



# Hayward Community Risk Reduction Plan

## Technical Support Documentation

PREPARED FOR THE CITY OF HAYWARD  
by Ascent Environmental, Inc.

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# 1 INTRODUCTION

This document describes technical work performed to support Hayward’s Community Risk Reduction Plan. The objective of the technical work was to identify and map regions of the city that are exposed to higher concentrations of toxic air contaminants (TACs) and fine particulate matter (fine particulate matter with an aerodynamic diameter of 2.5 microns or less [PM<sub>2.5</sub>]) and where future residents, in land use development projects, may also be exposed. Air dispersion modeling was used to identify areas with elevated air pollutant concentrations and higher population exposures. Dispersion modeling applies a time-averaged, simplified representation of turbulent, atmospheric transport to approximate how pollutants are carried, mixed, dispersed, and diluted by the local winds. Critical inputs to the dispersion models include estimations of emissions from major air pollution sources and source characteristics. This technical support documentation reports how emissions of major source categories were inventoried, methods used to estimate associated levels of cancer risk, and how dispersion modeling was employed.

Air pollutants considered in the analysis were emissions of primary PM<sub>2.5</sub> and TACs with documented cancer toxicities that are emitted by local sources, including traffic on freeways and major roadways, stationary sources, and railroads. The qualifier “primary” signifies that only compounds emitted directly were considered. Furthermore these compounds were assumed to be nonreactive. Compounds formed in the atmosphere from emissions of other pollutants, so-called secondary pollutants, were not included in this analysis. Secondary air pollutants were not considered in part because their formation involves complex chemical reactions that are not accounted for in the dispersion models applied in this analysis and in part because near-source exposures tend to be driven by emissions of primary pollutants; whereas, secondary pollutants form downwind of sources and tend to be more regionally distributed.

The cancer risk estimates developed by this study represent the levels of cancer risk throughout Hayward from a 70-year exposure to carcinogenic TACs emitted by local sources for a person who is born in the base year 2014, which is the earliest year when development may occur after the General Plan Update. This study also estimates the PM<sub>2.5</sub> concentrations in Hayward for the base year 2014 as well as the planning horizon year 2040.

This study was conducted according to the guidance in the Bay Area Air Quality Management District’s (BAAQMD) *Recommended Methods for Screening and Modeling Local Risks and Hazards (Recommended Methods)* (BAAQMD 2012) and ongoing guidance from BAAQMD staff.

This technical support document includes descriptions of the inventory of TAC and PM<sub>2.5</sub> emissions in Hayward (Section 2), the input parameters and source characterization used in the air dispersion modeling (Section 3), the approach for generating concentrations and cancer risk estimates from the modeling output (Section 4), the results and findings (Section 5), and a discussion about the uncertainties in the methods applied (Section 6).

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## 2 INVENTORY OF TOXIC AIR CONTAMINANT AND FINE PARTICULATE EMISSIONS

Local sources of TAC and PM<sub>2.5</sub> addressed by this study include vehicle activity on freeways and major roadways, stationary sources, and railroads.

### 2.1 ROADWAYS

Roadways modeled included all freeway segments that pass through or near the City's jurisdiction and various local roadways. Local roadways were chosen based on percent of diesel-powered truck volume relative to other road segments in Hayward as well as the road segment proximity to industrial land uses. A total of 18 local roads were chosen. Pollutants estimated for mobile-sources on local roadways included diesel particulate matter (diesel PM), both exhaust emissions and running loss (evaporative) emissions of total organic gases (TOG), PM<sub>2.5</sub> exhaust, PM<sub>2.5</sub> dust from brake wear and tire wear, and reentrained PM<sub>2.5</sub> road dust for all vehicle classes of cars and trucks (mobile sources).

Average annual daily trip (AADT) data and travel speeds were provided by Kittelson Associates for years 2010 and 2035. Kittelson formulated the AADT as part of its traffic analysis for the General Plan EIR. AADT values for base year 2014 and all subsequent years through 2035 were interpolated based on the average annual growth rate from 2010 to 2014. It was assumed that all traffic volumes would remain constant after 2035, including through the plan horizon year, 2040.

Emission factors for a vehicle fleet representative of Alameda County were developed using the state's Mobile Source Emissions Inventory model (EMFAC2011), which was developed by the California Air Resources Board (ARB) (ARB 2011). Composite emission factors were developed for each calendar year, expressed in grams per vehicle mile travelled. Then emission rates for each roadway segment were calculated based on the travel distance and AADT, expressed in grams per second. Emission rates were also adjusted using BAAQMD-recommended age sensitivity factors, which take into account the increased susceptibility of younger aged humans, to develop sensitivity-weighted emission rates. It was assumed that all emission factors would remain constant after 2035, including through the plan horizon year, 2040, because EMFAC2011 does not provide emission factors for subsequent calendar years.

Hourly mobile-source emissions was set to an hourly weekday profile for Alameda County, as provided by EMFAC2011. The diurnal profile sets hourly fractions (relative to peak traffic) representing hourly changes in traffic for each hour over a 24-hour day. Diurnal profiles (Figure 1) were specified for all vehicles and for heavy-duty trucks. While AADT for total vehicles and for heavy-duty trucks were specific to each roadway segment, the same diurnal profile was used for all roadway segments. The inclusion of diurnal profiles enables the model to account for different dispersion dynamics during different hours of the day, including wind direction, vertical mixing, and atmospheric stability.

