Recommended Protocol for Evaluating the Location of Sensitive Land Uses Adjacent to Major Roadways

March 2011

Version 2.4

This document is periodically updated to reflect the latest technical data. For the most current version, please visit www.AirQuality.org or call 916.874.4800.

Foreword

This *Recommended Protocol for Evaluating the Location of Sensitive Land Uses Adjacent to Major Roadways* (Protocol) provides a methodology for the assessment and disclosure of potential cancer risk from diesel particulate matter (DPM) attributable to siting sensitive land uses adjacent to freeways and major roadways.

This Protocol was developed to provide further guidance on the Air Resources Board's *Land Use and Air Quality Handbook: A Community Perspective*. It is intended to assist local land use jurisdictions in assessing the potential cancer risk of siting sensitive land uses adjacent to major roadways for DPM only.

The Protocol focuses on assessing cancer risk from DPM and provides a disclosure mechanism for those risks, while showing the relationship between potential cancer risk from DPM exposure and distance from the freeway or major roadway. Currently, the Protocol provides some limited information on the non-cancer acute and chronic health risks, but does not recommend that those risks be quantified. Instead, project documents should include a qualitative discussion of the non-cancer acute and chronic health risks.

This document does *not* provide an acceptable DPM cancer risk level or a regulatory threshold; therefore it does not establish which land use projects are acceptable and which are not. *Local land use jurisdictions retain all authority and decide after considering all relevant factors whether the land use project is appropriate.*

DPM emissions and traffic data used in the screening tables are specific to the region encompassing the Sacramento Metropolitan Air Quality Management District; therefore, the tables should only be applied to projects contemplated within its boundaries.

The District recommends that the Protocol be applied to project applications deemed complete on or after the SMAQMD Board endorsement date of January 25, 2007. The District does not recommend that projects whose environmental documents have already been certified as of that date be re-opened.

We invite users of this Protocol to contact SMAQMD planning staff or visit the District offices for consultation on the use of this Protocol at the earliest possible date.

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Document Revisions

October 2008, Version 2.0
On October 23, 2008, our Board of Directors approved major revisions to the Protocol and its Technical Appendix, including:

- Revised health risk assessment procedure, for consistency with state guidance
- Shading removed from the screening tables (note that the evaluation criterion remains)
- Expanded section on exposure reduction practices (potential mitigation measures)
- Guidance on addressing background risk levels, multiple sources, non-cancer health effects, and controversy in developing and reporting health risk values

In addition, we expanded the Technical Appendix to include step by step guidance on air dispersion modeling and health risk assessment. We updated traffic and emissions information to reflect 2008 EMFAC information, and we correspondingly updated the cancer risk values.

January 2009, Version 2.1
We updated traffic and emissions information to reflect 2009 EMFAC information, and we correspondingly updated the cancer risk values.

March 2009, Version 2.2
The roadway description on the second screening table was corrected, several sections citing the incorrect evaluation criterion were revised, and several cross referencing errors were corrected.

January 2010, Version 2.3
We updated traffic and emissions information to reflect 2010 EMFAC information, and we correspondingly updated the cancer risk values. In addition, we added new information on non-cancer health effects.

January 2011, Version 2.4
We updated traffic and emissions information to reflect 2011 EMFAC information and correspondingly updated the cancer risk values. In addition, we added information on the latest health impact studies. Most importantly, we are now using the terms ‘best management practices’ or ‘exposure reduction measures’ which we previously referred to as ‘mitigation measures’ and this section has also been updated. Finally, portions of the narrative text has been clarified and condensed, and portions of the document have been reformatted.

Introduction

In April 2005, the California Air Resources Board (ARB) released the *Land Use and Air Quality Handbook: A Community Health Perspective* (Land Use Handbook), which offers guidance on siting sensitive land uses in proximity to sources of air toxics. Sensitive land uses include residential communities, schools and school yards, day care centers, parks and playgrounds, hospitals and medical facilities.[1] One particular source of air toxics treated in the guidance is freeways and major roadways. These roadways are sources of diesel particulate matter (DPM), which ARB has listed as a toxic air contaminant.

