



BAY AREA AIR QUALITY
MANAGEMENT DISTRICT

California Environmental Quality Act

Air Quality Guidelines
Appendix E:
Recommended Methods
For Screening and
Modeling Local Risks
and Hazards

These guidelines are nonbinding recommendations, intended to assist lead agencies with navigating the CEQA process. They may be updated as needed in the future, and any updates will likewise be nonbinding and advisory.

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LIST OF ABBREVIATIONS

$\mu\text{g}/\text{m}^3$	micrograms per cubic meter
AADT	annual average daily traffic
AB 617	California Assembly Bill 617
AB	Assembly Bill
ADMRT	Air Dispersion Modeling and Risk Assessment Tool
ADT	average daily traffic
AERMOD	American Meteorological Society/U.S. Environmental Protection Agency Regulatory Model Improvement Committee [AERMIC] Regulatory Model
Air District	Bay Area Air Quality Management District
AP	Air Pollution
BAAQMD	Bay Area Air Quality Management District
BNSF	Burlington Northern Santa Fe Corporation
CalEEMod	California Emissions Estimator Model
CAP	Community Action Plan
CAPCOA	California Air Pollution Control Officers Association
CARB	California Air Resources Board
CEIDARS	California Emission Inventory Development and Reporting System
CEQA	California Environmental Quality Act
CPUC	California Public Utilities Commission
CRRP	community risk reduction plan
DEM	Digital Elevation Model
DEM format	USGS "Blue Book" standard DEM format
diesel PM	diesel particulate matter
District	Bay Area Air Quality Management District
EICs	Emissions Inventory Codes
EF	Emission Factor
EIC	Emissions Inventory Code
EMFAC	California Air Resources Board EMISSIONS FACTOR model
EPA	U.S. Environmental Protection Agency
facility ID	facility identification
FAH	fraction of time at home
FHWA	Federal Highway Administration
FT	fuel type

g/s	gram per second
GDF	gas-dispensing facility
GEP	good engineering practice
Guidelines	<i>CEQA Air Quality Guidelines</i>
HARP	Hotspots Analysis and Reporting Program
HARP2	California Air Resources Board Hot Spots Analysis and Reporting Program Version 2
HI	hazard index
HQ	hazard quotients
HRA	health risk assessment
MRLC	Multi-Resolution Land Characteristics Consortium
NAD83	North American Datum of 1983
NAD84	North American Datum of 1984
NED	U.S. Geological Survey National Elevation Dataset
NLCD	U.S. Geological Survey National Land Cover Database
NOx	nitrogen oxides
NSR	New Source Review
OEHHA	California Office of Environmental Health Hazard Assessment
OGRE	Oakland Global Rail Enterprise
OIG	Oakland International Gateway
PAH	polycyclic aromatic hydrocarbon
PBW	projected building width
PCB	polychlorinated biphenyl
PeMS	California Department of Transportation Performance Measurement Systems
PHEV	Plug-in Hybrid Electric Vehicles
PM ₁₀	particulate matter with a diameter less than or equal to 10 microns
PM _{2.5}	particulate matter with a diameter less than or equal to 2.5 microns
Pol	pollutant
Port	Port of Oakland
Pr	emissions process
PSD	Prevention of Significant Deterioration
RAST	Health Risk Assessment Standalone Tool
REL	reference exposure level
SCRAM	U.S. Environmental Protection Agency Support Center for Regulatory Atmospheric Modeling
<i>Syint</i>	Initial lateral dimension
<i>Szinit</i>	initial vertical dimension

TAC	toxic air contaminant
TIGER	Topographically Integrated Geographic Encoding and Referencing
TOD	Time of Day
TOG	total organic gases
UFP	ultrafine particles
UP	Union Pacific
UPS	United Parcel Service
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
VC	vehicle class
VHT	vehicle hours traveled
VMT	vehicle miles traveled
VOC	volatile organic compound
WAF	worker adjustment factor
WETA	San Francisco Bay Area Water Emergency Transportation Authority
WGS84	World Geodetic System of 1984
WRF	Weather Research and Forecasting



EXECUTIVE SUMMARY

The purpose of the “Recommended Methods for Screening and Modeling Local Risks and Hazards” is to assist project sponsors with conducting individual project and cumulative cancer risk and hazard analyses as part of their California Environmental Quality Act (CEQA) environmental review for proposed land use projects. This document provides the methodology used to perform preliminary screening and, if needed, detailed air quality analysis to assess potential cancer risk and hazard impacts.

This document should be used in conjunction with the Bay Area Air Quality Management District’s (Air District’s) *CEQA Air Quality Guidelines* (Guidelines) (BAAQMD 2022). When applying the methods presented in this document, the project sponsor should understand the modeling terms and methodology presented in Sections 2–8 to assess project-level impacts before using the screening maps in Section 9 to determine cumulative impacts. The cumulative assessment requires that the risks and hazards from the project be combined with the health impacts from surrounding sources, such as industrial facilities, rail, roadways, and marine vessels. The following screening maps have been developed¹ to assist project sponsors with quantifying the cumulative impacts from surrounding sources to determine whether further refinement is needed:

- ▶ **Updated Stationary Source Screening Map:** This web-based application maps the locations of stationary sources permitted by the Air District, including backup generators, gas stations, boilers, and auto body shops. For each source, the application lists the facility information and identifies conservative screening-level cancer risks, concentrations of particulate matter with a diameter less than or equal to 2.5 microns (PM_{2.5}) concentrations, and chronic hazard.

¹ Not all the maps described here will be available by the time this report is published. Please check the Air District CEQA tools website for updates.

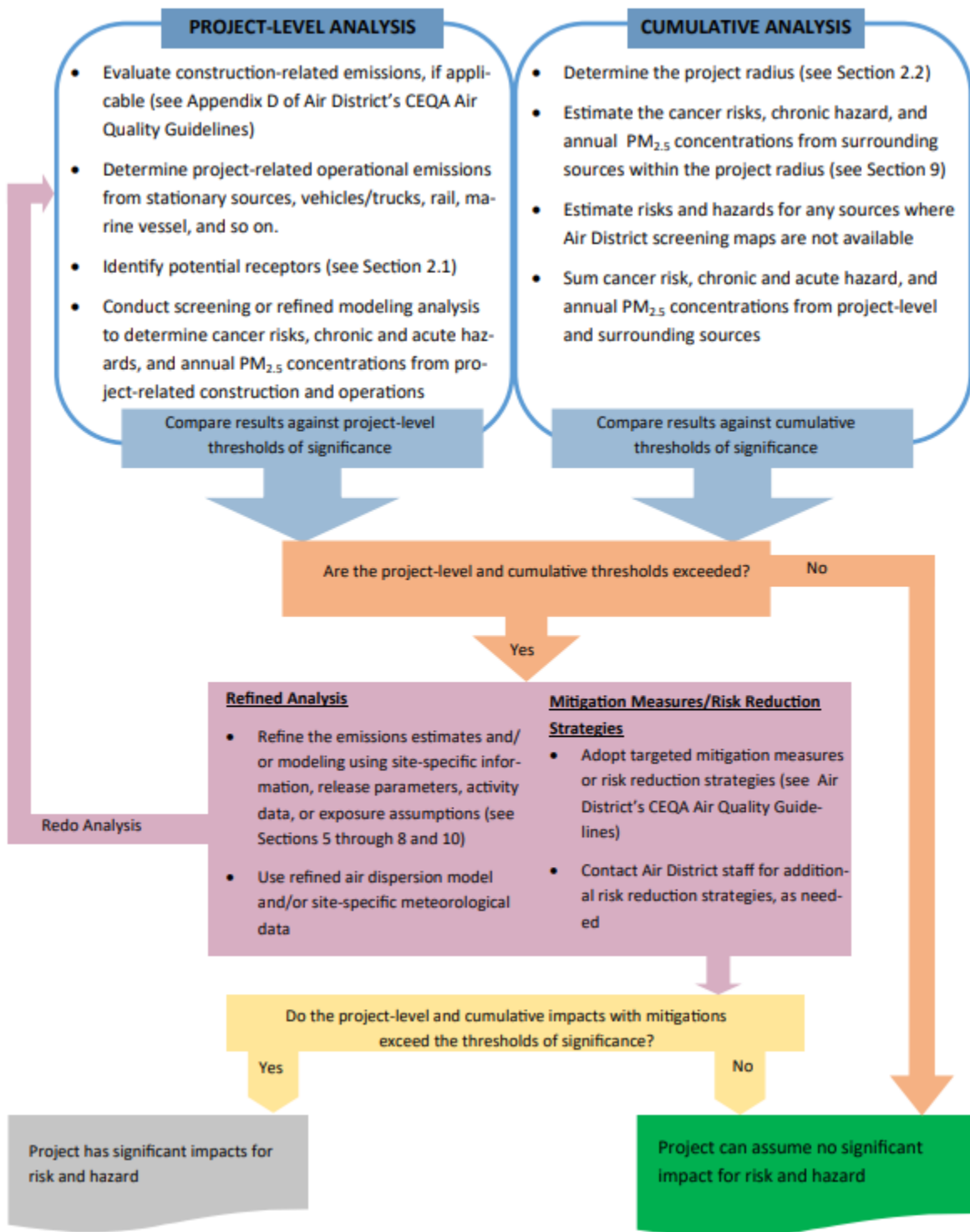
- ▶ **Updated Roadway Screening Map:** This web-based application presents the modeled PM_{2.5} concentrations, cancer risks, and chronic hazard indices from highways and surface streets, across a receptor grid.

New Rail Sources Screening Map: The District developed a new web-based application that estimates cancer risks, PM_{2.5} concentrations, and chronic hazards across the Bay Area from diesel locomotives used to transport freight along Class I rail lines, to transport people along commuter/passenger rail lines, and for goods movements at railyards in West Oakland and Richmond/North Richmond/San Pablo. The railyards were analyzed as part of the detailed community-scale modeling assessment under California Assembly Bill 617 (AB 617). These railyards serve as gateways for ferrying goods into the Bay Area and across the country. The assumptions and modeling parameters used for these screening tools are described in Section 9. These tools reflect the most current data at the time of publication. The tools may be periodically updated, and any changes will be reflected in updated versions of this document. For a detailed, step-by-step reference guide outlining the project-level and cumulative screening processes, see Figure ES-1, "Risk and Hazard Analysis Process Flow Chart."

If, after the screening process, the project-level or cumulative impacts exceed the District's recommended thresholds of significance, the project sponsor may choose to conduct a more refined modeling analysis for the proposed project or of surrounding sources. The suggested methodology for refining the analysis is provided in Sections 5–8 by source type and includes guidance on selecting the appropriate modeling tools and release parameters and addressing project-specific conditions. The risk assessment methodology is based on standard procedures developed by the California Office of Environmental Health Hazard Assessment (OEHHA) and is consistent with the District's permitting procedures, as appropriate. Project sponsors may deviate from the methods described in this document as necessary, provided that the justification is well documented.

It should be noted that health risk assessments (HRAs) used in project-level and cumulative analyses are decision-making tools used by health professionals for assessing public health impacts; they do not necessarily link an individual's exposures to environmental pollution to manifestation of a disease. Even the most detailed project or cumulative risk assessments could not evaluate the magnitude and interactions of all stressors and their effects on an individual. At best, the risk estimates of a risk assessment are an attempt to quantify the public health impact from known sources that can affect a community and offer alternatives and mitigation measures to reduce these stressors on the public.

Figure ES-1 Risk and Hazard Analysis Process Flow Chart



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1 INTRODUCTION

The Air District is providing this appendix, which replaces the 2012 document and incorporates revised and expanded descriptions of currently available screening tools and acceptable modeling methodologies for conducting a site-specific HRA. The purpose of this appendix is to provide recommended methodologies for assessing individual project and cumulative risks and hazards at a local, or community scale from air pollutants emitted from significant sources located close to nearby receptors. These methodologies are designed to assist lead agencies and project sponsors with assessing air quality impacts associated with exposures to toxic air contaminants (TACs) and PM_{2.5}.

In developing this update, the Air District created new tools and updated methodologies in response to common questions raised by practitioners, including:

- ▶ new section on how to assess impacts from overlapping construction and operation activities;
- ▶ new screening map to address impacts from passenger and freight rail;
- ▶ new screening map for select railyards in the Bay Area;
- ▶ new distance dilution factors for general sources;
- ▶ new modeling methodologies for conducting refined analysis from construction (see Appendix D of Guidelines), rail, and marine vessels;
- ▶ new section on estimating emissions and modeling impacts from stationary sources;
- ▶ revised modeling approach for roadway impacts; and
- ▶ updated exposure factors for discrete receptors.

The methodologies continue to follow a tiered approach. The level of effort and requirements for more site-specific information generally increase as the project sponsor 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 incorporating more site-specific modeling data will produce 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. For projects that exceed the thresholds of significance, the Air District has compiled a list of feasible mitigation measures in the Guidelines to assist project sponsors in reducing their project's impact on the environment.

This document includes guidance on the following topics:

- ▶ **Modeling Concepts and Source Types** introduces basic modeling concepts and defines source types commonly used in air dispersion modeling. Project sponsors should be familiar with these terms before they perform a screening or refined modeling analysis.
- ▶ **Source-Specific Modeling Methodology** describes the methodology for performing air dispersion modeling by source type (stationary source, roadway, rail, and commute ferry) and can be used in the project-level or cumulative analysis. The section has been expanded to include an approach for developing an emissions inventory using activity data and default modeling parameters when site-specific information is not available.
- ▶ **Screening Maps** provides an easy-to-use initial screening of cumulative impacts from nearby stationary sources, rail lines, railyards, or roadways. The section describes how to use the screening maps to determine whether the cumulative thresholds are exceeded. Project sponsors can also use the same methodology used in creating the screening maps to develop source emissions for their project, as appropriate.
- ▶ **Cancer Risks** describes the methodology for estimating the incremental lifetime cancer risk using age-appropriate exposure factors for various receptor types.
- ▶ **Chronic Noncancer Hazard and Acute Noncancer Hazard** describes the methodologies for estimating long-term chronic noncancer health impacts and short-term 1-hour acute exposures, respectively.

Although the original modeling methodology relied heavily on the California Air Pollution Control Officers Association (CAPCOA)'s *Health Risk Assessments for Proposed Land Use Projects* (CAPCOA 2009), the revised modeling methodology has been updated to be consistent with Air District's permitting requirements and specific Bay Area air quality modeling practices.

The risk assessment components are based on the procedures developed by OEHHA and is consistent with the Air District's Regulation 2-5: New Sources Review of Toxics Air Contaminants and Regulation 11-18: Reduction of Risk from Air Toxic Emissions at Existing Facilities.² These calculation methodologies may change over time as OEHHA further refines its exposure guidelines. **It is important that the project sponsor use the most current risk assessment methodology and toxicity factors from OEHHA's HRA guidelines.**

² District rules are available at the following link: <https://www.baaqmd.gov/rules-and-compliance/current-rules>.

For those practitioners familiar with the 2012 document, some significant recommended changes should be noted:

- ▶ AERMOD, AERSCREEN, and SCREEN are the only accepted air dispersion models for performing a screening or refined analysis.
- ▶ Fugitive dust emissions from construction and operations should be included in the project-level analysis. Project sponsors can use CalEEMod to estimate fugitive dust emissions from construction activities following the guidance provided in Appendix D of the Guidelines. Fugitive dust emissions from facility operations can be estimated using the Air District's *Permit Handbook*.
- ▶ Sensitive receptors have been expanded to include off-site workers and students, consistent with the Air District's permitting requirements.
- ▶ Emissions from emergency use and non-testing and non-maintenance hours should be included in the assessment for backup/standby generators.
- ▶ Use of the student scenario is recommended in all air quality analysis when a school is located within 1,000 feet of the project site.
- ▶ Default release parameters for modeling purposes are provided for select source types.
- ▶ The "maximum potential to emit" emissions from new stationary sources should be used in the project analysis.

This appendix addresses only health impacts related to exposures to TACs and PM_{2.5}. Project sponsors can review the Guidelines for methods to evaluate health impacts related to criteria air pollutants.

1.1 HEALTH CONCERNS

Despite improvements in air quality, air pollution concentrations continue to remain elevated in some Bay Area locations near major air pollution sources, such as freeways or large industrial facilities. Residents living in these areas may experience adverse health outcomes from their exposures to unhealthy levels of air pollution. The focus of this guidance is to provide lead agencies and project sponsors with the necessary tools for evaluating local community risk and hazard impacts associated with exposures to TACs and PM_{2.5} because they pose the greatest risk to people's health in the Bay Area. This appendix presents methods for assessing the potential health impacts from directly emitted PM_{2.5} and TACs emissions, not those formed through secondary reactions in the atmosphere, which requires complex photochemical modeling over large-scale, regional areas.

These compounds and their health impacts are summarized as follows:

- ▶ **Toxic air contaminants (TACs):** The California Air Resources Board (CARB) is responsible for identifying TACs, which are defined as pollutants "which may cause or contribute to an increase in deaths or in serious illness, or which may pose a present or potential hazard to human health." TACs are emitted into the air from a wide range of sources in the Bay Area, including diesel engines, cars, trucks, industrial processes, and gas stations. Types of TACs include diesel particulates, lead, benzene, formaldehyde, and hexavalent chromium. Diesel particulate matter

(diesel PM) is the most significant TAC, accounting for roughly 85 percent of the cancer risk from air toxics in the region. Exposure to TACs can cause serious health effects, including cancer and birth defects. Other adverse health effects can include damage to the immune system, neurological, reproductive (reduced fertility), development, and respiratory problems.

- ▶ **Fine particulate matter (PM_{2.5}):** Epidemiological studies have established that exposures to PM_{2.5} have serious adverse health impacts. PM_{2.5} can travel deep into lungs and enter the bloodstream. Fine PM originates from a variety of sources, including fossil fuel combustion, residential wood burning and cooking, and natural sources, such as wildfires and dust. Researchers established long ago that exposure to PM_{2.5} has negative effects on the respiratory system, such as triggering asthma attacks, aggravating bronchitis, and diminishing lung function. More recent studies have found that PM_{2.5} can also harm the cardiovascular system and may cause atherosclerosis (hardening of the arteries), ischemic strokes (cause by an obstruction of the blood supply to the brain), and heart attacks. Because of the serious cardiovascular effects of exposure to PM_{2.5}, studies have found a clear correlation between PM_{2.5} levels and exposure, and mortality. Studies also indicate that exposure to PM_{2.5} may be related to other negative health effects, including impacts on the brain, such as reduced cognitive function, as well as increased risk of diabetes. Recent research in the United States and internationally has begun to examine the potential health effects of even smaller particles, known as ultrafine particles (UFP), which are particles less than 1.0 micron in diameter. Findings to date demonstrate that UFPs can evade the body's defense mechanisms and penetrate deeply into lungs, the bloodstream, and organs. Exposure to PM_{2.5} remains the leading public health risk and contributor to premature death from air pollution in the Bay Area. More information on PM_{2.5} and associated health effects can be found in the Air District's informational report entitled *Understanding Particulate Matter: Protecting Public Health in the San Francisco Bay Area*" (BAAQMD 2012).

In the Bay Area, some urban and industrialized communities have higher TACs and PM_{2.5} concentrations compared to the rest of the Bay Area. These same communities are often faced with other environmental and socioeconomic hardships that further stress their residents and result in poor health outcomes. The air quality conditions in these affected communities are partially the result of past decisions related to land use and transportation planning. This methodology is designed to assist local jurisdiction in identifying and avoiding future land use conflicts to ensure health protection of all residents in a community.

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 PM_{2.5} emissions and concentrations in an entire community from new and existing sources. The goal of a CRRP is to cumulatively reduce TAC and PM_{2.5} concentrations for the entire community by following the comprehensive plan adopted by the local jurisdiction. This approach provides local agencies with a proactive alternative to address communities with high levels of risk on a project-by-project approach. The screening maps presented in Section 9 can be used as the basis of the community baseline conditions, or local agencies can apply the methodology from Section 9 to develop their own risks and hazards map. This proactive approach is encouraged for all communities, and especially those that are overburdened.

1.2 CEQA THRESHOLDS

Under the Guidelines, the Air District developed thresholds of significance for air pollutants emitted from a new project and for cumulative exposures that include emissions from a new project in combination with existing sources. The goal of the thresholds is to ensure that no source creates, and no resident 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 project-level significance thresholds, its emissions would be cumulatively considerable, resulting in significant adverse air quality impacts. Additionally, the thresholds were developed with the understanding that some areas may already be near or at the level of impact. A project would have a significant impact if the aggregate total of all surrounding significant sources plus the contribution from the project exceeds the cumulative thresholds.

The thresholds for local risks and hazards from TAC and PM_{2.5} are intended to apply to all sources of emissions, including both 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 and can also be found in Chapter 2 of the Guidelines (<https://www.baaqmd.gov/plans-and-climate/california-environmental-quality-act-ceqa/updated-ceqa-guidelines>).

Table 1 Thresholds of Significance for Local Community Risk and Hazard Impacts

Analysis	Thresholds of Significance
Individual project: construction and/or operations	Compliance with qualified community risk reduction plan, or <ul style="list-style-type: none"> ▶ increased cancer risk of > 10.0 cases in a million¹ ▶ increased noncancer risk of > 1.0 Hazard Index (Chronic and Acute) ▶ ambient PM_{2.5} increase > 0.3 µg/m³ annual average
Cumulative impacts	Compliance with qualified community risk reduction plan, or <ul style="list-style-type: none"> ▶ cancer risk > 100 cases in a million (from all sources) ▶ noncancer risk > 10.0 Hazard Index (from all local sources) (Chronic) ▶ PM_{2.5} > 0.8 µg/m³ annual average (from all local sources)

Notes: µg/m³ = micrograms per cubic meter; PM_{2.5} = particulate matter with a diameter less than or equal to 2.5 microns.

¹ The CEQA thresholds of significance do not reflect recent amendments adopted in 2021 to Regulation 2-5 that lower the cancer risk threshold to six cases in a million in overburdened communities. Project sponsors should contact the lead agency to determine the appropriate thresholds to use for their project.

1.3 CEQA EXEMPTIONS

All the maps provided by the Air District are designed to help project sponsors and lead agencies determine whether there are any potentially significant environmental effects associated with a project under CEQA. The first step is to determine whether the project is statutorily or categorically exempt from CEQA such that an environmental clearance document or disclosure is not required. There are no exceptions to statutorily exempt projects; however, certain projects that are categorically exempt under the Air District guidelines may emit toxic emissions or may be affected by existing toxic sources. Project sponsors should refer to Chapter 1 of the Guidelines (<https://www.baaqmd.gov/ceqa-guidelines>) for more information on categorical exemptions and the common sense exemption, or contact the Air District’s Planning Division at ceqa@baaqmd.gov.

1.4 PROCESS OVERVIEW

When performing the air quality analysis under CEQA, the Air District recommends that the project sponsor follow a tiered approach where at each successive step, the project's impacts (i.e., annual $PM_{2.5}$ concentrations, cancer risks, and hazards) and the combined cumulative impacts from surrounding sources are compared to the CEQA thresholds of significance. For the first tier, a screening model is recommended that requires minimal site-specific data. The first tier uses the screening methodology to estimate the project's impact and then combines the results from the screening maps to compare against applicable thresholds. If the thresholds are exceeded at the screening level (Tier 1), project sponsors can refine the analysis further by following Tier 2 recommendations and using complex air dispersion models, source-specific release parameters, and area-specific meteorology.

The tiered approach is flexible, and project sponsors can mix and match tier methodologies to suit the project needs. For example, Tier 2 refined models can be used to assess the project's impact, whereas the screening maps can be used to evaluate cumulative impacts. Both tiers are designed to address health impacts from new sources of TAC or $PM_{2.5}$ proposed for the project. Examples of new sources of TAC emissions include gasoline-dispensing facilities (i.e., gasoline stations), concrete batch plants, and auto body shops. Less obvious sources of TAC include diesel backup generators that are housed in the basement of hospitals, governmental agencies, and fire stations for use in case of power outages. Diesel PM is a TAC that is emitted into the atmosphere in the form of $PM_{2.5}$ through combustion of diesel fuel, but $PM_{2.5}$ can also be the sole pollutant emitted from a new source, as is the case for sandblasting, storage silo/piles, and aggregate handling.

As a first step, 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 to sensitive receptors. The project sponsors will need to determine the project radius and identify significant sources and receptors within that radius. The project's risk and hazard can then be compared to the project-level thresholds. CEQA requires that in addition to evaluating the individual project impact, the project sponsor must evaluate the cumulative impacts—the risks and hazards of the project combined with those from surrounding TAC and $PM_{2.5}$ sources. Impacts from the surrounding sources can be assessed using the screening maps. Project sponsors can then determine whether the health impacts from stationary and mobile sources within a 1,000-foot radius of the project, when added to the project's contribution, may have a significant cumulative impact. The project radius may be extended to include sources beyond 1,000 feet depending on the magnitude of their emissions, local meteorology, and contaminant fate and transport.

If project-level or cumulative thresholds of significance are exceeded, the project sponsor can conduct more refined modeling analysis by incorporating site-specific information into an approved air dispersion model. Project sponsors can also implement all feasible measures to mitigate the potential health impacts. The subsequent sections provide more detailed information on emissions methodology, screening maps, and air dispersion models for conducting a project-level and cumulative analysis.

1.5 STARTING POINT

The most current documentation (including this appendix), datasets for screening and modeling, and Air District staff contact information are available online at <https://www.baaqmd.gov/ceqa-resources>. This website serves as the starting point for all CEQA maps, methodology documentation, and data related to Air District-recommended screening and modeling of local risks and hazards. For questions on data availability and screening and modeling methods, please contact the Air District’s Planning Section at ceqa@baaqmd.gov.

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2 IDENTIFYING RECEPTORS, SURROUNDING SOURCES, AND PROJECT RADIUS

The recommended methods to evaluate local risks and hazards rely on 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 receptors should be considered?
- ▶ How is the zone of influence determined?
- ▶ What surrounding sources should be included in the cumulative analysis?
- ▶ How are impacts assessed when construction and operations activities overlap?

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

2.1 IDENTIFYING RECEPTORS

As part of the project-level analysis, project sponsors are required to identify receptors that may potentially be affected by the proposed project. The receptors closest to the project site may not in all cases be the most affected, because numerous factors, such as release height of the emission sources, the magnitude of the emissions, and the local meteorology and terrain, can play important roles in determining a pollutant's fate and transport. For the purpose of this appendix, receptors are defined as people—children, adults, and seniors—occupying or residing in:

- ▶ residential dwellings, including apartments, houses, condominiums, single-room occupancy units, and residential hotels;
- ▶ places of business;
- ▶ schools, colleges, and universities;
- ▶ daycare centers;
- ▶ hospitals;
- ▶ temporary housing, shelters, or encampments,
- ▶ detention centers or correctional facilities and
- ▶ senior-care facilities.

Consistent with the Air District's permitting requirements, the Air District recommends that project sponsors consider the following receptors in their assessment, as applicable:

- ▶ **Residential receptors** are receptors in off-site locations, either indoor or outdoor areas, where people live or spend most of their day. Residential locations include current residential land uses and areas that may be developed for residential uses in the future, given existing and planned zoning.
- ▶ **Worker receptors** are off-site locations where people work, including indoor and outdoor areas and commercial/industrial areas currently zoned or planned to be zoned for manufacturing, light or heavy industry, office, or retail activity.
- ▶ **Acute receptors** are receptors at off-site locations where individuals may be exposed to TACs for durations as short as 1 hour. An acute receptor location could be an off-property location (occasionally, it may be an on-site property) that is accessible to people. The project sponsor should use discretion in determining the likelihood of exposure and exclude areas such as roadways, bodies of water, rail tracks, steep terrain, and so on where people are unlikely to spend much time. The potential for even intermittent public exposure (e.g., beaches, picnic areas, playgrounds, sports fields, dog walking areas, outdoor event pavilions) is the determining factor when designating acute receptor locations.
- ▶ **Sensitive receptors** are individuals more susceptible to poor air quality (i.e., children, the elderly, and those with preexisting serious health problems affected by air quality). Land uses where sensitive individuals are most likely to spend time include schools and schoolyards, parks and playgrounds, daycare centers and preschools, hospices, dormitories, correctional facilities, nursing homes, hospitals, and residential communities. Students at K–12 schools are considered sensitive receptors for any project proposed within 1,000 feet of the school property. **The Air District recommends that a student scenario be included in the HRA when a school is located within 1,000 feet of the project.**
- ▶ **On-site receptors** are receptors inside the facility boundary that may be evaluated in cases when:
 - residents sleep or spend part of their day in an on-site building (e.g., work-provided on-site housing, dormitories at colleges, and housing on military bases);

- residents sleep or spend part of their day in an on-site residential building that is not owned by, leased, or monetarily tied to the facility or project being evaluated;
- sensitive receptors at on-site school, daycare, hospital, or adult/elderly care facility where people sleep or spend most of their day; or
- workers at an on-site area where people work but are not employed by or monetarily tied to the facility being evaluated (e.g., employees of restaurants in hotels, casinos, recreational/entertainment area, or airports).

The recommendation is that the health assessment be consistent with the Air District's permitting requirements and include evaluation of all possible receptors, as applicable. These locations can either be modeled as discrete receptor (individual receptor points) or encompassed within a larger receptor grid. The purpose is to ensure that the analysis is sufficiently health protective of the most vulnerable populations and captures the location where an individual will receive the highest exposure of TAC and PM_{2.5} emissions from the proposed project. Lead agencies at their discretion may recommend inclusion of areas zoned for residential use even if no residential development currently exists, to ensure health protection of future residents.