### 2.2 PERMITTED STATIONARY SOURCES

Stationary sources of air pollution—including larger facilities such as refineries, power plants, and chemical manufacturers as well as smaller facilities such as diesel generators, dry cleaners, gasoline dispensing facilities (i.e., gasoline pumps)—are regulated and subject to permit conditions established by BAAQMD. BAAQMD maintains a database of the permitted sources and their associated emissions. Emissions are determined by measurement (source testing) or engineering calculation based on process throughput. BAAQMD staff provided the modeling inputs needed for all permitted stationary sources located in the City of Hayward, including all release parameters—such as stack locations, stack heights, and stack diameters, and exhaust gas

flow rates and temperatures—which needed to determine plume rise and pollutant transport in dispersion models. The data set provided by BAAQMD also included a cancer risk factor for each of the stationary sources that was used to estimate cancer risk levels at all area receptors based on the air dispersion modeling results. The cancer risk factors provided by BAAQMD accounted for all the carcinogenic TAC emitted by each stationary source as well as their unique emissions rate. BAAQMD’s data set also included emission factors for determining the PM<sub>2.5</sub> concentrations generated by each stationary source.

A total of 314 different stationary sources were modeled, including the recently permitted Russell City Power Plant.

No changes in emission rates were assumed from 2014 to 2040 except for dry cleaners using perchloroethylene, a TAC that will no longer be allowed after January 1, 2023 due to a regulatory requirement.

## 2.3 RAILROADS

There are three primary shared freight and passenger railroad corridors located within the city of Hayward, including the Santa Clara branch line, and Nile branch line, and the Canyon Subdivision branch line—all owned by Union Pacific.

Emission factors for diesel PM and PM<sub>2.5</sub> exhaust associated with all rail activity were provided by BAAQD staff.

# 3 AIR DISPERSION MODELING

AERMOD View 8.2.0, developed by Lakes Environmental, in conjunction with Environmental Systems Research Institute (ESRI) ArcMap 10.2 was used to conduct the air dispersion modeling. Post-processing of all outputs was performed in Microsoft Excel 2010.

## 3.1 MODELING APPROACH

The modeling included emissions from roadways, permitted stationary sources, and rail roads within the city. Multiple model runs were developed in AERMOD View to reduce the run time of individual input files. All modeling was conducted with a unit emission rate of 1.0 gram per second (g/s) and individual sources—road segments, point sources, rail road segments—were assigned a unique “Source Group” in AERMOD View. This approach enabled the output files to be assigned appropriate emission rates and cancer risk values to estimate PM<sub>2.5</sub> concentrations and cancer risk levels from each individual source.

## AERMOD MODEL CONFIGURATION

The following input parameters were used in all model runs:

- ▲ Projected Coordinate System: Universal Transverse Mercator (UTM) zone 10
- ▲ Geographic Datum: World Geodetic System of 1984 (WGS84)
- ▲ Rural land use, in order to produce more conservative results, per guidance from BAAQMD staff
- ▲ Annual averaging of concentrations for the entire year of 2011

- ▲ Unit emission rate of 1 g/s
- ▲ United States Geological Survey 7.5 minute terrain data

## 3.2 METEOROLOGICAL DATA

BAAQMD provided AERMOD-ready surface and profile meteorological data from the Hayward Executive Airport Meteorological Station, located at 20301 Skywest Drive Hayward, California 94541 for year 2011. The meteorological data module was set to process the entire year of data.

## 3.3 RECEPTOR GRID

A master receptor grid was constructed to encompass all areas of the city that are already developed or are identified as Priority Development Areas for future growth, plus at least 1,000 feet from these areas. A grid spacing of 100 meters (m) by 100 m was used.

To reduce processing time for individual model runs, separate sub-grids for roadways and railroads were developed in ESRI software ArcMap 10.2 using a 2 kilometer (km) buffer around sources. All individual sub-grids consisted of a portion of the same receptors points from the master grid. The buffer was used to clip out receptor points from the master grid within the 2 km buffer of the sources to form the applicable sub-grid. All grids were built as a Uniform Cartesian grid with a flagpole height of 1.8m above the surface terrain and converted to Discrete Cartesian receptor points.

Once all models runs were complete, output dispersion factors (i.e., a “dummy” concentrations based on the dummy emission rate of 1.0 g/s, a.k.a., chi-over-Q values) for each sub-grid from each source type were combined to result in a total concentration value for each pollutant type and for each unique receptor point on the master grid.

## 3.4 SOURCE CHARACTERIZATION

### ROADWAYS

On-road emissions were modeled in AERMOD for high-volume roadways (e.g., Interstates 880, 580, and 238; Mission Boulevard, Foothill Boulevard) as well as local roads with high truck volumes (e.g., Hesperian Boulevard, Industrial Boulevard). Separate model runs were created for automobiles and trucks to account for the variation in hourly emissions based on hourly daily traffic volumes, release parameters, and emission rates between trucks and automobiles.

Road segments were developed from a Hayward road ESRI shapefile and were determined based on road segment traffic data that were used to develop emission rates, as described above in Section 2. The shapefile was used to trace volume line sources in AERMOD. Hourly variable emission factors were developed for automobiles and trucks, as described above in Section 2, and was applied to each model. Other model input parameters for on-road mobile sources are shown below in Table 1.