The Land Use Handbook recommends that sensitive land uses be sited no closer than 500 feet from a freeway or major roadway, a buffer area that was developed to protect sensitive receptors from exposure to diesel PM, which was based on traffic related studies that showed a 70 percent drop in PM concentrations at a distance of 500 feet from the roadway. Presumably, acute and chronic risks as well as lifetime cancer risk due to diesel PM exposure are lowered proportionately.

Because the ARB recommendations have major implications relative to land development projects, the Sacramento Metropolitan Air Quality Management District (SMAQMD) developed this Protocol to provide land use decision makers with a methodology to make informed land use decisions on siting new residential projects and other sensitive land uses in proximity to a freeway or major roadway. This Protocol is intended to give local officials the information needed to assess health risk issues within the spectrum of other land use issues that must be considered in the land use planning process. Other issues include housing and transportation needs, the benefits of urban infill, and community economic development priorities. The Protocol was not designed to be applied retroactively and should not be applied to project applications submitted and deemed complete on or before the SMAQMD Board endorsement date of January 25, 2007.

The Protocol defines a stepwise process that indicates the need for and methodology to conduct a site specific health risk assessment (HRA). In this process, project site specific characteristics are used to evaluate the potential cancer risk posed within the project and to determine whether a site specific HRA is warranted. When the Protocol indicates that the project proponent should conduct a site specific HRA, guidance is provided on how the HRA should be performed. *A site specific HRA is indicated when the screening tables indicate project risk greater than the evaluation criterion. Note that the current evaluation criterion of 276/million does not represent an acceptable cancer risk or a threshold of significance.* A site specific HRA allows the cancer risk to be based on more precise site specific characteristics than are available through the screening tables.

It is worth noting is that, as stricter emissions regulations and improved technologies phase in over the years, actual emissions are projected to decline which may result in reduced exposure to toxic air contaminants. However, these declines may be partially offset by increases in vehicle miles traveled.

[1] California Environment Protection Agency, California Air Resources Board, *Air Quality and Land Use Handbook: A Community Health Perspective* (2005), Page 2. www.**arb**.ca.gov/ch/landuse.htm

The Protocol contains the following sections:

Project Screening describes the stepwise project screening process used to determine whether a site specific HRA is recommended.

The Evaluation Criterion describes how the criterion was developed, and why.

Addressing Existing Background Levels provides recommendations on how to disclose existing ambient cancer risk in relation to project cancer risk, if desired.

Addressing Multiple Sources discusses how to proceed in assessing cancer risk for situations in which there are additional sources of diesel PM; for example, locomotives.

Addressing Non-Cancer Health Effects provides guidance on qualitatively discussing acute, chronic and non-cancer risks, such as asthma and disruptions in cellular function.

Other Air Toxics of Concern briefly discusses additional mobile source air toxics.

Site Specific Air Dispersion Modeling describes the methodology recommended for performing site specific dispersion modeling when the screening process indicates that one should be done.

Calculating Potential Cancer Risk describes how to calculate potential cancer risk using the air dispersion model outputs. A sample is provided.

Site Specific HRA Reporting and Controversy outlines the information to be included in the staff report or environmental document, and how to proceed if there is disagreement on how to conduct or disclose risk values.

Exposure Reduction Practices and Features is an evolving section that lists project-based ways to reduce DPM exposure.

Resources provides a list of resources for use in the project screening, air dispersion modeling, and HRA calculation process.

Background information for many aspects of the Protocol including screening table development and health risk evaluation procedures is given in the Appendix, which is available at http://www.airquality.org/ceqa/RoadwayProtocol.shtml.

Project Screening

The project screening approach is summarized as follows:

1. Determine if the nearest proposed sensitive receptor affected by the project is at least 500 feet from the nearest high traffic volume roadway (defined as a freeway, urban roadway with greater than 100,000 vehicles/day, or rural roadway with 50,000 vehicles/day). If the project is outside of the 500 foot distance, then the proposed project meets the ARB guidance distance and no further roadway-related air quality evaluations are recommended under this Protocol.

   If the project is within 500 feet, proceed to step 2.

2. Using the screening process described herein, determine if the nearest sensitive receptor's increase in individual cancer risk is lower than the evaluation criterion. If lower, then no further roadway-related air quality evaluation is recommended under this Protocol and the projected cancer risk value and screening table used should be disclosed in the environmental documentation. If higher risk, continue to step 3. *Note that the evaluation criterion does not represent an acceptable cancer risk or a threshold of significance.*

3. Complete a site specific HRA using procedures recommended herein, and disclose this information in the environmental documents.

