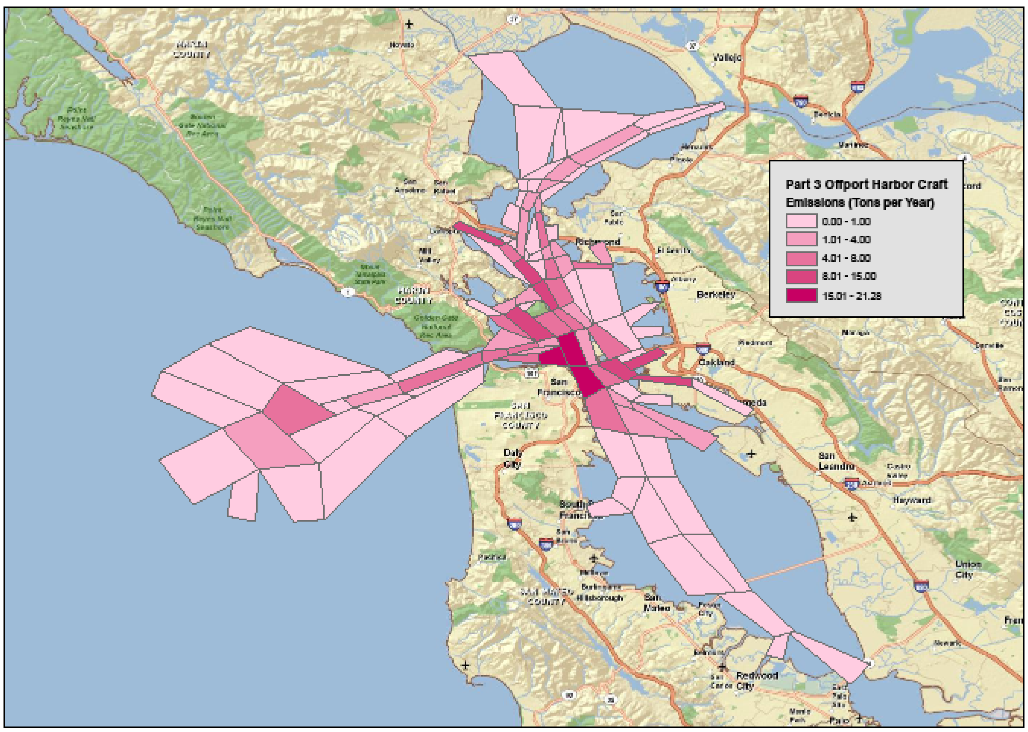
Spatial and Temporal Allocation of Emissions

Running dispersion models requires assigning spatial locations and temporal release profiles to emissions in each Part from each source. This is an important aspect in an HRA because where emissions are released and the time of day they are emitted can have a significant impact on the exposures to the emissions. In addition, many emission sources are not released from a single location but occur over a broad area.

To model emissions that occur over a broad area, the emissions are placed within a geometric figure (polygon) that approximates the region in which the emissions are released. Within the polygon, the emissions are evenly distributed. In most cases, spatial locations are derived from source data used for emissions inventory development. This is the case for ocean-going vessels (OGV), cargo handling equipment, and trucks. In some cases, spatial locations are estimated using surrogate data from a sample of data sources. This is the case for Part III commercial harbor craft where we had information from geographic information systems tracking devices on harbor craft that was used to determine where the emissions from harbor craft occurred.

An example of how emissions are spatially allocated is provided in Figure 7. Figure 7 presents the locations in which the harbor craft emissions from Part III were assumed to be released in the air dispersion modeling. As is shown, the harbor craft emissions were allocated in an area outside the Golden Gate Bridge and within the inner San Francisco Bay area. Each polygon represents a portion of the Part III harbor craft inventory and the darker the shading in the polygon, the more emissions that were released within that area. Additional figures depicting how the emissions from various sources were spatially allocated are provided in Appendix E.

Figure 7: Spatial Allocation of Harbor Craft Diesel PM Emissions in the San Francisco Bay Area



The time during the day (temporal profile) when emissions are released also can impact exposures. This is because the meteorological conditions change over the course of a day – emissions released only during daylight hours will see different meteorological conditions then emissions released over the entire 24-hour day. Because of this, the emission inventory needs to be adjusted to account for the time of day over which the emissions occur. For example, drayage truck emissions predominately occur between 6AM and 8PM while OGV hotelling emissions occur 24 hours a day. Temporal profiles were identified for each source category and for each part based on discussions with the Port and business representatives and previous studies of port-related operations. Table 4 provides the assumptions used for the temporal profiles for each emissions source.

Table 4: Temporal Distribution of Diesel PM Emissions for the West Oakland HRA

Category	Time Period	Activity Distribution	Hours Per Day
OGV - Hotelling	12AM – 12AM	100%	24
OGV- Transiting	4AM – 9PM 9PM – 4AM	75% 25%	17 7
Harbor Craft - Tugs	5AM – 8PM 8PM – 5AM	80% 20%	15 9
Harbor Craft - Other	7AM – 6PM 6PM – 7AM	80% 20%	11 13
On-Road Trucks – Part I (on-port)	6AM – 6PM 6PM – 6AM	98% 2%	12 12
On-Road Trucks – Part III	6AM – 6 PM 6PM – 6AM	80% 20%	12 12
Cargo Handling Equipment	9AM – 6PM 6PM – 9AM	80% 20%	9 13
Locomotives	12AM – 12AM	100%	24

Note: Values provided in Table 4 have been summarized from more detailed hourly distributions to provide a general idea of how the emissions are temporally distributed. Additional detail on the temporal distributions is` provided in Appendix B, Table B-8.

<u>Air Dispersion Model</u>

Currently there is not a scientific method to monitor directly for diesel PM in the air. However, air dispersion models can be used to estimate the concentration of diesel PM in the air. Air dispersion models use emission inventory data (magnitude, timing, and location of emissions), local meteorological information (wind speed, direction, temperature, etc.) and mathematical formulations that represent atmospheric processes to predict concentrations of a pollutant in the air.

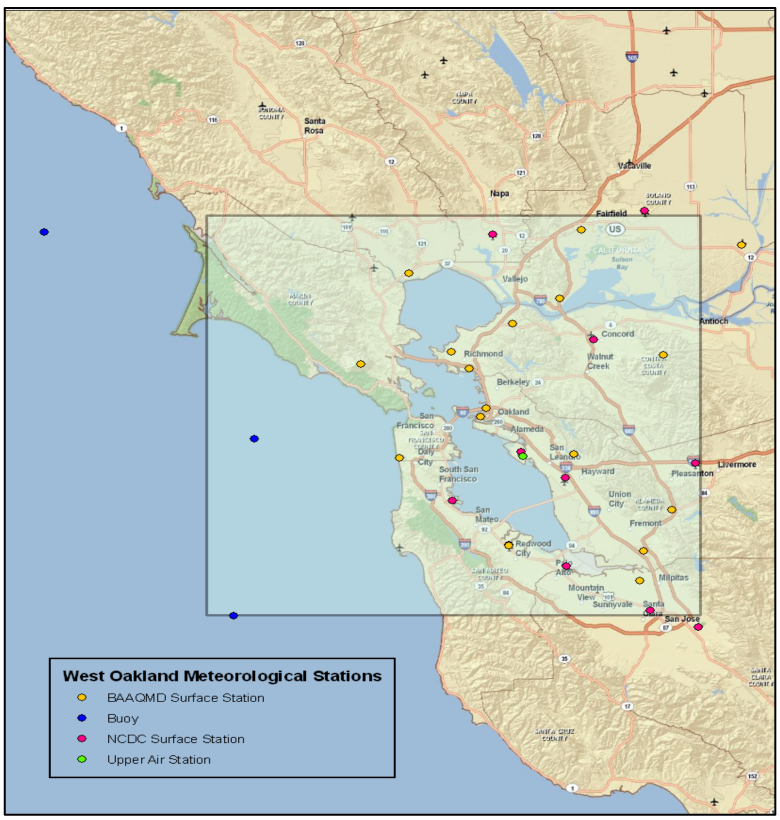
The selection of an air dispersion model depends on many factors, including: nature of the pollutant (e.g., gaseous, particulate, reactive, inert), characteristics of emission sources (point, area, volume, or line), relationship between emission source and receptor, meteorological and topographic complexities of the area, the complexity of the source distribution, spatial scale and resolution required for the analysis, level of detail and accuracy required for the analysis, and averaging times to be modeled. For this study, ARB staff used the United States Environmental Protection Agency (U.S. EPA) CALPUFF model to estimate the annual average concentration of diesel PM in the West Oakland community. As one of the U.S. EPA's preferred air dispersion models, CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model that can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, transformation, and removal. A key feature of CALPUFF is its ability to account for spatially varying meteorological conditions with a three-dimensional wind field. As such, CALPUFF is capable of producing more accurate results than simpler models that do not simulate spatially varying wind fields. This is particularly true when dealing with large study areas and complex terrain such as is the case in this study.[3]

Meteorological Data

The CALMET meteorological processor is a key component of the CALPUFF modeling system. Its primary purpose is to prepare meteorological inputs for running CALPUFF that accurately represent the ground level and upper air meteorology. Meteorological input data required for CALMET include surface, upper-air, and overwater data. Geophysical input data include terrain and land-use data.