2.2 DETERMINING THE PROJECT RADIUS

There are two project radii: one determined for the project-level analysis and another one for evaluating cumulative impacts. For assessing the *individual project* impacts of a new source or sources, no specific project radius is recommended. The project sponsor must ensure that the project radius encompasses all potential sources associated with the project and addresses the health impacts on receptors in the Bay Area. The project sponsor must ensure that its project's impacts have been fully characterized along all possible transportation routes, as well as identify receptors that may be affected. The location of maximum risk, hazard, and PM_{2.5} concentration affecting a receptor should be identified regardless of distance from the project site. For example, projects involving ocean-going vessels may be required to include transiting emissions up to 11 nautical miles from the entrance of Golden Gate Bridge.³

For assessing the *cumulative* impacts from a project's source(s) in combination with existing sources, a specific project radius is recommended. The Air District recommends that the cumulative analysis combine the risks and hazards from existing sources within 1,000 feet of the project's source(s) with the risks and hazards from the project's source(s). After the location of the maximally affected receptor is identified for the project's source(s), impacts from surrounding sources within the project radius are then assessed to determine their cumulative impact on the maximally affected receptor. Assessments should sum individual hazards or risks to find the cumulative impact at the location of the maximally affected receptor from the project's source(s). However, the 1,000-foot radius is not an absolute rule for excluding sources located beyond the radius of influence. The project radius may be expanded beyond 1,000 feet to include sources that are significant contributors to the overall cumulative risks and hazards at the maximum affected

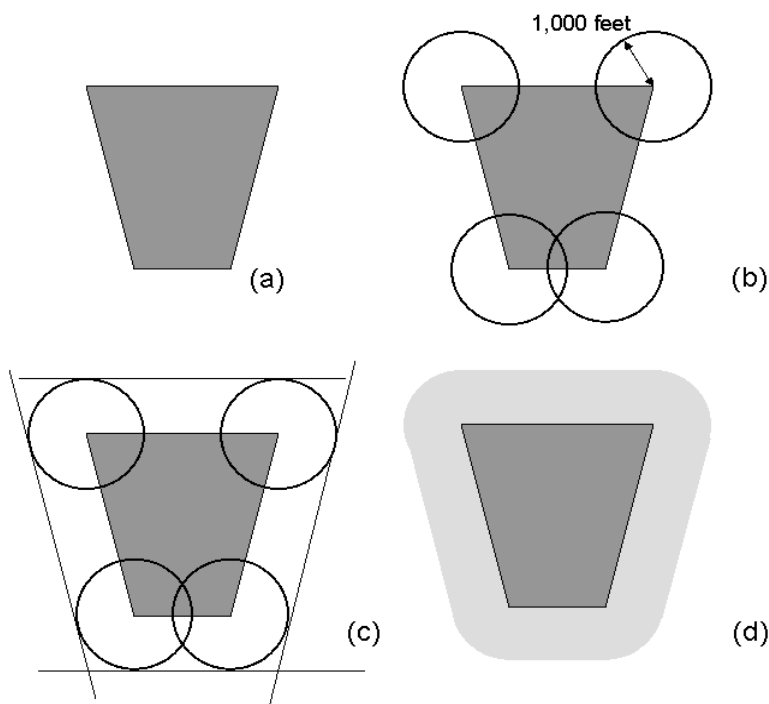
³ Under Regulation 2-2-610, all emissions from cargo carriers while they operate in the San Francisco Bay Area, or within California coastal waters up to 11 nautical miles from the Golden Gate Bridge (and any additional areas of California coastal waters adjacent to the San Francisco Bay Area if cargo carrier emissions in such areas would have substantial impact on air quality within the San Francisco Bay Area Air Basin), should be included as part of the source's emissions. Facilities must comply with this requirement if applying for offsets under Regulation 2-2.

receptor. For large, complex sources, such as those listed in Section 2.3, a larger radius may be appropriate, but the specifics should be determined on case-by-case basis.

To construct the cumulative impacts project radius, a polygon should be formed that is 1,000 feet from the property boundary of the new development. Geographic information system–based mapping programs provide a proximity feature for constructing such polygons based on linear distance. The polygon may be constructed by hand using the following steps (Figure 1):

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.

Figure 1 Constructing the Cumulative Impacts Project Radius



The shaded polygon (a) represents the property boundary. Circles of 1,000-foot radii (b) are added 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).

2.3 IDENTIFYING SOURCES FOR THE CUMULATIVE ANALYSIS

There are numerous sources of air pollution, and this section discusses which sources surrounding a project should be included in the cumulative assessment. A source is referred to as the locality where toxic emissions originate and are released into the atmosphere. It can refer to a physical device producing emissions or the location where project activities produce emissions, such as a construction site or roadway. Project sponsors are responsible for ensuring that every source of emissions from their project are included in the air quality analysis and are compliant with existing regulations. The Air District's *Permit*

Handbook (BAAQMD 2006) is a good reference guide for project sponsors seeking permits for new sources. Project sponsors can also use the methodology described in Sections 6–8 to estimate emissions and model air quality impacts from mobile sources associated with the project.

For the cumulative analysis, the Air District groups sources into three categories: common sources, complex sources, and minor- or low-impact sources. Common sources emit TACs or PM_{2.5} in significant enough quantity to warrant consideration but are simple enough as to lend themselves to simplified risk screening tools. Some common sources are:

- ▶ major roadways;
- ▶ gas stations;
- ▶ stationary diesel engines, such as stand-by backup generators;
- ▶ crematories;
- ▶ spray-booths;
- ▶ construction projects; and
- ▶ railroad tracks for locomotive diesel engines.

Because most of these sources are permitted, the Air District provides preliminary screening values based on their reported emissions or their maximum potential to emit for new sources (see Section 9.1). This appendix also presents methodologies for analyzing impacts from common sources because most of them are located close to residents and pose the greatest risks to Bay Area communities.

Complex sources pose the most significant risk, but because of their complexity or otherwise unique nature, they do not lend themselves to simplified screening maps or even modeling analysis that can be easily generalized. Examples of complex sources that generate significant pollution are:

- ▶ railyards;
- ▶ distribution centers and truck-related businesses;
- ▶ airports;
- ▶ oil refineries;
- ▶ chemical processing plants;
- ▶ power plants;
- ▶ marine vessels, including ocean-going vessels, ferries, tugboats, tankers, and barges;
- ▶ metal melting facilities; and
- ▶ cement plants.

Because some of these facilities are permitted by the Air District, conservative risks and hazards have been assigned to these facilities in the screening maps. The facility-specific screening values are based on the

emissions from the Air District permit⁴ but exclude emissions from most mobile sources supporting the facility, such as trucks, rail, construction equipment, airplanes, and marine sources. Quantification of emissions from these types of sources is complex and requires comprehensive knowledge of the sources of emissions, the number of sources, the activity level, and the types of pollutants emitted. Project sponsors can perform a refined modeling analysis for some of these sources using information presented in Sections 5–9 and reviewing the Air District's *Permit Handbook*. Completed HRAs are available from the Air District for select railyards under AB 617 and for large facilities under Regulation 11-18.

The last source type is minor or low-impact sources, which are unlikely to pose significant risks. The Air 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 and PM_{2.5} emissions. Minor, low-impact sources include:

- ▶ nondiesel standby generators and boilers,
- ▶ petroleum-based solvents used in dry-cleaning operations, and
- ▶ space-heating equipment.

These sources can be excluded from the analysis of local risks and hazards impacts.

2.4 ASSESSING IMPACTS FROM OVERLAPPING ACTIVITIES

Some projects, given their size, may require a phased construction schedule that allows residents and businesses to begin occupation on newly finished buildings while construction continues on other phases. Workers and residents in this case would be affected from ongoing construction activities combined with emissions from newly constructed access roads, as well as operations from new businesses. The analysis becomes complex because the location of the maximally exposed receptor (workers, residents, and possibly students) moves as each development and construction phase is completed.

The Air District recommends for any project involving overlapping activities (i.e., concurrent construction and operations) that the project sponsor identify the maximally exposed individual after each phase is completed. The Air District proposes the following approach for analyzing the health impact for projects with multiple overlapping activities (Figure 2).

Part I: When construction begins and no residents and workers are on-site:

- ▶ Evaluate the cancer risk, the hazard, and PM_{2.5} concentrations for the maximally exposed off-site worker/resident at location A (the locations may be different depending on the receptor) based on the first phase of construction.
- ▶ Include any mitigation measures required by the lead agency as conditions of approval.
- ▶ Use the appropriate exposure factors to be consistent with the construction phase being analyzed.

⁴ The current Stationary Source Screening Map is based on the latest 2020 emissions. Because emissions vary per year, the Air District periodically updates the screening maps to incorporate the latest emission inventory, noting the emission year.

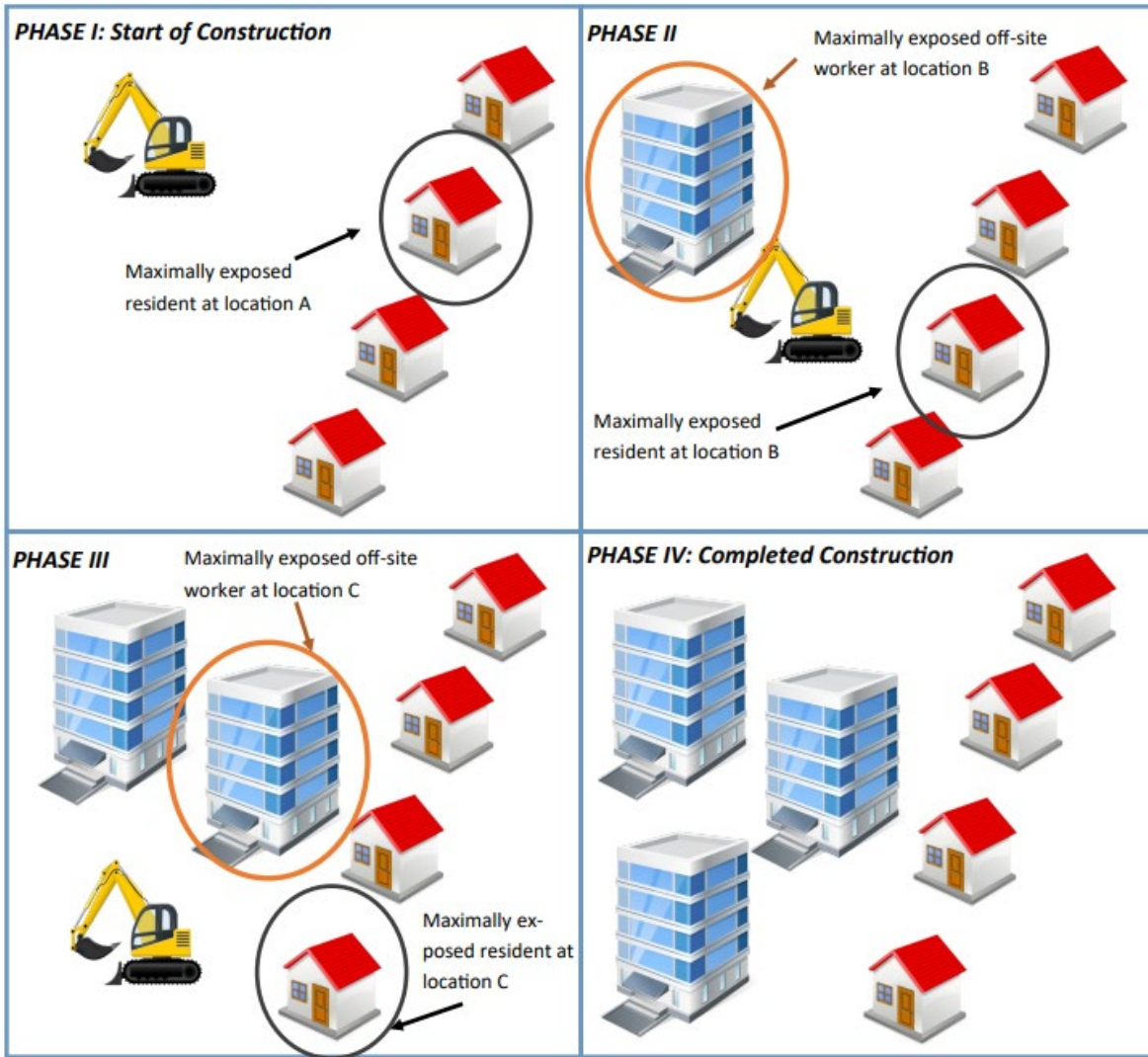
Part II: After the first phase is completed, residents/workers are on-site, and the second phase of construction begins:

- ▶ Evaluate the construction emissions from the second phase for the maximally exposed on-site worker/resident at location B (the locations may be different depending on the receptor).
- ▶ Evaluate operational emissions from new businesses within the project radius for workers/residents at location B. Include likely emissions from common sources found at most businesses, such as standby diesel generators, boilers, and trucks trips.
- ▶ Include any mitigation measures required by the lead agency as conditions of development.
- ▶ Determine the highest annual PM_{2.5} concentration for workers/residents at location B from the combined impact from construction and operations.
- ▶ Estimate the health impact from the combined construction and operation impacts for the workers/residents at location B. Care should be taken to ensure that appropriate exposure factors are used to represent the exposure duration consistent with the phase of development.
- ▶ When identifying the location B with the highest worker/resident exposures, the Air District recommends initially modeling the impacts from construction and operations separately using a fine receptor grid that extends beyond the site boundary and includes, at a minimum, the location of the maximally exposed off-site receptor (location A). Modeled concentrations from construction and operations are then combined at each receptor location to determine the maximally exposed worker/resident at location B.
- ▶ The project sponsor should additionally track the impact on the maximally exposed off-site receptor at location A that will be exposed to the emissions from the completed phase and ongoing construction activities. The cancer risks and chronic hazard are cumulative, so the risks should be added from the start of the construction (Part I) to the end of the second phase of construction. Please note that the maximally exposed off-site worker/resident during Phases I and II may be found at the same location.

Part III: For the next completed phase of development:

- ▶ The analysis will follow an iterative process as described above for Part II whereby impacts are determined for a new maximally exposed worker/resident at location C (the locations may be different depending on the receptor).
- ▶ It is recommended that the project sponsor continue to cumulatively aggregate the health impacts for receptors at locations A and B from impacts associated with the next phase of development. The project sponsor can discontinue tracking successive phases of development for previous maximally exposed receptors from other phases after maximum exposure duration for cancer risks and chronic hazards has been reached. (When this appendix was published, the acceptable exposure duration for residents was 30 years.)
- ▶ The next maximally exposed worker/resident is identified after each completed phase of development following this iterative process.

Figure 2 Illustration of How to Assess Impacts from Overlapping Activities



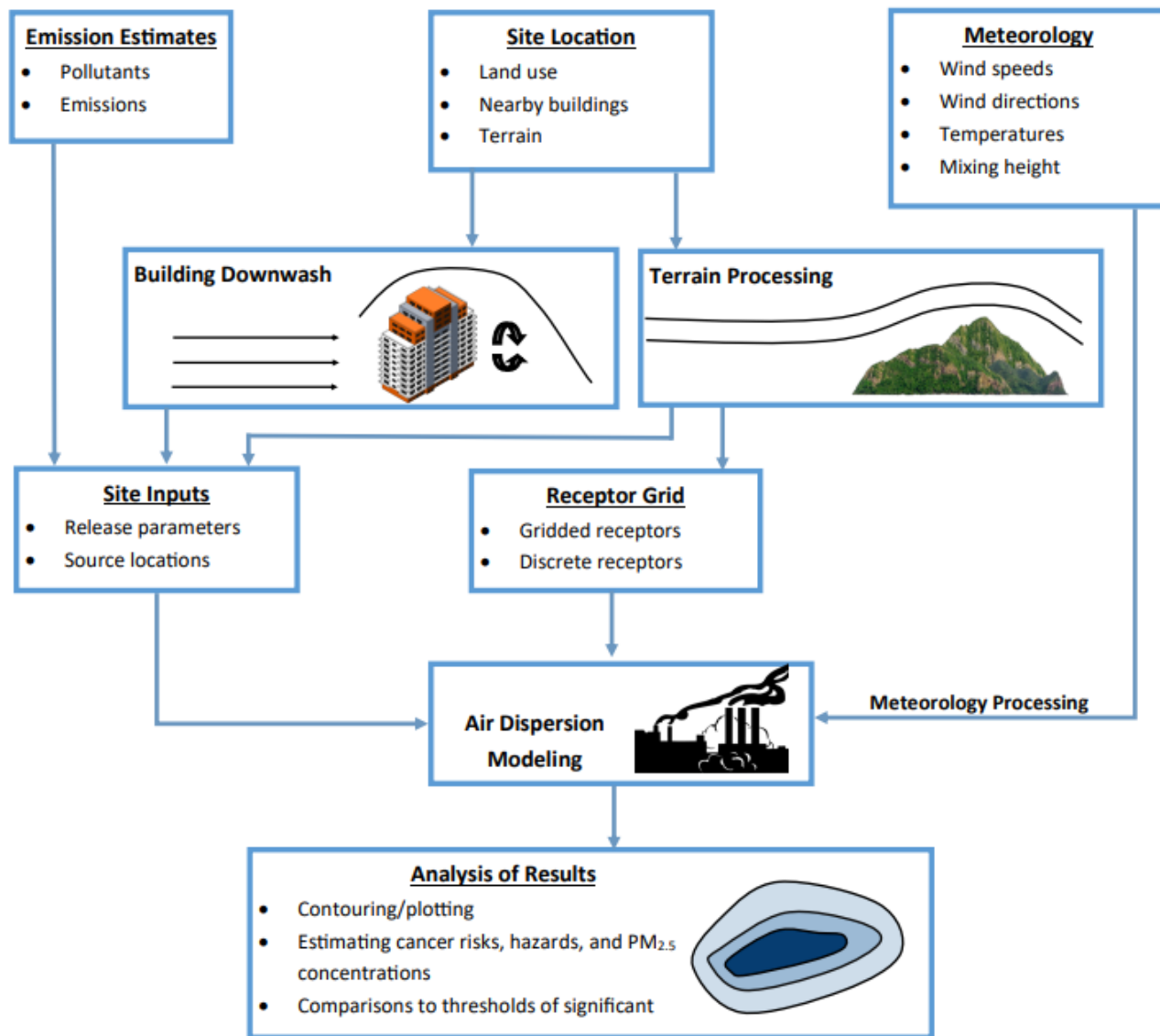


3 GENERAL AIR DISPERSION MODELING CONCEPTS

Air dispersion modeling is the mathematical estimation of pollutant impacts from emissions sources to a receptor location. Most projects rely on air dispersion modeling to estimate exposure concentrations to receptors from project and/or cumulative sources. Many of the concepts presented in this section are relevant whether a screening or refined modeling analysis is being performed.

Several factors determine the transport of pollutants in the atmosphere, including meteorological conditions, site configuration, emission release characteristics, surrounding terrain, and source types. Figure 3 presents a general overview of the process typically followed for performing an air dispersion modeling assessment. This section assumes that the project sponsor has some familiarity with air dispersion modeling terms and concepts and that additional information can be found in the users' guide of specific models. The following sections highlight key concepts that need to be defined before an air dispersion modeling analysis is conducted.

Figure 3 Generalized Process for Performing a Refined Air Dispersion Modeling Analysis



Source: CAPCOA 2009.

3.1 RECOMMENDED AIR DISPERSION MODELS

Several air dispersion models approved by federal and state agencies are available depending on the type of source being modeled and site conditions. The Air District recommends for CEQA purposes that either the SCREEN3 model (EPA 1995) or AERSCREEN be used for screening Tier 1 analysis and that the American Meteorological Society/U.S. Environmental Protection Agency Regulatory Model Improvement Committee (AERMIC) Regulatory Model, AERMOD (EPA 1998; Paine et al. 2003; Cimorelli et al. 2002), be used in a refined Tier 2 modeling analysis. AERMOD is currently the U.S. Environmental Protection Agency’s (EPA’s) preferred near-field air dispersion model (Guideline on Air Quality Models in 40 CFR Part 51, Appendix W; EPA 2001) and is required on any HRA submitted to the Air District in support of a permit application. Note that project sponsors are not required to consistently use only screening models in Tier 1 and refined

models in Tier 2; at any time, project sponsors can mix and match which model to apply depending on the sources associated with their project and the available information.

The advantages of using a screening model include ease of use and the possibility of eliminating insignificant sources from further analysis. Both SCREEN3 and AERSCREEN⁵ predict the maximum 1-hour concentrations at specified receptor distances based on minimal project information and default worst-case meteorological conditions. If the source is found to be an insignificant contributor to the overall health impacts from the project, then it could be eliminated from further analysis because the screening analysis incorporates relatively conservative assumptions to ensure that the health impacts are not underestimated. If the results of the screening analysis exceed the thresholds, then a refined Tier 2 analysis can be performed, requiring detailed information on site operations and local meteorology.

The SCREEN3 model is a single-source Gaussian plume model that provides maximum ground-level concentrations from point, area, volume, and flare sources (see Section 4 for details describing each source type), as well as concentrations in the cavity zone, and concentrations related to inversion breakup and shoreline fumigation. The model includes worst-case default meteorological data that incorporates the full combinations of wind speeds and stability classes. The model also allows inputs on building downwash, terrain, and fumigations. AERSCREEN incorporates some of the improved modeling algorithms used in AERMOD and, being more current, differs from SCREEN3 by having additional modules that can handle building wake effects; user-defined meteorological conditions, such as surface characteristics and temperatures; and terrain.

The main limitation of both screening models is that they are designed to estimate the worst-case concentration representing the value from the plume centerline regardless of the source-receptor-wind direction orientation. There is an option in the recommended refined model, AERMOD, to input terrain and building data while in the screening mode. In general, the AERSCREEN program will produce slightly more conservative results than the screening mode of AERMOD because AERSCREEN and SCREEN3 perform a more precise search to isolate the receptor distance with the highest concentration.

More sophisticated models are highlighted in the next tier of analysis where multiple sources and site-specific meteorological data can be used. Refined models, such as AERMOD, require much more site-specific information, allowing for greater characterization and more representative results. The models require some familiarity with air dispersion modeling concepts, as well as site conditions and emission release characteristics of the sources to be modeled. Subsequent sections discuss some key modeling concepts that can be applied, as applicable, to both the screening and Tier 2 air modeling analyses. The project sponsor should refer to the air model user's guide for additional information.

⁵ The SCREEN3 and AERSCREEN models can be downloaded from the EPA web site at <https://www.epa.gov/scram/air-quality-dispersion-modeling-screening-models>. User's guides for both models can also be downloaded from this website. A user-friendly interface is also available for SCREEN3 as a free download from Lakes Environmental web site at <https://www.weblakes.com/products/screen/index.html>.

3.2 COORDINATE SYSTEM

Any modeling assessment requires a consistent coordinate system for defining locations of the receptors and sources and, where necessary, for considering 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.

Most air dispersion models use the Universal Transverse Mercator (UTM) coordinates, which divide the world into zones, number sequentially, and span six degrees of longitude or latitude/longitude (in decimal degrees). The UTM system uses meters as its basic unit of measurement, which makes it easier for identifying specific locations in local assessments than latitude/longitude. The Bay Area and most of northern California are located in Zone 10. The project sponsor should ensure that a consistent horizontal datum (e.g., NAD84 [North American Datum of 1984] or WGS84 [World Geodetic System of 1984]) is used for all elements (receptors, sources, buildings, terrain) defined for the project. Using difference datums within the same assessment may lead to significant errors and relative location differences of up to 200 meters.⁶

For a localized assessment, the project sponsor may use relative coordinates based on distance from reference datum point 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 reference point. All facility buildings and sources are then related spatially to this origin, and 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, receptors, or other geographic features 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.

3.3 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 being either complex or simple, described as follows:

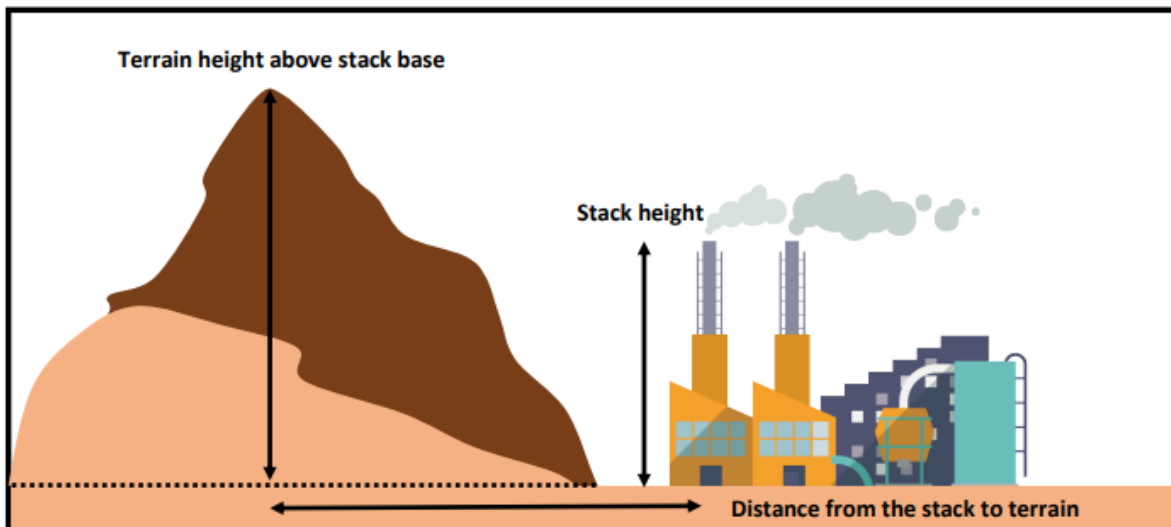
- ▶ Complex terrain: The terrain elevations within 50 kilometers of the stack are above the top of the source stack being evaluated in the air modeling analysis (Figure 4).
- ▶ Simple terrain: The terrain elevations within 50 kilometers of the stack are below the top of the source stack being evaluated in the air modeling analysis. The "Simple" terrain can be divided further into two categories:

⁶ For example, NAD27 (North American Datum of 1927) is based on location of a fixed reference station, whereas NAD83 (North American Datum for 1983) uses an earth-centered reference. The difference between the two datums ranges from 10 to more than 200 meters, depending on the location.

- 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 0 meters.
- Simple elevated terrain, as illustrated in Figure 5 is used where terrain elevations exceed stack base but are below stack height.

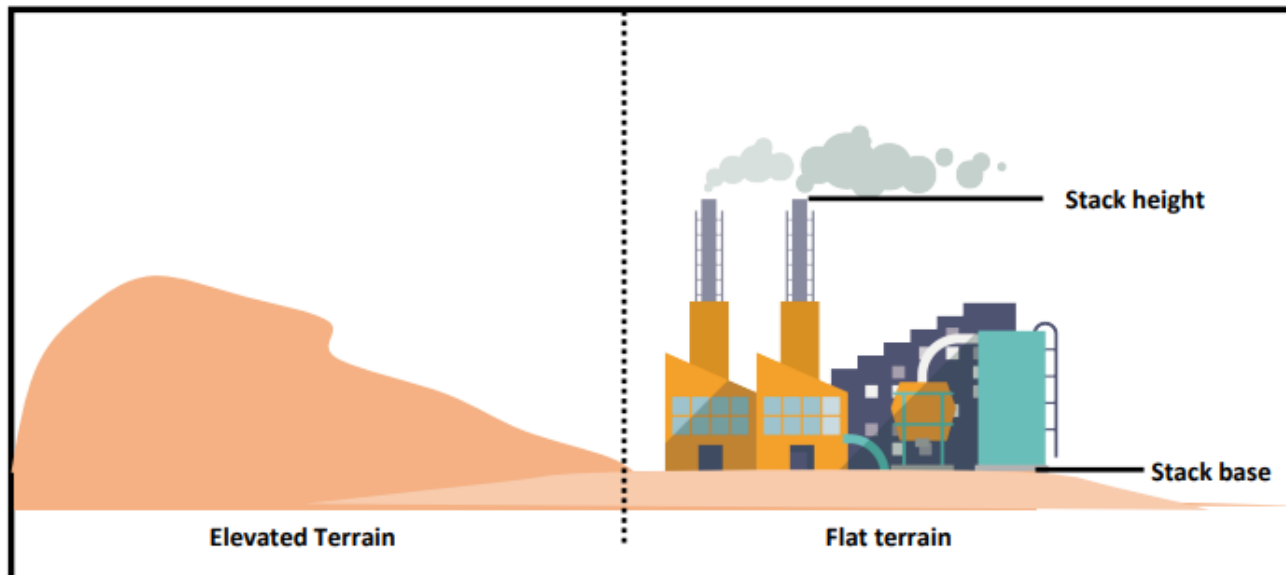
Each air dispersion model has algorithms to incorporate different terrain types found at a project site. Care should be taken to accurately identify terrain conditions surrounding the project as it defines how the pollutant will disperse in the environment. Information on the surrounding terrain is required for any regulatory modeling applications for both simple and complex situations. SCREEN3 supports flat, elevated, and complex terrain. If the simple flat terrain is selected, 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.

Figure 4 Complex Terrain Conditions



Source: CAPCOA 2009

Figure 5 Two Types of Simple Terrain Conditions



Source: CAPCOA 2009

Digital terrain data can be read by modules in both AERSCREEN and AERMOD. The preprocessor program, AERMAP (EPA 2018), uses the terrain data to determine base elevations at each receptor and source for use in AERMOD. Digital elevation data or other geographic data sources processed through AERMAP can be used to determine the appropriate terrain for a project site. Digital elevation terrain data are available from a variety of vendors in several different formats. AERMAP accepts terrain data in the following formats:

- ▶ U.S. Geological Survey (USGS) National Elevation Dataset (NED) data are seamless bare earth elevation layer of The National Map set at one-third arc second (10 meter) resolution. NED is the highest-resolution, best-quality Digital Elevation Model (DEM) data across the United States in a seamless raster format that combines the USGS 1:24,000-scale DEM for the conterminous United States and 1:63,360-scale DEM data for Alaska. NED data are available for importing into widely used commercial software packages in several formats, such as ArcGrid, GridFloat, IMG, BILS, and GeoTIFF.
- ▶ USGS "Blue Book" standard DEM format (herein referred to as the DEM format) consists of an overall header followed by terrain profiles that have location-based subheaders and evenly spaced terrain elevation points called nodes. Each DEM file covers a section of land based on latitude and longitude coordinates. Only Level 2 or 3 quality DEM data are recommended for use because these datasets have been smoothed and systematic errors removed.
- ▶ XYZ format is a text file of horizontal location and elevation data that can be converted to "Blue Book" DEM format using a program available on EPA's Support Center for Regulatory Atmospheric Modeling (SCRAM) website.