Figure 1: Information Needed to Screen a Project

- Roadway orientation (north-south, or east-west)
- Project orientation (north, south, east or west of roadway)
- Peak hourly traffic volume provided by Caltrans

Information needed to screen a project is shown in Figure 1.

The Evaluation Criterion

The evaluation criterion is a cancer risk value that is based on the reasonable worst case siting situation within the boundaries of the SMAQMD. It is the level of increased individual risk corresponding to a 70 percent reduction from the highest roadway risk in Sacramento County. It is calculated based on a hypothetical sensitive receptor located 50 feet[2] from the edge of the nearest travel lane for the highest peak traffic volume reported by Caltrans for Sacramento County (24,000 vehicle per hour) east (downwind) of a north-south roadway.

The evaluation criterion for projects submitted in 2011 is 276/million.

The evaluation criterion is calculated by reducing the worst case at 50 feet by 70 percent: 70 percent of 919/million = 276/million.

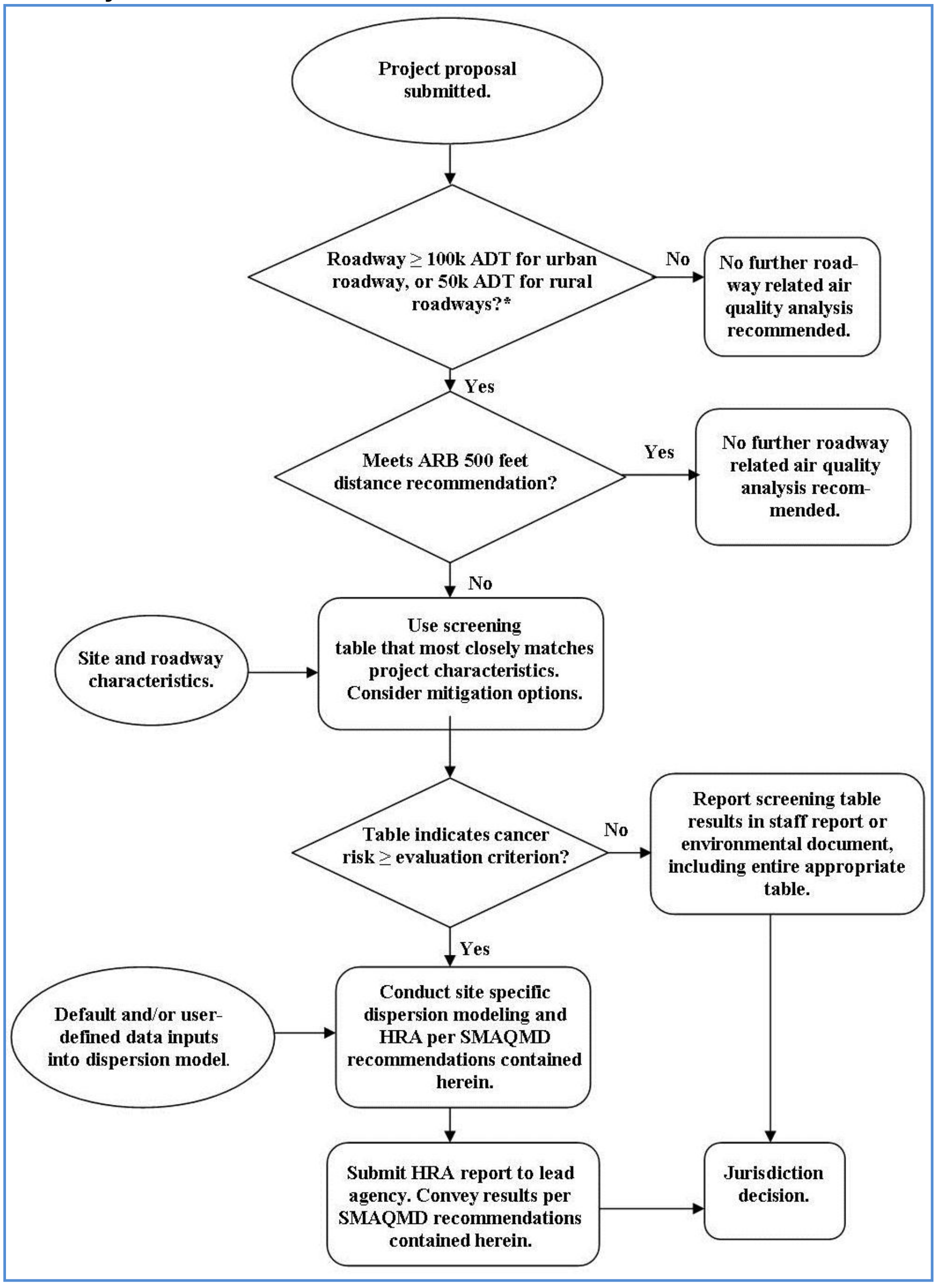
[2] Previous versions calculated the evaluation criterion from 10 feet. In order to more closely align with ARB modeling methodology set forth in the Land Use Handbook, SMAQMD now uses the 50 foot distance to determine the evaluation criterion.