Meteorological data used in this study were obtained from the National Climatic Data Center (NCDC), the Bay Area Air Quality Management District (BAAQMD), and the National Weather Service stations. Data on meteorological observations from 30 inland surface stations (13 from NCDC and 17 from BAAQMD), 3 ocean buoys, and 1 upper air station were collected for this study. In Figure 8, we show the various meteorological data collection sites that provided information for the CALMET processor.

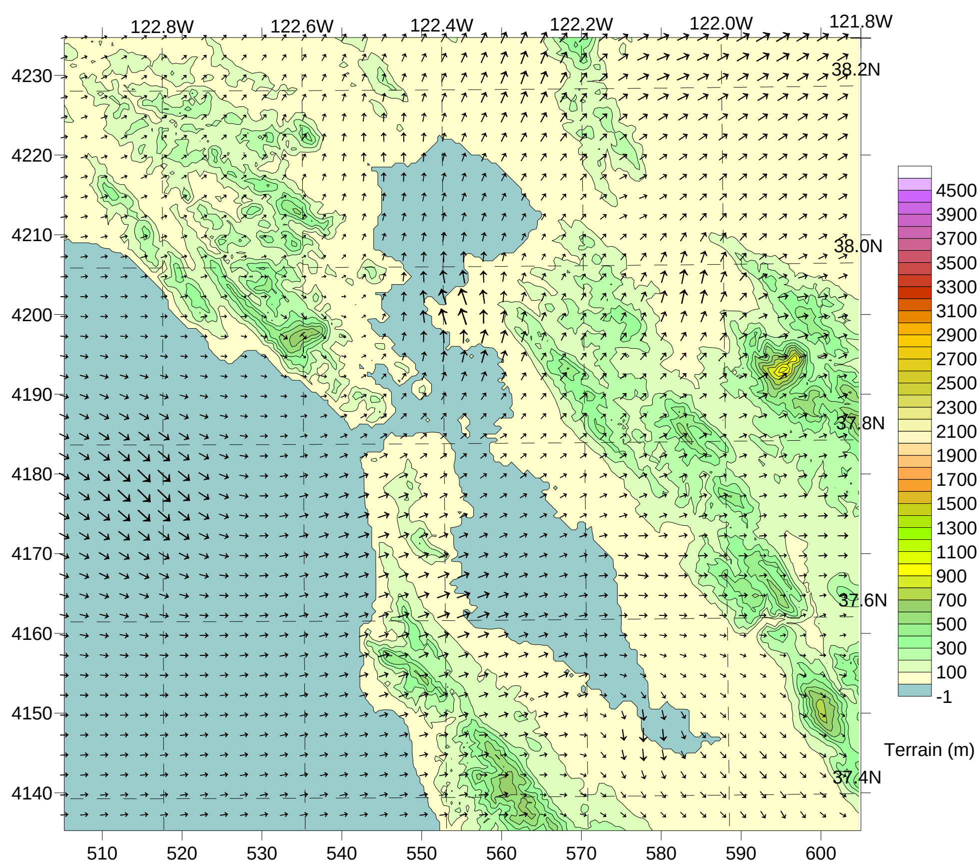
Figure 8: Location of Meteorological Stations Providing Meteorological Data for the West Oakland Community HRA



[3] In order to incorporate the impacts of Part II, the UP Railyard, with the impacts of Parts I and III, we modeled the Part II emissions using CALPUFF. The modeling results using AERMOD can be found at http://www.arb.ca.gov/railyard/hra/hra.htm. Throughout this report, any summary tables or comparisons are based solely on the CALFUFF modeling results for Part II.

CALMET is uniquely suited to be able to simulate complex local effects of terrain and wind flow that can impact the concentrations of a pollutant. This is particularly important in this study since the emission sources span a wide area starting from the ocean (west of San Francisco) to the Golden Bridge through the inner San Francisco Bay, to the Port and areas over land. This domain covers an area of very complex wind flows and terrain including over-water areas, over-land areas, and both flat regions and hilly areas. An example of the wind field plot for the model domain over a one-hour period is provided in Figure 9. The arrows on the figure designate both the direction and magnitude (speed) of the wind (i.e., the bigger the arrow, the greater the wind speed). In this example, surface winds were highly variable with terrain features and show almost all phenomena of complex terrain, such as circulation, mountain/hill blocking, channeling, and valley flows. In the northern coastal ranges of the San Francisco Bay Area, the winds were lighter and showed the damping or blocking effects (slowing down of the winds) of the mountains. In the inner San Francisco Bay, winds flow through the Golden Gate Bridge and then turn toward the northeast and/or north. These winds then flow into the inland valley areas of Napa, Fairfield, and Sacramento. In addition, the plot shows how the wind field converges in valley locations and diverges as it meets mountains and hills.

Figure 9: Illustration of Complex Terrain and Wind Flow Patterns in the San Francisco Bay Area



Additional details on the modeling methodology are provided in Appendix B. In addition, Appendix F provides the wind roses and statistics for San Francisco Bay area meteorological stations; Appendix G provides additional examples of CALMET wind fields; and Appendix H provides the results from a sensitivity study evaluating the effects of wet and dry deposition.

Exposure Assessment

For this study, we estimated both the cancer and non-cancer health impacts from the exposures to diesel PM emissions. Below we provide brief descriptions of the methodologies used.

Potential Cancer Risks: The potential cancer risks were estimated using standard risk assessment procedures based on the annual average concentration of diesel PM predicted by the model and a health risk factor (referred to as a cancer potency factor) that correlates cancer risk to the amount of diesel PM inhaled.

The methodology used to estimate the potential cancer risks is consistent with the Tier-1 analysis presented in OEHHA's Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments (OEHHA, 2003). A Tier-1 analysis assumes that an individual is exposed to an annual average concentration of a pollutant continuously for 70 years.[4] The cancer potency factor was developed by the OEHHA and approved by the State's Scientific Review Panel on Toxic Air Contaminants (SRP) as part of the process of identifying diesel PM emission as a toxic air contaminant (TAC).

The estimated diesel PM concentrations and cancer risk levels produced by a risk assessment are based on a number of assumptions. Many of the assumptions are designed to be health protective so that potential risks to individuals are not underestimated. Therefore, the actual cancer risk calculated is intentionally designed to avoid under-prediction. There are also many uncertainties in the health values used in the risk assessment. Some of the factors that affect the uncertainty are discussed later in Chapter III.

Non-Cancer Health Impacts: A substantial number of epidemiologic studies have found a strong association between exposure to ambient particulate matter (PM) and adverse health effects (CARB, 2002). As part of this study, ARB staff conducted an analysis of the potential non-cancer health impacts over the broader San Francisco Bay Area region in the study domain associated with exposures to the model-predicted ambient levels of directly emitted diesel PM (primary diesel PM) from the Port. The non-cancer health effects evaluated include premature death, hospital admissions, asthma-related and other lower respiratory symptoms, work loss days, and minor restricted activity days.

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[4]According to the OEHHA Guidelines, the relatively health-protective assumptions incorporated into the Tier-1 risk assessment make it unlikely that the risks are underestimated for the general population.

ARB staff assessed the potential non-cancer health impacts associated with exposures to the model-predicted ambient levels of directly emitted diesel PM (primary diesel PM) over the entire modeling domain. The population in the domain was determined from U.S. Census Bureau year 2000 census data and then was projected to the year of 2005. Using the methodology peer-reviewed and published in the Staff Report: *Public Hearing to Consider Amendments to the Ambient Air Quality Standards for Particulate Matter and Sulfates*, (PM Staff Report) (CARB, 2002), we calculated the number of annual cases of death and other health effects associated with exposure to the PM concentration modeled over the entire modeling area.[5] Non-cancer health impacts were not separately estimated for the West Oakland community. However, the impact of Port operation on regional PM mortality would include the impacts on the West Oakland community.