AERSCREEN allows the project sponsor to incorporate terrain impacts by reading DEM or NED files. To use this option, the project sponsor must create a demlist.txt file where the first line describes the type of terrain file being used (i.e., DEM or NED). The second line is blank, and the third line lists the location of the file in NAD coordinates. The fourth line begins the list of terrain files with each file on a separate line.

When AERSCREEN is run, the project sponsor will be prompted to provide source coordinates and associated NAD datum before creating the required terrain file for modeling.

For refined modeling, AERMAP is programmed to read NED or DEM formatted files using UTM coordinate system for sources and receptors. NED data can be obtained from the Multi-Resolution Land Characteristics Consortium (MRLC) (<http://www.mrlc.gov/>) in GeoTiff format.⁷ DEM data files for California with 30 x 30 meter resolution are available for free downloads from CARB.⁸ The DEM files are in 7.5-minute format, compatible for use in CARB's Hotspots Analysis and Reporting Program (HARP). DEM data can also be obtained from commercial sites on the Internet.⁹

The Air District recommends using NED data first in GeoTIFF format as input into AERMAP if available or, alternatively, using either the DEM 1 arc-second (approximately 30-meter resolution) or one-third arc-second (10-meter resolution) if NED data are not available. The project sponsor should ensure that the reference datum for the NED and DEM files are based on NAD83 (North American Datum of 1983) or WGS84.

There are different requirements for importing NED and DEM files into refined air models. The project sponsor should review the specific model's user's manual to determine whether the format is compatible or whether files need to be exported to another program for preprocessing. The AERMAP User's Guide (EPA 2018) also has recommendations regarding the dimensions of the NED/DEM array required to accurately characterize the terrain surrounding a project. The guide states that terrain features exceeding a 10 percent elevation slope from any given receptor be included in the array. The project sponsor should plan for additional time as needed to process the terrain data if the array is expanded. The lead agency may also be consulted to make a case-by-case determination regarding the array size needed for a project.

When using the AERMOD dispersion model, it should be noted that there is no distinction in the model between elevated terrain below the release height of the pollutants and terrain above the release height. A parameter called hill height scale must be included with the receptor elevation for any location with elevated terrain for AERMOD to properly model dispersion in that area. Hill height scale is the terrain height and location that has the largest effect on dispersion for every receptor in a complex terrain scenario. AERMAP generates hill height scale, along with base elevation, for every receptor.

3.4 URBAN OR RURAL CONDITIONS

Screening and refined modeling take into account two types of land use categories: urban and rural. The land use category determines how the air dispersion model accounts for the dispersive nature of the "convective-like" boundary layer that forms during nighttime conditions because of the urban heat island effect. The classification of a site as urban or rural can be determined using one of the procedures suggested by Irwin in EPA's document Guideline on Air Quality Models (EPA 2001). Of the two procedures—Auer's land use procedure and the population density procedure—the land use procedure is the preferred method. The land use method classifies the land use within the total area surrounding the source following the

⁷ Instructions for downloading NED data in a GeoTIFF format from MRLC is described here: https://static.azure.gov/aqd/how_2_download_%20ned_data.pdf.

⁸ DEM files from CARB are available at <https://ww2.arb.ca.gov/resources/documents/harp-digital-elevation-model-files>.

⁹ It should be noted that websites change over time and that the data may have been migrated to other websites in the future since the publication of this report.

meteorological land use scheme from Auer. However, the Auer method is manually intensive and relies on subjective interpretation of the results by the project sponsor. Instead, the Air District recommends using the AERSURFACE tool (EPA 2008), which determines surface characteristics required by AERMET. AERSURFACE reads and processes land cover data from the USGS National Land Cover Database (NLCD). The Air District recommends using NLCD for 2016 (NLCD_2016) because it is the most comprehensive land cover data currently available and is compliant with the Air District’s HRA Modeling Protocol (BAAQMD 2020). The NLCD_2016 can be used to determine the types of land cover present at and around the project-specific location. AERSURFACE matches the NLCD_2016 land cover categories to the surface characteristics of the land cover in the project area and assigns land cover counts for each category. Project sponsors enter the project coordinates, datum, and study radius (3 kilometers from project site centroid) into AERSURFACE, and the tool counts the number of 30x30-meter grid cells that fall into each of the 20 land use classifications. Only four of the 20 categories relate to developed land (Table 2).

Table 2 NLCD_2016 Land Cover Categories

Type	Use and Structures	Description
21	Developed, Open Space	Areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
22	Developed, Low Intensity	Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.
23	Developed, Medium Density	Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.
24	Developed, High Intensity	Highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.

The Air District classifies NLCD_2016 categories 23 (Developed, Medium Intensity) and 24 (Developed, High Intensity) as “urban” for the purpose of determining AERMOD dispersion algorithms. If over 50 percent of the grids are assigned to categories 23 and 24, then the area is classified as urban; otherwise, the area is classified as rural. For simplicity, the project sponsor can model both urban and rural land uses and use the most conservative concentrations predicted from the two analyses.

It should be noted that the dispersion model, AERMOD, allows rural and urban terrain to be selected for different sources within the same model run. However, Section 6.2.1.1 of EPA’s Guideline on Air Quality Models (Appendix W) recommends modeling all sources within an urban complex using the urban option even if some sources may be defined as rural based on the land use procedures. For example, some sources may be within an urban area but close enough to a body of water or other nonurban land use category to result in a predominantly rural classification within 3 kilometers of the source. Treating such sources as urban is consistent with the fact that the urban heat island is not a local effect but is more regional in character.

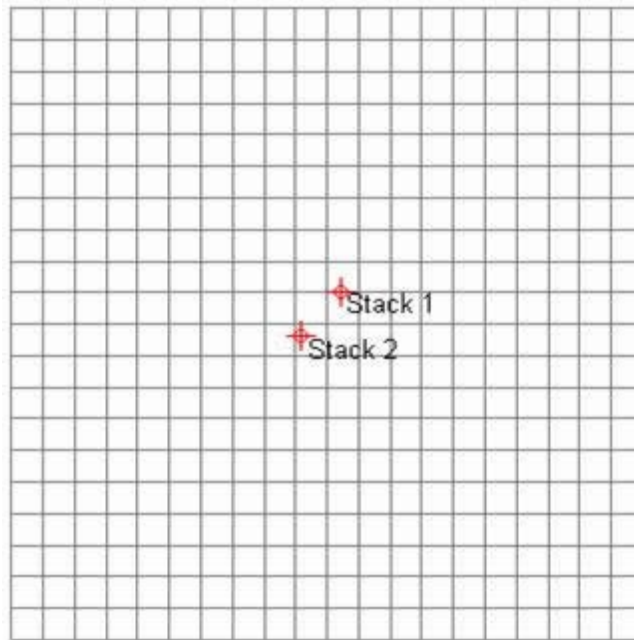
3.5 RECEPTOR GRID

Exposure point concentrations are estimated by the air dispersion model at user-defined discrete receptor locations and at each point of a receptor grid. A receptor grid is used to identify a uniform series of receptor locations where air concentrations will be predicted. The receptor grid does not correspond to actual locations of sensitive receptors but is a means of developing isopleths that illustrate the dispersion pattern of the source emissions and anticipated exposure concentrations in the community or project radius. Discrete receptors are used in the model to represent actual individualized locations where people work or reside (see Section 2.1 for the definition of receptors). Fence line receptors, which correspond to the placement of receptors along the perimeter of the project's property, address off-site worker exposures from neighboring properties and if residential developments are built near the project in the future.

Several techniques can be used in air dispersion modeling for defining a receptor grid. For screening purposes, a simple straight line of receptors that are spaced equal distances from the source may suffice. Refined modeling commonly uses Cartesian receptor grid, which is defined by an origin with receptor points evenly (uniform) or unevenly (nonuniform) spaced around the origin. Figure 6 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 affected receptor. A Cartesian grid should be designed with a receptor spacing of 20 meters out to a minimum distance of 325 meters (1,000 feet) from the property boundary. A larger grid spacing can be applied for distances greater than 325 meters. For example, a 50-meter spacing could be applied between 325 meters and 500 meters from the boundary and 100-meter spacing for distances beyond 500 meters. Using a combination of fine, tightly spaced receptors near the source and coarse grid of receptors located outside of the fine grid reduces the modeling time but maintains sufficient resolution for identifying the maximum impact area (Figure 7). Fenceline receptor spacing should not exceed 20 meters along the property perimeter. However, a tighter grid spacing may be warranted to ensure that the modeling has captured all areas that may potentially be affected from the project. Situations may arise where these distances may not apply and alternative spacing is used, such as with high stacks, where the impacts occur far away from the source so receptors are placed at distances greater than 2,000 meters, or short stacks, where a tighter grid spacing may be required near the source.

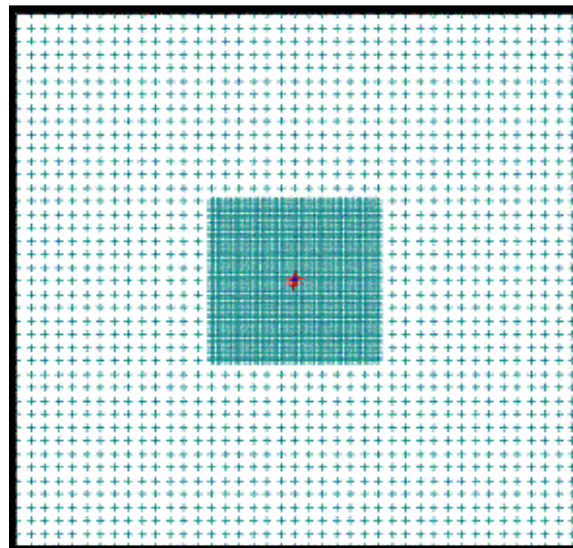
Another less commonly used receptor grid is a polar grid system, which is characterized by an origin with receptor points defined by the intersection of concentric rings, which have defined distances in meters from the origin, with direction radials that are separated by specified degree spacing. Figure 8 illustrates a sample uniform polar receptor grid. 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 maximally exposed individual is not clearly identified. As a result, polar grids should generally be used in conjunction with a Cartesian grid to ensure adequate coverage for defining plume dispersion and exposure concentrations.

Figure 6 Example of a Cartesian Grid



Source: CAPCOA 2009

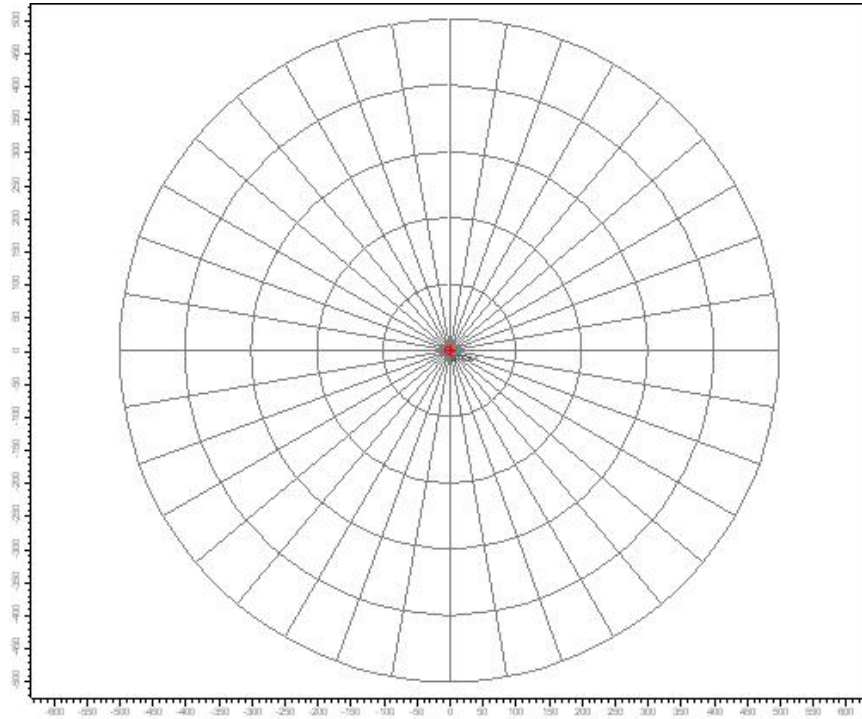
Figure 7 Sample Combination Grid System with Two Types of Receptor Spacing



Source: CAPCOA 2009

Whichever receptor grid is used, the ultimate goal is to ensure that all potential exposures to residential and workers have been evaluated. The concentration estimated at each receptor location represents a person's exposure through inhalation of pollutants emitted from the project and, accordingly, a flagpole height of 1.5 meters,¹⁰ representing the average breathing zone, is recommended for all receptors. The flagpole height may be adjusted as necessary to address impacts on specific receptors such as students or young children. Project sponsors also have the option of using flagpole receptor height of zero, which will produce the most conservative exposure concentrations.

Figure 8 Example of a Polar Grid



Source: CAPCOA 2009

¹⁰ The flagpole receptor height of 1.5 meters is consistent with the District's permitting procedures under Regulation 2-5. Receptor heights of 1.8 meters were used in the West Oakland and Richmond-North Richmond-San Pablo Community Action Plans under AB 617.

3.6 AVERAGING TIMES

“Averaging time” refers to three different time increments: (1) for comparisons to the thresholds of significance (30 years, annual, or 1 hour), (2) for a receptor that is exposed to air pollution from a project, and (3) for situations when a facility or source is emitting pollution into the environment. All three conditions must be well understood before a project-level assessment is started.

The Air District has defined different thresholds depending on the health effects and time of exposure. Cancer risks and chronic noncancer hazard are assessed for long-term exposures. Acute noncancer health effects are usually based on a maximum 1-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 project. Screening models (e.g., SCREEN3 or AERSCREEN) generally estimate the worst-case 1-hour concentrations from the centerline of the plume. The 1-hour concentration is then multiplied by time-averaging factors to produce concentrations for other time increments. For example, multiplying the 1-hour concentration by 0.1 is an approximation of the annual average concentration.

The averaging time defined in the thresholds of significance describes the length of time during which the receptor is exposed to the project-level and cumulative impacts. Two important factors are required for a receptor to be exposed to pollution: (1) the receptor must be present while (2) a source is emitting pollutants. “Averaging time” is a term used to describe both situations when a source and receptor are present. In the first instance, averaging time expresses the time during which a receptor is exposed to pollution. Residents are assumed to be exposed for 24 hours a day, 350 days per year (assuming 15 days of vacation). Other receptors are anticipated to have lower exposures because they spend less time at one location. For example, workers typically work 5 days per week, and their corresponding exposures would be 250 days per year. The project sponsor is cautioned to thoroughly review and understand the factors used in estimating the risks and hazards because some recommended factors (i.e., worker 8-hour breathing rates) already incorporate receptor-specific exposures and activity patterns. More detailed discussions on the exposure factors are presented in Section 10.

The second use of averaging time defines the source emissions and facility operations. Some facilities operate 24 hours a day, 365 days per year, whereas others operate when employees are present. Refinements can be made in the modeling to more accurately predict exposure concentration by incorporating project-specific conditions, such as variable source emission rates or limited hours of operation. For example, a source that operates intermittently can be modeled by matching the hours of operation to the corresponding hours of meteorological data. The Air District cautions that if adjustments are made to reduce the emissions to less than 24 hours of operation, corresponding adjustments must be made to the emission factors to ensure that the modeled emissions are equivalent to the project’s annual emissions. An example is provided in the box below for adjusting the emissions for noncontinuous operation, and more information can be found in AERMOD’s user’s guide. It should be emphasized that any adjustments taken in the modeling analysis that restricts the hours of operation of a source will be required as a permit condition after the environmental document is certified.

Example of Modeling Emissions from a Noncontinuous Operating Source

For most modeling runs, the source emissions will be set at a unit emission rate of 1 g/sec, equivalent to 31,536 kg/year (i.e., 1 g/sec x 3,600 sec/hr x 8,760 hr/year for 24 hrs/day, 365 days per year of operation).

For every hour that the source is not emitting, the operating hours must be adjusted accordingly so that the total annual unit emission rate still equals the annual emissions of 31,536 kg/year. The project sponsor can vary emissions from different time periods, including hourly, daily, monthly, and seasonally in AERMOD. Typically, this option is used to characterize routine shutdowns and startups of sources related to maintenance and operating schedules. When adjusting the hourly emission rate, the hour of day displayed in AERMOD corresponds to the hour ending at the time of display. For example, hour 7 corresponds to the hour from 6 a.m. to 7 a.m.

If a source emits only 12 hours per day, from 6 a.m. to 6 p.m., 365 days per year, then the project sponsor must make an adjustment to the hour of day (HROFDY) emission factor in the AERMOD configuration file. The emission factor of two (EMISFACT HROFDY 2.0) should be used for hours when the source is operating and an emission factor of 0 for hours when the source is not operating. As long as the emission rate is kept at 1 g/sec, the total daily emissions would remain consistent for 24 hours of operation. This methodology applies only to assessments evaluating annual average or chronic exposures. The project sponsor should be cautious when restricting the hours of operations in the modeling because the project will be required to accept these hours as part of the permit conditions for the project.

A second dispersion analysis is required to evaluate short-term exposures, such as acute health hazards. In this case, the user must enter a value of 1 for emission factor for the hours during which the source is emitting and 0 for the hours when the source is not emitting. If a value greater than 1 is used, the acute hazard index will be overestimated by the model.

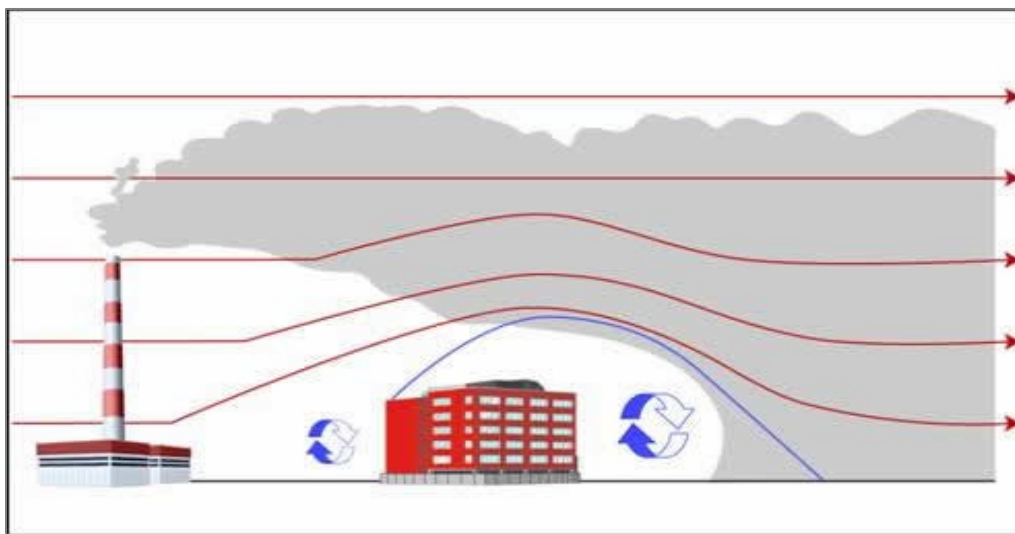
In addition, the exposure concentration accounts for the length of time during which the source is emitting for comparison to the threshold. This issue is particularly relevant for construction emissions because operational emissions are assumed to remain constant over the assessment term of the threshold. For construction, most projects are intermittent and are completed before reaching the typical residential assessment term of 30 years. In these cases, the Air District recommends analyzing the project for only the duration when emissions are produced.¹¹ For the remaining years, emissions are set to 0. For example, suppose a housing construction project that is anticipated to start in the beginning 2020 and finish at the end of 2021 will start housing residents by 2022. Emissions associated with the construction will be based on 2 years of activity (annual assessments of PM_{2.5} concentrations from 2020 to 2021). For the residential evaluation, the maximum exposed individual will be exposed to 2 years of construction emissions and 28 years of operations resulting in cumulative 30-year exposure. The 1-year PM_{2.5} evaluation will be based on highest annual PM_{2.5} emissions from construction or operations.). The lead agency may consider lowering the cancer risk threshold for short-term exposures as suggested by OEHHA because higher exposures over a short period may pose a greater risk than similar exposure spread over a much longer period.

¹¹ For projects subject to permitting requirements under the District's Regulation 2-5: New Source Review of Toxics Air Contaminants or 11-18: Reduction of Risk from Air Toxic Emissions at Existing Facilities, cancer risk must be evaluated for no less than 3 years.

3.7 BUILDING IMPACTS

Both screening and refined air dispersion modeling are capable of modeling impacts from neighboring buildings. 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. 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, the presence of buildings increases the amount of *wind shear* and, as a result, turbulence, as seen in a *turbulent wake zone* (Figure 9).

Figure 9 Dispersion Pattern Attributable to Building Downwash



Source: CAPCOA 2009

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 the 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. EPA (1990) states, “If stacks for new or existing major sources are found to be less than the height defined by 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.”

EPA’s refined formula for determining GEP stack height is:

$$GEP = H + 1.5 \cdot L$$

where:

GEP = Good Engineering Practice

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

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

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

$$\text{Distance of stack to building} \leq 5 \cdot L$$

The projected building width is the maximum length of a building that could affect air flow around and over the structure. It is the responsibility of the project sponsor to identify whether any building in the vicinity of the project meets 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 project sponsor is prompted to enter the building height, minimum horizontal building dimension, and maximum horizontal building dimension in meters. If automated distances or the discrete distances option is used in the SCREEN3 model, wake effects are included in the calculations. More information on modeling building effects can be found in the SCREEN3 User's Guide (EPA 1995).

The more refined models, such as AERMOD and the screening model, AERSCREEN, can model the effects of complicated sites consisting of up to hundreds of buildings. AERMOD requires the following information to perform building downwash analysis:

- ▶ X and Y locations in UTM coordinates for all stacks and building corners;
- ▶ height for all stacks and buildings (meters); for buildings with more than one height or roofline, identify each height (tier); and
- ▶ base elevations for all stacks and buildings.

For buildings with more than one height or roofline, the corner coordinates and heights are required along each building tier. Base elevations can be obtained from the terrain array processed in AERMAP (see Section 3.3) or entered directly into the program where baseline elevations may have changed because of new construction.

3.8 METEOROLOGY

Meteorology (e.g., prevailing wind direction) plays an important role in determining the downwind concentration and the location of the greatest affected receptor. In addition, 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 is the most stable, or least turbulent, class. Table 3 lists the six classes, and Table 4 provides the meteorological conditions that define each class.

Table 3 Stability Classes

Stability Class	Definition
A	Very stable
B	Unstable
C	Slightly unstable
D	Neutral
E	Slightly stable
F	Stable

Table 4 Meteorological Conditions That Define Each Stability Class

Surface Wind Speed (m/sec)	Daytime Incoming Solar Radiation Strong	Daytime Incoming Solar Radiation Moderate	Daytime Incoming Solar Radiation Slight	Nighttime Cloud Cover >50%	Nighttime Cloud Cover < 50%
<2	A	A, B	B	E	F
2–3	A, B	B	C	E	F
3–5	B	B, C	C	D	E
5–6	C	C, D	D	D	D
>6	C	D	D	D	D

SCREEN3 allows project sponsors to either select a combination of stability class and wind speeds or input a single stability class and wind speed combination. These options are described as follows:

- ▶ *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 Air District recommends running SCREEN3 using the full meteorological data. The project sponsor should be aware that SCREEN3 predicts the maximum 1-hour concentration at each receptor location. The 1-hour concentration is then multiplied by 0.1 to convert to an annual concentration for comparison to the thresholds. To use the annual average conversion factor, SCREEN3 must be run using the full meteorological dataset.

AERSCREEN uses the MAKEMET program to generate specific worst-case meteorological matrix based on representative ambient air temperatures; minimum wind speed; and site-specific surface characteristics, such as albedo, Bowen ratio, and surface roughness. CARB¹² provides air basin-wide temperature tables representing maximum and minimum temperatures for 2004–2013 by season for all valid meteorological monitoring stations in the air basin. AERSCREEN then integrates the terrain and building downwash algorithms to perform the modeling run. AERSCREEN estimates the worst-case 1-hour concentrations from a single source but can also identify impacts from 3-hour, 8-hour, 24-hour, and annual averaging periods using ratios applied against the 1-hour concentration.

Refined models use measured meteorological data (e.g., winds, air temperature, atmospheric stability, mixed layer heights) collected from stations to simulate the transport and dispersion of air pollutants. The Air District maintains AERMOD-ready meteorological data sets for 35 sites in the Bay Area consisting of 11 sites at airports, 14 sites from major facilities, and 10 sites operated by the Air District. Table 5 summarizes the stations where the Air District has processed AERMOD-ready meteorological data files that can be obtained by submitted a public records request.¹³

The Air District processes the raw meteorological data sets, consisting of hourly wind and temperature data using the AERMET software. Consistent with EPA guidance, the data are reviewed to ensure that less than 10 percent of the data and 15 percent of the calm hours are missing per quarter. Only one radiosonde station, Oakland International Airport, operates in northern California and supplies all upper air data used for every refined air dispersion modeling application for the Bay Area.

ADJ_U* is a regulatory option in AERMOD modeling systems that adjusts the surface friction velocity parameter in the surface file to improve model performance for sources that have peak concentrations under low wind, stable atmospheric conditions. The ADJ_U* option is not required for stations that collect local turbulence data as part of the meteorological data. For the stations listed in Table 5, only the airport data are required to use the ADJ_U* option in AERMET because those sites do not provide local turbulence data in the publicly available data sets.

¹² AERSCREEN data from CARB is available at <https://ww2.arb.ca.gov/resources/documents/harp-aerscreen-meteorological-data>.

¹³ Public records can be submitted electronically at <https://www.baaqmd.gov/contact-us/request-public-records>.

Table 5 Locations of Meteorological Stations in the Bay Area

Airports ¹	Major Facilities	Air District Meteorological Stations
Concord-Buchanan Field Gnoss Field Hayward Air Terminal Livermore Municipal Airport Moffet Federal Airfield Napa County Airport Oakland International Airport San Francisco International Airport San Jose International Airport Sonoma County Airport Travis Air Force Base	Chevron Refinery Conoco Phillips Carbon Plant (closed 2014) Conoco Phillips Cummings Conoco Phillips Hillcrest Conoco Phillips Rodeo Former Golden Eagle Refinery ² Former Shell Refinery East ³ Former Shell Refinery West ³ Valero Administration Building Valero Warehouse Contra Costa Power (closed 2018) Dow Chemical Pittsburg Pacific Gas and Electric Company (closed 2012) Oakland Sewage Treatment Plant	Concord Fort Funston (inactive as of 5/13/2016) Livermore Rincon Napa College San Carlos San Martin Santa Rosa (closed 2014) Sonoma Baylands Suisun Sewage Treatment Plant Vallejo Former NUMMI Plant (closed 2010) ⁴

¹ The ADJ_U* option must be selected in AERMET if project sponsors are using airport meteorological data.

² Although Golden Eagle Refinery was purchased by Marathon in 2018, the Air District continues to assign the former refinery name to processed AERMET files collected from this station.

³ The Air District continues to assign the former refinery name to processed AERMET files although Shell Refinery was purchased by PBF Energy in 2020.

⁴ The NUMMI meteorological tower was removed when the facility was sold to Tesla. Four years of processed AERMET is available from this station that can be used for CEQA projects proposed in the Fremont area.

A representative meteorological dataset for refined modeling is selected on a case-by-case basis because of the uneven coverage of meteorological towers and the complex terrain in the Bay Area. The most appropriate meteorological station for a project matches the meteorological conditions (wind speeds and directions), terrain, and surrounding land use of the project and is not necessarily the meteorological station closest to a project site. When a representative meteorological dataset for a project is selected, the following steps should be performed:

- ▶ The wind rose and terrain elevation should be evaluated together when selecting a meteorological set for AERMOD. Investigate the wind rose at all representative meteorological sites in surrounding areas of the project, and determine whether the wind speeds and directions are similar at the project. Note any differences or similarities in terrain elevation between the project and the meteorological sites, especially if there are any barriers separating the two locations.
- ▶ If there are significant differences in terrain elevation or land use between the project and the closest meteorological tower, the air dispersion model should be run multiple times using meteorological data from all nearby stations. The resulting concentration estimates should be compared against each other and can serve as upper and lower bounds of the possible exposure concentration.
- ▶ If the land use is considerably different between the project site and the meteorological station, the recommendation is for the project sponsor to assess whether this difference would significantly affect the model results. Land use parameters (surface roughness, albedo, and Bowen ratio)

processed using the processor, AERSURFACE, are used in AERMET to characterize the mixing height, vertical temperature gradient, and mechanical mixing of the pollutant plume as it disperses and mixes in the atmosphere.¹⁴ The comparison should evaluate whether the mixing height and the vertical temperature gradient are not significantly different within 10–20 miles of the station. The project sponsor may observe significant differences in the mechanical mixing because of differences between the nearby upwind land use and the terrain roughness. If the land use is different but the roughness is similar in scale, such as water versus open or grassy flat terrain, mechanical mixing may not be significantly different.

- ▶ Project sponsors have the option of using the default worst-case meteorological datasets if there are no meteorological stations close to the project site or if a terrain barrier exists between the project and the station, in which case none of the comparisons suggested above can be performed. The project sponsor may consider using data from a meteorological station further away from the project site if it can demonstrate that the station is located in an area with terrain and land use similar to those of the project site.

The report accompanying the modeling should provide a detailed technical justification for the meteorological station selected and used in the dispersion modeling and HRA. The project sponsor should also ensure that sufficient meteorological data are available at the selected station to ensure that the worst-case meteorological conditions are adequately represented in the modeled results. Regulatory programs administered by the Air District, including the Prevention of Significant Deterioration (PSD) and New Source Review (NSR) for major facilities, require 5 years of meteorological data when available to support the HRA. For CEQA, the Air District recommends use of a representative 1 year of meteorological data, consistent with procedures for conducting HRAs under Regulation 2-5. The lead agency can request that additional years of meteorology be used to ensure that meteorological conditions are adequately represented in the air quality analysis.

