Recommended Methods for Screening and Modeling Local Risks and Hazards

Bay Area Air Quality Management District
939 Ellis Street
San Francisco, CA 94109

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BAY AREA AIR QUALITY MANAGEMENT DISTRICT

EXECUTIVE SUMMARY

The purpose of the "Recommended Methods for Screening and Modeling Local Risks and Hazards" (document) is to assist lead agencies in conducting a risk and hazard analysis as part of their CEQA environmental review for proposed land use projects. The Report provides detailed guidance on how to screen projects for potential risk and hazards impacts and, if necessary, how to conduct site-specific computer modeling.

This document compliments and helps implement the Bay Area Air Quality Management District's (BAAQMD or District) 2010 CEQA Guidelines (Guidelines) and thresholds of significance for particulate matter and toxic air contaminants (TACs). The thresholds were developed to encourage focused infill development in the region, reduce vehicle emissions, and protect public health by raising awareness regarding the effects of siting people near existing and/or new sources of toxic air containments. The Guidelines also outline a methodology for analyzing potential risk and hazard impacts to sensitive receptors from proposed land use developments. This document, used in conjunction with the Guidelines, provides greater detail on how to perform preliminary screening, and if needed, detailed computer modeling of potential risk and hazard impacts from a new source of toxic emissions on existing receptors, or from existing sources of toxic emissions to new receptors.

When applying the methods presented in this document, the user should first apply the recommended screening process to their proposed project to determine whether air quality modeling is necessary. The screening tools are described in Section 3.0. For new receptor projects, lead agencies should review the risks from nearby roadways, freeways, and stationary sources. This document describes in detail how to screen for potential risk and hazards from TAC sources using the following tools:

- **Surface Street Screening Tables:** Through the use of computer models, the District estimated particulate matter equal to or less than 2.5 microns in diameter ($PM_{2.5}$) concentration and cancer risk values for roadways based on annual average daily traffic (AADT) for each of the nine Bay Area counties. The county specific tables provide estimated $PM_{2.5}$ concentration and cancer risk by distance away from the roadway. The hazard index was found to be minimal for all surface streets and is therefore not included in the tables. Local planners can use these tables to determine if a project may be adversely impacted from local roadways and decide if further modeling is needed.

- **Freeway Screening Analysis Tool:** The District developed a Google Earth™ application that maps each State highway link in the Bay Area, where highway links are defined by Caltrans mileposts. For each link, District modeled $PM_{2.5}$ concentration, cancer risk, and hazard index, values at various distances from the edge of each side of the highway. This information is available at elevations of six feet and 20 feet to represent sensitive receptors on the first and second floors of buildings. Local planners can use this application to determine if a project may be adversely impacted from freeways and determine if further modeling is needed.

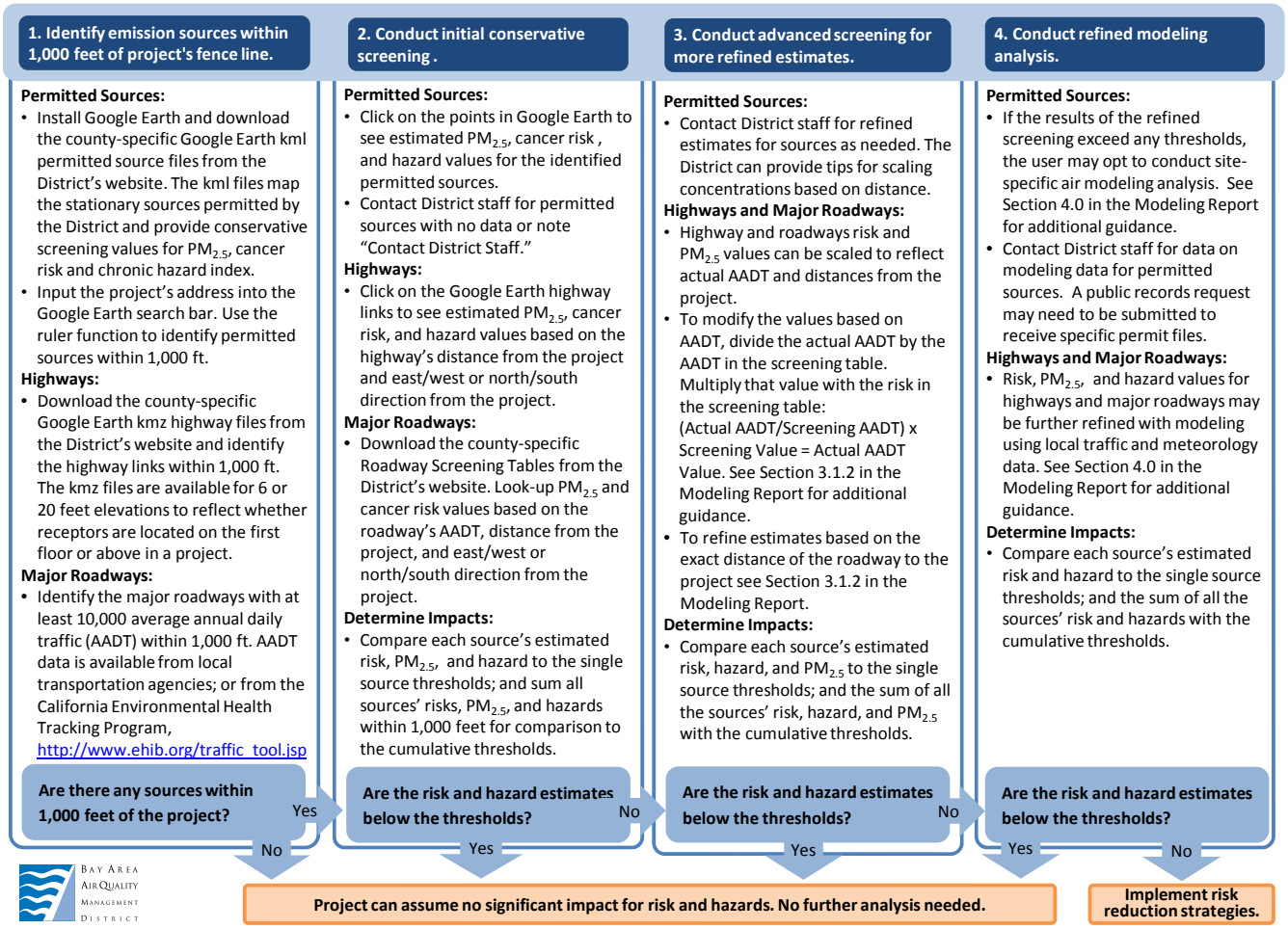
- **Stationary Source Risk and Hazard Screening Analysis Tool:** The District developed a Google Earth™ application that maps the locations of all the stationary sources in the region that the District permits, such as back-up generators, gas stations, dry cleaners, and auto body shops. For each source, the application lists the name of the source and conservative screening level cancer risk and $PM_{2.5}$ concentration values. Users can use this application to estimate the potential risks from stationary sources to particular project sites and determine if proposed projects may be adversely impacted and if further modeling is needed.

The assumptions and modeling parameters used for these screening tools are detailed in this Report in Section 3.0. These tools reflect the most current data available as of May 1, 2011. For a detailed step-by-step reference guide outlining the screening process, see Figure ES-1 below, the "BAAQMD Risk and Hazard Screening Analysis Process Flow Chart".

If after the screening process, a project is found to have potential risk and hazard impacts that exceed the District's recommended thresholds of significance, the user may choose to conduct site specific modeling for the proposed project. In this case, the user should apply the recommended modeling approach described in Section 4.0 of this document. The District provides a step-by-step approach to selecting the appropriate modeling tools, modeling parameters, and responding to project-specific conditions. These modeling guidelines are based on standard procedures developed by the California Office of Environmental Health Hazard Assessment (OEHHA) for toxicity values and age sensitivity, and are consistent with the most current risk assessment methodology and toxicity factors used in the District's Regulation 2, Rule 5: New Source Review of Toxic Air Contaminant. Users may deviate from the methods described in the document as found necessary, for example, to factor in the amount of time that receptors spend indoors verses out-of-doors, provided such deviations are justified with scientific documentation.

Figure ES-1: Risk and Hazard Screening Analysis Process Flow Chart

BAAQMD Risk and Hazard Screening Analysis Process Flow Chart:



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1.0 INTRODUCTION

This document is a companion document to the Bay Area Air Quality Management District's (BAAQMD; District) *California Environmental Quality Act (CEQA) Air Quality Guidelines* (BAAQMD 2010a) and to the *California Environmental Quality Act Thresholds of Significance* (BAAQMD 2010b). The purpose of this document is to provide a recommended methodology for assessing risks and hazards at a local, or community, scale from air pollutants emitted from common urban source types to nearby receptors. The methodology can be used to assess single-source impacts from either an individual new source or impacts on new receptors (such as new residents in a housing project) from existing sources of toxic emissions.

The methodology follows a tiered approach. The level of effort and requirements for more site specific information generally increases as the user progressively moves through each tier. Each tier provides concentrations and risks that are directly comparable to the applicable Thresholds of Significance, although it is important to note that the use of more site specific modeling input data produces more accurate results. Also, progression from one tier to the next in a sequential fashion is not necessary and a refined modeling analysis can be conducted at any time.

The following sections describe:

- **Screening Tables** provide an easy-to-use initial comparison to determine if nearby sources or roadways may have a significant impact to a receptor. The section describes how to use the screening tables to determine if a site specific modeling analysis and risk assessment are warranted. The section also identifies sources that are likely to have low emissions such that their health impacts are below the thresholds.

- **Refined Modeling Approach** describes the recommended methodology for performing dispersion modeling and estimating emission factors if the project exceeds the thresholds based on the screening analysis.

- **Cancer Risks** describes methodology for estimating the incremental lifetime cancer risk using age-sensitivity factors.

- **Chronic Hazard Health Impacts and Acute Hazard Health Impacts** describes the methodology for estimating short term one hour acute exposures and long term chronic noncancer health impacts.

The modeling methodology presented in this document are based on the California Air Pollution Control Officers Association (CAPCOA)'s Health Risk Assessments for Proposed Land Use Projects (July, 2009 – available through www.CAPCOA.org). While the District has relied heavily on the CAPCOA report for much of the detailed modeling methodology, they have been modified in certain instances as noted in each section to address specific Bay Area air quality modeling issues.

The Exposure Assessment components are based on the procedures developed by the California Office of Environmental Health Hazard Assessment (OEHHA). These calculation methodologies may change over time as OEHHA further refines its exposure guidelines. **It is important that the user apply the most current risk assessment methodology and toxicity factors from OEHHA's health risk assessment guidelines.**

1.1 Health Concerns

The focus of this guidance is to provide a methodology for evaluating local community risk and hazard impacts associated with toxic air contaminants (TACs) and particulate matters with diameters equal to or less than 2.5 microns ($PM_{2.5}$). TACs are a defined set of airborne pollutants that may pose a potential hazard to human health. Sources of TACs include industrial and mobile sources and similar to $PM_{2.5}$, can be emitted directly to the atmosphere or through reactions with different pollutants. This report presents methods for assessing the potential health impacts from direct $PM_{2.5}$ and TACs emissions, not those formed through secondary reactions in the atmosphere.

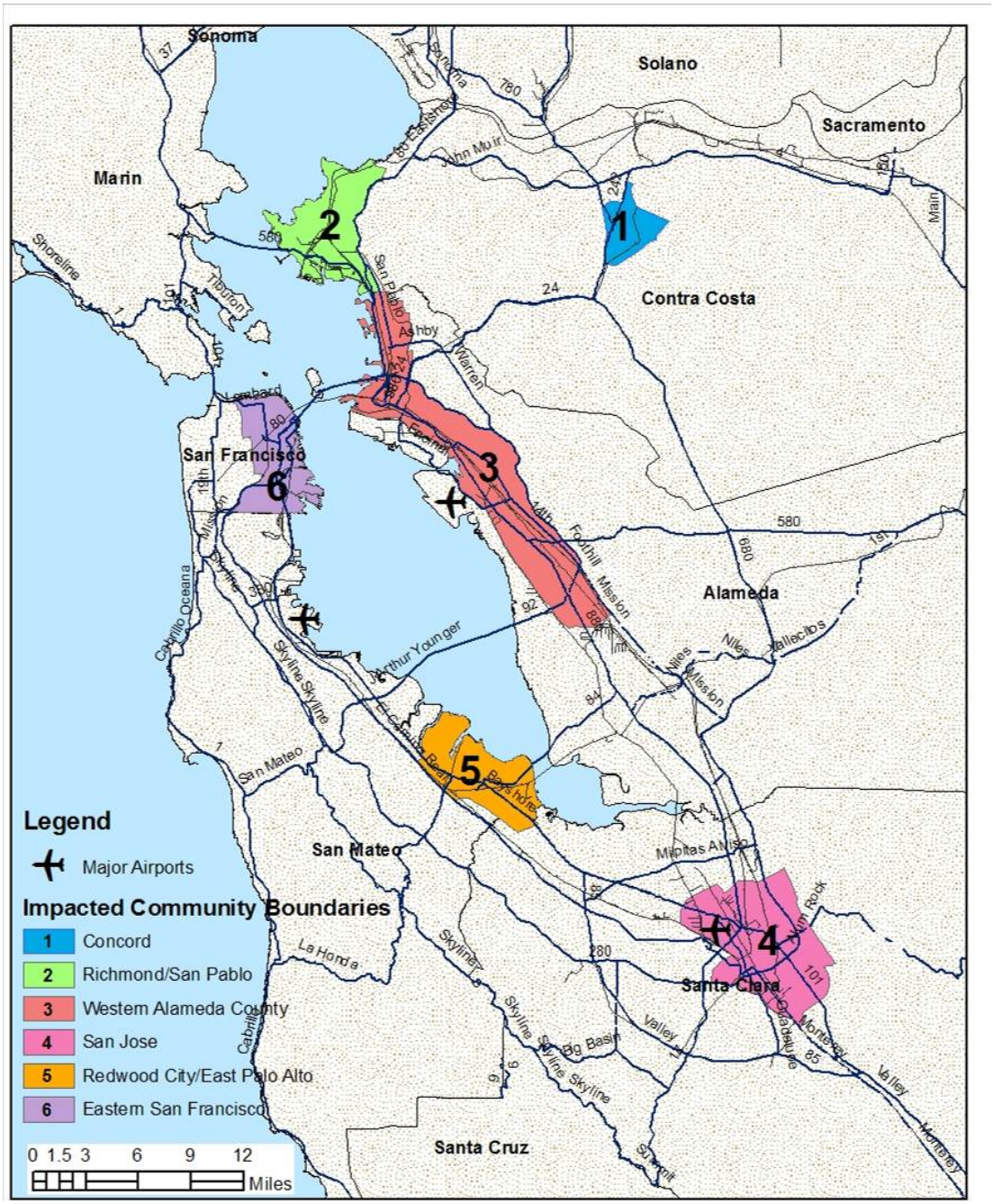
The potential health effects associated with TACs include both long term health impacts including cancer, birth defects, neurological damage, asthma, bronchitis or genetic damage and short term effects such as eye watering, persistent cough, running nose, throat pain, and headaches. Many scientific studies have linked fine particulate matter and traffic-related air pollution to respiratory illness and premature mortality. In the Bay Area, there are number of urban and industrialized communities where the exposure to TACs is relatively high in comparison to others. These same communities are often faced with other environmental and socio-economic hardships that further stress their residents and results in poor health outcomes. To address community risk from air toxics, the District initiated the Community Air Risk Evaluation (CARE) program in 2004 to identify locations with high levels of risks from TACs co-located with sensitive populations. Using year 2005 emission inventory combined with demographic and health statistics, the CARE program identified impacted communities based on a combination of high TAC concentrations, presence of significant sources, and proximity to low-income, sensitive populations. Figure 1 shows the impacted communities (December 2009), which include Western Alameda County, Concord, eastern San Francisco, Redwood City/East Palo Alto, Richmond/San Pablo, and San Jose.

The air quality conditions in the impacted communities are partially the result of past decisions related to land use and transportation planning. The District has developed this document to help identify and avoid land use conflicts by providing a methodology for assessing the potential health impacts to new residents from existing sources and from new sources on existing residents within a community. The objective is to ensure that future growth in a community is health protective and effective mitigations are implemented to reduce potential adverse impacts.

In addition to the guidance provided herein, local jurisdictions also have the option of developing Community Risk Reduction Plans (CRRPs) as a means of reducing the overall exposure to TAC and PM2.5 emissions and concentrations in an entire community from new and existing sources. The goal of a CRRP is to bring TAC and $PM_{2.5}$ concentrations for the entire community covered by the Plan down to acceptable levels as identified by the local jurisdiction and approved by the

Air District. This approach provides local agencies a proactive alternative to addressing communities with high levels of risk on a project-by-project approach. This proactive approach is encouraged for all communities, and especially those within a CARE impacted community.

Figure 1 – CARE Impacted Communities (December, 2009)



1.2 CEQA Thresholds

Under the CEQA guidance, the District developed thresholds of significance for air pollutants emitted from a new project and for cumulative exposures that includes emissions from a new project in combination with existing sources. The goal of the thresholds is to ensure that no source creates, or receptor endures, a significant adverse impact from any individual project, and that the total exposure from all nearby sources does not result in a significant adverse impact. If a project exceeds the identified significance thresholds, its emissions in concert with contributions from all nearby sources may result in significant adverse air quality impacts.

The thresholds for local risks and hazards from TAC and $PM_{2.5}$ are intended to apply to all sources of emissions, including both permitted stationary sources and on- and off-road mobile sources, such as sources related to construction, busy roadways, or freight movements. The thresholds of significance for TAC and $PM_{2.5}$ are listed in Table 1.

Table 1. Threshold of Significance for Local Community Risk and Hazard Impacts

Analysis	New Source	New Receptor
Individual Project	Compliance with qualified community risk reduction plan OR To the nearest receptor (resident) regardless of distance: Increased Cancer Risk > 10 in a million Increased Chronic and Acute Hazard Index > 1.0 Ambient $PM_{2.5}$ concentration increase > 0.3 ug/m^3	Compliance with qualified community risk reduction plan OR From the source with the highest cancer risk, $PM_{2.5}$ concentration, or hazard in comparison to other sources within the 1,000 foot radius of the receptor: Increased Cancer Risk > 10 in a million Increased Chronic and Acute Hazard Index > 1.0 Ambient $PM_{2.5}$ concentration increase > 0.3 ug/m^3
Cumulative Impacts	Compliance with qualified community risk reduction plan OR Common sources within 1,000 foot radius of the individual project modeled to the maximum likely exposed individual (resident) based on the individual source analysis: Cancer Risk > 100 in a million Chronic Hazard Index > 10.0 $PM_{2.5}$ concentration > 0.8 ug/m^3	Compliance with qualified community risk reduction plan OR Major sources within 1,000 foot radius of the receptor: Cancer Risk > 100 in a million Chronic Hazard Index > 10.0 $PM_{2.5}$ concentration > 0.8 ug/m^3

1.3 Overview Process

The District recommends a tiered approach where at each successive step, the project's $PM_{2.5}$ and TAC cancer risk and hazards are compared to the CEQA thresholds. A tiered approach addresses health impacts from two of the most common types of projects: (1) a new source of TAC or $PM_{2.5}$ is proposed for a community (see Figure 2) and (2) a new residential development is proposed that may be impacted from existing sources (see Figure 3).

Examples of new sources of TAC emissions include gasoline dispensing facilities (i.e., gasoline stations), dry cleaners, and autobody shops. Less obvious sources of TAC include diesel back-up generators that are housed in the basement of hospitals, governmental agencies, and fire stations, in case of power outages. Examples of projects that may be impacted from existing nearby TAC sources such as roadways, stationary sources, railyards, airports, and ports include residential developments, mixed use commercial-residential developments, commercial buildings, and daycare centers.

The flow charts (Figures 2 and 3) show how to proceed with the CEQA process to determine if a project is impacting or being impacted by sources of TAC. The initial step is to determine whether the project is categorically exempt from CEQA. For some cases, a project may not be exempt because the health risk may trigger an exception (CEQA §15300.2).

For projects that are not exempted and considered significant, the project site-specific characteristics and surrounding conditions are used to evaluate the potential cancer risk, hazard, and $PM_{2.5}$ concentrations posed by the project or to a new receptor. For these projects, the project sponsors must determine the project radius and identify significant sources and receptors within the project radius. The project sponsor can initially screen the project by comparing the screening values based on distances to the nearest major roadway and/or emissions from significant sources to the CEQA thresholds. The District provides screening tables for California designated highways and certain existing permitted, stationary sources as an initial screen to determine if nearby sources or roadways may have a significant impact on a project. The District is recommending that in additional to evaluating the individual impact from a single source, the project sponsor should also evaluate the cumulative impacts from all TAC and $PM_{2.5}$ sources. The cumulative impacts are the summation of the cancer risks, hazards, and $PM_{2.5}$ concentrations from all significant sources identified within 1,000 foot radius of the project.

If the screening values from the project exceed the single source or cumulative thresholds, the project sponsor can conduct more refined modeling analysis by incorporating additional site-specific information. Project sponsors can also implement all feasible measures to mitigate the potential health impacts. This document discusses several tiers of refined modeling analysis that may be performed with each successive tier requiring more site-specific information. For the first tier, a screening model is recommended that requires minimal site-specific data. More complex modeling analysis can be conducted based on the available source specific data.

Figure 2 – Tiered Approach for Estimating Community Risks and Hazards from New Sources

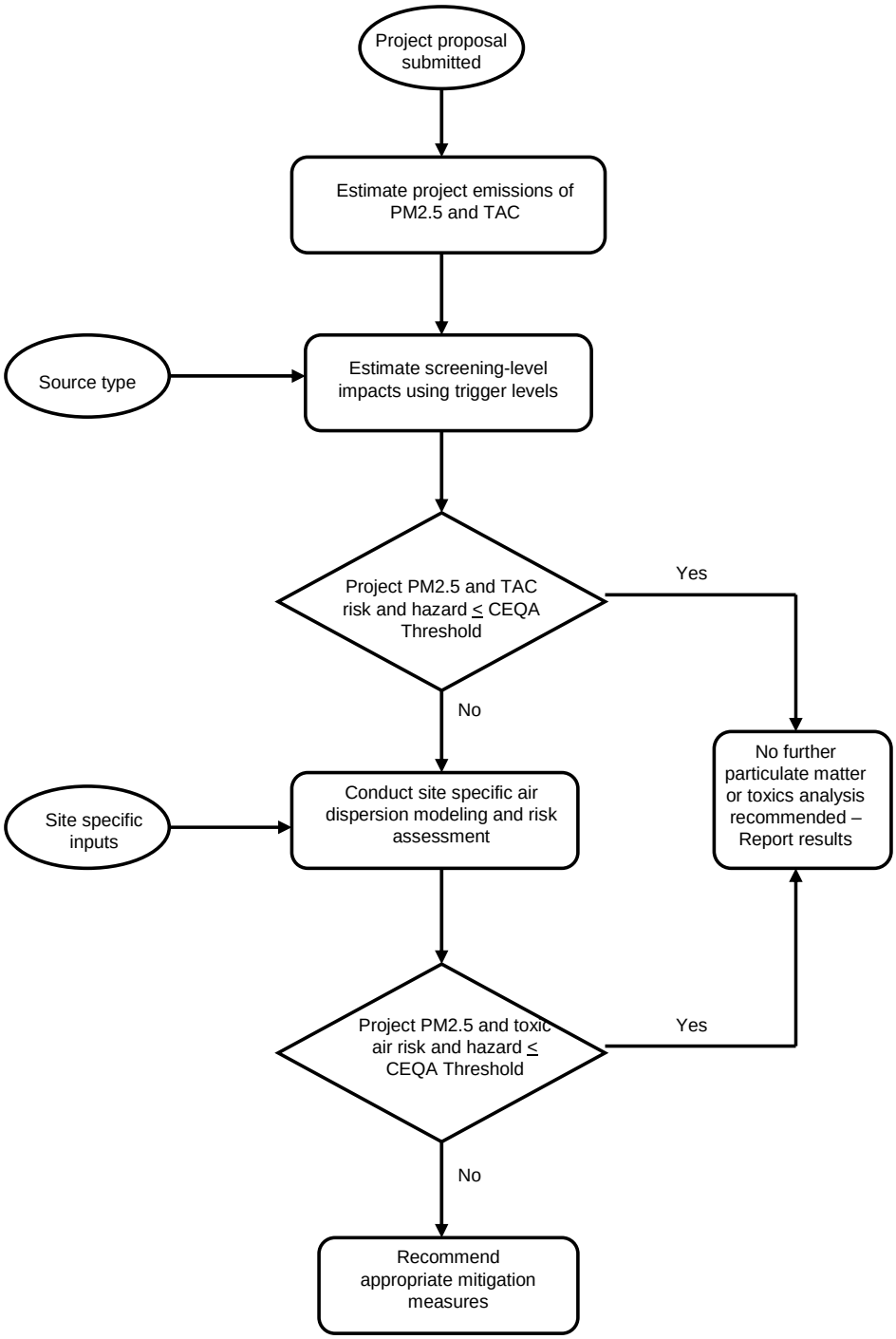
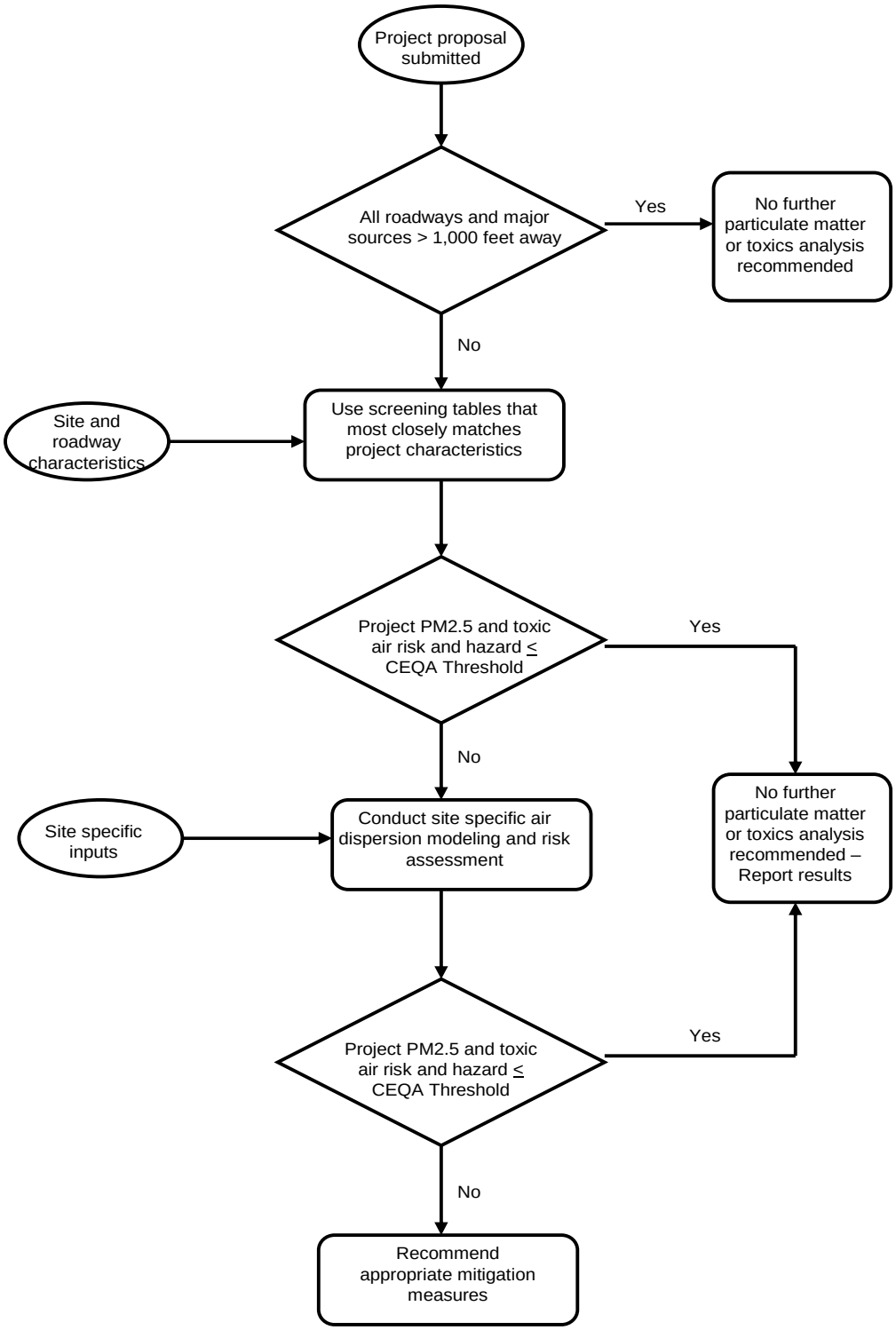


Figure 3 – Tiered Approach for Estimating Community Risks and Hazards from New Receptors



1.4 Starting Point

The most current documentation (including this document), datasets for screening and modeling, and District staff contact information are available on-line at http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES/Tools-and-Methodology.aspx. This URL serves as the starting point for all CEQA tools, methodology documentation, and data related to District recommended screening and modeling of local risks and hazards. For questions on data availability and screening and modeling methods, please contact the District's Planning, Rules, and Research Division at (415) 749-4995.

2.0 IDENTIFYING SOURCES, RECEPTORS, AND IMPACT AREA

The screening methods for local risks and hazards recommended in this document rely upon several key definitions to identify the pollution sources and the receptors of potential concern and to establish the area where potential impacts are evaluated.

- What emissions sources should be analyzed?
- What receptors should be considered?
- How should cumulative impacts of toxic air contaminants and particulate matter be determined and over what area?

This section provides some key definitions and recommended methods for making these preliminary determinations.

2.1 Identifying Sources

For the purposes of this methodology document, the District defines three types of sources:

- *Common sources* whose emissions of TACs or $PM_{2.5}$ are significant enough to warrant consideration when siting new receptors or when determining cumulative impacts but simple enough as to lend themselves to simplified risk screening tools;

- *Complex sources* whose emissions may pose significant risks but that are complex, or otherwise unique in nature, such that they do not lend themselves to simplified screening tools or even modeling analysis that can be easily generalized; and

- *Minor, low-impact sources* that are unlikely to pose a significant risk.

Each of these three types is defined in this section. Focus is given to the common sources because they generally pose the greatest risks in the Bay Area. Complex sources are important to consider if the proposed project is sited nearby; but they will require specific and specialized analysis. A detailed methodology for assessing risk from complex sources is beyond the scope of this document. Minor, low-impact sources can be neglected from risk and hazard assessments for new projects.

2.1.1 Common Sources

Common sources may be significant sources of local risk and hazards from TAC or $PM_{2.5}$ and, for the purposes of this document are defined to include the following:

- Freeways and major roadways;
- Gas stations;
- Stationary diesel engines, such as stand-by back up generators;
- Dry cleaners;
- Crematories;
- Spray-booths;
- Construction projects; and
- Railroad tracks for trains with diesel engines.

Risk screening tables or risk screening tools are provided for some of these common sources. This risk may expand as screening tools are developed in the future.