[5] In late October 2008, ARB released a new methodology for estimating premature deaths associated with long-term exposures to fine airborne particulate matter in California that increases the relative risk factor from 6% to 10% increase in premature death per 10µg/m^3 increase in PM2.5 exposures. ARB staff used the 6% relative risk factor in this study, using the 10% relative risk factor increases the estimated premature deaths reported by 67%.

III. SUMMARY OF RESULTS

In this chapter, we provide the summary of results for the potential cancer risks and non-cancer health impacts. It is important to note that no background or ambient diesel PM concentrations are incorporated into the risk quantification. Based on the most recent estimate of basin wide risk in 2000, the estimated background potential cancer risk due to diesel PM in the San Francisco Bay Area is about 480 excess cancers per million (CARB, 2007). However, given the magnitude of the diesel PM emissions for all three parts and the predominate onshore wind flow, it is difficult to accurately estimate how much of the background in West Oakland community is from activities covered in Part I, II, and III versus activities located north or east of West Oakland. In addition, the potential cancer risks only take into consideration the potential cancer risk due to inhalation of diesel PM. This is because studies have shown that the risk contributions by other pathways of exposure, such as ingestion, are negligible relative to the inhalation pathway.

Due to the large number of emissions sources and the way the emissions were allocated to Parts I, II, and III, there are numerous ways of analyzing and presenting the results from this study. For this summary of results, we focused on the potential cancer risks from all sources and parts on the West Oakland community. We also provide the results from an analysis of the potential cancer and non-cancer impacts of Port-related emissions on the broader regional domain. Additional analyses are provided in Appendices C and D.

A. Potential Cancer Risk[6]

West Oakland Potential Cancer Risks from All Sources

Figure 10 shows the risk isopleths for all diesel PM emission sources from all three parts superimposed on the map that covers the small (10 km x 10 km) domain used to study the potential cancer risks in the West Oakland community. As can be seen, the entire West Oakland community is exposed to elevated potential cancer risks from diesel PM emissions that occur adjacent to and in the West Oakland community.

[6] As stated earlier, a modeling domain of 100 km x 100 km with a grid resolution of 500 m x 500 m was used in the modeling effort. The effective land area (excluding the Port property and the over water region) is about 6,500 square kilometers (3,800 square miles). The population within the modeling receptor domain is about 5 million based on the U.S. Census Bureau's year 2000 census data. Similarly, the effective land area of the West Oakland community is about 7.7 square kilometers (3 square miles) and the population within the community is about 22,200. The risk numbers, impacted areas, and affected population presented in this chapter are based on the effective land area within the modeling domain; that is, the risk, the area, and the number of population within the port property and over the ocean/lake/water surfaces are excluded from this analysis. Note that if the modeling domain expands, the risks, impacted areas, and affected population presented in this analysis would change.

Figure 10: Estimated West Oakland Community Potential Cancer Risk from All Diesel PM Emissions Sources (Parts I, II, & III)

Notes: The risk levels are based on the 80th Percentile Breathing Rate. Total Modeled Emissions = 845 T/Y in 2005. Modeling Domain = 10 km x 10 km. Resolution = 250 m x 250 m. The dashed line represents the boundary for the West Oakland community.

Using the U.S. Census Bureau's year 2000 census data, we estimated the population within the isopleth boundaries. As shown in Table 5, the entire population of the West Oakland Community, about 22,000 people are exposed to risk levels greater than 500 in a million and over 50 percent of the residents living in the West Oakland Community are exposed to a risk level of greater than 1000 in a million.

Table 5: West Oakland Community Summary of Impacted Area and Affected Population by Potential Cancer Risk Levels from All Emission Sources (2005)

Potential Cancer Risk Level	Impacted Inland Area		Affected Population	
	Acres	Percent	Number	Percent
Risk > 10	1,800	100%	22,200	100%
Risk > 100	1,800	100%	22,200	100%
Risk > 200	1,800	100%	22,200	100%
Risk > 500	1,800	100%	22,200	100%
Risk > 1000	1,000	56%	11,000	50%

Notes: Total area for the community = 1,800 acres; total population = 22,200

As discussed previously, the emission sources were grouped or classified into three parts: the Maritime Port of Oakland (Part I), the Union Pacific Railyard (Part II), and the other non-port and non-UP diesel PM emissions that occur near and in the West Oakland community (Part III). The diesel PM emissions and corresponding population exposed for the three parts are presented in Table 6. All three parts exert significant health impacts to the West Oakland community. Emissions from each part (Part I, II, & III) individually result in risk levels of greater than 10 in a million throughout the entire West Oakland community and affect every resident. The zone of impact for potential risk levels above 100 in a million resulting from either Part I or Part III emissions also encompass the entire West Oakland community.

Table 6: West Oakland Community Summary of Impacted Area and Affected Population by Potential Cancer Risk Levels from Part I, II, & III Emission Sources (2005)

Potential Cancer Risk Level	Impacted Inland Area (acres)				Affected Population			
	Part I (Port)	Part II (UP)	Part III (Non-port/Non-UP)	Combined	Part I (Port)	Part II (UP)	Part III (Non-port/Non-UP)	Combined
Risk > 10	1,800	1,800	1,800	1,800	22,200	22,000	22,200	22,200
Risk > 100	1,800	280	1,800	1,800	22,200	1,800	22,200	22,200
Risk > 200	770	80	1,800	1,800	7,000	100	22,200	22,200
Risk > 500	0	0	1,700	1,800	0	0	20,500	22,200
Risk > 1000	0	0	480	1000	0	0	6,300	11,000

Notes: Total area for the community = 1,800 acres; total population for the community = 22,200

In Table 7, the percentage of the overall population-weighted cancer risk[7] that can be attributed to each part is provided. As can be seen, the West Oakland community has an overall population-weighted risk of nearly 1,200 chances in a million due to the diesel PM emissions from Parts I, II, and III. Of this, the Port operations (Part I) account for about 16 percent of the overall cancer risk or 200 potential cancer cases per million. UP operations (Part II) account for about 4 percent of the overall cancer risk or 43 potential cancer cases per million people. Non-port and non-UP operations (Part III) account for the largest share of the overall potential cancer risk in the West Oakland community, about 80 percent of the total risk or about 950 potential cancer cases per million people.

Compared with Part I or Part II, the emissions from Part III exert the most significant health impacts on the community. Part III emissions are responsible for one out of three residents in the community being exposed to potential cancer risk levels greater than 1000 in a million and everyone in the community is exposed to levels of greater than 500 in a million. As can be seen in Table 7, the elevated potential cancer risk levels are primarily due to on-road trucks.

[7] Population-weighted cancer risk or "average risk" is calculated using the following equation:

$$\bar{R} = \frac{\sum_{i}^{n} \left(R_i \, x \, POP_i\right)}{\sum_{i}^{n} POP_i}$$

Where R_i is the estimated risk in grid cell i; POP_i is the allocated number of population in grid cell i; n is the total number of grid cells within the modeling domain. For the West Oakland community, the population-weighted cancer risk is essentially similar to the average risk.

Table 7: Population-weighted Potential Cancer Risks in West Oakland Community by Part and by Source Category

Source Category	Part I (Port)	Part II (UP)	Part III (Non-port/Non-UP)	Combined
OGV Transiting, Maneuvering, & Anchoring	57	0	23	81
OGV Hotelling	57	0	10	67
Harbor Craft	15	0	78	93
Trucks	42	7	795	844
Cargo Handling Equip.	16	21	7	43
Locomotives	4	15	37	56
Others	0	0	2	2
Total	192 (16%)	43 (4%)	951 (80%)	1186 (100%)