Table 1 Air Dispersion Model Input Parameters	
AERMOD Input Field	User Inputs
Source type	Line Volume, Separated, Surface-Based
Plume Width	Shoulder-to-shoulder distance of Roadway Segment
Plume Height	5 meters
Release Height	Automobiles: 0.46 meters, Trucks: 3 meters
Emission Rate	1 grams per second

## PERMITTED STATIONARY SOURCES

A total of 314 permitted sources were modeled in AERMOD. Most permitted sources were modeled as point sources which included vertical, horizontal, and capped stacks. Gas dispensing facilities were modeled as volume sources. Default parameters for many of the permitted sources were used where source-specific parameters were unknown. The default parameters used were based on recommendations and guidance from BAAQMD's Recommended Methods for Screening and Modeling Local Risks and Hazards (BAAQMD 2012) with assistance from BAAQMD staff.

## RAILROADS

Railroads were modeled in a similar way to on-road sources. Multiple model runs were created with rail segments and sub-grids. Hourly emissions rates were applied based on train activity in Hayward. Release parameters were the same as those for the truck model runs, as shown above in Table 1.

# 4 POLLUTANT CONCENTRATIONS AND CANCER RISK

This section outlines the methods employed to determine cancer risk levels and PM<sub>2.5</sub> concentrations from all the local emission sources modeled.

## 4.1 CONCENTRATION ESTIMATES

The concentration of pollutants at each receptor location was calculated for each modeled source by multiplying its annual average emission rate for each pollutant by the dispersion factor estimated by AERMOD. Dispersion factors are calculated using AERMOD with unit emissions (i.e., 1 g/s) from each source, as described in Section 3.1. The annual average concentration of a pollutant is the product of the annual average emission rate for the pollutant and the dispersion factor generated by air dispersion modeling. This relationship is explained in greater detail in BAAQMD's *Recommended Methods* (BAAQMD 2012).

PM<sub>2.5</sub> concentrations were calculated for all source types, including on-road motor vehicles on freeways and major roadways, permitted stationary sources, and rail activity. Concentrations of diesel PM and other TACs were also calculated for these sources to estimate their contribution to potential cancer risk. The estimation of potential cancer risk is discussed in greater detail in the next section.

## 4.2 CANCER RISK ESTIMATION

Excess cancer risk is expressed as the incremental probability that an individual will develop cancer over a lifetime as a direct result of exposure to potential carcinogens. The estimated risk is a unitless probability, often expressed as the number of people who might get cancer per million people similarly exposed. The cancer risk attributed to a TAC is calculated over an assumed 70-year lifetime of exposure by multiplying the chemical intake (in this case, by inhalation) or dose by the chemical-specific cancer potency factor (CPF).

Cancer risk is the product of the average annual TAC concentration(s), the inhalation intake factor (by a person), and the cancer potency factor of the TAC(s). Per BAAQMD's guidance, age-specific sensitivity factors were also incorporated into the estimate of cancer risk (BAAQMD 2012). An age-specific sensitivity factor increases the risk in early years of exposure to account for increased sensitivities during fetal development and early childhood. The equations used to estimate cancer risk are presented in detail in BAAQMD's *Recommended Methods* (BAAQMD 2012).

TACs contributing to cancer risk include diesel PM from roadway traffic, railroad activity, and some stationary sources (e.g., backup generators); a variety of TACs contained in exhaust emissions of TOG (e.g., naphthalene, acetaldehyde, formaldehyde) and evaporative loss emissions of TOG (e.g., benzene, ethyl benzene) from roadway traffic in addition to many different TACs from a variety of stationary sources (e.g., toluene, xylene, hexane). Speciation of TOG emissions was performed in accordance with BAAQMD's *Recommended Methods* (BAAQMD 2012).

## 5 MAPPING OF RESULTS

Included at the end of this section, four separate maps demarcating cancer risk and PM<sub>2.5</sub> concentrations in the city were developed in GIS using the cancer risk levels and annual average PM<sub>2.5</sub> concentrations estimated for each receptor in the master grid.

The cancer risk map, shown in Exhibit 1, indicates the level of cancer risk throughout Hayward from a 70-year exposure to carcinogenic TACs emitted by local sources for a person who is born in the base year 2014. Exhibit 1 demarcates areas where the cancer risk is considered to be "Low" (i.e. less than 100 in a million) and "High" (i.e. greater than 100 in a million). The 100-in-a-million demarcation level was used because it is the threshold of significance BAAQMD recommends in its May 2010 CEQA guidance for evaluating the cumulative contribution of cancer risk from the combined exposure of all local sources (BAAQMD 2010).

Exhibit 2 and Exhibit 3 show the spatial distribution of estimated annual average PM<sub>2.5</sub> concentrations in base year 2014 and plan horizon year 2040, respectively. Exhibits 2 and 3 demarcate areas where the average annual concentrations of PM<sub>2.5</sub> would be "Low" (i.e. less than ranges of 12 µg/m<sup>3</sup>) and "High" (i.e. greater than 12 µg/m<sup>3</sup>). A PM<sub>2.5</sub> concentration of 12 µg/m<sup>3</sup> is notable because it is the annual average concentration-based California Ambient Air Quality Standard. Exhibits 2 and 3 indicate that levels of PM<sub>2.5</sub> concentrations are generally below the CAAQS for a majority of the City of Hayward. In addition, emission factors of PM<sub>2.5</sub> exhaust from on-road mobile sources are expected to decline in the future as new vehicles replace older ones. Emission of PM<sub>2.5</sub> from brake wear, tire wear, and reentrained road dust will increase with the projected increase in VMT and thereby result in a combined overall increase of PM<sub>2.5</sub> from local sources. Changes in operations of stationary sources would have an effect on future PM<sub>2.5</sub> concentrations as well.

