San Francisco Department of the Environment

Bayview Hunters Point Community Diesel Pollution Reduction Project

Final Report

February 2009

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Prepared for:

San Francisco Department of the Environment
11 Grove Street
San Francisco, CA 94102
Contact: Anne Eng (anne.eng@sfgov.org)
Phone: (415) 355-3735

Prepared by:

ICF Jones & Stokes
630 K Street, Suite 400
Sacramento, CA 95814
Contact: Tony Held (theld@jsanet.com) or Jeff Ang-Olson (jangolson@icfi.com)
Phone: (916) 737-3000

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Executive Summary

The Bayview Hunters Point neighborhood has historically been the industrial center of the City of San Francisco. The area's land uses include a mix of industrial and residential uses, together with some of the City's major freight transportation corridors. Due to this pattern of development, the health of local residents has been affected by environmental contamination of the community's soil, water, and air.

Several environmental studies have focused on the impacts of diesel exhaust on local health. Diesel Particulate Matter (Diesel PM) is a complex mixture of pollutants emitted during the combustion of diesel fuels. The pollutant is listed by the State of California as a known carcinogen. Scientific studies also show that ambient particulate matter, of which Diesel PM is an important component, is associated with a series of adverse health effects, including premature mortality, increased hospital admissions, heart and lung diseases, increased cough, adverse respiratory symptoms, and other cardiac effects. A number of studies have shown higher incidence of asthma at residential or school sites with high outdoor concentrations of fine particles.

The purpose of this study is to quantify the diesel emissions sources within Bayview Hunters Point (BHP), determine the health impacts on local residents, and recommend actions to reduce these negative health impacts.

This study was conducted in partnership with Greenaction, a nonprofit organization focused on environmental justice issues within San Francisco. Greenaction provided feedback on this report and conducted community meetings to inform local residents of its conclusions and recommendations.

Inventory of Diesel PM Emissions

In order to determine the local health impacts of Diesel PM emissions, we conducted an inventory of emission sources in BHP for the year 2007. These sources can be generally described as activities that burn diesel fuel, and are categorized as mobile sources (including trucks, buses, and locomotives), and stationary sources (including off-road construction equipment and diesel generators).

- **Trucks and buses** are responsible for 23% of all Diesel PM emissions within BHP. The majority of truck activity in the area occurs on Highway 101 and Interstate 280, with additional truck traffic on arterial streets such as Cesar Chavez Street, 3rd Street, Cargo Way, Evans Avenue, and Bayshore Boulevard. A small portion of truck traffic is found on local roads connected to arterial streets.

- **Railroad locomotives** account for 3% of Diesel PM emissions in BHP. Most locomotive emissions are produced by the Caltrain commuter line, which runs north-south through the neighborhood. A small portion of emissions is caused by the SF Bay Railroad, which moves freight between the Port of San Francisco and the Union Pacific rail yard in South San Francisco.

- **Construction activities** were the largest source of Diesel PM in BHP in 2007, accounting for 70% of total emissions. This is due to the number of projects in the community and the powerful diesel equipment used in construction. Approximately 400 projects in BHP are estimated to have required off-road diesel equipment for demolition or construction in 2007. These projects were mainly related to the construction of single-family dwellings, as well as several condominium developments and commercial / industrial buildings. It is important to note that there is some uncertainty associated with the calculated construction emissions due to variations between emissions models. However, the results reported here are based on current modeling practice for the California Air Resources Board.

- **Diesel generators** are responsible for 4% of total Diesel PM emissions in BHP. Diesel generators are used primarily as back-up power for industries and utilities. Due to the limited operating hours of these generators, total Diesel PM emissions from this category are relatively small. There are 60 diesel generators currently permitted in the 94124 zip code, which spans BHP. They are concentrated at six locations, and two of these locations together hold 45 generators: the City's Central Shops at 1800 Jerrold Avenue and the City's southeast wastewater treatment plant at 750 Phelps Street.

Emissions from the Port of San Francisco are largely excluded from this study. The San Francisco Port Authority is currently conducting a parallel review of emissions related to port activities. In order to prevent duplication, we excluded all diesel emissions occurring on Port property, as well as any marine emissions from ships and harbor craft. The only Port-related diesel emissions included in this study are emissions from freight trucks as they travel from the Port through BHP.

Table ES-1 presents a summary of Diesel PM emissions in the BHP area, by source type.

Table ES-1. Summary of BHP Diesel Emissions, 2007

Source	Diesel PM Emissions (lbs / year)	Percent
Trucks and Buses	3,646	23%
Railroad Locomotives	481	3%
Construction	10,880	70%
Generators	638	4%
Total	**15,645**	100%

Health Risks of Diesel PM Emissions

This study used a series of dispersion simulations to estimate the level of Diesel PM concentration that BHP residents are exposed to, and to estimate the corresponding health risk. Dispersion modeling was done in two stages:

- Major heavy-duty vehicle routes (freeways and arterials) were simulated with the CAL3QHCR model.
- All other activity (non-arterial traffic, rail, construction, and diesel generators) was simulated with the AERMOD (version 07026) model.

We modeled the spatial distribution of Diesel PM concentration across the entire BHP region as well as at 25 sensitive receptors (schools and child care centers). The highest modeled average annual Diesel PM concentration in the study area is 3.1 $\mu g/m^3$, while the median across the entire study area is 0.29 $\mu g/m^3$. The average Diesel PM concentration and standard deviation are 0.27 ± 0.15 $\mu g/m^3$. Nearly all grid receptors in the study area (99.8%) show annual average concentrations of locally generated Diesel PM of less than 1.0 $\mu g/m^3$.

To correlate cancer risk to the inhaled concentration of Diesel PM, we converted the modeled Diesel PM concentrations to risk values, making use of the California unit risk factor (cancer potency factor) for Diesel PM of 3×10^{-4} $(\mu g/m3)^{-1}$. This means a risk level of 300 per million per microgram of suspended Diesel PM in a cubic meter of air. Effectively, this estimate represents the excess risk of contracting cancer from breathing Diesel PM pollution at the given level continuously for 70 years. Figure ES-1 shows the resulting excess cancer risk is between 100 and 200 per million for most of study area, with higher risk values in several locations.

Figure ES-1
Excess Cancer Risk from Diesel PM Concentration, per Million

The corresponding excess cancer risk values predicted within the study area from local sources range from about 8 to about 920, with an area-wide average and standard deviation of about 82 ± 46 per million. About 63 percent of the area has excess risk values less than 100 per million. At the 25 sensitive receptors, the modeled excess cancer risk ranges from a low of 57 per million to a high of 116 per million.

Note that trucks, locomotives, construction equipment, and generators emit pollutants other than diesel PM that can cause adverse health impacts. For example, diesel engines are a major source of nitrogen oxide (NOx) emissions, which reacts in the atmosphere to form ground-level ozone (smog). Ground-level ozone can cause asthma and respiratory illness. Diesel engines also emit other toxic air contaminants, such as benzene and acrolein, which have both carcinogenic and non-carcinogenic effects. The impact of these other pollutants is beyond the scope of this report.

Mitigation Strategies

A variety of strategies can reduce the emissions of Diesel PM in the BHP neighborhood and the exposure of BHP residents to Diesel PM. These strategies can be grouped into three broad categories:

- Technological strategies targeting engines, exhaust, and fuels
- Operational strategies targeting vehicle operation, traffic patterns, and driver behavior
- Land-use strategies targeting building design and facility siting.

Given the health impacts caused by diesel pollution in BHP, the menu of potential mitigation strategies, and the current and upcoming regulations and programs affecting diesel emissions, we developed recommendations for City action to reduce diesel health impacts in BHP.

This study suggests that the greatest opportunity for air quality and public health benefits lies in mitigating the emissions from construction equipment, which accounted for 70% of total Diesel PM emissions in the area in 2007. Truck and bus emissions accounted for an additional 23% of total emissions and represent another opportunity for improving air quality and public health. Thus, our recommendations focus primarily on mitigation recommendations for construction equipment and trucks, as well as land use strategies that reduce exposure to all Diesel PM emissions.

Recommendations for Construction Equipment Mitigation

Construction emissions are large due to several factors related to equipment design and operation. First, the engines in machinery can be as large as 500 horsepower for a tractor or loader, resulting in greater fuel consumption and emissions. Further, construction equipment has historically been less regulated than trucks or buses in terms of emissions standards. Finally, construction machinery spends much time idling when not in use.

San Francisco’s Clean Construction Ordinance will help to reduce Diesel PM emissions from major public construction projects, beginning in March 2009. Moreover, the California Air Resources Board’s (ARB) in-use off-road diesel rule will take effect for large fleets beginning in 2010. Medium fleets are not covered by ARB’s rule until 2013, and small fleets until 2015. Thus, the City’s focus should be on reducing emissions from private construction projects that employ medium and small equipment fleets.

- **Recommendation 1: Certify and promote clean construction fleets.** The City’s Clean Construction Ordinance is encouraging contractors to upgrade their fleets in order to qualify for City contracts. The City does not have legal authority to place similar requirements on private construction projects. However, this ordinance could be complemented by a voluntary program that certifies businesses as “clean construction contractors” and promote certified businesses within San Francisco. The program could be similar to the City’s Green Business Program, and would also seek to educate fleet owners on steps to reduce emissions. This program would lower construction emissions in BHP as well as citywide.

- **Recommendation 2: Educate local businesses about ARB’s in-use off-road rule.** ARB’s in-use off-road diesel rule will have a dramatic effect on construction fleet emissions when it takes effect. Large fleets are affected first and are generally best equipped to comply. The City can assist in implementing these regulations through outreach to local construction businesses, particularly smaller businesses. These regulations will require fleet owners to (1) meet annual emission targets, (2) retire older equipment and retrofit emission control devices, and (3) register fleet equipment and emissions calculations with ARB. A successful outreach program would educate local businesses on regulation requirements and assist in annual reporting requirements. The ARB rules allow for credit for “early action,” which may be attractive to some businesses and would speed arrival of air quality benefits to the City. The City could also help to promote compliance with the off-road equipment idling limits, by educating fleet owners and possibly reporting violators.

- **Recommendation 3: Assist local business in applying for available grants and loans.** Both ARB and the U.S. EPA provide grant and loan programs to assist businesses in complying with state and federal regulations on off-road equipment. These include ARB’s Pilot Off-Road Loan Incentives program, the Carl Moyer program, and EPA’s Smartway Clean Diesel Finance Program. In addition, local grants from the Bay Area Air Quality Management District (BAAQMD) provide millions of dollars each year for reductions in diesel emissions. These programs place application and reporting burdens on businesses in order to qualify for financing, which can discourage participation. There is an opportunity for a San Francisco program to assist local businesses in identifying and pursuing grants and loans. Such assistance would speed adoption of ARB and EPA regulations within San Francisco.

Recommendations for Truck Mitigation

Reducing emissions of Diesel PM from trucks within BHP can be difficult, in part because trucks operating in the area may be coming from outside the City, outside the Bay Area, or even outside the State. Moreover, the roadway system falls under multiple jurisdictions, with the City controlling arterial streets and local roads and Caltrans operating and maintaining the freeways. Cost-effective mitigation strategies for the City involve increasing compliance with statewide regulations and leveraging existing incentive funding sources.

- **Recommendation 4: Educate ion local businesses about and enforcement of ARB idling regulations and cite violators.** ARB regulations limit truck and bus idling to five minutes. Enforcement of this regulation requires participation by local police departments as well as California Highway Patrol, both of which can issue citations to truckers who violate the idling restrictions. The City can assist in reducing idling emissions by increasing SFPD enforcement of existing regulations. Progress on this recommendation can be measured by how many truckers have been contacted in outreach efforts and how many enforcement citations are issued.

- **Recommendation 5: Educate local businesses about ARB’s new in-use truck rule.** In December 2008, ARB approved a statewide in-use truck and bus rule, the most far-reaching diesel emission regulation in the state’s history. The rule applies to existing vehicles already on the road. For fleets with four or more vehicles, the regulation require the installation of exhaust retrofits in 2010 and 2011 and accelerated engine or vehicle replacement from 2012 to 2022. The new policy places additional reporting burdens on owners of truck fleets. The City can maximize and accelerate the air quality benefits of this rule by educating local businesses on how to achieve compliance and assisting fleet owners with annual reporting requirements.

- **Recommendation 6: Assist local business in applying for available grants and loans.** Most of the grant and loan programs described above for construction equipment also provide funding for the retrofit or replacement of trucks and buses. These programs from ARB and EPA assist truck owners in complying with state and federal regulations. In addition, local grants from the Bay Area Air Quality Management District (BAAQMD) provide millions of dollars each year for reductions in diesel emissions. As with off-road funding initiatives, these programs require application and reporting documentation in order to qualify. The City can increase the rate of participation among local businesses by helping companies identify and pursue grants and loans.

Other Recommendations

- **Recommendation 7: Research and target controls at City-owned generators.** Diesel generators account for only 4% of Diesel PM emissions in BHP. However, the health risk assessment suggests that the highest Diesel PM concentrations in BHP occur in close proximity to the largest cluster of generators – the area around the City's Central Shops (at 1800 Jerrold Avenue) and the City's neighboring southeast wastewater treatment plant (at 750 Phelps Street). Our emissions estimates for these sources depend heavily on assumptions about generator usage. As a first step, the City should conduct additional research into generator activity at these two facilities, and others if possible. The City should also investigate additional emission control strategies for its generators. This could include biodiesel (expanding the City's municipal fleet program to cover stationary generators) and/or exhaust retrofits (e.g., diesel particulate filters).

- **Recommendation 8: Increase the availability of biofuels within BHP.** The City requires use of B20 blend biodiesel in the entire fleet of City vehicles. As a result, the supply and distribution of biodiesel within San Francisco has grown to meet city demand. The City can increase adoption of biofuels among BHP businesses by encouraging the development of biodiesel stations and facilities within the community. Further education and outreach to neighborhood trucking and construction companies will inform fleet owners of the benefits to biodiesel. This recommendation can be adopted quickly using the existing resources of the Biodiesel Access Task Force.

- **Recommendation 9: Retrofit existing facilities with building filtration technologies.** The City has recently proposed a policy that would require building filtration technologies in new residential units located in areas with high PM concentration. These ventilation systems reduce residential exposure to emissions. However, this proposed regulation will have little immediate impact because it only applies to new construction projects. The City could speed up the adoption of building filtration systems by applying the requirement to existing buildings undergoing renovation. By adding this regulation to the City's permitting process, the Department of Building Inspection can mandate its installation when construction permits are issued. The City could also extend application of this requirement to selected non-residential facilities, such as schools and day care centers.

1 Introduction

1.1 Purpose and Overview

The Bayview Hunters Point neighborhood has historically been the industrial center of the City of San Francisco. The area's early, largely unregulated development resulted in mixed land uses, with residential areas interspersed with meatpacking, breweries, and other businesses and industries within the same block. Today, local land uses continue to include a mix of industrial and residential uses, together with some of the City's major freight transportation corridors. Due to this pattern of development, the health of local residents has been affected by environmental contamination of the community's soil, water, and air.

While many of the neighborhoods heavy industrial facilities, such as the San Francisco Naval Shipyard, have closed or relocated, local residents are still exposed to pollution from a variety of sources. Several environmental studies have focused on the impacts of diesel exhaust on local health. Diesel Particulate Matter (Diesel PM) is a complex mixture of pollutants emitted during the combustion of diesel fuels. The pollutant is listed by the California's Office of Environmental Health Hazard Assessment (OEHHA) as a known carcinogen. A recent health risk assessment showed that residents of Bayview Hunters Point are exposed to high levels of diesel exhaust, resulting from the use of trucks, construction equipment, and other diesel machinery within the community.[1] The level of diesel exhaust is particularly high due to the community's proximity to heavily-traveled truck routes, including Hwy. 101 and I-280. In addition, levels of exhaust are elevated due to construction projects distributed throughout the neighborhood.

The purpose of this study is to quantify the diesel emissions sources within Bayview Hunters Point, determine the health impacts on local residents, and recommend actions to reduce these negative health impacts.

1.2 Study Area Description

Bayview Hunters Point (BHP) is located in the southeastern quadrant of the City and County of San Francisco. The 5-digit zip code, 94124, is used by the U.S. Census Bureau to compile data for the 4.8-square mile area generally bounded by Cesar Chavez Street to the north, U.S. 101 to the west, San Mateo County to the south, and San Francisco Bay to the east. The BHP community encompasses the neighborhoods of Executive Park, Bayview Hill, Candlestick Point, South Basin, Silver Terrace, Town Center (Third Street), Northern Industrial, Central Bayview (Oakdale), Hunters Point Hill, India Basin, and Hunters Point Shoreline. A map of the study area is shown in Figure 1-1.

BHP contains a high proportion of minority and low-income populations, creating a potential for environmental justice issues. An evaluation of data from the 2000 U.S. Census indicates that BHP contains significantly higher percentages of minorities and poverty rates than San Francisco as a whole. The racial characteristics of the study area reflect a population that is largely African American and more ethnically diverse than the City. African Americans account for 47% of the area population, and Asians and Hispanics account for approximately 40% of the remaining area residents. The population of African Americans within the study area account for 27% of the total African American population within the City of San Francisco.