3.9 MULTIPLE SOURCES

When evaluating the air quality impacts from a project, the assessment evaluates the health impacts from all sources associated with the project but also includes a cumulative analysis where the impacts from all significant sources, such as industrial facilities and roadways surrounding the project or receptor, are combined with the project impacts and compared to applicable thresholds. When the plumes from multiple sources emerge, the plume rise can be enhanced, because of combined wake effects, which can make the resulting downwind concentration different from the summed results from individual model simulations. Source groups in refined models enable the creation of the source group "ALL", which accounts for 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.

¹⁴ The three land use characteristics (surface roughness, albedo, and Bowen ratio) are already incorporated into Air District-processed AERMOD-ready meteorological data sets.

Screening models predict concentrations from one source at a time; consequently, the output from multiple runs must be summed if more than one source is affecting 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* (1992).

3.10 MULTIPOLLUTANT CONCENTRATIONS

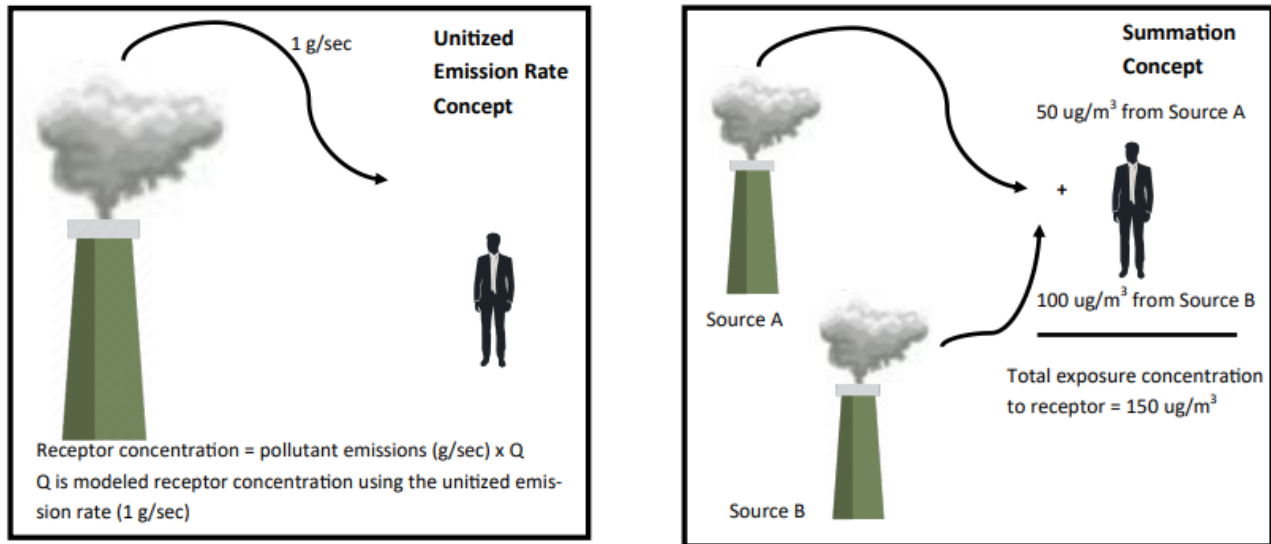
Air dispersion models (screening and refined models) are not equipped to automatically address emissions of multiple pollutants from a shared emission source when emission rates vary between different pollutants, by season, or by time of day. One approach to address this issue is to model each scenario in separate model runs for each specific pollutant type and/or year of meteorological data. This approach 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 multiyear averages for estimating cancer risk, the procedure becomes more complex. Discussions on how to perform each of these methods is provided below.

Both the screening and refined 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 nonlinear, predicted concentrations scale linearly with emissions. This relationship allows the project sponsor to input a unit emission of 1 gram per second (g/s) to be emitted at the source that can then be multiplied by the actual emission rate for each chemical to predict the downwind concentration of that pollutant at that specific receptor location. This methodology can be applied when using either the screening or refined models. Figure 10 (left image) helps visualize this concept, using an emission rate of 1 g/s.

The unitized emission rate concept applies only to single sources. For assessments with multiple sources, the project sponsor can model each source independently by using a unitized emission rate of 1 g/s. The unitized emission rate is 1 g/s for point or volume source and 1 gram per second per square meter for area source. The concentration at the receptor can then be multiplied by the actual chemical emission rate (in unit matching those used in the modeling), and the final receptor concentration is the sum of the exposure concentrations from all sources. This is called the summation concept, whereby the concentration and deposition fluxes at a receptor are the linear addition of the resulting values from each source. Figure 10 (right image) depicts the summation concept for a point or volume sources, but a similar methodology can be applied to area sources. The project sponsor can use a postprocessor, such as CARB's HARP2 program (<https://ww2.arb.ca.gov/our-work/programs/hot-spots-analysis-reporting-program>) to automatically process model results that have been predicted using a unitized emission rate.

Figure 10 Unitized Emission Rate (Left) and Summation (Right) Concepts



Note: The same dispersion runs can be used to estimate acute hazard index, chronic hazard index, cancer risk, and PM_{2.5} concentrations if the model output includes the maximum one hour and the annual average concentrations.

3.11 FUMIGATION

The screening models can be used to assess impacts from 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 available only 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. Both SCREEN3 and AERSCREEN (using the SCREEN3 fumigation algorithm) can model marine conditions near the shoreline. Most refined models, such as AERMOD, are designed to model typical land conditions where surfaces heat up during the day and cool off at night, resulting in unstable weather patterns during the day and stable conditions at night. Large temperature fluctuations usually are not experienced near large bodies of water, where it takes longer for the surrounding land to heat up and dissipate the heat after the heat source is gone. Selecting the appropriate stability class in the meteorology may be difficult because the stability in marine boundary layer is dependent on the temperature difference between air and water, whereas the heating and cooling of the land surface determine the stability class for land areas. This can result in large differences between the two atmospheric layers at the shoreline interface. Modeling the turbulent dispersion along coastal areas is beyond the algorithms currently available in AERMOD. It is recommended that projects near the shoreline with stacks exceeding 10 meters use SCREEN3 or AERSCREEN to evaluate shoreline fumigation and inversion breakup.

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4 SOURCE TYPES USED IN MODELING

If using screening or refined models, the project sponsor must select an appropriate source type that best characterizes how source emissions are released from the project and/or surrounding facilities. After the source release type is selected, the project sponsor must gather the required source parameters that define the physical features of the source or plume. Most of the common source types are available in both screening and refined models. Further descriptions of each of the source types are provided in the following sections.

4.1 POINT SOURCES

A point source is a single, identifiable source of air emissions, such as releases from stacks and isolated vents. Typically, vents from gas dispensers at gasoline stations, diesel prime and backup generators, boilers, coffee roasters, crematoriums, paint strippers, tanks, and soil extraction units are modeled as point sources. The outlet can be located on the roof or side of the building while the device itself is located at the ground level or in the garage, which is the case for most diesel backup generators. Input requirements for point sources in screening mode are presented in Table 6.

Table 6 Modeling Parameters for Point Sources

Parameter	Units	Description
Emission Rate	gram/sec	Emission rate of the pollutant from the stack
Stack Height	meters	Stack height above the ground
Stack Inside Diameter	meters	Inner diameter of the stack emitting the pollutant
Stack Gas Exit Velocity	meters/sec	If exit velocity is not provided by the operator, the exit velocity (V_s) can be determined using the stack gas exit flow rate (V ; m ³ /sec) and stack diameter (d_s ; m) as follows: $V_s = \frac{4 \cdot V}{\pi \cdot d_s^2}$
Stack Gas Temperature	°K	Temperature of the released gas
Ambient Air Temperature	°K	Average atmospheric temperature in the vicinity of the source. If no ambient temperature data are available, assume a default of 293°K. For nonbuoyant releases, the stack temperature may be the same as the ambient temperature.

Notes: °K = degrees Kelvin

If a fixed rain cap (e.g., open-sided conical structure) is on top of the stack such that the vertical release is diverted horizontally, the stack parameters will need to be modified to account for changes in the plume's buoyancy and momentum. No adjustment to the release parameters is required if a hinged rain flap (or cap) is installed as it does not impede the vertical flow of the exhaust plume. Project sponsors should refer to Attachment 1 of CAPCOA's *Health Risk Assessments for Proposed Land Use Projects* (CAPCOA 2009) for additional guidance.

4.2 AREA SOURCES

An area source is a two-dimensional source of diffused air pollutant emissions emitted at a uniform height, such as a landfill, storage pile, slag dump, lagoon or ponds, or liquid spills. AERSCREEN and SCREEN3 define the rectangular area source to align with the north-south axes where the angle of the source relative to north is automatically set to 0 degrees. The long dimension of the area source is in the x-direction, whereas the short dimension is along the y-direction. AERMOD and other refined models have the ability to define area sources as nonrectangular polygons that can be rotated relative to the north-south axis. The Air District typically models emissions from landfills as an area source. Table 7 presents a list of parameters required to model area sources.

Area sources are assumed to be rectangular or square with a maximum length/width aspect ratio of 10:1. For irregularly shaped emission sources, project sponsor can select the AREAPOLY for polygon areas or AREACIRC for circular-shaped area sources. Please refer to the AERMOD User's Guide for more information.

Table 7 Modeling Parameters for Area Sources

Parameter	Units	Description
Emission Rate	gram/sec-m ²	Emission rate of the pollutant per unit area
Source Release Height	meters	Source height above ground
Longer Side Length of Rectangular Area	meters	Longer side of the rectangular source
Shorter Side Length of Rectangular Area	meters	Shorter side of the rectangular source
Angle	degrees	Orientation angle for the rectangular area from north, measured positive in the clockwise direction. If the angle is greater than 0, the source will be rotated clockwise around the southwest corner.
Initial Vertical Dimension of Plume (<i>Szinit</i> ; AERSCREEN Only)	meters	<ul style="list-style-type: none"> ▶ For surface-based emissions, divide the vertical dimension of the source by 2.15. ▶ For an elevated source on or adjacent to a building, divide the building height by 2.15. ▶ For an elevated source not on or adjacent to a building, divide the vertical dimension of the source by 4.3.
Receptor Height Above Ground	meters	This may be used to model impacts on “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 1.5 meters (i.e., breathing zone), but the project sponsor may enter 0.0 meter to represent ground level, the breathing zone of an adult.
Wind Direction Search Option (SCREEN3 Only)		Because 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 SCREEN3 model provides the project sponsor with two options for treating wind direction. The regulatory default option is “yes,” which results in a search of a range of wind directions is recommended (see Section 3.8).

4.3 VOLUME SOURCES

A volume source is a three-dimensional source of diffuse air pollutant emissions that is used to model releases unrestricted by any physical means from a variety of industrial sources, such as building roof monitors, fugitive leaks, multiple vents, conveyor belts, rail lines, and roads. Another example would be the emissions from an automobile paint shop with multiple roof vents or multiple open windows. EPA recommends modeling entrained road dust from haul trucks as adjacent volume sources unless receptors are located within the exclusion zone (EPA 2012). Typically, the Air District uses the volume source option to model emissions from gas dispensers at gasoline stations and vehicle emissions from roadways and rail lines. Table 8 presents the parameters required to model volume sources in AERMOD.

Table 8 Modeling Parameters for Volume Sources

Parameter	Units	Description
Emission Rate	gram/sec	Emission rate of the pollutant
Plume Height	meters	Initial vertical dimension of the sources: <ul style="list-style-type: none"> ▶ If source is in motion, Plume Height = Source Height • 1.7 ▶ If source is stationary, Plume Height = Stationary Height
Source Release Height	meters	Release Height = 0.5 • Plume Height
Side length	meters	Length of the side of the volume side. An additional 6 meters should be added to the width to account for wake effects if roadways or rail lines are being modeled.
Initial Lateral Dimension (<i>Syinit</i>)	meters	<ul style="list-style-type: none"> ▶ For a single volume source, divide the side length by 4.3. ▶ For line sources represented by adjacent volume sources, divide the side length by 2.15. ▶ For line sources represented by separated volume sources, divide the center-to-center distance between sources by 2.15.
Initial Vertical Dimension (<i>Szinit</i>)	meters	<ul style="list-style-type: none"> ▶ For a surface-based source, divide the vertical dimension (Plume Height) of the source by 2.15. ▶ For an elevated source on or adjacent to a building, divide the building height by 2.15. ▶ For an elevated source not on or adjacent to a building, divide the vertical dimension (Plume Height) of the source by 4.3.
Receptor Height Above Ground	meters	This may be used to model impacts on “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 1.5 meters (i.e., breathing zone), but the project sponsor may enter 0.0 meter to represent ground level, the breathing zone of an adult.

For sources in motion, such as rail and vehicles, the plume height is adjusted to account for the effects of vehicle-induced turbulences. For all adjacent volume sources, the initial vertical dispersion coefficient is estimated as follows (AERMOD User’s Guide for surface-based sources):

$$Szinit = \frac{H \cdot \gamma}{2.15}$$

where the initial vertical dimension of the source is equal to the average source height (H) multiplied by the motion-induced turbulence effects (γ), which equals 1 when the sources are not moving or 1.7 when vehicles are in motion (EPA 2015a). In addition, EPA recommends that an additional 6 meters be added to the width to account for wake effects. Unlike other sources, AERMOD does not calculate results for receptors located within the exclusion zone surrounding volume sources. The radius of the exclusion zone from the centroid of the volume is estimated as:

$$r_{EZ} = (2.15 \cdot Syinit) + 1.0_m$$

If receptors are to be placed as close as 5 meters from the roadway, the maximum width of the roadway to be modeled in AERMOD should be 8 meters because the exclusion zone would be 9 meters. (The distance from the centroid of the volume source to the end of the roadway is 4 meters, and the distance from the roadway to

the receptor is 5 meters.) A series of volume sources can be used to represent each traffic lane to ensure that the full extent of the roadway is modeled and to avoid placement of receptors within the exclusion zone.

4.4 LINE SOURCES

The line source is used to model releases from a variety of sources that are in motion, such as horizontal conveyor belts, rail lines, and roadways. AERMOD uses the same algorithms for line sources that are used for area sources and will produce identical results for equivalent source parameters inputs. Roadways and rail lines are routinely modeled as either line or volume sources, and each approach has its advantages and disadvantages. If a line source is used, the advantages include placement of receptors within the exclusion zone; the use of fewer user-defined inputs; and uniform emission density across the roadway, which may be more realistic under certain conditions. Alternatively, a volume source contains a meander algorithm and mimics an initial, well-mixed plume but cannot calculate concentrations for receptors within the exclusion zone. The Air District encourages the project sponsor to select an appropriate source type that will achieve the most conservative results for their project analysis. The only exception is when modeling entrains road dust from haul trucks, in which case EPA recommends that adjacent volume sources be used. Line source parameter inputs are listed in Table 9.

Table 9 Modeling Parameters for Line Sources

Parameter	Units	Description
Emission Rate	gram/sec-m ²	Emission rate of the pollutant per unit area
Starting Coordinates	meters	UTM Easting and Northing locations for the start of the line source
Ending Coordinates	meters	UTM Easting and Northing locations for the end of the line source
Plume Height	meters	Initial vertical dimension of the sources: <ul style="list-style-type: none"> ▶ If source is in motion, Plume Height = Source Height • 1.7 ▶ If source is stationary, Plume Height = Source Height
Source Release Height	meters	Release Height = 0.5 • Plume Height
Width	meters	Width of the source (minimum is 1 meter). An additional 6 meters should be added to the width to account for wake effects if roadways or rail lines are being modeled.
Initial Vertical Dimension (<i>Szinit</i>)	meters	<ul style="list-style-type: none"> ▶ For a surface-based source, divide the vertical dimension (Plume Height) of the source by 2.15. ▶ For an elevated source on or adjacent to a building, divide the building height by 2.15. ▶ For an elevated source not on or adjacent to a building, divide the vertical dimension (Plume Height) of the source by 4.3.
Receptor Height Above Ground	meters	This may be used to model impacts on “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 1.5 meters (i.e., breathing zone), but the project sponsor may enter 0.0 meter to represent ground level, the breathing zone of an adult.

Notes: g/sec-m² = grams per second per meter squared.

When Should a Source Be Modeled as a Line Rather Than a Volume?

Sources that travel along designated routes (paths), such as paved roadways, rail lines, and shipping lanes, typically are modeled as a line or volume source. The selection of the appropriate source type when modeling is important because the predicted concentrations can vary by as much as 60 percent. When selecting the appropriate source type, the choice depends how the source plume will disperse after it enters the environment. For example, sources that have limited vertical dispersion but expand laterally can be modeled as a line source. Sources that release plumes that expand vertically and laterally are better represented as volume sources.

For project sponsors less familiar with modeling, the Air District has the following recommendations:

- ▶ *If the receptor is located downwind of the heavily traveled roadway or railroad tracks, the road/rail line can be modeled as a line source.*
- ▶ *If the receptor is located upwind of the heavily traveled roadway or railroad tracks, then the recommendation is to model the road/rail line as a volume source.*
- ▶ *If the receptor is located within the exclusion zone (see Section 4.3) and emissions from the mobile source has limited dispersion, then mobile sources can be modeled as a line source.*
- ▶ *Mobile sources operating at construction sites and quarries should be modeled as volume sources.*
- ▶ *Ships and other ocean-going vessels should be modeled as volume sources.*



5 STATIONARY SOURCE ANALYSIS

Stationary sources are defined as sources that remain in a single location while they are operating; however, some sources, such as portable engines, are considered stationary sources even though they are moved, as needed, from one location to another. These sources are generally permitted by the Air District; thus, the recommendation to analyze the impacts from these sources follows guidance in the Air District's *Permit Handbook*.

5.1 SOURCE EMISSIONS

The Air District recommends that the project sponsor quantify emissions of PM_{2.5} and toxics from the following project-related sources:

- ▶ new sources that will require permits;
- ▶ permitted sources that are subject to change because of the project;
- ▶ sources exempt from permitting requirement that are part of the project;
- ▶ rail service operating on the project site (see Sections 7 and 9.3);
- ▶ ships, barges, tugs, and other vessels that will be used during operations;
- ▶ off-road equipment (e.g., forklifts, cranes, loaders, generator sets) used for operations at the project site (see Appendix D of the Guidelines);
- ▶ on-road mobile source emissions from residents, workers, customers, and vendors visiting or operating at the project site (see Sections 6 and 9.2);

- ▶ fugitive emissions from sources such as permitted sources, stockpiles, and road dust; and
- ▶ significant area sources, if applicable (e.g., landscaping equipment)

For stationary sources that will be permitted by the Air District, their emissions should be estimated following the methodology outlined in the Air District's *Permit Handbook*. This includes most standby and prime generators, pumps, boilers, gas stations, turbines, autobody shops, heaters, and so on. For new sources, the emissions will be based on the maximum potential to emit, estimated in the permit application to the Air District. An additional requirement outside of permitting is being recommended for diesel-powered standby and backup generators under CEQA. These generators are used by data centers, grocery stores, office buildings, retail stores, cell towers, fire stations, and others to supply emergency electrical power during utility outages. The generators are tested monthly and must be properly maintained based on strict limits set forth in their permit. Although the hours for emergency use are exempt from permitting, the Air District recommends combining the emissions (PM_{2.5} and diesel PM) from operations or emergency use (nontesting and nonmaintenance) with the allowable testing and maintenance hours for any generators evaluated in the air quality analysis under CEQA. This approach is consistent with EPA and Air District requirements when determining whether a generator triggers New Source Review or Title V permitting requirements.

Backup generators are also being used for electricity generation during Public Safety Power Shutoff events to reduce the risks of wildfires caused by electricity transmission and distribution networks (CARB n.d.). In this instance, a project sponsor can include an additional 100 hours per year for each generator for nontesting and nonmaintenance purposes. Alternatively, project sponsors can substantiate use of site-specific nontesting and nonmaintenance hours for standby generator operation. Project sponsors can also obtain information on standby generator use from the CPUC Emergency Load Reduction Program and CPUC information on temporary emergency generation use.

Any incremental emissions above the baseline levels will be disclosed and included in the project-level analysis. A project that requires the installation and operation of new sources must be evaluated at its maximum potential to emit, which is consistent with the Air District's permitting requirements. Thus, the entire project emissions include:

- ▶ newly permitted equipment at the potential to emit level,
- ▶ new or modified permit-exempt sources,
- ▶ new nonpermitted sources, and
- ▶ existing sources that would be modified under the project.

Emissions from existing sources and equipment operating at the facility but not related to the project will be included in the cumulative assessment (see Section 11).

5.2 RELEASE PARAMETERS

Stationary facilities that produce air pollution—including complex sources, such as metal smelting, wastewater treatment plants, and refineries, as well as smaller facilities, such as diesel generators, gasoline-dispensing facilities (gas stations), and boilers—are regulated and subject to permit conditions established by the Air District. Where the sources are known, the project sponsor will present detailed source-specific information on their emissions and physical release parameters as part of the project analysis. Projects involving development of retail or commercial space may not have foreknowledge of the future occupants and their sources, making it difficult to quantify the potential risks and hazards. Project sponsoring following the tiered methodology may find it difficult to obtain the required detailed facility information necessary to improve the accuracy of the screening results.

To assist project sponsors, the Air District is developing a centralized electronic database to store source-specific information and release parameters used in HRAs under Regulations 2-5 and 11-18. Unfortunately, the database will be available for only a limited number of facilities, such as: (1) facilities located within the modeling domain of a completed Community Scale Technical Assessment¹⁵ under AB 617, (2) facilities requesting a permit modification that triggered an HRA under Regulation 2-5, and (3) facilities completing an HRA under Regulation 11-18. In many cases, even for facilities where release information is available, the data may be incomplete or obsolete.

Until the database is available, some modeling parameters can be found through a detailed review of the Air District's permit files for each facility. Another source of historic release parameters is the California Emission Inventory Development and Reporting System (CEIDARS) data submitted to CARB annually, but given the age of the information and lack of quality assurance, the Air District is not recommending its use unless the values are confirmed in the permit files. There still remain other permitted sources for which detailed information is not available because:

- ▶ sources are exempt,
- ▶ the Air District does not have jurisdiction to regulate these sources,
- ▶ source emissions are below the trigger levels specified in Regulation 2-5,
- ▶ source emissions are below the standards set forth in the regulation,
- ▶ sources were permitted before the adoption of Regulation 2-5,
- ▶ sources do not emit toxic air pollutants recognized by OEHHA,
- ▶ sources are registered,
- ▶ abatement devices have been installed that may affect emission release parameters, or
- ▶ emissions are generated from a complex emission train involving multiple fugitive and controlled processes that are grouped into a single source category for permitting purposes.

¹⁵ The District completed a Community Action Plan for West Oakland in 2019 and will complete a similar analysis for Richmond-North Richmond-San Pablo in 2023.

To assist project sponsors with collecting the necessary information for the modeling analysis, the Air District worked with a consultant to develop general default parameters for the most common source categories. The process involved reviewing numerous permit files and extracting release parameters from the highest-emitting sources in each source category. A mean value for each parameter was selected from the collective source information contained in the permit files as representative default value. The default values are not meant to be conservative but representative of typical, recent conditions because many of the historic sources lacked release information because they were permitted before the adoption of Regulation 2-5.

Gas-Dispensing Facilities. Gas-dispensing facilities (GDFs), both retail and nonretail, are permitted by the Air District following an HRA demonstrating compliance with Regulation 2-5 thresholds. Emissions are estimated through multiple sources and release points to account for losses from loading, breathing, refueling, hose permeation, and spillage. CARB recently released the *Gasoline Service Station Industrywide Risk Assessment Technical Guidance* (CARB 2021a), which includes default release parameters used to develop their screening tool. Project sponsors can use the default parameters to conduct a refined modeling analysis or use the gas station risk assessment look-up tool, available at <https://ww2.arb.ca.gov/resources/documents/gasoline-service-station-industrywide-risk-assessment-guidance>. If they use the look-up tool, project sponsors may contact the Air District's Engineering Section to obtain information necessary to use the tool, including the facility's annual throughput limit. Output from the tool includes estimated maximum cancer risks to residents and workers and chronic and acute hazard indices.

All Other Stationary Sources. The most common stationary sources permitted by the Air District are generators (prime and standby) followed by various other sources such as GDFs, paint booths, autobody shops, solvent cleaners, and printers. Some release parameters may be available in the permit file, particularly for generators and soil vapor extraction operations, which emit pollutants exceeding the trigger levels specified in Regulation 2-5. However, for any facility permitted before adoption of Regulation 2-5, release parameters will not be available.

To fill this data gap, the Air District conducted various surveys to gather release parameters for the highest emitting generators. Significant effort was put forth to obtain release parameters from generators commonly used in office buildings, grocery stores, box stores, and data centers to supply emergency power when utilities are down. Many older pre-tier and Tier 0 engines are still in operation because of their low use and high replacement costs. Default parameters were developed for these generators based on responses from surveys in addition to review of available permit files. As noted, these values are not meant to be conservative or typical as generator emission exhaust comes from numerous locations (e.g., vertically from the roof of skyscrapers to the garage). There is no single set of parameters that can be used to represent the possible range of emission points from all generators. The project sponsor is cautioned to use these defaults only when available permit files yield no additional information.

General default release parameters are available for sources that release pollutants through a stack or point, such as boilers, coffee roasters, crematoriums, paint strippers, tanks, and soil vapor extraction units. Most of these sources are subject to Regulation 2-5; thus, a thorough review of the permit files is recommended before default parameters are applied. When the release mechanism for a source is unknown or multiple release types are present, a volume source can be used to characterize the emissions.

Default parameters (used only when no other sources of information are available) are presented in Table 10 and can be applied in the screening or refined modeling analysis.

The default parameters should be used for common sources only if no other data source is available. Project sponsors should use Table 11 only in cases when the future occupants at the project site are unknown or project sponsors are refining the health impacts from surrounding facilities in the cumulative analysis after exceeding the screening level cumulative thresholds and a comprehensive review of the Air District's permit files was conducted. For large, complex sources, such as refineries, chemical plants, landfills, wastewater treatment plants, and foundries, the project sponsor should initially review the permit files because some modeling data will be available from past HRAs conducted under Regulation 2-5 and full site inventories and assessments conducted under Regulations 12-15 and 11-18.

Table 10 Default Modeling Parameters for Common Stationary Sources¹

Source Description	Source Type	Default Parameter	Default Value
Prime or standby generator	Point	Stack height Stack diameter Exit temperature Exit velocity	3.66 m (12 ft) 0.183 m (0.6 ft) 467°C (872°F) 45.3 m/sec (8,923 ft/min)
Sources with incomplete modeling information	Point	Stack height Stack diameter Exit temperature Exit velocity	6.1 m (20 ft) 0.305 m (1 ft) 371°C (700°F) 17.8 m/sec (3,500 ft/min)
No information available	Volume	Release height Initial lateral dimension Initial vertical dimension	1.8 m 10 m 1 m

Notes: °C = degrees Celsius; ft = feet; ft/min = feet per minute; m = meter.

¹ These values should be applied only when no other modeling information is available. The source type indicates the type of sources in AERMOD that should be used for dispersion modeling.

5.3 MODELING CONSTRUCTION IMPACTS

After emissions are estimated using CalEEMod (combined with any off-model calculations; see Appendix D), the project sponsor can then start the air dispersion modeling analysis to assess the potential risk and hazards associated with construction-related activities for the individual project. The Air District recommends the following comparisons:

- ▶ Ensure that the daily mass emissions derived from CalEEMod for particulate matter with a diameter less than or equal to 10 microns (PM₁₀) and PM_{2.5} from fugitive dust and vehicle exhaust are aggregated with the daily emissions from other construction-related activities.
- ▶ Compare the annual average PM_{2.5} concentrations for every year of construction to the thresholds of significance. PM_{2.5} is emitted directly from equipment/vehicle exhaust or as fugitive emissions from soil disturbance, demolition, brake and tire wear, and resuspended road dust. PM_{2.5} emissions from each of these activities are quantified by CalEEMod. Project sponsors can use either a screening model or a refined model to predict the annual average downwind concentrations of PM_{2.5} based on source emissions from CalEEMod. If a screening model is used, the annual average

concentration is estimated by multiplying the maximum 1-hour concentration by 0.1. Both off-site workers and residents should be considered potential receptors (see Section 2.1).

- ▶ Compare the cancer risks and hazards from toxic compounds from construction activities to the thresholds of significance. Sources of toxic emissions at construction sites include off-road and on-road equipment/trucks powered by diesel fuel, generators powered by diesel, natural gas, or propane, and gasoline-powered vehicles. Fugitive emissions from resuspended road dust may also contain toxic emissions if the soil surrounding the site contains known toxic contamination or during demolition of structures containing asbestos. PM₁₀ emissions from diesel fuel-powered vehicles and equipment may be used as a surrogate for diesel PM. Either a screening model or a refined model can be used to estimate the downwind exposure concentrations at each receptor. The final risk and hazard modeled should represent the cumulative exposures anticipated from all construction-related activities.¹⁶

When construction impacts are modeled using either a refined model or a screening model, area or volume sources are commonly used to represent specific construction activities and equipment. Area sources are used to characterize construction activities, such as demolition, site preparation, grading, paving, and building construction. The area sources will match the dimensions and locations of the construction activities being modeled. Volume sources are used to represent the on-site property movement of off-road equipment and vehicles and off-site trips of haulers, vendors, and workers. Use of adjacent volume sources, equally distanced, to characterize vehicle movements is consistent with EPA’s Haul Road Workgroup Final Report (EPA 2012) and gives project sponsors flexibility to customize the modeling by adjusting the height of the vehicles and the width of the roadway. It should be noted that extensive computation time is required when modeling roadways and on-site activities as adjacent volume sources, and project sponsors should plan accordingly. The Air District recommends using project-specific vehicle heights, if available, in the modeling. A separate modeling analysis will need to be run for each vehicle class (e.g., haul truck, worker truck) on the project because of differences in their release parameters. Table 11 presents the recommended source parameters when roadways are modeled as volume sources if site-specific information is not available.