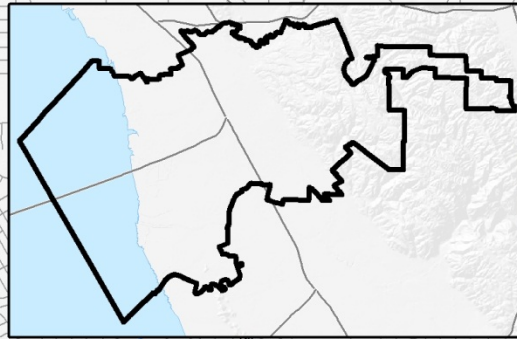
Exhibit 4 is a combination of Exhibit 1, 2, and 3 and represents the "High" health risk exposure areas in the City of Hayward. This exhibit was developed by overlapping the cancer risk plots and the PM<sub>2.5</sub> concentration plots and clipping the plot to include all high risk cancer areas and PM<sub>2.5</sub> areas. The resulting exhibit may be used to

represent existing and future conditions equally, as the future PM<sub>2.5</sub> high risk areas are all contained within the high risk cancer areas.

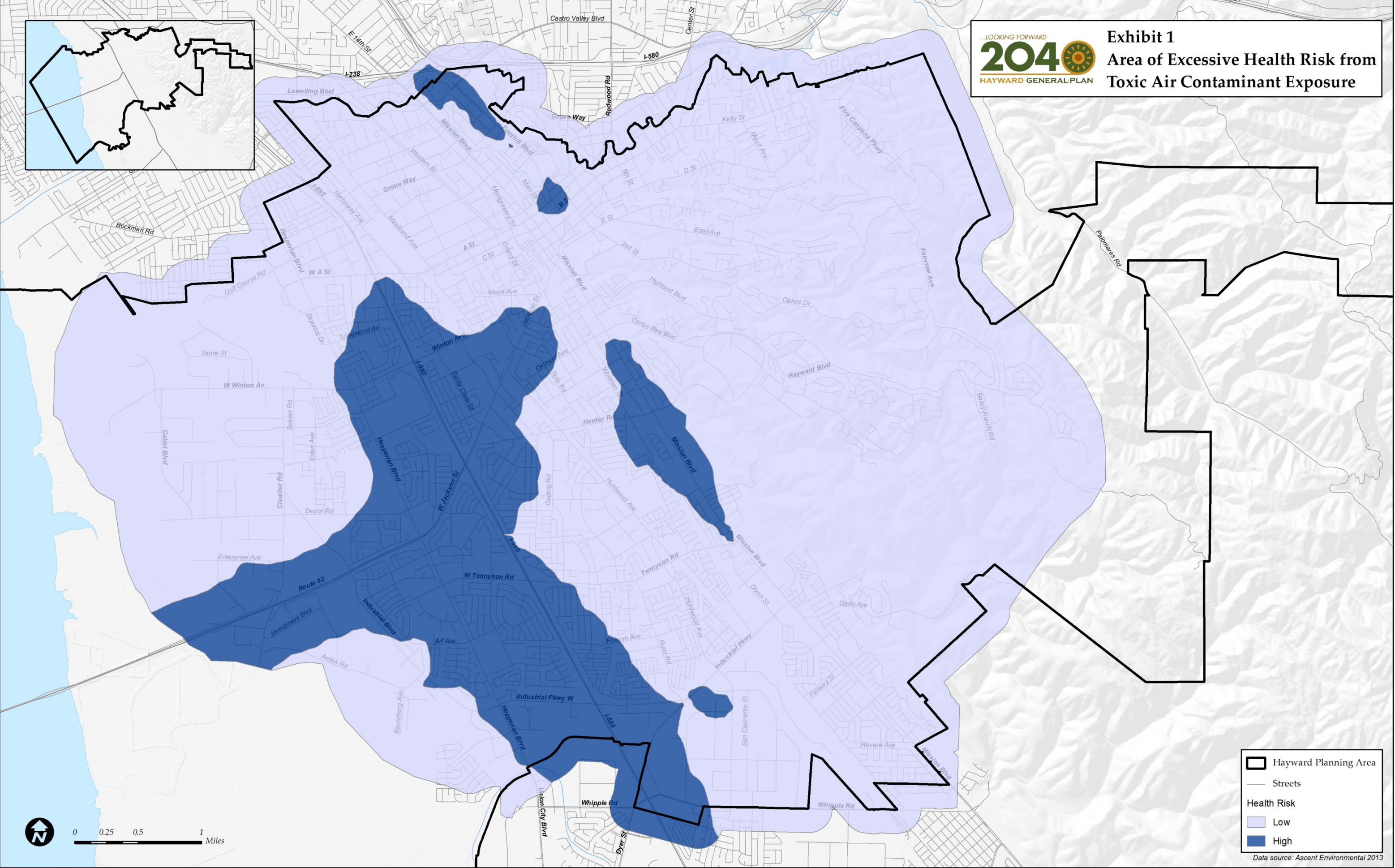
When assessing the maps to draw conclusions, it is important to consider what they portray and how they were produced. Specifically, the dispersion modeling, from which the maps are derived, show concentrations of directly emitted PM<sub>2.5</sub> and cancer risk associated with directly emitted TACs at locations near local emissions sources. The results do not reflect regional or long-range transport of air pollutants. Nor do they include the effects of the chemical transformation (formation or loss) of pollutants. Mapping of the modeling results is intended to aid local planning efforts by identifying areas where emission reductions or other efforts may be implemented to help protect current and future residents from major local sources of air pollution.