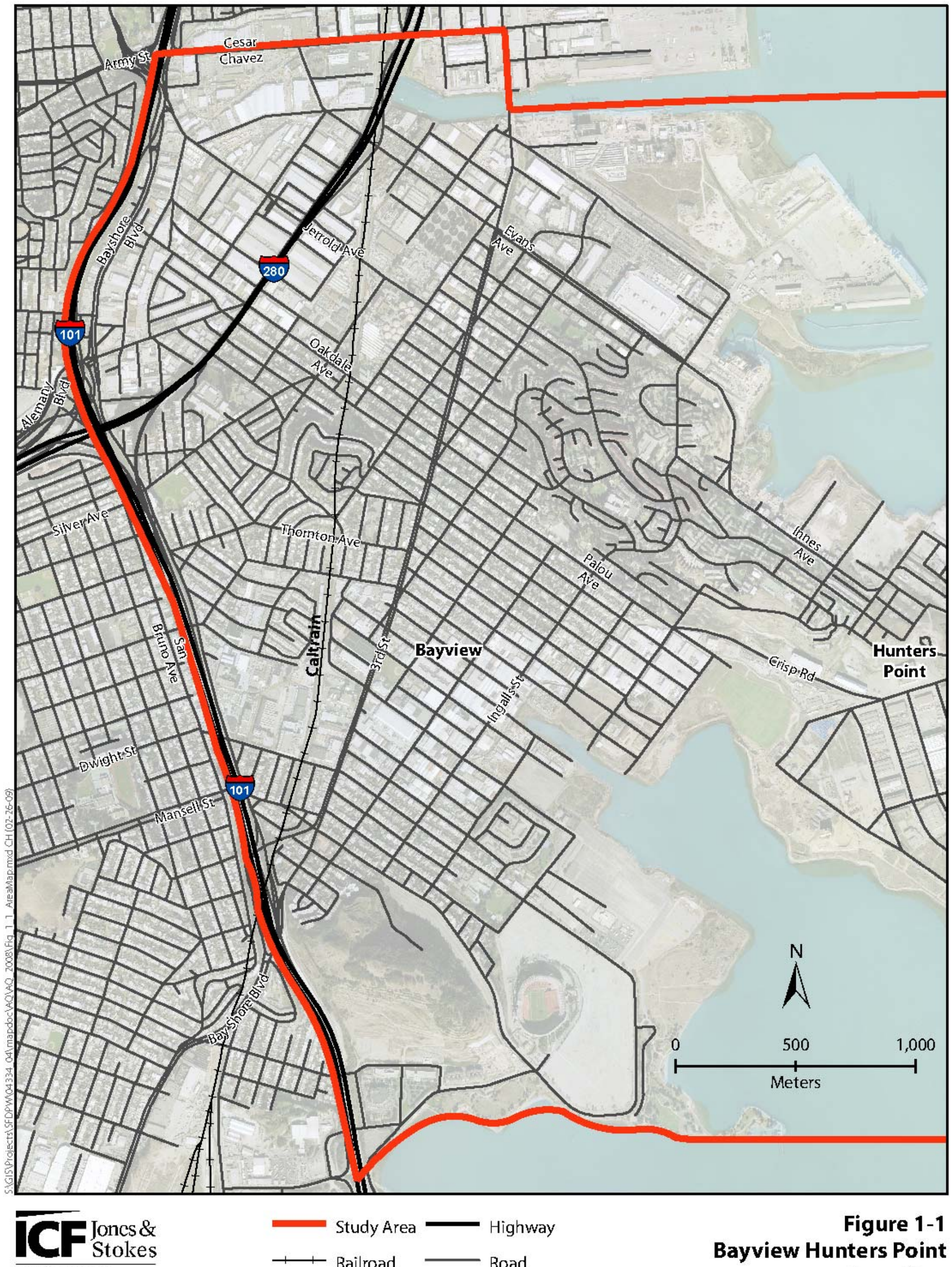


Figure 1-1
Bayview Hunters Point Area Map

The BHP community also contains a larger low-income population than surrounding areas. Median household income in the BHP area was nearly 33% lower than the median household income for the City as a whole. The percent of BHP residents with incomes below the poverty level was 21.6% in comparison to approximately 11.3% of the City's residents.

1.3 Report Organization

The remainder of this report is divided into three sections:

Section 2 identifies major sources of Diesel PM emissions and calculates the quantity of emissions. These emission sources can be generally described as activities that burn diesel fuel, and are categorized as mobile sources (including trucks, buses, and locomotives), and stationary sources (including off-road construction equipment and diesel generators). The report presents an estimate of total diesel PM emissions from these sources for year 2007. The resulting emission inventory provides inputs for health impact assessment as well as a baseline against which future inventories can be compared.

Section 3 models exposure levels for Diesel PM within Bayview Hunters Point, and determines the resulting health impacts. The ambient concentration of Diesel PM is calculated from the magnitude and location of source emissions (from Section 2) as well as geographical and meteorological characteristics of BHP. The resulting concentration levels, as calculated throughout the neighborhood, are used to determine the magnitude of Diesel PM exposure that residents experience. Finally, the cancer risk of Diesel PM emissions, measured in excess cancers over a 70-year exposure period, is calculated at several sensitive receptor sites (schools and child care facilities).

Section 4 examines options for mitigating Diesel PM exposure and recommends an action plan for implementing mitigation measures. Opportunities for reducing exposure are categorized as technological alternatives, operational alternatives, and land use alternatives. Each alternative is compared in terms of benefits, costs, and effectiveness. These options are explored in the context of other regulatory efforts at the City, State and Federal level. From this matrix of mitigation options, an action plan is developed that identifies a selection of measures that can be implemented to most effectively reduce Diesel PM exposure.

2 Inventory of Diesel PM Emissions

In order to determine the local health impacts of Diesel PM emissions and monitor future changes in emission levels, it is necessary to conduct a full inventory of emission sources and quantify of the amount of Diesel PM emitted. This study calculates emission levels, measured in pounds, for year 2007. When data for 2007 were not available, the best available data were considered. Emission sources include diesel trucks, buses, locomotives, off-road construction equipment and diesel generators.

Emission calculations are conducted in two steps. First, the activity level of each source is determined and expressed in appropriate terms. The activity level of on-road vehicles, such as trucks and buses, are expressed in terms of vehicle miles traveled (VMT) per year. In contrast, off-road equipment such as construction equipment and generators are measured as the product of engine power and duration of operation, and expressed in terms of horsepower-hours (hp-hr) per year. Activity of locomotives, which travel in and out of Bayview Hunters Point, is measured as the amount of fuel consumed within the neighborhood, and expressed as gallons per year.

Second, the resulting source activity is converted into emission levels using an appropriate emission factor, expressed in terms of emissions per unit of activity. Emission factors are determined based on guidance from the Environmental Protection Agency (EPA) and California Air Resource Board (ARB), as well as emission modeling calculations. The final emission inventory for year 2007 is shown in aggregate and separated by source type.

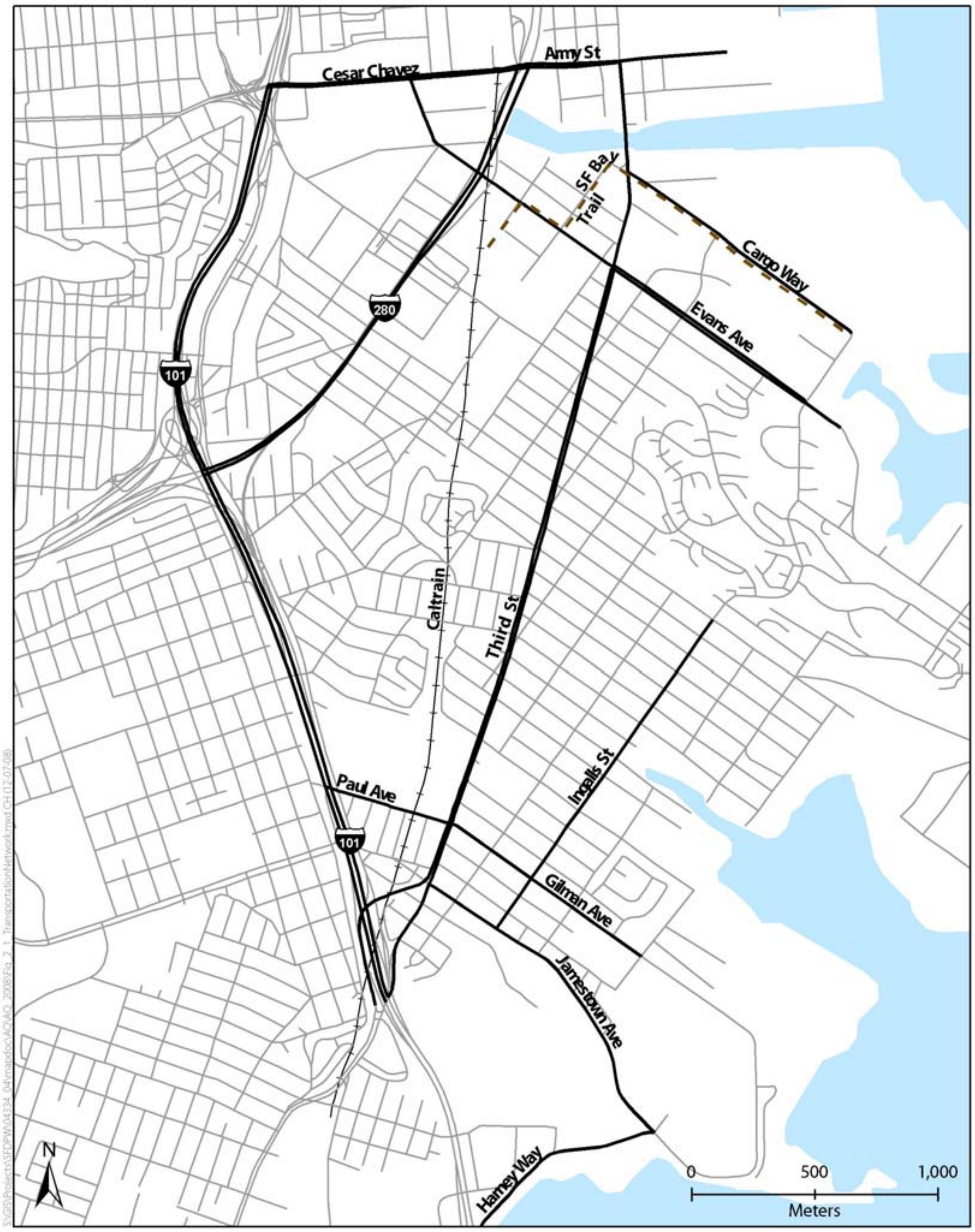
This emission inventory is inclusive of most sources within BHP, but excludes certain zones or projects. Notably, emissions associated with the Port of San Francisco are not included in this study because a parallel study is being conducted to quantify emissions associated with the port's operations. Section 2.5 describes all sources excluded from this study.

2.1 Trucks and Buses

Diesel PM emissions from trucks and buses account for 3,646 lbs. of PM in 2007, or 23% of all emissions within BHP (Table 2-5). While truck emissions are more difficult to measure due to the number of vehicles within Bayview Hunters Point, emission calculation is possible by combining data sets from Caltrans, community interviews, surveys of local businesses, and truck counts at local intersections.

The majority of truck activity in BHP occurs on Highway 101 and Interstate 280, with additional truck traffic on arterial streets such as Cesar Chavez Street, 3rd Street, Cargo Way, Evans Avenue, and Bayshore Boulevard. A small portion of truck traffic is found on local roads connected to arterial streets. Depending on road type, the origins and destinations these trips may lie inside or outside the neighborhood. Freeway traffic is largely external to the community and passes through without stopping. Arterial truck traffic mainly originates or terminates at truck-intensive industry or commercial uses. Truck traffic occurs on local streets, connecting local businesses to the larger transportation network. As each category is measured with different data sources, each category requires a unique calculation approach. Figure 2-1 shows the layout of freeways and arterial streets within BHP.

For the purposes of this analysis, a dual approach was developed to measure truck traffic in the project area. First, truck traffic on freeways and arterial roads was measured using a combination of intersection counts, segment counts, and freeway counts. The most recent freeway counts were reported for 2006, while intersection counts were measured in 2007. It is assumed that all vehicle counts are representative of year 2007 traffic. Second, truck and bus traffic on local roads was calculated by identifying major neighborhood sources of truck trips, as well as surveying local businesses for truck usage. The resulting neighborhood heavy-duty vehicle activity was apportioned to on-network travel and off-network travel.



ICF Jones & Stokes

Figure 2-1
Location of Freeway and Arterial Street Network

Total neighborhood truck and bus activity was determined by combining on-network activity from traffic counts with off-network activity from source identification. The resulting total activity is presented as VMT per year, broken down by speed of travel.

An adjustment factor was applied to all truck counts to account for the mix of gasoline vehicles and diesel vehicles in the truck fleet. The percentage of diesel vehicles varies by truck class; while nearly all combination and 3-axle trucks are diesel-powered, many 2-axle trucks run on gasoline. In order to determine diesel emissions, gasoline trucks must be excluded from activity (VMT) calculations. Gasoline VMT is excluded using data regarding truck fleet characteristics in the EPA MOBILE6 emissions model. Specifically, MOBILE6 contains data on the distribution of trucks by truck category and the share of diesel trucks in each category. The results of this conversion determine the activity level of diesel trucks in BHP, measured by VMT per year.

Note that by calculating vehicle activity in terms of VMT per year, we did not directly account for congestion along specific segments, such as Hwy. 101 near San Francisco General Hospital. However, congestion is included in the analysis indirectly through use of the EMFAC emissions model. EMFAC includes typical congestion levels when calculating truck emissions.

This study does not report emissions from school buses separately. School bus emissions are an important community issue, but explicit quantification of school bus activity is outside the scope of this report. The majority of school bus emissions were captured along with other trucks through arterial truck counts, and the amount of pollution not captured by this approach are very small in comparison with total truck emissions. Since school buses are a large community concern, they may warrant closer examination in a future study.

2.1.1 Activity on Freeways

Heavy truck traffic occurs on two freeways in BHP: Highway 101 runs along the western border of BHP, and I-280 runs through the northern portion of the community. Data on truck volumes are compiled by the Caltrans Division of Traffic Data Branch for all routes in the State Highway System. Truck counts for both Highway 101 and I-280 were obtained from the *2006 Annual Average Daily Truck Traffic on the California State Highway System* report, which was released in December 2007. This document reports direct measurements of truck volume by freeway segment, presented in Annual Average Daily Traffic (AADT).

Table 2-1 defines each segment of freeway within BHP. Diesel truck volumes for each segment are listed for average daily volume as measured by Caltrans, as well as calculated and segment length and annual VMT. In total, freeway truck diesel activity accounts for 5.12 million VMT within BHP.

Table 2-1. Diesel Truck VMT on Highway 101 and I-280

Freeway	Segment Start	Segment End	Length (miles)	Diesel Truck Daily Volume	Annual Diesel Truck VMT
Hwy. 101	Beatty / Alana	3rd St.	0.53	4,906	949,085
Hwy. 101	3rd St.	Paul Ave.	0.56	4,904	1,002,368
Hwy. 101	Paul Ave.	US 280	0.86	4,184	1,313,438
Hwy. 101	US 280	Cesar Chavez St.	1.04	3,002	1,139,480
I-280	Hwy. 101	Cesar Chavez St.	1.32	1,487	716,600
Total Highway Diesel Truck VMT per year					**5,120,971**

2.1.2 Activity on Arterial Streets

Truck activity off the freeways can also have a significant impact on local air quality. These activities include trucks traveling on arterial streets, generally between large industrial and commercial centers, and trucks traveling on local roads, generally for smaller business and public transit uses. We analyze each of these categories separately; this section discusses traffic on arterial streets while the next section describes traffic on local roads.

ICF-Jones & Stokes conducted heavy truck counts in the Bayview Hunters Point community for the 2006 BTIP report. Truck counts were performed by individuals at selected intersections during peak AM and PM times. These truck counts include both medium-duty and heavy-duty trucks. While the volume at each intersection is not segmented by truck type, the ratio of medium to heavy trucks is assumed equal to the freeway truck share.

Trucks were counted on major truck arterial streets, including Cesar Chavez St., 3rd St., Evans St., Paul Ave. / Gilman Ave., Bayshore Ave., Harney Way, Ingalls St., Jamestown Ave., and Cargo Way. Traffic along these arterials includes traffic to/from large truck sources, such as the Port of San Francisco, San Francisco Wholesale Produce Market, Monster Park, and other sources. Remaining truck activity on local roads is accounted for in the following section.

The arterial network defined for this study includes nearly all major arterial segments with heavy truck traffic. However, because the street network in BHP is so extensive, not all segments could be included in the analysis. A small number of short segments were not analyzed, including Jerrold Ave. between Hwy. 101 and Phelps St., and Phelps St. between Jerrold Ave. and Oakdale Ave. While these short segments were excluded, the arterial truck counts together with the local road activity estimates (described below) capture the vast majority of truck activity in the study area.

Table 2-2 lists the defined arterial segments, segment length, and annual truck VMT. In total, diesel truck traffic along defined arterial segments accounts for 1.62 million VMT per year within Bayview-Hunters Point.