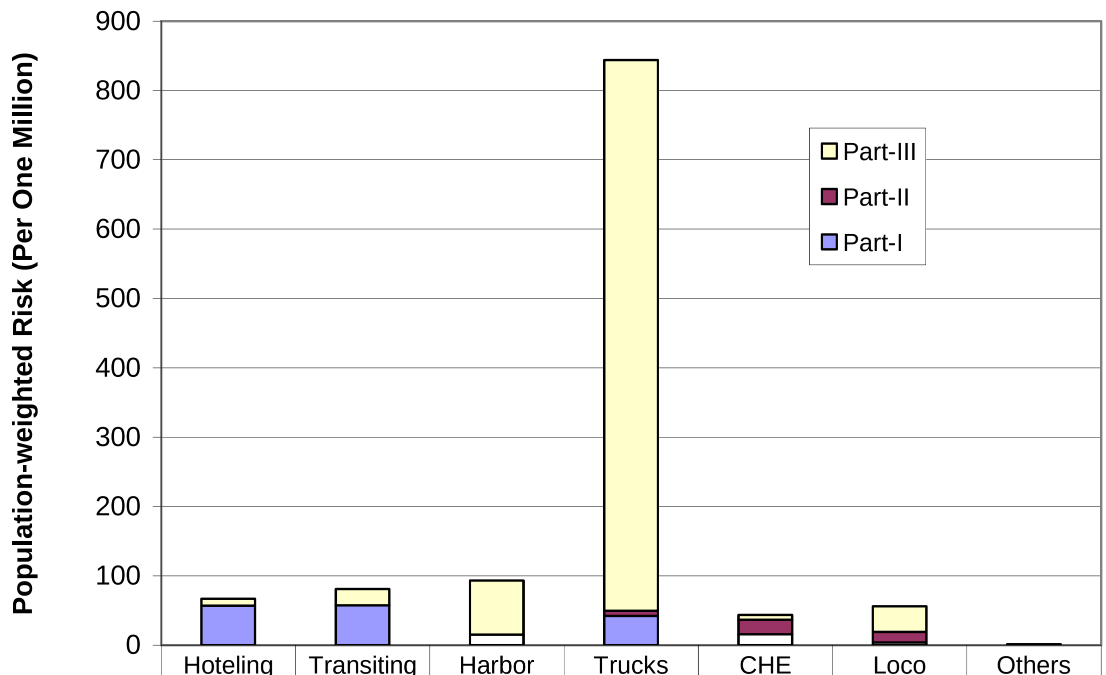
Notes: Total area for the community = 1,800 acres; total population = 22,200. Part III anchorage activities are included with impacts from Part III hotelling.

The magnitude of emissions and the location of the emissions from the diesel-fueled equipment and vehicles used in and around the West Oakland community results in different levels of exposures in the community. In Table 7 and Figure 11, the contributions to the overall risk from each source category by part are shown. On-road trucks result in much higher localized risks when compared to other sources. This is in part due to the fact that the West Oakland community is surrounded by major freeways that have a significant amount of heavy-duty truck traffic. In addition, there is very little buffer between the freeways and highly populated areas. Also, many trucks travel through the neighborhoods, increasing exposures to residents that live along the city streets.

As discussed above, truck emissions are relatively more uncertain than other categories due to limitations in the availability of data describing the magnitude and intensity of trucking operations in the West Oakland community. These data limitations may have led to an overestimate in the overall magnitude of trucking emissions in the West Oakland community, and an underestimate of the fraction of total trucking emissions and risks attributable to trucks that service the Port of Oakland. Although these estimates are uncertain, the results from the risk assessment are clear. Trucking operations are the largest single source of health risk to the West Oakland community, even though they are not the largest source of emissions in the modeling domain. Whether those trucking operations are generated by trips visiting the Port or other businesses is of interest, but is not necessary to prioritize and control trucks as an emissions source. The ARB has already adopted a rule that requires the clean-up of trucks servicing California's Ports (Port Drayage Truck Regulation), and is currently developing a similar rule to cover all other trucking operations (Private Fleet Regulation). Together, these rules will require in the future (2010 for trucks servicing the Port of Oakland; around 2014 for all others) that all trucks operating in the community must be 85% cleaner than trucks operating in the community today.

Other sources of emissions, such as ocean-going vessels, harbor craft, and locomotives, also generate significant population weighted potential cancer risks to the West Oakland community that individually exceed 50 in a million. These levels are significant and require reduction. Their impacts are not as high as trucks, because the location of these sources are further away from residents of the West Oakland community, and pollutant concentrations decrease with distance as they are dispersed in air. Additional information and discussion on the public health impacts from the various emission sources are provided in Appendices C and D.

Figure 11: Population-weighted Potential Cancer Risks by All Sources/Parts for West Oakland Community



	Hoteling	Transiting	Harbor	Trucks	CHE	Loco	Others
Part-III	10	23	78	795	7	37	2
Part-II	0	0	0	7	21	15	0
Part-I	57	57	15	42	16	4	0

Notes: Total area for the community = 1,800 acres; total population for the community = 22,200. Part I = Port; Part II = UP; Part III = Non-Port/Non-UP. Hotelling = OGV hotelling. Transiting = OGV Transiting. Harbor = Harbor Craft. CHE = Cargo Handling Equipment. Loco = Locomotives. Part III anchorage activities are included with impacts from Part III hotelling

Understanding the impacts from the various emission sources and locations of emissions can be complicated. As can be seen from the previous charts and tables, there are several different ways of presenting and looking at the data from the HRA. Since one of the primary reasons for this study was to assist in determining the most beneficial diesel PM mitigation strategies, it is important to understand how reductions in emissions from a source category and the geographic location of sources will impact the overall population-weighted risk; that is, which reductions in diesel PM emissions will reduce the potential cancer risk the most.

Table 8 provides a comparison of the relative impact that reductions in diesel PM emissions will have on the potential cancer risk. This comparison shows the relative change in potential cancer risk for each ton of diesel PM emissions reduced per year. In Table 8, we provide this comparison for each of the source categories and geographic locations.[8] Looking at each part (Part I, II, and III), emissions from on-road trucks generate the most potential risk per ton of diesel PM emissions followed by locomotives and cargo handling equipment. For example, for each ton of diesel PM reduced from Part III on-road trucks, we would expect to see a reduction of about 9 in a million in the potential cancer risks in the West Oakland community. For Port sources (Part I), on-road trucks generate the greatest potential cancer risk per ton of diesel PM emissions followed by locomotives, harbor craft, and OGV hotelling. Emission sources at the UP Railyard had similar impacts for each category. With respect to Part III emission sources, on-road trucks had the highest impact on the West Oakland community followed by locomotives and cargo handling equipment.

Table 8: Relative Change in Potential Cancer Risk per Ton of Diesel PM Emissions Reduced (2005)

Source Category	Part I (Port)	Part II (UP)	Part III (Non-Port/Non-UP)
	Risk/ Emissions		
OGV Transiting	0.4	--	0.1
OGV Hotelling	0.9	--	0.3
Harbor Craft	1.1	--	0.3
Trucks	2.1	3.8	8.8
Cargo Handling Equip.	0.7	3.9	1.6
Locomotives	2.0	3.9	7.9
Others	-		0.1

Notes: OGV Transiting includes OGV emissions from transiting, maneuvering and anchorage except that for Part III, anchorage impacts are included with hotelling. Emissions = Diesel PM emissions in tons/year for the year 2005 and the values are from Table 2 and Appendix A. Risk = Average potential cancer risk per million and the values are from Table 7. Total area for the community = 1,800 acres; total population for the community = 22,200

[8] It's important to note that these comparisons are most useful as a guide when comparing one source to another and not as a literal prediction of the community change in risk as emissions are reduced.

West Oakland Community Future Projections of Potential Cancer Risks – 2010, 2015, 2020

Reducing diesel PM emissions is one of ARB's top priorities. In the 1990's, ARB and the federal government adopted measures, such as new engine standards for on- and off-road vehicles and equipment. These measures are providing benefits today and will continue to provide benefits into the future as older vehicles and equipment are replaced with newer, cleaner engines. However, federal engine standards are not generating emissions reductions quickly enough to meet federal air quality attainment standards or to provide relief to local communities that are impacted by carcinogenic diesel PM.

In 2000, ARB adopted its Diesel Risk Reduction Plan (DRRP) which established a goal of reducing diesel PM emissions by 85 percent in 2020. (CARB, 2000) In 2006, ARB adopted its Goods Movement Emissions Reduction Plan, which reiterated the DRRP diesel PM goal, and set additional targets for emissions reductions. (CARB, 2006) Meeting these goals requires the adoption of new regulations designed to generate accelerated reduction in diesel PM emissions. ARB has recently adopted several regulations targeting the clean-up of port-related equipment and vehicles.

Measures have been adopted for cargo-handling equipment, truck refrigeration units, port drayage trucks, off-road construction equipment, commercial harbor craft, and ocean-going vessels (shore power). More recently, in July 2008, ARB approved a regulation requiring the use of cleaner fuels in OGV main engines, auxiliary boilers, and auxiliary engines. And, in December of this year, ARB will consider a rule to require the clean-up of the private on-road heavy-duty truck fleets. These regulations will result in significant reductions in diesel PM and other exhaust emissions.