2.1.2 Complex Sources

The District regulates and permits stationary sources of air pollution and administers incentive funds to reduce pollution from mobile sources. The mobile sources are not directly regulated or permitted by the District; however, they may contribute a significant portion of the emissions attributed to non-permitted facilities. Quantification of emissions from these types of sources is complex and requires comprehensive knowledge on the sources of emissions (i.e., trucks, locomotives, construction equipment, airplanes, etc.), number of sources, and the types of pollutants emitted. In addition, District has permitted several single facilities that have numerous permits such as in the case of oil refineries which make TAC and $PM_{2.5}$ quantification difficult. Examples of complex sources that generate significant pollution include:

- Major ports, including the Port of Oakland;
- Railyards;
- Distribution centers and truck-related businesses;
- Airports;
- Oil refineries;
- Power plants;
- Metal melting facilities; and
- Cement plants.

The modeling approach for these types of sources are beyond the scope of this document and it is recommend that the project sponsor contact their lead agency for further information on how to address emissions from these sources if they are located within the project radius.

2.1.3 Minor, Low-Impact Sources

The District has identified several sources that do not pose a significant health impact even in combination with other nearby sources. These determinations were made through extensive modeling, source tests, and evaluation of their TAC emissions. The minor, low-impact sources include:

- Roads with less than 10,000 total vehicles per day and less than 1,000 trucks per day;
- Non-diesel boilers;
- Soil-vapor extraction wells; and
- Cooking (excluding under-fired charbroilers) and space-heating equipment.

Sources that meet these criteria can be excluded from the CEQA process.

2.2 Identifying Receptors

For the purpose of this document, receptors are defined as people—children, adults, and seniors—occupying or residing in:

- Residential dwellings, including apartments, houses, condominiums;
- Schools, colleges, and universities;
- Daycares;
- Hospitals; and
- Senior-care facilities.

Modeling should assume that these dwellings and facilities shelter receptors. At this time, the methodology does not include significant thresholds for on-site and off-site worker exposures. The Occupation Safety and Health Administration (OSHA) is the main federal agency that adopts laws and regulations for ensuring safe and healthful work environment to prevent injuries and protect the health of workers. All employers must follow OSHA regulations to ensure the health and well being of their employees. As part of the District's permitting process, exposures to off-site workers and residents are evaluated prior to issuing any permits.

2.3 Determining the Project Radius

For assessing community risks and hazards, the District recommends that a region around the proposed project be defined by a *project radius* for assessing potential impacts on new receptors and cumulative impacts of new sources. More specifically, a 1,000 foot radius is generally recommended around the project property boundary to identify existing sources that may individually or cumulatively impact new receptors and to identify existing sources that may contribute to the cumulative impact of new sources. The following section provides details on the purpose of and methods for setting the project radius.

2.3.1 New Receptors

For any proposed project that includes the siting of new receptors, assess impacts from sources of toxic air contaminants and $PM_{2.5}$ within 1,000 feet of the proposed project. The 1,000 foot radius is recommended for assessing risks and hazards from both individual sources and the cumulative effects of multiple nearby sources (i.e., proposed project plus existing and foreseeable future projects).

For large, complex sources, such as those listed in Section 2.1 above, a larger radius may be appropriate, but the specifics should be determined on a case-by-case basis.

2.3.2 New Sources

For assessing the project alone impacts of a new source or new sources, no project radius is recommended. In this case, the location of maximum risk, hazard, and $PM_{2.5}$ concentration affecting a receptor should be identified.

For assessing the *cumulative* impacts of a new source or sources in combination with existing sources, a project radius is recommended. Assessment of impacts from existing sources within 1,000 feet of the new source(s) in combination with risks and hazards from the new source(s) is recommended. Once the location of the maximally impacted receptor is identified for the new source(s), additional cumulative impacts are assessed at that location from other sources within the radius of the project (i.e. not the receptor). Assessments should sum individual hazards or risks to find the cumulative impact at the location of the maximally impacted receptor from the new source(s).

2.3.3 Constructing the Project Radius

To construct the project radius, a polygon should be formed that is 1,000 feet from the property boundary of the new development. GIS programs provide a proximity feature for constructing such polygons based on linear distance. The polygon may be constructed by hand following the steps below (see Figure 4):

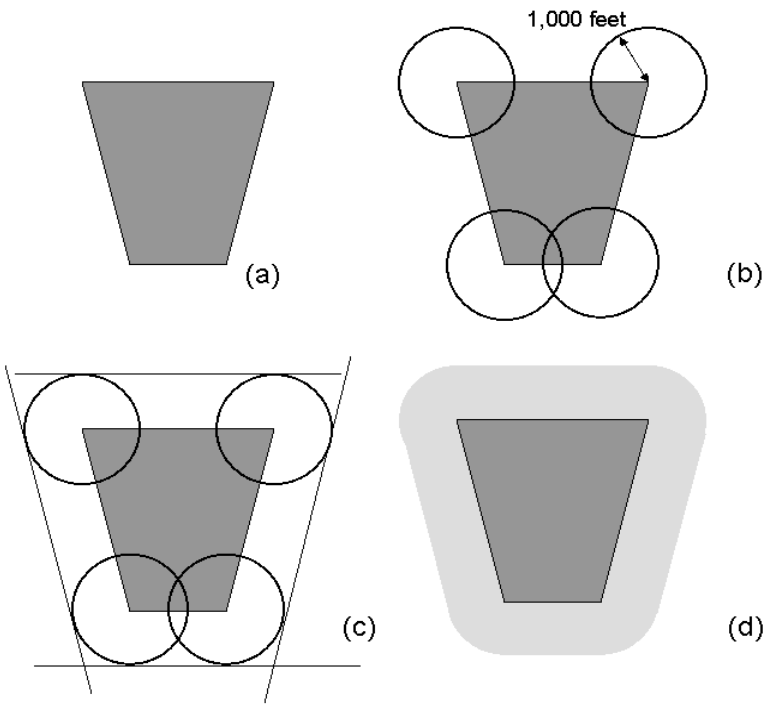
1. Create a map to scale representing the property boundary of the proposed project.
2. On the map, construct circles centered on the corners of the property boundary.
3. Form a polygon by drawing straight lines that are tangent to adjacent circles.

2.3.4 Selecting an Approach

As outlined in Section 1.0, the recommended methodology follows a tiered sequence of analysis, with the level of effort and requisite site-specific information increasing as the user progresses from screening to site specific modeling. Since the data requirements and screening or modeling tools differ with the approach, the user is encouraged to plot his or her approach in advance and select the appropriate tools as needed. The following list provides an outline of the data,

screening tools, or models necessary for each of the tiered approaches. Subsequent sections describe the data, screening tools, and models—as well as where to find them—in more detail.

Figure 4. Constructing the project radius. The shaded polygon (a) represents the property boundary. Circles of 1,000 foot radius (b) are constructed with centers at the polygon corners. Line segments (c) are drawn tangent to the circles. Line segments are truncated at the points of tangency to create the project radius (d).



Approach: Check source locations relative to the 1,000 foot project radius
Data:

- 1,000 foot project radius
- Source locations

Approach: Project Screening
Data/Tools:

- 1,000 foot project radius
- Source locations
- Screening tables (stationary, roadway, railroad tracks)
- Screening tool (construction)
- Receptor locations (for new sources)

Approach: Detailed Modeling
Data/Models:

- 1,000 foot project radius
- Stationary source: locations, emissions, release parameters
- On-road mobile: Roadway locations, traffic counts for cars and trucks, emission factors
- Off-road mobile: location data, activity estimates, load factors, emission factors
- Meteorological data
- Receptor locations (for new sources)
- One or more of the following models: SCREEN3, ISC, AERMOD, CAL3QHCR

3.0 SCREENING TABLES

The methodology outlined here provides a stepwise process that indicates the need for and approach for conducting a more detailed risk analysis. In the first step, project characteristics and distances from common sources are used to screen projects using District-provided screening tables for surface streets, highways, and permitted sources. This section describes how to use the screening tables and the methodology used to develop the tables.

3.1 Roadways

The District developed roadway screening tables for all California highways and surface streets. Surface street screening tables are based on annual average daily traffic (AADT) counts. In order to use the tables, project sponsors must first gather vehicle count information for all major roadways within 1,000 foot radius of the proposed project. Only roadways that have over 10,000 vehicles per day should be included in the evaluation.

3.1.1 Traffic Counts

The Traffic Data Branch of the California Department of Transportation (Caltrans) collects and disseminates on-line (http://traffic-counts.dot.ca.gov/) traffic counts in various formats for freeways and roadways that are part of the State Highway System. State Highways are signed Interstate, California, and US, as shown in the examples in Figure 5 below. Caltrans does not collect traffic count information on locally maintained surface streets. Count information for locally maintained streets is available from the City or County Public Works Department, Traffic Engineers office, in the area where the street is located or from the County-specific Congestion Management Authority.

Caltrans makes available the following data sets:

- **Traffic Volumes** (Annual Average Daily Traffic; AADT) for all vehicles on California State highways. Searches by route of these data sets are available on-line (http://traffic-counts.dot.ca.gov/). Data sets include traffic count estimate for highway segments relative to milepost markers or major cross streets. For projects south or west of the nearest milepost location, select counts designated as “back”. For projects north or east of the nearest milepost location, select “ahead”.

- **Truck Traffic** (Annual Average Daily Truck Traffic) on California State highways. Annual average daily truck traffic is estimated as the total truck traffic for the year divided by 365 days. Counts are provided relative to the post mile markers. For projects south or west of the nearest milepost, select counts designed as "B" for back leg. Projects north or east of a mile post, select "A" for ahead. The "O" designation is used for cases in which the counts along the back and ahead legs are equal.

Figure 5. Caltrans collects and disseminates traffic counts for State Highways, which are signed as Interstate, California, and US.

Annual average daily traffic is the total volume for the year divided by 365 days. The traffic count year is from October 1st through September 30th. Only a few locations in California are actually counted continuously, but most counts are verified periodically. Traffic counting is generally performed by electronic counting instruments moved from location throughout the State in a program of continuous traffic count sampling. The resulting counts are adjusted to an estimate of annual average daily traffic by compensating for seasonal influence, weekly variation and other variables. Each count location is identified by the post mile which corresponds to a point on a highway. The post mile increases from the beginning of a route within a county to the next county line generally increasing from south to north and west to east directions. The post miles are reset at each county line. All traffic volume figures listed include traffic in both directions unless otherwise indicated. Included in the data is an estimate of the "peak hour" traffic at all points on the State highway system. This value is intended for use in estimating the amount of congestion experienced and indicates how near to capacity the highway is operating. Peak hour traffic normally occurs on the roadway every weekday and on a few rare occasions, the peak hour counts are exceeded a few hours each year.

In addition to the highway counts, California Environmental Health Tracking Program (CEHTP) has developed a traffic volume linkage tool that allows user to obtain traffic volumes near specific locations. The CEHTP is a program within the California Department of Public Health and is funded by the Centers for Disease Control and Prevention. The traffic counts are estimated using the Caltrans Highway Performance Monitoring System (HPMS) data for California based on the year 2004. The web connection to the site can be found at: http://www.ehib.org/page.jsp?page_key=136. The tool can be used to determine the number of vehicles that travel daily near a proposed project. The user enters the latitude and longitude of a site location and the radius of influence for which roadway traffic are needed. The tool includes a program that geocodes individual street address to a latitude and longitude coordinate system or the coordinates may be determined through Google Earth™ as well. The tool provides AADT along each roadway and a summation of all traffic within the radius of influence. The advantage of this program is that it provides surface street counts for most major surface streets in the Bay Area. However, the data are from 2004 and may not be reflective of current site conditions. The

data are appropriate for screening purposes, but the District recommends contacting the County Public Works Department or Congestion Management Authority for site-specific modeling analysis. For projects in San Francisco, the San Francisco Transportation Agency maintains a program called SFCHAMPS that contains the projected traffic volume for all surface streets in San Francisco.

3.1.2 Surface Streets

Surface streets are defined as any road in the Bay Area that is not designated a California highway. Surface streets include both roads on rural and urban lands that have been incorporated into a city's jurisdiction or are un-incorporated and are part of the county. Proximity to the roadway and the vehicle traffic on that roadway are key factors in determining whether the impact from a local surface street is significant under CEQA. To determine the impact from local surface streets, the District developed county specific surface street screening tables based on the AADT on a roadway.

The tables were developed using the following methodology:

- $PM_{2.5}$ concentrations were estimated using the base year 2014. For the 70 year cancer risk analysis, annual average emissions were estimated using the latest version of California Air Resources Board's (CARB) EMission FACtors (EMFAC2007) for 2014 through 2040. Because EMFAC2007 does not estimate emissions beyond 2040, the emissions from year 2040 where then applied to remaining years (2041 through 2084).

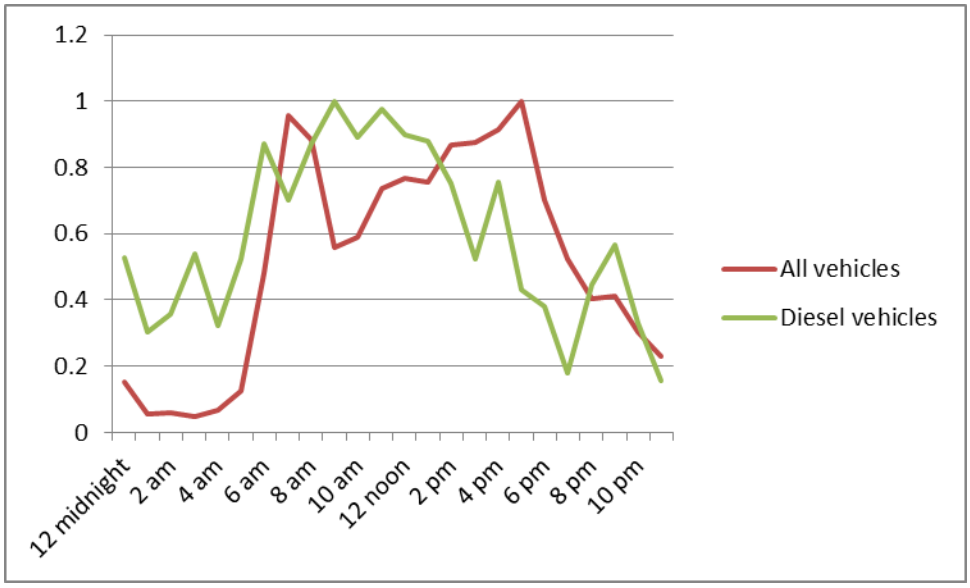
- Modeling was completed for AADT ranging from 10,000 to 100,000 vehicles per day. The AADT and annual emissions were scaled by the hourly diurnal factor derived using the VMT for $PM_{2.5}$ and diesel particulate matter (see Section 4.3.3.1). The diurnal scaling factor was developed by dividing each hourly VMT by the total VMT estimated for the day. The AADT and emissions were then multiplied by the scaling factor for each hour to develop hourly vehicle volumes and emissions. Figure 6 presents the diurnal scaling factors for Alameda County as an example of what was used in the model. The two different diurnal factors were derived depending on whether the model was estimating concentrations from all vehicles versus diesel trucks alone. As illustrated in the figure, there are two peak emissions point corresponding to the morning and evening commute times. For the diesel exhaust, the peak appears to occur at 9 am. All of the nine Bay Area counties have similar diurnal patterns.

- The District averaged the county-specific emissions from EMFAC2007 for speeds of 0 mph to 35 mph based on a temperature of 60 degrees Fahrenheit and humidity of 60%.

- Hourly vehicle volume and emissions were input into roadway model CAL3QHCR to estimate annual average concentrations. All roadways were assumed to be at ground level and receptors were set at six feet (1.8 meters). The model was run for to estimate $PM_{2.5}$, total organic gases, and diesel exhaust concentrations. The percentage of trucks traveling on surface streets was estimated using the California Motor Vehicle's Stock Travel and Fuel Forecast (MVSTAFF) report (http://www.dot.ca.gov/hq/tsip/tab/mvstaff.html) for 2006. This annual report estimates,

and forecasts the annual statewide and countywide number of vehicles, vehicle miles of travel, vehicle fuel consumption, and vehicle fuel economy. The fraction of trucks traveling on surface streets was estimated by weighing the truck VMT by the total VMT for all vehicles on non-State highways per county (see Table 2). MVSTAFF defines trucks as vehicles with at least two axles and six tires. EMFAC2007 county total diesel emission factors (which include all diesel vehicles) were adjusted to match the MVSTAFF definition of truck counts.

Figure 6. Example Diurnal Scaling Factor for Alameda County (relative to peak-hour traffic)



- Meteorological data collected from the District's monitoring stations were input to the CAL3QHCR model. The meteorological station and year the data were collected are noted in the screening tables. Each roadway was modeled assuming a link length of one kilometer.

- Age sensitivity factors (ASF) were applied in estimating the cancer risk to yearly emissions starting in 2014 through 2030. ASFs are used to account for the increased susceptibility of infants and children to carcinogens, as compared to adults. A factor of 10 was applied for exposures that occur from the third trimester of pregnancy to two years of age, and by a factor of three for exposures that occur from two years through 15 years of age (see Section 4.3.3.1 for how these age sensitivity values were applied).

Table 2. Truck Percentage on Non-State Highways using MVSTAFF 2006

County	Estimated Truck % along non-state highways
Alameda	4.09
Contra Costa	3.59
Marin	2.84
Napa	3.91
San Francisco	2.85
San Mateo	3.13
Santa Clara	3.51
Solano	3.63
Sonoma	4.32

- The screening tables were further refined to account for anticipated diesel reductions from CARB's On-road Heavy Duty Diesel Vehicles (In-Use) Regulation[1]. The District estimated a percentage of diesel reduction anticipated per year based on phased in compliance dates specified in the diesel regulations adopted by CARB. Table 3 presents a summary of the diesel reduction anticipated per year for all diesel vehicles.

Table 3. Percent Reduction Anticipated per Year Based on CARB's Diesel Regulations

Year	Emission Reduction % based on CARB diesel regulations
2014	0.22
2015	0.37
2016	0.39
2017	0.41
2018	0.41
2019	0.4
2020	0.38
2021	0.38
2022	0.38
2023	0.36
2024	0.34
2025	0.31
2026	0.29
2027	0.267
2028	0.244
2029	0.221
2030	0.198
2031	0.175
2032	0.152
2033	0.129
2034	0.106
2035	0.083
2036	0.06
2037	0.037
2038	0.014
≥ 2039	0

The screening tables present the $PM_{2.5}$ concentrations and cancer risks for roads with 10,000 to 100,000 vehicles per day at specified distances away from the edge of the nearest travel lane of a road to the project. Each table presents concentrations for north/south or east/west roadway configurations. These sets of tables correspond to projects located upwind or downwind of the roadway with respect to the prevailing wind direction. Concentrations were estimated 10 feet, 50 feet, 100 feet, 200 feet, 500 feet, 700 feet, and 1,000 feet from the edge of the roadway (farthest lane) closest to the project. Roadways with less than 10,000 vehicles per day are consider minor, low-impact sources and inclusion of these roads in CEQA evaluation is not warranted. In addition, the tables do not include acute or chronic noncancer hazards since the maximum hazards estimated from the highest AADT were significantly below the thresholds.

The first step in using the tables is to download the county specific tables in which the project will be located. The screening surface street tables are located at the District web site: http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES/Tools-and-Methodology.aspx. Prior to using the tables, the user must know: (1) which roads exceed 10,000 AADT within 1,000 foot radius of the project and their associated AADT and (2) the distance from the project to the roadway.

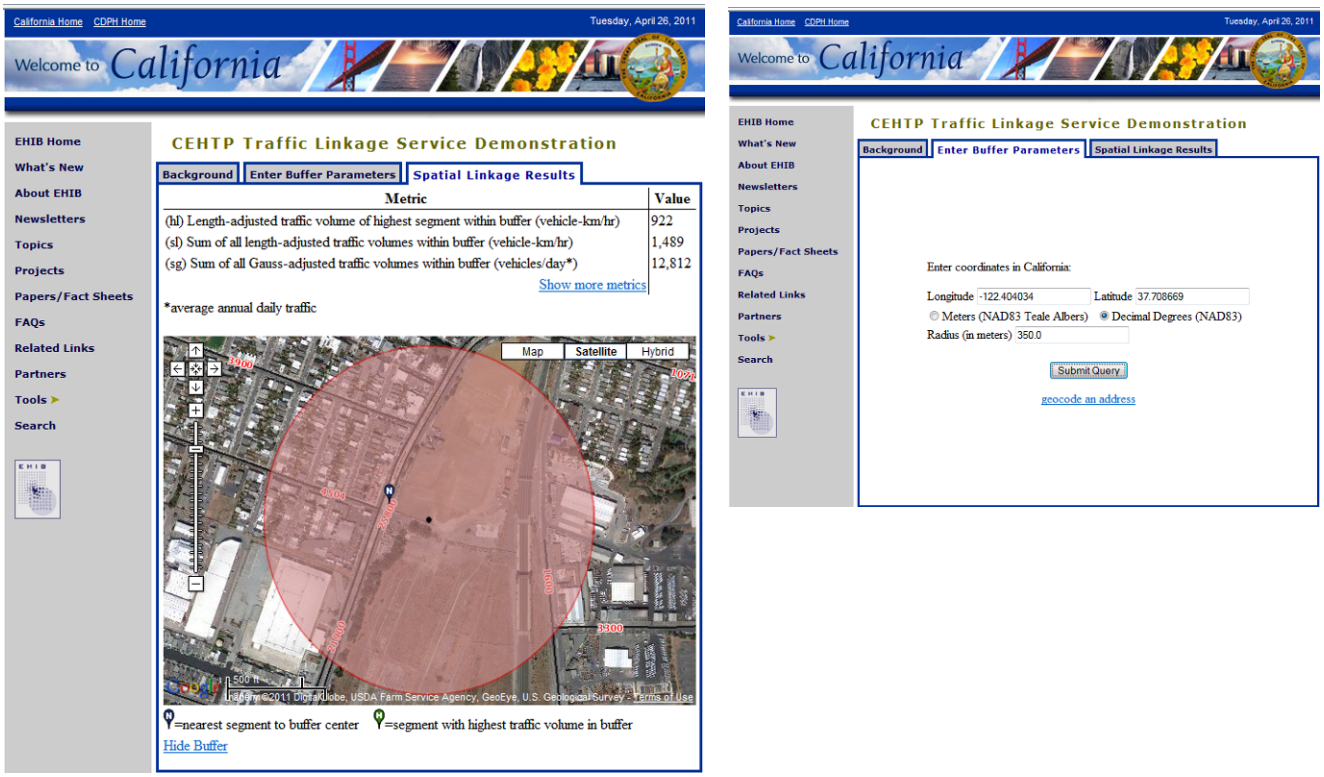
To identify roads with greater than 10,000 AADT near a project site, the District recommends using CEHTP's traffic volume tool (see Section 3.1.1 for further discussion). The web connection to the site can be found at: http://www.ehib.org/page.jsp?page_key=136. The tool can be used to determine the number of vehicles that travel daily near a proposed project. The user enters the latitude and longitude (in degrees) of a project location and the radius of influence for which roadway traffic are needed. The tool includes a program that geocodes individual street address to a latitude and longitude coordinate system or the coordinates may be determined through Google Earth™ by selecting "option" in the "tools" bar and clicking on "show lat/long in decimal degrees". The tool then provides an aerial map of the project site with the AADT along all roadways within a user defined radius around the project. An example is shown below in Figure 7 for a hypothetic

[1] Information available online at http://www.arb.ca.gov/msprog/onrdiesel/onrdiesel.htm

project in San Francisco. The latitude and longitude coordinates were taken from Google Earth™. In this example, only the main road going through the center of the circle has AADT greater than 10,000 vehicles (i.e., 25,800).

To determine the distance from the project to the roadway, the project sponsor can use the ruler tool in any mapping program. District routinely uses the ruler tool in Google Earth™ to measure the distance from the edge of the project to the nearest traffic lane. Continuing with the example in Figure 7, Plant Number 3520 is located approximately 276 feet west of the roadway that has 25,800 vehicles per day (see Figure 8).

Figure 7. Example of the CEHTP's Traffic Count



The user then opens the county-specific surface street screening table in which the project is located. Based on the predominant direction of the roadway, the user selects either the north-south or east-west directional tables. For the example in Figure 8, the roadway is located in San Francisco in a north-south direction, has 25,800 vehicles per day, and is approximately 276 feet from the source. To estimate the risks and hazards, the user matches the AADT in the row header with the distance from the project to the roadway in the column header. For cases in which the exact AADT or distances are not estimated in the table, the user should select the more conservative value between the two estimated values. In Table 4, the estimated cancer risk for the example is 2.31 cases per million and the $PM_{2.5}$ concentration is 0.092 ug/m^3.

Figure 8. Example of Google Earth™ Ruler Tool

The cancer risk and $PM_{2.5}$ concentrations can be further refined by linearly interpolating the AADT and the distance between the project and the roadway. For example, the user can average the values between 20,000 and 30,000 AADT to estimate the values for a roadway has an AADT of 25,800. In the example, the $PM_{2.5}$ concentration for 25,000 AADT at 200 feet would be 0.077 ug/m^3 (the average between 0.061 ug/m^3 at 20,000 AADT and 0.092 ug/m^3 at 30,000 AADT). To further refine the estimate, the user can also linearly interpolate based on the distance. In the example above, the project is located approximately 300 feet west of the roadway with an AADT of about 25,000. The first step is to determine the $PM_{2.5}$ concentrations at 200 and 500 feet for an AADT of 25,000 by averaging the values at 20,000 and 30,000 AADT (see Table 5). The next step is to then ratio the $PM_{2.5}$ concentrations for 25,000 AADT by the difference between the values at 200 feet and 500 feet as shown in the calculation below.

$$PM_{2.5\ 300\ feet} = PM_{2.5\ 200\ ft} - (PM_{2.5\ 200\ ft} - PM_{2.5\ 300\ ft}) \times (200\ ft - 300\ ft) / (200\ ft - 500\ ft)$$
$$= 0.077 - (0.077 - 0.027) \times (-100\ ft)/(-300\ ft)$$
$$= 0.060\ ug/m^3$$

Another way to interpolate the concentration between distances is to determine the incremental change in concentrations over even distances. In the example above, the user can estimate the $PM_{2.5}$ concentrations for every 100 feet increments from 200 to 500 feet. The user subtracts the difference between the two distances in the table (in this example, it would be 0.077 ug/m^3 – 0.027 ug/m^3 = 0.050 ug/m^3) and divides by the number of 100s between the distances (i.e, three). The incremental difference for each progression of 100 feet is 0.017 ug/m^3. This implies that for every 100 feet that a project moves further away from that roadway, the $PM_{2.5}$ concentration decreases by 0.017 ug/m^3. In this example, the $PM_{2.5}$ concentration at 300 feet is then 0.060 ug/m^3 ($PM_{2.5}$ concentration of 0.080 at 200 feet subtracted by the increment of 0.017 ug/m^3) and is 0.043 ug/m^3 at 400 feet.

Table 4. Example Cancer Risk and $PM_{2.5}$ Estimation for Surface Street

NORTH-SOUTH DIRECTIONAL ROADWAY							
Annual Average Daily Traffic	Distance East or West of Surface Street - Cancer Risk (per million)						
	10 feet	50 feet	100 feet	200 feet	500 feet	700 feet	1,000 feet
1,000	No analysis required						
5,000							
10,000	2.13	2.10	1.49	0.65	0.36	0.27	0.22
20,000	2.22	2.49	2.22	1.55	0.62	0.51	0.38
30,000	3.37	3.56	3.28	2.31	0.97	0.75	0.55
40,000	4.26	4.46	4.27	3.10	1.33	1.06	0.79
50,000	5.79	6.49	5.78	4.00	1.68	1.33	0.96
60,000	7.81	8.55	7.34	4.76	1.95	1.55	1.15
70,000	9.82	10.60	8.90	5.52	2.22	1.77	1.33
80,000	11.22	12.12	10.17	6.31	2.53	2.02	1.52
90,000	12.63	13.63	11.44	7.10	2.85	2.27	1.71
100,000	14.03	15.15	12.71	7.88	3.17	2.53	1.90

NORTH-SOUTH DIRECTIONAL ROADWAY							
Annual Average Daily Traffic	Distance East or West of Surface Street - PM2.5 Concentration (ug/m^3)						
	10 feet	50 feet	100 feet	200 feet	500 feet	700 feet	1,000 feet
1,000	No analysis required						
5,000							
10,000	0.080	0.063	0.044	0.016	0.012	0.000	0.000
20,000	0.092	0.101	0.092	0.061	0.021	0.016	0.012
30,000	0.129	0.147	0.129	0.092	0.032	0.022	0.017
40,000	0.166	0.193	0.175	0.120	0.051	0.037	0.024
50,000	0.249	0.267	0.239	0.166	0.064	0.050	0.029
60,000	0.341	0.359	0.304	0.198	0.076	0.057	0.039
70,000	0.433	0.451	0.368	0.230	0.087	0.064	0.050
80,000	0.495	0.516	0.421	0.263	0.099	0.074	0.057
90,000	0.557	0.580	0.474	0.296	0.111	0.083	0.064
100,000	0.618	0.645	0.526	0.329	0.124	0.092	0.071

Table 5. Linearly Interpolated $PM_{2.5}$ Concentrations Based on Distance and AADT

AADT	200 feet	300 feet	500 feet
20,000	0.061	NA	0.021
25,000	0.077	0.060	0.027
30,000	0.092	NA	0.032

A similar methodology can be applied to cancer risk. In this example, the project in San Francisco did not exceed the $PM_{2.5}$ threshold or cancer risk. However, if the thresholds for either cancer risk or $PM_{2.5}$ were exceeded, the user can determine whether additional modeling is warranted or implementation of mitigation measures is appropriate. It should be noted that these screening tables are conservative because they are based on selecting meteorology from a single station as being representative for the entire county. If the user chooses to conduct a more refined modeling analysis by including more site-specific meteorology and truck fractions, the District recommends the following general procedures outlined in Section 4.0.

3.1.3 California Highways

This two part section describes a set of on-line tables that are available for estimating local, air quality-related, risks and hazards in the San Francisco Bay Area generated by motor vehicles traveling on the California State highway network. The first part of this section briefly discusses the data sources and technical approach used to produce the tables, including assumptions made in the technical approach. The second part of this section includes the location of the tables, presents recommended methods for applying the on-line tables, and provides an example application for a Bay Area location.

Data Sources and Technical Approach

To assess the air pollution from on-road motor vehicles on the State highways, an air quality modeling system was developed. This section describes the data sources and technical approach used within the modeling system. The main data sources and model inputs include the roadway network, the emissions, meteorological inputs, receptor locations, and risk factors and reference exposure levels for the emitted pollutants. Each of these elements is briefly described below.

Modeling Period

- The on-line tables for risks and hazards from motor vehicles on California freeways and highways in the Bay Area used emissions from year 2014. All $PM_{2.5}$ concentrations and hazard indices were calculated for year 2014. Cancer risk values were calculated for a seventy year period using emissions starting in year 2014 and continuing to year 2084.

- Meteorological data used were the latest year available for each of 64 stations in the Bay Area. Most of the observed meteorological data were from the period 2000 to 2008, but earlier years were used to maximize spatial coverage. The earliest data set used was from 1970. These years were all assumed to be representative of current meteorological conditions.

Freeway and Highway Network

- A representation of the State roadway network in the Air District boundaries (Figure 9) was developed by reconciling the National Highway Planning Network (NHPN) spatial database with the 2008 Topographically Integrated Geographic Encoding and Referencing (TIGER) Line spatial database. Both these data sources were available as geographical information system (GIS) shapefiles. The NHPN shapefile was adopted as

the primary data source. Road links missing from the NHPN data were filled in using data from the TIGER shapefile. The highway network was divided into segments, *links*, based on the availability of traffic counts on each roadway. There are 1236 links (numbered 0 through 1235) in the Bay Area network for which emissions were calculated and risks and hazards were estimated.