Table 2-2. Diesel Truck VMT on Arterial Segments in BHP

Street	Segment Start	Segment End	Length (miles)	Diesel Truck Daily Volume	Diesel Truck Annual VMT
3rd St.	Hwy. 101	Jamestown Ave.	0.19	1,093	51,916
3rd St.	Jamestown Ave.	Paul Ave.	0.16	1,173	46,928
3rd St.	Paul Ave.	Carroll Ave.	0.23	1,208	69,446
3rd St.	Carroll Ave.	Oakdale Ave.	0.66	1,291	213,072
3rd St.	Oakdale Ave.	Evans Ave.	0.52	1,256	163,238
3rd St.	Evans Ave.	Cargo Way	0.24	1,191	71,440
3rd St.	Cargo Way	Cesar Chavez St.	0.28	1,457	101,966
Cesar Chavez St.	Hwy. 101	Evans Ave.	0.36	761	68,475
Cesar Chavez St.	Evans Ave.	Pennsylvania Ave.	0.27	761	51,357
Cesar Chavez St.	Pennsylvania Ave.	3rd St.	0.25	704	44,000
Evans Ave.	Cesar Chavez St.	3rd St	0.72	1,275	229,566
Paul Ave.	Bayshore Blvd.	3rd St.	0.30	483	36,249
Gilman Ave.	3rd St.	A. Walker Drive	0.63	731	115,210
Bayshore Blvd.	Hwy. 101	Paul Ave.	0.55	1,019	140,117
Harney Way	Alana Way	Jamestown Ave.	0.38	153	14,576
Ingalls St.	Egbert Ave.	Carroll Ave.	0.10	217	5,424
Ingalls St.	Carroll Ave.	Thomas Ave.	0.37	241	22,268
Jamestown Ave.	3rd St.	Harney Way	0.87	626	136,232
Cargo Way	3rd St.	Jennings St.	0.59	279	41,192
Total Arterial Diesel Truck VMT per year					**1,622,672**

While the truck counts summarized in Table 2-2 provide total VMT, they do not provide the time spent idling at the origin or destination of each truck trip. Since extended truck idling can be a significant source of Diesel PM emissions, this value must be calculated separately from running emissions by using additional GIS measurements and assumptions regarding truck trips.[2]

For this analysis, idling time is calculated for the origin and destination of each truck trip that originates or terminates in BHP. The length of the longest possible trip along the arterial network is 3.0 miles, achieved by traversing the community northbound along 3rd St. from Highway 101 to Evans St., northbound to Cesar Chavez St., then westbound returning to Highway 101. As trips along the arterial network will vary between 0 and 3.0 miles, a conservative distance of 2.0 miles is chosen for average trip length. Because there were 1.6 million VMT along the arterial network, an estimated 81,000 truck trips occur each year along the arterial network.

Not all truck trips in BHP originate or terminate in the study area. Trips that pass through the community, including all freeway trips and a small proportion of arterial trips, do not contribute any extended idling emissions. A small number of trips will remain internal to the community, with idling emissions occurring both at the origin and the destination. However, due to the community's industrial nature, the vast majority of truck trips will be external, with one end within the community and one end outside the community. It is assumed that 80% of arterial truck trips either originate or terminate in BHP, while an additional 5% both originate and terminate in the community.

By this measure, there are approximately 730,000 trip origins and destinations within BHP each year. There is little information on the length of truck idling. ARB estimates that heavy-duty trucks in California idle an average of 20.8 minutes per trip.[3] This estimate was based on data collection from a sample that included long-haul trucks, and trucks in the BHP region likely idle less than this per trip. We assume 15 minutes of idling per trip end. This leads to a total of 182,000 hours of idling associated with trips counted on the arterial network. Additional idling time is calculated for trips on local roads.

2.1.3 Activity on Local Roads

Aside from freeways and arterial streets, truck and bus traffic occurs on local roads. The largest contributors to this category are (1) local businesses that operate diesel trucks, and (2) MUNI buses traveling on local streets. Each of these sources is analyzed separately to calculate heavy-duty vehicle VMT and idling time.

The sources for this analysis were chosen based on several factors, including: prior BTIP work, input from the San Francisco Department of Environment, neighborhood research, and interviews. The largest sources of truck traffic were considered for analysis. In order to prevent double counting, some truck-based businesses were excluded from this accounting. Many truck sources, such as the Port of San Francisco, are located adjacent to arterial streets defined in the prior section, so activity from these sources is captured in arterial truck counts.

Local Businesses

As an initial effort to identify BHP truck-based businesses, ICF Jones & Stokes designed and mailed a survey to determine which businesses operate diesel trucks. The San Francisco Department of the Environment provided a cover letter to explain the project, which accompanied the survey.

For businesses that did not respond to the survey, truck activity was estimated from information collected from similar businesses. Based on this information, the following assumptions were made: roofing and metal work companies operate one diesel truck, construction companies operate two diesel trucks, trucking companies operate five diesel trucks, large moving and shipping businesses operate nine diesel trucks, and all other businesses operate zero diesel trucks.

Survey results show that, on average, trucks complete two trips each weekday. These assumptions were applied to each of the truck-based businesses in the community, for an estimated total of 238 diesel trucks operating for a combined total of 123,760 trips per year. Each trip is associated with one origin or destination, and produces idling emissions at each trip end.

GIS analysis shows that the length of most off-network trips is less than one mile. As a conservative estimate, we applied a trip length of one mile to each off-network trip. We calculated idling time using the same assumptions as in the prior section, with 15 minutes of idling time at each trip end. The calculated annual non-arterial diesel truck VMT is 123,760, with 30,940 hours of idling time.

MUNI

The Municipal Transportation Agency (MUNI) provides public transit in San Francisco. Within the project area, MUNI operates nine bus routes and one electrified light rail line. While the MUNI fleet contains both diesel and electrified buses, the routes in BHP all rely on diesel-powered vehicles.

MUNI bus routes typically operate with 10 to 15 minute headways between 6am and 11pm, with reduced frequency and hours on weekends. Within the project area, MUNI operates 7,387 bus trips per week.[4] The length of bus trips within the community range between 0.6 and 2.6 miles. However, a portion of MUNI volume is already accounted for with intersection counts on the freeways and arterial roads, so this analysis focuses on MUNI route segments on non-arterial roads.

MUNI does not maintain a depot within BHP, so all bus trips begin and end outside the community. Therefore, we did not account for idling emissions separately. Local road VMT (i.e., VMT not on freeways or arterial roads) is calculated using measured route distance and schedule frequency. In total, MUNI accounts for 659,000 VMT per year within the community, of which 449,000 is not included in the arterial network. Table 2-3 summarizes information about MUNI routes, schedules, and VMT.

Table 2-3. MUNI VMT on Local Roads

Bus Route	Length within BHP (miles)	Length on Local Roads (miles)	Frequency (# buses / week)	VMT / year	Local Road VMT / year
9X (NB)	2.3	0.0	763	91,254	0
9AX (NB)	2.3	0.0	75	8,970	0
19	2.0	1.3	1,259	130,936	83,799
23	2.6	2.6	860	116,272	116,272
24	1.0	1.0	1,567	81,484	81,484
29	1.1	0.2	1,284	73,444	11,351
44	2.4	2.4	1,145	142,896	142,896
56	0.6	0.6	434	13,540	13,541
Total				**658,798**	**449,342**

2.1.4 Emissions

Diesel emissions from the on-road sources were evaluated using ARB's EMFAC2007 emissions model and vehicle activity data. The EMFAC model calculates emission rates from all motor vehicles (e.g., passenger cars, heavy-duty trucks, buses) operating on highways, freeways and local roads in California. Emission rates from EMFAC are multiplied by vehicle activity data to calculate emission inventories associated with the proposed project. This section documents the assumptions, model inputs, and results of BHP EMFAC analysis. Table 2-4 includes Diesel PM emission factors for Heavy-Duty Trucks at different speeds. Emission factors were then multiplied by the vehicle activity to obtain emissions in the study region. .

Table 2-4. Heavy-Duty Truck Diesel PM Emission Factors

Road Type	Speed (mph)	Running Emission Factor (grams/mile)	Idling Emission Factor (grams/hour)
Arterial / Local	0	-	0.877
Arterial / Local	35	0.234	-
Freeway	55	0.186	-

The total Diesel PM emissions from trucks and buses are presented in Table 2-5, as determined from activity levels and emission factors shown above. Over 50% of emissions in this category are caused by trucks along Highway 101 and I-280. Because emissions are concentrated along these corridors, nearby residents and businesses will be disproportionately impacted. Section 3 contains a thorough analysis of this issue. Idling emissions are much smaller than freeway emissions but are still a significant source, accounting for over 10% of truck emissions. This indicates that mitigation measures that target idle reduction may be effective in reducing emissions. Section 4 of this report contains further discussion of mitigation options.

Table 2-5. Truck & Bus Diesel PM Emissions in BHP

Source	Diesel PM Emissions (lbs / year)	Share of Mobile Emissions
Freeway	2,100	57.6%
Arterial / Local	1,133	31.1%
Idling	413	11.3%
Trucks and Buses - Total	**3,646**	**100.0%**

2.2 Locomotives

Railroad activities are a small source of diesel PM emissions within BHP, accounting for 481 lbs. of PM in 2007, or 2.9% of total emissions (Table 2-6). Two rail lines operate within the community, offering mass transit and goods movement services. Nearly all locomotive emissions are related to the Caltrain commuter line, which runs north-south through the neighborhood. A small portion of emissions is caused by the SF Bay Railroad, which moves freight from the Port of San Francisco southbound to the Union Pacific rail yard in South San Francisco.

Freight trains used to play a larger role in BHP industrial activity. Observers will note old rail lines running along many of the neighborhoods current and former industrial zones. Occasionally, as can be seen on Carroll St., these old lines are still used for freight transport. However, the vast majority of rail activity is due to Caltrain and SF Bay Railroad. While this section only examines these two sources, the calculated emission levels accurately reflect all rail activity in BHP.

2.2.1 Activity

Rail activity is measured in terms of fuel consumed within the community boundaries. When this data were not available, fuel consumption was calculated from rail timetables and fuel expenditures. In 2007, an estimated 32,518 gallons of diesel fuel were consumed by rail activities within BHP.

Caltrain

Caltrain operates 96 trains per day between San Francisco and San Jose, passing through BHP without any station stops. The Caltrain rail line travels 2.3 miles north through the neighborhood, accruing 58,604 train miles per year. Along its entire 77 mile route, Caltrain travels 1.4 million train miles per year.

Fuel consumption of Caltrain service is calculated as the product of annual train-miles and locomotive fuel economy, in miles per gallon. Rail fuel economy is not typically expressed in these terms, but can be calculated using available data. According to the 2007 Annual Budget Report, Caltrain consumed $1.7 million of diesel fuel in 2007. In this year, the average OPIS diesel price was $2.23 per gallon (OPIS is the accepted fuel price benchmark for U.S. federal, state, municipal and county governments).[5]

At this price, Caltrain consumed 745,000 gallons of diesel fuel in 2007 over the entire corridor. Accordingly in that year, average fuel economy was 1.84 MPG. When the average fuel economy is applied to train-miles traveled specifically within BHP, we calculated that Caltrain consumed 31,918 gallons of diesel fuel within the community in 2007.

SF Bay Railroad

The San Francisco Bay Railroad provides switcher service within the Port of San Francisco rail yard, as well as connecting service through BHP to the Union Pacific (UP) rail yard in South San Francisco. Of the total 7.2 mile trip length, 2.4 miles, or 33%, occurs within the project area.

SF Bay Railroad annually consumes 1,800 gallons of diesel.[6] Because diesel fuel is consumed during line-haul (i.e., connecting service between the Port of San Francisco and the UP rail yard) and switching operations, we allocated more than 33% of diesel fuel to the study area. As a conservative estimate, half of all fuel consumed by SF Bay Railroad (i.e., 900 gallons) was allocated to the study area.

2.2.2 Emissions

Rail emissions were calculated by multiplying rail activity (in gallons of diesel fuel) by an emission factor expressed in terms of grams of Diesel PM per gallon of fuel. Emission factors (6.46 grams/gallon) were taken from the U.S. EPA's Regulatory Support Document for locomotive emission standards, adopted in 1998. At this emission rate, rail activity contributes 481 lbs. of Diesel PM emissions annually. Over 95% of rail emissions are attributable to Caltrain service, roughly equivalent to emissions from truck idling. Table 2-6 summarizes activity and emissions from locomotives.

While emissions from SF Bay Rail are small, the company has instituted several "greening" policies to make further reductions. Currently, SF Bay Rail has replaced the diesel in its locomotives with 100% biodiesel (B100 blend) fuel, significantly reducing PM emissions. Since the calculations in this section do not take into account this improvement, the results are slightly conservative. However, since SF Bay Rail only accounts for 0.2% of overall PM emissions, the difference caused by this assumption is small.

Table 2-6. Activity and Emissions from Locomotives, 2007

Rail Line	Fuel Consumption (gal)	Emission Factor (g/gal)	Diesel PM Emissions in BHP (lbs / year)
Caltrain	31,918	6.46	455
SF Bay Rail	1,800	6.46	26
Total	**33,718**		**481**

2.3 Construction Equipment

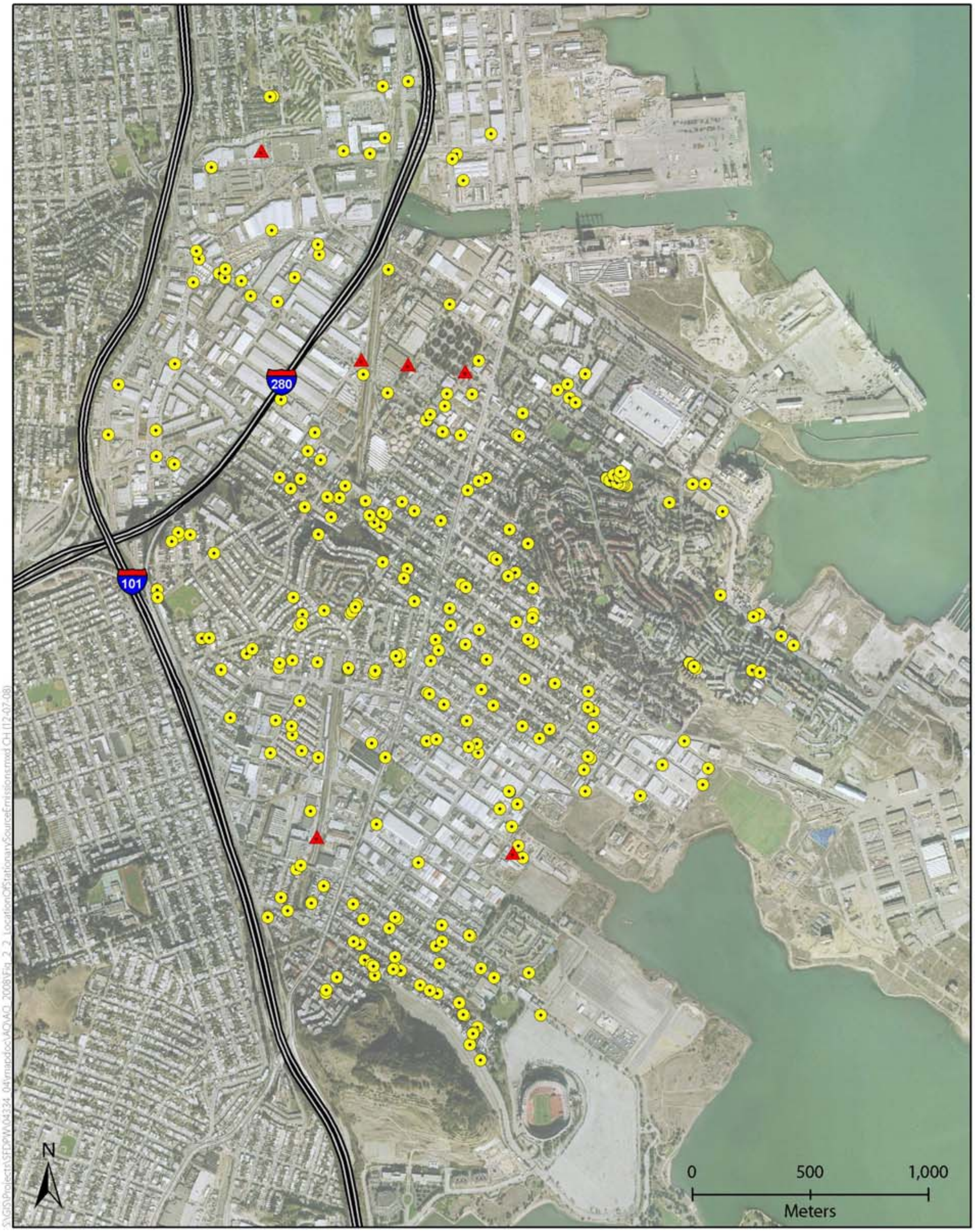
In 2007, construction activities were the dominant source of Diesel PM in BHP, accounting for 10,880 lbs. of PM in 2007, or 69.6% of total emissions (Table 2-7). This is due to the number of projects in the community and the powerful equipment used in construction. Typical construction equipment is powered by large diesel engines. Even when idling, these become large emitters of Diesel PM.

Unlike truck and rail emissions, which are relatively constant from year to year, construction emissions may vary greatly depending on the level of construction activity. The construction activity compiled in this emissions inventory is for construction projects permitted in 2007. Ongoing construction projects on Port of San Francisco property east of Cargo Way are excluded from this report since they are the subject of a parallel study conducted by the port.

This study accounts for construction equipment that was operated within BHP, regardless of where its operators were based. Some of this construction equipment undoubtedly belongs to companies based outside BHP. Further, while some equipment is owned or rented by companies within BHP, it was only included in this study if it was operated within the boundaries of the community.

2.3.1 Activity

A list of construction permits issued in 2007 within the 94124 zip code was provided by the San Francisco Department of Building Inspection (DBI). This list included nearly 5,700 permits. The vast majority of these permits were for small home remodeling or re-roofing projects, which would not likely require the use of diesel equipment. Of the permits provided by DBI, approximately 400 projects are estimated to have required off-road diesel equipment for demolition or construction. These projects were mainly related to the construction of single family dwellings, as well as several condominium developments and commercial / industrial buildings. Total construction activity, along with related emissions is summarized in Table 2-7. Construction projects were located throughout the BHP region, as seen in Figure 2-2.