### Exhibit 1 Area of Excessive Health Risk from Toxic Air Contaminant Exposure



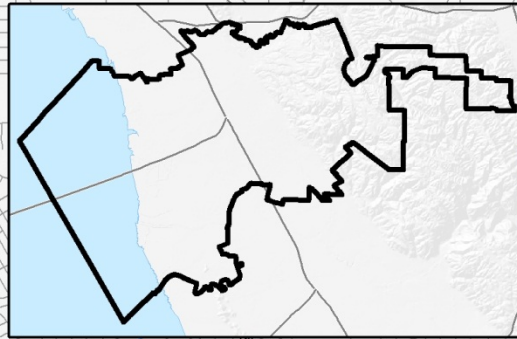
Legend:

- Hayward Planning Area
- Streets
- Health Risk
  - Low
  - High

Data source: Ascent Environmental 2013

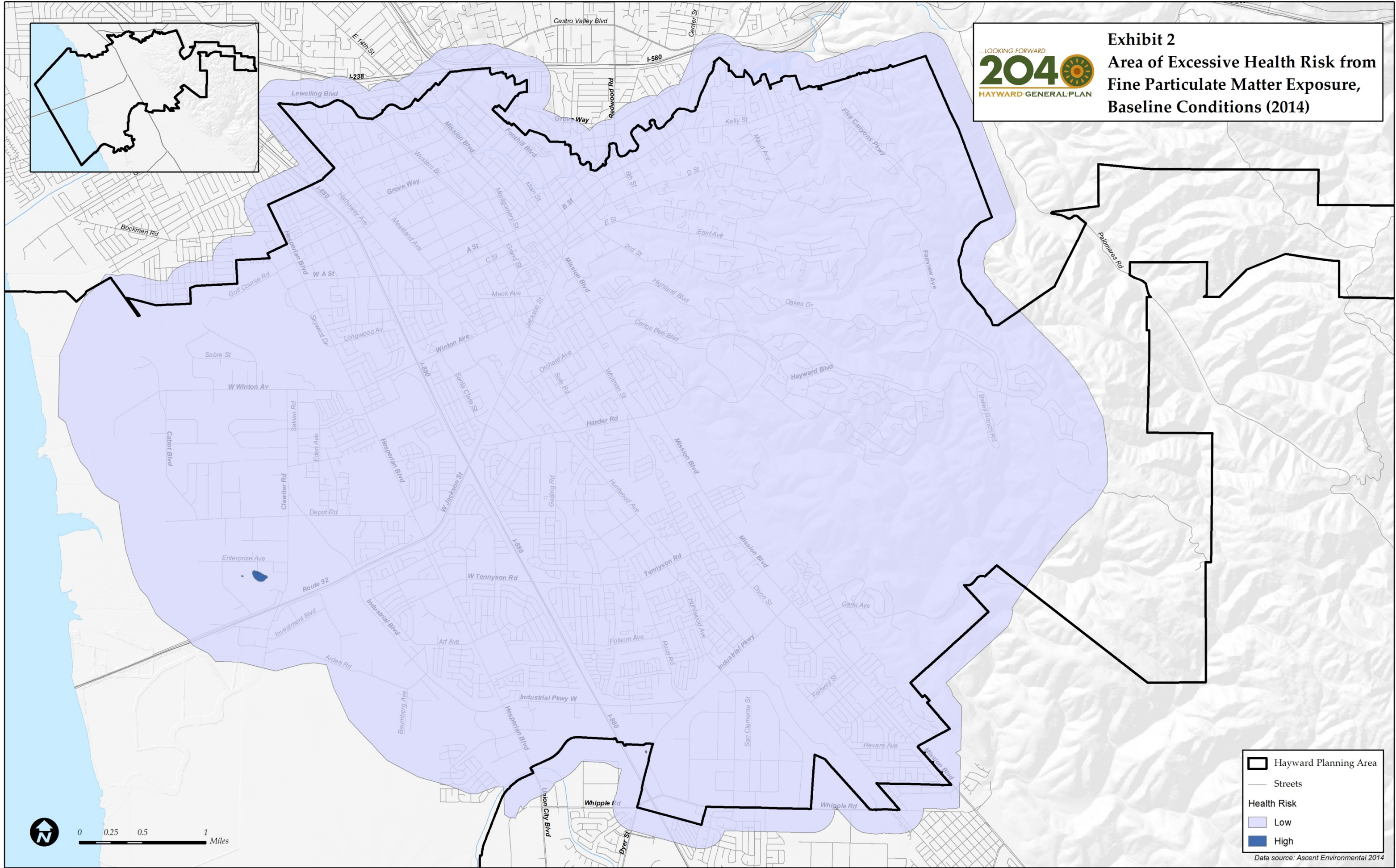






...LOOKING FORWARD  
**2040**  
 HAYWARD GENERAL PLAN

**Exhibit 2**  
**Area of Excessive Health Risk from**  
**Fine Particulate Matter Exposure,**  
**Baseline Conditions (2014)**