Table 11 Recommended Volume Source Configuration for Construction Projects

Modeling Parameters	Recommended Value If Site-Specific Data Are Not Available
Vehicle Height	4.0 meters for trucks 1.53 meters for nontrucks
Plume Height	6.8 meters for trucks 2.6 meters for nontrucks
Source Release Height	3.4 meters for trucks 1.3 meters for nontrucks
Width of Plume	Width of different lanes of traffic + 6 meters for wake effects. Recommended maximum 8-meter width for adjacent volume sources with additional volumes added, as necessary, to cover the width of the road and wake.
Initial Lateral Dimension (<i>S_{yinit}</i>)	Width of plume/2.15
Initial Vertical Dimension (<i>S_{zinit}</i>)	3.16 meters for trucks 1.21 meters for nontrucks

Modeling Parameters	Recommended Value If Site-Specific Data Are Not Available
Emissions	Grams/sec

The emission rates used in the model are derived by converting the annual emission rates from CalEEMod to units of grams per second based on the number of hours and days during which construction activity would occur. The rate is then further divided by the number of volume sources representing each roadway link and entered as the emissions for each volume source comprising the roadway link. If using the refined model, AERMOD, the project sponsor should ensure that receptors are not placed within the volume source exclusion zone (see Section 4.3). This issue can be avoided by representing the different travel lanes using a series of adjacent volume sources.

Fugitive sources should be modeled as area sources or volume sources, depending on the emission source. Vehicle-related fugitive emissions from brake and tire wear and resuspended dust should be modeled as adjacent volume sources following the methodology discussed above. The PM_{2.5} emissions from these vehicle-related fugitive sources can be combined with the PM_{2.5} exhaust emissions so no additional modeling analysis is required. However, fugitive emissions from brake and tire wear and resuspended dust are excluded from the toxic evaluation to assess cancer risk because these emissions are not associated with combustion of diesel fuel. Area sources can be used to model most other types of general construction activities. The modeled area should match the approximate location of the expected construction activities on-site. Care should be taken to include only areas of expected activities and exclude areas with limited to no construction activities because this will underpredict exposures to the community.

The modeling should account for all receptor locations within 1,000 feet, extended as appropriate, surrounding the construction site boundary using a receptor grid spacing of 20 meters. Fenceline receptors should be included in the analysis if sensitive receptors are located along or close to the property boundary. The flagpole height for all receptors of 1.5 meters should be used to be consistent with Air District's permitting procedures under Regulation 2-5. The Air District recommends conducting a student analysis for any school located within 1,000 feet of the construction project.

In most cases, the construction and operational emissions and values will be compared separately to the applicable thresholds unless construction and operational activities overlap, such as when construction occurs in phases, and residents begin living in one phase of the development while the next construction phase begins. In this example, the overlapping emissions from construction and operations would be summed and compared against the applicable thresholds.

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6 ROADWAY ANALYSIS

The Air District's screening map identifies risks, hazards, and annual $PM_{2.5}$ concentrations for all paved roadways in the nine counties of the Bay Area as described in Section 9.2, along with the assumptions and default datasets used to prepare the map. These assumptions and defaults ensure complete coverage of all roadways and efficiency in estimating emissions and conducting air quality dispersion modeling. However, because defaults may not be representative of local conditions, project sponsors can further improve the accuracy of the modeling results by incorporating local conditions in the air quality analysis. Project sponsors can follow the methodology presented in Section 9.2 to conduct a project-specific roadway analysis or refine the default assumptions to improve the accuracy of the health impacts identified in the cumulative analysis. Project sponsors can use the assumptions from the screening map to support Tier 1 analysis (see Section 9.2). This section provides a methodology for performing a more detailed Tier 2 assessment for roadway impacts using local activity data other than the defaults used in the screening map to improve the emissions estimate and modeling configuration.

6.1 EMISSION ESTIMATES

Depending on the availability of local data, the Air District recommends that project sponsors follow the methodology outlined in Section 9.2 to estimate link-level $PM_{2.5}$ and TAC emissions from all processes while substituting underlying default datasets with site-specific information, including the following detail.

Vintage. The screening map was developed with a base year of 2022. All the activity and emissions data were collected and prepared to represent the 2022 level and then held consistent for the 30-year span for risk analysis. Project sponsors may consider a base year more representative of the project year. They can also consider developing 30-year baseline emissions that incorporate per mile emission changes per year resulting from adoption of federal, state, and local regulations and fluctuating activity (volume) levels.

Traffic Activity (Volume, Speed, Fleet Mix). The screening map was developed using telematics-based volume and speed data purchased from Bentley Systems (Bentley), as well as a fleet mix derived from Caltrans's Performance Measurement Systems (PeMS)¹⁷ data or the EMFAC2021 model. The Air District performed validation on traffic volume and speed only for limited highway links when the measured traffic data from PeMS were available. Project sponsors can apply site-specific traffic activity, including measured or modeled traffic data (by vehicle class, if possible) from the local transportation authority, such as city/county engineering, congestion management, or transportation department, and special study data with field measurements to further improve the air quality analysis.

Emission Factors. The emission factors will change as a result of changes to technology, regulations, and methodology that have occurred since the development of the screening map. The roadway screening values incorporate EMFAC2021 emission factors that include the latest county vehicle registration data, regulations implemented since EMFAC2017, and results from a new research study for brake wear PM emissions. Because the EMFAC model is periodically updated, project sponsors should ensure that they are using the most up-to-date emissions factors released by CARB. They may also use lower emission factors for projects surrounding ports by selecting the Port Truck (POAK) vehicle class in EMFAC as a surrogate of freight trucks.

For road dust emissions, if the roadway conditions within the project radius are different from the county default, the project sponsor is encouraged to develop the site-specific emission factors following equations in Section 9.2. For example, if the roadways have new pavements and a more frequent schedule of street sweeping, project sponsors could conduct road surface sampling to derive their own silt loading data. They may use a different fleet average weight if only certain types of vehicles travel on the roadways (e.g., light-duty commuter vehicles).

6.2 MODELING CONFIGURATION

The air quality dispersion modeling conducted during the development of screening maps requires complex analysis that evaluates the impacts from thousands of roadway links. Most of the recommended model configurations are applicable only to AERMOD because the screening models do not have these options available. Project sponsors could perform a more focused AERMOD analysis using local inputs as described below.

Volume or Line Source. The Air District configured the roadway screening map using a series of line sources. However, the same analysis can be performed using adjacent volume sources that extend across each roadway. (Further discussion is presented at the end of Section 4.4.) Volume sources can be placed following the geometry of roadway centerlines. Project sponsors can reconfigure the volume source locations using third-party software (e.g., AERMOD View) that uses a graphic user interface combined with aerial maps to more accurately follow the roadway geometry. This way, project sponsors can control the size and interval of volume sources and ensure their representativeness to the roadways being modeled. Project sponsors also should ensure that if either volume or line sources are used to represent roadways in the air dispersion modeling, the results are conservative and protective of local residents' health.

¹⁷ Available at <https://dot.ca.gov/programs/traffic-operations/mpr/pems-source>.

Diurnal Profile. The diurnal profiles used in the screening map were derived from hourly traffic volumes obtained from Bentley and PeMS data. Although minor, the impacts from vehicle speeds on hourly emissions of certain processes are not reflected in the model. Project sponsors can develop diurnal profiles based on actual hourly emissions, especially for projects that would significantly improve congestion on local streets.

Temporal Variation. The roadway screening map was based on an aggregated temporal level where daily activity was based on average activity over the year. With fewer links within the radius of influence, project sponsors could conduct a more refined scale modeling. For example, if traffic activity of the roadways has different seasonal or weekday/weekend patterns, the modeling could be performed by season and/or weekday/weekends and then aggregated to predict annual pollutant concentrations in the risk analysis.

These refinements are meant to improve the representativeness of the project analysis and increase the accuracy of results. The impact on the analysis results (e.g., reduce or increase the risk) will be case by case and subject to the characteristics of the project itself.

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7 PASSENGER RAIL ANALYSIS

The Air District provides screening maps for most Class I rail lines based on annual fuel consumption rates and commuter/passenger rail lines using diesel locomotives. Descriptions of the assumptions and timetables used to develop the screening tool are provided in Section 9.3. Because train frequencies and arrival/departure schedules are adjusted annually to accommodate commuter demands, the prepared screening values may no longer be representative of expected risks along each rail line. This section provides a methodology for performing a more detailed Tier 2 assessment, if warranted for passenger and commuter lines, to assess cumulative impacts because most project-level analysis does not address commuter/passenger rail service. The Air District is not providing guidance for conducting a more detailed Tier 2 assessment of Class I rail lines, found in some project-level analysis, because it requires detailed activity data and equipment inventory information that are not publicly available.

To estimate health impacts related to Amtrak passenger rail or commuter service, project sponsors can rely on the posted train schedule to estimate activity level emissions following the methodology outlined in Section 9.3. The approach calls for estimating diesel PM emissions from locomotive exhaust and idling by rail link as a function of the number of locomotives per day that run along each link, average speed, and frequency of stops. The timetables provide the number of train stops at each station, as well as the times and frequency of the train stops.

Use the following approach to estimate the emissions along each rail link:

1. Estimate the number of locomotives per day at each stop within a minimal 500-meter radius of the project site. Project sponsors should be prepared to expand this radius, as needed, to ensure that all significant rail emissions near the project site are included. Use the posted timetable and

schedule to estimate the daily number of trains that travel on the line per weekday versus weekend. The level of service is assumed to remain constant in this analysis.

2. Estimate a weighted average daily number of trains that travel along the line by multiplying the number of weekday trains by 5/7 added to the number of weekend trains multiplied by 2/7. The level of service and number of trains are assumed to remain constant.

$$\text{Daily Trains} = \text{Weekday Trains per day} \cdot \frac{5}{7} + \text{Weekend Trains per day} \cdot \frac{2}{7}$$

3. Determine the locomotive idling times at stations within the 500-meter (or more) radius of the project site. Typically, idling times vary from 2 to 10 minutes to accommodate timed connections to other public transportation. If the project is located near the end or beginning of the rail lines, include the time required to power on (power down) the engines; a minimum of 20 minutes can be used if the time is unknown.
4. Calculate the diesel PM emissions from locomotives based on idling at stations or turnarounds and running exhaust between stations. Use the following equation to estimate the daily running exhaust emissions of diesel PM along the rail lines:

$$E_{\text{Running}} = \frac{1}{s} (EF_{\text{Running}} \cdot N \cdot L)$$

where:

E_{Running}	=	emissions of diesel PM per rail link per day (g)
s	=	average speed (mph)
EF_{Running}	=	emission factor by rail link (g/h)
N	=	number of locomotives that travel on the rail link per day (unitless; from Step 2)
L	=	length of rail link (mi)

Available speeds and emissions factors are presented in Tables 25, 27, and 28, but the project sponsor should ensure that the latest regulatory approved emission factors are used. The average speed can be estimated by dividing the distance between stations by the elapsed time based on the scheduled departure and arrival times. For stations located along the rail link, the running emissions are assumed to occur uniformly across the link except within a 500-foot radius of the station where idling emissions will dominate. Idling emissions are estimated by multiplying the emission factor by the number of stops on each link and the length of time spent at each stop:

$$E_{\text{Idling}} = EF_{\text{Idling}} \cdot N \cdot T$$

where:

E_{Idling}	=	emissions of diesel PM per rail link per day (g)
EF_{Idling}	=	emission factor for diesel PM by rail link (g/h)
N	=	number of locomotives that travel on the rail link per day (unitless; from Step 2)
T	=	idling time for each stop or turnaround on rail link per day (h)

The emission factors presented in Tables 25, 27, and 28 are based on a fleet mix of GP4x and Dash 9 locomotives achieving Tier 1 emission standards. As the locomotive fleet turns over, the project sponsor should ensure that fleet mix and corresponding emission factors are representative of locomotives used on the rail lines. The emissions are then the sum of emissions associated with exhaust from the locomotive and idling emissions emitted while passengers are boarding or disembarking locomotives at stations.

After emissions are estimated, the emissions can then be used in the screening or refined models to estimate the exposure concentrations in the cumulative analysis. The rail lines can be modeled as adjacent volume sources or line sources. If site-specific release data are not available, Table 12 presents acceptable defaults that can be used.

The project sponsor can use a unit emission rate or the estimated emissions in the dispersion model. However, care should be taken to ensure that the individual source (volume) emissions used in the model are equal to the total emissions when summed for the entire rail link. This is addressed by dividing the total emissions for the link by the number of volume sources used to model the link. For line sources, the emissions are estimated per line source and are dependent on the area of emissions. Even though activity levels on each rail route vary per hour, diurnal changes are not taken into account using this methodology because emissions are assumed to remain constant all day. Use a receptor grid spacing of 20 meters out to a distance of at least 325 meters to ensure that all receptors of interest and the project area are positioned within the grid.

Table 12 Default Release Parameters for Passenger Rail Lines

Parameter	Values
Source Release Height	4.06 - 5.9 meters ¹
Source Width	11 meters
Initial Lateral Dimension	5.12 meters (applicable only for volume source)
Initial Vertical Dimension	3.78 meters
Receptor Height Above Ground	1.5 meters

Notes:

¹Represents range of acceptable release heights used in assessments to evaluate emissions from railyards located in Richmond and Oakland, California.

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8 COMMUTER FERRY ANALYSIS

Marine sources are defined as vessels used in the transport and movement of people and commodities across water bodies. As with the commuter rail lines, the methodology presented in this section pertains to estimating impacts from sources that likely will be assessed only in the cumulative analysis because most projects do not involve marine vessels. Marine vessels are classified into three distinct categories: ocean-going vessels, commercial harbor craft (e.g., ferries, excursion vessels, fishing boats, tugboats, barges), and recreational/pleasure craft. This section focuses on passenger ferries, although other harbor craft can be assessed using the methods discussed below. The main engines are propulsion engines used for transit while auxiliary engines, usually generators, provide on-board electrical power. Most ferries rely on diesel fuel to power both the main and auxiliary engines, producing diesel exhaust and fine particulate matter that can affect coastal areas. Because these engines are larger and often less regulated than land-based engines, they tend to emit more air pollutants than land-based engines.

Accurately modeling emissions from marine sources requires extensive engine-specific information, such as operations, routes, and activity data. This section provides the project sponsor with a methodology for conducting a refined assessment under Tier 2 only for commuter ferries and excursion vessels because their activity data and fleet information can be accessed through published documents. Other types of commercial harbor craft, including fishing boats, tugboats, and barges, require boat-specific activity data available only through contact with individual owners.

8.1 EMISSIONS METHODOLOGY

This subsection describes the methodology for performing a Tier 2 emissions estimation for commuter ferries and excursion vessels in the Bay Area. There are numerous public and private ferry and excursion

vessel operators that offer commuter transport and/or excursions in and about the San Francisco Bay Area. Commuter ferries travel on fixed routes at a set schedule, operating at the highest practical speed consistent with weather/sea conditions and fuel efficiency. High-speed commuter ferry service runs between nine cities and San Francisco; there is limited service between Alameda and South San Francisco; new service to Redwood City was being considered before service was limited because of the COVID-19 pandemic (Table 13). Alameda hosts three ferry berths, whereas San Francisco operates a terminal year around at the Ferry Building in addition to two seasonal terminals at Oracle Park and Chase Center during San Francisco Giants baseball games and Warrior basketball games.

Excursion vessels operate on more flexible routes and schedules and may include low speed or idling on the water as part of the excursion. Most excursion vessels are used for sightseeing historic landmarks, such as Alcatraz and Angel Island, and/or for outings/venues, such as whale watching or wine tasting in Bay Area waters. Most of these operators berth in San Francisco with the exception of Commodore Cruises, which operates from a private berth in Alameda. A list of the major operators and their home berths is provided in Table 14.

Table 13 Bay Area Ferry Route by Operator

Ferry Operator	Ferry Route Connecting Cities
San Francisco Bay Area Water Emergency Transportation Authority	Alameda/Oakland–San Francisco Harbor Bay (Alameda)–San Francisco* Richmond–San Francisco South San Francisco–Alameda/Oakland South San Francisco–Harbor Bay (Alameda) ¹ Vallejo/Mare Island–San Francisco
Golden Gate Ferry	Larkspur–San Francisco Tiburon–San Francisco Sausalito–San Francisco
Tideline	Berkeley–San Francisco*

¹ Service along these routes is temporary suspended due to the COVID-19 pandemic.

² Small private operators, such as Tideline, use smaller ferries and have fewer scheduled trips; thus, default parameters presented in this section cannot be applied to these vessels

Table 14 Major Excursion Vessel Operators and Berth

Excursion Vessel Operator ¹	Berth
Red and White Fleet	San Francisco
Blue and Gold Fleet	San Francisco
Commodore Cruise and Events	Alameda
Hornblower Cruises and Events	San Francisco

¹ Other small excursion fleets, including San Francisco Bay Adventures, Wine Tasting on the Bay, Golden Gate Bay Cruise, and San Francisco Bay Adventures, have fewer scheduled trips or trips are booked as needed. The default parameters presented in this section cannot be applied to these vessels.

Both the commuter ferries and the excursion vessels emit pollutants while transiting or navigating the Bay waters and while at berth, loading and unloading passengers. The Air District recommends following the emissions calculations presented in CARB’s 2021b report titled Appendix H: 2021 Update to the Emission Inventory for Commercial Harbor Craft: Methodology and Results (CARB 2021b). Much of the information required to estimate the emissions can be obtained from CARB, San Francisco Bay Area Water Emergency Transportation Authority (WETA), and ferry and excursion vessel schedules.

PM₁₀ emissions can be estimated using the following equation (CARB 2021b):

$$E_{PM10} = EF_0 \cdot F \cdot [1 + D \cdot \frac{A}{UL}] \cdot HP \cdot LF \cdot T_o$$

where:

- E_{PM10} = Emissions of PM₁₀ by vessel (g)
- EF_0 = Zero-hour PM emission factor as a function of model year, horsepower, and engine use (propulsion or auxiliary) [g/(hp-hr)]
- F = Fuel correction factor (to account for emission reductions from burning cleaner fuel) (unitless)
- D = Engine deterioration factor (percentage increase of emissions when the engine is at the end of its useful life) as a function of horsepower (unitless)
- A = Current age of engine (yrs)
- UL = Engine useful life as a function of vessel type and engine use (unitless)
- HP = Engine horsepower rating (hp)
- LF = Engine load factor as a function of vessel type and engine use (unitless)
- T_o = Operating hours for activity (hrs)

CARB methodology requires using engine-specific emission factors by horsepower and model year in addition to a deterioration rate and a fuel correction factor. Because vessel-specific information is not always available, statewide and Bay Area average factors can be used from CARB and WETA. Statewide average factors from CARB (2021b) for emission factor, load factor, deterioration factor, number of engines per vessel, engine useful life, and fuel correction factor are shown in Table 15. Information on engine age and horsepower, which is not provided in CARB’s 2021b report, can be obtained by contacting the vessel operators. If vessel-specific data are not available, default values shown in Table 16, which represent Bay Area-specific average factors collected in 2017 from CARB’s statewide commercial harbor craft survey, can be used.

Table 15 Statewide Ferry and Excursion Vessel Operating Parameters

Vessel Type	Engine	N	EF [g/(hp-hr)]	F	D	LF	UL (years)
Ferry	Main	2.01	0.36	0.82	0.67	0.42	20
	Auxiliary	1.23	0.22	0.80	0.44	0.43	20
Excursion	Main	2.01	0.08	0.80	0.67	0.42	20
	Auxiliary	1.23	0.58	0.82	0.44	0.43	20

Notes: D = engine deterioration factor; EF = emission factor; F = fuel correction factor; g/hp-hr = grams per horsepower-hour; LF = load factor; N = average number of engines of each type per vessel based on CARB’s inventory; UL = useful life.

Table 16 Bay Area 2017 Average Vessel Operating Parameters¹

Vessel Type	Engine	A (year)	HP
Ferry	Main	12	1,526
	Auxiliary	9	158
Excursion	Main	4	520
	Auxiliary	13	70

Notes: A = engine age; HP = horsepower.

¹ Personal communications with CARB staff in 2017. Staff provided the summary table based on the Statewide Commercial Harbor Craft Survey.

Operating hours are route specific and can be estimated by determining the number of vessel arrivals and departures at each terminal based on the posted schedule. Care should be taken to tally weekday and weekend hours separately, including vessel calls to seasonal venues, and then to aggregate the individual results to determine the total annual operating hours.

The project sponsor should follow a similar methodology for estimating emissions from berthing. Berthing emissions occur when the vessels are docked at a terminal temporarily to load and unload passengers. To estimate emissions from berthing, the project sponsor can estimate the number of trip visits at each terminal based on the posted schedule. If a posted schedule is not available, as is the case for excursion vessels, average annual operating hours may be available from the vessel operators or through CARB's database via a request to CARB. If this information is unavailable, the default operating hours for excursion vessels are 1,843 hours for the main, propulsion engine and 1,254 hours for the auxiliary engine.

Although berthing time may vary depending on the terminal and number of passengers, the Air District found that on average, commuter ferries berth for approximately 10 minutes at each terminal. Berthing time may vary by terminal, and project sponsors may consider collecting this information through an on-site field study. Ferry and excursion vessels operate both the main and auxiliary engines during transiting and idling. The emissions from the main and auxiliary engines should be estimated separately using the parameters provided in Tables 14 and 15 and then combined in the modeling and risk analysis. All previous defaults provided above and the emission equation can be used to estimate emissions associated with berthing.

Diesel PM emissions can be assumed to be equal to the PM₁₀ emissions while PM_{2.5} emissions are estimated by multiplying the diesel PM emissions by the size fraction factor of 0.97.

8.2 MODELING CONFIGURATION

Navigational routes from commuter ferries and excursion vessels are modeled as adjacent volume sources during transiting and area source while at berth. A network map showing ferry and excursion routes can be found through satellite imagery from Google Earth. Because of their similar size, release parameters can be applied to both commuter ferries and excursion vessels. The beam of the vessel, provided by WETA¹⁸, can be used as the width of vessels.

¹⁸ Available from the WETA San Francisco Bay Fleet information at <https://sanfranciscobayferry.com/sites/default/files/SFBFfleet.pdf>.

The stack height, used to estimate the release height in modeling, is determined by vessel design. Some vessels have stack height/exhaust pipes situated just above the water line at the rear of vessel, whereas others have pipes routed vertically to release pollutants well above the vessel top deck. The stack heights are measured with respect to the waterline, which is set at the zero mark. For an accurate stack height, the project sponsor will need to obtain information from the operator regarding which vessels typically provide service at or near the project site, and the stack height of these vessels. Golden Gate Ferry vessels all have stack heights of approximately 1 meter, whereas vessels operated by WETA and excursion services have stack heights of either 1 meter or approximately 12 meters. If release height is not available or observable, the Air District recommends using a release height of 12 meters.

The remaining modeling parameters can be derived based on the vessel's stack height and width. Because the vessels are in motion during transiting, the release height and initial vertical dispersion coefficient are adjusted with an added factor γ , equal to 1.7, to account for the effects of motion-induced turbulence (Table 17).

Table 17 Default Volume Release Parameters for Commuter and Excursion Vessels

Parameter	Values
Source Stack Height (H)	1 or 12 meters ¹
Source Width (W)	8.8 to 12 meters ²
Source Release Height	$0.5 \cdot PH = 0.5 \cdot \gamma \cdot \frac{H}{2.15}$
Initial Horizontal Dispersion Coefficients (S_{yinit})	$\frac{W}{2.15}$
Initial Vertical Dispersion Coefficients (S_{zinit})	$\frac{PH}{2.15} = H \cdot \frac{\gamma}{2.15}$

Notes: H = source stack height; PH = plume height, which is equal to 1.7 multiplied by the stack height; W = source width.

¹ Golden Gate Ferry vessels have a stack height of 1 meter, whereas vessels operated by WETA and excursion services have stack heights of either 1 meter or 12 meters. If release height is unknown, the Air District recommends using 12 meters in the modeling analysis.

² The shortest beam vessel of 8.7 meters was retired in 2017.

The project sponsor can use a unit emission rate or the estimated emissions in the dispersion model. However, care should be taken to ensure that the individual volume source emissions used in the model are equal the total emissions when summed over the entire transit route. This is addressed by dividing the total emissions for the route by the number of volume sources used to model the route in AERMOD. To match the activity level to the meteorological conditions, emissions for commuter ferries and excursion vessels can be allocated in the modeling based on their operating schedules by day of week; this would reflect only the operating hours of the ferries and excursion vessels and not necessarily the level of activity by hour.

Berth impacts can be modeled as a point or area source depending on the available data. The area source represents the area where the vessels will be docked while loading or unloading passengers. Because of the orientation of the exhaust stacks on some vessels, the release height can be set as the physical height of the stack. Since berthing vessels are stationary, the initial vertical dispersion coefficient and release height are estimated using $\gamma = 1$ (assuming no motion-induced turbulence that will increase initial dispersion). For point-source release, the project sponsor will need to estimate the exit velocity (or flow rate), temperature, and diameter of the exhaust stack. A more expansive receptor grid is recommended that encompasses all coastal residential areas that may be affected by these vessels along the transit route and surrounding terminals.

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9 CEQA SCREENING MAPS

The CEQA screening maps are designed to assist project sponsors in estimating risks and hazards from surrounding sources as part of the cumulative analysis. The screening maps provide conservative estimates for cancer risk, PM_{2.5}, and chronic hazard that are directly comparable to the CEQA thresholds. Project sponsors can also use these methods replacing default parameters with site factors to develop source emissions specific for their project. Acute hazards are not addressed in the screening maps because a cumulative threshold for such hazards has not been adopted.

9.1 STATIONARY SOURCE SCREENING MAP

Stationary facilities that produce air pollution—including complex sources, such as metal smelting, wastewater treatment plants, and refineries as well as smaller facilities, such as diesel generators, gasoline-dispensing facilities (gas stations), and boilers—are regulated and subject to permit conditions established by the Air District. The Air District maintains a database of its permitted facilities and their associated emissions. These emissions are determined either through direct measurement via source test or by engineering calculation based on process throughput and source-specific emission factors. Emissions from all permitted facilities are reported annually to CARB under CEIDARS¹⁹ and, subsequently, reported to EPA to supplement the National Emissions Inventory database²⁰.

The current version of the stationary source screening map is based on the CEIDARS report for 2020. Subsequent updates of the permitted source screening map will rely on the most recent emissions data

¹⁹ The CEIDARS 2.5 Database Structure can be found at <https://www.arb.ca.gov/ei/drei/maintain/dbstruct.htm>.

²⁰ The EPA National Emissions Inventory web page can be found at <https://www.epa.gov/air-emissions-inventories>.

from CEIDARS, and the emission inventory year will be referenced in the map and attached meta file. The emissions inventory focused on PM_{2.5} and TACs emissions, including diesel PM. Diesel PM is used as a surrogate to represent all carcinogenic compounds associated with the combustion of diesel fuel commonly used by standby generators and fire pumps. Speciated toxic compounds where CARB speciation profiles were applied to total organic gases (TOG) and/or PM emissions to proportion individual chemical contribution are included in the inventory for most sources, such as solvents and coatings, formulated gasoline from retail and nonretail stations, and generators powered by nondiesel fuels.

The stationary source screening map contains all the facilities in the Bay Area where a permit has been issued and that emit one or more TACs. The map was developed using the approved emissions data for permitted sources to estimate the cancer risks, chronic hazard index, and PM_{2.5} concentrations. The risks and hazards shown at the facility centroid were estimated by aggregating individual source emissions for that facility. The screening level cancer risks and PM_{2.5} concentrations are estimated to be intentionally conservative and are based on worst-case assumptions. These values do not represent the true risk values from a facility.

The stationary source screening maps contains the following information:

- ▶ **Facility ID:** The unique facility identification (facility ID) as assigned by the Air District. If the Facility ID is in the form of "facility ID – source ID," it represents the location and corresponding risks and PM_{2.5} concentrations for a specific standby diesel generator that responded to the Air District's 2011 survey. "Facility number – REM" denotes the "remaining" risks and PM_{2.5} concentration when contributions from individual generators were subtracted from the total estimated for the facility.
- ▶ **Facility name:** The facility name as listed in the Air District's permit.
- ▶ **Address, city, state, and zip code:** In most cases, the full address refers to the physical location of the facility except when multiple buildings are assigned to one permit (such as campuses). In that case, the physical location refers to the main building of the campus.
- ▶ **County:** The county is the location where the permitted facility is operating based on its physical address.
- ▶ **Latitude and longitude:** Latitude and longitude of the centroid location of the facility based on their physical address in decimal degrees (datum WGS84).
- ▶ **Cancer Risk:** The cancer risk (in millions), estimated using conservative assumptions aggregated from all permitted sources related to the facility.
- ▶ **Chronic_Hazard Index:** The chronic hazard (unitless), estimated using conservative assumptions if the facility emits TACs with assigned chronic reference doses.
- ▶ **PM_{2.5}:** Conservatively estimated annual PM_{2.5} concentrations assigned to the facility in units of micrograms per cubic meter (µg/m³).
- ▶ **Details:** Assists project sponsors in identifying whether a facility is a gas-dispensing facility or if the only permitted sources are generators/pumps to ensure that the appropriate source-specific distance decay factors (see in Section 9.5) are used.

- ▶ **NAICS Code**²¹: A hierarchical identification system used by Federal statistical agencies that provides a common industry definition for businesses in Canada, Mexico, and the United States.
- ▶ **NAICS Sector**: The first 2-digits in the code that defines the economic sector.
- ▶ **NAICS Subsector**: The 3rd-digit in the code that defines the production level within an economic sector.
- ▶ **NAICS Industry Group**: The 4th-digit in the code that further defines the production stream.

The screening-level health risk impacts in the stationary source screening table are calculated using health effect values adopted by OEHHA; health-protective assumptions relating to the extent of a resident's exposure, including age-specific exposure factors; and a conservative modeling procedure to establish the extent to which a TAC is dispersed into the atmosphere after its release from the source.