Note that we do *not* intend for the evaluation criterion to be interpreted as a "safe" risk level or a regulatory threshold; it is simply the point at which we recommend a site specific health risk assessment. A site specific HRA allows the cancer risk to be based on more precise site specific characteristics than are available through the screening tables.

Additional calculation information on the evaluation criterion is presented in the Technical Appendix.

Figure 2 describes the entire project evaluation process.

Figure 2: Stepwise Approach to Evaluating Sensitive Land Use Projects Adjacent to Major Roadways



To screen the project, use the project information to locate the appropriate cell in the screening tables to determine whether or not to move on to step 3. Always round to find the most conservative value.

Find the appropriate cell by referencing the roadway, project orientation, and appropriate traffic volume (from Caltrans) in the tables.

Choose the table that most closely reflects the roadway orientation; either Table 1 for East-West roadways and or Table 2 for North-South roadways. Within each table, there are matrices for projects that are upwind and downwind of the roadway.

Next, if the project is downwind of the roadway, look to the upper matrix in the table. If the project is upwind, look to the lower matrix. If the predominant compass orientation of the roadway is subject to dispute, then a north-south roadway orientation should be assumed.

Determine the appropriate row in the matrix according to Caltrans' peak hour traffic volume. Round the traffic volume reported by Caltrans up to the nearest entry in the matrix.

The increased cancer risk is shown in the cell that corresponds to the proposed distance from the roadway of the nearest affected sensitive receptor. For a new housing development, use the location of the nearest proposed residence. If the building envelopes are known, the receptor should be placed at the building. Otherwise, place the receptor at the edge of the property boundary.

If the risk is less than the evaluation criterion, a site specific HRA is not needed. Instead, the screening results should be disclosed and discussed in the environmental documentation or a staff report. Include the entire table for reference.

If the increased cancer risk is greater than the evaluation criterion, SMAQMD recommends performing a site specific HRA using on recommendations contained within this document. A site specific HRA allows the cancer risk to be based on more precise site specific characteristics than are available through the screening tables.

The screening tables follow.

Table 1: 2011 Diesel PM Cancer Risk (Potential Incremental Cancer Chances per Million People) North and South of an East-West Roadway

PROJECTS NORTH AND SOUTH OF AN EAST-WEST ROADWAY Version 2.4 EMFAC2007 (Analysis Year 2011)

Peak Hour Traffic (vehicle/hr)	Receptor Distance from Edge of Nearest Travel Lane (feet)							
	10	**25**	**50**	**100**	**200**	**300**	**400**	**500**
Incremental Cancer Risk Per Million: North (downwind)								
4000	188	165	137	102	67	51	41	35
8000	372	331	273	204	134	99	83	67
12000	550	487	404	299	197	149	121	102
16000	760	671	557	410	270	204	165	137
20000	951	840	696	515	337	254	207	172
24000	1138	1008	836	617	404	305	248	207
Incremental Cancer Risk Per Million: South (upwind)								
4000	102	86	67	48	32	22	19	16
8000	207	172	137	99	64	48	38	32
12000	305	254	200	143	92	70	54	48
16000	423	353	277	200	127	95	76	64
20000	531	442	347	248	159	121	95	80
24000	636	531	417	299	191	143	114	95