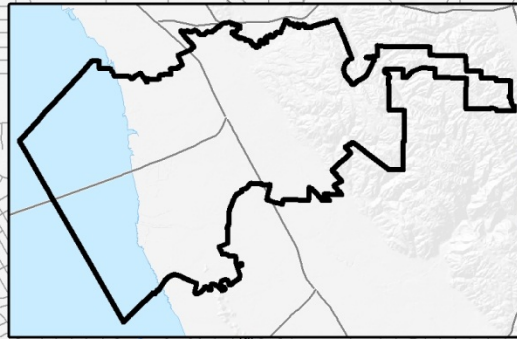


Hayward Planning Area  
 Streets  
 Health Risk  
 Low  
 High

Data source: Ascent Environmental 2014

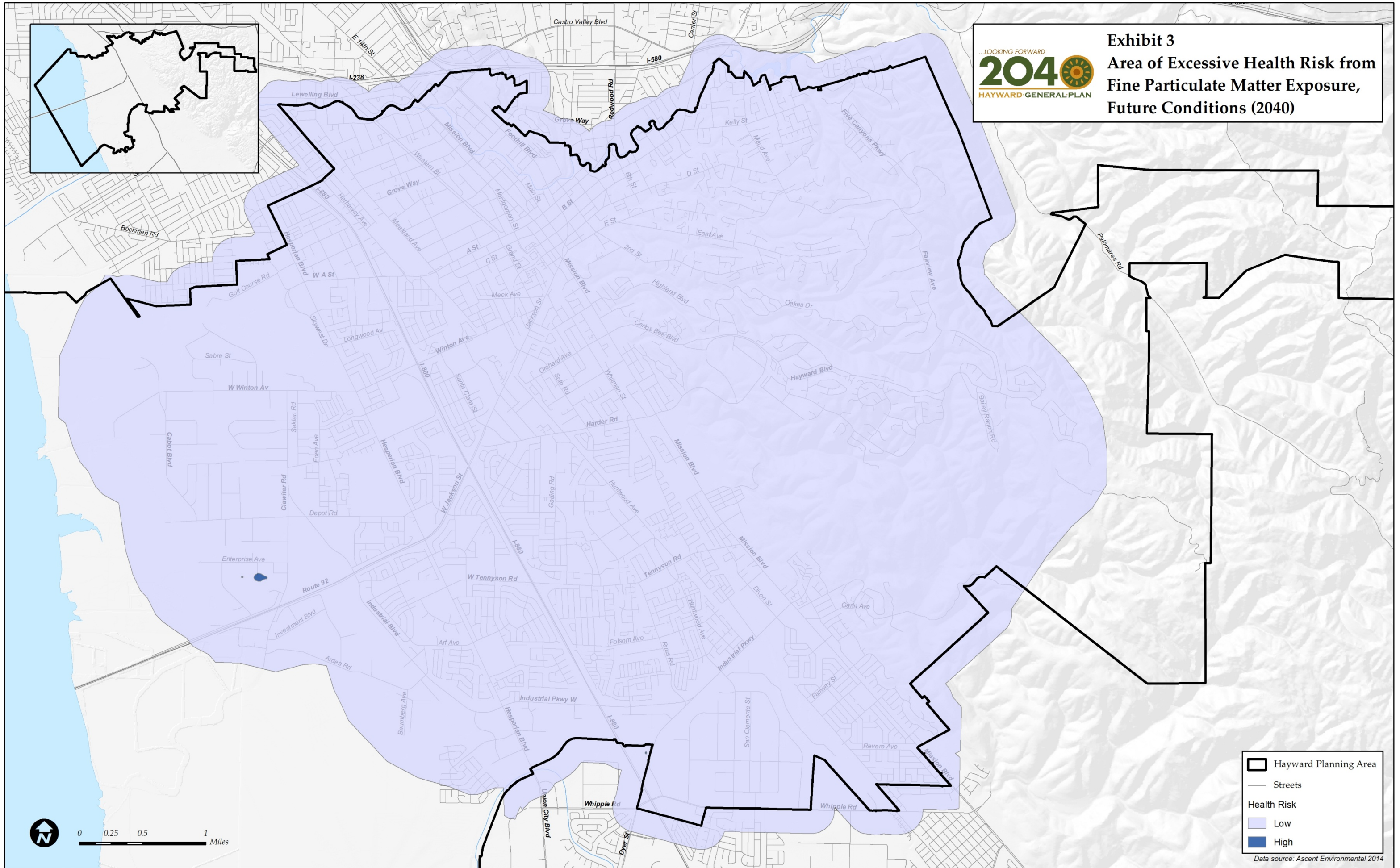






...LOOKING FORWARD  
**2040**  
 HAYWARD GENERAL PLAN

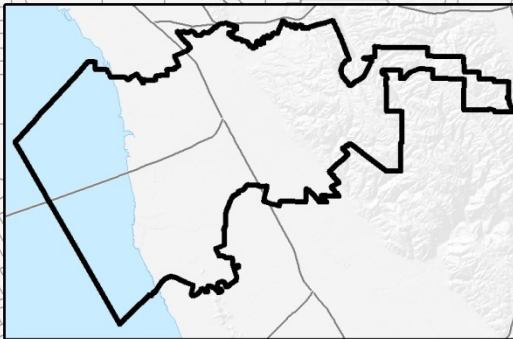
**Exhibit 3**  
**Area of Excessive Health Risk from**  
**Fine Particulate Matter Exposure,**  
**Future Conditions (2040)**