The number of lanes of traffic were developed starting with the number of lanes in the NHPN database. However, NHPN data did not include lane numbers for all highway links. For those links without assigned lane numbers, data were manually collected from Google Earth™ maps.

Emissions

To estimate emissions from on-road motor vehicles, vehicle activity (vehicle miles travelled) was first estimated on each roadway link, then activity-based emission factors were applied to estimate daily average emission totals on each link. Developing these emissions required a variety of data, including traffic volumes (activity), vehicle speeds, fleet mixes, emission factors, diurnal profiles, and growth and control factors (for projecting baseline traffic volumes and emission factors to future years). Sources of data used to estimate emissions are described below[2].

- Traffic activity on the State highway system was represented using 2009 Annual Daily Traffic (AADT) counts from the California Department of Transportation (Caltrans). AADT values represent the total traffic volume for the year divided by 365 days, and these counts are reported for state highway segments defined using milepost values. Caltrans provides AADT data for total traffic and for trucks only, with trucks classified by axle number (the two-axle class excludes pickups and vans with only four tires).

- Year 2009 traffic volumes were forecast to 2012 using county-level growth factors from the EMFAC2007 mobile source emissions model. EMFAC2007 was run for all Bay Area counties for 2009 and 2012, and vehicle miles of travel (VMT) output data were used to calculate the growth factors needed to project 2009 traffic volumes to 2012. Year 2012 activity data was assumed for all subsequent years.

- Vehicle speeds by highway segment were based on 2010 and 2015 outputs from the Metropolitan Transportation Commission's (MTC) BAYCAST-90 travel demand model.

- Link-level composite emission factors for trucks and light-duty vehicles were derived from EMFAC2007's Impact Rate Detail output (*.rtl files). EMFAC2007 was run for each year from 2012 to 2040, and details on calculating composite emission factors are provided in the section that follows. (Emissions past year 2040 were assumed to be constant at year 2040 levels.)

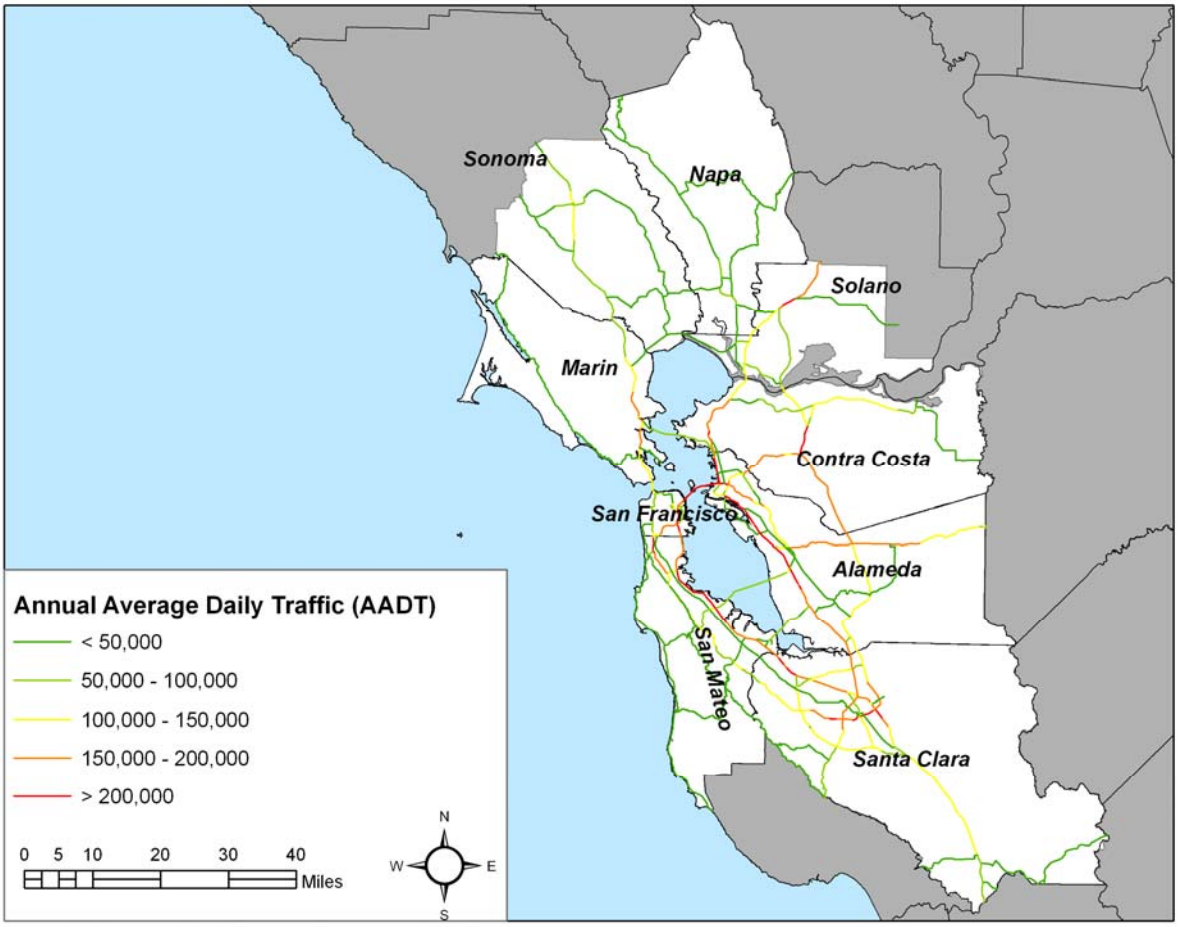
- County-specific diurnal profiles for trucks and light-duty vehicles were derived from EMFAC2007 (see Figure 6; Section 3.1.2).

[2] D. Yuan and S. Reid.Sonoma Technology, Inc., Technical Memorandum, Emissions estimates for State highways. April 27, 2011. STI-910044-TM, under contract to the Bay Area Air Quality Management District.

- Growth and control factors from CARB, including the impacts of the On-Road truck rule, were applied to estimates of emissions from on-road heavy duty trucks (see Table 4; Section 3.1.2).

The activity and speed data described above were linked to the GIS shapefile for the highway network. The base year AADT and truck percentages for each highway segment were joined as attributes to the State highway shapefile based on milepost values and roadway descriptions. Figure 9 shows a map of AADT-derived traffic volumes for the State highways in the Bay Area.

Figure 9. State highway network in the Bay Area Air Quality Management District, showing annual average daily traffic (AADT) on each highway link.



Once traffic volume and speed data were prepared, composite emission factors were developed for each highway link based on the associated truck percentage and average speed. Emission factors were generated for running exhaust and running losses only, as emissions for other modes (e.g., vehicle starts) are not relevant to the state highway system or are negligible compared to exhaust and running loss emissions. This general approach is consistent with the CT-EMFAC model, which is used by Caltrans to estimate transportation project emissions.

However, composite emission factors from CT-EMFAC could not be used directly because CT-EMFAC's truck emission factors include medium-duty vehicles (weight class of 5751 to 8500 lbs), while analysis of MVSTAFF[4] data for the state highway system indicated that Caltrans' AADT truck counts reflect heavy-duty truck (>8500 lbs) activity primarily. As a result, new composite emission factors for NOx, CO, TOG, SO2, CO2, PM, PM10, and PM2.5 were developed directly from EMFAC2007 runs for 2012 through 2040.

Meteorological information

Observed meteorological data from 64 sites in the Bay Area were used to supply wind speed and direction, mixing heights, and stability type information for dispersion modeling. These 64 sites provide reasonable approximations of common meteorological conditions for the 1236 roadway links. Most of the meteorological data are from the period 2000 to 2008, but some of the data were from the 1980's and 1990's. One site located near Moffet Field provided data from 1970. Recent wind measurements are available on-line, in a model-ready format at http://hank.baaqmd.gov/tec/data.

Receptor locations

Receptor locations were defined for locations at right angles to the center of each roadway link at distances of 10, 25, 50, 75, 100, 200, 300, 400, 500, 750, and 1,000 feet from the edge of the roadway (see Figure 10). Two sets of receptor heights were defined: 6 feet, which corresponding to typical breathing heights, and 20 feet, corresponding to a typical second-story height.

Dispersion Model

Emissions estimates, meteorological observations, and receptor locations were input to an air quality dispersion model to estimate near-roadway pollution concentrations. For modeling the State highway network, the model Rcaline[5] was applied. Rcaline is run within the statistical analysis and programming language R[6]. Rcaline provides an interface to the CALINE3[7] model developed by the California Department of Transportation (CalTrans). Given the same inputs, Rcaline has been tested to produce identical outputs CALINE.

Rcaline removes significant limitations found in previous implementations of CALINE. For example, it can be used to model large number of roadway links and a large number of receptors, limited only by available memory and CPU resources. By providing access to CALINE within the R environment, Rcaline facilitates running CALINE using contemporary data sources, such as GIS shapefiles, as input. Rcaline also provides full machine-precision access to CALINE model results in a convenient format. Rcaline facilitates the use basic R commands or third-party

[4] California Motor Vehicle Stock Travel and Fuel Forecast (see http://www.dot.ca.gov/hq/tsip/smb/mvstaff.html).
[5] D. Holstius. Rcaline: Modeling traffic-related pollution with R and the CALINE3 dispersion model. January 24, 2011. (Available on-line at http://169.229.208.128/groups/rcaline/).
[6] The R statistical analysis and programming language and documentation are freely available on-line at http://cran.r-project.org/.
[7] P.E. Benson. A review of the development and application of the CALINE3 and 4 models. *Atmospheric Environment*. Part B. Urban Atmosphere, 26(3):379-390, 1992.

R packages to visualize, compare, and export model results, for example producing shapefiles or Keyhole Markup Language (".kml") files as output.

Figure 10. Receptor locations (shown as white circles) to the west and east of a roadway link (shown as a red line). Receptor distances were taken from the edge of the roadway.

Estimating Risks and Hazards

- Unit risk factors and reference exposure levels for estimating cancer risk and hazard indices from diesel particulate matter and from gasoline exhaust and evaporative running losses were applied (see Sections 4 and 6).
- Age sensitivity factors (ASF) were applied in estimating the cancer risk to yearly emissions starting in 2014 through 2030 (see Table 11 in Section 4).

Output Format

The output from Rcaline used for the highway network is a compressed ".kml" file (".kmz"). A file was produced for each county and for each of the two sets of receptor heights (six feet and 20 feet). For example, two ".kmz" files are available for Alameda County, one at a typical receptor height (Alameda-6ft.kmz) and one at a typical 2nd story receptor height (Alameda-20ft.kmz). These files can be viewed using the Google Earth™ mapping software freely available online at http://www.google.com/earth/index.html. Each file shows a map of the highway network for the county. Selecting a link on the map will bring up a table with $PM_{2.5}$ concentrations in, units of micrograms per cubic meter; cancer risk, in units of expected risk per million; chronic hazard index, a unitless ratio; and acute hazard index, also a unitless ratio, at distances on either side of the highway.

Application of the Tables

The purpose of the highway screening tables is to provide an easy-to-use initial analysis to determine if nearby highway impacts to a new receptor are below the thresholds of significance. The outcome of the screening may be used to assess a determination of no further action or it may indicate that a more refined analysis is warranted.

The highway screening analysis tool present $PM_{2.5}$ concentrations, cancer risks, and chronic and acute hazard index for all State highway segments in the Bay Area at specified distances away from the edge of each highway link within a county. Each highway link includes a table with concentrations for north/south or east/west roadway configurations. Concentrations, risks, and hazards in the tables are provided at 10 feet, 25 feet, 50 feet, 75 feet, 100 feet, 200 feet, 300 feet, 400 feet, 500 feet, 750 feet, and 1,000 feet from the edge of the roadway closest to the project. Concentrations were estimated at two different heights, six feet and 20 feet. The six feet height estimates represent concentration levels when receptors are located on the ground floor of a building; and the 20 feet height estimates concentration levels, risks, and hazards at a eight typical of the second floor of a building. To apply these tables, the following steps are recommended:

1. Download the county-specific ".kmz" files in which the project will be located. The Google Earth™ ".kmz" tables are located at the District web site: http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES/Tools-and-Methodology.aspx. Prior to using the tables, the user must know the distance from the project to the highway. To determine the distance from the project to the roadway, the users can use the ruler tool in any mapping program. The District routinely uses the ruler tool in Google Earth™ to measure the distance from the edge of the project to the nearest traffic lane, see example in Figure 8 (Section 3.1.2) above. For new residential developments, the receptor should be placed at the edge of the property boundary.

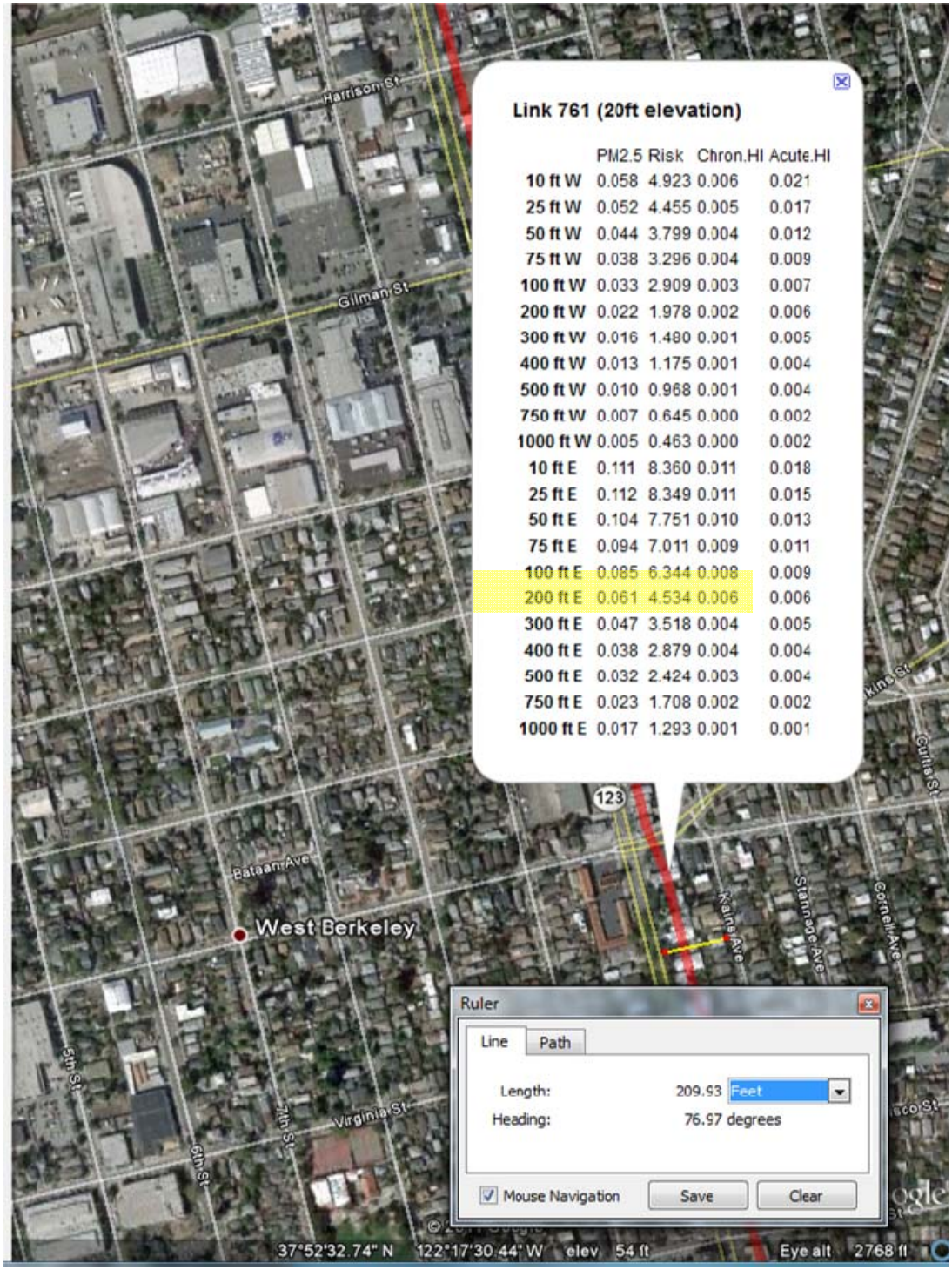
2. If the receptor does not have any significant highway sources within 1,000 foot radius, then the proposed project meets the distance requirements and no further single-source roadway-related air quality evaluation is recommended.

3. If there are highway segments within 1,000 feet of the roadway, the user then clicks on the highway segments within a 1,000 foot radius of the project. As an example, if a proposed project is located 200 feet east of San Pablo Avenue (Highway 123) in Berkeley, and it is known that the ground floor of the project will not house any receptors, the Alameda county ".kmz" file for 20 feet should be downloaded from the BAAQMD website.

4. Once opened in Google Earth™, the closest Highway 123 link to the project should be clicked on for a summary of the estimated risk and hazard impacts at that highway segment. A user would then use the risk and hazard impacts listed at 200 feet east of the freeway in its project analysis. In this case, the highway link table indicates that at 200 feet east of the highway, the $PM_{2.5}$ concentration is estimated at 0.061 ug/m^3, the cancer risk at 4.524 per million, the chronic hazard index at 0.006, and the acute hazard index at 0.006. Figure 11 below illustrates this example using a snapshot from Google Earth™.

5. If a project is located between two highway links for the same roadway, the higher values between the two highway links or distance points should be used.

Figure 11. Example of Applying the Highway Screening Tables



6. If the project is between two distances, tabulated values may be further refined by linearly interpolating between values in the table. The same linear interpolating

methodology outlined for roadways in Section 3.1.2 (see Table 5) may be used for highways.

7. If the user chooses to conduct a more refined modeling analysis by including more site-specific meteorology and truck fractions, the District recommends the following general procedures outlined in Section 4.0.

3.2 Permitted Sources

The District has developed a geographical database of cancer risks, hazards, and $PM_{2.5}$ concentrations for most stationary sources permitted by the District in the year 2008. This database is in the form of a set of compressed Keyhole Markup Language (kml) files that can be viewed with the Google Earth™ software package. The values represent concentrations near the fence-line of the plant.

Note that the screening-level impacts for health risk and $PM_{2.5}$ concentration in the permitted source geographical database are upper-bound estimates. **These values do not represent the true risk values from a plant.** Rather, because the estimates are conservative by design, if a plant passes screening, it can be assumed that it would pass a more site-specific, detailed modeling analysis.

For a few sources, the District modeled the emissions from all sources at the plant as part of its permit and has included the site-specific cancer risk, $PM_{2.5}$ concentrations, and hazards estimated from the health risk assessment in the database. These plants are noted in the database with an "*" at the end of their plant names.

The permitted source screening table contains all the plants in the Bay Area that have permits to operate and that emit one or more toxic air contaminants. The types of permitted sources include, but are not limited to: refinery sources, gasoline dispensing facilities, dry cleaners, diesel internal combustion engines, natural gas turbines, crematories, landfills, waste water treatment facilities, hospitals and coffee roasters. The screening table contains the following information:

- Unique Plant Number used by the District to identify them (Plant Number starting with "G" are gasoline dispensing facilities that be retail or non-retail)
- Plant name
- Geocoded location for the Plant (Universal Transverse Mercador (UTM) coordinates)
- Conservatively estimated health risk impacts due to emissions from the plant that are to be used for screening purposes only: Cancer risk (in millions) and chronic hazard index impacts unless an "*" has been added to the end of the plant name, in which case, the values were derived from a site-specific health risk assessment. Please note that the screening values do not include acute hazard index since the maximum values are significantly below the thresholds.
- Conservatively estimated $PM_{2.5}$ concentrations (in units of micrograms per cubic meters)

The screening-level health risk impacts in the permitted source screening table are calculated using health effect values adopted by the Office of Environmental Health Hazard Assessment

(OEHHA); health-protective assumptions relating to the extent of an individual's exposure, including age sensitivity factors; and a conservative modeling procedure to establish the extent to which a TAC is dispersed in the atmosphere after its release from the source.

For permitted source categories other than gasoline dispensing facilities, the screening-level impacts for health risk and $PM_{2.5}$ concentrations in the permitted source screening table are based on the same screening-level dispersion modeling procedure that was used to develop the trigger levels in District Regulation 2, Rule 5, Table 2-5-1, Toxic Air Contaminant Trigger Levels (http://www.baaqmd.gov/Divisions/Planning-and-Research/Rules-and-Regulations.aspx). This modeling uses a cavity effects screening procedure where dispersion is affected by aerodynamic downwash from a nearby building and relates emission rate to one-hour average ambient air concentrations. The cavity region occurs immediately adjacent to the lee side of the building and is often the "worst-case" dispersion scenario where receptor areas are in close proximity to the source being evaluated. The cavity effects equation is provided in EPA's Screening Procedures for Estimating the Air Quality Impact of Stationary Sources (EPA, 1992), and is incorporated into the EPA SCREEN3 model (EPA, 1995).
The cavity equation is as follows:

$$\text{Conc}_{\text{1 Hour Max}} = Q / (1.5 \times A \times u)$$

Where:
Conc = One hour maximum exposure concentration at the fenceline of the plant (ug/m^3);
Q = Emission rate (g/sec);
A = Cross section area of the building normal to the wind (m^2); and
u = Wind speed (m/sec).

The cavity effects equation requires the selection of the crosswind building area and the average wind speed. A value of 92.7 square meters was used for the crosswind building area (e.g., a building approximately 25 feet high x 40 feet wide). The average wind speed was taken to be two meters per second, based on EPA screening modeling guidelines. The cavity equation was used to estimate maximum one hour concentration. In order to estimate the annual average concentration for chronic exposure, a multiplying factor representing the ratio between annual average and one-hour maximum concentrations of 0.1 was used. This is the high-end value of the range of multiplying factors provided in EPA screening modeling guidelines (EPA, 1982).

Evaluating gasoline dispensing facilities (GDFs) are more complex because emissions come from spills, vents, and the dispensing pumps. For this source categories, the screening health risk calculations were further refined. EPA's AERMOD atmospheric dispersion model was used to develop worst-case ground-level concentrations and to develop distance adjustment multipliers. AERMET processed meteorological data sets used in the matrix of modeling runs include those for Concord, Hunters Point, Oakland Airport, Petaluma Airport, UC Richmond and San Jose Airport. Over two dozen different building dimensions were modeled to include downwash effects. GDF were conservatively modeled as a point source for the storage tank vent with a 10-feet high two inch diameter stack, 0.00035 m/s exhaust gas velocity and $294^{o}K$ exhaust gas temperature; and a single volume source for the refueling and spillage at the dispenser with

an initial lateral dimension of 2.3 feet. The fraction of emissions out the vent and at the dispenser was estimated at 0.073 and 0.927, respectively.

The screening health risk values calculated for GDFs are based on the worst-case concentrations determined through the AERMOD modeling results. Distance adjustment multipliers were developed to adjust (lower) the screening health risk values for GDF when the distance from the receptor location to the source is greater than 60 feet. The District followed the same methodology to estimate downwind multipliers for diesel engines since they are ubiquitous throughout the Bay Area. These distance adjustment multipliers are to be used only in conjunction with the screening health risk values for diesel engines and GDFs and may not be used for other source types. The user should contact the District Planning Division to receive copies of the downwind multipliers for these sources.

The screening-level impacts for health risk and $PM_{2.5}$ concentrations in the permitted source screening table do not represent actual impacts. Rather, the values are upper-bound estimates used as a screening tool to determine whether or not a refined modeling analysis is required and to identify those plants that may warrant further analysis to determine actual risk. The calculations used to determine the screening table impacts do not include source specific exhaust information such as stack height, exhaust gas exit velocity, exhaust gas temperature, nor do they account for the distances to actual receptors. A more refined analysis using source specific exhaust parameters, site specific meteorological data, site specific building dimensions and locations, and actual location of source and receptors is expected to result in significantly lower and more accurate values than those found in the permitted source screening table.

The permitted source screening table may be used to determine which plants to include in a refined modeling analysis for a project. The impacts for the plants identified can then be summed and compared to the trigger levels in the CEQA guidance document to determine if further analysis is required. Note that the UTM coordinates represent only a single point at a plant, which may not be the point closest to the project. Also, the reference points (North American Datum, NAD) for the UTM coordinates in the screening table may not be the same for all plants. UTM coordinates for some facilities may be reference to NAD27, while others are reference to NAD83. Potential distance offsets may be as great as 220 meters. In order to ensure that all relevant plants are included, the distance used to identify facilities from the permitted source screening table should extend a reasonable distance beyond the distance specified in the CEQA guidance document and actual locations should be verified.

All plant information within each of the nine Bay Area county were then converted to kml file format (format compatible with Google Earth™) that retained site-specific plant information and geocoded the plant coordinates. Each of the county files can be found at: http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES.aspx.

The Google Earth™ application is a free mapping software package that can be downloaded at: http://earth.google.com/. To use the application, a user should complete the following steps:

- Install Google Earth™ on user's computer;

- Download the county-specific permitted source data in kml file format from the District web site (see link above) onto a user's hard drive;
- Double click on the kmz file on the user's hard drive and it will automatically open Google Earth™ and plot the permitted sources as colored dots on a map; and
- Point to any source and a dialog box will open containing the plant number, GDF number, facility name, and estimates of risk, hazards, and $PM_{2.5}$ concentrations.

The user then uses the "polygon" tool in Google Earth™ to plot the 1,000 foot radius around the plant or the receptor to determine which sources should be included in the single source and cumulative analysis. As previously discussed, the estimates shown in these screening tables are conservative and do not account for dilution of the concentrations further downwind of the source. The District recommends initially summing the values for cancer risk, hazards, and $PM_{2.5}$ from all sources within 1,000 foot radius of the project to estimate cumulative impacts. In the example shown in Figure 12, a rough 1,000 radius (highlighted in yellow) is shown for Plant 10927. For the cumulative analysis, the District recommends summing the values for the two other sources found within 1000 foot radius, namely values for plants G9452 and 15416.

Figure 12. Example Stationary Source Inventory and Boundary

For plants that have "Contact District Staff" in the values, the user should download the "Stationary Source Inquiry Form" located at: http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES/Tools-and-Methodology.aspx. Instructions are provided in the form as to how to fill out and send the form to the District. If any single source exceeds the single source impact thresholds or the sum of all sources exceeds the cumulative impact thresholds then the user should consider possible mitigations that can reduce the potential air quality impacts.

4.0 REFINED MODELING APPROACH

If the screening analysis shows that a proposed project or new development may exceed the $PM_{2.5}$, risk, or hazard threshold, then a more refined modeling analysis may be prepared. A refined analysis is generally more accurate since it incorporates site-specific conditions that are not accounted for the screening approach.

There are several air dispersion models available that can be used in the refined analysis. The choice of model will vary depending on the modelers experience and the available site-specific information. The first tiers of models are screening models that are available through free downloads from US EPA web site. These models are easy to use and require limited site specific information including the types of source (point, area, or volume), dimensions of source, and emissions. These models simulate one source at a time and include default worst case meteorological data to predict the maximum one hour concentrations at a specific distance downwind of the source.

More sophisticated models are highlighted in the next tier of analysis where multiple sources and site-specific meteorological data can be used. The models require some familiarity with air dispersion modeling concepts and site conditions and emission release characteristics of the sources to be modeled. Note that the user is not required to conduct the analysis following this tiered approach; at any time, he or she can skip ahead to perform a more refined analysis.

4.1 General Air Dispersion Modeling Concepts

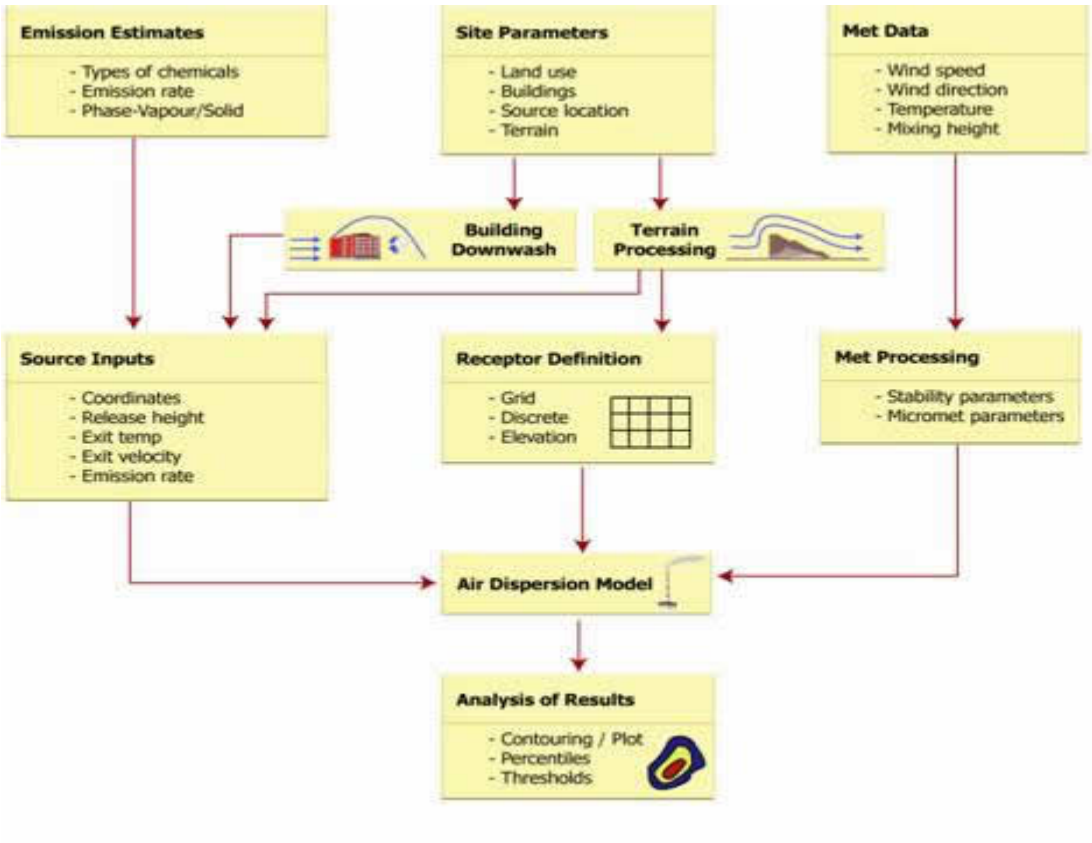
Air dispersion modeling is the mathematical estimation of pollutant impacts from emissions sources within a project radius. Several factors impact the fate and transport of pollutants in the atmosphere including, but not limited to meteorological conditions, site configuration, emission release characteristics, and surrounding terrain. Figure 13[11] presents a general overview of the process typically followed for performing an air dispersion modeling assessment. Highlighted in the figure are some key concepts that need to be defined prior to conducting an air dispersion modeling analysis.

4.1.1 Coordinate System

Any modeling assessment requires a coordinate system of the project radius to be defined in order to assess the relative distances from sources to receptors and, where necessary, to consider other geographical features. Using a standard coordinate system for a project increases the efficiency of the review process while providing real-world information about the site location. For screening purposes, a simple straight line of receptors that are spaced equal distances from the source may suffice. More refined models places receptors along a Cartesian grid or on radial distances from a center point.

[11] CAPCOA, 2009. Health Risk Assessments for Proposed Land Use Projects. Prepared by CAPCOA Planning Managers. Released July 2009.