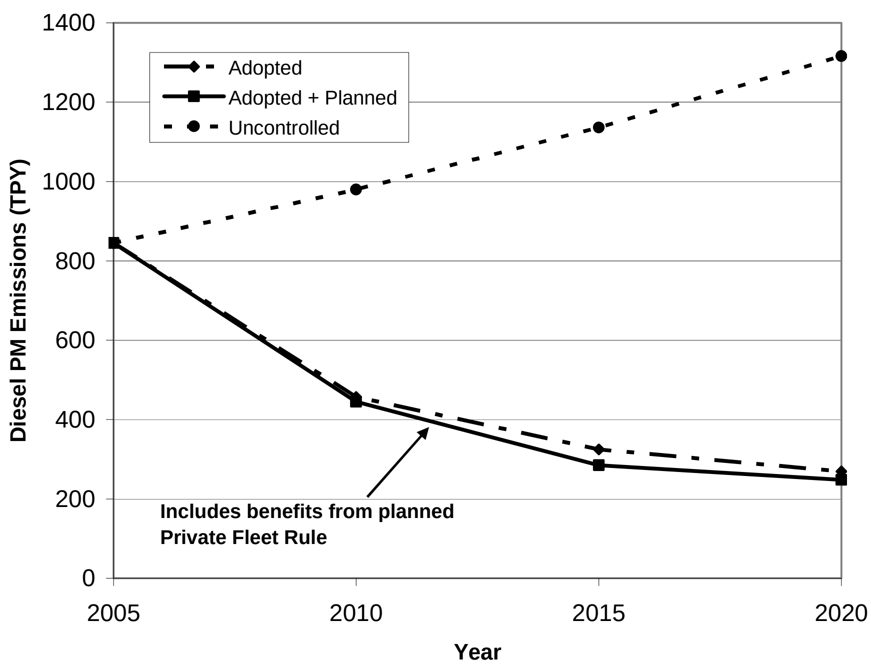
A summary of the various regulations and efforts to date are provided in Table 9. These efforts will result in significant emission reductions in future years, even when considering the expected growth in activities. Diesel PM emissions in the West Oakland community are projected to decline by over 75% by 2020. Future emissions estimates are presented in Figure 12. The upper dotted line reflects emissions without any controls, the dashed middle line reflects emissions taking into account all adopted regulations adopted and the lower solid line reflects emissions taking into account adopted measures and the one additional regulation scheduled for adoption this year - the private fleet truck rule.

The future reductions discussed here represent mainly actions by ARB to reduce emissions from diesel PM sources. There also have been actions undertaken since 2005 by the BAAQMD, Port, UP, shipping companies, terminal operators, and trucking companies that are not reflected in this analysis. Future actions that are currently being contemplated as part of the BAAQMD's Green Ports Initiative and the Ports Maritime Air Quality Improvement Plan are also not reflected in this analysis.

Table 9: ARB Regulations Adopted and Planned (2008) that Reduce Emissions from Diesel PM On- and Off-Road Vehicles and Equipment (adoption date provided in parenthesis)

Adopted Regulations	
New on-road heavy-duty diesel engine standards (October 2001)	Diesel truck operational idling limits (July 2004)
Tier 4 standards for new off-road diesel equipment (December 2004)	Clean up existing diesel cargo handling equipment at ports and intermodal railyards (December 2005)
California diesel fuel for harbor craft and intrastate locomotives (November 2004)	Clean up existing fleet of off-road diesel equipment (July 2007)
Low-sulfur diesel fuel for vehicles and off-road equipment (July 2003)	Clean up existing fleet of harbor craft (November 2007)
Heavy-duty engine manufacturers diagnostics (May 2004)	Cold ironing regulations (December 2007)
Heavy-duty on-board diagnostics (July 2005)	Clean up port truck fleets (December 2007)
Cleaner fuel for ship auxiliary engines (December 2005)[9]	Cleaner fuel for ship main engines, auxiliary engines and auxiliary boilers (July 2008)
2005 California Rail MOU	**Planned Regulations**
Transport refrigeration units (February 2004)	*Clean up existing private fleets of diesel trucks (December 2008)*

Figure 12: Projected Diesel PM Emissions for All Sources Evaluated in the West Oakland Community HRA (Parts I, II, & III)



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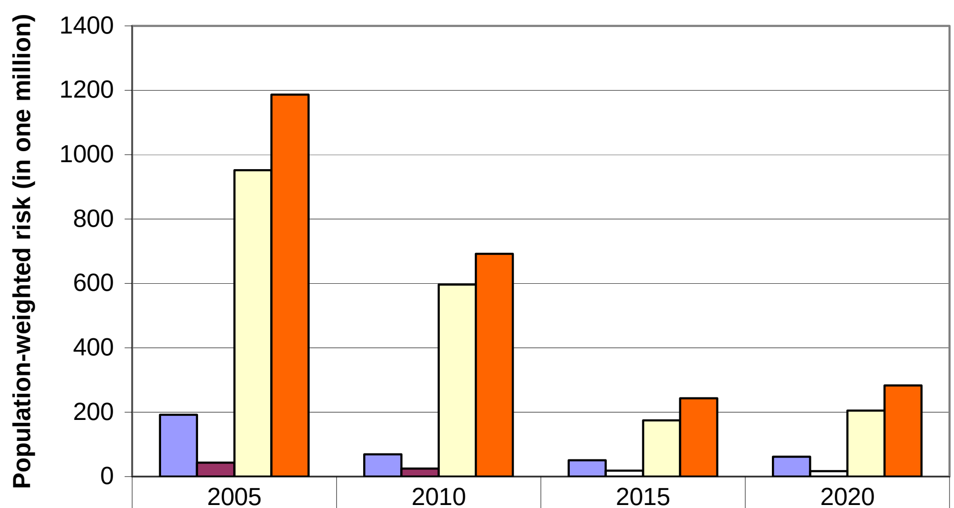
[9] The cleaner fuel for ship auxiliary engines regulation was suspended due to a court order in May 2008. The requirement for auxiliary engines to use cleaner fuels was subsequently incorporated into the recently adopted regulation requiring the use of cleaner fuels in ship auxiliary engines, main engines, and auxiliary boilers.

This decline in emissions will result in the reduction of the potential cancer (and non-cancer) risks due to exposures to diesel PM. In the West Oakland Community, as shown in Figure 13, we predict that the overall population-weighted risks will be reduced by about 80 percent in 2015 but then will begin to increase as growth begins to surpass the reductions required by regulatory programs. However, even with reduction in emissions due to the actions outlined in Table 9, the predicted remaining cancer risk in the 2010 timeframe will be over 650 in a million in the West Oakland community and in future years will be greater than 200 in a million. Clearly, additional actions are needed in the near-term to accelerate emission reductions and to reduce the health impacts from diesel PM emissions in the West Oakland community and the region as a whole. Additional actions are also necessary to help offset growth and further reduce risk levels in future years.

Figure 13: Projected Future Population-weighted Potential Cancer Risks in the West Oakland Community Resulting from Exposures to Diesel PM from all Emission Sources (Parts I, II, & III)



	2005	2010	2015	2020
Part I	192	69	51	61
Part II	43	25	18	17
Part III	952	597	174	205
Combined	1187	692	243	283

Notes: Total area for the community = 1,800 acres; total population for the community = 22,200. Part I = Port. Part II = UP. Part III = Non-port/Non-UP.

Regional Potential Cancer Risks from Port Operations[10]