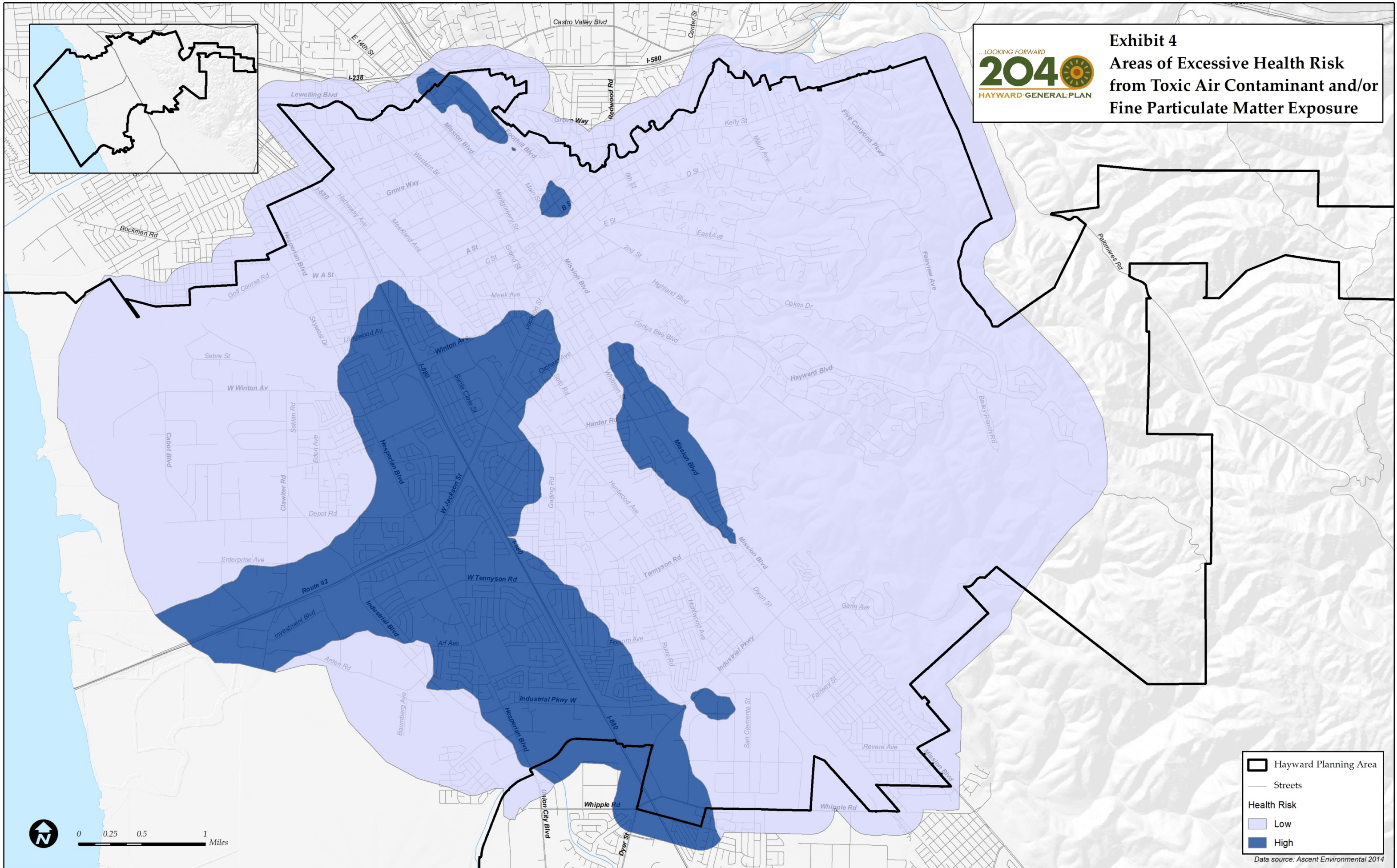
Hayward Planning Area  
 Streets  
**Health Risk**  
 Low  
 High

Data source: Ascent Environmental 2014





### Exhibit 4 Areas of Excessive Health Risk from Toxic Air Contaminant and/or Fine Particulate Matter Exposure



Legend:

- Hayward Planning Area
- Streets
- Health Risk
  - Low
  - High

Data source: Ascent Environmental 2014



As shown in Exhibit 1, cancer risk is largely a function of traffic on freeways and roadways that carry high volumes of vehicle traffic, particularly trucks. Exhibits 2 and 3 indicate that PM<sub>2.5</sub> concentrations are highest near industrial land uses and roads with high truck volumes. Exhibit 4 indicates that the highest health risk areas are in close proximity to freeways and industrial land uses.