ICF Jones & Stokes
an ICF International Company

▲ Diesel Generator
⊙ Construction Site

Figure 2-2
Location of Stationary Source Emissions

2.3.2 Emissions

Construction emissions of Diesel PM were calculated using URBEMIS 2007 (version 9.2.4) modeling software. To estimate construction emissions, URBEMIS 2007 analyzes the type of construction equipment used and the duration of the construction period associated with construction of each of the land uses. According to the URBEMIS 2007 model setup, construction of any project is broken down into several phases. For the purposes of this analysis, we assumed that building projects such as residential, commercial, and industrial projects have 4 phases: an excavation/grading phase, a paving phase, a building construction phase, and an architectural coating phase. Because the construction projects in the "other" category vary widely in size, an average sized project of 5 acres was used to represent this category in order to capture a reasonable amount of emissions. Projects in this category were assumed to encompass all four phases of building construction.

Because of the lack of information about the construction plans for the construction projects that took place in 2007, it was not feasible to obtain a detailed inventory of construction equipment that was used for each construction project within the constraints of this inventory. As a surrogate method, URBEMIS 2007 default values were used to identify the type and number of equipment that would be operating on a typical workday during the construction period for site grading, building construction, and paving activities. These default values represent typical construction equipment used to build single family dwellings, apartment units, and other projects.

URBEMIS 2007 default values were also used to estimate the acreage of most construction projects. However, acreage for single-family dwelling projects was reduced from a default value of 0.33 to 0.11 since the average residential lot in San Francisco is about 5,000 square feet (0.11 acre). Using URBEMIS, construction emissions were estimated for each project type. Resulting emissions are presented in Table 2-7.

Table 2-7. Construction-Related Activity and Diesel PM Emissions in 2007

Construction Project	Per Project Emissions (lbs)	Number of Projects	Total Emissions (lbs / year)
Single Family Housing	20	232	4,640
Demolition	0	49	0
8-Unit Apartment Complex	60	1	60
30-Unit Apartment Complex	60	1	60
50-Unit Senior Housing	600	1	600
71-Unit Condos	120	1	120
Commercial	60	17	1,020
Industrial	60	18	1,080
Other	60	55	3,300
Total		**375**	**10,880**

Since construction emissions are high in comparison with other sources, a sensitivity analysis was used to examine the influence of different input parameters on total emissions of single-family dwellings. While emissions were independent of project acreage, they were strongly correlated with the construction duration. A change in equipment activity (e.g., number of pieces of equipment, number of hours of operation per day) also has an effect on total emissions. For example, reducing the number of tractors/loaders/backhoes from 2 to 1 piece changed total emissions associated with the construction of a single-family dwelling by about 20%. And emissions were reduced by almost 40% if every piece of equipment were used for 4 hours per day, as opposed to the URBEMIS default assumptions of 6 – 8 hours per day. Because of the sensitivity of results to these input parameters, additional research on construction activity is recommended.

2.4 Diesel Generators

Diesel generators are used primarily as back-up power for industries and utilities in BHP. Due to the limited operating hours of these generators, total Diesel PM emissions from this category are small compared to other categories, accounting for 638 lbs. of emissions in 2007 (Table 2-8). Annual activity of diesel generators is measured in terms of horsepower-hours, the product of generator power and operating time. Emissions are calculated from activity and the appropriate emissions factor (expressed in lbs / hp-hr); however, the emission factor will vary by generator, depending on unit size and age.

By law, backup generators are limited to 20 hours of operation annually, above which they must meet stringent emission requirements (see Section 4.2 for more information).[7] ARB staff anticipates that most standby/emergency engines will comply with the emission standards by limiting their maintenance and testing to less than 20 hours per year instead of installing pollution control equipment on the generators. However, since data on actual operation are unavailable, and since operation varies from year to year as needs dictate, this analysis conservatively assumes that all generators operate at the maximum allowed level. Even so, diesel generators are a relatively small source of Diesel PM in BHP, accounting for 4.1% of total emissions.

2.4.1 Activity

Information on diesel generators within BHP was obtained from the Bay Area Air Quality Management District (BAAQMD). The BAAQMD provided a list of the 60 diesel generators currently permitted for the 94124 zip code. As Figure 2-2 shows, the generators are concentrated at just six locations throughout the study area, two of which hold 45 generators. The City's Central Shops at 1800 Jerrold Avenue have 22 generators permitted. The facilities at the City's neighboring southeast wastewater treatment plant have another 23 permitted generators, at 750 Phelps Street. In addition, some businesses and individuals in BHP operate small unpermitted diesel generators. While the effects of these unpermitted units are not taken into account in this study, the additional impact is expected to be small.

Of the 60 generators, approximately one-third are used only for emergency power and two-thirds are used for standby and emergency power. Most emergency power generators are less than 100 horsepower.

For the purposes of this study, we assumed that each generator runs for 50 hours per year total, which takes into account 30 hours of emergency use per year so that emissions could be conservatively estimated. Because diesel generator activity needs to be expressed in terms of hp-hour, the total hours of activity for each generator were multiplied by the power rating and a load factor of 0.43.[8] The load factor accounts for variable operation of the generator: at low settings, the unit emits low levels of Diesel PM, while at high settings the unit emits higher levels of the pollutant.

2.4.2 Emissions

Activity from diesel generators was estimated in horsepower-hours. Because the emission factors depend on the size and age of the generator, we calculated emissions for each generator individually by multiplying activity by emission factors. Emissions from diesel generators are summarized in Table 2-8, grouped by location.

Table 2-8. Diesel Generator Emissions, 2007

Address	Number of Generators in BHP	Emissions (lbs/year) in BHP
1300 Carroll Avenue	2	8
1800 Jerrold Avenue	22	68
200 Paul Avenue	10	426
2323 Cesar Chavez Street	2	10
750 Phelps Street	23	122
901 Rankin Street	1	4
Total	**60**	**638**

2.5 Other Sources

In addition to construction activity and power generation, several other stationary sources were considered for inclusion. However, these sources were not included in this analysis because their activity lies outside the scope of this project, or had already been accounted in other sections. In addition, some sources, such as the Municipal Asphalt Plant at 1801 Jerrold St., are not included because we lacked data about activity at these locations.

2.5.1 Port of San Francisco

The Port of San Francisco handles mostly dry bulk cargo. Three different port tenants move dry bulk cargo through facilities located at Pier 92 and Hanson Aggregates terminal at Pier 94. Sand reclaimed from San Francisco Bay or imported from Canada is discharged and processed through Pier 92 by both Hanson Aggregates and Bode Sand & Gravel.

Emissions from the Port of San Francisco are largely excluded from this study. The San Francisco Port Authority is currently conducting a parallel review of emissions related to port activities. In order to prevent duplication, we excluded all diesel emissions occurring on Port property, as well as any marine emissions from ships and harbor craft. The only Port-related diesel emissions included in this study are emissions from freight trucks as they travel from the Port through BHP.

There are tenants at the Port of San Francisco whose operations are not related to port operations. We assume the activity associated with the truck traffic generated by those tenants is captured by arterial intersection counts (Table 2-2).

2.5.2 Hunters Point Naval Base

As stated in the Hunters Point Shipyard Reuse Final EIR (2000), the Navy has not operated any stationary emission sources at Hunters Point Shipyard since 1974, and all Navy air permits have been terminated. The shipyard currently includes former Navy uses, and several of the former Navy buildings are leased out to light industrial uses and artist studios, which are unlikely to operate diesel vehicles. However, there are several moving, storage, and other uses that are likely to operate diesel trucks. We assume the activity associated with such truck traffic is captured by arterial intersection counts (Table 2-2).

2.5.3 Lennar Construction

Lennar is the lead developer for the Hunters Point Shipyard Development Plan. Future development will include infrastructure to support a mixed-use community with residential, commercial, industrial, and open space land uses. This project is currently undergoing environmental review, and therefore would not take place for several years. In 1997, the San Francisco Redevelopment Agency and the San Francisco Planning Department adopted the Hunters Point Shipyard Redevelopment Plan. Phase 1 of that plan includes the development of new housing on a 75-acre portion of the shipyard, known as Parcel A. Approximately 40 acres of Parcel A are currently under construction. Lennar construction activity, as well as other redevelopment construction activities, is both captured earlier in this section, and associated truck deliveries are accounted for in arterial intersection counts.

2.6 Summary of Emissions

Table 2-9 presents a summary of Diesel PM emissions in the BHP area, by source type. Construction activity is the largest emissions source, producing 70% of Diesel PM emissions. Truck and buses are the next largest source, responsible for 23% of BHP emissions.

Table 2-9. Summary of BHP Diesel Emissions, 2007

Source	Diesel PM Emissions (lbs / year)	Percent
Trucks and Buses	3,646	23%
Railroad Locomotives	481	3%
Construction	10,880	70%
Generators	638	4%
Total	**15,645**	100%

3 Health Risks of Diesel PM Emissions

A number of studies have shown that people living in close proximity to major transportation sources like roads experience higher exposure to pollutants that are directly emitted by motor vehicles.[9,10] At least one study suggests that people living near major rail terminals are also exposed to significantly higher concentrations of directly emitted pollutants.[11] Likewise, other studies suggests that nearby residents of marine ports and other industrial sources are exposed to significantly higher concentrations of pollution, including particulate matter.[12,13] Residents of affected neighborhoods are exposed to diesel PM pollutions while both outdoors and indoors. In fact, indoor levels of PM can sometime exceed outside levels.[14]

EPA's Health Assessment Document for Diesel Exhaust concludes that diesel exhaust is likely to be carcinogenic to humans at environmental exposure levels that the public faces (a "probable" human carcinogen)[15]. Scientific studies also show that ambient particulate matter, of which Diesel PM is an important component, is associated with a series of adverse health effects. These health effects are discussed in detail in the 2004 EPA Particulate Matter Air Quality Criteria Document for PM and the 2005 PM Staff Paper.[16,17,18] Health effects associated with short-term exposures (hours to days) to ambient PM include premature mortality, increased hospital admissions, heart and lung diseases, increased cough, adverse lower-respiratory symptoms, decrements in lung function and changes in heart rate rhythm and other cardiac effects. Studies examining populations exposed to different levels of air pollution over a number of years show associations between long-term exposure to ambient $PM_{2.5}$ and both total and cardio respiratory mortality.[19,20,21] Recent local impact studies have also documented the health effects resulting from PM exposures on or near roadways. Also, a number of studies have shown associations between residential or school outdoor concentrations of constituents of fine particles found in vehicle exhaust and adverse respiratory outcomes such as asthma.

Finally, the State of California, in the past two years has completed numerous studies of multiple rail yards and marine ports and has found that emissions from these facilities contributed significantly to elevated ambient concentrations near these sources leading to a substantial number of people being exposed to diesel engine emissions. Diesel PM is listed by the California's Office of Environmental Health Hazard Assessment as a known carcinogen with a cancer risk factor of 300 excess cancers per million people for one microgram per cubic meter ($\mu g/m^3$) of Diesel PM based on a 70-year exposure period. The South Coast Air Quality Management District has concluded that the cancer risk from Diesel PM inhalation is approximately 1,000 excess cancers per million people in the Los Angeles metropolitan area.

The diesel emission inventory described in the previous section identifies local sources of diesel exhaust in the Bayview Hunters Point neighborhood. This emission inventory is used in conjunction with a series of dispersion simulations to estimate the level of a resident's Diesel PM exposure. This section documents the methodology and results of a diesel particulate matter health risk assessment for the neighborhood.

3.1 Modeling Methodology

The emission inventory in the prior section discusses mobile and stationary Diesel PM source characteristics, locations, and activity influencing concentrations in the BHP. These are grouped into the following source categories:

- Heavy-duty vehicles on routes (freeways and arterial streets) within BHP
- Heavy-duty vehicles moving and idling along local roads (non-arterial traffic) throughout BHP
- Rail line and switcher locomotive sources,
- Construction equipment, and
- Minor stationary sources, namely, auxiliary diesel generators.

All emissions were developed in a manner to facilitate use in dispersion modeling and care was taken in their development to both minimize any effects of duplicated emissions (double counting) and to capture all relevant sources. All emissions were developed for a baseline activity year of 2007.

3.1.1 Sources

In this analysis, each of the above source groups was treated separately to simulate total Diesel PM concentrations through dispersion modeling. Dispersion modeling was done in two stages:

- Major heavy-duty vehicle routes (freeways and arterials) were simulated with the CAL3QHCR model
- All other activity (non-arterial traffic, rail, construction, and diesel generators) was simulated with the AERMOD (version 07026) model.

In all cases, sources were simulated using urban dispersion characteristics. No terrain effects were included in the modeling, as these were considered of minor importance to the relatively small, basin-like study area and the focus of modeling was only on local sources. Other details of the modeled sources are presented below.

While the concentration of Diesel PM may vary throughout the day, this study only reports an average concentration value. Modeling daytime and nighttime variation requires additional level of detail and is outside the scope of this report.

Freeways and Arterial Streets

Tables 2-1 and 2-2 in the prior section list all the freeways and intersections, respectively, considered major for the present analysis and discusses their analysis. Here, we consider these to be the full list of major heavy-duty vehicle links in the region.

Each of these major links was simulated with CAL3QHCR to allow optimum simulation of on-road, mobile source emissions, including queuing effects and accompanying idling emissions at intersections as well as vehicle wake effects. In this analysis, we used free-flow volumes, heavy-duty vehicle fractions, and resulting composite emission factors from the results of the emissions inventory. All freeway links were assumed to be free-flow with a corresponding speed of 55 mph. Each intersection is assumed to consist of two approach and two departure lanes, with all approach lanes queued. Signal parameters were assumed to be uniform for all intersections and include the traffic light cycle time of 90 seconds, red light duration time of 40 seconds, and the portion of yellow time not used for vehicle movement as 2 seconds. We simulated all arterials emanating from the intersections as 250 m in length. In all cases, we used a flat temporal profile of activity.

We determined the release height from heavy-duty vehicles on major roadways as follows. We assumed the initial vertical extent of the plume is about 1.7 times the average vehicle height, or 6.8 meters for a heavy-duty vehicle height of about 4.0 meters.[22] We then assigned the source release height to the midpoint of the initial vertical extent – 3.4 meters and assigned the initial vertical dispersion coefficient as the initial vertical extent divided by 2.15, or 3.2 meters. Figure 3-1 shows the locations of the various major heavy-duty vehicle links, as well as all other emission sources considered in this analysis.

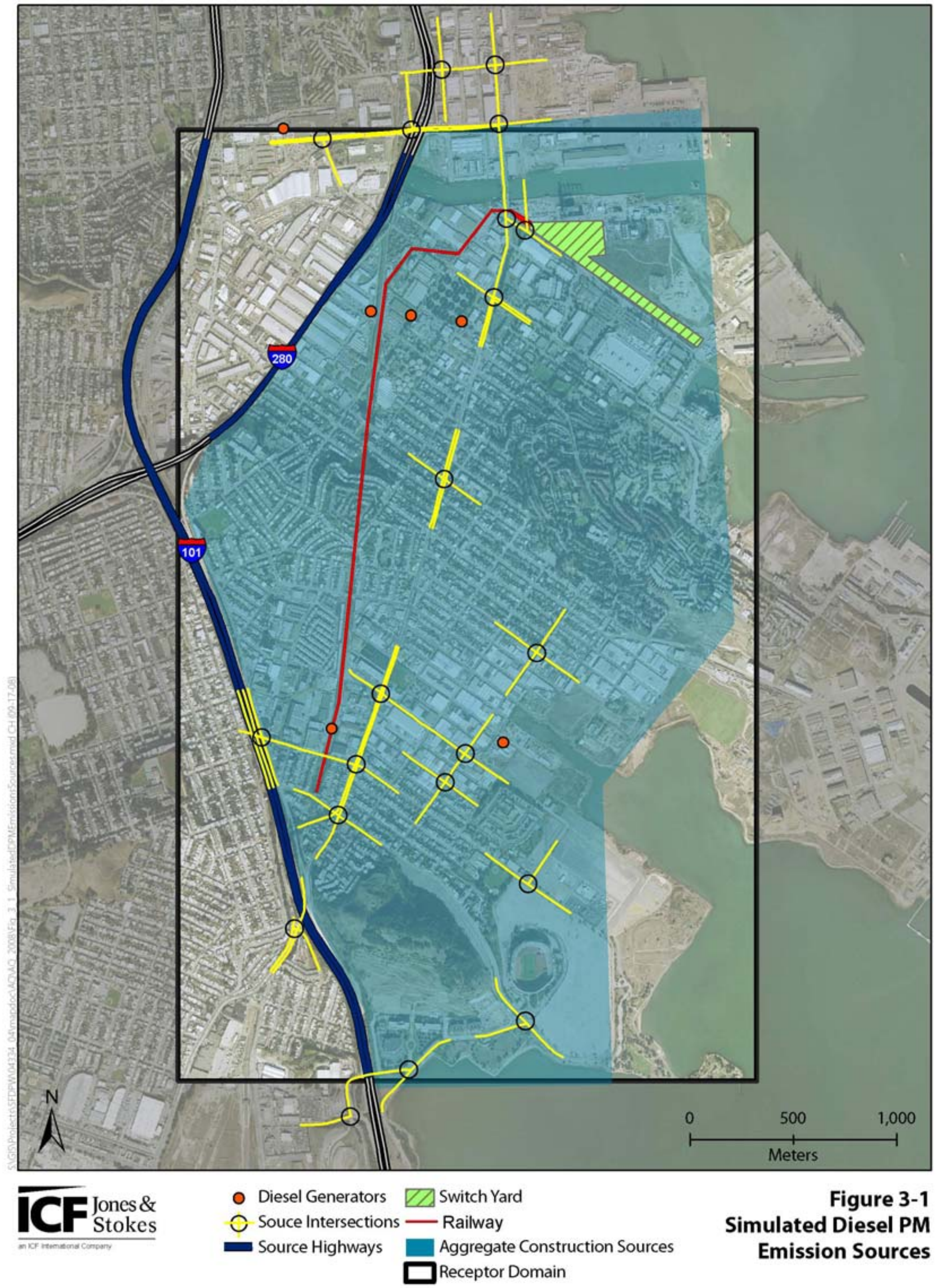


Figure 3-1
Simulated Diesel PM Emission Sources

Other Sources

We calculated non-arterial (local street) heavy-duty vehicle emission separately from emissions on freeways and arterial streets. Sources of non-arterial activity include local businesses throughout BHP as well as MUNI bus service. We estimated both the moving and idling emissions from these activities, as described in Section 2. Because, in principal, these emissions could occur throughout the region and to eliminate any spatial bias, we simulated these as an aggregate area source. This area source is shown as the large, blue polygon in Figure 3-1. The profile of these sources was considered constant over the 2007 modeling year. The release height was taken as 3.4 m with an initial vertical dimension of 3.2 m, consistent with the major link emissions.