Figure 13. Generalized Process for Performing a Refined Air Dispersion Modeling Analysis



Source: CAPCOA, 2009.

Most air models use the UTM coordinates. The UTM system uses meters as its basic unit of measurement and allows for more precise definition of specific locations than latitude/longitude. The project sponsor should ensure that the same horizontal datum is used throughout the project to define all objects (sources, buildings, and receptors). Defining some objects based on a NAD27 (North American datum of 1927) while defining others within a NAD83 (North American datum of 1983) can lead to significant errors in relative locations of up to 220 meters. The Google Earth™ mapping application can be used to determine UTM or latitude/longitude coordinates for the project area.

For a localized assessment, the user may use local coordinates that are relative to local set datum and not based on a geographic standard. For example, a facility may reference the northwest corner of the perimeter of the property boundary as the origin (0,0) of the coordinate system and have all other locations identified based on its location relative to this defined local datum. All plant buildings and sources are then related spatially to this origin as well as all site measurements are estimated relative to the local coordinate system.

The only caveat to using the local coordinate system is that it cannot be compared or spatially mapped to other sources or receptors in the actual world. For this reason, it is advantageous to

consider a geographic coordinate system that can specify the location of any object anywhere in the world with precision.

4.1.2 Receptor Grid

A receptor is defined as a point where an actual person (residential) may be located for a given period of time and may include:

- Residential dwellings, including apartments, houses, condominiums;
- Schools, colleges, and universities;
- Daycares;
- Hospitals; and
- Senior-care facilities.

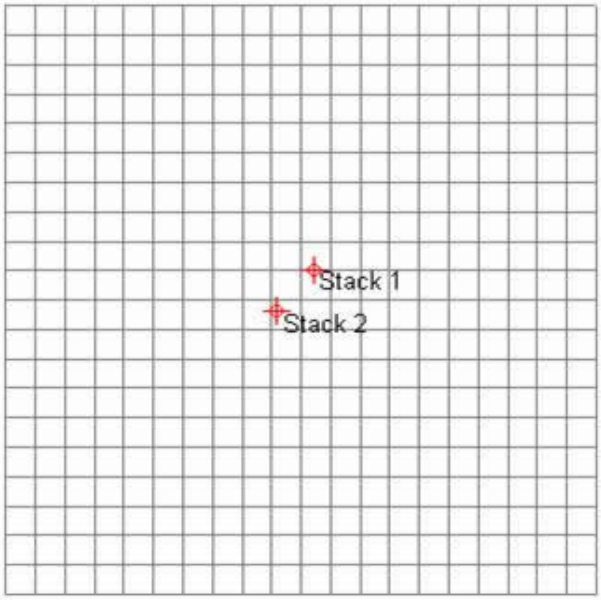
For CEQA evaluations, the length of time can vary from one hour for acute hazard evaluation, one year for $PM_{2.5}$ exposures, and 70 years for chronic cancer risk and hazard assessments. For each of these evaluations, the District is recommending that all sensitive receptors be identified within the project radius. Motels, trailer parks, residential camp grounds, and other places where people reside for long periods should also be considered sensitive, residential receptors.

The receptor grid identifies a series of receptor locations in which the model will estimate air concentrations. The grid does not necessary corresponds to actual home locations, but is a means of developing isopleths that illustrate the dispersion pattern of the source emissions and anticipated downwind concentration in the community or project radius. Discrete receptors that represent actual individualized locations (discrete receptors) where people reside can be added to the model. Fenceline receptors, which correspond to the placement of receptors along the perimeter of the project's property, should only be employed if there are existing or reasonably anticipated future sensitive receptors who will be residing in this area. Receptor grids do not always cover precise locations that may be of interest in modeling projects.

There are several techniques that can be used in air dispersion modeling for defining a receptor grid. The most commonly used receptor grid is the Cartesian grid, which is defined by an origin with receptor points evenly (uniform) or unevenly (non-uniform) spaced around the origin. Figure 14 illustrates a sample uniform Cartesian receptor grid. The grid should encompass the entire area of the project radius and be spaced appropriately to identify the most impacted receptor. For cases with emissions from short stacks or vents and a close property line, a receptor spacing of 10 meters may be sufficient. For taller stacks and greater distances to the property boundary, a receptor spacing greater than 25 meter, but less than 50 meters may be appropriate to ensure adequate coverage of the project area.

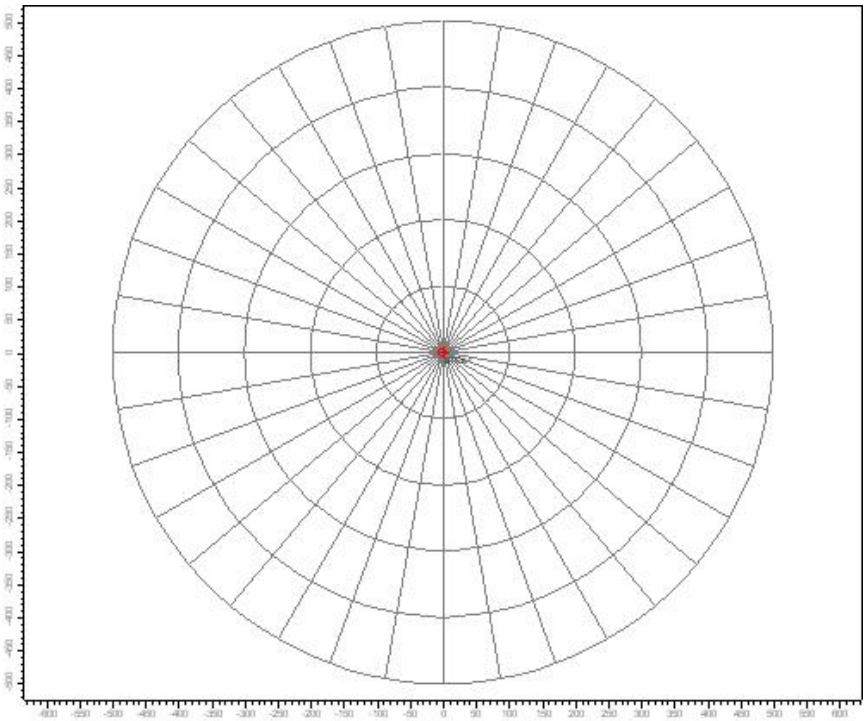
Another less commonly used receptor grid is polar grid system, which are characterized by an origin with receptor points defined by the intersection of concentric rings, which have defined distances in meters from the origin, with direction radials that are separated by specified degree spacing. Figure 15 illustrates a sample uniform polar receptor grid.

Figure 14. Example of a Cartesian Grid



Source: CAPCOA, 2009

Figure 15. Example of a Polar Grid



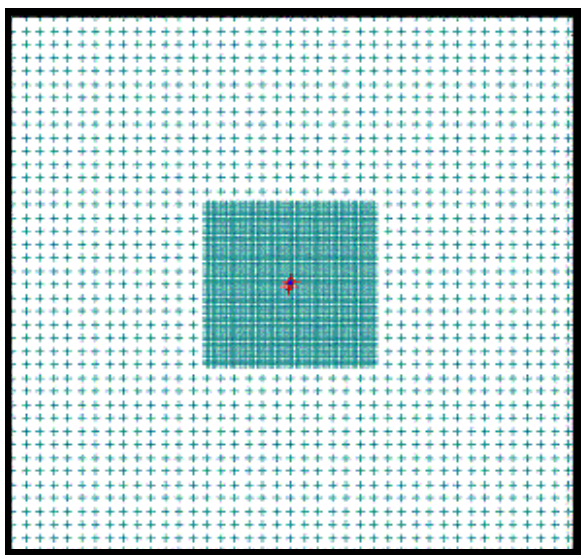
Source: CAPCOA, 2009

Polar grids are used when only one source or one dominant source is being modeled. However, for facilities with a number of significant emissions sources, receptor spacing can become too

coarse (receptor points are too far apart) when using polar grids such that the maximum impacted area is not clearly identified. As a result, polar grids should generally be used in conjunction with Cartesian grid to ensure adequate spacing.

The model estimates a concentration for each point of a grid which requires extensive computational time. For large modeling domains, project sponsors can use a combination of coarse and fine grids in one modeling run to encompass the project area. As illustrated in Figure 16, a fine grid receptor of tightly spaced receptors is defined near the source and larger grid spacing is defined for the area outside of the fine grid. The advantage of this approach is that it reduces the number of receptors, but maintains sufficient resolution such that the maximum impact area is well defined. Receptors should also be placed along the property boundaries. The spacing of these receptors depends on the distance from the emission sources to the facility boundaries. It is the responsibility of the user to demonstrate that adequate receptor grid spacing has been used and that the modeling results have captured all areas that may potentially be impacted from the project where the toxic thresholds may be exceeded.

Figure 16. Sample Combination Grid System with Two Types of Receptor Spacing



Source: CAPCOA, 2009

4.1.3 Averaging Times

A key advantage of the refined modeling analysis is the ability to select the appropriate averaging time with which to compare to the CEQA thresholds. The District has defined different thresholds depending on the health effects and time of exposure. For example, cancer risks and chronic noncancer hazard are assessed for long term exposures over 70 years. Acute noncancer health effects are usually based on a maximum one hour exposure. $PM_{2.5}$ concentrations are based on annual average exposures. The ability to assess air quality using the most appropriate effects-based averaging time means the refined air dispersion models provide a more representative assessment of health and environmental impacts of air emissions from a plant.

In addition to enabling the use of appropriate model averaging times, refined models allow the input of project-specific conditions such as variable source emission rates and hours of operation, to more accurately assess the concentrations over different averaging times. That is, a source that operates only during certain hours of the day can be modeled using only those hours of meteorological data. The averaging time should also reflect the time during which a receptor would be exposed. For example, suppose a construction project that is anticipated to start in 2010 and complete at the end of 2012 is projected to house new residents in 2013. The construction analysis should be performed for two years and compared to the appropriate thresholds. For the residential evaluation, the anticipated air concentrations from roads should be reflective of 2013 for $PM_{2.5}$, diesel exhaust, and acute hazard while the long term cancer exposures should be averaged over 2013 to 2083 (70 year exposure period).

4.1.4 Terrain

Terrain elevation is defined as the elevation relative to the facility base elevation. Terrain elevations can have a large impact on the air dispersion and deposition modeling results and therefore on the estimates of potential risk and hazard to human health and the environment. The terrain type is based on the project area and can be characterized as either being simple or complex described as follows:

- Complex Terrain: the terrain elevations within 50 kilometers of the stack are above the top of the source stack being evaluated in the air modeling analysis (see Figure 17).

- Simple Terrain: the terrain elevations within 50 kilometers of the stack are below the top of the source stack being evaluated in the air modeling analysis. The “Simple” terrain can be divided further into two categories:

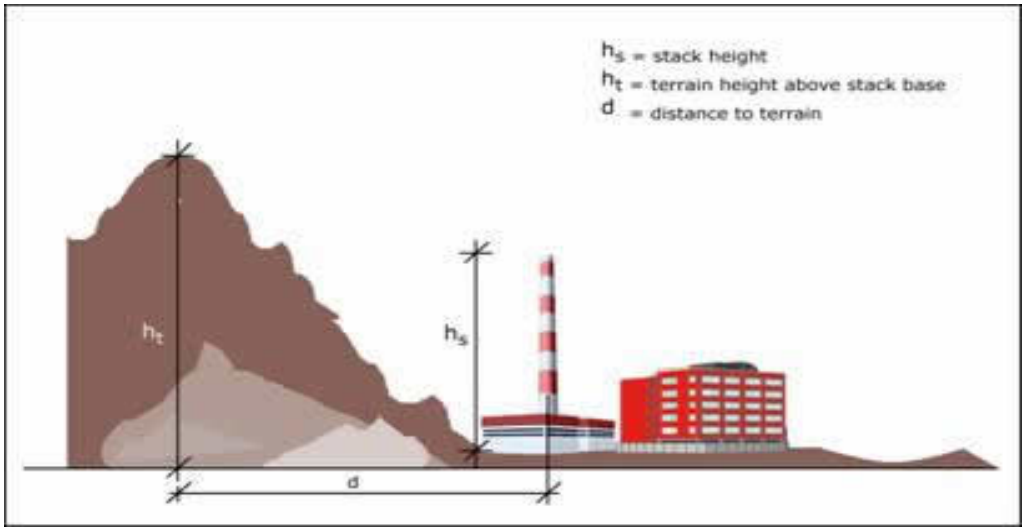
    - Simple Flat Terrain is used where terrain elevations are assumed not to exceed stack base elevation. If this option is used, then terrain height is considered to be zero meters (0.0 m).
    - Simple Elevated Terrain, as illustrated in Figure 18 is used where terrain elevations exceed stack base but are below stack height.

The identification of accurate terrain conditions is the responsibility of the user. It should be remembered that complex terrain is any terrain within the study area that is above the source release height. The appropriate terrain environment can be determined through the use of digital elevation data or other geographic data sources. Digital elevation terrain data is available from a variety of vendors in several different formats. Digital elevation model (DEM) data are available for free from Lakes Environmental's Web GIS web page http://www.webgis.com and USGS DEM files are available from CARB at http://www.arb.ca.gov/toxics/harp/maps.htm. USGS DEMs are in 7.5-minute format for use in the CARB’s HARP program and from Lakes Environmental in either 7.5 minute or 1 degree formats.

The District recommends using 7.5-minute data in air dispersion modeling rather than the coarse resolution 1 degree data. The project sponsor should also be mindful that the USGS DEMs are available in two horizontal datums. Older DEMs were commonly in NAD27 (North American

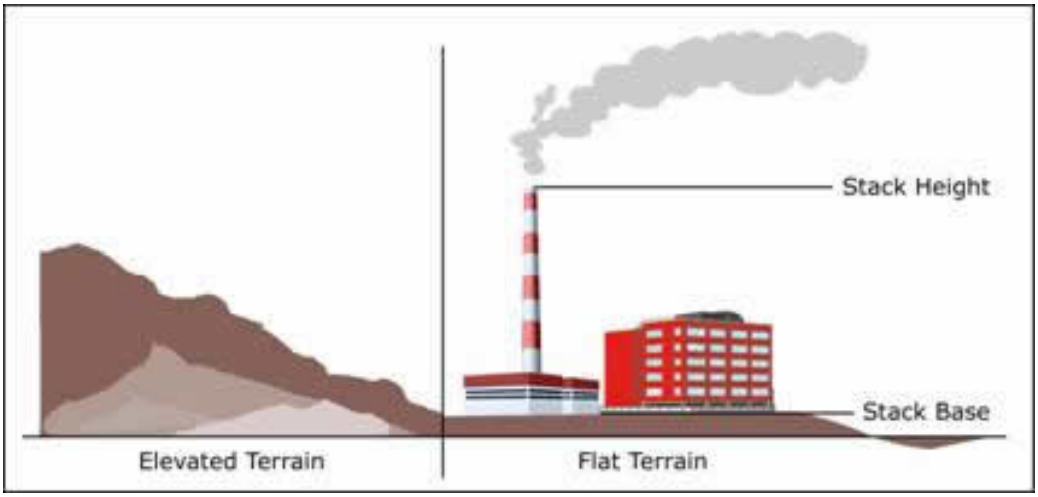
Datum of 1927) while many of the latest versions are in NAD83 (North American Datum of 1983).

Figure 17. Complex Terrain Conditions



Source: CAPCOA, 2009

Figure 18. Two Types of Simple Terrain Conditions



Source: CAPCOA, 2009

There are different requirements for importing DEMs file into refined air models. The user should review the air model's User's Manual to determine if the format is compatible or if files need to exported to another program for preprocessing (i.e., AERMAP must be used to pre-process the digital terrain data to make it compatible for AERMOD).

4.1.5 Urban or Rural Conditions

Refined modeling takes into account different types of land use categories: rural or urban. The classification of a site as urban or rural can be based on the Auer method specified in the EPA document *Guideline on Air Quality Models (40 CFR Part 51, Appendix W)*[12]. From the Auer's method, areas typically defined as Rural include:

- Residences with grass lawns and trees
- Large estates
- Metropolitan parks and golf courses
- Agricultural areas
- Undeveloped land
- Water surfaces

Auer suggests that an area can be classified as urban if it has less than 35% vegetation coverage or the area falls into one of the following use types:

Table 6. Urban Land Use

Type	Use and Structures	Vegetation
I1	Heavy industrial	Less than 5%
I2	Light/moderate industrial	Less than 5%
C1	Commercial	Less than 15%
R2	Dense single / multi-family	Less than 30%
R3	Multi-family, two-story	Less than 35%

Follow the Auer's method, explained below, for the selection of either urban or rural dispersion coefficients:

Step 1: Draw a circle with a radius of three kilometers from the center of the stack or centroid of the polygon formed by the facility stacks. Overlay a grid on top of the circle as illustrated in Figure 18.

Step 2: Identify each square as primarily being urban or rural under the land use classifications in Table 4. If over 50% of all the squares within the circle are I1, I2, C1, R2, and R3, then the area is classified as urban, otherwise the area is classified as rural.

Another approach to selecting the urban versus rural classification is to use the Population Density Procedure where the average population density, p, per square kilometer is determined.

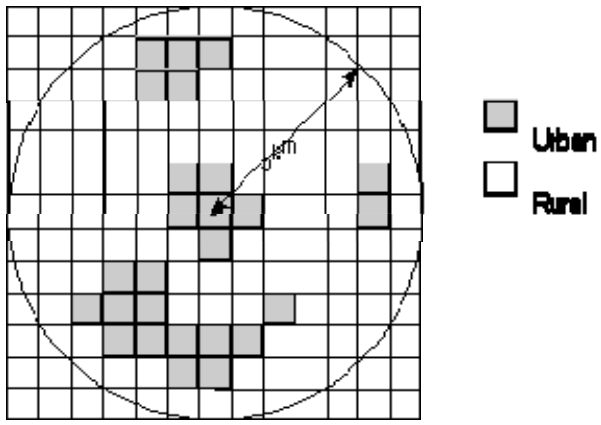
- If $p > 750$ people/km^2, select the Urban option,

[12] U.S. Environmental Protection Agency, 2001. Appendix W to Part 51 Guideline on Air Quality Models, 40 CFR Part 51. U. S. Environmental Protection Agency, Research Triangle Park, NC.

- If p <= 750 people/km^2, select the Rural option.

Of the two methods above, the land use procedure is considered a more definitive criterion. The population density procedure should be used with caution and should not be applied to highly industrialized areas where the population density may be low and thus a rural classification would be indicated, but the area is sufficiently built-up so that the urban land use criteria would be satisfied. In this case, the classification should be urban and urban dispersion parameters should be used. For simplicity, the project sponsor can model both urban and rural land uses and use the most conservative concentrations predicted from the two analyses. In most cases, the rural conditions will produce the highest downwind concentrations.

Figure 18. Example of How to Determine Land Use Designation



Source: CAPCOA, 2009

4.1.6 Building Impacts

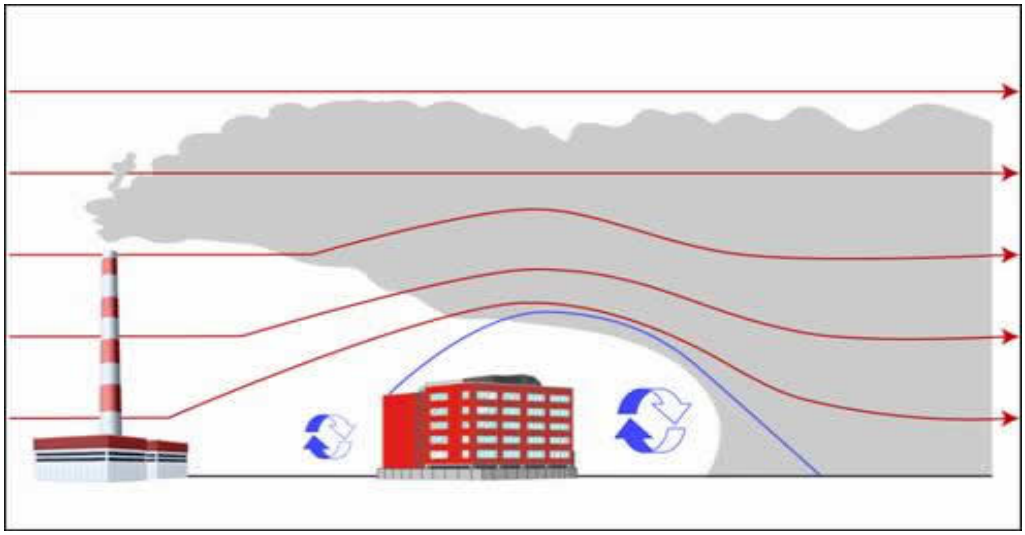
Buildings and other structures near a relatively short stack can have a substantial effect on plume transport and dispersion, and on the resulting ground-level concentrations that are observed. When the airflow meets a building (or other obstruction), it is forced up and over the building. On the lee side of the building, the flow separates, leaving a closed circulation containing lower wind speeds. Farther downwind, the air flows downward again. In addition, building increases the amount of *wind shear* and, as a result, more turbulence, such *as turbulent wake zone* (see Figure 19).

If a plume gets caught in the *cavity* caused by buildings, very high concentrations can result. If the plume escapes the cavity, but remains in the turbulent wake, it may be carried downward and dispersed more rapidly by the turbulence. This can result in either higher (reduced mixing) or lower concentrations (enhanced mixing) than would occur without the building, depending on whether the reduced height or increased turbulent diffusion has the greater effect.

There has long been a “rule of thumb” that a stack should be at least 2.5 times the height of adjacent buildings. This is called the “good engineering practice” (GEP) stack height. The US

EPA[13] states that "If stacks for new or existing major sources are found to be less than the height defined by the US EPA's refined formula for determining GEP height, then air quality impacts associated with cavity or wake effects due to the nearby building structures should be determined."

Figure 19. Dispersion Pattern due to Building Downwash



Source: CAPCOA, 2009

The US EPA's refined formula for determining GEP stack height is:

GEP Stack Height = H + 1.5L

where,

GEP = Good Engineering Practice

H = Building/Tier Height measured from ground to the highest point

L = Lesser of the Building Height (PB) or Projected Building Width (PBW)

US EPA recommends evaluating building downwash only when the building is considered sufficiently close to a stack to cause wake effects. Building effects should only be considered when the distance between the stack and the nearest part of the building is less than or equal to five (5) times the lesser of the building height or the projected width of the building.

$$\text{Distance}_{\text{stack-bldg}} <= 5L$$

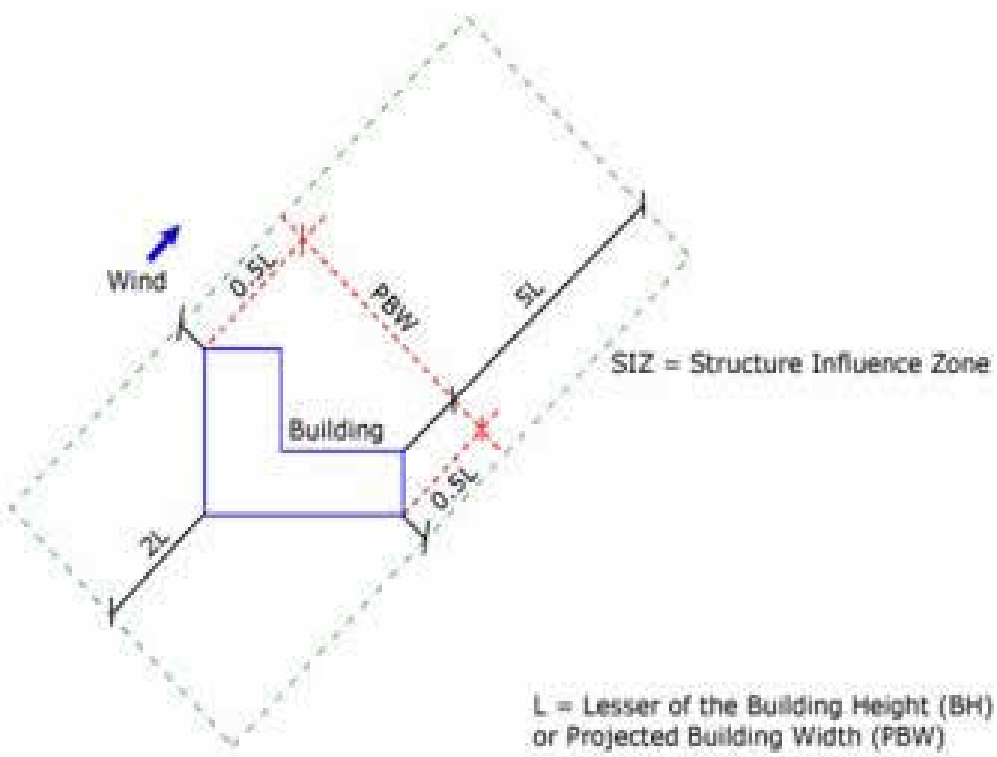
The user can use algorithms in US EPA's Building Profile Input Program – Plume Rise Model Enhancements (BPIP-PRIME) to estimate the directional-specific building heights and widths. For downwash analyses with direction-specific building dimensions, wake effects are assumed to occur if the stack is within a rectangle composed of two lines perpendicular to the wind

[13] U.S. Environmental Protection Agency, 1990. Stack Heights, Section 123, Clean Air Act, 40 CFR Part 51. U. S. Environmental Protection Agency, Research Triangle Park, NC.

direction, one at 5L downwind of the building and the other at 2L upwind of the building, and by two lines parallel to the wind direction, each at 0.5L away from each side of the building, as shown below. L is the lesser of the height or projected width. This rectangular area has been termed a Structure Influence Zone (SIZ). Any stack within the SIZ for any wind direction is potentially affected by GEP wake effects for some wind direction, or range of wind directions (see Figures 20 and 21).

It is the responsibility of the user to identify whether any building in the vicinity of the project meet the GEP requirements and building downwash effects should be considered. The recommended refined models incorporate algorithms to handle building downwash. The screening model, SCREEN3, considers the effects of a single building and the user is prompted to enter the building height, minimum horizontal building dimension, and maximum horizontal building dimension in meters. If using automated distances or discrete distances option in the SCREEN3 model, wake effects are included in the calculations. Cavity calculations are made for two building orientations, first with the minimum horizontal building dimension along wind, and second with the maximum horizontal dimension along wind. For more information regarding the cavity calculations, the user is referred to Section 3.6 of the SCREEN3 User's Guide[15] Section 3.6 (or see Section 3.2).

Figure 20. GEP 5L and Structure Influence Zone (SIZ) Areas of Influence



Source: CAPCOA, 2009.

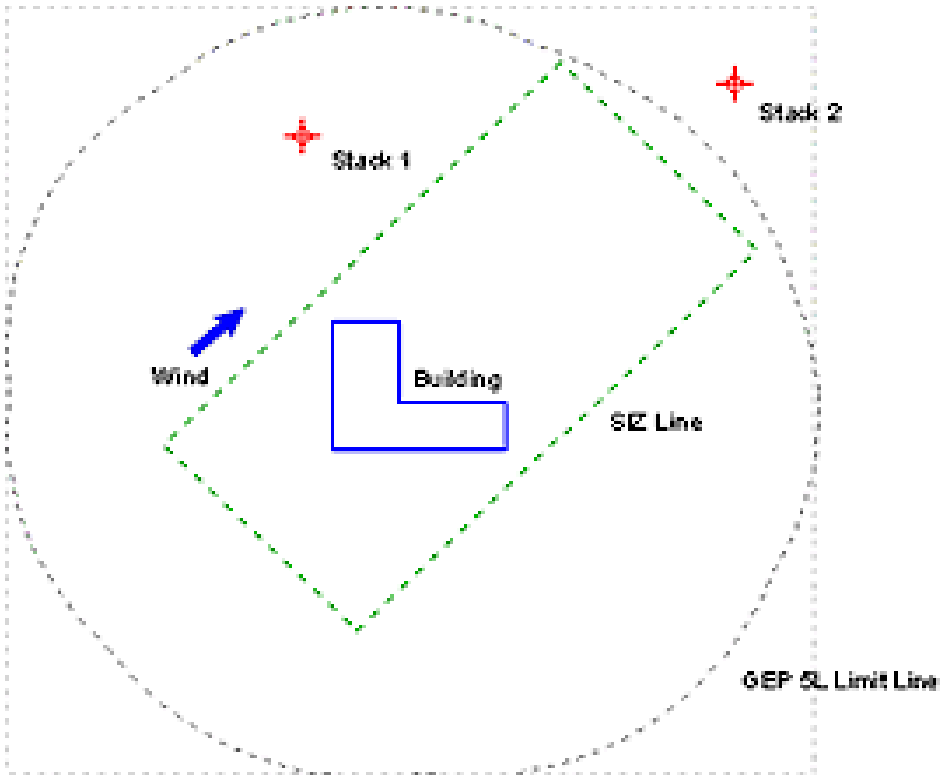
[15] U.S. Environmental Protection Agency, 1995. SCREEN3 Model User's Guide. EPA-454/B-95-004. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

The more refined models (such as AERMOD and ISCST3/ISC-PRIME) can model the effects of complicated sites consisting of up to hundreds of buildings. The inclusion of the PRIME (Plume Rise Model Enhancements) algorithm[16] to compute building downwash produces more accurate results. The following information is required to perform building downwash analysis within BPIP:

- X and Y location for all stacks and building corners.
- Height for all stacks and buildings (meters). For building with more than one height or roofline, identify each height (tier).
- Base elevations for all stacks and buildings.

For a more detailed technical description of the EPA BPIP-PRIME model see the Addendum to ISC3 User's Guide[17]. The BPIP User's Guide[18] provides details on how to input building and stack data to the program.

Figure 21. GEP 360° 5L and Structure Influence Zone (SIZ) Areas of Influence



Source: CAPCOA, 2009

[16] Schulman, L.L., D.G. Strimaitis and J.S. Scire, 2000: Development and evaluation of the PRIME plume rise and building downwash model. Journal of the Air & Waste Management Association, 50:378-390.

[17] Schulman, et al., 1997. Addendum - User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volume 1. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

[18] U.S. Environmental Protection Agency, 1995. User's Guide to the Building Profile Input Program, EPA-454/R-93-038, Office of Air Quality Planning and Standards, Research Triangle Park, N.C.

4.1.7 Multiple Sources

In a proposed project, multiple sources may be present, especially when modeling to evaluate cumulative impacts from all nearby sources to a receptor. When the plumes from multiple sources emerge, the plume rise can be enhanced, due to combined wake effects, and the downwind concentrations can be somewhat modified compared to summing individual simulations of the same sources. Source groups in refined models (i.e, AERMOD and ISC) enable the creation of source groups "ALL" that considered all the sources at the same time. Analysis of individual groups of sources in either model can be performed by using the SRCGROUP option. One example may be assigning each source to a separate source group to determine the maximum concentration generated by each individual source.

For screening models, only one source can be simulated at a time. For a screening model analysis, the District recommends summing the concentrations estimated from each source run to assess cumulative impacts from the proposed project.

4.2 Tier 1 SCREEN3

The District recommends the use of SCREEN3 as a first step in the screening analysis. The SCREEN3 model[19] was developed to provide an easy-to-use method of obtaining pollutant concentration estimates. The model is a single source Gaussian plume model which provides maximum ground-level concentrations from point, area, flare, and volume sources as well as concentrations in the cavity zone, and concentrations due to inversion break-up and shoreline fumigation. The SCREEN3 model is designed as a screening version of the Industrial Source Complex (ISC) model described in Tier 2. Worst-case default meteorological data is provided in the model which incorporates the full combinations of wind speeds and stability classes.