## 6 UNCERTAINTIES

The following sections summarize common sources of uncertainty associated with the emissions estimation, air dispersion modeling, and risk estimation components of this risk assessment study.

### 6.1 EMISSION ESTIMATES

There are a number of uncertainties associated with the estimation of emissions from each of the source categories considered that may affect the subsequent estimation of exposure concentrations and risk characterization. For example, uncertainties associated with the estimation of emissions from on-road motor vehicles may affect the subsequent estimation of exposure concentrations and risk characterization. Estimates of traffic volumes and truck fractions on specific roadways have significant uncertainties associated with them, especially in future years. Based on parameters provided in EMFAC2011, the vehicle fleet used in the modeling was based on a representative mix for Alameda County, which may or may not be the best representation of the vehicles owned by Hayward residents and businesses or the fleet of vehicles that make pass-through trips on the modeled freeway segments.

No attempt was made to project how rail emissions could change in future years. For instance, factors that influence the freight and shipping industry, such as changes in fuel costs, could dramatically affect the proportion of rail activity to truck activity.

Similarly, no attempt was made to forecast future changes to the stationary sources in the city.

### 6.2 MODELING APPROACH

In addition to uncertainty associated with emission estimates, there is also uncertainty associated with the estimated exposure concentrations. The limitations of the air dispersion model provide a source of uncertainty in the estimation of exposure concentrations. According to the U.S. Environmental Protection Agency (EPA), errors due to the limitation of the algorithms implemented in the air dispersion model in the highest estimated concentrations of +/- 10 percent to 40 percent are typical (EPA 2005).

Hayward includes many multi-story and variable-size buildings, which results in urban flow patterns that are likely influenced by recirculation and channeling in urban canyons. The dispersion modeling does not account for such patterns. The urban heat island effect, which results from surface heating of paved and built-up environment, is likely prevalent in some areas of the city and leads to longer periods of mixing and generally lower predicted air concentrations. AERMOD allows the user to model urban heat island impacts by selecting urban land use option. Although Hayward fits the definition of an urban area, the rural land use option was used in the AERMOD dispersion runs in order to estimate conservative air pollutant concentrations.

In addition, the dispersion modeling did not incorporate building height information to account for building downwash. The building downwash option in AERMOD accounts for the buildup of air pollution in the building cavity due to recirculating winds created by nearby buildings. The effects are governed by the building geometry and the wind direction. To take advantage of this option in the model, information about all the building heights and stacks within the City would be required. Typically, building downwash effects often lead to higher

concentrations downwind of the stack release. Not capturing these effects and using meteorological data from single monitoring site to represent transport throughout the city add to errors and uncertainties in the modeling approach.

Throughout the city, receptors were placed at a height of 1.8 meters (commonly called flagpole receptor height) above the surface terrain. This option is used to conservatively model exposures within an individual's breathing zone at ground level. Using flagpole receptors may not always capture the highest predicted concentration in cases where both the source and the residential receptors are elevated above the surface terrain.

Uncertainties in input parameters used to represent and model emission releases add uncertainty to the modeling approach. For all emission sources, where parameters such as stack height and diameter were unknown, default source parameters were used that are generally expected to produce more conservative results. In particular, many of the stack parameters for standby diesel generators were unknown and default release parameters were used. However in cases where the actual stack height is greater than the default used in the model, the exposure concentrations may be underestimated at downwind receptor locations. Due to potential discrepancies in actual emissions characteristics of a source and its representation in the model, exposure concentrations used in this assessment represent approximate exposure concentrations.

For example errors and uncertainties persist in the specification of locations of stacks at facilities, in spite of significant effort by BAQMD staff to verify facility data in its database of permitted stationary sources.

## 6.3 RISK CHARACTERIZATION METHODS

Numerous assumptions must be made in order to estimate human exposure to chemicals. These assumptions include parameters such as breathing rates, exposure time and frequency, exposure duration, and human activity patterns. While a mean value derived from scientifically defensible studies is a reasonable estimate of central tendency, the exposure variables used in this assessment are only estimates.

Cancer potency factors (CPFs) for toxic air contaminants established by the California Environmental Protection Agency/Office of Environmental Health Hazard Assessment (CalEPA/OEHHA) were used to estimate cancer risks associated with pollutant exposures. However, the CPF values derived by Cal/EPA for many pollutants, including that for diesel PM, are uncertain in both the estimation of response and dose. Public health and regulatory organizations such as the International Agency for Research on Cancer, World Health Organization, and EPA agree that diesel exhaust may cause cancer in humans. However, there is significant uncertainty in the value applied for the CPF.

The EPA notes that the conservative assumptions used in a risk assessment are intended to assure that the estimated risks do not underestimate the actual risks posed by a site and that the estimated risks do not necessarily represent actual risks experienced by populations at or near a site (EPA 1989).

The method applied to estimate cancer risk includes the age sensitivity factor recommended by CalEPA/OEHHA which increases the effective CPF to account for increased sensitivity of the young to cancer-causing pollutants. However, there may be pollutants in the urban environment whose cancer toxicity is magnified in ways that are not accounted for due to the combined presence other pollutants (synergic effects) or because of pre-existing conditions or sensitivities. Furthermore, there may be pollutants whose toxicity is not yet recognized or quantified and, as such, is unaccounted for in this risk assessment.

## 7 REFERENCES

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