For stationary source categories other than GDFs,²² the screening-level impacts for health risk and PM_{2.5} concentrations in the stationary source screening map are consistent with the methodology used to develop the trigger levels in the Air District's Regulation 2-5.²³ The modeling uses a cavity effects screening procedure whereby dispersion is affected by aerodynamic downwash from a nearby building and relates emission rate to 1-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 close to the source being evaluated. From EPA's *Screening Procedures for Estimating the Air Quality Impact of Stationary Sources* (EPA 1992), the cavity equation is as follows:

$$Conc = \frac{Q}{1.5 \cdot A \cdot u}$$

where:

- Conc* = 1-hour maximum concentration (µg/m³) at the fenceline of facility
- Q* = Emission rate (g/sec)
- A* = Cross section area of the building normal to the wind (m²)
- u* = Wind speed (m/sec)

The cavity effects equation requires the selection of the crosswind building area and the average wind speed. Building cross section was assumed to be 25 feet high by 40 feet wide, approximately 92.7 square meters. Calm winds of 2 meters per second, taken from EPA's screening modeling guidelines, was used. The maximum 1-hour concentration, estimated by applying these factors, was then multiplied by 0.1 to convert the 1-hour concentration to an annual average concentration, for determining risks and hazards comparable to the thresholds.

An alternative screening methodology was developed to address the multiple emission points associated with gas stations where losses occur through spills, pipe vents, and pumps. Various hypothetical scenarios were run using AERMOD to determine worst-case ground-level annual concentrations. AERMOD

²¹ U.S Census NAIC System 2022 manual: https://www.census.gov/naics/reference_files_tools/2022_NAICS_Manual.pdf

²² Cavity effects screening procedures were not applied to GDFs because of the complexity of the emission sources. A detailed explanation of the methodology used for gas stations is described further in this section.

²³ <http://www.baaqmd.gov/Divisions/Planning-and-Research/Rules-and-Regulations.aspx>.

compatible meteorological files were processed using AERMET for representative Bay Area cities, including Concord; Hunters Point in San Francisco; Oakland Airport; Petaluma Airport; the University of California, Richmond campus; and San Jose Airport. Building downwash effects were modeled for over two dozen different building configurations. Emissions were apportioned so that most of the losses (92.7 percent) were assigned to dispensers and the remaining fraction (7.3 percent) was assigned to vents. Given that most gas stations have similarly sized vents from their underground tanks, storage tank vents were modeled as point sources that were 10 feet in height and 2 inches in diameter, with 0.00035-meter-per-second exhaust gas velocity and an exhaust temperature of 294 degrees Kelvin. For each modeling scenario, six point sources representing dispensers were modeled along with a single volume source of lateral dimension of 2.3 feet to depict losses from refueling and spillage.

For each building configuration and meteorological dataset, the annual average atmospheric dispersion factor (also known as Chi/Q) for gas stations was estimated based on the modeling results from AERMOD. The Chi/Q factor, the ratio of the pollutant ground-level concentration (Chi) to the source emission (Q) at specified distances and directions from the source, describes the dilution and dispersal effects caused by the atmosphere after the pollutant is released. County-specific Chi/Q factors (Table 18) were estimated based on the most conservative modeling scenarios using the county-specific meteorology. The chemical-specific emissions were then multiplied by the Chi/Q factor for each county to produce conservative ground-level concentrations for each air pollutant. Future iterations of the GDF screening values starting in July 2022 will be derived following the recommended procedures for preparing gas station emission inventories and HRAs outlined in CARB’s *Gasoline Service Station Industrywide Risk Assessment Technical Guidance* (CARB 2021a). Project sponsors can opt out of using the Air District’s CEQA screening map and instead use CARB’s gas station screening tool to estimate cancer risk and chronic and acute hazards.

Table 18 Area-Specific Chi/Q for GDFs

County	Chi/Q (µg/m³ per gram/sec)
Alameda	3,782
Contra Costa	5,287
Marin	6,236
Napa	6,236
San Francisco	4,585
San Mateo	6,236
Santa Clara	3,420
Solano	6,236
Sonoma	6,236

Notes: µg/m³ = micrograms per cubic meter; GDF = gasoline dispensing facility; gram/sec = gram per second; Q = emission rate.

To quantify emissions for each permitted gas station, the Air District used reported annual throughputs collected during facility inspections. Because inspection throughputs were unavailable, maximum allowable throughputs were used, although most stations operate well below their allowable permit limit. Individual

chemical emissions²⁴ were estimated by multiplying the gas station throughput by the TOG speciation profile from CARB for evaporative losses from gasoline.

Cancer risks were estimated by multiplying the Chi/Q factor by the chemical-specific emissions, residential exposure factors, and chemical-specific potency factors as described in Section 10.1. Cancer risks were calculated over an assumed 30-year lifetime exposure duration. In accordance with OEHHA Guidelines (OEHHA 2015), the intake methodology includes age-sensitivity factors that address children's greater sensitivity from early exposure to carcinogenic compounds.

The screening map also provides estimated hazards based on chronic exposures to noncarcinogenic compounds and annual PM_{2.5} concentrations. The chronic noncancer hazards were calculated by dividing the long-term exposure levels and intake by the chronic reference exposure levels following the methodology in Section 10.2. Multipathway toxicity factors and reference exposure levels were used, when they were available from OEHHA, to account for additional exposures through noninhalation pathways. To ensure a conservative conclusion, facility hazards represent the sum of hazard quotients across all permitted sources at the facility. As noted above, estimates of acute hazard are not provided in the screening maps. Project sponsors can use CARB's Gas Station Risk Assessment Lookup Tool (CARB 2021a) to estimate acute hazard using the gas station's annual permitted throughput. Throughput information can be obtained from the Air District's permit via a public records request.

The modeled screening values shown in the stationary source map are not representative of actual health risks. Rather, the values are upper-bound estimates at the facility centroid for assessing whether a site-specific HRA is warranted. The screening approach relies on numerous conservative default assumptions that are not facility specific, and the estimates are not reflective of actual cancer risks likely to be experienced by nearby receptors. To adjust the screening values based on distance from the source to the receptor, the Air District provides source-specific distance decay factors in Section 9.5. If a facility's screening values (adjusted using the decay factors, as appropriate) are below the threshold, it is likely that the facility would pass a more site-specific, detailed modeling analysis.

A more refined analysis relying on source-specific release information and meteorological data is expected to result in lower and more accurate values than those found in the stationary source screening map. The screening map may be used to determine which facilities to include in the cumulative analysis. The impacts from the significant emitting facilities can then be summed and compared to the cumulative thresholds to determine whether further analysis is required. Note that the coordinates represent only a single point at the facility centroid, which is not the actual source locations and may not be the point closest to the project. Also, the datum for the coordinates in the screening map may not be the same for all facilities. Coordinates for some facilities may be referenced to NAD27, whereas others are referenced to WGS84 (i.e., NAD83). Potential distance offsets may be as great as 220 meters. To ensure that all relevant facilities are included, the distance used to identify facilities from the permitted source screening map should extend a reasonable distance beyond the distance specified in the Guidelines, and actual facility locations should be verified using the provided address in the screening map.

²⁴ Common chemicals found in gasoline include benzene, toluene, ethylbenzene, naphthalene, xylenes, and hexane. Additional chemicals may be present at lower percentages.

9.2 ROADWAYS SCREENING MAP

The Air District is developing the CEQA screening maps described in this section. The maps will be posted on the Air District CEQA website as they become available. In the meantime, project sponsors can use the methodology presented in this section to estimate screening values for their project and surrounding sources.

The roadway screening map provides estimated cancer risks, hazards, and PM_{2.5} concentrations for all Bay Area highways and surface streets. A fine-scale emissions inventory of PM₁₀, PM_{2.5} and TACs, which formed the foundation of the screening map, has been developed with a bottom-up approach relying on county-specific vehicle splits for surface streets and truck fractions from Caltrans's PeMS²⁵ for California freeways. The emissions for each roadway segment²⁶ (referred to as a "link") were then modeled in AERMOD, using wind field data generated from the Weather Research and Forecasting (WRF) modeling tool²⁷ and risk exposure assumptions. Note that the screening map was developed using the same methodology recommended for refined analysis, although default data were used for some parameters that may not match project conditions. Therefore, the project sponsor can incorporate site-specific data, such as vehicle speeds, vehicle counts, vehicle types, diurnal profiles, and meteorological data, to further improve the analysis, as described in Section 6.

Two types of emissions were estimated for roadways in the screening map: operational emissions and re-entrained road dust emissions.

Operational emissions results from the consumption of fuel or from wear of vehicle-related materials.²⁸ The emissions processes include:

- ▶ running exhaust, when pollutants are emitted from the tailpipe of the vehicle as the fuel is combusted;
- ▶ running loss, when hot fuel vapors escape from the fuel system or overwhelm the carbon canister during the vehicle's operation;
- ▶ tire wear, when PM is emitted as a result of a vehicle's tires contact with the road surface; and
- ▶ brake wear, when PM is emitted as a result of wear of brake materials as the vehicle's brakes are applied.

Emission factors from the four processes²⁹ were estimated using the latest version of the EMFAC2021, which is developed and maintained by CARB. *Entrained road dust* emissions (referred as road dust) are particulate matter from resuspended road surface material (dust) that is entrained by vehicles traveling on roads. Road dust emission factors were estimated following CARB's methodology for paved road dust (CARB 2021c), where roadway types of surface streets were assigned based on the average daily traffic

²⁵ Available at <http://pems.dot.ca.gov/>.

²⁶ Roadways are represented by multiple aligned roadway links or segments.

²⁷ Description of the WRF model is available at <https://www.mmm.ucar.edu/weather-research-and-forecasting-model>.

²⁸ In this analysis, emissions from transport refrigeration units on trucks (Port Trucks or non-Port Trucks) were not included.

²⁹ The emissions from other processes of on-road mobile sources, such as from start exhaust and resting evaporative loss, were not included in the bottom-up inventory; these emissions are generally a small portion of the total emissions for PM_{2.5} and diesel PM.

(ADT) counts following the relationship from EPA’s Air Pollution (AP) report *AP-42 Compilation of Air Pollutant Emissions Factors, Volume I: Chapter 13.2.1, “Paved Roads”* (EPA 2011).

Operational emissions from on-road mobile sources are calculated by source category, which is a combination of vehicle class, fuel type, emission process, and control technology. For this screening analysis, the four emission processes listed above and all the vehicle classes and fuel types defined in EMFAC2021 User Guide Appendix 4 were included (CARB 2021d). Appendix 4 also defines the EMFAC vehicle categories, which are groups of vehicle classes as summarized in Table 19. Collectively, the combined truck-related categories—Truck 1 and Truck 2—are referred to as “Trucks.” Road dust emissions are calculated based on the entire fleet (i.e., all vehicles together). It is important to estimate emissions at this level of detail in order to support the estimation of air toxic emissions (see Section 9.2).

Table 19 Emission and Vehicle Categories for Roadway Emissions¹

Emissions Category	Vehicle Category	Description/Vehicle Types
Operational	Non-Truck	Passenger cars, light-duty trucks, medium-duty trucks (GVWR ≤ 8,500 lbs), buses, motorcycles, motor homes, motor coaches
	Truck 1	Light-Heavy Duty Trucks (GVWR 8,501–14,000 lbs)
	Truck 2	Medium-Heavy Duty Trucks (GVWR 14,001–33,000 lbs) and Heavy-Heavy Duty Trucks (GVWR > 33,000 lbs)-
Road dust	All	Entrained road dust (PM ₁₀ and PM _{2.5}) on paved roads

Notes: GVWR = gross vehicle weight rating; PM₁₀ = particulate matter with a diameter less than or equal to 10 microns; PM_{2.5} = particulate matter with a diameter less than or equal to 2.5 microns.; lbs = pounds

¹ As defined in EMFAC2021, vehicle categories are generally based on gross vehicle weight rating.

A bottom-up fine-scale emissions inventory was developed using information on (1) the roadway network, (2) vehicle travel activity, and (3) emissions factors. The roadway network and the majority of travel activity data used for the screening map were purchased from Bentley. For all nine Bay Area counties, Bentley provided a geodatabase containing the roadway network with roadway attributes (e.g., length, the number of lanes), and travel activity (volume and speed) for 2019 by hour of the day for four-day types (Monday–Thursday, Friday, Saturday, and Sunday).

A description of the parameters from Bentley and other data sources used to develop a source-category specific emissions inventory is presented in the following sections.

Roadway Network. Bentley uses the HERE roadway network, which includes the roadway geometry and supporting data such as the number of lanes, roadway length, roadway elevation, and roadway functional class for each link. The roadway width, necessary for air dispersion modeling, was not provided by Bentley, so the roadway functional classes from Bentley were matched to corresponding roadway types (Table 19) from the Federal Highway Administration (FHWA) that establish standards for roadway construction. The width of each link was then estimated by multiplying the number of lanes (provided by Bentley) by the lane width based on the FHWA roadway type. The width per lane was based on guidance for roadways in urban areas as classified by FHWA (Table 20): 3.6 meters for freeways, 3.0 meters for arterials, and 2.7 meters for local roads (ASSHTO 2018).

Table 20 Cross-Reference of Road Type Classification Schemes Used in This Analysis

Bentley Functional Class	CARB Road Type	FHWA Road Type	Road Category
2 - Major Highways	Freeways	Freeway	Highway
3 - Minor Highways	Major Streets	Arterial	Surface Street
4 - Minor Streets	Collector Streets	Arterial	Surface Street
5 - Local Roads	Local Streets	Local	Surface Street

Notes: Functional classes were obtained from Bentley Systems and mapped to FHWA road type (AASHTO 2018), used to determine roadway width. Silt loading factors from CARB (2021c) were assigned by roadway type based on the ADT to estimate road dust emissions (see Section 9.2).

Travel Activity. Vehicle travel activity data, including the traffic volume, vehicle speed, and the fleet mix, were used to develop the emission inventory. These parameters are further described in Table 21.

Table 21 Travel Activity Parameters and Associated Data Sources Used for Estimating Emissions from On-Road Mobile Sources

Parameter	Description	Purpose	Reference/Data Source
Volume	Average total traffic fleet volume	Calculate vehicle miles traveled (VMT) and vehicles hours traveled (VHT), which are used to estimate emissions from all processes (operational and road dust).	Bentley Systems
Speed	Average total traffic fleet speed	(a) Estimate running exhaust and brake wear emissions (emission factors are speed dependent), and (b) estimate VHT.	Bentley Systems
Fleet Mix	Composition of vehicle fleet (i.e., volume or VMT fraction for each vehicle class and fuel type)	Apportion fleet-total VMT to each vehicle class and fuel type.	Caltrans PeMS, county-specific VMT-based fractions by vehicle class and fuel type from EMFAC2021

Notes: Parameters can vary hourly and by roadway link.

Volume and Speed. For each link, hourly traffic volume and speed by day type purchased from Bentley were used to calculate:

- ▶ VMT: the mileage of all vehicles traveling on a link over a specific period (e.g., hourly, daily) estimated as the product of volume (count) and link length (miles); VMT is used to estimate emissions from running exhaust, tire wear, brake wear, and road dust, and
- ▶ vehicle hours traveled (VHT): the travel time of all vehicles traveling on a link over a specific period (e.g., hourly, daily); VHT, which was estimated by dividing VMT (miles) by speed (mph), was used to estimate running loss emissions.

To improve the efficiency of AERMOD modeling, the two-way directional traffic data were merged into a single roadway representing the approximate centerline of the roadway. In this step, the number of lanes and traffic volumes in both directions were summed, while the hourly traffic speeds were averaged (weighted by hourly volume). The number of lanes was rounded down for links where the number of lanes was not a whole number because the fractional lane represented existing street parking.

The day type–specific traffic volume (Monday–Thursday, Friday, Saturday, and Sunday) was aggregated to derive annual average day volumes. Average day diurnal profiles for each link were developed by combining hourly traffic volumes across all day types. Similarly, the day type–specific vehicle speed was averaged using volume as a weighting factor. For each roadway link, two-way merged hourly VMT and VHT on an annual average day were calculated, and were then allocated to EMFAC2021 vehicle classes and fuel types by using fleet mix information (see “Fleet Mix” below).

Fleet Mix. The annual average fleet mix data were derived by road category (Table 19) based on several data sources as follows:

- ▶ For highways: The fractions of Truck and Non-Truck were first derived from the station-level traffic flow and truck flow in the 2019 annual average Time of Day (TOD) performance data from Caltrans PeMS system, which uses sensors to record traffic and truck flow on freeways³⁰, as described below. After assigning the vehicle fractions to each highway link, the Truck and Non-Truck fractions were further split based on 2022 county-specific VMT fractions following EMFAC2021 vehicle classes and fuel types, assuming 2022 Truck and Non-Truck fractions are the same as 2019.
 - The Air District performed an initial quality assurance by excluding PeMS stations with invalid data (e.g., truck flow and traffic flow are identical for all 24 hours). The hourly truck fractions were then derived for each PeMS station by ratioing the truck flow by traffic flow. The PeMS stations with unrealistically high truck fractions were removed if their average daily truck fractions are above a cut-off value of 0.1178 estimated as the 95th confidence interval of all truck fractions in the Bay Area.
 - The truck fraction from PeMS were assigned to highway links based on their spatial proximity to the corresponding PeMS stations with the same highway name and direction. For links without corresponding PeMS stations, the average fractions of the corresponding highway corridor (i.e., the traffic flow weighted average fractions of all PeMS stations for the same highway in the county) were used to fill the gap. Highways lacking PeMS stations were assigned the average truck fraction estimated from all PeMS stations within the county. For bridges (i.e., Golden Gate Bridge, Bay Bridge, San Mateo Bridge), a uniform truck fractions specific to each bridge were develop by averaging across all PeMS stations spanning the bridge to ensure continuity and consistency over the bridge span. .
 - Non-Truck fraction is the difference of one minus the truck fractions for each link.
- ▶ For surface streets: The 2022 county-specific VMT fractions by vehicle class and fuel type were derived from VMT data produced by EMFAC2021 based on the vehicle registrations in each county. All surface streets within each county were assigned the same 2022 county-specific fleet mix. The only exception is Port of Oakland, where Trucks dominate the daily traffic volume within the Port boundary. Therefore, the Air District assumed that only drayage trucks travel on roadway links within the Port of Oakland property. The assumption is conservative but more representative for the local condition.

³⁰ The PeMS system estimates truck flow at each detector based on the measured 5-minute, lane-by-lane values of flow and occupancy if they don't report truck volumes.

Emission Factors. 2022 annual average emission factors for each emission process were developed for PM_{2.5} and TOG as described below.

Operational Emission Factors. 2022 annual average PM₁₀, PM_{2.5}, TOG and ammonia emission factors³¹ by vehicle class, fuel type, and emission process for each county were generated from EMFAC2021.

Road Dust Emission Factors. For road dust, there are only PM emissions. PM₁₀ and PM_{2.5} emission factors were estimated for each roadway link following the CARB (2021c) methodology, which is reproduced below:

$$EF_{fleet} = k \cdot sL^{0.91} \cdot W_{fleet}^{1.02} \cdot \left(1 - \frac{P}{4N}\right)$$

where:

EF_{RD} = road dust emission factor (lb/mi)

k = particle size multiplier (0.00033 lb/VMT for PM_{2.5})

sL = road surface silt loading factor, based on CARB road type (Table 21) (g/m²)

W_{fleet} = fleet average vehicle weight (California default [2.4 tons] or calculated using the equations below)

P = number of “wet” (precipitation ≥ 0.01 in) days in averaging period (days) (Table 22)

N = total number of days in averaging period (days) ($N = 365$ days for annual analysis)

Entrained Road Dust on Paved Roads

The methodology for estimating entrained road dust along paved roads follows the approach outlined in EPA’s AP-42. Using CARB’s (2021c) or EPA’s recommend default values results in emissions that differ by as much as 200 percent. Reducing the uncertainties between the two sets of factors is important because nonexhaust emissions (i.e., brake wear and entrained road dust) are anticipated to dominate roadway emissions as exhaust emissions continue to decline. The Air District’s recommendation is to apply EPA’s default recommended values when project sources are subject to the Air District’s permitting requirements or regulations. For land use projects not subject to the Air District’s rules or regulations, project sponsors may apply CARB’s default factors for entrained road dust. Special considerations should be made to ensure that the appropriate factors for silt loading and vehicle weight, as defined in the project details, are used and justified in the report. The roadway screening map relies on CARB’s default factors as the purpose of the map was to evaluate cumulative impacts from existing roadways, which are not subject to the Air District’s permitting requirements or regulations.

For each link, the fleet average vehicle weight was calculated as follows, where subscripts denote vehicle aggregation levels: vehicle class (VC) (e.g., light-duty auto, light-duty truck) or the entire fleet (fleet) (i.e., all vehicle classes), where $x \in \{fleet, VC\}$:

$$F_{VC} = \frac{VMT_{VC}}{VMT_{fleet}}$$

$$W_{fleet} = \sum_{VC} W_{VC} \cdot F_{VC}$$

³¹ PM₁₀ is included to estimate emissions of diesel PM.

where

F_{VC} = VMT-based weighting factor for the vehicle class (unitless)

VMT_x = VMT of all vehicles at vehicle aggregation level x (miles)

W_x = weight of vehicle at vehicle aggregation level x (tons)

Therefore, the fleet average vehicle weight is simply the weighted average of all vehicle weights. Vehicle weights were taken from EMFAC2021. F_{VC} is the link-specific fleet mix developed from Caltrans's PeMS traffic activity as described in "Travel Activity."

The silting loading factor was assigned to each link based on its road type, as defined by the ADT. Initially, the Air District completed the modeling using the functional class assigned by Bentley following CARB's methodology (2021c), resulting in some surface streets having higher exposure concentrations than freeways. The Air District corrected the anomaly by assigned roadway type based on the ADT rather than the functional class. The ADT count assigned to each link by Bentley was cross-referenced to CARB's Road Types following EPA's AP-42 roadway definitions based on vehicle counts. Table 22 presents CARB Road Type classification and corresponding ADT and silt loading factor used to estimate road dust emission factors for each link. Table 23 presents the Annual Rainfall Days used to estimate road dust emission factors by County.

Table 22 Road Surface Silt Loading Factor (sL) by Road Type Used in CARB Method to Estimate Emission Factors from Road Dust Emissions

CARB Road Type	Average Daily Traffic Count	sL (g/m ²)
Freeways	≥ 10,000	0.015
Major Streets	≥ 5,000 and < 10,000	0.032
Collector Streets	≥ 500 and < 5,000	0.032
Local Streets	< 500	0.320

Notes: CARB = California Air Resources Board; grams per meter square; g/m²; sL = silt loading factor. Values taken from California Air Resources Board (2021c).

Table 23 Annual Rainfall Days (P) Where 0.01 Inch or Greater Precipitation Was Recorded by County

County	P (days)
Alameda	61
Contra Costa	60
Marin	66
Napa	68
San Francisco	67
San Mateo	60
Santa Clara	64
Solano	54
Sonoma	69

Notes: P = annual rainfall days
Values taken from CARB (2021c).

Emissions. 2022 annual average daily emissions of PM₁₀, PM_{2.5}, TOG and ammonia were calculated as the product of traffic activity and emission factors, with more details provided in this section.

PM and TOG. For operational emissions from on-road mobile sources, annual average daily emissions of PM₁₀, PM_{2.5}, TOG, and ammonia were estimated by roadway link by vehicle class (VC), and fuel type (FT), for each emissions process (Pr).

First, the annual average daily emissions (E) were calculated by link (L), vehicle class (VC) and fuel type (FT) for each of the emission process (Pr) and pollutant (Pol).

- ▶ For running exhaust, tire wear, and brake wear:

$$E_{VC,FT,Pr,Pol,L} = \sum_{h=1}^{24} VMT(h)_{VC,FT,L} \cdot EF(s(h))_{VC,FT,Pr,Pol}$$

where emissions (E, in g) are the product of hourly VMT and emission factors (EF) and then summed over all hours (h) of the day, and for running exhaust, the emission factor is a function of speed (s), which varies by hour of day.

- ▶ For running loss:

$$E_{VC,FT,Pr,Pol,L} = \sum_{h=1}^{24} VHT(h)_{VC,FT,Pr,Pol,L} \cdot EF_{VC,FT,Pr,Pol}$$

where the emissions are the product of the hourly VHT and emission factors (EF) and then summed over all hours (h) of the day.

For road dust from paved roadways, annual average daily emissions were estimated for the entire fleet by link.

- ▶ For road dust emissions on each link,

$$E_{fleet} = \sum_{h=1}^{24} VMT(h)_{fleet} \cdot EF_{fleet}$$

where the total fleet PM₁₀ and PM_{2.5} emissions are the product of hourly VMT and link-specific emission factors (EF) and then summed over all hours (h) of the day.

TACs. To evaluate risk and exposure from roadways, the annual average daily TAC emissions were also estimated for each link. CARB's PM and organic gas speciation profiles³² were applied on PM and TOG emissions calculated in "Emissions" to estimate TAC emissions, except for diesel PM.

Diesel PM emits only from diesel-powered vehicles. Its emissions were produced by simply filtering out running exhaust PM₁₀ emissions of vehicles whose fuel type is diesel.

The emissions of other TACs were estimated following the steps below:

- ▶ Assign CARB's Emissions Inventory Codes (EICs)³³ to the PM₁₀ and TOG emissions based on the vehicle class, fuel type, emission process, and control technology. The Air District assumed that all gasoline and Plug-in Hybrid Electric Vehicles (PHEV) have catalytic converters. This is because EMFAC2021 default suggests that the last model year of gasoline vehicles with non-catalytic

³² Available at <https://ww2.arb.ca.gov/speciation-profiles-used-carb-modeling>.

³³ Download EIC description from CARB's website: <https://ww2.arb.ca.gov/emission-inventory-documentation>.

converters is model year 1975. Considering the lifetime of vehicles, there should be little non-catalytic controlled vehicles remaining in the fleet in year 2019 and later.

- ▶ Retrieve CARB’s chemical speciation profiles and assignment files.³⁴ The speciation profiles contain the fractions of each chemical species (including TACs) in PM₁₀ or TOG for a specific type of source. The assignment files specify which speciation profile should be applied to each EIC code.
- ▶ Join the PM₁₀ and TOG emissions with PM₁₀ or TOG speciation profiles as the assignment files specify. The emissions of each TAC pollutant were then calculated by multiplying PM₁₀ or TOG emissions by the fraction of the TAC species in the corresponding profile.

For each link, the emissions from all processes were summed to generate annual average daily emissions by pollutant and emission/vehicle category (i.e., Road dust, Truck, Non-truck). The emissions were then converted to emission rates (g/s) representing the average hour of the annual average day, which is the emissions input for the postmodeling process, along with corresponding diurnal activity profiles as described in “Modeling Methodology.”

Modeling Methodology. The on-road modeling follows the methodology from EPA’s PM hot-spot analyses for transportation projects (EPA 2015b, 2015c).³⁵ On-road mobile sources were modeled as line-area sources in AERMOD. The location of the line sources (centroids) aligned with the roadway network provided by Bentley. A combination of the roadway functional class and the number of lanes (from Bentley) was used to approximate the total roadway width, extended 6.0 meters to address vehicle turbulence (EPA 2012). The width per lane was based on guidance for roadways in urban areas as classified by FHWA (see “Roadway Network”). The total width was taken as the number of lanes times the width per lane.

Two separate AERMOD dispersion modeling runs were performed because of the different release parameters and associated diurnal (activity) profiles for Non-Trucks and Trucks. For a given roadway segment, Non-Trucks and Trucks were modeled separately, keeping the location of the line sources constant between each model run.

For all line-area sources, the initial vertical dispersion coefficient was based on the AERMOD User’s Guide for surface-based sources (EPA 2018):

$$\begin{aligned} Sz_{init} &= PH / 2.15 \\ &= (H \cdot \gamma) / 2.15 \end{aligned}$$

where *PH* is the initial vertical dimension of the source plume (plume height), *H* is the average source (vehicle) height, and γ is a parameter to account for the effects of vehicle-induced turbulence, which equals 1 when vehicles are not moving or 1.7 when vehicles are in motion (EPA 2015a). *H* depends on the vehicle category and was taken as 1.53 meters for Non-Trucks and 4.0 meters for Trucks. Therefore, *Sz_{init}* was set to 1.21 meters for Non-Trucks and 3.16 meters for Trucks. Finally, the release height was estimated as the midpoint of the initial vertical dimension (i.e., *Relhgt* = 0.5 • *PH*). Therefore, *Relhgt* was initially set

³⁴ A brief description of assignment files is available on CARB’s website: <https://ww2.arb.ca.gov/source-code-assignment-speciation-profiles>. Please contact CARB staff listed in footnote 13 for the actual files.

³⁵ That being said, because this analysis is not a formal PM hot-spot analysis, some aspects of the modeling approach differed.

to 1.3 meters for Non-Trucks and 3.4 meters for Trucks. For sources that were not at grade, *Relhgt* was then adjusted based on the height of the elevated roadway or freeway.

The diurnal profiles for each link by vehicle category were developed based on hourly traffic volumes. For Non-Trucks, diurnal profiles for freeways and surface streets were developed using Bentley activity data. For Trucks, diurnal profiles for freeway links were developed based on data from the nearest PeMS site, or based on data of all PeMS sites for a specific freeway within a county if the freeway links are too far away from a PeMS site. County average diurnal profiles across all PeMS sites within a county were calculated and applied to surface streets. The only exception is Port of Oakland, where Trucks dominate the daily traffic volume within the Port boundary. Therefore, the diurnal profiles for roadway links in Port of Oakland were developed using Bentley volume which is more representative for the local conditions. For each link and vehicle category, the diurnal activity profile is composed of 24 values, and each is the ratio of hourly traffic volume over the average hourly traffic volume. These values are then used to scale the unit emission rate during the AERMOD run so that the hourly unit emission rate reflects the hourly variation of the actual emission rates.

Meteorological inputs to AERMOD are usually developed from data collected at meteorological stations. However, the coverage of such stations across the Bay Area is not sufficient to provide representative meteorological data for all roadways. Therefore, outputs from WRF Model version 3.8 were used to prepare the meteorological inputs to AERMOD. The Air District uses the WRF model to prepare meteorological data for regional modeling applications, assimilating observations into the model to minimize the difference between generated wind field data and real-world measurements. In addition, a model performance evaluation is conducted to ensure that WRF outputs are suitable for use in air quality modeling. The most recent WRF run available was for 2018, and required AERMOD parameters, such as hourly wind speed and direction, were extracted from this simulation. The Air District used a similar WRF-based approach to model potential impacts from emissions sources in the Richmond-North Richmond-San Pablo community as part of an emissions reduction plan being developed under AB 617.