Table 2: 2011 Diesel PM Cancer Risk (Potential Incremental Cancer Chances per Million People) East and West of a North-South Roadway								
PROJECTS EAST AND WEST OF A NORTH-SOUTH ROADWAY Version 2.4 EMFAC2007 (Analysis Year 2011)								
Peak Hour Traffic (vehicle/hr)	Receptor Distance from Edge of Nearest Travel Lane (feet)							
	10	**25**	**50**	**100**	**200**	**300**	**400**	**500**
Incremental Cancer Risk Per Million: East (downwind)								
4000	219	188	149	105	67	51	38	32
8000	442	378	299	210	134	99	80	67
12000	677	579	458	324	207	153	121	102
16000	900	773	611	429	273	204	162	134
20000	1126	964	766	537	343	254	204	169
24000	1352	1158	919	646	413	305	242	200
Incremental Cancer Risk Per Million: West (upwind)								
4000	140	108	83	54	35	25	19	16
8000	280	223	162	111	70	51	41	32
12000	429	340	248	169	105	76	60	51
16000	572	452	331	226	143	105	83	67
20000	716	566	417	283	178	130	102	83
24000	859	677	499	340	213	156	124	102

Reporting responsibilities are shown in Figure 3.

Figure 3: Screening Responsibilities and Reporting

- General project information
- Map showing project in relation to freeway or major roadway
- Distance to closest receptor and edge of nearest travel lane
- Peak hour traffic from Caltrans
- Cancer risk value at nearest receptor
- Entire appropriate table used in screening process, with project risk highlighted

Addressing Existing Background Risk Levels

The screening table cancer risk values do not include the existing background cancer DPM risk for Sacramento County of 360/million.[3]

If you choose to discuss existing background levels, the roadway risk should *not* dismissed as a percentage of the background or otherwise minimized, but rather characterized as risk *in addition* to project specific risk.

Addressing Multiple Sources

This methodology assumes that the roadway is a single, limited-access freeway, with no interchanges, traffic signals, or associated traffic queues.

Emissions and corresponding risk in certain situations may be higher than the screening tables indicate. Such situations include interchanges and applicable roadways near rail yards. Please

[3] ARB, http://www.arb.ca.gov/diesel/documents/rrstudy/rrstudy101404.pdf, viewed October 2006.

consult with SMAQMD staff early in the project planning process for more information on how to address risk in these situations.

Methods of incorporating multiple sources, freeway intersections, controlled traffic roadways (i.e. with traffic signals and intersections), and other, non-roadway, mobile toxic air contaminant sources (i.e., locomotives) into the HRA process may be the subject of future SMAQMD efforts.

Addressing Non-Cancer Health Effects

Living near freeways and major roadways is associated with non-cancer acute and chronic health effects.

- In 2009, researchers at the Columbia Center for Children's Environmental Health linked prenatal exposure to car, bus, and truck exhaust with **lower childhood IQ** scores.

- In 2009, a study by the University of Washington and the University of British Columbia found that infants living within 50 meters of a major highway had a 6% higher risk of developing **bronchiolitis** severe enough to require medical attention.

- In 2009, a study by McMaster University indicated that prolonged exposure to motor vehicle exhaust, including DPM, increased the probability of **severe pneumonia** in adults over 65 years of age.

- In February 2007, a study published in The Lancet showed that children living near a freeway had substantial **deficits in lung formation** compared with children living father away.

> Include a discussion of the potential non-cancer health risks in the staff report or environmental document.

- A February 2007 study published in the New England Journal of Medicine showed that postmenopausal women living in communities with high levels of fine particulate matter had a 150 percent **greater risk of dying from heart disease and stroke** than women living in less polluted areas.

- A December 2007 study published in the New England Journal of Medicine showed that adults with asthma who spent just 2 hours walking on a street with heavy diesel traffic suffered acute effects on their lung function, including lung and **airway inflammation**.

- An April 2003 study published in Environmental Health Perspectives showed that exposure to ultrafine particles from incomplete combustion of fuel as well as lubricating oils can bypass the body's defense mechanisms, enter cells and tissues, and **disrupt normal cellular function**.

- Studies published in February 2003 and September 2005 issues of Environmental Health Perspectives linked traffic-related pollutant exposure to **increased risk for low birth weight** and premature birth.

- In 2010, ARB cited a study estimating that over **9,000 people die** each year in California from diesel particulate matter exposure.