Locomotive emissions from activity along the SF Bay Rail Line, including the switcher yard, and from Caltrain activity were included in the emission inventory. Each of these sources was digitized and represented as an area source corresponding to the physical boundaries of the emissions. These are shown with the red line and green polygon in Figure 3-1. The profile of these sources was considered constant over the modeling year. As documented in the inventory, approximately 97 percent of railroad fuel consumed is due to Caltrain and occurs along the line, while the remaining 3 percent occurs from the SF Bay Railroad activity, which occurs along both the rail line and at the switch yard. We assumed equal distribution of the small activity by the SF Bay Railroad at the switch yard and along the line, resulting in 98.5 percent of total emissions allocated along the rail line and 1.5 percent to the switch yard. The release height was taken as 5.0 meters with an initial vertical dimension of 2.32 meters to represent rail activity, consistent with the ARB studies.

The emission inventory also characterized the construction emissions throughout the BHP region. As illustrated in Figure 2-2, construction activities are located throughout the entire domain. Thus, we modeled these as the continuous area source shown as the large, blue polygon in Figure 3-1. The profile of these sources was considered constant over the modeling year and the release height was taken as 3.4 m with an initial vertical dimension of 3.2 m.

The emission inventory also characterized the locations and emissions of minor stationary sources (backup diesel generators). In this analysis, we assumed the activity profile from these sources was constant throughout the entire year and modeled each as circular area sources with a diameter of 61 m (200 ft) to represent the typical dimension of the building housing each and to omit any angular bias from orientation.

3.1.2 Receptors

To characterize Diesel PM concentrations across the BHP region, as well as at key points, we employed two sets of receptors in the study. First, a rectangular grid of 1363 receptors was included to characterize the overall spatial distribution of concentrations. Secondly, 25 sensitive receptors – the same ones used in the previous BTIP analysis – were used here. Table 3-1 shows the list of sensitive receptors characterized in the study; Figure 3-1 shows the domain of gridded receptors enclosed by a black box. All receptors were modeled as a standard 1.8 m, or 5’9”, representative of a typical human. However, prior studies have shown that pollution concentrations stay constant at heights below 10 feet. Because of this, modeled results in this section are applicable to all men, women, and children.

The 25 sensitive receptors selected for this study, chosen to be consistent with the previous BTIP analysis, are representative of locations throughout the community. Sensitive receptors, as defined by state environmental regulations, are “people or institutions with people that are particularly susceptible to illness from environmental pollution, such as the elderly, very young children, people already weakened by illness (e.g., asthmatics), and persons engaged in strenuous exercise." The receptors identified here are intended to be those facilities most likely to contain significant concentrations of people meeting this definition, not necessarily all locations throughout the community where numbers of people congregate. The PM concentrations and resulting risk at any location may be inferred from Figures 3-2 and 3-3 of the draft Final Report.

Table 3-1. Sensitive Receptors Investigated in this Study

Name	Receptor Type	Address	UTM Easting (m)	UTM Northing (m)
Bret Harte	Elementary School	1035 Gilman Avenue	553,851	4,174,777
George Washington Carver	Elementary School	1360 Oakdale Avenue	554,084	4,176,286
Dr. Charles R. Drew	Elementary School	50 Pomona Avenue	553,442	4,176,228
Malcolm X Academy	Elementary School	350 Harbor Road	554,573	4,176,450
Twenty-First Century	Elementary School	2055 Silver Avenue	552,909	4,176,698
St. Paul of the Shipwreck Academy	Elementary and Middle School	1060 Key Avenue	552,698	4,176,665
Gloria R. Davis	Middle School	1195 Hudson Avenue	553,233	4,174,832
Thurgood Marshall	Middle School	45 Conkling	554,442	4,176,292
S.R. Martin College Preparatory	High School	2660 San Bruno Ave.	552,535	4,175,804
Lucy Harber Academy	Preschool	1744 Palou Avenue	553,440	4,176,669
Head Start	Preschool	1300 Phelps Street	553,412	4,176,833
San Francisco Head Start	Preschool	125 W. Point Road	554,560	4,176,673
M'Eadd Preparatory Day Care	Child Care	1777 Revere Avenue	553,027	4,176,251
Ideal Daycare	Child Care	1523 La Salle Avenue	553,973	4,176,645
Karen's Family Day Care	Child Care	1547 Innes Avenue	553,918	4,176,996
Tiny Tot's Family Day Care	Child Care	1570 Quesada Avenue	553,848	4,176,277
Angel Childcare for Infants	Child Care	1591 Hudson Avenue	553,910	4,177,138
Tweas Child Care	Child Care	107 Maddux Avenue	552,999	4,176,405
Cahead Brighter Future	Child Care	1331 Evans Avenue	554,297	4,177,174
C W's Child Care Service	Child Care	166 W. Point Road	554,604	4,176,641
Victoria's Family Daycare	Child Care	6 Bertha Lane	554,434	4,175,867
Little Folks Daycare	Child Care	1216 Quesada Avenue	554,434	4,175,867
Mama's GG Daycare	Child Care	6 Harbor Road	554,890	4,176,169
Girls 2000	Child Care	763 Jerrold Avenue	555,198	4,176,028
Frandelja Enrichment	Child Care	950 Gilman Avenue	553,998	4,174,686

3.1.3 Meteorological Data

The BTIP project analyzed onsite meteorology from ARB's Eastern San Francisco Sewage Treatment Plant (STP) in the BHP district, although CAL3QHC modeling was done with 1991 KSFO (San Francisco International Airport) surface and 1991 KOAK (Oakland International Airport) upper air data. We updated this information to employ on-site surface observations from 2007 from the STP, 2007 National Weather Service surface observations, and upper air observations from 2007 from KOAK. STP data was obtained from MesoWest.[23]

Use of this dataset aligns the meteorological observations with the emissions estimates to optimize representation of the resulting concentrations. We prepared all input data for the CAL3QHCR model with the MPRM (version 99349) preprocessor. Similarly, we prepared all data for the AERMOD calculations with the AERMET (version 06341) preprocessor.

3.2 Health Risk Results

Table 3-2 shows the resulting annual average Diesel PM concentration at each of the 25 sensitive receptors. Figure 3-2 shows the spatial distribution of annual average Diesel PM in the BHP region. Figure 3-3 shows the corresponding distribution of excess cancer risks per million.

The values shown as "Trucks" in Table 3-2 represent the aggregate contribution from moving and idling heavy-duty diesel vehicles, both on and off the network. The values shown as "Rail" represent aggregate activity at both the switch yard and rail line. Other categories are as labeled.

Potential excess cancer risks were estimated using standard risk assessment procedures based on the annual average concentration of Diesel PM in a method similar to that used in the BTIP analysis and also in ARB's HRA for the San Pedro Bay Ports. Here, model predicted annual-average concentrations were converted to risk values, making use of the California unit risk factor (cancer potency factor) for Diesel PM, 3×10^{-4} $(\mu g/m3)^{-1}$. This means a risk level of 300 per million per microgram of suspended diesel particulate matter per cubic meter of air, to correlate cancer risk to the inhaled concentration of Diesel PM. Effectively, this estimate represents the excess risk of contracting cancer from breathing Diesel PM pollution at the given level continuously for 70 years.

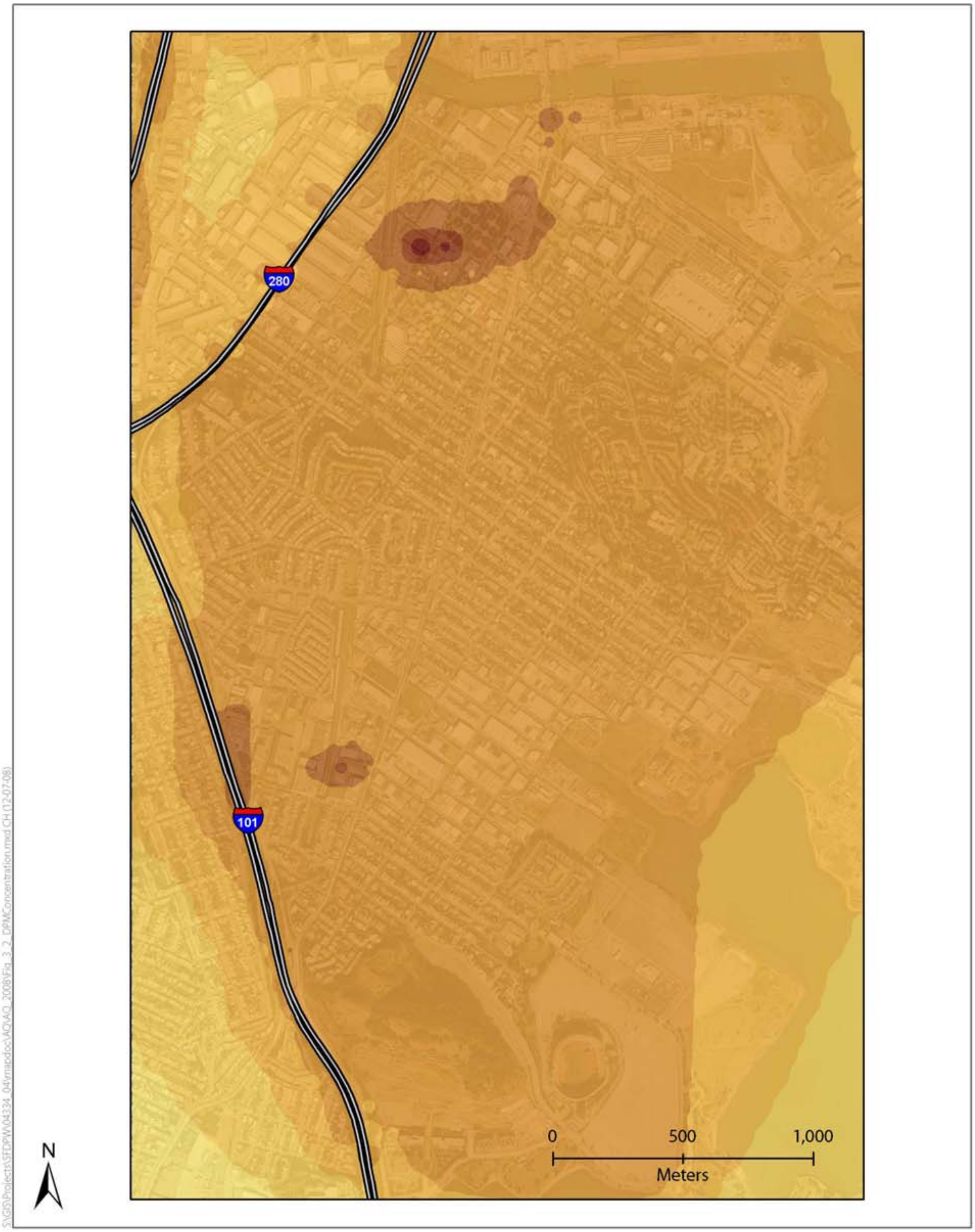
Cancer risks can be estimated by multiplying:

- the annual average Diesel PM concentration in $\mu g/m^3$,
- the unit risk factor for Diesel PM, and
- lifetime exposure adjustment.[24]

In this case, cancer risk is the probability of an individual contract cancer as a result of inhalation of a Diesel PM continuously over a period pf 70 years. The inhalation unit risk factor for diesel particulate was established by ARB as 300 in one million per continuous exposure of 1 μg/m3 of Diesel PM over a 70-year period, where a 70-year lifetime exposure is assumed for all receptor locations to most conservatively estimate public health impacts. Further, as was done in the BTIP and ARB HRA, a lifetime exposure adjustment factor of 1.0 was employed throughout the analysis to represent continuous exposure to the calculated Diesel PM concentrations .[25]

Table 3-2. Annual Average Diesel PM Concentrations and Predicted Excess Cancer Risks at Sensitive Receptors, 2007

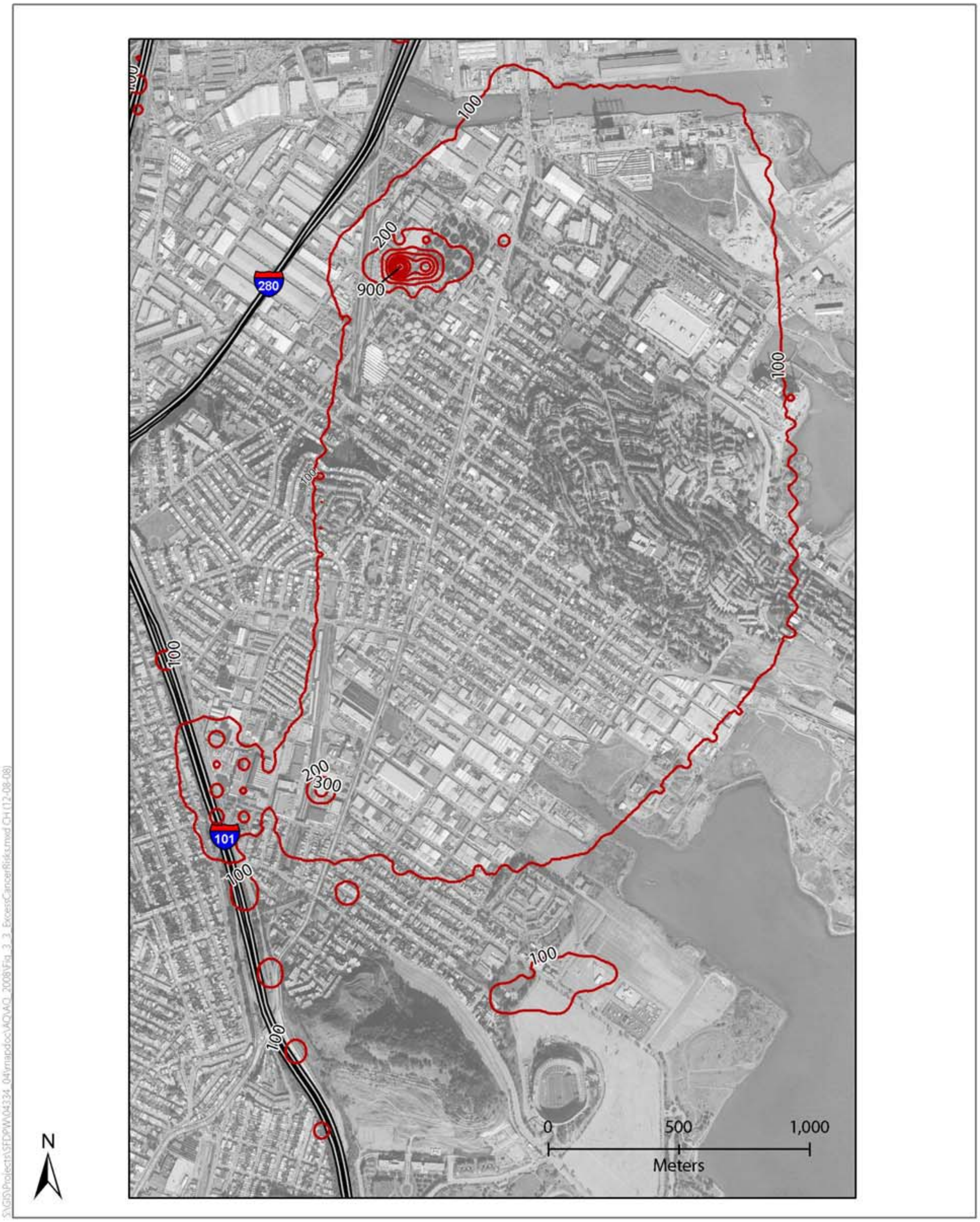
Name	Annual Average Diesel PM Concentrations (Micrograms per Cubic Meter)						Excess Cancer Risk per Million
	Trucks	Construction	Muni	Rail	Generators	Total	
Bret Harte	0.036	0.275	0.002	0.002	0.002	0.317	95
George Washington Carver	0.028	0.321	0.003	0.009	0.003	0.363	109
Dr. Charles R. Drew	0.031	0.291	0.002	0.028	0.003	0.355	106
Malcolm X Academy	0.027	0.329	0.003	0.006	0.003	0.368	110
Twenty-First Century	0.033	0.237	0.002	0.005	0.003	0.280	84
St. Paul of the Shipwreck Acad.	0.053	0.216	0.002	0.002	0.002	0.275	82
Gloria R. Davis	0.027	0.328	0.003	0.006	0.003	0.367	110
Thurgood Marshall	0.035	0.199	0.002	0.003	0.002	0.241	72
S.R. Martin College Preparatory	0.132	0.054	0.000	0.003	0.002	0.190	57
Lucy Harber Academy	0.040	0.291	0.002	0.035	0.005	0.372	112
Head Start	0.033	0.284	0.002	0.045	0.006	0.370	111
San Francisco Head Start	0.027	0.329	0.003	0.006	0.005	0.370	111
M'Eadd Preparatory Day Care	0.029	0.256	0.002	0.008	0.003	0.298	89
Ideal Daycare	0.031	0.317	0.003	0.011	0.004	0.365	110
Karen's Family Day Care	0.031	0.309	0.002	0.012	0.013	0.367	110
Tiny Tot's Family Day Care	0.030	0.313	0.002	0.011	0.003	0.360	108
Angel Childcare for Infants	0.035	0.303	0.002	0.013	0.035	0.388	116
Tweas Child Care	0.030	0.255	0.002	0.007	0.003	0.298	89
Cahead Brighter Future	0.030	0.318	0.003	0.009	0.024	0.383	115
C W's Child Care Service	0.027	0.329	0.003	0.006	0.005	0.369	111
Victoria's Family Daycare	0.028	0.321	0.003	0.006	0.004	0.362	109
Little Folks Daycare	0.028	0.321	0.003	0.006	0.004	0.362	109
Mama's GG Daycare	0.025	0.319	0.003	0.005	0.003	0.354	106
Girls 2000	0.016	0.191	0.002	0.004	0.003	0.215	65
Frandelja Enrichment	0.044	0.278	0.002	0.001	0.002	0.328	98



DPM Concentration

- > 2
- 1-2
- 0.5 - 1
- 0.2 - 0.5
- 0.1 - 0.2
- 0.05 - 0.1
- 0.025 - 0.05
- < 0.025

Figure 3-2
Diesel PM Concentration
(Micrograms per Cubic Meter)



Contour Interval = 100 per Million

Figure 3-3
Excess Cancer Risks from Diesel PM Concentration, per Million

ICF Jones & Stokes
an ICF International Company

The highest modeled average annual Diesel PM concentration in the study area is 3.1 $\mu g/m^3$, while the median across the entire study area is 0.29 $\mu g/m^3$. The average Diesel PM concentration and standard deviation are 0.27 ± 0.15 $\mu g/m^3$. Essentially all grid receptors in the study area (99.8%) show annual average concentrations of locally generated Diesel PM of less than 1.0 $\mu g/m^3$.