Risk Estimates. Cancer risks were estimated by combining the pollutant concentrations at each receptor location by the residential exposure factors and chemical-specific potency factors as described in Section 10. Cancer risks were calculated over an assumed 30-year lifetime exposure duration. In accordance with OEHHA's HRA guidelines, the intake methodology addresses health impacts from children's greater sensitivity from early exposure to carcinogenic compounds.

The screening map also provides estimated hazards based on chronic exposures to noncarcinogenic compounds and annual PM_{2.5} concentrations. The chronic noncancer hazards were calculated by dividing the long-term exposure levels and intake by the chronic reference exposure levels following the methodology in Section 10. Multipathway toxicity factors and reference exposure levels were used, when available from OEHHA, to account for additional exposures through noninhalation pathways. To ensure a conservative conclusion, receptor hazards represent the sum of hazard quotients from all on-road mobile processes.

The modeled screening values are partially site specific for 2019 because much of the link-specific activity data were incorporated into the modeling. In most cases, the values are upper-bound estimates for assessing whether a site-specific HRA is warranted. The screening approach relies on numerous county defaults that are not necessarily location specific, and project sponsors are encouraged to perform their

own roadway analysis depending on the availability of site-specific data. (The recommended methodology is provided in Section 6.)

9.3 RAIL LINES FOR PASSENGER, COMMUTER, AND FREIGHT

The Air District has developed a new rail source screening map that predicts the cancer risks, hazards, and PM_{2.5} concentrations from diesel locomotives³⁶ used to transport freight along Class I rail lines and to transport people along commuter/passenger rail lines. The rail source map also incorporates the health impacts from select railyards in West Oakland and Richmond-North Richmond-San Pablo, analyzed as part of AB617 (see Section 9.4 for more information). A bottom-up emissions inventory of PM_{2.5} and diesel PM was developed based on the arrival/departure schedule for commuter/passenger trains and fuel consumption rates for the two major freight rail lines operating in the Bay Area. The emissions were then processed through the air dispersion model, AERMOD, using WRF wind field data. The project sponsor may refine the screening estimates further based on changes in the commuter/passenger schedule, increases/decreases in freight traffic, updated emission factors, or evaluation of Class III or short rail lines.

The network railroad map was initially based on a shapefile from the Topographically Integrated Geographic Encoding and Referencing (TIGER) Line spatial database.³⁷ The rail line features were then realigned as necessary to match the satellite imagery in Google Earth. In the shapefile, each rail line consists of smaller segments (or links) that span short distances along each track. In the Bay Area, passenger and freight services may run along a single track (i.e., the track is shared by both services) or along parallel tracks. For modeling purposes, parallel rail tracks were consolidated onto a single track, and emissions from freight and commuter lines were aggregated. For freight activities, emissions from locomotives that perform switching operations (referred to as “switchers,” which assemble or disassemble rail cars from trains) were evenly distributed along their assigned subdivision line.

The following sections describe the approach used to estimate the emissions for freight and commuter rail that formed the basis of the rail source screening map.

Freight Haul Lines. The rail screening map presents risks along Class I line-haul rail lines that are serviced by two freight rail providers: Burlington Northern Santa Fe Corporation (BNSF) and Union Pacific (UP). Although the map focuses on risks along Class I rail lines, the Air District recommends that project sponsors consider Class III rail lines or short lines in the cumulative analysis if the lines are close to the project site.

BNSF and UP transport goods to and from the Bay Area to the San Joaquin Valley (east), Sacramento (north), and the Peninsula (south). They provided the Air District with the average diesel fuel consumption and miles traveled in 2020 along each county subdivision line (Table 24) in the Bay Area, as well as EPA fuel-based emission factors (g/gal) for converting fuel consumption to emissions. Emissions from switchers were included in the fuel-based emissions estimates and distributed uniformly across specific subdivision lines.

³⁶ Rail service using locomotives powered by electric power or fuel cells, such as the Bay Area Rapid Transit (BART), are not included in this analysis.

³⁷ Available at <https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.html>.

Table 24 Freight Subdivision Lines Operating in the Bay Area

County	Subdivision	Start Location	End Location
Alameda	Coastal	San Leandro	Alameda County line
	Martinez	10th Street, Oakland	Alameda County line
	Niles	10th Street, Oakland	Newark
	Oakland	San Leandro	Alameda County line
	Tracy	Contra Costa County line	Alameda County line
	Warm Springs	Niles Boulevard, Fremont	Alameda County line
Contra Costa	Martinez	Alameda County line	Contra Costa County line
	Tracy	Martinez	Contra Costa County line
San Francisco	San Francisco	King Street, San Francisco	San Francisco County line
San Mateo	San Francisco	San Francisco County line	San Mateo County line
Santa Clara	Coast	Alameda County line	Santa Clara County line
	San Francisco	Santa Clara County line	San Jose
	Warm Springs	Alameda County line	San Jose
Solano	Martinez	Contra Costa County line	Davis

Passenger Rail Lines. Amtrak offers several intercity passenger rail services along the Capital Corridor, California Zephyr, Coastal Starlight, and San Joaquin routes. Emissions by link were estimated using the available schedule for fall 2021 because many of the service providers resumed normal service after 1.5 years of curtailed hours and reduced service forced by the COVID-19 pandemic. For each link, emissions were estimated as the sum of running exhaust emissions from the locomotive during transit, and idling emissions while loading (unloading) passengers at stations.

To estimate the emissions, the number of locomotives per day that run along each link, as well as information on the activity along each rail line, is required. The activity along each Amtrak route is a function of the estimated average speed of the train and the frequency of the stops. To determine the number of stops, the Air District used the posted timetable and schedule by Amtrak.³⁸ The timetables identify the number of train stops at each station and the times and frequency of the train stops. These timetables were used to determine the following information:

- ▶ The daily number of trains was calculated as the number of weekday and weekend trains weighted by 5/7 and 2/7, respectively.
- ▶ The idling times varied from 2 to 10 minutes at certain stations to accommodate timed connections to other public transportation; the average idling time (to pick up and drop off passengers) was approximately 90 seconds at most stations. Trains can also spend up to 20 minutes idling to power up (or power down) the engine at the beginning (or end) of a route.

³⁸ The most recent timetable, posted in fall 2021, was used. Timetables were obtained from <http://www.amtrak.com/train-schedules-timetables> (accessed October 2021).

Based on the timetable, the number of daily trips along each route is presented in Table 25. The level of service and number of trains were assumed to remain constant.

Table 25 Amtrak Activity by Route

Routes	Destinations	Number of Weekday Trains per Day	Number of Weekend Trains per Day
Capital Corridor	Fairfield–Oakland	22	18
	Oakland–Coliseum	14	14
	Coliseum–San Jose	14	14
California Zephyr	Emeryville–Fairfield	2	2
Coastal Starlight	Gilroy–Fairfield	2	2
San Joaquin	Antioch–Oakland	10	10

Locomotives operate under a series of load modes (notches) that, combined with idling, determine the operating mode and the corresponding emission factors. The throttle notch is based on the load expected at each station, as well as the average speed. Emission factors and speeds used for each passenger line are presented in Table 26. The average speed was estimated as the distance traveled by the train on a route (or a portion thereof) divided by the elapsed travel time (based on the scheduled departure and arrival times) of the train between stations. An average throttle notch of three was used for the Capital Corridor because of the frequent stops, whereas for all remaining routes (which have fewer stops), a throttle notch of four was used.

Table 26 Diesel PM Emission Factor (EF) and Average Speeds by Amtrak Service/Route

Train Service	Mode/Throttle Notch	EF (g/h)	Average Speed (mph)
All passenger service	Idling	47.9	0.0
Capitol Corridor	3	210.9	35.0
California Zephyr	4	226.4	36.8
Coastal Starlight	4	226.4	40.0
San Joaquin	4	226.4	44.4

Notes: EF = emission factor; g/h = grams per hour; mph = miles per hour.

Diesel PM emission factors were derived from the Port of Oakland 2005 Seaport Air Emissions Inventory (Environ 2008), adjusted for fuel sulfur content of 15 parts per million by weight in compliance with CARB's Marine and Locomotive Diesel Fuel regulation (adopted November 2004 and compliant with regulations passed by EPA^{39,40}). All passenger rail services were assumed to have a fleet mix based on GP4x and Dash 9 locomotives with respective certification levels being pre-controlled and achieving Tier 1 emissions. Emissions were estimated for locomotives based on idling at stations or turnarounds and running exhaust between stations. Daily running exhaust emissions of diesel PM on each link were estimated as:

$$E_{RUN} = \frac{1}{S} (EF_{RUN} \cdot N)$$

³⁹ EPA's regulations for emissions from locomotives are available at <https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-emissions-locomotives>.

⁴⁰ EPA's domestic regulations for emissions from marine compression-ignition (diesel) engines are available at <https://www.epa.gov/regulations-emissions-vehicles-and-engines/domestic-regulations-emissions-marine-compression>.

where:

- E_{DPM} = emissions of diesel PM per rail link per day (g/mile-d)
 s = average speed (mph) (Table 25)
 EF_{DPM} = emission factor by rail link (g/h) (Table 25)
 N = number of locomotives that travel on the rail link per day (1/day)

Running exhaust emissions were assumed to occur along each link, excluding a 1,000-foot buffer around each station. Idling emissions estimated 500 feet before and after a station were estimated by multiplying the idling emission factor by the number of train stops on each link, which varied by rail service and link:

$$E_{IDLE} = EF_{IDLE} \sum_i N_i \cdot T_i$$

where:

- E_{DPM} = emissions of diesel PM per rail link per day (g/day)
 EF_{DPM} = emission factor for diesel PM by rail link (g/h) (Table 25)
 N = number of locomotives that travel on the rail link i per day (1/day)
 T = idling time for each stop or turnaround on rail link i per day (h)

The daily emissions along each rail link are the summation of the running and idling emissions:

$$E_{DPM} = (E_{IDLE} + E_{RUN}(L - S \cdot 0.189 \text{ miles}))$$

where:

- E_{DPM} = emissions of diesel PM per rail link per day (g/d)
 S = number of stations along the link (unitless)
 E_{IDLE} = idling emissions by rail link (g/day)
 E_{RUN} = running emissions by rail link (g/mile-day)
 L = length of rail link (miles)
 0.189 = length of link (500 feet before and after a station) emitting idling emissions (miles)

Even though activity levels varied per hour for each train route, the diurnal profile (fraction of total daily emissions that are produced per hour) for emissions from passenger rail was assumed to be evenly distributed over a 24-hour period.

Commuter Rail Lines. In the Bay Area, commuter rail services offer public transportation from residential areas to major metropolitan centers. The following major commuter rail services are included in the screening map:

- ▶ ACE Rail stops at major cities between San Jose and Stockton.
- ▶ SMART Rail is a rail service along U.S. Highway 101 in the North Bay that currently services 12 stations from northern Santa Rosa to the ferry terminal in Larkspur, Marin County. The long-term plan is to expand the line by constructing four additional stations to provide service through Cloverdale in Sonoma County.
- ▶ Caltrain provides commuter rail service from San Francisco through San Mateo and Santa Clara Counties for terminus in San Jose Diridon, Tamien, and Gilroy.
- ▶ eBART is a BART extension in east Contra Costa County that uses diesel multiple-unit trains to travel along the median of State Route 4 to connect Hillcrest Avenue and Railroad Avenue in Antioch to the Pittsburg/Bay Point BART station.

Commuter locomotives in the Bay Area operate under different levels of service depending on the ridership. Caltrain has the highest demand with more than 50,000 weekday riders and three levels of daily service available: Baby Bullet (highest average train speed and minimum stops), limited service (slower average train speed and more selective stops compared to the Baby Bullet), and local service (slowest average speed and frequent stops). Service on SMART, eBART lines, and ACE lines continue to offer a single level of service.

Similar to passenger rail analysis, running and idling emissions were estimated along each link by rail service. Emissions were estimated based on the daily number of locomotives that run along each link, the number of stations located on the link, the average speed of each locomotive, and the number of stations within each link. Online timetables from fall 2021 were used to assess the number of stations along each line and the scheduled arrival and departure times and frequency in which locomotives stopped at each station. Locomotives were assumed to idle for 90 seconds at each station except for terminus stations, where the idling time increases to 20 minutes to account for powering up or down the locomotive engine. To determine the daily number of trains, the number of weekday and weekend trains were weighted by 5/7 and 2/7, respectively.

The number of daily trips along each route is presented in Table 27 for all commuter service as of fall 2021. For years beyond 2021, the level of service and number of trains were assumed to remain constant; however, commuter train schedules change from year to year to meet ridership demands, so project sponsors are encouraged to ensure that the assumptions used to develop the screening tables remain valid for their project analysis.

Table 27 Summary of Activity Level for Each Commuter Service

Routes	Destinations or Level of Service	Number of Weekday Trains per Day	Number of Weekend Trains per Day
Caltrain	Local	0 (Gilroy–Capitol)	0 (Gilroy–Capitol)
		37 (Tamien)	40 (Tamien)
		46 (Diridon–San Francisco)	32 (Diridon–San Francisco)
	Limited	6 (Gilroy–Capitol)	0
		12 (Tamien)	0
		46 (Diridon–San Francisco)	0
	Baby Bullet	0 (Gilroy–Capitol)	0
		0 (Tamien)	0
		12 (Diridon–San Francisco)	0
ACE	San Jose–Livermore	8	0
eBART	Pittsburg–Antioch	139	132
SMART	Windsor–Larkspur	26	12

Emissions for commuter locomotives follow the same methodology and locomotive fleet mix used for passenger rail line, described in “Passenger Rail Lines.” The throttle notch for each commuter service was estimated based on the load expected at each station and the average speed. Table 28 presents a summary of the emission factors and speeds that were used for ACE, eBART, and SMART commuter rail. Caltrain operates at variable speeds and throttle notches based on the frequency of stops in each county. The Caltrain Baby Bullet operates on average at throttle notch five because stops are infrequent, whereas the local and limited locomotives operate at slower speeds, at throttle notch three. Table 29 summarizes

the emission factors and speeds for Caltrain by station. The average speed was estimated using the distance traveled by the train for a portion of or the entire route divided by the scheduled departure and arrival times of the train at the corresponding stations.

Table 28 Diesel PM Emission Factor (EF) and Average Speeds by Commuter Service

Train service	Mode	EF (g/h)	Average Speed (mph)
ACE	Idling	47.9	0
	Running	210.9	35
eBART	Idling	6	0
	Running	18	35
SMART	Idling	6	0
	Running	18	35

Notes: ACE = Altamont Corridor Express; eBART = BART extension in east Contra Costa County; emission factor; g/h = grams per hour; mph = miles per hour; SMART = Sonoma-Marín Area Rail Transit.

Table 29 Diesel PM Emission Factor (EF) and Average Speeds for Caltrain

Train service	Mode	EF (g/h)	Average Speed (mph)
All stations	Idling – Local/Limited	47.9	0
	Idling – Bullet	16.9	0
San Francisco stations	Running – Local	210.9	36.7
	Running – Limited	210.9	38.2
	Running – Bullet	377.2	53.6
San Mateo to Tamien station	Running – Local	210.9	31.8
	Running – Limited	226.4	45.2
	Running – Bullet	437.9	60.8
Tamien station to Gilroy	Running – Local/Limited	226.4	40.7

Notes: EF = emission factor; g/h = grams per hour; mph = miles per hour.

Emissions were estimated under two modes of operations: idling at stations and running between stations. Emissions are a function of the emission factor, the number of daily locomotives that travel on each rail link, average speed, the number of stations, and the time spent idling. The data are then entered into the equations presented in “Passenger Rail Lines” to estimate emissions along each commuter line by link. Running emissions were distributed equally along the rail line except within 1,000 feet of a station (500 feet before and after a station), where idling emissions were applied. Emissions were assumed to be evenly distributed throughout a 24-hour period and remain constant for 30 years. No reduction in emissions related to future electrification of the Caltrain line was accounted for in the analysis. Caltrain is expected to partially electrify its route in the future after financial support is secured (latest date is 2024). It is expected that 25 percent of service would continue to rely on diesel locomotives after partial electrification.

Modeling Methodology. Emissions from locomotives on consolidated rail lines⁴¹ in the Bay Area were modeled as volume sources using a downloaded shapefile from the TIGER Line spatial database. Volume

⁴¹ For simplicity, emissions from all rail services (passenger and freight) were consolidated into single rail lines, which were then modeled in AERMOD.

source locations were modeled with a width of 11 meters (width of locomotives plus 6 meters for wake effects) and source release height of 4.06 meters based on average heights for freight and passenger locomotives.⁴² Initial lateral dimension (*Syinit*) and initial vertical dimension (*Szinit*) were determined based on the equations used for volume sources: $Syinit = 5.12$ meters and $Szinit = 3.78$ meters. Emissions were assumed to be constant in time. Meteorological data were based on wind field data generated using the WRF model for 2018. (See "Emission Factors" for additional information.)

Risk Estimates. Cancer risks were estimated by combining the exposure concentration at each receptor location with the residential exposure factors and chemical-specific potency factors, as described in Section 10. The chronic noncancer hazards were calculated by dividing the long-term exposure levels and intake by the chronic reference exposure levels. The intake methodology recommended by OEHHA includes consideration of the health impacts on children related to their greater sensitivity from early exposure to carcinogenic compounds. Multipathway toxicity factors and reference exposure levels were used, when available from OEHHA, to account for additional exposures through noninhalation pathways. Annual PM_{2.5} concentrations were also estimated for comparison to the thresholds.

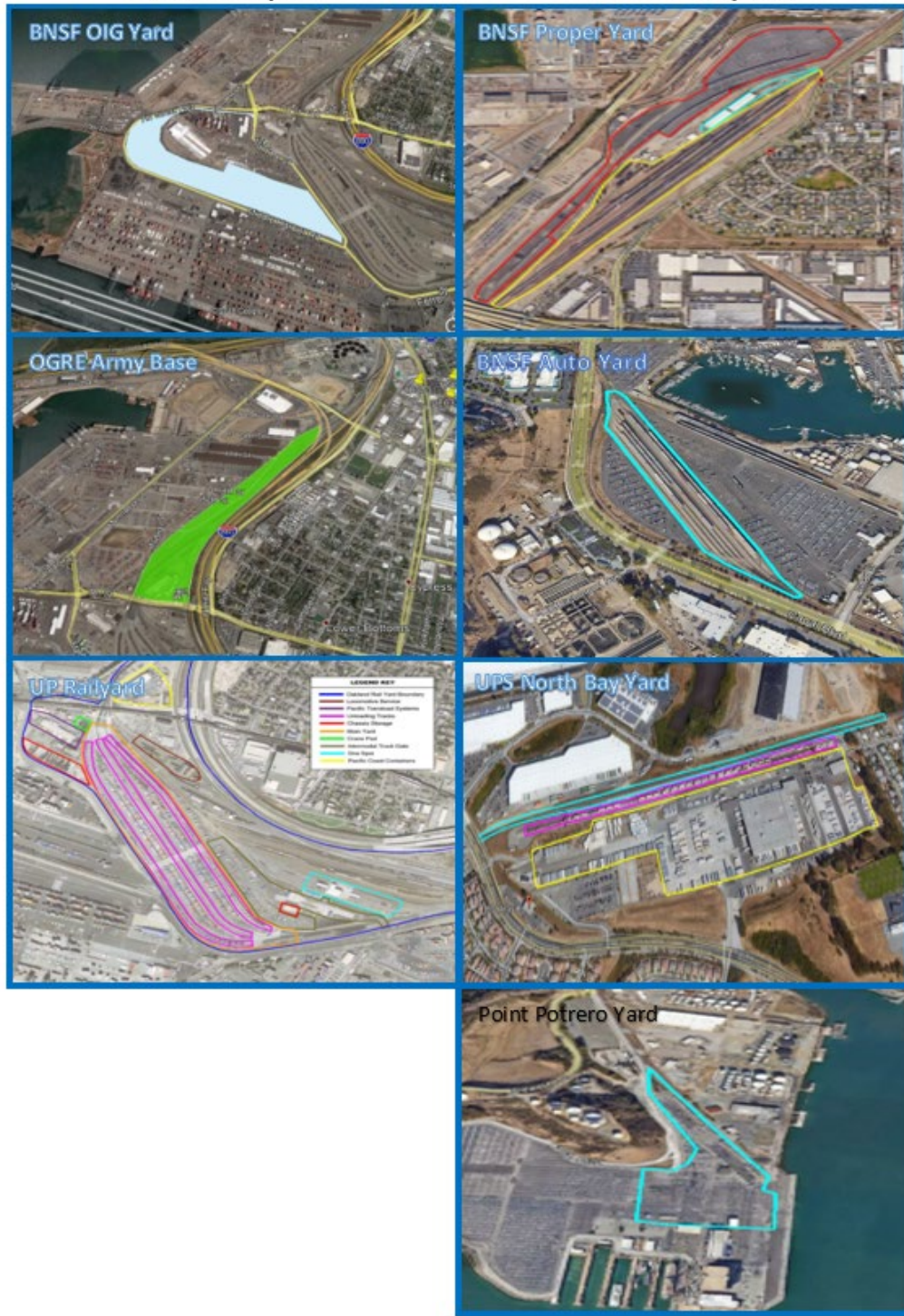
The modeled screening values are refined estimates reflective of fall 2021 passenger train schedules and 2020 fuel use for freight. In most cases, further modeling from the rail sources will not be necessary unless the train schedule changes, the emission factors/fuel use/fuel blends are updated, new routes/services are added, or changes are made to freight transport. The project sponsor may rerun the modeling analysis using meteorology or other factors to ensure consistency with the project analysis. As previously noted, the screening map quantified impacts related only to Class I line-haul and commuter/passenger rail service. Health impacts from Class III line-hauls, short rail lines, and railyards are not incorporated in the screening map; therefore, project sponsors are encouraged to quantify these emissions if these sources are located close to their project sites. Section 7 provides methods for refining the estimates from locomotive engines operating along passenger/commuter rail.

9.4 SELECT RAILYARDS

The rail source screening maps includes health impacts from select railyard located in communities where the Air District has conducted a detailed community-scale modeling assessment under California AB 617. The Air District implemented the AB 617 program in 2018 by partnering with local communities to address long-standing disparities in air quality and related health outcomes. The Community Action Plan (CAP) for West Oakland was adopted by the Air District's Board of Directors in 2019 while the CAP for Richmond/San Pablo is scheduled to be completed in 2023. Both communities have major railyards that serve as gateways for ferrying goods into the Bay Area and across the country. Figure 11 presents the locations of the railyards included in the rail sources screening map.

⁴² Average locomotive heights for Amtrak, Caltrains, and UP locomotives are 15.42 feet, 16.17 feet, and 15.67 feet, respectively, based on results of a Google search on February 8, 2022.

Figure 11 Railyards in West Oakland and Richmond



Three railyards operate in West Oakland within the boundaries of the Port of Oakland (Port) area. The Port has two railyards on its property: Oakland International Gateway (OIG) railyard, which is leased by BNSF, and Outer Harbor Intermodal Terminal, which is operated by Oakland Global Rail Enterprise (OGRE), on the former Oakland Army Base. BNSF is a Class I interstate railroad that serves as a transfer point for Port cargo containers. OGRE is a small regional Class III railroad serving portions of the former Oakland Army Base. A UP railyard is also located within the Port area, but it is privately owned and operated. It serves as an intermodal yard for freight movements through the Port, as well as a yard for handling domestic non-Port freight.

BNSF operates two railyards in Richmond located near each other: (1) Richmond Proper Yard, located at 303 S Garrard Boulevard, and (2) Richmond Main Yard (known as Richmond Auto Yard), located at 861 Wharf Street. The Proper Yard receives all incoming trains carrying manifest cargo and intermodal cars before being diverted by rail to other BNSF yards or customer sites. The Auto Yard is used primarily as an automotive storage facility for imported cars that arrive by switcher locomotive or that are individually driven from Potrero Point Marine Terminal. The loaded rail cars are then shunted to the Proper Yard for transport. United Parcel Service (UPS) operates the third railyard in Richmond, called the North Bay Yard, located at 1601 Atlas Road. The North Yard serves as an important transportation link for shipping packages from the Bay Area to Chicago and the rest of the country. A fourth yard, located at the Potrero Point Marine Terminal, moves imported cars from the terminal to the Proper Yard for shipping across the country.

Emissions. A bottom-up inventory was developed for each of these railyards and is described in detail in the technical appendix attached to the respective Community Action Plan. A summary of the sources included in the inventory and the estimated emissions are presented in Table 29. In general, inventories were composed of emissions from arriving-departing line-haul locomotives, switching and yard locomotives used to move railcars within the yard, and heavy-heavy duty diesel trucks. For trucks, emissions were estimated for running exhaust, brake and tire wear, and resuspended entrained road dust. Additional sources, such as cargo-handling equipment and transport refrigeration units, were included for yards where activity data were available. Because these emissions are reflective of the base year, the project sponsor is cautioned to adjust the inventory and the corresponding health impacts to account for year-to-year activity changes. As noted in Table 30, not all sources associated with each railyard are included in the map as permitted sources, and some mobile sources were combined into a single inventory for ease in modeling.

Table 30 Railyard Sources and Emissions Modeled under AB 617

City	Railyard/Year	Sources	Diesel PM Emissions (tons per year)	PM _{2.5} Emissions (tons per year)
Oakland	BNSF OIG Yard (2017)	Line haul	0.007	0.007
		Switcher	0.175	0.161
	OGRE Army Base (2017)	Switcher	0.077	0.071
	UP Railyard (2017)	Line haul	0.049	0.049
		Switcher	0.85	0.85
		Rail operations	0.213	0.195
Richmond	BNSF Auto Yard (2019)	Switcher	0.140	0.129
		Trucks	0.0039	0.0092
	BNSF Proper Yard (2019)	Line haul	0.064	0.059
		Switcher	0.243	0.224
		Trucks	0.0039	0.0092
		TRUs	0.0055	0.005
	UPS North Bay Yard (2019)	Line haul	0.096	0.088
		Switcher	0.281	0.258
		Trucks	0.028	0.065
	Point Potrero Yard (2019)	Line haul	0.061	0.056
		Cargo-handling equipment	0.000238	0.00226

Notes: BNSF = Burlington Northern Santa Fe Corporation; OGRE = Oakland Global Rail Enterprise; OIG = Oakland International Gateway; TRU = transportation refrigeration unit; UP = Union Pacific; UPS = United Parcel Service.

Modeling. To configure sources for AERMOD, the Air District identified individual areas representing the source activities. In most cases, separate areas were delineated in the model to represent line-haul, switcher, and truck activities. When the activities could not be bound to separate areas, a single source area was used, and emissions from all activities were combined in the modeling. Emissions from each of sources were distributed uniformly throughout the area source and were assumed to be constant in time. A release height of 4.78 meters was used for line-haul locomotives and switchers operating at the railyards. *Szinit* was set to 3.78 meters, based on the equations for on-road mobile sources. Heavy-heavy duty trucks were assumed to have a release height of 5.5 meters and *Szinit* of 2.56 meters, consistent with the previous HRA performed by CARB for West Oakland.⁴³ Additional modeling details can be found in the technical appendix of each of the respective Community Action Plans.

Risk Estimates. Cancer risks were estimated by combining the exposure concentration at each receptor location with the residential exposure factors and chemical-specific potency factors, as described in Section 10. The chronic noncancer hazards were calculated by dividing the long-term exposure levels and intake by the chronic reference exposure levels. The intake methodology recommended by OEHHA includes

⁴³ For the *West Oakland Action Plan*, different release heights were used to model heavy-heavy duty trucks in railyards versus roadways to be consistent with CARB’s Diesel Particulate Matter Health Risk Assessment for West Oakland. Project sponsors, however, are encouraged to use the same release heights for similar vehicle classes in their air quality analysis.

consideration of the health impacts on children related to their greater sensitivity from early exposure to carcinogenic compounds. Multipathway toxicity factors and reference exposure levels were used, when available from OEHHA, to account for additional exposures through noninhalation pathways. Annual PM_{2.5} concentrations were also estimated for comparison to the thresholds.

The modeled screening values for each railyard reflect 2017 (West Oakland) or 2019 (Richmond) conditions. The project sponsor can further refine the estimates depending on changes in activity level, updated emissions factors, inclusion of other sources, or demarcation of source areas. As previously noted, the screening map quantifies the impacts from the highest-emission sources at railyards, but minor sources should not be ignored if they are deemed significant based on their proximity to residential receptors.

9.5 DISTANCE DECAY FACTORS

The Air District developed decay factors embedded in the Health Risk Calculator that can be applied to the stationary source screening map to reflect reduced air concentrations (and associated health impacts) from atmospheric mixing after the pollutant is released. Category-specific decay factors were developed for GDFs and diesel combustion engines (generators). These decay factors are to be used only in conjunction with the screening health risk values for diesel engines and gas stations and may not be used for other source types. General decay factors were developed for application to all remaining sources. The following sections describe the methodology used to develop each category specific decay factor.

Gas Stations. The decay factors for gas stations were created by running AERMOD multiple times under multiple conservative modeling scenarios. Representative meteorological data from several cities were used in conjunction with various building configurations and release parameters. The worst-case Chi/Q (predicted air concentration based on emission of 1 gram per second) was selected based on the various modeling runs, to create decay factors at set distances away from the station (Table 31). The decay factors for GDFs are used to assess only cancer risks and hazards; gas stations do not emit fine particulate matter.

The Air District plans to discontinue use of the decay factors listed in Table 30 in future iterations of the GDF screening values. Starting in July 2022, GDF screening values will be derived following the recommended procedures for preparing gas station emission inventories and HRA outlined in CARB's Gasoline Service Station Industrywide Risk Assessment Technical Guidance. Project sponsor can use the available screening tool from CARB to estimate cancer risk, chronic hazard, and acute hazard from gas stations using permitted throughput limits.