The main limitation of the model is that it only estimates concentrations from one source at a time and, consequently, the output from multiple runs must be summed if more than one source is impacting a project or receptor (i.e., sum the maximum concentration from individual source runs to determine impacts from multiple sources). The concentrations are estimated following the procedures outlined in EPA's document "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources"[20].

The SCREEN3 model can be downloaded from the US EPA web site at http://www.epa.gov/scram001/dispersion_screening.htm. A user-friendly interface is also available for SCREEN3 as a free download from Lakes Environmental web site at http://www.weblakes.com/download/us_epa.html.

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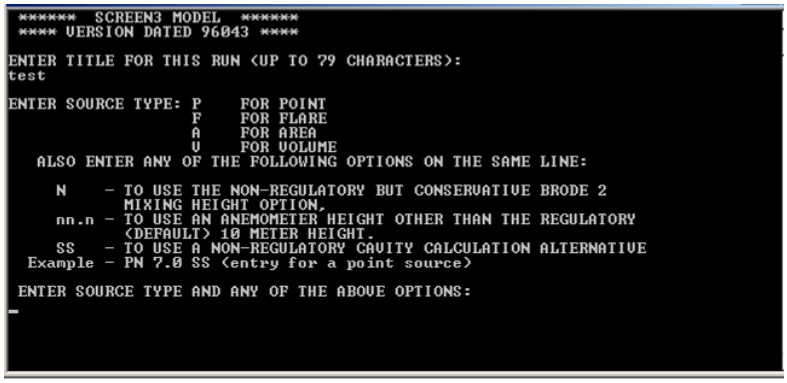
[19] U.S. Environmental Protection Agency, 1995. SCREEN3 Model User's Guide. EPA-454/B-95-004. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

[20] U.S. Environmental Protection Agency, 1992: Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised, October 1992 (EPA-450/R-92-019), User's Guide for the Industrial Source Complex (ISC2) Dispersion Models: Volume II—Description of Model Algorithms. U.S. Environmental Protection Agency, OAQPS, Research Triangle Park, NC 27711. Publication No. EPA-450/4-92-008b.

The input requirements of SCREEN3 are minimal for a screening analysis. Refined models such as ISC, AERMOD, and CAL3QHCR discussed in the Section 4.3, require much more site-specific information allowing for greater characterization and more representative results. To perform a modeling study using SCREEN3, the user must first identified the type of sources to be modeled. As shown in Figure 22, the SCREEN3 can model a point, flare, area, or volume source. For modeling flare sources, the District recommends consulting CAPCOA's Health Risk Assessments for Proposed Land Use Projects (July 2009). Based on the type of source selected, the user will enter the physical and emissions characteristics that includes the emissions rates, stack heights, etc. The model also allows for inputs on meteorological conditions, building downwash, terrain, and fumigations. The most commonly used options are discussed in further detail below.

The District is in the processes of developing a database that contains modeling parameters for some permitted gasoline dispensing facilities, crematoriums, dry cleaners, and prime and back-up diesel generators. Until this information becomes available via the District web site, users should contact the District's Planning Division to obtain such parameters for permitted sources.

Figure 22. Source Types Modeled in SCREEN3



4.2.1 Point Sources

A point source is a single, identifiable source of air emissions. Point sources are typically used when modeling releases from sources like stacks and isolated vents. Typically, vents from gas dispensers at gasoline stations, vent stack from dry cleaner using perchloroethylene, diesel prime and backup generators, boilers, coffee roasters, cremetariums, paint strippers, tanks, and soil extraction units are modeled as point emissions. Each of these sources are a single point where emissions are released into the atmosphere and in some cases, the outlet may be located on the roof of the building while the source itself is located at ground level, such is the case for most diesel back-up generators. Input requirements for point sources in SCREEN3 include:

- **Emission Rate** [g/sec]: The emission rate of the pollutant.
- **Stack Height** [m]: The stack height above ground.
- **Stack Inside Diameter** [m]: The inner diameter of the stack.

- **Stack Gas Exit Velocity** [m/s] or Stack Gas Exit Flow Rate [m3/s]: Either the stack gas exit velocity or the stack gas exit flow rate should be given. The exit velocity can be determined from the following formula:

  $Vs = 4*V/(\pi*(d_s\text{^}2))$

  Where,

  V_s = Exit Velocity
  V = Flow Rate
  d_s = Stack Inside Diameter

- **Stack Gas Temperature** [K]: The temperature of the released gas in degrees Kelvin.
- **Ambient Air Temperature** [K]: The average atmospheric temperature (K) in the vicinity of the source. If no ambient temperature data are available, assume a default value of 293 degrees Kelvin (K). For non-buoyant releases, the user should input the same value for the stack temperature and ambient temperature.

4.2.2 Area Source

An area source is a two-dimensional source of diffused air pollutant emissions such as a landfill, storage pile, slag dump, and lagoon. SCREEN3 allows definition of a rectangular area, aligned with the north-south axes while area sources selected in the more complex models have the ability to handle other shapes and can be rotated relative to the north-south axis. The District typically models emissions from landfills as an area source.

- **Emission Rate** [g/(s-m^2)]: The emission rate of the pollutant. The emission rate for area sources is input as an emission rate per unit area (g/(s-m^2)).
- **Source Release Height** [m]: The source release height above ground.
- **Longer Side Length of Rectangular Area** [m]: The longer side of the rectangular source in meters.
- **Shorter Side Length of Rectangular Area** [m]: The shorter side of the rectangular source in meters.
- **Receptor Height Above Ground** [m or ft]: This may be used to model impacts at “flagpole” receptors where the receptor is located above ground level, e.g., to represent the roof or second story of a building. The default value is assumed to be 0.0 m (i.e., ground-level receptors), but the user may enter 1.5 meter to represent the height of an average adult.
- **Wind Direction Search Option**: Since the concentration at a particular distance downwind from a rectangular area is dependent on the orientation of the area relative to the wind direction, the SCREEN model provides the user with two options for treating wind direction. The regulatory default option is “yes” which results in a search of a range of wind directions (see Section 4.2.4 for more details).

4.2.3 Volume Source

A volume source is a three-dimensional source of diffuse air pollutant emissions that is used to model releases from a variety of industrial sources, such as building roof monitors, fugitive leaks

from an industrial facility, multiple vents, conveyor belts, and roads. Another example would be the emissions from an automobile paint shop with multiple roof vents or multiple open windows. Typically, the District uses the volume source option to model emissions from gas dispensers at gasoline stations, vehicle emissions from roadways, and fugitive emissions from dry cleaners that use perchloroethylene. Default parameters for gasoline stations are described in Section 4.3.2. Parameters required to model volume source include:

- **Emission Rate** [g/sec]: The emission rate of the pollutant in grams per second (g/s).
- **Source Release Height** [m]: The source release height above ground surface at the center of the volume.
- **Initial Lateral Dimension** [m]: See Table 5 for guidance on determining initial dimensions. Units are meters.
- **Initial Vertical Dimension** [m]: See Table 5 below for guidance on determining initial dimensions. Units are meters.
- **Receptor Height Above Ground** [m or ft]: This may be used to model impacts at "flagpole" receptors where the receptor is located above ground level, e.g., to represent the roof or second story of a building. The default value is assumed to be 0.0 m (i.e., ground-level receptors), but the user may enter 1.5 meter to represent the height of an average adult.

Table 7. Recommended Procedures for Estimating Dimensions of Volume Sources

Type of Source	Procedure for Obtaining Initial Dimension
Initial Lateral Dimension ($_{yo}$)	
Single Volume Source	S_{yo} = (side length)/4.3
Line Source (Represented by Adjacent Volume Sources)	S_{yo} = (side length)/2.15
Line Source (Represented by Separated Volume Sources)	S_{yo} = (center to center distance)/2.15
Initial Vertical Dimension ($_{zo}$)	
Surface-Based Source ($h_e \sim 0$)	S_{zo} = (vertical dimension of source)/2.15
Elevated Source ($h_e > 0$) on or Adjacent to a Building	S_{zo} = (building height)/2.15
Elevated Source ($h_e > 0$) not on or Adjacent to a Building	S_{zo} = (vertical dimension of source)/4.3

4.2.4 Meteorology

Meteorology plays an important role in determining the downwind concentration. Not only does the meteorology (i.e, prevailing wind direction) determine the location of the highest impacted receptor, it also determines the concentration. The amount of turbulence in the atmosphere increases the entrainment and mixing of unpolluted air into the plume and thereby acts to reduce the concentration of pollutants in the plume (i.e, enhances the plume dispersion). The amount of atmospheric turbulence is categorized into six stability classes: A, B, C, D, E and F. Class A is the most unstable, or most turbulent, class, and class F the most stable, or least turbulent, class. Table 8 lists the six classes and Table 9 provides the meteorological conditions that define each class.

Table 8. Stability Classes

Stability class	Definition	Stability class	Definition
A	very unstable	D	Neutral
B	Unstable	E	slightly stable
C	Slightly unstable	F	Stable

Table 9. Meteorological Conditions that Define Each Stability Class

Surface windspeed		Daytime incoming solar radiation			Nighttime cloud cover	
m/s	mi/h	Strong	Moderate	Slight	> 50%	< 50%
< 2	< 5	A	A – B	B	E	F
2 – 3	5 – 7	A – B	B	C	E	F
3 – 5	7 – 11	B	B – C	C	D	E
5 – 6	11 – 13	C	C – D	D	D	D
> 6	> 13	C	D	D	D	D

SCREEN3 allows the user to either select a combination of stability class and wind speeds or input a single stability class and wind speed combination. Each option is described as:

- *Full Meteorology (All Stability Classes and Wind Speeds):* uses a combination of all six stability classes (five for urban sources) and their associated wind speeds to identify the "worst case" meteorological conditions, i.e., the combination of wind speed and stability that results in the maximum ground level concentrations.

- *Single Stability Class:* uses a selected stability class to be used (A through F) with a range of wind speeds to determine ground level concentrations.

- *Single Stability Class and Wind Speed:* uses a selected stability class and wind speed to estimate the ground level concentrations.

The District recommends running the SCREEN3 model using the full meteorological data. The user should be aware that SCREEN3 provides the maximum one hour concentrations at each receptor locations. The one hour concentrations are then multiplied by 0.1 to convert to annual concentrations for comparison to the thresholds. For using the annual average conversion factor, SCREEN3 must be run using the full meteorological dataset.

4.2.5 Additional Parameters

SCREEN3 model also considers building downwash, terrain heights, and fumigation effects. The building downwash option is only applicable to point and flare source types. Downwash occurs when the aerodynamic turbulence induced by nearby buildings cause a pollutant emitted from an elevated source to be mixed rapidly toward the ground (downwash), resulting in higher ground-level concentrations. The user must input the building dimensions (height, length, and width) to use this option.

SCREEN3 supports flat, elevated and complex terrain (see Section 4.1.4 for more information). If the simple flat terrain is selecting, the terrain heights must not exceed stack base elevation. In most cases, the terrain height is considered at ground level (0 meters). In a simple elevated terrain where the terrain heights exceed the stack base but are below stack height, the terrain height above stack base should be entered. If elevated or complex terrain is used, distance and terrain heights must be provided.

The last option available through SCREEN3 is fumigation. Fumigation occurs when a plume that was originally emitted into a stable layer is mixed rapidly to ground level when unstable air below the plume reaches plume level. The fumigation option is only available for point and flare source types if:

- The rural dispersion coefficient was selected (for rural inland sites), and
- The stack height >= 10 meters

The fumigation option can also be used to model shoreline fumigation effects by entering the distance to the shoreline.

4.3 Tier 2 Complex Model Input Data

More refined modeling is recommended for projects in which the screening analysis exceeds the thresholds or a more site specific characterization is required because it is complex with multiple sources. Refined models such as ISC, AERMOD, and CAL3QHCR require much more site-specific information, but yields greater characterization of the project and more representative results.

4.3.1 Recommended Models

The recommended models for use in refined modeling analysis include:

Refined Models:
- ISCST3 and
- AERMOD

Roadway Model:
- CAL3QHCR

Both ISC and AERMOD follow similar modeling methodologies for conducting air dispersion analysis. The primary differences are the preprocessors used to develop the meteorological data and the terrain elevations. The District already processes meteorological data from numerous stations throughout the Bay Area in ISC-compatible format (available on-line at http://hank.baaqmd.gov/tec/data/). At this time, only a limited number of stations have AERMET processed data; though such data can be requested from the District through a public records request. (Public records requests for AERMET-processed data can be made online at http://www.baaqmd.gov/Divisions/Legal/Public-Records-Request.aspx.) Both ISC and AERMOD include non-regulatory options; however, at this time, the District is recommending that all regulatory options be selected for conducting CEQA evaluations.

Alternative models may be used; however, the user should consult with the lead agency to ensure that conditions warrant their use. A brief overview of each of the recommended models is provided below.

Industrial Source Complex (ISC)

The Industrial Source Complex – Short Term (ISCST3) dispersion model is a steady-state Gaussian plume model, which can be used to assess pollutant concentrations and/or deposition fluxes from a wide variety of sources including volume, point, and area sources. The ISCST3 dispersion model from the U.S. EPA was designed to support the EPA's regulatory modeling options, as specified in the Guidelines on Air Quality Models (Revised)[21]. The model also accepts pre-processed site-specific meteorological data that is available through the District web site at: http://hank.baaqmd.gov/tec/data/.

The ISC models requirements include:

- Meteorological Data Processing - PCRAMMET or District provided preprocessed data
- Obtain Digital Terrain Elevation Data (If terrain is being considered)
- Building Downwash Analysis (BPIP-PRIME) – Project requires source and building information

[21] U.S. Environmental Protection Agency, 1986. Guidelines on Air Quality Models (Revised) and Supplement A. EPA-450/2-78-027R. U.S. Environmental Protection Agency, Research Triangle Park, NC.

- Final site characterization – complete source and receptor information
- ISC – Run the ISC model.
- Visualize and analyze results.

Unlike AERMOD (described in below), the ISC models do not contain a terrain pre-processor. As a result, receptor elevation data must be obtained through alternative means. The use of an inverse distance algorithm for interpolating representative receptor elevations is an effective method. The ISC model can be downloaded from US EPA web site at http://www.epa.gov/scram001/dispersion_alt.htm.

AERMOD

The American Meteorological Society/EPA Regulatory Model Improvement Committee (AERMIC) Regulatory Model, AERMOD[22,23,24] was specially designed to support the U.S. EPA's regulatory modeling programs. AERMOD is the next-generation air dispersion model that incorporates concepts such as planetary boundary layer theory and advanced methods for handling complex terrain. AERMOD was developed to replace the Industrial Source Complex Model-Short Term (ISCST3) as U.S. EPA's preferred model for most small-scale regulatory applications.[25,26] AERMOD can be downloaded from the US EPA web site at http://www.epa.gov/scram001/dispersion_prefrec.htm.

The AERMOD program is comprised of three programs: (1) AERMET – preprocessor for making compatible meteorological data sets, (2) AERMAP - preprocessor for digital terrain data, and (3) AERMOD – air dispersion model. Files generated from AERMET and AERMAP are then read by AERMOD in estimating downwind concentrations. Steps for using AERMOD are as follows:

- Meteorological Data Processing (AERMET is used for this)
- Obtain Digital Terrain Elevation Data (If terrain is being considered)

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[22] U.S. Environmental Protection Agency, 1998. Revised Draft - User's Guide for the AMS/EPA Regulatory Model – AERMOD. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

[23] Paine, R.J., R.W. Brode, R.B. Wilson, A.J. Cimorelli, S.G. Perry, J.C. Weil, A. Venkatram, W.D. Peters and R.F. Lee, 2003. AERMOD: The Latest Features and Evaluation Results. Paper # 69878 presented at the Air and Waste Management Association 96th Annual Conference and Exhibition, June 22-26, 2003. Air and Waste Management Association, Pittsburgh, PA 15222.

[24] Cimorelli, A.J., S.G. Perry, A. Venkatram, J.C. Weil, R.J. Paine, R.B. Wilson, R.F. Lee, W.D. Peters, R.W. Brode, J.O. Paumier, 2002: AERMOD: Description of Model Formulation. U.S. Environmental Protection Agency, EPA-454/R-02-002d (draft dated October 31, 2002). Available from http://www.epa.gov/scram001.

[25] U.S. Environmental Protection Agency, 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models (Revised), Volume 1. EPA-454/B-95-003a. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

[26] U.S. Environmental Protection Agency, 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volume II – Description of Algorithms. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. Available from website http://www.epa.gov/scram001 as of January 2003.

- Building Downwash Analysis (BPIP-PRIME is used for this) – Project requires source and building information
- Final site characterization – complete source and receptor information
- AERMAP – Perform terrain data pre-processing for AERMOD air dispersion model if required.
- AERMOD – Run the model.
- Visualize and analyze results.

Overall, AERMOD was designed to be the next generation model that builds on the formats already established in the ISC models. ISC and AERMOD are both steady state plume models and the input and output files are similar.

CAL3QHCR

CAL3QHCR is a refined version of the original CALINE (California Line Source Dispersion Model) that was developed as a modeling tool to predict roadside PM or CO concentrations. The model is designed to estimate total air pollutant concentrations from highways from both moving and idling vehicles. The model can process a full year of hourly meteorological data and incorporate emissions, traffic, and signalization data for each hour of a week. The model can be obtained from EPA at http://www.epa.gov/scram001/dispersion_prefrec.htm.

Refined models such as ISC, AERMOD, and CAL3QHCR have many input options, and are described further throughout this document as well as in their respective technical documents[27,28,29,30]. Both ISC and AERMOD support a variety of source options similar to SCREEN3. For each type of sources, the requirements are identical for ISC and AERMOD regardless of the model being used. The following section outlines the inputs required for each source type. Detailed descriptions on the input fields for these models can be found in supporting documents for ISC[31,32] and for AERMOD[33]. The CAL3QHCR model is a roadway

[27] Cimorelli, A.J., S.G. Perry, A. Venkatram, J.C. Weil, R.J. Paine, R.B. Wilson, R.F. Lee, W.D. Peters, R.W. Brode, J.O. Paumier, 2002: AERMOD: Description of Model Formulation. U.S. Environmental Protection Agency, EPA-454/R-02-002d (draft dated October 31, 2002). Available from http://www.epa.gov/scram001.

[28] U.S. Environmental Protection Agency, 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models (Revised), Volume 1. EPA-454/B-95-003a. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

[29] U.S. Environmental Protection Agency, 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volume II – Description of Algorithms. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. Available from website http://www.epa.gov/scram001 as of January 2003.

[30] U.S. Environmental Protection Agency, 1997. Addendum to ISC3 User's Guide – The Prime Plume Rise and Building Downwash Model. Submitted by Electric Power Research Institute. Prepared by Earth Tech, Inc., Concord, MA.

[31] U.S. Environmental Protection Agency, 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models (Revised), Volume 1. EPA-454/B-95-003a. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

[32] U.S. Environmental Protection Agency, 1997. Addendum to ISC3 User's Guide – The Prime Plume Rise and Building Downwash Model. Submitted by Electric Power Research Institute. Prepared by Earth Tech, Inc., Concord, MA.

model and is not designed to model other types of sources such as point and volumes sources typically used in AERMOD and ISC. However, the other models can model roadways in additional to various other types of sources. For this reason, discussions on the CAL3QHCR input are presented in the roadway modeling section 4.3.3.

The user is not required to complete the screening tables or SCREEN3 analysis prior to conducting a refined analysis. An overview of the modeling approach and general steps for using each refined model are provided below.

4.3.2 Stationary Source Types

POINT SOURCES

Point sources are generally used to model emissions from stacks or vents. Typically, vents from gas dispensers at gasoline stations, vent stack from dry cleaner using perchloroethylene, diesel prime and backup generators, boilers, coffee roasters, cremetariums, paint strippers, tanks, and soil extraction units are modeled as point emissions. Each of these sources are a single point where emissions are released into the atmosphere and in some cases, the outlet may be located on the roof of the building while the source itself is located at ground level, such is the case for most diesel back-up generators. The data required to model point source include:

- **Source ID**: An identification name for the source being defined, up to 8 characters in length.
- **X Coordinate**: The x (east-west) coordinate for the source location in meters (center of the point source).
- **Y Coordinate**: Enter here the y (north-south) coordinate for the source location in meters (center of the point source).
- **Base Elevation** [m]: The source base elevation. The model only uses the source base elevation if elevated terrain is being used.
- **Release Height above Ground** [m]: The source release height above the ground in meters.
- **Emission Rate** [g/sec]: The emission rate of the pollutant in grams per second.
- **Stack Gas Exit Temperature** [K]: The temperature of the released gas in degrees Kelvin.
- **Stack Gas Exit Velocity** [g/sec]: The stack gas exit velocity in meters per second or the stack gas flow rate. The exit velocity can be determined from the following formula:

  $$\mathbf{Vs = 4*V/(\pi*(d_s\text{^}2))}$$

  Where,

  V_s = Exit Velocity
  V = Flow Rate
  d_s = Stack Inside Diameter

- **Stack Inside Diameter** [m]: The inner diameter of the stack.

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[33] Cimorelli, A.J., S.G. Perry, A. Venkatram, J.C. Weil, R.J. Paine, R.B. Wilson, R.F. Lee, W.D. Peters, R.W. Brode, J.O. Paumier, 2002: AERMOD: Description of Model Formulation. U.S. Environmental Protection Agency, EPA-454/R-02-002d (draft dated October 31, 2002). Available from http://www.epa.gov/scram001.

The District is developing a database containing some of the modeling parameters for gasoline dispensing facilities, dry cleaners, and prime and back-up diesel generators. Until the data becomes available through the District web site, users can contact the District's Planning Division for more information.

AREA SOURCES

An area source is a two-dimensional source of air pollutant emissions, used for modeling sources such as a landfill, storage pile, slag dump, or lagoon. The District typically models emissions from landfills as an area source. Area source modeling can also be used to simulate emissions from roadways although they are more commonly modeled as volume sources. Discussion on how to address roadway emissions using ISC or AERMOD is presented in Section 4.3.4. The parameters required to model area sources include:

- **Source ID**: An identification name for the source being defined, up to 8 characters in length.
- **X Coordinate**: The x (east-west) coordinate for the vertex (corner) of the area source that occurs in the southwest quadrant of the source. Units are in meters.
- **Y Coordinate**: The y (north-south) coordinate for the vertex (corner) of the area source that occurs in the southwest quadrant of the source. Units are in meters.
- **Base Elevation** [m]: The source base elevation. The model only uses the source base elevation if elevated terrain is being used. The default unit is meters.
- **Release Height above Ground** [m]: The release height above ground in meters. The ISC and AERMOD models can estimate concentrations from receptors located within the area source by integrate only the portion of area that is upwind of the receptor. However, the District does not recommend placement of receptors within the area source since concentrations may be underestimated by not accounting for emissions emitted directly beneath the receptor.
- **Emission Rate** [g/(s-m^2)]: Enter the emission rate of the pollutant. The emission rate for area sources is input as an emission rate per unit area. The same emission rate is used for both concentration and deposition calculations.
- Options for Defining Area: In ISC, the shape of the area source must be a rectangle or square. The maximum length/width aspect ratio for area sources is 10 to 1. If this is exceeded, then the area should be divided to achieve a 10 to 1 aspect ratio (or less) for all sub-areas. See ISC Documentation[34] for more details on inputting area data. In addition to the rectangular area, AERMOD can have circular or polygon areas defined (see AERMOD documentation[35] for details).

[34] U.S. Environmental Protection Agency, 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models (Revised), Volume 1. EPA-454/B-95-003a. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

[35] Cimorelli, A.J., S.G. Perry, A. Venkatram, J.C. Weil, R.J. Paine, R.B. Wilson, R.F. Lee, W.D. Peters, R.W. Brode, J.O. Paumier, 2002: AERMOD: Description of Model Formulation. U.S. Environmental Protection Agency, EPA-454/R-02-002d (draft dated October 31, 2002). Available from http://www.epa.gov/scram001.

The District recommends submitting a public records request to receive emissions estimates and modeling parameters for permitted landfills.

VOLUME SOURCES

A volume source is a three-dimensional source of diffuse air pollutant emissions that is used to model releases from a variety of industrial sources. The District uses the volume source option to model emissions from gas dispensers at gasoline stations, vehicle emissions from roadways, and fugitive emissions from dry cleaners that use perchloroethylene. Parameters required to model volume source include:

- **Source ID**: An identification name for the source being defined, up to 8 characters in length.
- **X Coordinate**: The x (east-west) coordinate for the source location in meters. This location is the center of the volume source.
- **Y Coordinate**: The y (north-south) coordinate for the source location in meters. This location is the center of the volume source.
- **Base Elevation** [m]: The source base elevation. The model only uses the source base elevation if elevated terrain is being used. The default unit is meters.
- **Release Height above Ground** [m]: The release height above ground surface in meters (center of volume).
- **Emission Rate** [g/s]: The emission rate of the pollutant in grams per second. The same emission rate is used for both concentration and deposition calculations.
- **Length of Side** [m]: The length of the side of the volume source in meters. The volume source cannot be rotated and has the X side equal to the Y side (square).
- **Building Height** (If On or Adjacent to a Building) [m]: If the volume source is elevated and is on or adjacent to a building, then specify the building height. The building height can be used to calculate the Initial Vertical Dimension of the source. Note that if the source is surface-based, then this is not applicable.
- **Initial Lateral Dimension** [m]: This parameter is calculated by choosing the appropriate condition in Table 5 in Section 4.3.3. This table provides guidance on determining initial dimensions. Units are in meters.
- **Initial Vertical Dimension** [m]: This parameter is calculated by choosing the appropriate condition in Table 5 in Section 4.3.3. This table provides guidance on determining initial dimensions. Units are in meters.

Refueling emission and spillage from gas dispensing stations at gas stations and fugitive emissions from dry cleaning machines are modeled as volume sources by the District. For gas dispensing stations, the horizontal and vertical dimensions represent the actual shape of the dispenser. The release height when modeling emissions from refueling is the height of the hose nozzle. For emissions related to spillage, the horizontal and vertical dimensions are the same as when modeling refueling emissions except that the release height is set as zero (ground floor release). To simply the method, the District also collected information from over 450 stations and have consolidated the data to provide general default parameters for modeling in cases where only the number of dispensers are known. The average height of dispenser is approximately 7.3 feet and the initial vertical dimension is 3.4 feet (7.3 feet divided by model factor 2.15). The

lateral dimension is related to the number of dispensers at the gas station. Based on the survey responses sent out by the District, the lateral dimension (L) is equal to:

$$L = -0.0129 \times n^2 + 1.0845 \times n + 2.3943$$

Where:
L = lateral dimension (feet)
n = number of gasoline dispensers

For example, for a station that has five dispensers, the initial lateral dimension is 7.5 feet.

For the dry cleaner, most of the emissions are released through the vent stack; however, a small fraction of emissions are released from the dry cleaning machine as fugitive emissions. To model these fugitive emissions, the District recommends using the dimensions of the room that houses the machine. For more information regarding modeling parameters, contact the District's Planning Division.

4.3.3 Roadway Sources

There are a number of air dispersion models that can be used to predict concentrations from roadway emissions. CAL3QHCR is a preferred/recommended US EPA model for roadway modeling that relies on local meteorology. Both ISC and AERMOD models can be used to model roadways as a line of volume sources (see Section 4.3.3.3) for more details). When all three models (ISC, AERMOD, and CAL3QHCR) were modeled for the same scenario[36], the concentrations predicted from all three models were consistent and consequently, any of the three models could be used effectively to predict pollutant concentrations from roadway emissions.

The first section discusses how to estimate emission rates for roads that can then be used in the refined models. The methodology for running the CAL3QHCR is presented in Section 4.3.3.2 and the following Section 4.3.3.3 presents the approach to modeling roadways using ISC and AERMOD. The step by step guidance demonstrates how to use the CAL3QHCR model to estimate $PM_{2.5}$ emissions and cancer risks from total organic gases and diesel particular matter. The example calculations are taken from CAPCOA's Health Risk Assessments for Proposed Land Use Projects. For additional guidance, consult the User's Guide to CAL3QHCR, Version 2.0 [37].

4.3.3.1 EMFAC Emissions Data

In order to model roadway impacts, the emissions and number of vehicles must be estimated on an hourly basis as input into CAL3QHCR. Caltrans does not provide hourly traffic counts. To

[36] CAPCOA. 2009. Health Risk Assessments for Proposed Land Use Projects. Prepared by CAPCOA Planning Managers. Released July 2009. Available at: http://www.capcoa.org/.
[37] User's Guide to CAL3QHC Version 2.0, EPA-454/R-92-006 (Revised, with CAL3QHCR addendum), September 1995.

obtain hourly estimates of traffic volumes used for modeling, the hourly profiles from CARB's EMFAC model can be used. The current version of EMFAC is 2007 version 2.30; however, the user is recommended to check the CARB web site at: http://www.arb.ca.gov/msei/onroad/latest_version.htm to ensure that the latest version is downloaded. The web site also contains a detailed user's manual that illustrates how to use the program. The model combines information on the type of vehicle class, number of vehicles, and distance traveled by the vehicle to estimate emissions factors for variety of pollutants including total organic gases (TOG), reactive organic gases (ROG), and $PM_{2.5}$. The vehicle fleet currently modeled is categorized into 13 classes (ranging from passenger cars to heavy duty trucks) that represent type of vehicle, weight class, and fuel types (i.e, gas, diesel, and electric) that operate on highways, freeways, and local roads in California. The number of vehicles in each class is based on an analysis of the Department of Motor Vehicles (DMV) registration data. The vehicle fleet is specific to the year and county selected.

The CAL3QHCR requires that for every roadway link the user enters hourly data on the number of vehicles per hour and the emissions per vehicle mile traveled. The user can also assume a constant value for both inputs, but the resulting $PM_{2.5}$ concentrations would be overly conservative. EMFAC provides, for each California County, an hourly profile of vehicle miles travelled (VMT) by vehicle class (cars and trucks). The total daily VMT can be used to normalize the hourly VMT by dividing each hourly value by the total VMT, which creates a diurnal scaling factor (also commonly referred to as normalization factor) for estimating hourly traffic volumes. The diurnal scaling factor is then multiplied by the AADT (from the Caltrans counts for highways or CEHTP's traffic volume spatial linkage tool for local streets) to obtain an estimate of the hourly traffic counts. Hourly emissions per vehicle mile traveled are estimated by dividing the hourly emissions from EMFAC by the corresponding hourly VMT. This process can be followed for both cars and trucks. Details for estimating each of these emissions from the EMFAC output files are provided below.

Input parameters to the EMFAC model include:

- Year: first year of project build out or when residents are living in the development. The model can estimate emissions between 1970 to 2040,
- Season: Select annual average,
- Geographic Area: select use average, San Francisco for Air Basin, and Bay Area for Air District.
- Model Years: The model years of vehicles to be used in developing the emissions for the year. Select all.
- Vehicle Class: Types of vehicle classes to be included in the emission estimates. Select all.
- I/M Program Schedule: select default.
- Mode and Output: these options allow the user to select the output format for the emissions data. The District recommends select Burden: Area planning inventory because it provides emissions data in units of tons per day.
- BURDEN inventory files: Select Detailed Planning Inventories (CSV), which will produce an emission file that is Microsoft Excel comma separated values (csv) file compatible to any spreadsheet program.
- Output Frequency: select hourly

- Output Particulate as: select $PM_{2.5}$ for comparison to applicable thresholds
- Output Hydrocarbons as: select TOG

Selecting these parameters, the EMFAC model produces an output file that contains:

- VMT/1000 for each hour,
- $PM_{2.5}$ emissions for each hour
- Total organic gas emissions for each hour

Figure 22 is a screen shot of the first page of the EMFAC Burden output file, which shows the first hour of emissions applicable to 12:00 midnight. The boxed hourly data is the data that will be used in to develop the input data for CAL3QHCR.