The corresponding excess cancer risk values predicted within the study area from local sources range from about 8 to about 920, with an area-wide average and standard deviation of about 82 ± 46 per million. About 63 percent of the area has excess risk values less than 100 per million.

For comparison, the South Coast Air Quality Management District has concluded that the cancer risk in the Los Angeles metro area from Diesel PM inhalation is approximately 1,000 excess cancers per million people. Specifically, the results of the MATES III study throughout the Los Angeles region showed areas near the ports to have about 1,100 to 3,700 excess cancers per million from all pollutants. Near the Central Los Angeles area, the risk was about 1,400 to 1,900 per million, and the basin-wide excess risk was 1,194 per million. Approximately 84% of this cancer risk is due to Diesel PM.[26] The ARB recently completed a risk evaluation for the West Oakland Community that showed excess cancer risks of 190 per million due to emission sources at the Port of Oakland, 40 per million due to UP Rail Yard emission sources, and 950 per million due to other sources in and around West Oakland, or a total excess cancer risk of about 1,180 per million in the community.[27]

It is noteworthy that cancer risks, shown by Figure 3-3 tend to exhibit hotspots around the principal sources. This is not a surprising result, indicating that the concentrations from local sources are dominated by a few major sources, generating selected, localized hotspots of Diesel PM concentrations and resulting risk. While truck emissions are concentrated linearly along heavy corridors such as Highway 101 and Interstate 280, these linear hot spots do not appear in Figure 3-3. Since linear transportation emissions are dominated by peak hot spots caused by generators, they do not form a significant feature in Figure 3-3. The highest excess cancer risk from this analysis is seen in the area approximately bounded by 3rd Street, Oakdale Ave., the I-280, and Evans Ave. This seems to be driven by an aggregation of sources in that area, including the rail line, several diesel backup generators, and a major intersection.

While this section describes estimates of the cancer risk associated with diesel PM, it is worthwhile to note that trucks, locomotives, construction equipment, and generators emit pollutants other than diesel PM that can cause adverse health impacts. For example, diesel engines are a major source of nitrogen oxide (NOx) emissions, which reacts in the atmosphere to form ground-level ozone (smog). Ground-level ozone can cause asthma and respiratory illness. Diesel engines also emit other toxic air contaminants, such as benzene and acrolein, which have both carcinogenic and non-carcinogenic effects. The impact of these other pollutants is beyond the scope of this report.

4 Mitigation Strategies

This section presents opportunities to mitigate the adverse impacts of diesel pollution in the BHP neighborhood. Section 4.1 reviews a large number of mitigation strategy options, discussing their pros and cons. It concludes with a summary matrix. Section 4.2 provides a brief overview of the current and future regulations on diesel emission sources, which have a bearing on the recommendations for City action. Section 4.3 presents our recommendations for mitigation strategies to be pursued by the City.

4.1 Overview of Mitigation Strategy Options

A variety of strategies can reduce the emissions of Diesel PM in the BHP neighborhood as well as the exposure of BHP residents to these emissions. These strategies can be grouped into three broad categories:

- Technological strategies targeting engines, exhaust, and fuels
- Operational strategies targeting vehicle operation, traffic patterns, and driver behavior
- Land-use strategies targeting building design and facility siting.

The strategies described vary widely in terms of their effectiveness and cost. Where possible, we discuss the cost and qualitative and quantitative benefits associated with each mitigation measure.

4.1.1 Technological Mitigation Strategies

Technical mitigation options include those that:

- Make changes to the design of the engine itself
- Install an “after-market” device which does not affect the way that the engine operates, but instead cleans up the exhaust after it has left the engine
- Use a non-standard alternative diesel fuel or other alternative fuel which produces less PM emissions and burns more cleanly.

These approaches to emissions reductions are not mutually exclusive. In fact, some after-treatment technologies work better with alternative diesel fuels. Each fuel and technology option has a different cost, and some may pose significant implementation challenges on particular engines or vehicles where space is a premium.

Equipment Replacement (Accelerated Turnover)

Replacing older trucks and non-road equipment with newer, cleaner diesel trucks and non-road equipment can significantly reduce emissions. This strategy can work well when it is directed at a specific truck population that tends to be older than average.

Replacing an older truck with a model year 2007 or newer truck will reduce PM emissions by at least 85%. There are also emissions benefits of replacing an older truck or non-road equipment with a used but newer truck or non-road. For instance, replacing a model year 1993 or older engine with a model year 1994-2006 heavy-duty engine can reduce PM emissions significantly, since the PM standards are lower (from 0.25 g/b-hp-hr for pre-1991 engines to 0.1 g/b-hp-h for 1994-2006 engines). Likewise, replacing older construction equipment for newer construction equipment can have significant PM emissions reductions.

The cost of purchasing new equipment is significant. A new heavy-duty truck can cost $80,000 or more. Large off-road construction equipment can be even more expensive. The cost of accelerated vehicle retirement depends on the remaining life of the existing equipment and the equipment resale value. All else being equal, equipment that meets more stringent emissions standards is often slightly more expensive than comparable equipment without advanced emission controls. For example, there is some evidence that model year 2007 and newer trucks cost slightly more than 2006 engines due to the pollution control devices that are required. Some school bus fleets ordered more 2006 buses so that they would not have to pay the $5,000 to $7,000 incremental cost of a 2007 bus.

Replacement with Hybrid Technology

Hybrid vehicles contain a secondary energy source (usually batteries or hydraulic accumulators) in addition to the primary engine, and electronic control systems to allow both energy sources to power the vehicle in varying combinations depending on operating conditions. Diesel-electric and diesel-hydraulic single unit trucks for specific applications (e.g., for urban pick-up and delivery) have entered commercial production; hybrid combination trucks are expected to be available by 2010.

Hybrid trucks are most suitable for duty cycles that involve stop-and-go traffic, frequent idling, and stationary operation, and thus are good candidates for replacing older diesel trucks in applications such as port drayage, refuse collection, and local urban delivery. The purchase cost of new hybrid trucks is considerably higher than that of new conventional trucks, although the reduced fuel usage of hybrids offsets some of the higher cost over time. The cost of a new medium-heavy duty diesel hybrid truck is approximately $100,000. Because the technology is relatively new, reliable data on the emissions reductions obtainable with in-use truck fleets are scarce. Available information suggests that PM emissions could be reduced by 30%, in proportion to the fuel use reduction.[28] [29]

Diesel Engine Repowering

By replacing an older existing diesel engine with a newer, cleaner diesel engine, significant NOx and PM emission reductions can be obtained at lower cost than replacing the entire truck or piece of construction equipment. Repowering is generally feasible for pre-1994 engines, though case-by-case evaluation is necessary due to physical and cost constraints. Repowering a pre-1994 truck with a 2004-2006 model year engine, where feasible, could reduce NOx emissions by 50% or more and PM emissions by 60% or more. However, repowering pre-2007 trucks with 2007+ engines is not feasible unless it is combined with a retrofit because 2007+ engine technology will include exhaust after-treatment which may require substantial modifications to the truck chassis.[30]

The cost of engine repowering ranges from $20,000 to $40,000 for on-road trucks, depending on the size and model year of the engine. The burden of upgrading trucks can be lessened through monetary incentives and grant programs from ARB and EPA. For older trucks, engine repowering can be more cost-effective than truck replacement in reducing emissions. There must be proof of disposal of the older engine to ensure that it is not resold into the California market for used engines.

Exhaust Treatment Devices

Exhaust treatment devices often can be retrofitted to existing trucks with only minor modifications to the exhaust system. The exhaust technologies summarized below are currently available in the marketplace and have been proven effective in truck fleets.

- **Diesel Oxidation Catalyst** – A diesel oxidation catalyst (DOC) retrofit system consists of either an in-line engine muffler replacement or an add-on control device. A DOC is a considered a Level One Technology by ARB because it is verified by ARB to eliminate greater than 25% but less than 50% of the particulate matter emissions. DOCs have been implemented in off-road (construction) engines for more than 20 years, with over 250,000 engine retrofits, most notably in the underground mining industry, and are on over 1.5 million heavy duty highway trucks in the U.S since 1994.[31] DOC catalysts include platinum or other precious metals and will vary with engine size, application, and sales volume. For mobile sources, the cost can range from $1,000-$4,000. For construction equipment, DOCs can be significantly more expensive. ARB has reported costs ranging from $2,100 for a 275 horsepower engine, to as much as $20,000 for a 1,400 hp engine.[32]

- **Flow-Through Filters** – Flow-through filter (FTF) technology is a relatively new method of reducing diesel PM emissions. FTFs are considered Level 2 ARB verified technology that eliminates greater than 50% but less than 85% of the particulate matter emissions. FTFs trap more PM emissions than a regular DOC. They may enable diesel retrofit clean-up for applications that may be unsuitable for traditional particulate filters, which can become blocked when used on equipment with a stop-and-go duty cycle and low exhaust temperatures. So far, there have been limited commercial use of the flow-through filters but there is an increasing interest in this technology due to its ability to significantly reduce PM emissions from older, “dirtier” diesel engines. Estimates in cost vary between $6,000 and $8,000.

- **Diesel Particulate Filter** – Diesel particulate filters (DPFs) are termed passive or active, depending on the method used to regenerate, or oxidize the captured particulate matter. DPFs are considered Level 3 technology because it is verified by ARB to eliminate more than 85% of the particulate matter emissions. Worldwide, more than 200,000 DPFs have been installed as retrofits and more than 1 million DPF-equipped cars have been sold in Europe. DPFs have also been used successfully on a variety of off-road engines since the mid-1980s. DPFs are required in all new on-road 2007 and newer diesel vehicles. In general, DPFs are much more expensive than DOCs and FTFs. For on-road mobile sources, the price ranges from $6,000-$15,000, and units require 4 -12 hours for installation. Prices may vary significantly with the cost of platinum and other precious metals.

Alternative Fuels

A variety of alternative fuels can reduce truck emissions. Alternative forms of diesel fuel, such as biodiesel or oxygenated diesel, can be used by most diesel trucks without modification to the engine. Other alternative fuels include natural gas, propane, and new hybrid-electric technologies. Liquid natural gas, compressed natural gas, and propane technologies are proven and commercially available.

- **Biodiesel** – Biodiesel is a renewable fuel made of vegetable oils, animal fats, and recycled cooking oils. B20, composed of 20% biodiesel and 80% regular diesel, is currently the most common biodiesel blend because it is comparable to conventional diesel fuel in terms of performance and cost, and does not require engine modifications. B20 is also the minimum blend level allowed for Energy Policy Act of 1992 (EPAct) compliance.[33] Use of B20 will reduce PM emissions by approximately 10% compared to conventional diesel; B100 (100% biodiesel) reduces PM by 45%. Higher blend levels such as B50 or B100 require special handling and may require equipment modifications such as the use of heaters (in colder climates) or changing seals and gaskets that come in contact with the fuel. A B100 blend also reduces fuel efficiency by approximately 10%.[34] Biodiesel can slightly increase NOx emissions. The cost of biodiesel is currently comparable to conventional diesel, due in part to a federal excise tax credit.

- **Oxygenated Diesel** – Oxygenated diesel is a blend of diesel fuel with a small amount of an alcohol (up to 10%), either ethanol or methanol, and proprietary hydrocarbon additives that keep the alcohol from separating out of the diesel. In a diesel engine, the alcohol provides increased combustion oxygen similar to biodiesel, with similar results. Ethanol is lower in reactivity and higher in oxygen content, making it preferred over methanol, which could also be used. Oxygenated diesel fuel provides similar PM reductions as biodiesel. However, both methanol and ethanol are more volatile than diesel fuel, and can produce explosive vapors in the event of a fuel spill or as a result of fuel tank heating. This hazard is similar to the hazard posed by gasoline, and it is much greater in a confined space. As with biodiesel, NOx emissions may slightly increase, prompting the need for additional additives such as fuel-borne catalyst. Currently, oxygenated diesel is not widely available.

- **Fuel-Borne Catalysts** – Metal-based powdered catalysts can be added to diesel in very low concentrations to promote more complete combustion, reducing emissions of both NOx and PM. Various companies sell proprietary catalyst packages, which may include small amounts of platinum, cerium, other precious metals, or iron compounds. As noted above, some biodiesel blends contain a fuel borne catalyst to reduce NOx emissions. Strategies to implement catalyst formulations are most effective when the chemical is added by bulk fuel by the supplier at the fuel terminal, rather than by the operator directly to the fuel tank on individual pieces of equipment. In general it is better to purchase the additives in bulk fuel, as it is easier to control and monitor dosage. The cost of fuel-borne catalysts is uncertain at this time. Given the low quantities necessary, the cost per gallon is expected to be relatively low, and of the same order of magnitude as other alternative diesel fuel options.

- **Compressed Natural Gas** – Compressed Natural Gas (CNG) can only be run with new CNG engines. In general, CNG can reduce PM emissions by 70-90 percent if catalyst technology is also used (which reduces the ultra fine PM, formaldehyde, and methane). If an oxidation catalyst is not used, methane and formaldehyde emissions will be much higher than diesel engines. CNG can also reduce NOx emissions by approximately 60%, although sometimes increases in NOx emissions can occur. This strategy is costly to implement, since it requires the purchase of new CNG trucks or non-road construction equipment as well as new refueling infrastructure and maintenance facilities. Further, these vehicles require a specialized CNG refueling infrastructure. A new CNG bus can cost up to $30,000 more than a conventional diesel bus. The cost of the CNG fuel is similar to the cost of diesel fuel.

Electrification

Vehicle electrification programs can reduce PM emissions by replacing diesel engines with electric motors in certain applications. This strategy requires significant infrastructure investments, typically utilizing an overhead catenary or a third rail contact. Caltrain locomotives and MUNI buses are the best candidates for electrification projects, given past investment and technology upgrades. Several MUNI bus lines currently operate with electrified overhead lines. MUNI has plans to expand the number of electrified lines as part of a program to eliminate diesel emissions by year 2020. Caltrain has explored similar projects to electrify the rail corridor, but little progress has been made.

Electric buses and locomotives are non-polluting, and can contribute to air quality improvement goals in the locations where they are used. Once the electrification infrastructure is in place, operating and maintenance costs may be reduced significantly. Depending on the energy source, electric power may be cheaper than diesel, and electric motors generally need less maintenance and are more reliable than the diesel equivalent.

4.1.2 Operational Mitigation Strategies

This section describes operational strategies to reduce diesel emissions. Some strategies such as equipment idling reduction and control, engine preventative maintenance, and equipment operator training are options that reduce diesel emissions while also achieving significant reductions in operating costs and effect on-road and non-road sources. Other operational strategies, such as congestion mitigation and traffic rerouting, are focused on on-road engines and work to reduce diesel emissions in certain locations.

Equipment Idle Reduction and Control

Unnecessary idling occurs when trucks or buses wait for extended periods of time to load or unload, or when equipment is left running when not being used. California has strict five-minute idling laws for on-road diesel trucks that have a gross vehicle weight of 10,000 lbs or more (see Section 4.2). However, there is limited enforcement of this rule. Unlike on-road vehicles, there is no state limit on idling for non-road engines. Idling reduction also apply Transportation Refrigeration Units (TRUs), which are used to cool truck trailers and shipping containers with perishable goods. Distribution centers can be installed with electrical hook-ups to allow TRUs to shut down when trucks are parked.