Other Toxic Air Pollutants of Concern

Table 3 lists the cancer potency factors for the more prevalent mobile source air toxics (MSATs) from vehicle sources. For diesel particulate matter, the cancer potency factor is 1.1E + 00. The cancer potency factor assumes standard exposure and breathing rates as documented by OEHHA/ARB.

Significant health risks are associated with carcinogenic toxic air contaminant emissions in vehicle exhaust. The most significant carcinogenic toxic air contaminants in vehicle emissions identified are 1, 3-butadiene and benzene from gasoline-fueled vehicles, and diesel PM from diesel-fueled vehicles.[4] The cancer risk due to diesel PM exposure is more significant than the other carcinogenic MSATs.

Table 3: Cancer Potency Factors for Prevalent MSATs	
Air Toxic Species	**Cancer Potency Factor (increased risk per mg/kg-day)**
Diesel PM	1.1E + 00
Benzene	1.0E-01
1,3-Butadiene	6.0E-01

Because the cancer risk posed by vehicle MSAT emissions is dominated by diesel PM exposure, the screening tables are based on diesel PM cancer risk. Nevertheless, the same screening methodology and a site specific HRA can be applied to other MSATs if so desired.

Site Specific Air Dispersion Modeling

If the screening indicates a potential cancer risk greater than 276/million, SMAQMD recommends a site specific HRA to provide additional project specific information for decision making and disclosure purposes.

A site specific HRA requires calculating ambient pollutant concentrations resulting from the mass exhaust emission rate. PM10 is used as a proxy for the relative measure of diesel PM. More information on PM10 is provided in the Appendix (see *Resources*).

SMAQMD recommends the CAL3QHCR model for estimating roadway emissions concentrations. It will output PM10 concentrations expressed in micrograms per cubic meter ($\mu g/m^3$) at the defined receptor locations. It is a refined version of the original CALINE (California Line Source Dispersion Model) line source model that was developed tool to estimate roadside CO concentrations. It can be used to estimate PM10 concentrations at defined receptor locations by processing hourly meteorological data over a year, hourly emissions, and traffic volume. The model can be obtained at no cost from EPA[5].

[4] Reducing Toxic Air Pollutants in California's Communities, brochure from www/arb.ca.gov/toxics/toxics.htm, viewed May 2006
[5] http://www.epa.gov/scram001/dispersion_prefrec.htm, viewed June 2006

Table 4: 2011 Relative Traffic Volumes and PM10 Emission Rates

Hour of Day	Multiplier for Relative VMT	*Grams/mile*	Hour of Day	Multiplier for Relative VMT	*Grams/mile*
0	0.15	*0.07*	12	0.76	*0.03*
1	0.06	*0.06*	13	0.75	*0.03*
2	0.07	*0.05*	14	0.86	*0.03*
3	0.04	*0.26*	15	0.87	*0.03*
4	0.07	*0.10*	16	0.92	*0.03*
5	0.12	*0.08*	17	1	*0.02*
6	0.47	*0.05*	18	0.69	*0.02*
7	0.94	*0.03*	19	0.52	*0.02*
8	0.89	*0.03*	20	0.40	*0.03*
9	0.56	*0.04*	21	0.41	*0.03*
10	0.59	*0.04*	22	0.30	*0.02*
11	0.73	*0.04*	23	0.23	*0.03*

CAL3QHCR requires meteorological (met), traffic, vehicle emissions and project/roadway orientation data. SMAQMD recommends and can supply 1987 met data, which represents average conditions.

CAL3QHCR requires hourly traffic volumes and can be found using Caltrans roadway traffic data and the 2011 relative VMT multipliers, which are shown in Table 4. The hourly traffic volume will be the product of the relative VMT multipliers with the roadway peak traffic volume, which is obtained from the Caltrans as discussed in the section entitled *Project Screening*. If needed, future traffic volumes should be calculated using the most current version of EMFAC2007.