In this first example, the methodology is shown to estimate the $PM_{2.5}$ concentrations from all vehicles traveling on roadways. The following section shows a similar methodology for estimating cancer risk and hazard associated with diesel trucks and gasoline vehicles. It should be noted that the District recommends setting up two modeling runs to fully characterize roadway impacts: one file for $PM_{2.5}$ and organic gas emissions from all vehicles and a second file for diesel alone. The reason is that the diurnal scaling factors shown in Figure 6 for the two source groups are significantly different and will produce different results when coupled with the hourly meteorological data.

PREPARING HOURLY DATA FOR $PM_{2.5}$ ESTIMATIONS

Step 1. To develop hourly traffic count values needed by CAL3QHCR, the first step is to estimate a diurnal scaling factor that will be used to determine the number of vehicles per hour. The user must first enter the total VMT/1000 corresponding to each hour from the EMFAC output file. By reviewing the list of hourly VMT, select the highest hourly VMT count reported by EMFAC. Figure 23 shows an example. In this example, the highest hourly VMT count is 2,618,000 miles, which falls on Hour 17, 5:00 pm. Next, divide each hourly VMT value from EMFAC by the highest hourly VMT count (2,618,000 miles), resulting in a diurnal hourly scaling factors.

Step 2. The next step is to estimate the number of vehicles that travel on the roadway on hourly basis. This is accomplished by multiplying each diurnal scaling factor times the road's peak hour traffic count. The peak hour represents the highest number of vehicles that normally occurs on a weekday. The peak hour traffic count nearest to the proposed receptors should be used. The peak hour traffic count is available on Caltrans's website at http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/index.htm. The user should select *back peak* hour for projects south or west of the nearest milepost location. For projects north or east of the nearest milepost location, select *ahead peak* hour. Table 8 provides an example calculation where the diurnal scaling factors from Figure 18 are multiplied by the peak hour of 11,900 vehicles per hour. It should be noted that peak hour of traffic should match the exact time in which the highest VMT occurs (for this example, it is hour 17 at 5:00 pm). In addition, the sum of all the hourly counts should approximately equal the AADT for the roadway.

Figure 22. Example Scenario EMFAC Output for Estimating $PM_{2.5}$ Emissions

Title : San Francisco County Subarea Annual CYr 2012 Default Title - BUR
Version : Emfac2007 V2.3 Nov 1 2006
Run Date : 2010/04/16 09:06:50
Scen Year: 2012 -- All model years in the range 1968 to 2012 selected
Season : Annual
Area : San Francisco County
I/M Stat : Enhanced Interim (2005)
Emissions: Tons Per Hr00

	Light Duty Passenger Cars				Light Duty Trucks				Medium Duty Trucks				Heavy Duty Trucks: Gasoline Trucks			Heavy Duty Trucks: Diesel	Total HD Trucks	Urban Buses	Motor-cycles	All Vehicles
	Non-cat	Cat	Diesel	Total	Non-cat	Cat	Diesel	Total	Non-cat	Cat	Diesel	Total	Non-cat	Cat	Total	Trucks	Trucks	Buses	cycles	Vehicles
Vehicles	1667	269502	700	271869	521	115500	822	116843	61	22048	1366	23474	150	2422	2572	6035	8606	1116	14663	436572.
VMT/1000	0.	84.	0.	85.	0.	37.	0.	38.	0.	8.	3.	11.	0.	0.	0.	13.	14.	2.	1.	149.
Trips	55.	14204.	32.	14291.	17.	6076.	41.	6134.	4.	1489.	460.	1953.	37.	679.	716.	197.	913.	49.	246.	23586.
Total Organic Gas Emissions																				
Run Exh	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start Ex	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Total Ex	0.00	0.01	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.05
Diurnal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hot Soak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Running	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Resting	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Total	0.00	0.03	0.00	0.03	0.00	0.02	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.08
Carbon Monoxide Emissions																				
Run Exh	0.02	0.17	0.00	0.19	0.01	0.11	0.00	0.12	0.00	0.02	0.00	0.03	0.00	0.00	0.01	0.02	0.03	0.02	0.05	0.43
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start Ex	0.00	0.09	0.00	0.09	0.00	0.05	0.00	0.05	0.00	0.02	0.00	0.02	0.01	0.07	0.07	0.00	0.07	0.00	0.00	0.24
Total Ex	0.03	0.25	0.00	0.28	0.01	0.15	0.00	0.16	0.00	0.05	0.00	0.05	0.01	0.07	0.08	0.02	0.10	0.02	0.05	0.67
Oxides of Nitrogen Emissions																				
Run Exh	0.00	0.02	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.11	0.11	0.04	0.00	0.21
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start Ex	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Total Ex	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.01	0.01	0.02	0.00	0.01	0.01	0.11	0.12	0.04	0.00	0.22
Carbon Dioxide Emissions (000)																				
Run Exh	0.00	0.04	0.00	0.04	0.00	0.02	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.09
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start Ex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Ex	0.00	0.04	0.00	0.04	0.00	0.02	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.10
PM2.5 Emissions																				
Run Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start Ex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Ex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
TireWear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BrakeWr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Lead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SOx	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Consumption (000 gallons)																				
Gasoline	0.02	3.97	0.00	3.99	0.01	2.20	0.00	2.20	0.00	0.63	0.00	0.63	0.00	0.05	0.05	0.00	0.05	0.01	0.03	6.92
Diesel	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.15	0.15	0.00	0.00	0.00	2.03	2.03	0.44	0.00	2.62

Title : San Francisco County Subarea Annual CYr 2012 Default Title - BUR
Version : Emfac2007 V2.3 Nov 1 2006
Run Date : 2010/04/16 09:06:50
Scen Year: 2012 -- All model years in the range 1968 to 2012 selected
Season : Annual
Area : San Francisco County
I/M Stat : Enhanced Interim (2005)

Step 3. The next step is to estimate the hourly emission rates in grams per vehicle miles traveled. $PM_{2.5}$ emissions data are reported by EMFAC in tons/hour and need to be converted to grams/hour. The grams/hour values are then divided by hourly VMT (as reported by EMFAC), to obtain grams per vehicle mile per hour for input into CAL3QHCR.

For the $PM_{2.5}$ analysis, the annual average concentrations predicted from the model are directly compared to the thresholds. The $PM_{2.5}$ analysis does not use toxicity factors, exposure pathway, or exposure duration common in risk assessments. Instead, the annual average $PM_{2.5}$ concentrations predicted from the model are compared to the thresholds.

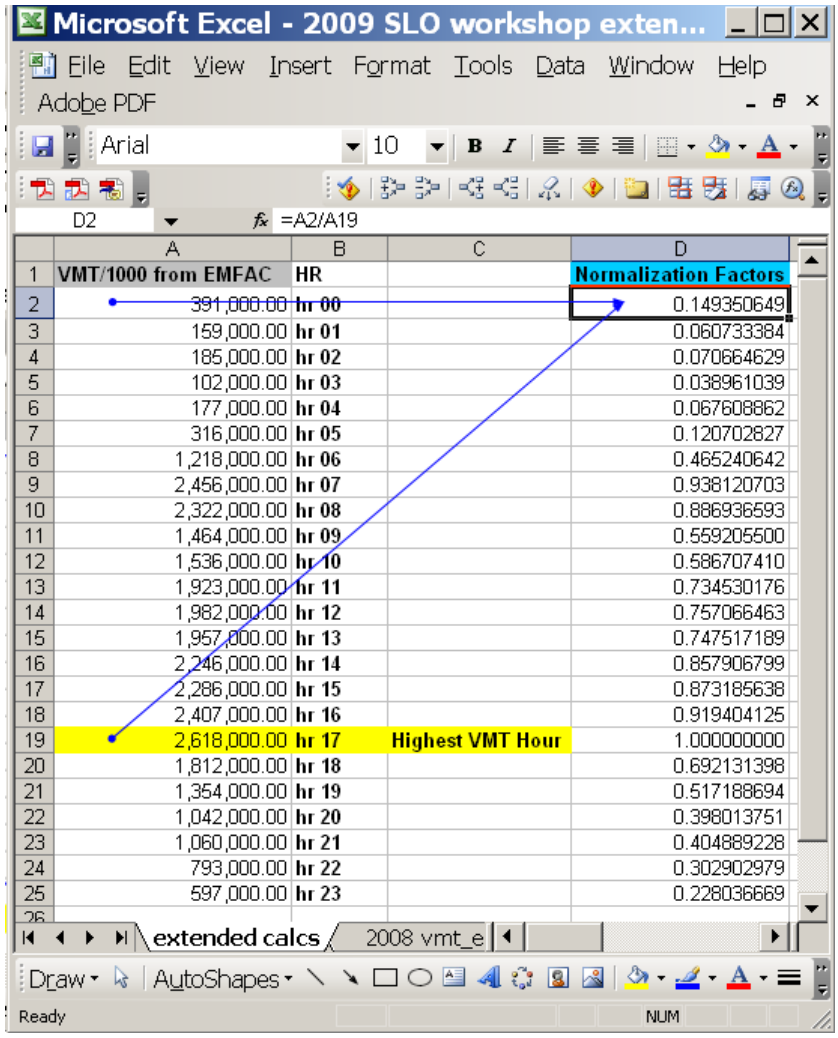
PREPARING HOURLY DATA FOR CANCER RISK AND HAZARD ESTIMATIONS

In estimating cancer risks and hazards associated with roadway emissions, the District considered:

- Diesel $PM_{2.5}$ emissions from all diesel vehicles (passenger cars, trucks, and buses);

- Total organic gas (TOG) emissions from tailpipes of non-diesel vehicles; and
- TOG emissions from evaporative running losses from non-diesel vehicles.

Figure 23. Calculating the Diurnal Scaling Factor (i.e, Normalization Factor)



	A	B	C	D
1	VMT/1000 from EMFAC	HR		Normalization Factors
2	391,000.00	hr 00		0.149350649
3	159,000.00	hr 01		0.060733384
4	185,000.00	hr 02		0.070664629
5	102,000.00	hr 03		0.038961039
6	177,000.00	hr 04		0.067608862
7	316,000.00	hr 05		0.120702827
8	1,218,000.00	hr 06		0.465240642
9	2,456,000.00	hr 07		0.938120703
10	2,322,000.00	hr 08		0.886936593
11	1,464,000.00	hr 09		0.559205500
12	1,536,000.00	hr 10		0.586707410
13	1,923,000.00	hr 11		0.734530176
14	1,982,000.00	hr 12		0.757066463
15	1,957,000.00	hr 13		0.747517189
16	2,246,000.00	hr 14		0.857906799
17	2,286,000.00	hr 15		0.873185638
18	2,407,000.00	hr 16		0.919404125
19	2,618,000.00	hr 17	Highest VMT Hour	1.000000000
20	1,812,000.00	hr 18		0.692131398
21	1,354,000.00	hr 19		0.517188694
22	1,042,000.00	hr 20		0.398013751
23	1,060,000.00	hr 21		0.404889228
24	793,000.00	hr 22		0.302902979
25	597,000.00	hr 23		0.228036669

Source: CAPCOA, 2009

VMT and emissions from these sources are quantified in the detailed summary provided by EMFAC. The user must select the appropriate data from EMFAC output (csv file) in order to quantify emissions from these sources. The procedures for developing the emission files follow steps similar to those for $PM_{2.5}$ emissions except that two separate emissions files will be developed–one for TOG from non-diesel vehicles and one for diesel vehicles to account for the differences in VMT and emissions from diesel versus gasoline vehicles.

Table 8. Example Calculation for Estimating Hourly Traffic Count

Time of day	Traffic Count (vehicles/hour)
Hr 00	1777
Hr 01	723
Hr 02	841
Hr 03	464
Hr 04	805
Hr 05	1436
Hr 06	5536
Hr 07	11164
Hr 08	10555
Hr 09	6655
Hr 10	6982
Hr 11	8741
Hr 12	9009
Hr 13	8895
Hr 14	10209
Hr 15	10391
Hr 16	10941
Hr 17	**11900**
Hr 18	8236
Hr 19	6155
Hr 20	4736
Hr 21	4818
Hr 22	3605
Hr 23	2714

Source: CAPCOA, 2009

Step 1. The first step is to develop hourly traffic counts for vehicles reflective of non-diesel TOG and diesel $PM_{2.5}$ emissions. Similar to the PM estimation, the user must first develop diurnal scaling factors to order to estimate the hourly traffic counts. The user first runs the EMFAC model to generate Burden inventory files. The base year in which the EMFAC model is run should be projected to the year in which residents are anticipated to occupy the development. The user creates two files: one for diesel $PM_{2.5}$ and the other for non-diesel TOG. For the TOG file, the user enters the total VMT/1000 and emissions from total exhaust ("Total Ex") from tailpipe emissions and running evaporative losses ("Running"). Figure 24 has the corresponding categories highlighted in red squares with the corresponding values circled in blue. For diesel $PM_{2.5}$ emissions, the user must sum the individual diesel contributions from each diesel vehicle category (i.e., light duty passenger cars, light duty trucks, medium duty trucks, and heavy duty trucks). The easiest method for summing each of the individual diesel contributions is to use a spreadsheet program that adds user defined cells containing emissions and VMT data. The user

can then copy the formula to the next hour of emissions. Figure 25 shows an example of the TOG and diesel emissions for each hour based on emissions in 2009 for San Francisco County.

To develop the diurnal scaling factor for TOG and diesel $PM_{2.5}$ emissions, the user normalizes each hourly VMT by the highest VMT (Table 9). For TOG, the highest VMT is at Hour 17, 5:00 pm of 1,038,000. The scaling factor for each hour is estimated by dividing each hour VMT per hour by 1,038,000. At hour 17, the scaling factor will be one. Next, the user follows the same procedures for diesel emissions. In the example provided, the highest VMT occurs at 9:00 am (Hour 9) of 44,000. Each hour VMT is then divided by 44,000 to produce the scaling factors for diesel exhaust.

Step 2. The next step is to estimate the number of vehicles that travel on the roadway each hour by multiplying each normalization factor times the road's peak hour traffic count. For TOG emissions, the peak hour of traffic represents the highest number of vehicles that normally occurs on a weekday. The data are available through Caltrans's website (http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/index.htm). The peak hour traffic count nearest to the proposed receptors should be used. The user should select back peak hour for projects south or west of the nearest milepost location. For projects north or east of the nearest milepost location, select ahead peak hour.

For diesel emissions, the process is more complex since the numbers of diesel trucks traveling on the roadway are not readily available. The District recommends estimating the number of diesel trucks by determining the percentage of vehicles on the road that are trucks. Caltran's web site reports the annual average daily truck traffic on California State Highway System. If the percentage of trucks is not available through Caltrans, the user may use a conservative default of 10% to represent the highest percentage of diesel trucks on the roadway.

In this example, approximately 1.7% of the vehicles on Highway 280 at the intersection of Highway 101 in San Francisco are trucks. The peak one hour of vehicles at the same location is 14,400 vehicles. Assuming 1.7% of the vehicles are trucks, the peak hour of trucks is 245 trucks. The number of vehicles that travel each hour on the road is then estimated by multiplying the hourly diurnal scaling factor by the peak hour of vehicles or trucks.

The sum of all the hourly counts should approximately equal the AADT (vehicles or trucks) for the roadway.

Step 3. The last step is to develop the hourly emission rates in grams per vehicle miles traveled for TOG and diesel. The hourly emissions for TOG and diesel were taken from the EMFAC output files as described in Step 1. For TOG, the emissions from tailpipe and evaporative losses are summed to produce a combined TOG emission per hour. Both emissions estimates from EMFAC are reported in tons per hour and needs to be converted to gram/hour. The grams/hour emissions are then divided by the VMT per hour for each hour (as reported by EMFAC), to obtain grams per vehicle mile per hour for input into CAL3QHCR.

Figure 24. Example EMFAC Output File for Estimating TOG Emissions

```
Title    : San Francisco County Subarea Annual CYr 2012 Default Title - BUR
Version  : Emfac2007 V2.3 Nov 1 2006
Run Date : 2010/04/16 09:06:50
Scen Year: 2012 -- All model years in the range 1968 to 2012 selected
Season   : Annual
Area     : San Francisco County
I/M Stat : Enhanced Interim (2005)
Emissions: Tons Per Hr00
```

	Light Duty Passenger Cars Non-cat	Cat	Diesel	Total	Light Duty Trucks Non-cat	Cat	Diesel	Total	Medium Duty Trucks Non-cat	Cat	Diesel	Total	Heavy Duty Trucks Gasoline Trucks Non-cat	Cat	Total	Diesel Trucks	Total HD Trucks	Urban Buses	Motor-cycles	All Vehicles
Vehicles	1667.	260502.	700.	271860.	521.	115500.	822.	116843.	61.	22048.	1366.	23474.	150.	2422.	2572.	6035.	8606.	1116.	14663.	416572.
VMT/1000	0.	84.	0.	85.	0.	37.	0.	38.	0.	8.	3.	11.	0.	0.	0.	13.	14.	2.	1.	149.
Trips	55.	14204.	32.	14291.	17.	6076.	41.	6134.	2.	1480.	160.	1953.	37.	679.	716.	197.	913.	49.	246.	23586.
Total Organic Gas Emissions																				
Run Exh	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start Ex	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Total Ex	0.00	0.01	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.05
Diurnal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hot Soak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Running	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Resting	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Total	0.00	0.03	0.00	0.03	0.00	0.02	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.08
Carbon Monoxide Emissions																				
Run Exh	0.02	0.17	0.00	0.19	0.01	0.11	0.00	0.12	0.00	0.02	0.00	0.03	0.00	0.00	0.01	0.02	0.03	0.02	0.05	0.43
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start Ex	0.00	0.09	0.00	0.09	0.00	0.05	0.00	0.05	0.00	0.02	0.00	0.02	0.01	0.07	0.07	0.00	0.07	0.00	0.00	0.24
Total Ex	0.03	0.25	0.00	0.28	0.01	0.15	0.00	0.16	0.00	0.05	0.00	0.05	0.01	0.07	0.08	0.02	0.10	0.02	0.05	0.67
Oxides of Nitrogen Emissions																				
Run Exh	0.00	0.02	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.11	0.11	0.04	0.00	0.21
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start Ex	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Total Ex	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.01	0.01	0.02	0.00	0.01	0.01	0.11	0.12	0.04	0.00	0.22
Carbon Dioxide Emissions (000)																				
Run Exh	0.00	0.04	0.00	0.04	0.00	0.02	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.09
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start Ex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Ex	0.00	0.04	0.00	0.04	0.00	0.02	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.10
PM2.5 Emissions																				
Run Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start Ex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Ex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
TireWear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BrakeWr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Lead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SOx	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Consumption (000 gallons)																				
Gasoline	0.02	3.97	0.00	3.99	0.01	2.20	0.00	2.20	0.00	0.63	0.00	0.63	0.00	0.05	0.05	0.00	0.05	0.01	0.03	6.92
Diesel	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.15	0.15	0.00	0.00	0.00	2.03	2.03	0.44	0.00	2.62

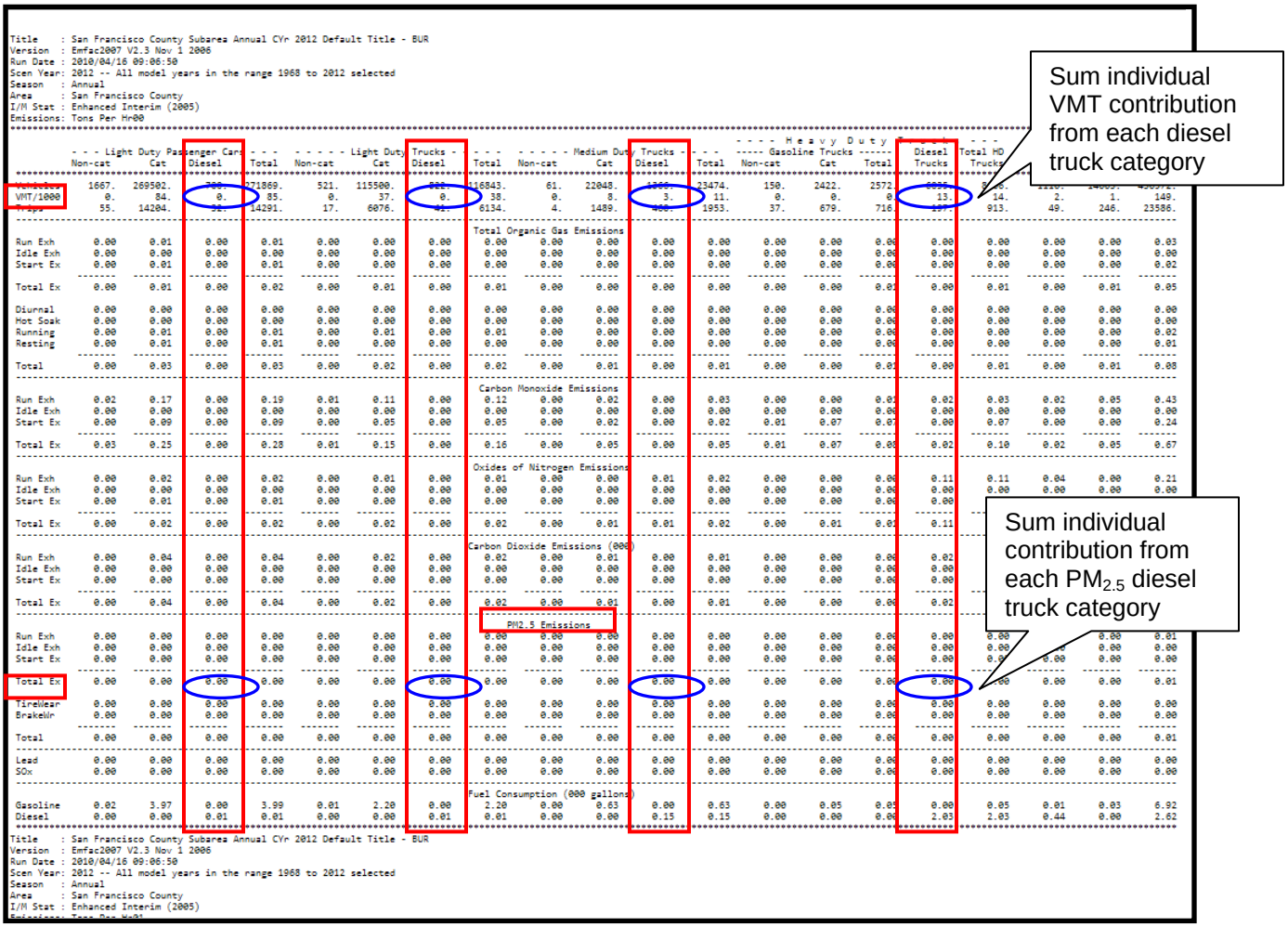

```
Title    : San Francisco County Subarea Annual CYr 2012 Default Title - BUR
Version  : Emfac2007 V2.3 Nov 1 2006
Run Date : 2010/04/16 09:06:50
Scen Year: 2012 -- All model years in the range 1968 to 2012 selected
Season   : Annual
Area     : San Francisco County
I/M Stat : Enhanced Interim (2005)
```


The above discussion presents the methodology for estimating annual average concentrations for a particular year, but for cancer risk where the threshold is based on 70-year exposure period, additional refinements are necessary to translate the single year exposure to 70-year average lifespan exposure. The user will run the CAL3QHCR model using the inputs specified above, but additional spreadsheet calculations are required to weight the annual average concentration over a 70-year exposure duration.

An added complication in the analysis is that not only do the VMT and emissions vary per year, but in addition, the District has adopted OEHHA's age sensitivity factors (ASF) (see the District's Regulation 2, Rule 5). ASFs are used to account for the increased susceptibility of infants and children to carcinogens, as compared to adults. The ASF calculation procedure includes the use of age-specific weighting factors in calculating cancer risks from exposures of infants, children and adolescents, to reflect their anticipated special sensitivity to carcinogens. OEHHA recommends weighting cancer risk by a factor of 10 for exposures that occur from the third trimester of pregnancy to two years of age, and by a factor of three for exposures that occur

from two years through 15 years of age. These weighting factors are applied equally to all carcinogens.

Figure 25. Example EMFAC Output File for Estimating Diesel Emissions



Title : San Francisco County Subarea Annual CYr 2012 Default Title - BUR
Version : Emfac2007 V2.3 Nov 1 2006
Run Date : 2010/04/16 09:06:50
Scen Year: 2012 -- All model years in the range 1968 to 2012 selected
Season : Annual
Area : San Francisco County
I/M Stat : Enhanced Interim (2005)
Emissions: Tons Per Hr00

	Light Duty Passenger Cars Non-cat	Light Duty Passenger Cars Cat	Light Duty Passenger Cars Diesel	Light Duty Total	Light Duty Non-cat	Light Duty Cat	Light Duty Trucks Diesel	Light Duty Total	Medium Duty Trucks Non-cat	Medium Duty Trucks Cat	Medium Duty Trucks Diesel	Medium Duty Total	Heavy Duty Gasoline Trucks Non-cat	Heavy Duty Gasoline Trucks Cat	Heavy Duty Gasoline Trucks Total	Heavy Duty Diesel Trucks	Total HD Trucks
Vehicles	1667.	269502.	[illegible]	271869.	521.	115500.	[illegible]	116843.	61.	22048.	[illegible]	23474.	150.	2422.	2572.	[illegible]	[illegible]
VMT/1000	0.	84.	0.	85.	0.	37.	0.	38.	0.	8.	3.	11.	0.	0.	0	13.	14.
Trips	55.	14204.	[illegible]	14291.	17.	6076.	[illegible]	6134.	4.	1489.	[illegible]	1953.	37.	679.	716.	[illegible]	913.
Total Organic Gas Emissions																	
Run Exh	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start Ex	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Ex	0.00	0.01	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Diurnal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hot Soak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Running	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Resting	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.03	0.00	0.03	0.00	0.02	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.01
Carbon Monoxide Emissions																	
Run Exh	0.02	0.17	0.00	0.19	0.01	0.11	0.00	0.12	0.00	0.02	0.00	0.03	0.00	0.00	0.00	0.02	0.03
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start Ex	0.00	0.09	0.00	0.09	0.00	0.05	0.00	0.05	0.00	0.02	0.00	0.02	0.01	0.07	0.07	0.00	0.07
Total Ex	0.03	0.25	0.00	0.28	0.01	0.15	0.00	0.16	0.00	0.05	0.00	0.05	0.01	0.07	0.08	0.02	0.10
Oxides of Nitrogen Emissions																	
Run Exh	0.00	0.02	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.01	0.02	0.00	0.00	0.00	0.11
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start Ex	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	[illegible]
Total Ex	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.01	0.01	0.02	0.00	0.01	0.02	0.11	[illegible]
Carbon Dioxide Emissions (000)																	
Run Exh	0.00	0.04	0.00	0.04	0.00	0.02	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.02	[illegible]
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	[illegible]
Start Ex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	[illegible]
Total Ex	0.00	0.04	0.00	0.04	0.00	0.02	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.02	[illegible]
PM2.5 Emissions																	
Run Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start Ex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Ex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
TireWear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BrakeWr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Lead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SOx	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Consumption (000 gallons)																	
Gasoline	0.02	3.97	0.00	3.99	0.01	2.20	0.00	2.20	0.00	0.63	0.00	0.63	0.00	0.05	0.05	0.00	0.05
Diesel	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.15	0.15	0.00	0.00	0.00	2.03	2.03

Title : San Francisco County Subarea Annual CYr 2012 Default Title - BUR
Version : Emfac2007 V2.3 Nov 1 2006
Run Date : 2010/04/16 09:06:50
Scen Year: 2012 -- All model years in the range 1968 to 2012 selected
Season : Annual
Area : San Francisco County
I/M Stat : Enhanced Interim (2005)

The first step in developing the 70-year average concentration is to run the EMFAC model to produce annual VMT and emissions of TOG and diesel $PM_{2.5}$ for every year from the start date of occupancy of the development or when new source is operational to 2040, the last year of emissions forecast by EMFAC. In the EMFAC model under Input 1, the user can select Step 2 – Calendar Years where the list of available years for which the emissions will be estimated can be included in the analysis (see Figure 26).

Each year of emissions of TOG and diesel PM2.5 and VMT should then be extracted from the EMFAC output file using the methodology described in Step 1 above. Table 10 presents an example table generated for San Francisco County that includes emissions and VMT from EMFAC for the years 2010 through 2080. Note: the EMFAC model only estimates emissions to 2040 and the user must then apply 2040 emissions for the remaining years.

Table 9. Example TOG and Diesel Emissions and Diurnal Scaling Factor

SAN FRANCISCO COUNTY 2009							
	TOG Emissions				**Diesel Only**		
Hours	VMT/1000	Total Ex (tons/hour)	Running (tons/hr)	Diurnal Scaling Factor	VMT/1000	PM2.5 (tons/hour)	Diurnal Scaling Factor
0	145	0.06	0.02	0.14	17	0	0.39
1	55	0.03	0.01	0.05	12	0	0.27
2	45	0.03	0.01	0.04	7	0	0.16
3	22	0.01	0	0.02	3	0	0.07
4	57	0.02	0.01	0.05	4	0	0.09
5	110	0.05	0.02	0.11	11	0	0.25
6	477	0.18	0.07	0.46	27	0	0.61
7	976	0.4	0.18	0.94	23	0	0.52
8	904	0.42	0.17	0.87	40	0.01	0.91
9	564	0.31	0.12	0.54	44	0.01	1.00
10	592	0.28	0.12	0.57	35	0.01	0.80
11	751	0.35	0.16	0.72	41	0.01	0.93
12	784	0.34	0.18	0.76	39	0.01	0.89
13	768	0.32	0.15	0.74	37	0.01	0.84
14	895	0.35	0.18	0.86	36	0.01	0.82
15	907	0.37	0.18	0.87	30	0	0.68
16	940	0.38	0.19	0.91	40	0.01	0.91
17	1038	0.43	0.2	1.00	25	0	0.57
18	720	0.29	0.14	0.69	14	0	0.32
19	541	0.23	0.11	0.52	7	0	0.16
20	412	0.17	0.07	0.40	17	0	0.39
21	423	0.16	0.07	0.41	28	0	0.64
22	316	0.12	0.05	0.30	18	0	0.41
23	235	0.1	0.04	0.23	4	0	0.09

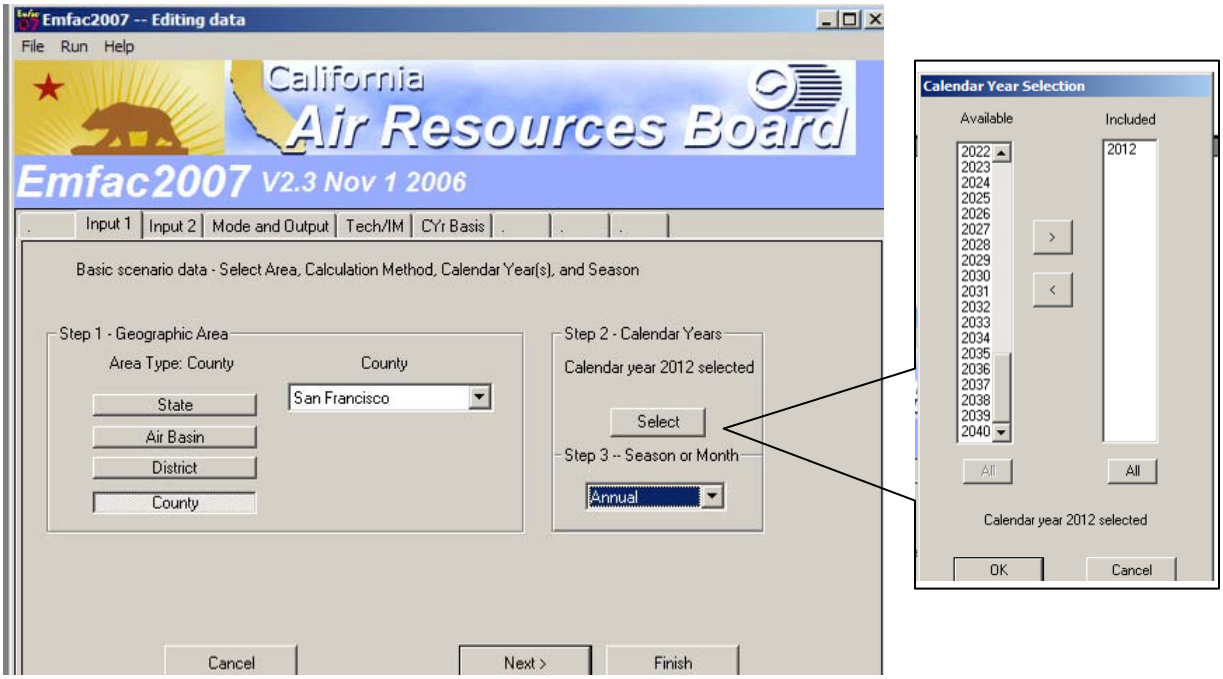
To estimate the 70-year average emissions, the user would generally average the emissions extracted from the EMFAC model. However, because of the age sensitivity factors (ASFs) for cancer risk estimates, more calculation is required. Because both the emissions and ASFs vary per year, the method for estimating 70-year average concentrations must account for variations in both. For estimating cancer risk where the emissions do not vary by year, concentrations can simply be multiplied by a cumulative ASF of 1.7 that incorporates the overall variations in ASFs.