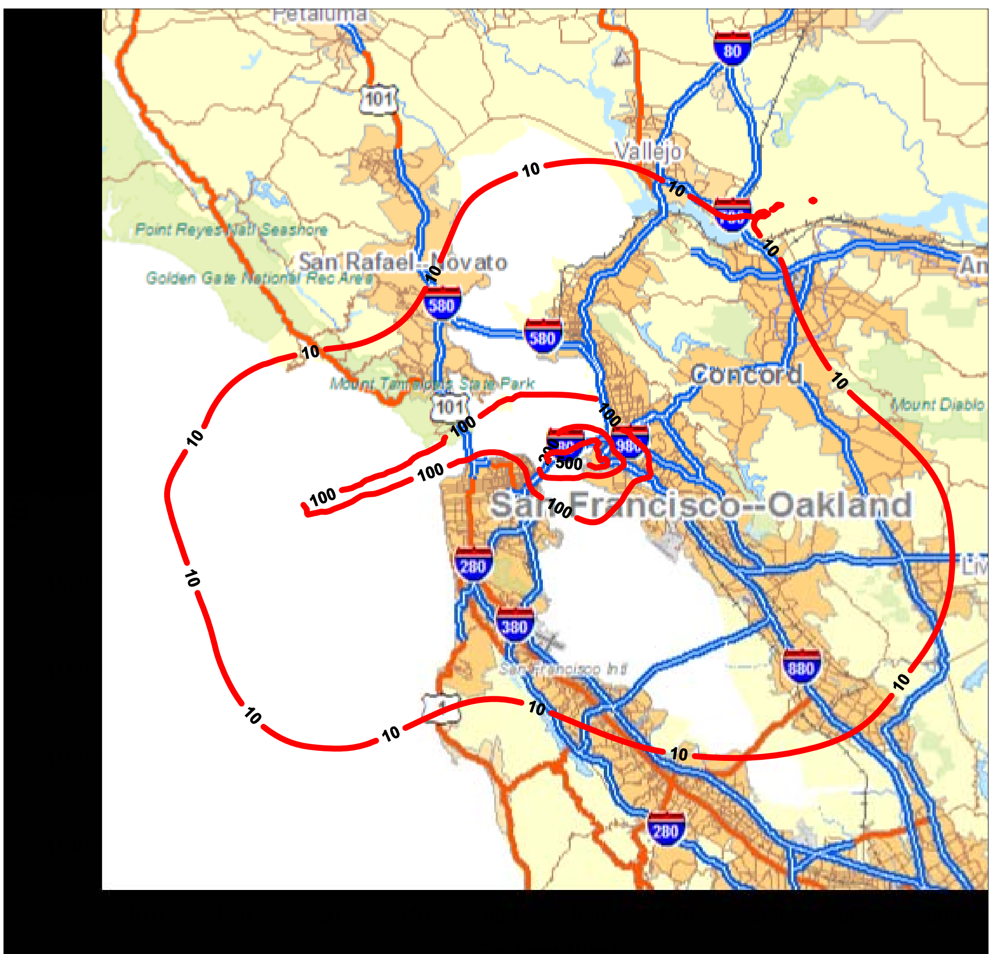
Figure 14 shows the risk isopleths for all diesel PM emission sources from Part I, the Maritime Port of Oakland, superimposed on the map that cover the regional (100 km x

[10] ARB staff also evaluated the impacts from all ocean-going vessel diesel PM emissions (Part I and Part III combined) and all on-road trucks on the broader Bay Area region. These analyses are provided in Appendix C.

100 km) domain. For the regional domain, the risk contour of 10 in a million extends over a large area, covering about 35 percent of the land-based areas within the domain. Risk levels of greater than 100 in a million also result in the broader Bay Area from the Port diesel PM emissions, however the higher risk levels are primarily located overwater.

The estimated cancer risks presented in Figure 14 are not intended to be a complete estimate of the total cancer risk from exposure to diesel PM throughout the modeling domain. As discussed earlier, the average potential cancer risk from diesel PM in the BAAQMD is about 480 chances per million. Since we are looking at the potential cancer risk contribution over a large region, it is reasonable to view these risks as "above background" risks except in the immediate vicinity of the West Oakland Community. Thus, the estimated risk at the 10 in a million isopleths is estimated to be about 490 in a million when the background risk of 480 is included.

Figure 14: Estimated Potential Cancer Risk in the Regional Domain from Port (Part I) Diesel PM Emissions Sources



Notes: The risk levels are based on the 80th Percentile Breathing Rate. Total Modeled Emissions = 265 T/Y in 2005. Modeling Domain = 100 km x 100 km. Resolution = 500 m x 500 m. Total area for the regional domain = 1,564,000 acres; total population for the regional domain = 5 million.

Using the U.S. Census Bureau's year 2000 census data, we estimated the population within the isopleth boundaries. As shown in Table 10, about 130,000 people out of the 5 million people living within the domain boundaries are exposed to risk levels of over 100 in a million due to the diesel PM emissions from Port operations. Approximately 3.2 million people are exposed to risk levels of greater than 10 in a million. This is about 65 percent of the total population in the modeling domain region. There are about 60 acres located near the West Oakland community that have risk levels greater than 500 in a million which demonstrates that significant impacts from Port emissions also occur outside of the West Oakland community.

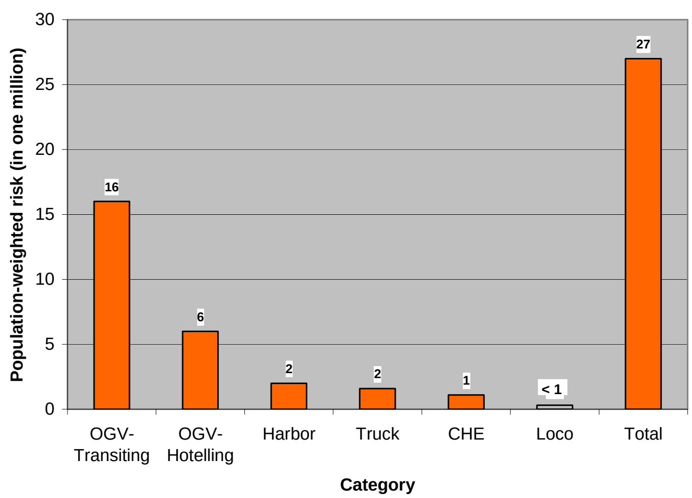
Table 10: Summary of Impacted Regional Area and Affected Population by Potential Cancer Risk Levels from the Maritime Port of Oakland Activities (2005)

Potential Cancer Risk Level	Impacted Inland Area		Affected Population	
	Acres	Percent	Number	Percent
Risk > 10	551,500	35%	3,179,000	66%
Risk > 100	11,800	1%	131,000	3%
Risk > 200	2,600	<1%	9,600	<1%
Risk > 500	60	<1%	20	<1%
Risk > 1000	0	0%	0	0%

Note: Total area for the regional domain – 1,564,000 acres; total population = 5 million

The various diesel PM emission sources from Port operations result in different contributions to the regional potential cancer risks. As seen in Figure 15, overall, the Port emissions result in a regional population-weighted risk of 27 potential cancer cases per million people exposed. Of this, OGV emissions contribute the most to the overall risk levels.

Figure 15: Population-weighted Potential Cancer Risk in the Regional Domain Due to Maritime Port of Oakland Diesel PM Emissions (2005)



Notes: Total area for the regional domain = 1,564,000 acres; total population for the regional domain = 5 million. Harbor = Commercial Harborcraft. CHE = Cargo Handling Equipment. Loco = Locomotive

Regional Future Projections of Potential Cancer Risks from Port Operations– 2010, 2015, 2020

The ARB adopted regulations presented previously in Table 9 will also result in a reduction of the regional potential cancer risks that result from exposures to emissions from the Port. Similar to the figures provided for the West Oakland community, Figure 16 provides the projected emissions trends for Port emissions and Figure 17 presents the regional future population-weighted potential cancer risks due to Port emissions. As is shown, the emissions from Port operations are forecasted to decline over the next several years as the adopted regulations are implemented. These reductions in emissions will result in the reduction of the potential cancer risks due to exposures to diesel PM. Over the broader San Francisco Bay area included in the model domain, the population-weighted cancer risks will be reduced by about 70 percent in 2020.

Figure 16: Projected 2010, 2015, and 2020 Diesel PM Emissions for Port (Part I) Source Categories