The model also requires geographical data that defines the calculational domain. Identify the x-y coordinates of the beginning and end of the roadway section. The length of the roadway should be at least 10,000 feet (5,000 for each link) to ensure pollutant capture. The link width (mixing zone) also needs to be specified (in feet, arbitrary origin, y axis aligned with north). For example, a six-lane freeway might consist of six 12-feet wide lanes, and a 62-feet wide median, or 134 feet. Add to this an additional 10 feet on each side of the roadway to account for the wake of moving vehicles and the total link width becomes 154 feet. Also specify the elevation of the roadway compared to the surrounding area. For roadways at grade, this height is 0; for elevated and depressed roadways, this is the positive or negative relative height, respectively.

Identify the x, y and z coordinates for a set of receptors at 50, 100, 200, 300, 400, and 500 feet as well as the closest proposed receptor to the roadway. SMAQMD recommends the standard receptor height of 6 feet (z coordinate), even when considering multistory projects. If the building envelopes are known and included in the application to the land use authority, the receptor should be placed at the building. Otherwise, place the receptor at the edge of the property boundary. All parameters are specific to the project site subject to the HRA, and need to be defined and noted accordingly.

CAL3QHCR has many other features that allow modeling traffic intersections, traffic signaling, and traffic queuing. If these features are to be employed, consult the CAL3HQCR User's Guide[6].

Complete the risk assessment for 6 receptor distances from the roadway including the receptor location for the nearest potentially affected receptor in order to disclose the relationship between cancer risk and receptor distance from the freeway or major roadway.

Table 5: Additional CAL3QHCR Parameters

Parameter	Default	
Calculation averaging time (min)	60	
Surface roughness (cm, from 3 to 400). For mixed uses and others not listed here, the modeler should make a reasonable assumption.	single family	108
	offices	170
	apartments	370
Settling velocity (cm/s)	0	
Deposition velocity (cm/s)	0	
Site setting (U=urban, R=rural)	U	
Form of traffic volume, emission rate data (1=one hour's data, 2=one week of hourly data)	2	
Pollutant (P for PM10 to give output in µg/m^3)	P	
Hourly ambient background concentration (µg/m^3)	0	
Roadway height indicator (AG=at grade, FL=elevated and filled, BR=bridge, DP=depressed)	AG	
Roadway height (ft, 0 if AG, relative height if FL, BR, or DP)	0	

Calculating Potential Cancer Risk

SMAQMD recommends that the risk assessment methodology follow the recommendations contained within ARB's Recommended Interim Risk Management Policy for Inhalation Based Cancer Risk, which was established in consultation with the Office of Environmental Health and Hazard Assessment (OEHHA). ARB recommends using the 80th percentile breathing rate pathway. This is the midpoint value between the mean and high-end points for the breathing pathway and corresponds to a breathing rate of 302 liters/kilogram-day.

To calculate potential cancer risk using the 80th percentile breathing rate, the inhalation dose must first be determined. The inhalation dose is calculated as follows:

$$Dose = \frac{(Cair)(DBR)(A)(EF)(ED)(1 \times 10^{-6})}{AT}$$

Where:

Dose = Dose through inhalation (mg/kg/d)

[6] User's Guide to CAL3QHC Version 2.0, EPA-454/R-92-006 (Revised, with CAL3QHCR addendum), September 1995.

1×10^{-6}	=	Micrograms to milligrams conversion (10^{-3} mg/µg), liters to cubic meters conversion (10^{-3} m^3/l)
Cair	=	Concentration in air (µg/m^3), annual average from CAL3QHCR
DBR	=	Daily breathing rate (L/kg body weight-day or L/kg-day)
A	=	Inhalation absorption factor
EF	=	Exposure frequency
ED	=	Exposure duration
AT	=	Averaging time

Use the default inputs below for the inhalation dose equation.

Table 6: Recommended Default Values for Dose Equation	
EF	350 days/year
ED	70 years
AT	70 years (25,550 days)
DBR	302 (80th percentile) L/kg body weight-day
A	1

The following example dose calculation is based on a hypothetical average annual concentration 0.70µg/m^3:

$$\text{Dose}=\frac{\left(\frac{0.70\mu g}{m^3}\right)\left(\frac{302L}{kg-day}\right)(1)\left(\frac{350days}{year}\right)(70years)\left(\frac{1x10^{-3}mg}{1\mu g}\right)\left(\frac{1x10^{-3}m^3}{liters}\right)}{25{,}550days}$$