Step 1. The first step is to develop sensitivity weighting factors (SWF) that are the age sensitivity values multiplied by the duration of the exposure by the lifetime of the exposure. This is expressed as:

Sensitivity Weighing Factor = ASF x Length of Exposure (year) / 70 year lifespan

Table 11 summarizes the SWF for every year of exposure up to 70 years.

Figure 26. Example EMFAC 70 Year Emissions and VMT



Step 2. The user then estimates 70-year average emission rates by multiplying each SWF by the corresponding emissions (grams/vehicle mile) for that year. Table 12 presents an example calculation for diesel $PM_{2.5}$ for San Francisco County using the values presented in Tables 10 and 11.

The 70-average emission rate is then the sum of the individual sensitivity weighted emission rates. In this example presented in Table 12, the 70-year average emission rate is 0.262 grams/vehicle mile.

Step 3. To predict the 70-year average concentrations at downwind receptor locations, the user must scale the emissions used in the base year run using CAL3QHCR by the 70-year average emissions. For example, suppose the diesel $PM_{2.5}$ emissions for San Francisco County in 2014 were 0.22 grams/vehicle miles along Highway 101. Using this emission rate in the CAL3QHCR model, the annual average downwind concentration 100 feet east of the freeway is estimated as 10 ug/m^3. To estimate the 70-year average concentration of diesel PM2.5 at this receptor location, the user must ratio the predicted concentration at the receptor by the base emissions from 2014 and the 70-year emissions as follows:

70 yr Avg Conc (ug/m^3) = Annual Avg Conc (ug/m^3) x [70-year SWF Emission (g/mile) / Base Yr Emissions (g/mile)]

Or

$$11.8 \text{ ug/m}^3 = 10 \text{ ug/m}^3 \times [0.262 \text{ ug/m}^3 / 0.22 \text{ ug/m}^3]$$

Table 10. Example VMT and Emissions for 70 Year Exposure

	SAN FRANCISCO COUNTY				
	Emissions from Total Organic Gases			Diesel Only	
Year	VMT/1000	Total Exhaust (tons/day)	Evaporative Losses (tons/day)	VMT/1000	Diesel PM2.5 (tons/day)
2014	13343	3.65	1.92	570	0.11
2015	13500	3.41	1.85	572	0.11
2016	13634	3.23	1.79	576	0.11
2017	13778	3.03	1.73	577	0.11
2018	13928	2.85	1.67	580	0.1
2019	14081	2.7	1.62	585	0.1
2020	14235	2.52	1.57	593	0.1
2021	14392	2.41	1.53	597	0.1
2022	14550	2.31	1.49	600	0.11
2023	14711	2.23	1.45	604	0.11
2024	14875	2.16	1.41	610	0.11
2025	15039	2.1	1.38	613	0.1
2026	15244	2.07	1.35	619	0.09
2027	15448	2.02	1.32	625	0.09
2028	15656	1.98	1.3	629	0.1
2029	15869	1.77	1.27	641	0.09
2030	16086	1.73	1.24	647	0.09
2031	16303	1.69	1.22	655	0.1
2032	16524	1.66	1.19	663	0.1
2033	16749	1.63	1.17	669	0.1
2034	16979	1.61	1.15	676	0.09
2035	17212	1.59	1.14	683	0.09
2036	17448	1.57	1.13	691	0.09
2037	17683	1.56	1.12	696	0.09
2038	17921	1.56	1.12	704	0.09
2039	18160	1.55	1.11	712	0.08
2040-2084	18405	1.55	1.11	721	0.08

As noted above, the age sensitivity values increased the predicted 70-year average concentrations predicted by the model to account for the anticipated special sensitivity experienced by infants and children to carcinogens. The methodology presented above would also be applied to estimating 70-year concentrations from tailpipe exhausts and evaporative losses. For the cancer risk estimates alone, the user can further reduce the diesel exhaust concentrations by accounting for the expected reductions based on CARB's on-road regulations. Table 3 presents the percent reductions expected from all diesel vehicles based on the on-road regulations. These percentages can be directly applied to the respective concentrations estimated through modeling. The risk calculations to account for the toxic components in TOG are further detailed in Section 5.2.

Table 11. Sensitivity Weighting Factors

Risk Year	Year Used in Roadway Modeling	Period (years)	Age Sensitivity Factor	Sensitivity Weighting Factor
1	2014	1	10	0.143
2	2015	1	10	0.143
3*	2016	1	4.75	0.068
4	2017	1	3	0.043
5	2018	1	3	0.043
6	2019	1	3	0.043
7	2020	1	3	0.043
8	2021	1	3	0.043
9	2022	1	3	0.043
10	2023	1	3	0.043
11	2024	1	3	0.043
12	2025	1	3	0.043
13	2026	1	3	0.043
14	2027	1	3	0.043
15	2028	1	3	0.043
16	2029	1	3	0.043
17**	2030	1	1.5	0.021
18	2031	1	1	0.014
19	2032	1	1	0.014
20	2033	1	1	0.014
21	2034	1	1	0.014
22	2035	1	1	0.014
23	2036	1	1	0.014
24	2037	1	1	0.014
25	2038	1	1	0.014
26	2039	1	1	0.014
27	2040 – 2084	44.25	1	0.632

Note: at age 2*, the factors are weighted for 0.25 years by 10 and 0.75 years by 3; at age 16**, the factor is weighted by 0.25 years at 3 and 0.75 by 1.

Table 12. Example 70 Year Average Emissions for Diesel $PM_{2.5}$ in San Francisco County

Emission Year	Sensitivity Weighting Factor	VMT (miles) /1000	Diesel PM2.5 (tons/day)	Emission Rate (g/vehicle-mile)	Sensitivity Weighted Emission Rate (g/vehicle-mile)
2014	0.14	567	0.14	0.224	0.032
2015	0.14	567	0.12	0.192	0.027
2016	0.068	569	0.12	0.191	0.013
2017	0.043	572	0.12	0.19	0.008
2018	0.043	572	0.12	0.19	0.008
2019	0.043	570	0.11	0.175	0.008
2020	0.043	572	0.11	0.174	0.007
2021	0.043	576	0.11	0.173	0.007
2022	0.043	577	0.11	0.173	0.007
2023	0.043	580	0.1	0.156	0.007
2024	0.043	585	0.1	0.155	0.007
2025	0.043	593	0.1	0.153	0.007
2026	0.043	597	0.1	0.152	0.007
2027	0.043	600	0.11	0.166	0.007
2028	0.043	604	0.11	0.165	0.007
2029	0.043	610	0.11	0.164	0.007
2030	0.021	613	0.1	0.148	0.003
2031	0.014	619	0.09	0.132	0.002
2032	0.014	625	0.09	0.131	0.002
2033	0.014	629	0.1	0.144	0.002
2034	0.014	641	0.09	0.127	0.002
2035	0.014	647	0.09	0.126	0.002
2036	0.014	655	0.1	0.139	0.002
2037	0.014	663	0.1	0.137	0.002
2038	0.014	669	0.1	0.136	0.002
2039	0.014	676	0.09	0.121	0.002
2040 - 2084	0.632	683	0.09	0.12	0.076

4.3.3.2 CAL3QHCR Data Files

The US EPA's CAL3QHCR model is an air dispersion model for predicting air quality impacts of pollutants near roadways. The CAL3QHCR is a refined version of the original California Line Source Dispersion Model (CALINE) that was developed as a modeling tool to predict

roadside carbon monoxide (CO) concentrations. The CAL3QHCR model not only predicts CO concentrations, but also can be used to estimate ambient $PM_{2.5}$ concentrations from idling or moving motor vehicles. The model processes up to one year of hourly meteorological data and vehicular emissions and traffic volumes can be specified for every hour.

The CAL3QHCR model requires the following inputs:

- **One year of meteorological data** – the model can be run using ISC compatible meteorological data if the filename extension is changed to ".asc",
- **Hourly traffic volumes** (in units of vehicles per hour) that can be derived using Caltrans data and normalization factors,
- **Hourly vehicle emissions** (in units of grams per vehicle mile) are derived from EMFAC,
- **Receptor locations** - location to the nearest sensitive receptor from the edge of the travel lane, in addition to the generic receptor grid (for example, 1,000 meters by 1,000 meters grid with 50 meter grid spacing) in X-Y coordinates, and
- **Surface roughness -** depending on the land use can range from 3 cm to 400 cm,
- **Roadway orientation** in terms of its X-Y coordinates (arbitrary origin/0,0), including length and width.

An example scenario is described below to illustrate how to develop the input files necessary for running CAL3QHCR model. Further details regarding the model can be found in CAPCOA's Health Risk Assessments for Proposed Land Use Projects (where this example was presented) and in US EPA's User's Manual for CAL3QHCR.

The CAL3QHCR input file requires data be defined in the calculational domain such that the X-Y coordinates at the beginning and at the end of the roadway section are defined. These have an arbitrary origin, with the positive y axis aligned toward north. For the example presented in this section, nine potential receptors are assumed to lie directly south of an east-west free-flow freeway with a peak hour traffic count of 11,900 vehicles. The freeway is assumed to be 120 feet wide, with an additional 10 feet on each side to account for the wake of moving vehicles[38], making for a total link width of 140 feet. If modeling diesel emissions from trucks, the District recommends using a source height of 2.3 meters (10 feet).

This example scenario relies on basic information needed to complete the modeling using CAL3QHCR model. The width (mixing zone) of the roadway is defined as the width of the freeway including all of the lanes of traffic and the shoulders. If the road does not have a shoulder, then it is recommended that an additional 10 feet be added to the edge of the nearest travel lane to the receptor to account for the wake of moving vehicles. The length of the roadway to be modeled should be at a minimum of one kilometer. The District does not recommend modeling more than five kilometers of a roadway for estimating local-scale impacts, unless the proposed project itself exceeds five kilometers in length.

CAL3QHCR requires that the elevation of the roadway in comparison to the surrounding area be specified in the input files. For most projects, the elevation of the roadway is at grade and consequently, the height of the road is set at zero. For elevated roadways such as an overpass,

[38] The mixing zone is an area where dispersion results are considered to be inaccurate.

the relative height is positive; and for depressed roadways such as an underpass, the relative height is negative.

The z-coordinate (receptor breathing height) for the receptor grid must be specified. In most cases, the default recommendation is 1.5 meters or 6 feet, which approximates an average receptor height. There are special instances where the residents are living on the second floor with commercial/retail areas on the ground level. Even in these instances, the District recommends using the default height of 1.5 meters.

Figure 27 illustrates the example scenario described in this section. The freeway is 120 feet wide, and after accounting for the wake of 10 feet on each side of the freeway, the total link width to be used in the model is 140 feet. The length of the roadway modeled is three kilometers, or 1.5 kilometers on each side from the center point. The roadway is at grade. A receptor has been placed at the edge of the roadway to define the roadway dimensions; however the dispersion results for this receptor should be discarded as they are not accurate at roadway edges. The District recommends using a receptor grid that encompasses the length of the roadway and has receptors spaced every 50 to 100 meters. Other parameters and recommended defaults required by the model are listed in Table 13.

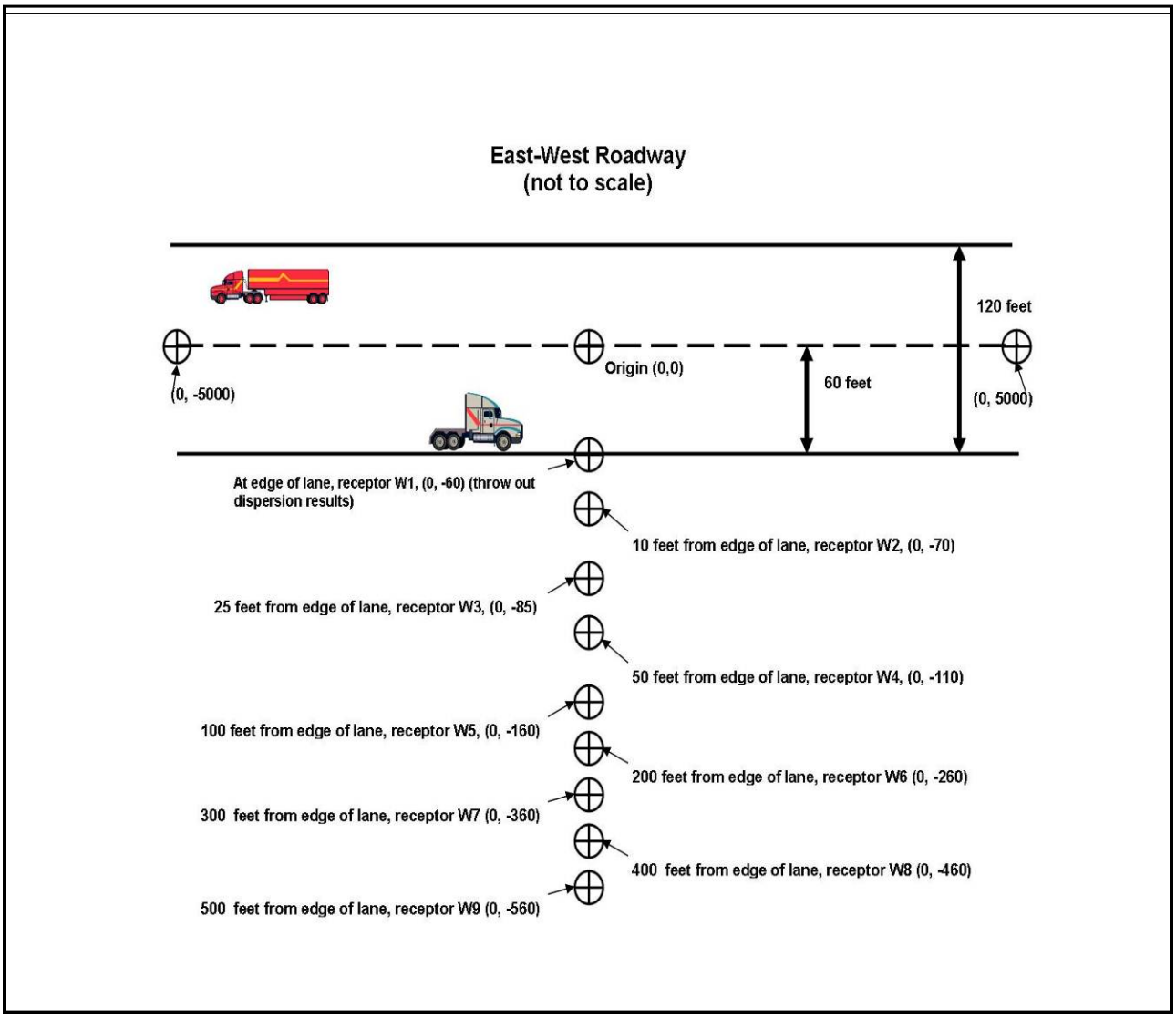
Downloading CAL3QHCR Model:

The CAL3QHCR model can be downloaded from EPA's Preferred/Recommended Dispersion Models website (http://www.epa.gov/scram001/dispersion_prefrec.htm). There are five files needed to run the program:

- input file (.inp),
- batch file (.bat),
- control file (.ctl),
- meteorological data file (.met), and
- executable file (.exe).

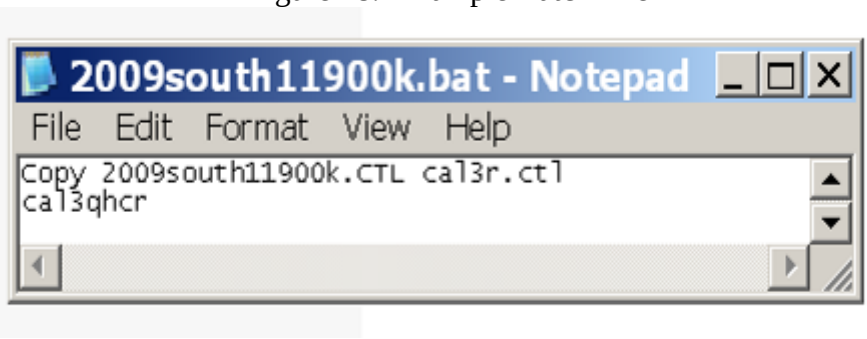
The first step is to select a name for the model run. For the example above, the name of the example scenario run is "2009south11900k". The simplest method for creating the control file is to copy the existing file with a new name. This is done by preparing a batch file (.bat) that is a DOS file batch command. To prepare the file, the user has to right click on the file to open it for editing. (Note that opening or double clicking on the file will cause the program to run. If this happens, simply delete the files the program creates and start again.) Once the file is open, the user types in the filename of the run after the word "Copy". Figure 28 shows an example of how a batch file is created.

Figure 27. Example Scenario East-West Roadway and Receptors Placements for CAL3QHCR



Source: CAPCOA, 2009

Figure 28. Example Batch File



Source: CAPCOA, 2009

Table 13. Other Recommended Parameters for Input into CAL3QHCR

Parameter	Default	
Calculation averaging time (min)	60	
Surface roughness (cm, from 3 to 400). For mixed uses and others not listed here, the modeler should make a reasonable assumption.	single family	108
	offices	170
	apartments	370
Settling velocity (cm/s)	0	
Deposition velocity (cm/s)	0	
Site setting (U=urban, R=rural)	U	
Form of traffic volume, emission rate data (1=one hour's data, 2=one week of hourly data)	2	
Pollutant (P for PM to give output in $\mu g/m^3$)	P	
Hourly ambient background concentration ($\mu g/m^3$)	0	
Roadway height indicator (AG=at grade, FL=elevated and filled, BR=bridge, DP=depressed)	AG	
Roadway height (ft, 0 if AG, relative height if FL, BR, or DP)	0	

Preparing Control File:

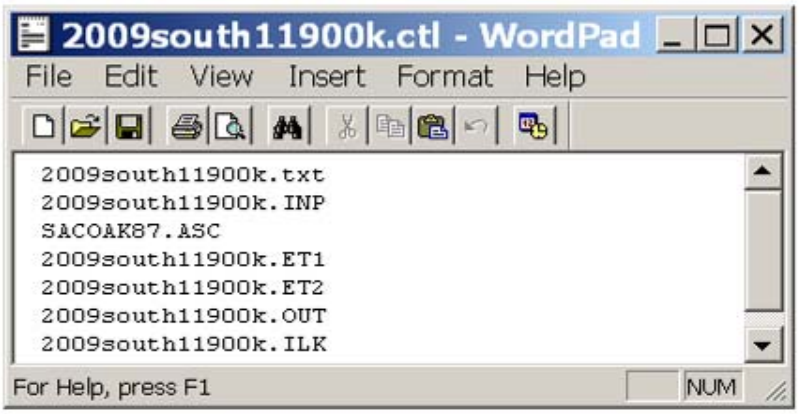
CAL3QHCR looks to the control file to find the file names that are read into the program and outputted by the program. The control file identifies all of the files that the CAL3QHCR will need to complete the run. The user will type the filename of the run in front of each file extension, except the .ASC file (meteorological file), where the user will type in the meteorological data file name. The control file should also be given the same filename with the ctl extension. Figure 29 presents example control file.

The meteorological file can be downloaded from the District web site at http://hank.baaqmd.gov/tec/data/. The user should select a meteorological station that is closest to their proposed project. Once the file is downloaded, the user should change the extension on the file to ".met".

Preparing Input File:

The input file contains the scenario parameters including the emissions and traffic volumes on roadways. The variables to be included in the file have been discussed above. To develop the file, it is recommended that the user edit an existing file (i.e., example file) such as the file provided with the model download, or by editing over a file that was previously used for another project. The user should remember to rename the file prior to editing. An example of the input file is presented in Figure 30 along with detailed explanations of the inputs.

Figure 29. Example Control File



Source: CAPCOA, 2009

Executing the Model Run:

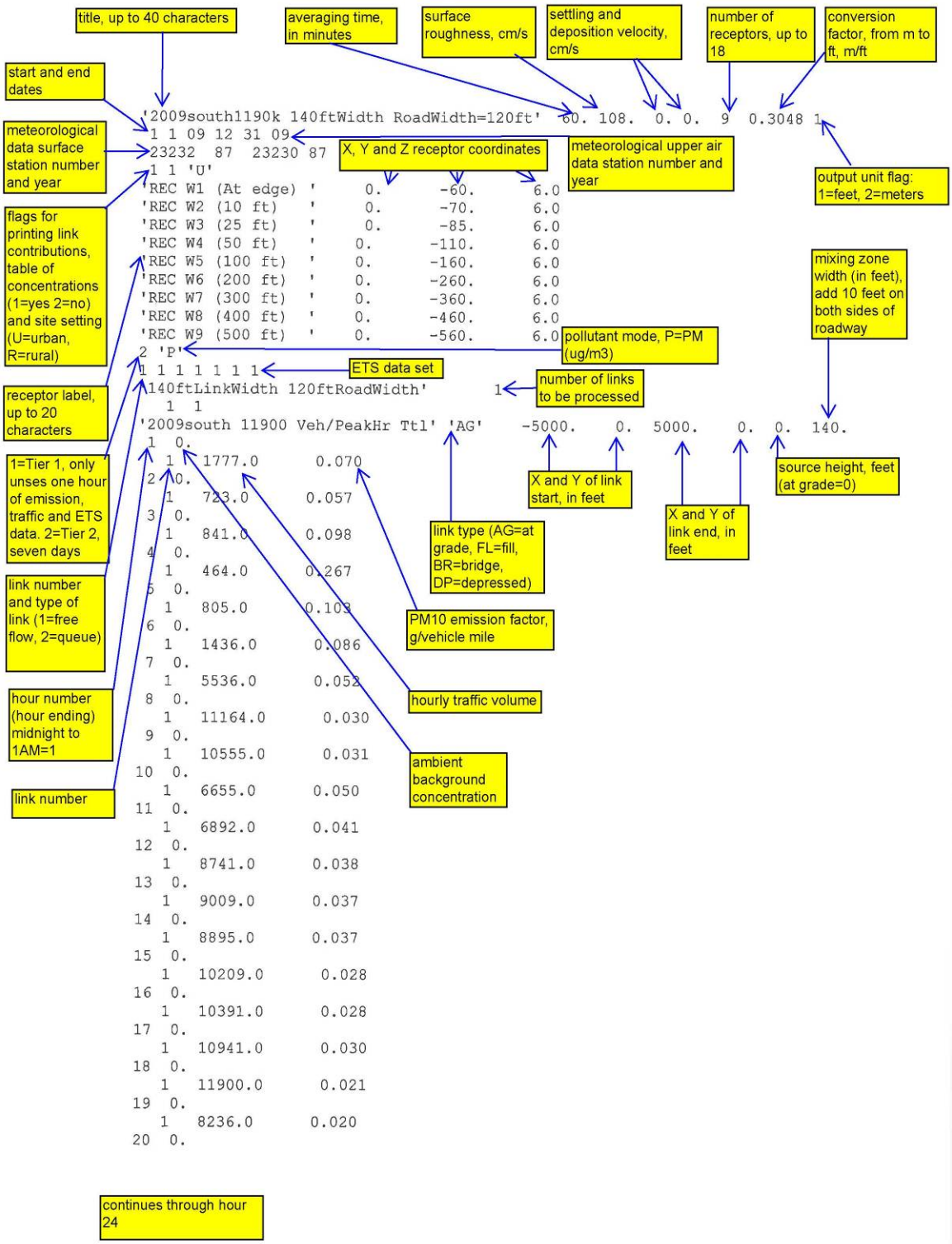
To run the file, the user will double click on the batch file (.bat). The model will produce a series of files with extensions .ET1, .ET2, .ILK, .OUT, .txt, and .ctl. The user should review the file with the extension ".txt" to ensure that no errors were encountered during the run.

The output file (.OUT) will show, among other information, the highest annual average concentrations. Figure 31 presents an example of the relevant output data from the model run.

This example estimates the annual average concentration of PM for a particular roadway at specified receptor locations. However, to translate the concentration to represent a 70-year average concentration, the user must take into account the changes in travel demand over the next 70 years. Discussion is provided in Section 6.0 on modifying the annual average concentration predicted from the model to a 70-year average concentration in which cancer risk can be predicted for comparison to the CEQA thresholds. The user should review the output files and ensure that air concentrations were predicted for each receptor. In cases where the values are zero, the user may consider rerunning the model, but increasing the emissions by a standard factor (i.e., multiplying the emissions by 1000 times). The user then divides the modeled air concentration by the same factor that was used to increase the emissions to yield the actual predicted concentration at each receptor.

In addition, this example provides a general overview of modeling the most common roadway scenarios; however, the model is also designed to model the effects at traffic intersections, traffic signaling, and traffic queuing. These features are site-specific and the user's manual for the model should be consulted.

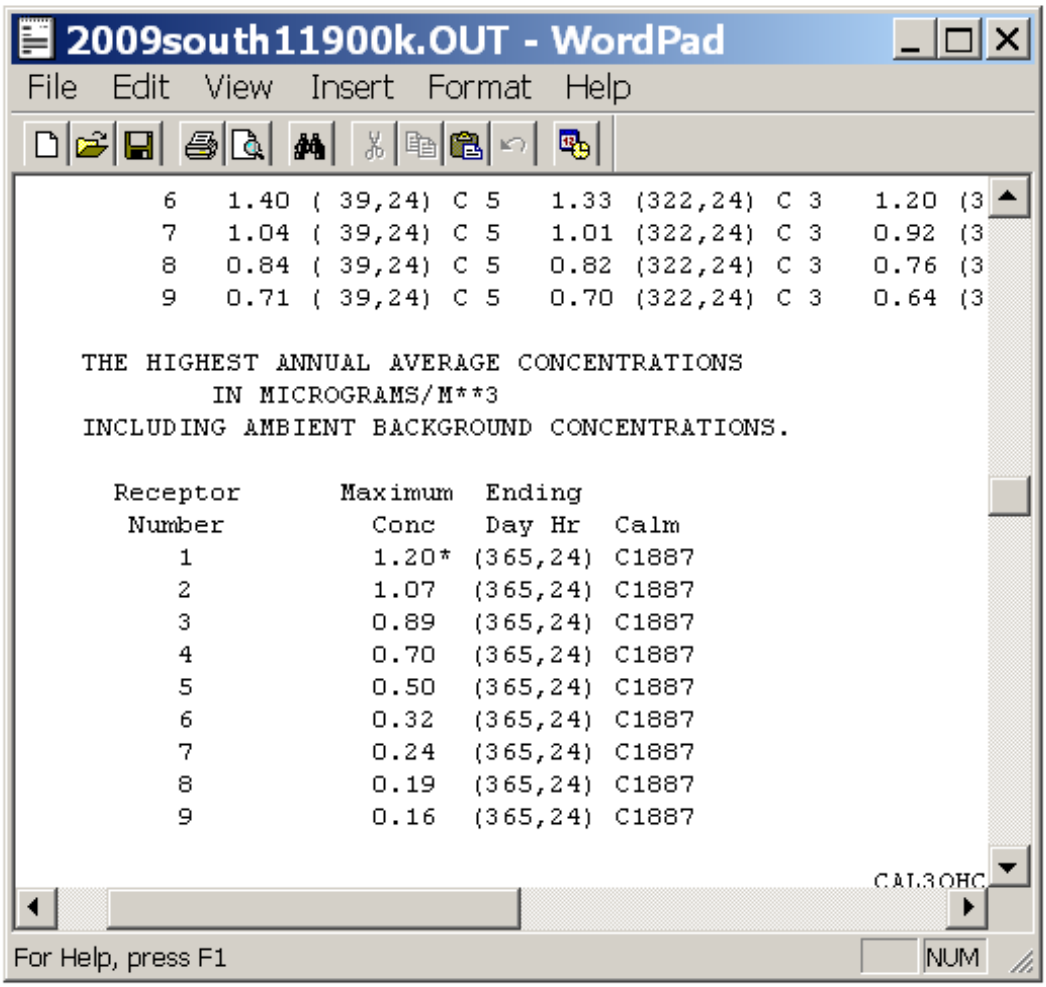
Figure 30. Example Input File




```
'2009south1190k 140ftWidth RoadWidth=120ft'  60. 108.  0. 0.  9  0.3048 1
 1 1 09 12 31 09
23232  87  23230 87
 1 1 'U'
'REC W1 (At edge) '     0.      -60.      6.0
'REC W2 (10 ft)   '     0.      -70.      6.0
'REC W3 (25 ft)   '     0.      -85.      6.0
'REC W4 (50 ft)   '     0.     -110.      6.0
'REC W5 (100 ft)  '     0.     -160.      6.0
'REC W6 (200 ft)  '     0.     -260.      6.0
'REC W7 (300 ft)  '     0.     -360.      6.0
'REC W8 (400 ft)  '     0.     -460.      6.0
'REC W9 (500 ft)  '     0.     -560.      6.0
2 'P'
1 1 1 1 1 1 1
140ftLinkWidth 120ftRoadWidth'          1
   1  1
'2009south 11900 Veh/PeakHr Ttl' 'AG'    -5000.    0.  5000.    0.  0.  140.
 1  0.
   1   1777.0       0.070
 2  0.
   1    723.0       0.057
 3  0.
   1    841.0       0.098
 4  0.
   1    464.0       0.267
 5  0.
   1    805.0       0.109
 6  0.
   1   1436.0       0.086
 7  0.
   1   5536.0       0.052
 8  0.
   1  11164.0       0.030
 9  0.
   1  10555.0       0.031
10  0.
   1   6655.0       0.050
11  0.
   1   6892.0       0.041
12  0.
   1   8741.0       0.038
13  0.
   1   9009.0       0.037
14  0.
   1   8895.0       0.037
15  0.
   1  10209.0       0.028
16  0.
   1  10391.0       0.028
17  0.
   1  10941.0       0.030
18  0.
   1  11900.0       0.021
19  0.
   1   8236.0       0.020
20  0.
```

Source: CAPCOA, 2009

Figure 31. Example Output File



4.3.3.3 Roadway Modeling using ISC or AERMOD

Roadway impacts can also be modeled using ISC or AERMOD. The advantage of using these models over CAL3QHCR is that most projects including impacts from numerous stationary sources as well as roadways. The CAL3QHCR model is limited to only roadway modeling while ISC and AERMOD can model the impacts from both roadways and stationary sources. For example, a commercial development may have toxic emissions from truck transportation, gasoline dispensing facility, dry cleaners, and standby diesel generators. The user can choose to model these additional sources using ISC or AERMOD and then superimpose the concentrations with those predicted by CAL3QHCR. The simpler option is to model the sources and roadways together using either ISC or AERMOD; results of roadway modeling using ISC and AERMOD are consistent with those from using CAL3QHCR. Procedures for using ISCST3 and AERMOD to model emissions from roadways are discussed below.