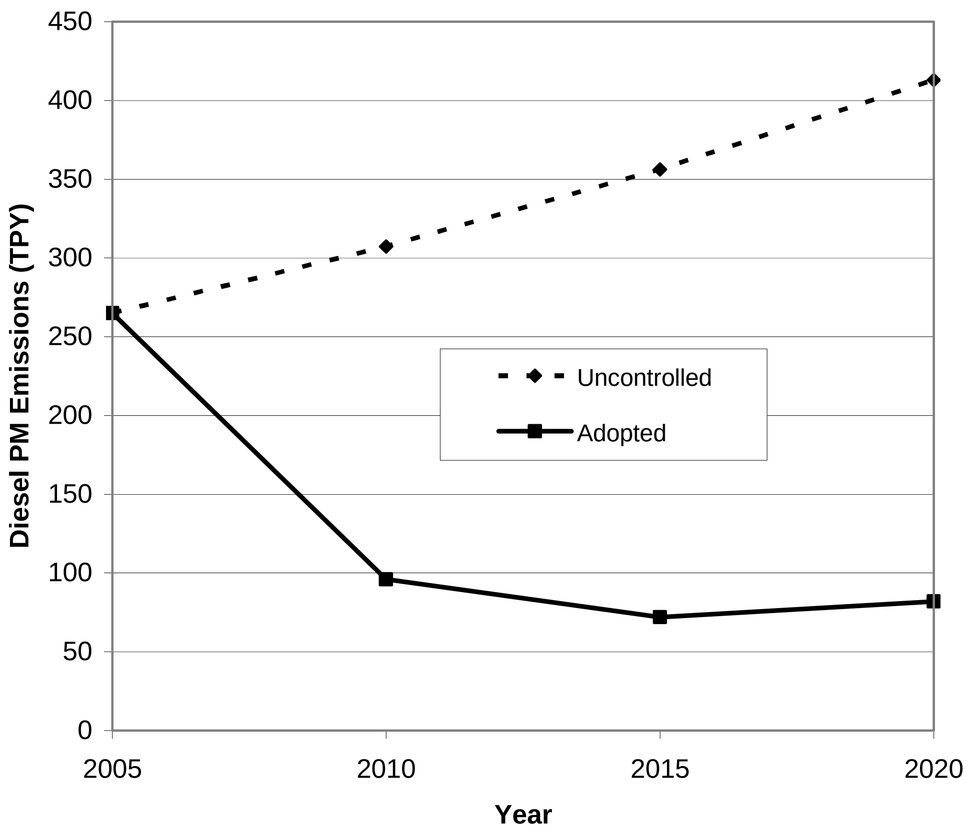
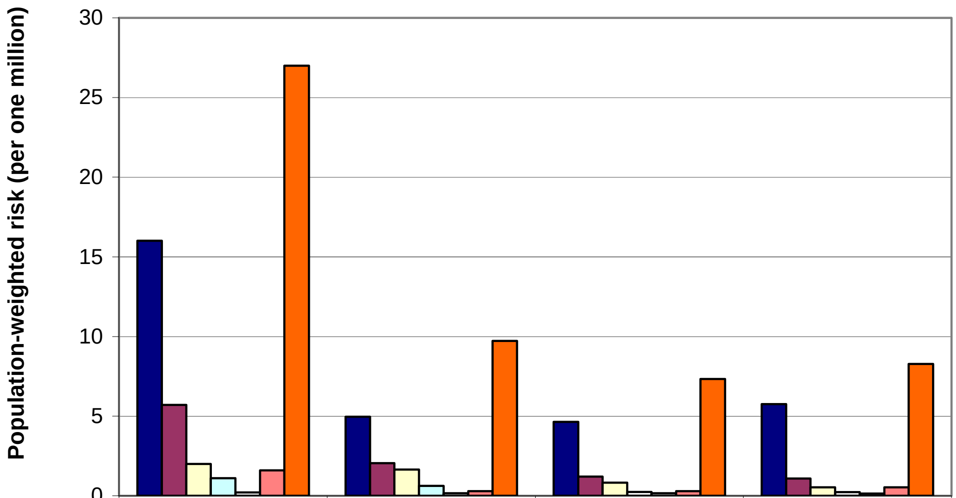


Figure 17: Projected Population-weighted Potential Cancer Risk by Category for Port Operations in the Regional Domain



	2005	2010	2015	2020
OGV-Transiting	16	5.0	4.6	5.8
OGV-Hotelling	5.7	2.1	1.2	1.1
Harbor Craft	2.0	1.6	0.8	0.5
CHE	1.1	0.6	0.2	0.2
In-Port Locomotive	0.2	0.2	0.2	0.1
In-Port Truck	1.6	0.3	0.3	0.5
Total	27	9.7	7.3	8.3

Year

Notes: Total area for the regional domain = 1,564,000 acres; total population for the regional domain = 5 million. CHE = cargo handling equipment.

B. <u>Non-Cancer Health Impacts</u>

<u>Regional Non-Cancer Health Impacts from Port of Oakland Emissions</u>

As discussed previously, a substantial number of epidemiologic studies have found a strong association between exposure to ambient particulate matter (PM) and adverse health effects (CARB, 2002; CARB, 2006). As part of this study, ARB staff conducted an analysis of the potential non-cancer health impacts associated with exposures to the model-predicted ambient levels of directly emitted diesel PM (primary diesel PM) within the modeling domain for diesel PM resulting from Port operations (Part 1). Several counties are located within the modeling domain including San Francisco, Marine and parts of Alameda, Sonoma, Napa, Solano, Contra Costs, and Santa Clara counties. The non-cancer health effects evaluated include premature death, hospital admissions, asthma-related and other lower respiratory symptoms, work loss days, and minor restricted activity days.

Consistent with U.S. EPA (EPA, 2004), ARB has been using the PM-mortality relationship from Pope et al. (Pope, 2002) since the adoption of the Emission Reduction Plan for Ports and Goods Movement (GMERP) (CARB, 2006). The methodology for estimating premature death and other health impacts is described in Appendix A of the GMERP. Ambient levels of directly emitted diesel PM from Port operations were predicted for each 500 meter by 500 meter grid cell within the modeling domain (100 km x 100 km) using the CALPUFF model. The population within each grid cell that was older than 30 years (about 3 million people) was determined from U.S. Census Bureau year 2000 census data. Using U.S. EPA's BENMAP program, we estimated the number of annual premature deaths and several other non-cancer health effects that are likely to occur within the modeling domain due to exposure to the directly emitted diesel PM emissions from Port operations. The health effect estimates are based on concentration-response functions derived from published epidemiological studies relating changes in ambient concentrations to changes in health endpoints, the population affected, and the baseline incidence rates.[11]

The estimated regional non-cancer health impacts for directly emitted diesel PM from Port operations are presented in Table 11. As is shown in Table 11, we estimate that, in the modeling area, there would be about 18 premature deaths (for ages 30 and older), 8 hospital admissions due to respiratory and cardiovascular causes, 290 asthma-related and other lower respiratory symptoms, 2,600 days of work loss; and 15,000 minor restricted activity days.

Table 11: Estimated Non-cancer Health Impacts Resulting from Maritime Port of Oakland 2005 Diesel PM Emissions

Endpoint	# of Cases per Year (Mean)	# of Cases per Year 95 % Confidence Interval
Premature Death	18	5-32
Hospital Admission (Respiratory & Cardiovascular)	8	4-12
Asthma - Related & Other Lower Respiratory Symptoms	290	110-460
Acute Bronchitis	24	0-54
Work Loss Day	2,600	2,200-3,100
Minor Restricted Activity Days	15,000	13,000 – 18,000

To put the premature deaths estimates in context, ARB estimated in the Goods Movement Report that directly emitted diesel PM contributed to 1,200 premature deaths per year statewide, or about 160 premature deaths in the San Francisco Bay Area per year. (CARB, 2006)

[11] In October 2008, ARB released a revised methodology for estimating premature deaths associated with long-term exposures to fine airborne particulate matter in California that increases the relative risk factor from 6% to 10% increase in premature death per 10μg/m^3 increase in PM2.5 exposures (CARB, 2008). Using the 10% relative risk factor would increase the estimated premature deaths reported above by 67%.

Several assumptions were used in our estimation. They involve the selection and applicability of the concentration-response functions to California data, exposure estimation, subpopulation estimation, baseline incidence rates, and the threshold. These are briefly described below.

- Premature death calculations were based on the concentration-response function of Pope et al. (Pope, 2002). The ARB staff assumed that concentration-response function for premature mortality in the model domain is comparable to that in the Pope's study. It is known that the composition of PM can vary by region, and not all constituents of PM have the same health effects. However, numerous studies have shown that the mortality effects of PM in California are comparable to those found in other locations in the United States, justifying our use of Pope et al's results. Also, the U.S. EPA has been using Pope's study for its regulatory impact analyses since 2000. For other health endpoints, the selection of the concentration-response functions was based on the most recent and relevant scientific literature. Details are in CARB's PM Staff Report (CARB, 2002).

- The ARB staff assumed the model-predicted exposure estimates could be applied to the entire population within each modeling grid. That is, the entire population within each modeling grid of 500 m x 500 m was assumed to be exposed uniformly to modeled concentration. This assumption is typical of this type of estimation.

- The ARB staff included only directly emitted PM and did not account for secondary PM formed from NOx and SOx emissions.

- The ARB staff assumed the baseline incidence rates were uniform across each modeling grid, and in many cases across each county. This assumption is consistent with methods used by the U.S. EPA for its regulatory impact assessment. The incidence rates match those used by U.S. EPA.

It should be noted that because the estimates apply to a limited modeling domain (100 km by 100 km), the affected population is small, and hence the overall estimated health impacts are smaller than estimates made on a statewide basis. In addition, to the extent that only a subset of health outcomes is considered here, the estimates should be considered an under-estimate of the total public health impact.