Table 31 Gas Station Decay Factors

Distance (feet)	Decay Factor (unitless)	Distance (feet)	Decay Factor (unitless)
66	1.000	541	0.040
82	0.728	558	0.038
98	0.559	574	0.036
115	0.445	590	0.034
131	0.365	607	0.033
148	0.305	623	0.031
164	0.260	640	0.030
180	0.225	656	0.029
197	0.197	672	0.028
213	0.174	689	0.027
230	0.155	705	0.026
246	0.139	722	0.025
262	0.126	738	0.024
279	0.114	754	0.023
295	0.104	771	0.022
312	0.096	787	0.022
328	0.088	804	0.021
344	0.082	820	0.020
361	0.076	836	0.020
377	0.071	853	0.019
394	0.066	869	0.018
410	0.062	886	0.018
426	0.058	902	0.017
443	0.055	918	0.017
459	0.052	935	0.016
476	0.049	951	0.016
492	0.046	968	0.015
508	0.044	984	0.015
525	0.042		

Diesel Internal Combustion Engines. Internal combustion engines, such as those used in standby generators and fire pumps, are commonly found in most commercial buildings to provide emergency power during power outages. To develop decay factors for these internal combustion engines, 150 air dispersion scenarios were run using AERMOD. The modeling runs included assumptions for various stack release parameters, two dozen building configurations for downwash considerations, and six different meteorological data sets. The worst-case Chi/Q from the modeling analysis was selected to create the decay factors presented in Table 32. The decay factors represent the diminished exposure (and cancer risk and fine PM concentrations) based on distance from the exhaust stack related to atmospheric mixing. To

ensure that the decay factors are conservative, results from the HRA found in several permit applications were compared against the screening values and adjusted accordingly, using the decay factor for the maximum exposure residential receptor. As designed, the screening value results (adjusted with the decay factors) were above the cancer risks threshold in 85 percent of the cases. For the remaining 15 percent of the cases, the adjusted screening values were below the cancer risk threshold. Based on this assessment, the Air District concluded that the screening map, when adjusted with the appropriate decay factors, provides a conservative estimate of potential cancer risks.

Table 32 Diesel Engine Decay Factors

Distance (feet)	Decay Factor (unitless)	Distance (feet)	Decay Factor (unitless)
82	0.8500	492	0.1200
98.4	0.7300	525	0.1000
115	0.6400	590	0.0900
131	0.5800	656	0.0800
164	0.5000	722	0.0700
197	0.4100	787	0.0600
230	0.3100	853	0.0500
262	0.2800	918	0.0400
295	0.2500	984	0.0155
328	0.2200	1,050	0.0120
361	0.1800	1,115	0.0092
394	0.1600	1,181	0.0071
426	0.1500	1,246	0.0054
459	0.1400		

General Sources. For all other source types (i.e., those that are not diesel engines or gas stations), a general decay factor was developed to conservatively reduce exposure point concentrations and associated risks based on distance from the source. Various modeling analyses using both stack (point) and area source release parameters were run using EPA's SCREEN3 model. Evaluation of the results at various receptor distance found that analysis using the area source produced the most conservative and consistent decay factors compared to the stack, where peak downwind concentrations were dependent on the stack height and release strength. Area source dimensions were modeled from 5 to 50 feet in length with release heights from ground level to 20 feet. The rural land use option was selected over the urban option because it produced more gradual, conservative decay factors. Table 33 presents the decay factors that can be applied to all sources not classified as a gas station or internal combustion engine.

Table 33 Generic Decay Factors

Distance (feet)	Decay Factor (unitless)	Distance (feet)	Decay Factor (unitless)
33	0.883	525	0.330
49	0.855	541	0.319
66	0.827	558	0.309
82	0.801	574	0.299
98	0.775	591	0.290
115	0.750	607	0.280
131	0.726	623	0.271
148	0.702	640	0.262
164	0.679	656	0.254
180	0.658	673	0.246
197	0.636	689	0.238
213	0.616	705	0.230
230	0.596	722	0.223
246	0.577	738	0.216
262	0.558	755	0.209
279	0.540	771	0.202
295	0.523	787	0.195
312	0.506	804	0.189
328	0.489	820	0.183
344	0.474	837	0.177
361	0.458	853	0.171
377	0.444	869	0.166
394	0.429	886	0.160
410	0.415	902	0.155
427	0.402	919	0.150
443	0.389	935	0.145
459	0.376	951	0.141
476	0.364	968	0.136
492	0.353	984	0.132
509	0.341		



10 ESTIMATING HEALTH RISK AND HAZARD

HRA is decision-making tool used to assess whether potential emissions emanating from a facility or project may be harmful to local residents. HRA combines the annual average chemical concentrations predicted using an air dispersion model from Section 3.1 by the chemical intakes and chemical-specific toxicity values provided here. The outcome is a cancer risk and hazard index that can be used for comparisons to applicable thresholds. The cancer risk is the incremental probability that an individual will develop cancer over a lifetime as a direct result of exposures to potential carcinogens from anthropogenic sources. The estimated risk is a unitless probability, often expressed as chances in a million. A hazard index is used to assess noncancer health impacts for different exposure scenarios (chronic and acute). A hazard index is the ratio of the potential exposures to a chemical by the levels at which no adverse effects are expected.

At present, EPA has defined de minimis risks for carcinogens as being within the range of 10^{-4} to 10^{-6} excess lifetime cancer risk. The Air District uses 10^{-5} (10 in a million) excess lifetime cancer risk as a point of departure, meaning that a higher risk is deemed unacceptable on a project basis. Year 2021 amendments to Regulation 2-5 have limited the cancer risk to 6 in a million for designated communities that are overburdened by air pollution and other health disparities. At this time, the Air District is not proposing to change the cancer risk threshold to align with amendments made in Regulation 2-5. It should be noted that the risk of cancer described here is an increased probability of contracting cancer during a lifetime as a result of exposure to toxics from a project. It does not represent an actual incidence of cancer in an exposed population, nor does it equate to deaths from cancer, because not every cancer case results in death. A hazard index of 1.0 is the target threshold for assessing noncancer hazards by project, although a value greater than 1.0 does not necessarily correlate to a statistical probability of harm.

The following sections present the risk assessment methodology for estimating risks and hazards consistent with the Air District's regulation.

10.1 CANCER RISK

Cancer risks are calculated over an assumed 30-year exposure duration averaged over a 70-year lifetime combined with the annual average chemical concentrations, chemical intakes, and chemical-specific toxicity factors. The chemical concentrations are modeled using site-specific release parameters, from the point of release to the exposure point at the downwind receptor locations, as described in Section 2.1. The chemical intake or dose describing the frequency and duration of the exposure is estimated using receptor's breathing rates, exposure duration, and exposure frequency. In accordance with OEHHA's revised HRA guidelines (2015) and *Technical Support Document for Cancer Potency Factors* (OEHHA 2009), the Air District has adopted an intake methodology that addresses children's greater sensitivity and health impacts from early exposure to carcinogenic compounds. The updated calculation procedures include the use of age-specific weighting factors, breathing rates, fraction of time at home, and reduced exposure durations. Each factor is described below and presented in Table 34:

- ▶ Age sensitivity factors account for the heightened sensitivity of children to carcinogens during fetal development and early childhood. Consistent with OEHHA, the Air District uses a factor of 10 for exposures that occur from the third trimester of pregnancy to 2 years of age, 3 for exposures that occur from 2 years through 15 years of age, and 1 for all other age groups. The Air District has been incorporating age sensitivity factors into its permitting processes since 2010.
- ▶ Daily breathing rates are the age-specific daily air intake. OEHHA developed a range of rates for four age groups: last trimester to newborn, newborn to 2 years of age, 2 years to 16 years of age, and older than 16 years of age. Consistent with recommendations by CAPCOA and CARB, the Air District uses the 95th percentile breathing rates for the most sensitive age groups (less than 2 years of age) and 80th percentile for all other age groups.
- ▶ Fraction of time at home (FAH) refers to the estimated amount of time residents stay at home. In past HRAs, the Air District assumed that residents are home 24 hours a day, 7 days a week. OEHHA in its 2015 Risk Assessment Guidance recommends less than 100 percent of the time based on population and activity statistics. Consistent with OEHHA, the Air District recommends an FAH of 0.73 for 16-year-olds and above and 1 for under 16 to address exposures at local schools close to emitting facilities.
- ▶ Exposure duration is the length of time that an individual is continuously exposed to air toxics. Previously, the Air District used a 70-year lifetime exposure duration for residents over a 70-year lifespan. Based on updated demographic data, the Air District follows OEHHA's recommendation of a 30-year exposure duration, consistent with EPA, for residents.

Table 34 presents a summary of the exposure factors for residents, off-site workers, and students.

Table 34 Exposure Factors

RESIDENTIAL RECEPTORS

Factor	Units	Age Group: Last Trimester to Newborn	Age Group: 0 to 2 Years Old	Age Group: 2 to 16 Years Old	Age Group: > 16 Years Old
Daily breathing rate	liters/kg-day	361	1,090	572	261
Age sensitivity	unitless	10	10	3	1
Fraction of time at home	unitless	1	1	1	0.73
Exposure duration	years	0.25	2	14	14
Exposure frequency	days/year	350			

OFF-SITE WORKERS

Factor	Units	Values
Daily breathing rate	liters/kg-8 hrs	230 (95% percentile 8-hour breathing rate for 16- to 70-year-olds)
Age sensitivity	unitless	1
Exposure duration	years	25
Exposure frequency	days/year	250

STUDENTS/DAYCARES

Factor	Units	Age Group: 0 to 2 Years Old	Age Group: 2 to < 16 Years Old
Daily breathing rate	liters/kg-8 hrs	1,090	520
Age sensitivity	unitless	10	3
Exposure frequency	days/year	350	180–350
Exposure duration	years	Cumulative, maximum years children will be attending school and/or daycare	Cumulative, maximum years children will be attending school and/or daycare

¹ Based on the maximum number of days children will be present at the school or daycare, including classroom instruction, summer schools/camps, afterschool programs, and athletic programs.

The factors are combined in the following equation to calculate the dose, an expression describing the chemical intake of an individual over their lifetime:

$$Dose_i = (CF \cdot EF \cdot \sum_j^{30 \text{ years}} \{C_{i,j} \cdot DBR_j \cdot FAH_j \cdot ED_j \cdot ASF_j\}) \div AT$$

where:

$Dose_i$ = Accumulated dose for an individual breathing carcinogen i for 30 continuous years (mg/kg-day)

CF = Conversion factor (10^{-6} mg-m³/μg-L)

EF = Exposure frequency (350 days per year⁴⁴)

DBR_j = Daily breathing rate during year j (L/kg-day)

⁴⁴ The screening map uses an exposure frequency of 350 days per year, consistent with OEHHA and EPA guidance. The total of 350 days per year represents the number of days individuals will reside in their home less approximately 2 weeks of vacation.

- FAH_j = Fraction of time at home during year j (unitless)
 ED_j = Exposure duration of year j (years)
 $C_{i,j}$ = Annual average concentration for pollutant i during year j ($\mu\text{g}/\text{m}^3$) equal to the emission rate (g/sec) multiplied by the source type Chi/Q (dilution factor $\mu\text{g}/\text{m}^3$ per g/sec)
 ASF_j = Age sensitivity factor for year j ; the value of the factor is higher in early years of exposure (unitless)
 AT = Averaging time (25,550 days, equivalent to 70-year lifespan)

Cancer risk is estimated by multiplying the dose in units of milligrams of pollutant per kilogram of body weight per day (mg/kg-day) by the cancer potency factor [CPF: (mg/kg-day)⁻¹]:

$$\text{Cancer Risk} = \text{Dose} \cdot \text{CPF}$$

The CPF is the 95 percent upper confidence limit on the increased cancer risk from a lifetime exposure to a chemical. The potency factors that are used in an environmental clearance document must be those promulgated by OEHHA. These toxicity values can be found at <https://oehha.ca.gov/chemicals>. Some CPFs are available in Table 2-5-1 of Air District Regulation 2-5. However, amendments to the table require approval by the Air District's Board of Directors and thus may not include the most current CPFs available from OEHHA. If a substance is emitted and toxicity values have not been identified by OEHHA, other sources of data and provisional values may be used.

The dose is paired to the route-specific CPFs based on the exposure pathway describing how the individual comes into contact with the chemical. Typically, the air quality analysis addresses impacts related to exposures of volatile organic gases emitted into the air. Because these chemicals do not appreciably deposit to soil, surface waters, or plants, exposures occur mainly through inhalation. However, a small subset of compounds—semi-volatile organic and metal toxicants—are emitted partially or totally as particles subject to deposition. These chemicals can be ingested as they are deposited on soil, absorbed through the skin (dermal), or transferred to an infant through the mother's milk. For all multipathway chemicals, the exposure pathways that must be evaluated for residential, student, and worker scenarios include inhalation, soil ingestion, and dermal contact. Breast milk consumption must be evaluated for residents if polycyclic aromatic hydrocarbons (PAHs), lead, dioxin, furans, or polychlorinated biphenyls (PCBs) are emitted from the project site. Less typical exposure routes, such as ingestion of homegrown produce and fish, may be explored on a site-specific basis.

Table 35 summarizes the possible exposure routes to be considered for any project following OEHHA guidance. Consult with the lead agency to determine which pathways must be considered for the project. To account for the additional risks from exposure to most common noninhalation pathways, multipathway CPFs⁴⁵ from OEHHA are used in combination with the noninhalation dose equation. Project sponsors can also use the following modules to assess multipathway exposures: the Air Dispersion Modeling and Risk Assessment Tool (ADMRT) and the Health Risk Assessment Standalone Tool (RAST) in CARB's HARP2⁴⁶ program.

⁴⁵ Multipathway CPFs are listed in Table 2-5-1 of Regulation 2-5 under CP weighing factors. CP weighing factors can be used in combination with the inhalation dose to estimate risks from multiple pathways. Project sponsors should check the OEHHA web site to ensure that the latest CPFs are being used in the analysis.

⁴⁶ Available at <https://ww2.arb.ca.gov/our-work/programs/hot-spots-analysis-reporting-program>.

Table 35 Exposure Pathways

Receptor	Mandatory Exposure Routes	Site Condition–Dependent Exposure Pathway
Resident	<ul style="list-style-type: none"> ▶ Inhalation ▶ Soil ingestion ▶ Dermal exposure to contaminated soil ▶ Breast-milk consumption¹ 	<ul style="list-style-type: none"> ▶ Homegrown produce ingestion ▶ Angler-caught fish ingestion ▶ Drinking water ingestion ▶ Home-raised animal product ingestion (e.g., cow’s milk, meat, and eggs)
Worker	<ul style="list-style-type: none"> ▶ Inhalation ▶ Soil ingestion ▶ Dermal exposure to contaminated soil 	
Student	<ul style="list-style-type: none"> ▶ Inhalation ▶ Soil ingestion ▶ Dermal exposure to contaminated soil 	

¹ Consideration of the breast-milk consumption pathway is mandatory in the air quality analysis if PAHs, creosotes, lead, dioxin, furans, or PCBs are emitted from the project site.

CARB’s Hot Spots Analysis and Reporting Program Version 2 (HARP2) is the recommended model for calculating and presenting HRA results because it follows the risk assessment guidance methodology and is consistent with the Air District’s Regulation 2-5. HARP2 can also assess potential health impacts posed by chemicals that must be analyzed using a multipathway (e.g., inhalation and noninhalation) approach. Project sponsors can use the version of AERMOD included in the Air Dispersion Modeling and Risk Tool (ADMRT) of HARP2, or if they are using a vendor-purchased version of AERMOD, the estimated concentrations can be imported from plotfiles as “Import/Calc GLCs” into the ADMRT.

As discussed previously, HRAs performed by the Air District use toxicity values approved by the Air District’s Board of Directors in Regulation 2-5. To access the table in ADMRT, select the “use Bay Area AQMD approved health table” option in “Settings” under the “File” heading. To address the health impact from multipathway pollutants, a deposition rate must be entered by the user. The Air District recommends using the conservative rate of 0.05 meter per second for risk assessments if at least one source on the project is not abated with a verifiable control. A deposition rate of 0.02 meter per second may be used if all multipathway pollutant sources have verifiable particulate matter controls and the emitted particulates are in the PM_{2.5} size fraction.

The Air District recognizes that the assumptions used in the risk methodology may be overly conservative, especially when receptors such as workers or students spend less time at a site or if the sources do not operate continuously. Project sponsors can deviate from the prescribed inputs if they provide justification regarding the actual receptor behaviors and activity patterns. Conversely, receptors such as workers may experience higher than estimated coincident exposures when the source emits only when the receptor is present. One of the methods to address the higher exposure is to apply a worker adjustment factor (WAF) in HARP2 to align the worker hours with the times when the source is emitting. (WAF can be entered under the Inhalation tab by selecting “Use adjustment factors.”) This method can be used even if the

source was modeled in AERMOD with noncontinuous emissions.⁴⁷ It should be noted that this method can be applied for adjusting the cancer risk for worker or students but not for residents. The WAF is estimated using the following equation by first adjusting for the hours that a source is emitted and then making a corresponding adjustment accounting for the hours when a receptor will be present at the site:

$$WAF_{Cancer} = \frac{H_{Resident}}{H_{Source}} \cdot \frac{D_{Resident}}{D_{Source}} \cdot DF$$

where:

WAF_{Cancer}	=	Worker adjustment factor for cancer risk
$H_{Resident}$	=	Hours per day of residential exposure (24 hours)
H_{Source}	=	Number of hours per day that the source operates (hours)
$D_{Resident}$	=	Number of days per week that the resident is exposed (7 days)
DF	=	Discount factor (unitless)

The discount factor accounts for situations when the receptor is present at the site, but the source is not emitting:

$$DF = \frac{H_{Coin}}{H_{Worker}} \cdot \frac{D_{Coin}}{D_{Worker}}$$

where:

DF	=	Discount factor (unitless)
H_{Coin}	=	Hour per day that the receptor's schedule coincides with when the source is emitting (hours)
H_{Worker}	=	Hours that the receptor is at the site per day (hours)
D_{Coin}	=	Number of days per week that receptor's schedule coincides with when the source is emitting (days)
D_{Worker}	=	Number of days that the receptor is at the site per week (days)

A discount factor of 1 should be used in cases where the source is emitting at all times when the receptor is present at the site. For example, the WAF for the case when the source and the worker follow a standard work schedule (i.e., DF equal to 1) is $4.2 = 24 \text{ hrs}/8 \text{ hrs} \cdot 7 \text{ days}/5 \text{ days} \cdot 1$. This example emphasizes the importance of adjusting the estimated cancer risks using WAF for a noncontinuous source because the nonadjusted cancer risk would be underestimated by 420 percent. The increased cancer risk is attributed to the worker being exposed to 100 percent of the annual emissions from the source because the source operates only when workers are at the site rather than the typical 23 percent if the same source emissions were evenly distributed throughout the year. A good example is a construction site where nonfugitive emissions occur from workers operating off-road equipment and related construction activities at the job site.

Care should be taken if the WAF is used in the assessment, and justification should be provided to support the facility operating hours and the worker or student schedule. The Air District cautions that if the WAF is used to characterize the risk to students, care should be taken to ensure that the number of days and hours that students are present at the site is accurate and conservative. For example, many schools offer on-site early morning drop-offs and afterschool programs to care for students with working parents.

⁴⁷ Adjustments to the source emissions for noncontinuous sources should follow the methodology outlined in Section 3.6 to ensure that a full year of emissions are modeled.

Athletic programs may also be offered at the schools with practices and games scheduled after school or during the weekends. By restricting the hours of operation used in the modeling for noncontinuous sources, the project will be required to accept the modeled emissions schedule as a permit condition after the environmental document is certified.

For projects that operate a mixture of continuous and noncontinuous sources, the WAF cannot be applied in HARP2 because the adjustment will be applied to all sources within the modeling run, resulting in a significant overestimation of cancer risk from continuously operating sources. Another way of handling this situation is to adjust the unit emissions using the WAF on noncontinuous sources to avoid additional modeling runs. However, a separate dispersion run will be required to estimate the worker chronic hazard where the adjustment is removed because the WAF does not apply to noncancer health impacts.

The project sponsor may take other site-specific considerations into account when estimating the dose given sufficient justification. For example, the exposure duration of 30 years may be reduced to accommodate a shorter period, such as temporary housing at a shelter, hostel, or transitional home. Project sponsors may also consider reduced exposures by accounting for the time receptors spend on-site. It is recommended that the project sponsor analyze the project's risk and hazards using the standard assumptions before making any adjustments to the exposure duration. Only in cases where the project exceeds the threshold should additional modifications be considered. The project sponsor 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.

It is not permissible to omit sources or pollutants from a project in an environmental clearance document unless the source has negligible health impacts. An HRA must include all sources of emissions that will emanate from a project, including all sources of potential emissions whether or not they are subject to the Air District permitting requirements. The permitting process excludes most mobile source emissions and emissions from exempt sources and focus primarily on sources subject to the Air District regulation in the permit application. Additionally, all sources that emit for which OEHHA has identified a toxicity value must be included in the HRA. Risks are not estimated for chemicals lacking OEHHA-approved toxicity values. A challenge to the completeness of the risk assessment can be made if sources or pollutants are omitted. The total chances per million cancer risk for the project is the sum of the pollutant-specific risk values from all sources associated with the project.

10.2 CHRONIC NONCANCER HAZARD

Hazard is the potential for developing noncarcinogenic health effects as a result of exposures to chemicals over the exposure period. Unlike cancer risk, hazard is not a probability but is a measure estimated as a ratio of the magnitude of the receptor's exposure relative to a chemical-specific reference level that poses no appreciable health effect to all receptors (including sensitive populations). Two types of hazards are used in risk assessment, depending on the timeframe of the exposures: acute for short-term, 1-hour exposures and chronic for long-term exposures. This section discusses the chronic long-term hazard, and Section 10.3 discusses the acute hazard.

Hazard is based on the concept that there is a level of exposure below which no adverse effects will be observed, referred to as the reference exposure level (REL). The REL is the estimated daily exposure concentration that a person can be exposed to without any adverse effects. RELs are designed to be protective of the most sensitive individuals within the population, so it is not necessary to incorporate factors such as breathing rates, exposure frequency, or other age sensitivity values, used in the cancer dose, to determine the hazard. Only RELs available from OEHHA should be used in any risk analysis (<https://oehha.ca.gov/air/general-info/oehha-acute-8-hour-and-chronic-reference-exposure-level-rel-summary>), and although RELs are listed in Table 2-5-1 of the Air District's Regulation 2-5, project sponsors should ensure that they are using the most current values.

The noncancer chronic hazard is calculated by dividing the annual average concentration, estimated from the air dispersion model, by the REL for that chemical:

$$HQ_i = \frac{C_i}{REL_i}$$

where:

HQ_i = Hazard quotient for exposure to chemical i (unitless)

C_i = Annual average concentration of chemical i ($\mu\text{g}/\text{m}^3$)

REL_i = Chronic noncancer reference exposure level for chemical i ($\mu\text{g}/\text{m}^3$)

A hazard quotient is used to describe the exposure to a single chemical through a single exposure pathway (e.g., inhalation). In accordance with OEHHA's risk assessment guidelines, chronic noncancer hazards should be assessed for both inhalation and noninhalation (e.g., ingestion and dermal contact) chronic exposures. Similar to CPF, multipathway RELs⁴⁸ are available to assess health impacts on receptors from all applicable exposure pathways. Project sponsors are encouraged to use the available modules in CARB's HARP2 program to assess the noncancer hazard index from multipathway exposures. Pollutants that have OEHHA-approved toxicity values must be included in the chronic hazard estimates. A challenge to the completeness of the risk assessments can be made if these substances are omitted.

The total noncarcinogenic hazard attributable to exposure to all chemicals through a single exposure pathway is known as the hazard index (HI). Although it is common practice to sum the contribution across all HIs, the formal methodology is to sum the individual hazard quotients (HQs) for chemicals affecting the same toxic endpoint, target organ, or organ systems. For the purposes of the risk assessment, it is reasonable to estimate the receptor's total hazard as the sum of the HIs across all pathways regardless of the portal of entry associated with each exposure pathway or the unique toxic endpoint and toxicity mechanism. The resulting HI should then be compared against the threshold of 1. If the total HI exceeds the hazard threshold, then further evaluation can be taken to determine whether:

- ▶ one or more chemicals has an HQ exceeding the threshold or

⁴⁸ Multipathway RELs are listed in Table 2-5-1 of Regulation 2-5 under CREL weighing factors. CREL weighing factors can be used in combination with estimated exposure concentration to estimate the hazard from multiple pathways. Project sponsors should check the OEHHA website to ensure that the latest CPFs are being used in the analysis.

- ▶ the summation of several chemical-specific HQ by health effect or target organ, each less than the threshold, results in the exceedance.

In the first case, the presence of at least one chemical-specific hazard that is greater than the threshold indicates a potential for noncarcinogenic health effects. For the second case, a detailed analysis is required whereby the total HI is summed according to major health effects or a target organ/system being affected. Generally, health effects from exposure to multiple chemicals through multiple pathways that target different organs are not additive and thus, summing HI across all chemicals, pathways, and organs may result in an overestimation of the noncarcinogenic hazard. Each segregated HI by health effects and/or target organ should be compared against the threshold. If the segregated HI exceeds the threshold, there is a potential for noncarcinogenic health effects. However, if all the segregated HI are less than the target hazard level, then the project is not likely to cause noncarcinogenic health effects from exposure to project-related chemicals.

10.3 ACUTE NONCANCER HAZARD

The acute hazard is described as the potential noncarcinogenic effects resulting from short-term exposures—in this case, 1 hour of exposure. The potential for acute noncancer hazards is evaluated by comparing the maximum short-term exposure level to an acute REL following the same methodology for chronic hazard. The acute REL is a chemical concentration level at or below which no adverse health effects are anticipated by sensitive individuals exposed for 1 hour. Acute RELs are available from OEHHA at <https://oehha.ca.gov/air/general-info/oehha-acute-8-hour-and-chronic-reference-exposure-level-rel-summary> and in Table 2-5-1 of the Air District's Regulation 2-5, although project sponsors should verify that they are using the most current values.

The acute noncancer hazard is calculated by dividing the maximum 1-hour concentration, estimated from the air dispersion model, by the acute REL for that chemical:

$$HQ_{acute} = \frac{C_{one\ hr\ max}}{REL_{acute}}$$

where:

HQ_{acute}	=	Acute hazard quotient for exposure to chemical i (unitless)
$C_{one\ hr\ max}$	=	1-hour maximum concentration of chemical i ($\mu\text{g}/\text{m}^3$)
REL_{acute}	=	Acute noncancer reference exposure level for chemical i ($\mu\text{g}/\text{m}^3$)

In accordance with OEHHA's risk assessment guidelines, acute noncancer hazards should be assessed only for the inhalation exposure pathway.

As with the chronic noncancer calculation, for multiple substances that affect the same organ system, the individual substance HQs are summed to determine the HI. Project sponsors can take the reasonable step of estimating the receptor's total acute hazard as the sum of the HIs across all pathways regardless of the toxic endpoint and toxicity mechanism. Further evaluation of comparing the individual chemical HI or segregating HI based on target organ/system can be performed if the total hazard exceeds the acute threshold. If all the segregated acute HI are less than the target hazard level, then the project is not likely to cause noncarcinogenic health effects from exposure to project-related chemicals.

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11 CUMULATIVE ANALYSIS

Cumulative analysis is the aggregation of health impacts from multichemical and multipathway exposures from all significant sources (stationary and mobile sources) to receptors living within a geographic area of the project. The primary aim of the cumulative analysis is to inform the project sponsor and the lead agency about the public health implications associated with the project. The results of the cumulative analysis can be used in an explicit analysis to identify targeted risk mitigation strategies on sources, chemicals, or pathways that most contribute to the receptors' risk.

The Air District recommends the following step-wise process for conducting a cumulative analysis, and project sponsors are encouraged to review the referenced subsection for additional information:

- ▶ Determine the project radius for inclusion of sources in the cumulative analysis (see Section 2.2). The project radius is based on the distance from either the new source or the receptor depending on the type of project.
- ▶ Identify all present and foreseeable future sources within the project radius (see Section 2.3). The sources may include highways and high-volume roadways, truck distribution centers, ports, railyards, rail lines, refineries, airports, chrome plating facilities, crematoriums, dry cleaners using perchloroethylene, airports, standby and prime generators, and GDFs.
- ▶ Use the source-specific CEQA screening tools, described in Section 9, to estimate the cancer risk, chronic hazards, and PM_{2.5} concentrations from surrounding sources.

- ▶ Estimate the cancer risk, chronic hazard, and PM_{2.5} concentrations from significant sources where screening tools are not available. Project sponsors can use the guidance found in Sections 5–8 for additional assistance.
- ▶ Sum the individual cancer risk, chronic hazard, and PM_{2.5} concentrations from all sources and the project's contribution to nearby receptors surrounding the project site.
- ▶ Compare the project's cumulative cancer risks, chronic hazards, and PM_{2.5} concentrations against the applicable cumulative thresholds (see Section 1.2) to conclude whether a public health concern exists.

Where the project involves construction prior to operation, the Air District recommends that the exposure duration for the health risk analysis start during construction and continues through to the operations. For example, if construction is anticipated to occur for 3 years, then the residential exposure starts with an unborn child at the third trimester (when construction begins) and continues until the child is 2.75 years of age. The child is then exposed to the project operations through adulthood for another 27.25 years. The maximum impacted receptor may be at different locations during construction versus operations as new sources are installed. In that case, the project sponsor has the option of summing the contribution to the maximum exposed individual from construction and operations regardless of the location or determining the maximum exposed individual by summing the contribution from construction and operations across multiple receptor locations surrounding the project. The project-level results from combined construction and operations can then be compared against the project-level thresholds of significance. The Air District recommends that a second air quality analysis be included for 30 years of operations from the project if emissions from operations exceed the construction impacts. Similar to the project-level analysis, operational and construction impacts from the project are aggregated with the risks, hazards, and PM_{2.5} concentrations associated with the surrounding sources to assess cumulative impacts. If the cumulative impacts from the combined project and surrounding sources are above the cumulative thresholds, the project is cumulatively considerable and mitigations may be warranted.



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