Managing equipment operations and training workers to reduce unnecessary idling is a relatively easy way to lower operating costs and help reduce the environmental impact of construction and trucking operations. For an on-road truck, eliminating one hour of idling reduces PM emissions by two grams and NOx emissions by 136 grams. For off-road equipment, emissions benefits vary by equipment type. For a typical backhoe loader, reducing a single hour of unnecessary idling would reduce PM emissions by 13 grams and NOx emissions by 155 grams.[35]

Preventative Maintenance

A preventative maintenance program seeks to maintain engines at their original level of performance and eliminate the high cost of catastrophic engine failure. Proper maintenance can also significantly reduce fuel consumption and emissions. Basic maintenance, such has changing the oil and oil filter at proper intervals, can improve fuel economy by two to three percent.[36]

There are significant emissions impacts from improperly maintained diesel engines. An EPA study of on-road heavy diesel engines shows improperly maintained equipment can cause increases in CO, NOx, and PM emissions. A general conclusion is that higher emissions and oil consumption typically translate to lower efficiency and increased fuel consumption.

All equipment owners can implement the basic elements of a preventative maintenance program. Contractors have reported cutting the need for engine rebuilds in half following improvements in the management of preventive maintenance. Many companies have initiated good preventative maintenance programs at very low costs since the only administrative cost for these simple programs is labor time to track maintenance requirements.

Congestion Reduction

Vehicle emissions in congested corridors tend to be higher, since acceleration and deceleration tend to generate higher emissions than traffic at constant speeds. Planning agencies can influence the movement of trucks within some areas of the region at certain times, changing the travel speeds for both trucks and other traffic and improving traffic flow. Congestion-related emissions can also be reduced by better managing non-recurring incidents that disrupt traffic flow. This can involve clearing vehicle crashes more quickly, planning for special events, and scheduling and organizing road work at off-peak times.

Historically, congestion reduction programs have involved restricting truck movements during peak hours, designating specific loading zones, delivery schedules, and truck routes, as well as multiple business delivery consolidation. Some strategies are also voluntary, and are designed to create incentives for trucks to use roadways during off-peak time periods. While the costs of congestion reduction are unclear, incident management programs in particular have been found to be a relatively cost-effective means to reduce congestion and associated emissions.

Traffic Routing

Rerouting traffic away from sensitive sites can reduce PM exposure to sensitive individuals, even if it does not reduce emissions overall. Sensitive sites are where sensitive individuals are most likely to spend time, including schools and schoolyards, parks and playgrounds, day care centers, nursing homes, hospitals, and residential communities.

Alternate routes can be provided for truck operations that discourage detours into residential neighborhoods. In addition, signs can be posted which can direct truck traffic away from specific hot spots or sensitive locations such as schools. The cost of this strategy is generally low if it involves only signage. Costs can be higher if implementation depends on outreach and enforcement.

4.1.3 Building and Land Use-Based Mitigation Strategies

In addition to the mitigation measures that are implemented at the source of the emissions, there are several building and land use strategies that can reduce PM exposure.

Filtration Systems

One strategy involves installing filtration systems for residential and commercial buildings, which can provide fresh air filtration to mitigate PM exposure. Heating, ventilation, and air conditioning (HVAC) systems can be equipped with high efficiency filters for particulates and a carbon filter can remove other chemical matter. Ventilation systems can thus protect sensitive users from both on-road and off-road diesel emissions.

Filtration systems can remove 80% of fine particulate matter, mitigating all expected additional roadway effects of particulates. Collateral benefits include improved public health through a reduction in allergen loads. Regular maintenance for the HVAC and filtration systems should be planned to ensure that PM emissions can be removed from the building.[37]

Siting of Sensitive-Receptor Facilities

Land-use strategies can be used to minimize the siting of new facilities near sources of high diesel emissions. ARB's *Air Quality and Land Use Handbook* makes the following recommendations regarding siting new sensitive land uses near sources of Diesel PM emissions.[38]

Land Use Source of Air Pollution	Air Resources Board Recommendations
Freeways and High Volume Roadways	• Avoid siting sensitive land uses within 500 feet of a freeway, urban roads with 100,000 vehicles/day, or rural roads with 50,000 vehicles/day.
Distribution Centers	• Avoid siting sensitive land uses within 1,000 feet of a distribution center (that accommodates more than 100 trucks per day, more than 40 trucks with operating TRUs per day, or where TRU operations exceed 300 hours per week). • Take into account the configuration of existing distribution centers and avoid locating residences and other sensitive land uses near entry and exit points.
Rail Yards	• Avoid siting sensitive land uses within 1,000 feet of a major service and maintenance rail yard. • Within one mile of a rail yard, consider possible siting limitations and mitigation approaches.
Ports	• Consider limitations on the siting of sensitive land uses immediately downwind of ports in the most heavily impacted zones. • Consult with local air districts for the latest available data on health risks associated with port emissions.

Reducing PM exposure is only one consideration in determining the appropriate land-use; there is a need to balance other considerations, including housing and transportation needs, economic development priorities, and other quality of life issues.

4.1.4 Summary Table

Table 4-1 provides a summary and comparison of diesel mitigation options for Bayview Hunters Point. Mitigation options are compared across the following categories:

- Benefits: What are the program's direct and indirect air quality benefits?
- Cost: What are the costs to implement the strategy?
- Cost-Effectiveness: What is the cost per ton of Diesel PM reduction?[39]
- Control: Besides the City's own equipment, how can the City initiate and carry out this strategy among private fleets?
- Monitoring: How easily can the program's benefits be tracked or measured?

Table 4-1: Summary of Mitigation Strategies

Strategy	Benefits	Cost	Cost Effectiveness	Control	Monitoring
Equipment Replacement	Up to 85% less Diesel PM. More effective with older trucks.	$40,000-$80,000 for replacement truck. Borne by operators. State / federal grants available.	$100,000 per ton	City can educate & assist local businesses in applying for state / federal grants.	Easily tracked; one-time transaction.
Hybrid Technology	Reduces fuel use and emissions by 30%, compared to conventional	Currently 50% more than new diesel truck.	$400,000 per ton	City can provide incentive with green promotion programs e.g., SF Green Business Certification	Requires registration of hybrid fleet.
Engine Repowering	Reduces PM by 60% or more.	$20,000-$40,000 per engine.	$65,000 per ton	City can educate & assist local businesses in applying for state / federal grants.	Easily tracked; one-time transaction.
Diesel Oxidation Catalyst (DOC)	Reduces PM by 25%-50% (ARB Level 1).	$1,000-$4,000 for trucks, up to $20,000 for const. equipment.	$18,000 per ton	City can educate local businesses about technology benefits and availability.	Easily tracked through ARB certification and purchase records.
Flow-Through Filter (FTF)	More effective than DOC. Reduces PM by 50%-85% (ARB Level 2).	More expensive than DOC. $6,000-$8,000 for trucks.	$20,000 per ton	City can educate local businesses about technology benefits and availability.	Easily tracked through ARB certification and purchase records.
Diesel Particulate Filter (DPF)	Eliminates more than 85% of PM (ARB Level 3).	On-road vehicles: $6,000-$15,000. Requires annual maintenance.	$22,000 per ton	City can educate local businesses about technology benefits and availability.	Easily tracked through ARB certification and purchase records.
Biodiesel	B20 reduces PM 10%-15%. Can slightly increase NOx.	Retail price equivalent to diesel, due to federal biodiesel tax credit.	No incremental cost to consumer	City biofuels commission can work with suppliers to build B20 stations within SF.	Easily tracked through monitoring alternative fuel distribution points.
Oxygenated Diesel	Similar benefits as biodiesel	Retail price similar to biodiesel, but fuel availability an issue. Requires infrastructure upgrades for pumping stations.	No incremental cost to consumer (assuming fueling infrastructure in place)	City can work with suppliers to make alternative fuels available & assist local businesses in applying for grants.	Easily tracked through monitoring alternative fuel distribution points.
Natural Gas (CNG)	Reduce PM up to 90% with proper filtering technology.	New CNG trucks costs 50% more than conventional. Also significant infrastructure costs.	$400,000 per ton	Education. Fueling stations are large projects and difficult to influence.	Easily tracked through monitoring alternative fuel distribution points.

Strategy	Benefits	Cost	Cost Effectiveness	Control	Monitoring
Electrification	Reduce PM 100% by eliminating diesel. Only appropriate for locomotives / MUNI	Caltrain: $11 million per mile. Muni: Significant infrastructure costs.	> $1 million per ton	MUNI has full control over electrification of its fleet.	MUNI has full monitoring capabilities & annual reporting obligations.
Idle Reduction	Reduced emissions commensurate with fuel savings.	Net benefit to businesses – save money by using less fuel.	Net cost savings	City outreach to businesses about benefits, enforcement of existing code.	Very difficult to track comprehensively. Spot-inspections are more effective.
Preventative Maintenance	Reduced fuel consumption and emissions, improved equipment life.	Net benefit to businesses – prevents excessive engine wear.	Net cost savings	City can educate and encourage businesses to develop maintenance programs.	Very difficult to monitor. Reliant on business participation.
Congestion Reduction	Mitigating congestion reduces fuel use and emissions from traffic delays.	Redesigning street network: high capital costs. Incident mgmt: relatively low cost	Varies widely	City (MTA) has control over layout and design of street network.	Congestion monitored annually by MTA / Caltrans.
Traffic Routing	No net emission reduction. Can reduce exposure at sensitive receptors.	Depends on implementation approach: from new signage to new infrastructure.	N/A	City (MTA) has control over layout and design of street network.	Truck volume monitored by MTA / Caltrans. Exposure at sensitive receptors requires separate study.
Filtration Systems	Captures up to 80% of ambient PM.	Moderate costs to building owners. ($2,600 per unit installation, $75/yr operation).	N/A	City can implement regulations as building codes.	May be monitored through Dept Building Inspection.
Facility Siting	Reduced PM exposure at sensitive-receptor sites.	Varies significantly. Add'l cost for new facility may be relatively small.	N/A	City can influence location of sites via zoning and permitting process.	Easily tracked due to small number of facilities and slow rate of change.

4.2 Regulatory Environment

New local, state, and federal regulations are driving changes in the way diesel vehicles and construction equipment are manufactured, maintained, and operated. These regulations have implications for what the City can do to further reduce diesel emissions. Before presenting strategy recommendations, this section briefly reviews current and upcoming regulations.

4.2.1 Key Federal Regulations

On-Road Vehicles. The U.S. Environmental Protection Agency (EPA) sets emissions standards for new on-road heavy-duty vehicles and off-road equipment. For on-road trucks and buses, stringent new PM standards took effect beginning in 2007. Under these standards (which apply only to new vehicles), the allowable level of PM emissions from trucks is ten times lower than for pre-2007 trucks (see Appendix). All manufacturers are using diesel particulate filter technology to achieve this level of reduction.

Off-Road Equipment. EPA has set similar standards for off-road equipment (including generators and construction equipment), but they take effect later. For new construction equipment, Tier 2 and 3 standards are already in effect. The most stringent emission standards (Tier 4) for non-road engines will be phased in primarily from 2008 through 2013 (see Appendix). These standards are analogous in stringency to the 2007 emissions standards for on-road trucks. Similar to the on-road regulations, the emissions regulations on construction equipment apply only to new equipment, which means that without incentives or programs to address existing equipment, the full effect of new regulations will not be felt for many years.

Locomotives. For locomotives, EPA adopted new emission standards March 2008. The standards include retrofits of existing equipment as well as new engine emission standards (Tier 3 and Tier 4). The Tier 4 standards are analogous to the 2007 heavy-duty truck standards and will result in large reductions in PM emission rates – more than 90% lower than uncontrolled locomotives (see Appendix). The Tier 4 standards take effect beginning in 2015. They will very likely require use of exhaust after-treatment devices for the first time on locomotives. Existing engines will be subject to retrofit at the time they are rebuilt.

4.2.2 Key State Regulations

In-Use Truck and Bus Rule. On December 12, 2008, ARB approved a statewide in-use truck and bus rule, the most far-reaching diesel emission regulation in the state's history. Unlike EPA standards, the ARB rule applies to existing vehicles already on the road. The rule targets most in-use trucks in the state over 14,000 lb gross vehicle weight rating (GVWR). For fleets with four or more vehicles, the regulations require the installation of exhaust retrofits in 2010 and 2011 and accelerated engine or vehicle replacement from 2012 to 2022. The regulation also adds compliance flexibility by allowing fleets to choose among three compliance options that best suit their situation. In all cases, fleets can comply by purchasing used vehicles. School buses are required only to add exhaust retrofits, and generally are not be required to replace engines. Fleets with one to three vehicles are exempt from the 2010 and 2011 retrofit requirements. By December 31, 2012, small fleets need to show they have one 2004 model year engine (or newer) with an exhaust retrofit. By 2017 the vehicle needs to be replaced with one meeting the 2010 EPA emissions standards. Any other vehicles in a small fleet need to be upgraded between 2013 and 2023.[40]

In-Use Off-Road Diesel Rule. In 2007, ARB approved the In-Use Off-Road Diesel Vehicle Regulation to reduce emissions from existing off-road vehicles, including construction equipment, forklifts, and airport ground equipment. The regulation establishes annual emission standards which become increasingly stringent over time. Fleet owners, including public agencies, private businesses, and individuals, must maintain or upgrade their existing equipment to maintain compliance with the annual emission targets. If an organization is unable to meet the annual targets, it must upgrade or replace its equipment to bring the fleet closer to compliance. The regulation takes effect earliest for the largest fleets, those with over 5,000 horsepower of affected vehicles. For these large fleets, the first fleet average compliance dates are in 2010. For medium fleets, those with 2,501 to 5,000 hp, the first fleet average compliance dates are in 2013. The requirements are delayed until 2015 for fleets of 2,500 hp or less.

Truck Idling Regulations. Diesel trucks with a gross vehicle weight of 10,000 lbs or more are prohibited from idling for more than five (5) minutes within California's borders. While sleeper trucks were originally exempted, since January 2008, the in-use truck requirements require operators of both in-state and out-of-state registered sleeper berth equipped trucks to manually shut down their engine when idling more than five minutes at any location within California. In addition, ARB's 2005 regulatory measures require 2008 and newer model year heavy-duty diesel engines to be equipped with a non-programmable engine shutdown system that automatically shuts down the engine after five minutes of idling or optionally meet a stringent NOx idling emission standard. In addition, the regulations require that diesel-fueled auxiliary power systems (APS) and fuel-fired heaters installed on trucks must meet emission standards.[41]

Off-Road Equipment Idling Regulations. ARB's In-Use Off-Road Diesel Vehicle Regulation also includes limits on equipment idling. Under the regulation, as of June 15, 2008, diesel equipment cannot idle for longer than five (5) consecutive minutes. The limit does not apply in certain situations, such as when queuing, idling to verify that the vehicle is in safe operating condition, idling for testing, servicing, repairing or diagnostic purposes, or idling necessary to accomplish work for which the vehicle was designed (such as operating a crane). In addition, as of March 1, 2009, medium and large fleets must also have a written idling policy that is made available to operators of the vehicles and informs them that idling is limited to 5 consecutive minutes or less.

Diesel Generator Requirements. ARB has developed several airborne toxic control measures (ATCMs) to reduce diesel emissions, including standards and requirements that apply to stationary diesel generators. By January 1, 2009, in-use diesel generator engines over 50 horsepower must meet diesel PM limits that vary depending on the number of hours used per year (see Appendix). The standards do not apply if the engine is used less than 20 hours per year.

4.2.3 Key City of San Francisco Ordinances and Policies

Clean Construction Ordinance

The City's Clean Construction Ordinance No. 70-07, passed on March 27, 2007, affects non-road construction equipment at publicly funded construction sites. City-contracted projects subject to the emissions control requirements include:

- "Major construction projects" – those that take 20 or more cumulative work days to complete
- Projects using "high use" vehicles or construction equipment (25 HP ore more), meaning equipment used for 20 hours or more during any portion of the project.

Beginning in March 2009, all work required to be performed under a major public works contract must:

(1) utilize only off-road equipment and off-road engines fueled by biodiesel fuel grade B20 or higher, and

(2) utilize only high use equipment that either (a) meets or exceed Tier 2 standards for off-road engines or (b) operates with the most effective verified diesel emission control strategy.[42]

Port Construction Equipment Requirements

The San Francisco Port Commission, Resolution No. 07-22, adopted on March 13, 2007, laid out some specific exhaust controls which pertained to construction equipment related to all Port activities in the city. It requires that "construction equipment which have an engine rating of 100 horsepower (hp) or more, shall meet, at a minimum, the Tier 2 California Emission Standards for Off-road Compression ignition Engines as specified in California Code of Regulations, Title 13, section 2423(b)(1). In the event a Tier 2 engine is not available for any off-road engine larger than 100 hp, that engine shall be equipped with a Tier 1 engine. In the event a Tier 1 engine is not available for any offroad engine larger than 100 hp, that engine shall be equipped with a catalyzed diesel particulate filter (soot filter), unless certified by engine manufacturers that the use of such devices is not practical for specific engine types."[43]

Executive Directive 06-02: Biodiesel for Municipal Fleets

In 2006, the City committed to introducing biofuels into all municipal fleets. The intent of this ordinance was to speed the adoption of alternative fuels in San Francisco, reducing City emissions and petrochemical consumption. Starting in 2007, all 1,600 of the city's diesel vehicles including ambulances and street sweepers have been retrofit to run on a blend of B20 biodiesel fuel.[44] Since then, the City has expanded its biofuels programs with the Biofuel Access Task Force. The goal of this body is to increase the availability and use of biodiesel within the city, by educating local residents and businesses as well as encouraging the installation of biodiesel filling stations.

Building Filtration Regulation

In November 2008, the City authorized regulations to require air filtration systems for residential developments exposed to high Diesel PM emission levels. These regulations require that developers assess air quality at a construction site, and install ventilation systems when concentration levels exceed city standards.