C. <u>Uncertainty and Limitations</u>

Risk assessment is a complex process which requires the integration of many variables and assumptions. Due to these variables and assumptions, there are uncertainties and limitations with the results. Generally, the assumptions are designed to be health protective so that the estimates of risks to individuals are not underestimated. Below is a discussion of uncertainty associated with the key elements used in a risk assessment. These key elements are the heath risk values, the air dispersion modeling used to predict diesel PM concentrations, and the model input parameters.

Uncertainty Associated with Health Values

Scientists often use animal studies to predict how a chemical affects humans in the development of health values that are then used in a risk assessment. Scientists cannot be sure that humans will respond exactly the same way as animals do to a chemical. Also, animals used in these studies are often given very high doses of a chemical to produce negative health effects. These doses are much higher than what people are actually exposed to in the environment. When available, as is the case with diesel PM, scientists use studies of people exposed at work to develop health values to estimate potential cancer risk from environmental exposures. This can introduce uncertainty in the potential risk estimated for the general public because there is a wide range of responses among all individuals, and there can be a wider range of responses in the general public than in the workers in an epidemiology study. In addition, for diesel PM, the actual worker exposures to diesel PM were based on limited monitoring data and were mostly derived based on estimates of emissions and duration of exposure. Different epidemiological studies also suggest somewhat different levels of risk. When the Scientific Review Panel (SRP) identified diesel PM as a toxic air contaminant, they endorsed a range of inhalation cancer potency factors (1.3×10^{-4} to 2.4×10^{-3} $(\mu g/m^3)^{-1}$) and a risk factor of 3×10^{-4} $(\mu g/m3)^{-1}$, as a reasonable estimate of the unit risk.[12] From the unit risk factor an inhalation cancer potency factor of 1.1 $(mg/kg\text{-}day)^{-1}$ may be calculated.

Uncertainty Associated with Air Dispersion Modeling

As mentioned previously, there is no direct measurement technique for diesel PM. This analysis used air dispersion modeling to estimate the concentrations to which the public is exposed. While air dispersion models are based on the state-of-the-art formulations, there are uncertainties associated with the models. The primary purpose of this study was to prioritize emission sources/categories from the Ports operation which are to be regulated. The U.S. EPA CALPUFF model was selected for use in this study because it is the most applicable for the region being modeled and the variety of emission sources addressed. In addition, it currently is one of several U.S. EPA's recommended air dispersion model at this time.

Uncertainty Associated with the Model Inputs and Domain

The model inputs include emission rates, emission release parameters, meteorological conditions, and dispersion coefficients. Each of the model inputs has uncertainty

[12] The Scientific Review Panel (SRP/Panel) is charged with evaluating the risk assessments of substances proposed for identification as toxic air contaminants by the Air Resources Board (ARB) and the Department of Pesticide Regulation (DPR). In carrying out this responsibility, the SRP reviews the exposure and health assessment reports and underlying scientific data upon which the reports are based, which are prepared by the ARB, DPR, and the Office of Environmental Health Hazard Assessment (OEHHA) pursuant to the sections 39660-39661 of the Health and Safety Code and sections 14022-14023 of the Food and Agricultural Code.

associated with it. Among these inputs, emission rates and meteorological conditions have the greatest affect on the modeling results. Emission rates for each source were calculated from the emission inventory developed for the HRA. The emission inventory has several sources of uncertainty including: emission factors, equipment population and age, equipment activity, load factors, and fuel type and quality. The uncertainties in the emission inventory can lead to over predictions or under predictions in the modeling results. To minimize uncertainty, we relied on the most current information available. There are two emission source categories, harbor craft and on-road trucks, where we have identified areas for improvement. Brief discussions on these are provided below.

On-road Trucks: Part III on-road truck (port drayage truck and on-road non-port-related trucks) emissions were estimated for individual roadway links within the modeling domain. Developing these emissions required obtaining information about truck travel on individual roadway links, which are developed by local transportation agencies using travel demand models. Travel demand models estimate vehicle population and activity estimates such as speed and vehicle miles traveled (VMT) based on data about population, employment, travel, income, roadway and transit networks and transportation costs. The activity is then assigned a spatial and temporal distribution by allocating them to roadway links and time periods. For this assessment staff utilized these enhanced spatial data specific to the Bay Area to estimate emissions at the neighborhood scale. As with most travel demand model networks, roadway maps are accurate for freeway and major arterials, while smaller streets are represented schematically and do not necessarily follow actual travel routes. As a result, the spatial allocation of emissions from minor arterials and roadways in this risk assessment is less accurate than for freeways and major arterials.

While developing the inventory, staff compared the travel demand model activity, total vehicle miles traveled, to the activity estimated by ARB's emission inventory model (EMFAC2007). EMFAC is federally accepted model for estimating regional emissions for air quality and transportation conformity assessments. The results for Alameda County showed a significant difference between total vehicle miles traveled estimates by the travel demand model and EMFAC. The local agency network contained more than twice as many truck vehicle miles traveled than EMFAC2007. To evaluate this difference we compiled available truck count data and compared results to the local agency network. Results were mixed, indicating that while for most roadways vehicle miles traveled appeared to be overestimated, some appeared to be underestimated. We considered reducing truck volumes on the roadway network for consistency with EMFAC, but ultimately decided that this would generate as much uncertainty as it would resolve. As a result, we decided to use the local agency network as provided to us. We believe the truck activity on the roadway network we used, while potentially overestimating the total vehicle miles traveled, provided the best representation of trucking operations within the modeling domain.

Another area of uncertainty is the contribution of truck emissions from Port activities. Two data sources were used for this estimate. Staff combined data collected by the Port for Part I of emissions inventory as well as data used to develop the drayage truck emission inventory for the 2007 Drayage Truck Rule (CARB, 2007C). Specifically, the Port of Oakland data was used to quantify emissions on Port property, and to and from port property to the freeway on-ramps. Data from ARB's drayage truck inventory was used to estimate emissions from the freeway entrance to the domain boundary. Absent a detailed origin-destination survey, it was assumed that all trips leaving the Port of Oakland traveled through the modeling domain on freeways through the community rather than arterials or secondary roadways. This approach, while capturing the total population of port trucks, doesn't allocate those emissions to local streets where emissions are also likely to occur. It may also underestimate the magnitude of emissions from these trucks, because port trucks traveling within the community will have different operating characteristics, such as speed, than trucks traveling on freeways. This potential underestimation of port truck emission combined with a potential overestimation of all truck emissions would result in an underestimated fraction of emissions attributable to the Port.

To address the lack of data on origin-destination for trucks in the West Oakland community, the BAAQMD has initiated a contract designed to count trucks and survey idling behavior. Both ARB and BAAQMD have also recommended to the Port of Oakland that they conduct origin-destination studies of trucks servicing the port of Oakland in order to improve Port truck emissions estimates both within West Oakland and in the Bay Area and San Joaquin Valley. Results from these efforts were not available to refine this risk assessment, but could be used in the future to do so.

Harbor Craft: Commercial harbor craft include passenger ferries, tug boats, tow boats, push-boats, crew vessels, work boats, pilot vessels, supply boats, research vessels, United States Coast Guard vessels, hovercraft, emergency response vessels, and barges. ARB staff estimated emissions from harbor craft for the Bay Area (Part III) using the statewide commercial harbor craft emission estimation methodology. More detailed information about the development of this emissions inventory can be found in the document titled, Emissions Estimation Methodology for Commercial Harbor Craft Operating in California (CARB, 2007B). This document can be accessed at http://www.arb.ca.gov/regact/2007/chc07/appb.pdf.

There are no comprehensive databases of commercial harbor craft population or activity. As described in CARB (2007B) we developed the inventory by compiling several incomplete population databases, and conducting a survey or commercial harbor craft operations. By necessity, the statewide inventory assumes that vessels operate only in the vicinity of their home port, whereas we believe some harbor craft transit between ports, especially in the Bay Area. As a result, inventory estimates may not accurately reflect where actual vessel operations occur. The statewide inventory also assumes engine operation parameter averages by vessel type are indicative of operations in the Bay Area. This may or may not be true. Finally, the statewide commercial harbor craft inventory provides no information on spatial allocation within regions. To develop a spatial allocation we had a limited data set of GPS-based second by second vessel traffic data that is generated as a result of national vessel safety programs. We used these data, representing a limited number of vessels, to estimate the spatial activity patterns of all commercial harbor craft in the Bay Area. The ARB is actively working on improving commercial harbor craft emissions inventories by integrating new data sources, conducting new surveys, and taking advantage of new data that will be provided as a result of the recently adopted commercial harbor craft regulation.

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