The data that are required to model roadway emissions using ISC and AERMOD are similar to those required for using CAL3QHCR. They include the following:

- **Meteorological data** – preprocessed meteorological files for ISC are available though the District web site at http://hank.baaqmd.gov/tec/data/.
- **Traffic data and vehicle emissions** – The same data as discussed above for the CAL3QCHR model are used.
- **Roadway configuration** – The entire width of the roadway including the shoulder is the lateral dimension of the area source. Receptors should be located the same as with the CAL3QCHR model. The initial vertical dimension is the height of the vehicle (i.e., passenger car or truck) to account for the turbulent mixing that is created from vehicle traffic.
- **Terrain data** – For ISC, elevation data must be entered manually. AERMAP is used to generate the elevations and hill slopes for receptors and sources for input to the AERMOD model. Digital Elevation Model (DEM) files for use in AERMAP are available from a variety of sources.

The ISC and AERMOD model emissions from four basic types of sources: point, area, and volume. Emissions from idling vehicles located at a loading dock can be modeled as point sources. Area sources have been used in the past to model emissions from parking lots. The District recommends modeling emissions from travelling vehicles as area sources.

The parameters required to model area sources include:

- **Source ID**: An identification name for the source being defined, up to 8 characters in length.
- **X Coordinate**: The x (east-west) coordinate for the vertex (corner) of the area source that occurs in the southwest quadrant of the source. Units are in meters.
- **Y Coordinate**: The y (north-south) coordinate for the vertex (corner) of the area source that occurs in the southwest quadrant of the source. Units are in meters.
- **Base Elevation** [m]: The source base elevation. The model only uses the source base elevation if elevated terrain is being used. The default unit is meters.
- **Release Height above Ground** [m]: The release height above ground in meters. The release height of the passenger vehicle and/or truck should be used. The District recommends using a height of 10 feet for trucks and height of 1.5 feet for passenger cars.
- **Emission Rate** [g/(s-m^2)]: Enter the emission rate of the pollutant. The emission rate for area sources is input as an emission rate per unit area. The same emission rate is used for both concentration and deposition calculations.
- **Defining Area**: In ISC, the shape of the area source must be a rectangle or square. The maximum length/width aspect ratio for area sources is 10 to 1. If this is exceeded, then the area should be divided to achieve a 10 to 1 aspect ratio (or less) for all sub-areas. The lateral dimension is the entire width of the roadway including all lanes of traffic and the shoulders. If the road does not have a shoulder, then it is recommended that an additional 10 feet be added to the edge of the nearest travel lane to the receptor to account for the wake of moving vehicles. The length of the roadway to be modeled should be at a minimum of one kilometer. The District cautions users to not model roadways beyond five kilometers in length unless the side of the proposed project nearest to the roadway exceeds five kilometers.

A receptor grid similar to CAL3QHCR modeling should be used of at least one kilometer by one kilometer with receptors spaced every 50 to 100 meters. For each receptor and each specified

source group, the output file will contain the highest predicted annual average concentrations for the specified averaging time. Multiple files can be created for multiple source groups (which can be single sources or multiple sources depending upon those specified by the user) and for each averaging time modeled. The user can specify specific plotfiles to be generated as *.XOQ file that can be read through third party packages such as the Hot Spots Analysis and Reporting Program (HARP). They also can be used by graphics programs incorporated into the model interface programs or software such as SURFER to generate isopleths of concentration for a visual display of the results.

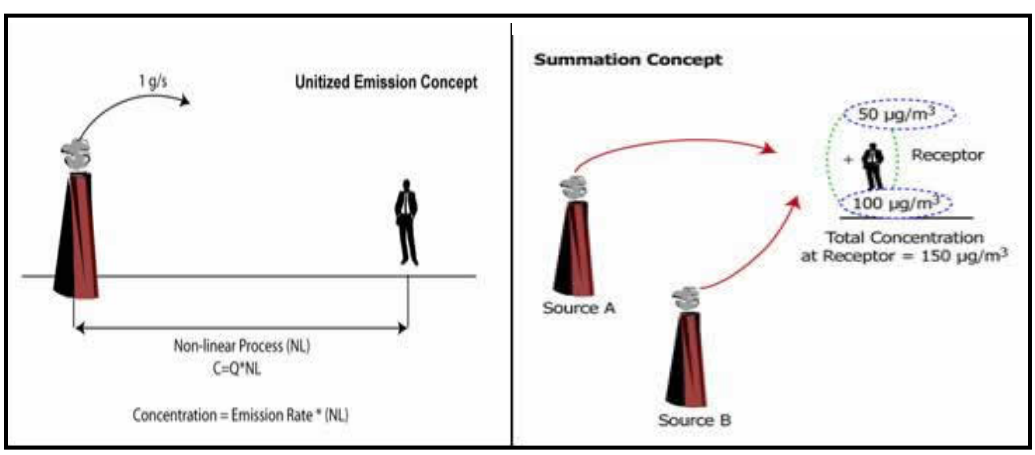
4.3.3.4 Multi-Pollutants Concentrations

Many industrial sources emit multiple pollutants. Models are not equipped to automatically perform modeling of different pollutants that may share the same emission source, but have pollutant-specific emission rates or pollutant-specific variations in emission rates (emissions change per year). One approach to address this issue is to model each scenario in separate model runs for each specific pollutant type and/or year of meteorological data. This requires extensive modeling times and organizational effort to track the results of each separate run.

A simpler solution is to apply unitized, or normalized, emission rates in which the results from the model can be scaled by the actual chemical-specific emissions rate. Then individual pollutant concentrations may be summed. For determining the multi-year averages for estimating cancer risk, the procedure becomes more complex. Discussions on how to perform each of these methods is provided below.

Most air dispersion models produce a Gaussian (bell-shaped) dispersion pattern. The model incorporates the hourly meteorological conditions, terrain elevations, and site characteristics to estimate the downwind concentration. Although the dispersion is non-linear, predicted concentrations scale linearly with emissions. This relationship allows the user to input a unit concentration of one gram/sec to be emitted at the source that can then be multiplied by the actual emission factors for each chemical to predict the downwind concentration of that pollutant at that specific receptor location. Figure 32 helps visualize this concept, by describing an emission rate of 1 g/s (left).

Figure 32. Unitized Emission Rate (left) and Summation (right) Concepts



The Unitized Emission Rate Concept only applies to single sources. For assessments with multiple sources the user can model each source independently by using a unitized emission rate of one gram per sec. For area sources, the unitized emission rate is one gram per second per square meter (1 g/sec/m^2). The concentration at the receptor can then be multiplied by the actual chemical emission rate, and the final result from all the sources will be summed. This is called the Summation Concept, where the concentration and deposition fluxes at a receptor are the linear addition of the resulting values from each source. Figure 27 (right) depicts the Summation concept. The user can use a post-processor such as CARB's HARP program (http://www.arb.ca.gov/toxics/harp/harp.htm) to automatically process model results that have been predicted using a unitized emission rate.

The user should be aware that separate dispersion runs should be performed for estimating acute hazard index, chronic hazard index, cancer risk, and PM2.5 concentrations.

4.4 Tier 3 Model Refinements

The models described above can be further refined to increase the accuracy of the predicted downwind concentrations. The refinements are site-specific and should be determined in conjunction with the lead agency to ensure the changes are appropriate and accurate. The following section provides some available refinements to improve the accuracy of the models.

4.4.1 Variable or Seasonal Emissions

The ISCST3 and AERMOD models both contain support for variable emission rates. This allows for modeling of source emissions that may fluctuate over time since some sources may emit only during certain periods of time. Industrial processes often fluctuate depending on supply and demand requirements. This affects some sectors seasonally, particularly facilities involved in food processing. For example, soup production makes use of agricultural produce which is at its highest in the late summer. Production schedules for soup production typically ramp up resulting in different emissions during the late summer and early fall than at mid to late winter.

Emissions can be varied within the ISCS and AERMOD models by applying scaling factors to different time periods. These emission differences can be accounted for by the application of variable emission factors, with control over the following time periods:

- By Season and hour-of-day
- By Season, hour-of-day, and day-of-week
- By Season, hour, week

For example, for a source that is non-continuous, a factor of 0 is entered for the periods when the source is not operating or is inactive. Model inputs for variable emissions rates can include the following time periods:

- Seasonally

- Monthly
- Hourly
- By Season and hour-of-day
- By Season, hour-of-day, and day-of-week
- By Season, hour, and week

4.4.2 Receptors Located Above Ground Level

In numerous new development projects in the Bay Area, residential units are situated above ground floor commercial/retail areas. The user should work closely with the lead agency to determine the most realistic and long term scenario in which residents would be exposed to toxic air contaminants. If it is determined that residents in their homes will be exposed for the longest duration (up to 12 hours per day) and at the highest concentrations, then receptor heights should be representative of each floor in which residents are living. For example, if a standby generator is located across the street from a four story apartment building with commercial/retail space on the ground floor. The release height of the stack from the generator is approximately 25 feet above ground level. In this case, it may be more conservative and realistic to model concentrations to the second story apartments rather than ground level receptors where the residents would spend significantly less time. In the freeway screening tables, the District has provided estimated cancer risk, $PM_{2.5}$ concentrations, and hazards for second story residential occupancy (20 feet) with commercial uses assumed on the first floor.

4.4.3 On-Site Meteorology

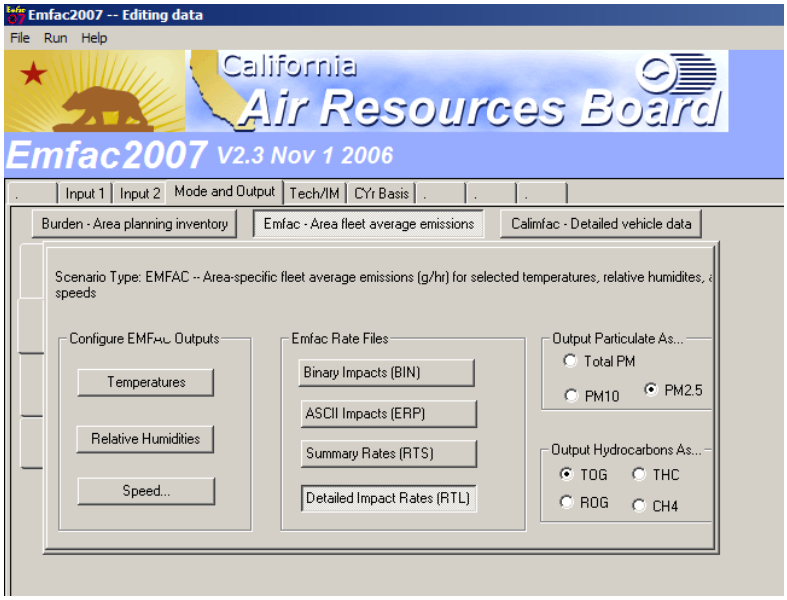
The District receives and collects meteorological data from over 30 stations in the Bay Area. Not every proposed project is in close proximity to one of these stations and a project sponsor may choose to collect their own meteorological data for one year prior to development of the site. There are numerous siting requirements that have to be met in selecting an appropriate location for a meteorological tower. As a general rule, meteorological sensors should be sited at a distance beyond the influence of obstructions, such as buildings and trees. The measurements should also be representative of the project area and be located in a secure and accessible area so that the operator can make any necessary repairs. EPA's Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV, Meteorological Measurements, version 2.0 (Final) (dated January 20, 2008) is a complete reference guide for siting, construction, and collecting meteorological data that adheres District's modeling and accuracy criteria. Approval for the placement of meteorological tower should be obtained from the District prior to any site preparation activities or installation of any equipment.

4.4.4 Constant Vehicle Speed on Local Roadways

In the roadway modeling, the District recommends using the full range of variable vehicle speeds in the EMFAC model to predict roadway emissions. This is a conservative method of accounting for variable vehicle speeds experienced on many of the major highways in the Bay Area. However on local surface streets, a more constant vehicle speeds may be experienced. In this case, surveyed vehicle speeds using automatic counters over a defined study period (over

one week) may result in a more representative speed that can be used in EMFAC. The user can input a specific speed, temperature, and relative humidity under "Mode and Output" in the EMFAC model. Instead of selecting Burden – Area Planning category, the user will select the second option entitled Emfac – Area Fleet Average Emissions. Figure 33 presents a screen shot of the Emfac Area Fleet screen. The District does not recommend setting a single speed for highway travel. The Emfac output was used to estimate annual emissions for speeds of 0 to 35 mph on surface streets.

Figure 33. Example of Emfac-Area Fleet Average Emissions Screen



5.0 CUMULATIVE ANALYSIS

The District is recommending that users examine toxic and $PM_{2.5}$ sources that are located within 1,000 feet of a proposed project site for comparisons to cumulative thresholds of significance. The sources may include, but are not limited to, highways and high volume roadways, truck distribution centers, ports, rail yards, refineries, airports, chrome plating facilities, crematoriums, dry cleaners using perchloroethylene, airports, standby and prime generators, and gasoline dispensing facilities. The user should include all past, present, and foreseeable future sources within a 1,000 foot radius (or beyond where appropriate) from the fenceline of the sources, or from the location of a receptor, plus the contribution from the project. To gather this information, the District recommends:

- Conducting a site walk of the area to determine the locations of significant sources that are not permitted by the District,
- Use District's county-specific kml file created for Google Earth™ that contains information of most permitted sources near the proposed project area
- Contact county-specific congestion management agency to identify local surface streets within the 1,000 foot radius that have over 10,000 vehicles per day

The project sponsor initially evaluates the cumulative impacts by utilizing the screening tables and kml files provided by the District. The cumulative impacts are the summation of the cancer risks, hazards, and $PM_{2.5}$ concentrations from all significant sources identified within 1,000 foot radius of the project. For new sources, the project sponsor should first identify the location of the maximum exposed receptor from the single source screening analysis. In the cumulative analysis, the user evaluates the risks and hazards from all sources within 1,000 foot radius of the new source to the maximally exposed receptor that was identified through the single source analysis. The risks, hazards, and $PM_{2.5}$ concentrations at the maximally exposed receptor locations are then compared against the thresholds of significance. For new receptors, the cumulative analysis evaluates the risks and hazards from all sources within 1,000 foot radius of the receptor.

In some cases, proposed projects may be substantially large where both new receptors and new sources will be added to a community in phases. Sufficient number of new receptors may generate air pollution impacts from their added vehicle trips and support services such as bus and truck deliveries. The District is recommending that new receptors not be evaluated as a new source unless the project sponsor anticipates an additional 10,000 vehicles per day on local streets that are attributable to the new residential development. If the development is anticipated to have more than 10,000 additional vehicles per day on the roads, the District recommends evaluating the sum of the existing traffic with the additional new traffic volume for comparison to the screening tables. If the user conducts a refined modeling analysis, the roadway impacts based on the combined traffic volumes (existing and new traffic) should be compared to the single source thresholds. For the cumulative analysis, the District recommends including all sources within 1000 feet of the roadway be evaluated to estimate the impact to the maximally exposed receptor (i.e., in most cases, this will be the new residential development).

6.0 ESTIMATING HEALTH RISK AND HAZARD

Generally, a health risk assessment for CEQA purposes must include all sources of emissions that will emanate from a project. This includes existing and proposed plant-wide emissions. This includes all sources of potential emissions whether or not they are subject to the District permitting requirements. Additionally, all sources that emit for which OEHHA has identified as having toxicity values must be included in the health risk assessment.

It is not permissible to omit permitted sources under CEQA, even if these sources will be evaluated during the permit process. The permitting process does not evaluate the cumulative risk associated with the entire plant, only the individual permit unit. A challenge to the completeness of the risk assessments can be made if these sources are not included in the analysis.

It is also not permissible to omit pollutants in the plant risk assessment, assuming that these emissions will be evaluated separately. Pollutants that have OEHHA approved toxicity values must be included in the chronic and acute hazard estimates. Again, a challenge to the completeness of the risk assessments can be made if these substances are omitted.

Health risks and hazards shall be assessed by following the procedures described in OEHHA's Health Risk Assessment Guidelines for the Air Toxics Hot Spots Program (August 2003), and any State risk assessment and risk management policies and guidelines, such as CAPCOA's Guidance Document for Health Risk Assessments for Proposed Land Use Projects (July 2009 - http://www.capcoa.org/rokdownloads/HRA/CAPCOA_HRA_LU_Guidelines_8-6-09.pdf). The OEHHA Health Risk Assessment Guidelines contain several sections which identify (a) the overall methodology, (b) the exposure assessment assumptions and procedures, and (c) the health effects data (cancer potency factors, chronic reference exposure levels, and acute reference exposure levels).

A summary of OEHHA's Health Risk Assessment Guidelines and an index of the relevant documents are located at: http://www.oehha.ca.gov/air/hot_spots/index.html

OEHHA's risk assessment methodology (August 2003) is located at:
http://www.oehha.ca.gov/air/risk_assess/index.html

The exposure assessment and stochastic technical support document (September 2000) is located at: http://www.oehha.ca.gov/air/exposure_assess/index.html

The Technical Support Document for Cancer Potency Factors: Methodologies for Derivation, Listing of Available Values, and Adjustments to Allow for Early Life Stage Exposures (May 2009) is located at: http://www.oehha.ca.gov/air/hot_spots/tsd052909.html

The Technical Support Document for the Derivation of Noncancer Reference Exposure Levels (RELs) (June 2008) is located at: http://www.oehha.ca.gov/air/hot_spots/rels_dec2008.html

OEHHA is currently working on revising the risk assessment methodology, as well as the exposure assessment and stochastic technical support documents (TSDs). Upon adoption, these revisions will be incorporated into the CEQA guidelines.

6.1 Exposures

Most of the toxicants assessed are volatile organic compounds that remain as gases when emitted into the air. These chemicals are not subject to appreciable deposition to soil, surface waters, or plants. Therefore, human exposure does not occur to any appreciable extent via ingestion or dermal exposure. Significant exposure to these volatile organic toxicants emitted into the air only occurs through the inhalation pathway. If the emissions consist of only substances that enter the body through the inhalation pathway, the risk assessment methodologies cited under the Air Toxics "Hot Spots" Emissions Inventory and Risk Assessment Program can be used.

However, a small subset of compounds, semi-volatile organic and metal toxicants, are emitted partially or totally as particles subject to deposition. Ingestion and dermal pathways as well as the inhalation pathway must be evaluated for these chemicals for all potential receptor populations. An exception to this is diesel particulate, which is modeled only through the inhalation pathway. A software program, the Hot Spots Analysis and Reporting Program (HARP), is the recommended model for calculating and presenting HRA results. The latest

version of HARP can be downloaded at http://www.arb.ca.gov/toxics/harp/harp.htm. The intent in developing the HARP software is to provide consistent risk assessment procedures. In addition, HARP is designed to assess potential health impacts posed by substances that must be analyzed by a multipathway (e.g., inhalation and non-inhalation) approach.

The District recognizes that the assumptions used in the risk methodology may be overly conservative especially in cases where residents are assumed to spend 24 hours every day for 70 years in outside activity near their homes. The user can deviate from the prescribed inputs in this section if they can provide scientific documentation regarding actual receptor behaviors and activity patterns. For example, the user may consider reducing the exposure duration from 70 years to a shorter time period if the housing is temporary (i.e., shelters, hostel, temporary housing). User may also consider reduced exposures by accounting for the time residents spend indoors. It is recommended that prior to making any adjustments to the exposure duration that the user first analyzes the project's risk and hazards using the standard assumptions. Only in cases where the project exceeds the threshold should additional modifications be considered. The user should keep in mind that the activity patterns of the most vulnerable populations (i.e., infants and seniors) may prove to be the most conservative receptor.

6.2 Cancer Risk

Cancer risk assessment as currently practiced involves estimating exposure to carcinogenic chemicals and multiplying the dose times the cancer potency factor. The toxicity values that are used must be those that the California Office of Environmental Health Hazard Assessment (OEHHA) has identified. These toxicity values can be found at (http://www.arb.ca.gov/toxics/healthval/healthval.htm). If a substance is emitted and toxicity values have not been identified by OEHHA, other sources of data can be applied.

In accordance with OEHHA's revised health risk assessment guidelines (specifically, OEHHA's Technical Support Document (TSD) for Cancer Potency Factors, May 2009), calculation of cancer risk estimates should also incorporate age sensitivity factors (ASFs). The revised TSD for Cancer Potency Factors provides updated calculation procedures used to consider the increased susceptibility of infants and children to carcinogens, as compared to adults. The updated calculation procedure includes the use of age-specific weighting factors in calculating cancer risks from exposures of infants, children and adolescents, to reflect their anticipated special sensitivity to carcinogens. OEHHA recommends weighting cancer risk by a factor of 10 for exposures that occur from the third trimester of pregnancy to 2 years of age, and by a factor of 3 for exposures that occur from 2 years through 15 years of age. These weighting factors should be applied to all carcinogens. For estimating cancer risk for residential receptors, the incorporation of the ASFs results in a cancer risk adjustment factor (CRAF) of 1.7. For estimating cancer risk for student receptors, a CRAF of 3 should be applied. For estimating cancer risk for worker receptors, a CRAF of 1 should be applied.

The procedures for estimating the cancer risk is as follows:

- **Step 1.** Model the emissions to determine both the annual average ground-level concentrations and the maximum one hour concentration (or other period depending on the acutely toxic substance).

- **Step 2.** Create a separate plot file for the annual average and one hour maximum ground level concentrations produced from the air dispersion model.

- **Step 3.** Open the plot file in any spreadsheet application and ensure that the data are parsed into individual cells.

- **Step 4.** Prior to estimating the cancer risk, the first step is to estimate the dose by applying the following formula to each ground-level concentration:

$$\text{Dose} = (C_{air} * \text{DBR} * \text{EF} * \text{ED} * \text{CF}) / \text{AT}$$

  where:

  Dose = dose through inhalation (mg/kg-day)
  C_{air} = air concentration ($\mu g/m^3$) from air dispersion model
  DBR = daily breathing rate (302 L\kg body weight-day for adult and 581 L/kg-day for child)
  EF = exposure frequency (350 days/year)
  ED = exposure duration (70 years)
  CF = conversion factor (10^{-6} ([mg/µg] * [m^3/L])
  AT = averaging time (25,550 days or 70 years)

- **Step 5.** To estimate the cancer risk, the dose is multiplied by the cancer potency factor and the CRAF:

$$\text{Cancer Risk} = (\text{Dose} * \text{CRAF} * \text{Cancer Potency Factor})$$

  where:

  Cancer Risk = risk (potential chances per million)
  Dose = dose through inhalation (mg/kg-day)
  CRAF = 1.7 (residential receptors with constant concentrations over 70 years)
  Cancer Potency Factor = toxicity factor (mg/kg-day^{-1})

Cancer risk adjustment factors should be used to calculate cancer risk estimates for all applicable exposure pathways and potential receptor populations. Please note that these ASFs represent default values. In cases where there are adequate data for specific carcinogen potency by age, OEHHA will recommend chemical-specific adjustments to cancer risk estimates. In addition, OEHHA is currently revising the TSD for Exposure Assessment. When the revised TSD for Exposure Assessment is finalized and adopted, the Guidelines will be revised accordingly.

The potential cancer risk shall be calculated using standard risk assessment methodology. For residents, they include the assumptions that potential exposures occur 24 hours per day, 350 days per year for a 70-year lifetime.

The methods presented above are applicable to most scenarios except in the case of estimating cancer risks from roadway impacts specifically from tailpipe and evaporative losses from non-diesel vehicles due to the mixture of individual compounds that make up TOG. For cancer risks from diesel particulate matter, cancer potency values are available and the methodology provided above should be used. It should be noted that the age sensitivity values were incorporated into the emissions estimates for roadway in Section 4.3.3.2, so CRAF should not be included in the risk calculations due to TOG and diesel PM emissions.

The District presented an approach in Section 4.3.3.2 for estimating the 70-year average concentrations at downwind receptor location. To estimate the cancer risk from TOG, the user must first speciate the different compounds that make up the toxic portions of TOG. A weighted toxicity value is then developed that incorporates the individual toxicity of each compound that make up TOG. The District uses the following breakdown in Tables 14 and 15 of the toxic portion of TOG for tailpipe and evaporative losses.

Table 14. Toxic Speciation of TOG due to Tailpipe Emissions

Toxic Compounds	**EMFAC Gasoline TOG Speciation (% TOG)**	**Unit Factor**	**(HARP) Residential Cancer Risk Factors $(ug/m^3)^{-1}$**	**Unit Cancer Risk Weighted Factor $(ug/m^3)^{-1}$**	**Chronic Noncancer Reference Dose (ug/m^3)**	**Unit Chronic Noncancer Risk Weighted Factor (ug/m^3)**	**Acute Noncancer Reference Dose (ug/m^3)**	**Unit ACUTE Noncancer Risk Weighted Factor (ug/m^3)**
Acetaldehyde	0.28%	0.0028	0.0000027	7.537E-09	140	0.39	470	1.31
Acrolein	0.13%	0.0013	0	0	0.35	0.00046	2.5	0.0033
Benzene	2.47%	0.0247	0.000029	7.169E-07	60	1.48	1300	32.14
1,3-Butadiene	0.55%	0.0055	0.000174	9.487E-07	20	0.11	0	0
Ethylbenzene	1.05%	0.0105	2.52E-06	2.643E-08	2000	20.97	0	0
Formaldehyde	1.58%	0.0158	6.08E-06	9.602E-08	9	0.14	55	0.87
Hexane	1.60%	0.0160	0	0	7000	111.92	0	0
Methanol	0.12%	0.0012	0	0	4000	4.89	28000	34.22
Methyl Ethyl Ketone	0.02%	0.0002	0	0	0	0	13000	2.37
Naphthalene	0.05%	0.0005	0.000035	1.641E-08	9	0.0042	0	0
Propylene	3.06%	0.0306	0	0	3000	91.86	0	0
Styrene	0.12%	0.0012	0	0	900	1.11	21000	25.79
Toluene	5.76%	0.0576	0	0	300	17.27	37000	2129.65
Xylenes	4.80%	0.0480	0	0	700	33.61	22000	1056.22
Toxicity Weighted Factor				**1.81E-06**		**283.77**		**3282.58**

Table 15. Toxic Speciation of TOG due to Evaporative Losses

Toxic Compounds	EMFAC Gasoline TOG Speciation (% TOG)	Unit Factor	(HARP) Residential Cancer Risk Factors $(ug/m^3)^{-1}$	Unit Cancer Risk Weighted Factor $(ug/m^3)^{-1}$	Chronic Noncancer Reference Dose (ug/m^3)	Unit Chronic Noncancer Risk Weighted Factor (ug/m^3)	Acute Noncancer Reference Dose (ug/m^3)	Unit ACUTE Noncancer Risk Weighted Factor (ug/m^3)
Benzene	0.36%	3.60E-03	2.90E-05	1.04E-07	6.00E+01	2.16E-01	1.30E+03	4.68E+00
Ethylbenzene	0.12%	1.18E-03	2.52E-06	2.97E-09	2000	2.36E+00	0	0
Hexane	1.54%	1.54E-02	0	0	7000	1.08E+02	0	0
Toluene	1.70%	1.70E-02	0	0	300	5.11E+00	3.70E+04	6.30E+02
Xylenes	0.58%	5.78E-03	0	0	700	4.05E+00	2.20E+04	1.27E+02
Toxicity Weighted Factor				**1.07E-07**		**120**		**762**

The weighted toxicity values are then developed for each emission source by multiplying the TOG speciated percentage of each individual compound by its corresponding toxicity value. The summation of all of the individual weighted toxicity values is then cumulative weighted toxicity that should be applied in the risk and hazard calculations.

6.3 Chronic Noncancer Hazard

The potential for chronic non-cancer hazards is evaluated by comparing the long-term exposure level to a chronic Reference Exposure Level (REL). A REL is a concentration level at or below which no adverse health effects are anticipated. RELs are designed to protect sensitive individuals within the population. Noncancer chronic hazard are calculated by dividing the annual average concentration by the REL (Reference Exposure Level) for that substance. The equation for estimating the hazard quotient is:

$$\text{Hazard Quotient} = C_i/REL_i$$

Where:
C_i = Concentration in the air of substance i (annual average concentration in $\mu g/m^3$)
REL_i = Chronic noncancer Reference Exposure Level for substance i ($\mu g/m^3$)

The hazard index (HI) is the sum of the individual HQs for TACs identified as affecting the same target organ or organ systems. HQs for different organ systems are not added, for example, do not sum respiratory irritation HQs with cardiovascular effects. The following equation is used to calculate the Hazard Index for the eye irritation endpoint:

$$\text{Hazard Index } (HI_{eye}) = HQ_{\text{substance 1(eye)}} + HQ_{\text{substance 2(eye)}}$$

In accordance with OEHHA's risk assessment guidelines, chronic non-cancer hazards should be assessed for inhalation and non-inhalation (e.g., ingestion and dermal contact) chronic exposures.

6.4 Acute Noncancer Hazard

The potential for acute non-cancer hazards is evaluated by comparing the maximum short-term exposure level to an acute Reference Exposure Level (REL). A REL is a concentration level at or below which no adverse health effects are anticipated. RELs are designed to protect sensitive individuals within the population. The calculation of acute noncancer impacts is similar to the procedure for chronic noncancer impacts. The equation is as follows:

$$\text{Acute HQ} = \text{Maximum Hourly Air Concentration } (\mu g/m^3) \text{ / Acute REL } (\mu g/m^3)$$

In most cases for a single substance, the acute Hazard Quotient is the highest one hour air concentration divided by the acute REL for that substance. There are a few substances that have acute RELs for exposure periods other than 1 hour. In those cases, the maximum air concentration for the appropriate exposure period (e.g., 8 hours) is divided by the acute REL. As with the chronic noncancer calculation, for multiple substances that impact the same organ system, the individual substance HQs are summed to determine the HI. In accordance with OEHHA's risk assessment guidelines, acute non-cancer hazards should only be assessed for the inhalation exposure pathway. No exposure period adjustments are necessary for acute health impact calculations.