The regulations apply to new construction projects of large residential complexes, and depend on the site location. The requirements are active for any construction site adjacent to or near freeways and major arterial streets. Developers can meet these standards using several methods, including adding filtration systems to ventilation sources of outdoor air, recirculating and filtering indoor air, drawing ventilation from a location away from the emission source, and locating units set back from the roadway.

An analysis of the proposed regulation shows that while the filtration requirements add construction costs for developers, the overall economic impact is positive. Filtration units are estimated to cost $2,600 per unit at the time of construction, but reduce health care costs by an estimated $2,100 annually.[45]

4.3 Recommendations for Action

Given the health impacts caused by diesel pollution in BHP, the menu of potential mitigation strategies, and the current and upcoming regulations and programs affecting diesel emissions, where should the City focus its efforts to reduce diesel health impacts in BHP? This section presents recommendations for City action. The goal of these recommendations is to achieve the greatest reduction in Diesel PM health impacts using methods that are feasible and effective.

This study suggests that the greatest opportunity for air quality and public health benefits lies in mitigating the emissions from construction equipment, which accounted for 70% of total Diesel PM emissions in the area in 2007. Truck and bus emissions accounted for an additional 23% of total emissions and represent another opportunity for improving air quality and public health. The remaining 7% are due to locomotives and generators combined. Thus, our recommendations focus primarily on mitigation recommendations for construction equipment and trucks, as well as land use strategies that reduce exposure to all Diesel PM emissions.

Some of these recommendations have been partially implemented in the past. For example, community groups in BHP have taken a leadership role in the Pacific Institute's "Ditching Dirty Diesel Anti-Idling Day of Action", informing local truckers and businesses about the need to reduce idling. Additional initiatives like this will provide further benefits to BHP residents.

4.3.1 Recommendations for Construction Equipment Mitigation

Construction emissions of Diesel PM result from the use of diesel-powered equipment in construction projects. The magnitude of emissions is large due to several factors related to equipment design and operation. First, the engines in machinery can be as large as 500 horsepower for a tractor or loader, resulting in greater fuel consumption and emissions. Further, construction equipment has historically been less regulated than trucks or buses in terms of emissions standards. Finally, construction machinery spends much time idling when not in use. Successful mitigation strategies will target these factors to reduce emissions.

San Francisco's Clean Construction Ordinance will help to reduce Diesel PM emissions from major public construction projects, beginning in March 2009. Moreover, ARB's in-use off-road diesel rule will take effect for large fleets beginning in 2010. Medium fleets are not covered by ARB's rule until 2013, and small fleets until 2015. Thus, the focus should be on reducing emissions from private construction projects that employ medium and small equipment fleets.

Recommendation 1: Certify and promote clean construction fleets

The City's Clean Construction Ordinance is encouraging contractors to upgrade their fleets in order to qualify for City contracts. The City does not have legal authority to place similar requirements on private construction projects. However, this ordinance could be complemented by a voluntary program that certifies businesses as "clean construction contractors" and promote certified businesses within San Francisco. The program could be similar to the City's Green Business Program, and would also seek to educate fleet owners on steps to reduce emissions. This program would lower construction emissions in BHP as well as citywide.

Since this recommendation consists of an expanded or new city outreach program, initial progress on this item can be measured by the extent of the program's implementation. First steps involve assembling stakeholders within the City and in local industries, determining the program's scope, and identifying funding opportunities. Once the Clean Construction Program has been implemented, success can be measured by the number of contractors that have been certified. By tracking each contractor's equipment fleet, the City can determine the amount of emissions reduction.

Recommendation 2: Educate local businesses about ARB's in-use off-road rule

ARB's in-use off-road diesel rule will have a dramatic effect on construction fleet emissions when it takes effect. Large fleets are affected first and are generally best equipped to comply. The City can assist in implementing these regulations through outreach to local construction businesses, particularly smaller businesses. These regulations will require fleet owners to (1) meet annual emission targets, (2) retire older equipment and retrofit emission control devices, and (3) register fleet equipment and emissions calculations with ARB. A successful outreach program educates local businesses on regulation requirements and assists in annual reporting requirements. Currently, ARB is conducting training sessions throughout California to educate fleet owners on the newly implemented regulation. The rules allow for credit for "early action," which may be attractive to some businesses and would speed arrival of air quality benefits to the City. The City could also help to promote compliance with the off-road idling limits, by educating fleet owners and possibly reporting violators.

If this recommendation were implemented, the City would collaborate with ARB to speed up the implementation of construction equipment regulations within BHP. The City can use ARB data to determine how quickly the BHP construction equipment is "greened". In addition, the City can measure the success of outreach efforts. A successful outreach can be measured by the number of participants in community meetings, or the number of returns from a mail-in survey. Finally, the City can measure progress by how quickly the city's construction fleet is cleaned up.

Recommendation 3: Assist local business in applying for available grants and loans

Both ARB and EPA provide grant and loan programs to assist businesses in complying with state and federal regulations on off-road equipment. ARB's Pilot Off-Road Loan Incentives program provides guarantees to assist businesses in securing loans to upgrade or replace construction equipment. While this program does not provide grants, it assists businesses with marginal credit secure loans for which they would otherwise not qualify.

Additional assistance is provided by ARB through the Carl Moyer program, which offers grants to upgrade on-road and off-road engines. In order to qualify for the grant, businesses must demonstrate the emissions benefits that would be achieved through the grant. Similarly, EPA's Smartway Clean Diesel Finance Program provides grants for the retrofit and replacement of construction equipment. In addition, local grants from the Bay Area Air Quality Management District (BAAQMD) provide millions of dollars each year for reductions in diesel emissions.

These programs place large application and reporting burdens on businesses in order to qualify for financing. These requirements can discourage participation. There is an opportunity for a San Francisco program to assist local businesses in identifying and pursuing grants and loans. Such assistance would speed adoption of ARB and EPA regulations within San Francisco. A program targeted at BHP construction businesses would be most effective in reducing Diesel PM emissions within the community.

This outreach recommendation is designed to connect local businesses with state and federal funds. The process will involve assisting local contractors with grant applications. A successful program can be measured by how many applications are submitted, or how many grants are awarded. In addition, in order to address environmental justice concerns, the City can track the participation of businesses from disadvantaged areas.

4.3.2 Recommendations for Truck Mitigation

Mitigating emissions of Diesel PM from trucks within BHP can be difficult, in part because trucks operating in the area may be coming from outside the City, outside the Bay Area, or even outside the State. Moreover, the roadway system falls under multiple jurisdictions. The City has more control and influence over arterial streets and local roads than over freeways, which are operated and maintained by

Caltrans. Similarly, the City may be more effective in working with trucking businesses located within San Francisco rather than businesses based in other municipalities which may be operating in the city. However, the City can still effectively mitigate truck emissions through several approaches.

Truck emissions can be mitigated using similar methods as with construction emissions. As such, many of these recommendations rely on the same resources as in the prior section. These recommendations can be implemented in conjunction with or independent of construction mitigations.

Recommendation 4: Education and enforcement of ARB idling regulations

ARB regulations limit truck and bus idling to five minutes. Enforcement of this regulation requires participation by local police departments as well as California Highway Patrol, both of which can issue citations to truckers who violate the idling restrictions. The City can assist in reducing idling emissions by increasing SFPD enforcement of existing regulations. While participation by the department may be limited due to budget constraints, a periodic enforcement campaign can be effective in raising awareness of the regulations within the San Francisco business community. The mitigation measure can have greater impact within BHP through targeted enforcement measures within the community.

This recommendation requires outreach to local businesses, which should consist of (1) surveys about truck idling and (2) education on idling regulations. A successful outreach can be measured by the number of participants in community meetings, or the number of returns from a mail-in survey. Additionally, the City can monitor how many trucks are given citations for idling within BHP. However, this measure can be misleading, as a high number of citations may indicate excessive idling or a successful enforcement program.

Recommendation 5: Educate local businesses about ARB's new in-use truck rule

In December 2008, ARB approved a statewide in-use truck and bus rule, the most far-reaching diesel emission regulation in the state's history. The rule applies to existing vehicles already on the road. For fleets with four or more vehicles, the regulation require the installation of exhaust retrofits in 2010 and 2011 and accelerated engine or vehicle replacement from 2012 to 2022. The new policy places additional reporting burdens on owners of truck fleets. The City can maximize and accelerate the air quality benefits of this rule by educating local businesses on how to achieve compliance and assisting fleet owners with annual reporting requirements. Since residents of BHP are exposed to a high level of emissions from trucks, this mitigation measure would disproportionately benefit the community relative to other neighborhoods.

If this recommendation were implemented, the City would collaborate with ARB to speed up the implementation of truck regulations within BHP. The City can use ARB data to determine how quickly the BHP construction equipment is "greened". In addition, the City can measure the success of outreach efforts. A successful outreach can be measured by the number of participants in community meetings, or the number of returns from a mail-in survey. Finally, the City can measure progress by how quickly the city's construction fleet is cleaned up.

Recommendation 6: Assist local business in applying for available grants and loans

Most of the grant and loan programs described above for construction equipment also provide funding for the retrofit or replacement of trucks and buses. These programs from ARB, EPA, and BAAQMD assist truck owners in complying with state and federal regulations. As with off-road funding initiatives, these programs require application and reporting documentation in order to qualify. The City can increase the rate of participation among local businesses by helping companies identify and pursue grants and loans. Such assistance would speed adoption of ARB and EPA regulations within San Francisco. A program targeted at BHP construction businesses would be most effective in reducing Diesel PM emissions within the community.

This outreach recommendation is designed to connect local truckers with state and federal funds. The process will involve assisting local contractors with grant applications. A successful program can be measured by how many applications are submitted, or how many grants are awarded. In addition, in order to address Environmental Justice concerns, the City can track the participation of truckers from disadvantaged areas.

4.3.3 Other Recommendations

The recommendations in prior sections focus on improving the fleet of construction equipment and trucks operating in BHP. The City can also pursue several other mitigation strategies that reduce air quality impacts in BHP.

Recommendation 7: Research and target controls at City-owned generators

Diesel generators account for only 4% of Diesel PM emissions in BHP. However, the health risk assessment described in Section 3 suggests that the highest Diesel PM concentrations in BHP occur in close proximity to the largest cluster of generators – the area around the City's Central Shops (at 1800 Jerrold Avenue) and the City's neighboring southeast wastewater treatment plant (at 750 Phelps Street). As described in Section 2, we were not able to obtain operating activity for individual generators; therefore, emissions estimates for these sources depend on our assumptions about hours of use and load factors. As a first step, the City should conduct additional research into generator activity at these two facilities, and others if possible.

As described above, new ARB rules regarding stationary generators take effect beginning January 1, 2009 (see appendix for details). These rules may contribute to generator emission reductions at the City facilities. The City should also investigate additional emission control strategies for its generators. This could include biodiesel (expanding the City's municipal fleet program to cover stationary generators) and/or exhaust retrofits (e.g., diesel particulate filters).

The city can implement the two parts of this recommendation can be implemented independently, and track progress on each part separately. First, the City can track the actual usage of each generator, to better measure Diesel PM in each "hot spot". Progress can be measured by how many of the city's generators are reported each year. Second, the City can track how many generators are upgraded to new standards. A successful program would upgrade all generators and track annual usage.

Recommendation 8: Increase the availability of biofuels within BHP

In 2005, the City enacted a policy that required municipal diesel vehicles to use B20 blend biodiesel. In 2007, this policy was implemented across the entire fleet of City vehicles. As a result, the supply and distribution of biodiesel within San Francisco has grown to meet city demand. This activity was aided through the Biodiesel Access Task Force, which has educated businesses on biodiesel benefits and assisted in the development of biodiesel stations. The City can increase adoption of biofuels among BHP businesses by encouraging the development of biodiesel stations and facilities within the community.

Further education and outreach to neighborhood trucking and construction companies will inform fleet owners of the benefits to biodiesel. This recommendation can be adopted quickly using the existing resources of the Biodiesel Access Task Force.

A successful biodiesel program will replace a large portion of diesel consumption with biodiesel. While it is difficult to track how much biodiesel is used by vehicles within San Francisco boundaries, it is simpler to measure how much biodiesel is sold within the city. Two metrics can be applied: the number of biodiesel stations or pumps within the city, and the quantity of fuel sold. A successful program will increase biodiesel sales and provide residents with many places to purchase the fuel.

Recommendation 9: Retrofit existing facilities with building filtration technologies

The City has recently adopted a policy to require building filtration technologies in new residential units located in areas with high PM concentration. These ventilation systems reduce residential exposure to emissions. However, this regulation will have little immediate impact because it only applies to new construction projects. Instead, its benefits will not be fully realized until a large portion of the City's housing has been rebuilt. The City could speed up the adoption of building filtration systems by applying the requirement to existing buildings undergoing renovation. By adding this regulation to the City's permitting process, the Department of Building Inspection can mandate its installation when construction permits are issued. The City could also extend application of this requirement to selected non-residential facilities, such as schools and day care centers.

Progress in this measure can be measured by how many buildings are built or retrofitted with filtration systems. As this program requires several policy actions, there are several milestones to successful implementation. First, the City must draft regulations to encourage or require existing buildings near pollution sources to be retrofitted with filtration systems. Second, the City should undertake a survey to determine how many dwelling units can benefit from filtration, and which units are located in disadvantaged areas. Once these steps are complete, the City can measure progress by how many of the identified dwelling units have been outfitted with filtration systems.

Appendix

Table A-1: EPA PM Emission Standards for On-Road Heavy-Duty Engines (g/bhp-hr)

Model Year	Heavy Duty Engines	Urban Bus Engines
1991	0.25	0.10
1994	0.10	0.07
1998	0.10	0.05
2004	0.10	0.05
2007	0.01	0.01

Table A-2: EPA PM Emission Standards for Locomotive Engines (g/hp-hr)

Emission Standard	Applicable Year	Line Haul Engines	Switching Engines
Uncontrolled Emissions		0.32	0.44
Tier 0 rebuild	2001	0.60	0.72
Tier 0 rebuild [a]	2008 / 2010	0.22	0.26
Tier 1	2002 – 2004	0.45	0.54
Tier 1 rebuild [a]	2008 / 2010	0.22	0.26
Tier 2	2005	0.20	0.24
Tier 2 rebuild [a]	2008 / 2013	0.10	0.13
Tier 3	2011 – 2012	0.10	0.10
Tier 4	2015	0.03	0.03

Note a: These are retrofit standards at the time of rebuild and phased in as retrofit kit availability allows.
Source: *Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters Per Cylinder*. EPA420-R-08-001. March 2008.

Table A-3: EPA PM Emission Standards for Non-Road Diesel Equipment (g/bhp-hr)

Engine Power	Tier	Starting Model Year	Standard
hp < 11	1	2000	0.75
	2	2005	0.60
11 ≤ hp < 25	1	2000	0.60
	2	2005	0.60
hp < 25	4	2008	0.30
25 ≤ hp < 50	1	1999	0.60
	2	2004	0.45
25 ≤ hp < 75	4	2013	0.02
50 ≤ hp < 100	2	2004	0.30
	3	2008	0.30
100 ≤ hp < 175	2	2003	0.22
	3	2007	0.22
75 ≤ hp < 175	4	2012	0.01
175 ≤ hp < 300	2	2003	0.15
	3	2006	0.15
300 ≤ hp < 600	2	2001	0.15
	3	2006	0.15
600 ≤ hp < 750	2	2002	0.15
	3	2006	0.15
175 ≤ hp < 750	4	2011	0.01
hp > 750	2	2006	0.15
	4	2011	0.075
	4	2015 (all gensets)	0.02
	4	2015 (all others)	0.03

Table A-4: ARB PM Emissions Standards for Stationary Diesel Engines > 50 HP (Installed and permitted on or after January 1, 2005)

	Emergency/Standby**	**Prime**
New Engines: >50 HP* (Installed and permitted on or after January 1, 2005)	The more stringent of: • Diesel PM limit of < 0.15 g/bhp-hr, or • Off-Road Engine Certification Standard for an off-road • engine of the same horsepower rating; and • < 50 hours per year for non-emergency operation. OR • The more stringent of • Diesel PM limit of < 0.01 g/bhp-hr, or • Off-Road Engine Certification Standard for an off-road engine of the same HP rating; and • 51 to 100 hours per year for non-emergency operation (upon District approval)	The more stringent of: • Diesel PM limit of < 0.01 g/bhp-hr; or • Off-Road Engine Certification Standard for an off-road engine of the same horsepower rating
In-Use Stationary Diesel Engines > 50 HP (Installed or permitted prior to January 1, 2005)	• Emergency use: not limited by ATCM • Non-emergency use: – < 20 hours/year: Not limited by the ATCM; – 21 to 30 hours/year: Diesel PM limit of < 0.40 g/bhp-hr; – 31 to 50 hours/year: District approval and Diesel PM limit of < 0.15 g/bhp-hr; – 51 to 100 hours/year: District approval and Diesel PM limit of < 0.01 g/bhp-hr.	• Diesel PM limit of < 0.01 g/bhp-hr; or • Reduce Diesel PM emissions by 85%; or • Reduce Diesel PM emissions by 30% by January 1, 2006, and meet Diesel PM limit of 0.01 g/bhp-hr limit in 2011.

*New stationary diesel engines less than or equal to 50 horsepower must meet the current Off-Road Engine Certification Standard for an off-road engine of the same horsepower rating.
**By January 1, 2009 all generators must be in compliance for in-use emergency standby and prime engine PM standards.

References

[1] Jones & Stokes, 2006. Bayview Transportation Improvement Project. Sacramento, CA. February 2006.

[2] Because idling time due to congestion and at stop signs and traffic lights are accounted for in the emission factors, it does not need to be estimated separately.

[3] California Air Resources Board, "EMFAC Modeling Change Technical Memo," Hector Maldonado, August 20, 2002.

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