Dose= 2.027×10^{-4} mg/kg-day

Multiply the dose by the cancer potency factor of 1.1 /kg-day/mg, and then by $1x10^6$ to express the risk per million people using the following equation:

$$\left(Inhalation\ \ Dose\frac{mg}{kg-day}\right)\left(Cancer\ \ Potency\ \frac{kg-day}{mg}\right)\left(1\times10^6\right)=Cancer\ Risk$$

For the above calculated dose of 2.027×10^{-4} mg/kg/day, cancer risk is calculated as follows:

$$\left(2.027x10^{-4}\ \frac{mg}{kg-day}\right)\left(1.1\frac{kg-day}{mg}\right)\left(1x10^6\right)=223\ \text{chances per million people}$$

The cancer risk potency factor was established using data from animal and human exposure studies and incorporates worst case, health-protective assumptions. Cancer risk assessments assume that the potential risk is directly proportional to the dose. (There is no identified threshold for carcinogenesis.) The potency factors are expressed as the upper bound probability of developing cancer assuming a continuous lifetime exposure to a substance at a dose of one milligram per kilogram body weight, expressed in units of inverse dose as a potency slope [i.e., (mg/kg/day)-1].

Guidance exists for calculating risks based on 9 year (EPA) and 30 year (Census Bureau) exposure timeframes. SMAQMD recommends, at this time and for this purpose, using the standard OEHHA 70 year timeframe as the basis for the site specific health risk assessment.[7]

Also worth noting is that while most time is spent indoors, some studies indicate that approximately 65% of roadway diesel PM penetrates household ambient air.[8]

Site Specific HRA Reporting and Controversy

Report the potential cancer risk values in a clear, concise and easily understandable manner using the SMAQMD methodology described herein. The HRA report should include the input and output files in an attached appendix. See Figure 4.

Figure 4: Site Specific HRA Reporting

- Emissions input data and calculation year, if different from Table 4. The HRA should represent emission and VMT data for the first year of exposure from the most recent version of Emfac.
- List of CAL3QHCR parameters in the format of Table 5; and an explanation of sources for user-defined parameters.
- Name and source of meteorological data.
- Table indicating the varying cancer risk at 50, 100, 200, 300, 400 and 500 feet.
- Cancer risk value for receptor nearest to the edge of the closest travel lane

Alternative or supplemental analyses that differ from SMAQMD methodology should be presented in a separate section or appendix.

Any conclusions drawn from the HRA results should be based on SMAQMD methodology, or methodology otherwise endorsed in consultation with SMAQMD.

Any disagreement between SMAQMD/OEHHA recommended HRA procedure and project proponent/land use jurisdiction procedure should be thoroughly detailed in the project document or environmental report.

[7] According to the Air Toxics Hot Spots Program Risk Assessment Guidelines: The Air Toxics Hot Spots Program Guidance Manual for the Preparation of Health Risk Assessments (Guidelines) published by the Office of Environmental Health and Hazard Assessment (0EHHA), the 9-year exposure scenario coincides with the U.S. EPA's estimates of average residence time. The 9-year exposure timeframe is for the first 9 years of life and is therefore protective of children. Children have higher intake rates on a per kilogram body weight basis and thus receive a higher dose of the pollutants. The 30-year exposure timeframe coincides with the U.S. EPA's high-end estimate of residence time. The 70-year exposure timeframe is considered to be the typical lifetime. According to the Guidelines, "OEHHA recommends the 70-year exposure duration be used for determining residential cancer risks. This will ensure that the person residing in the vicinity of the facility for a lifetime will be included in the evaluation of risk posed by that facility. Exposure durations of 9-years and 30-years may also be evaluated as supplemental information to show the range of cancer risk based on residency periods." For more information, please refer to the Air Toxics Hot Spots Program Risk Assessment Guidelines: The Air Toxics Hot Spots Program Guidance Manual for the Preparation of Health Risk Assessments. August, 2003.

[8] Arlene Rosenbaum, ICF San Francisco, prepared for Ted Palma, Office of Air Quality Planning and Standards, US EPA, *Appendix B, HAPEM4 Documentation, HAPEM4 User's Guide, Hazardous Air Pollution Exposure Model, Version 4*, November 29, 2000. http://www.epa.gov/ttn/atw/sab/appendix-b.pdf. Addendum, page 5.

Exposure Reduction Practices and Features

District staff highly recommends incorporating exposure reduction features to reduce pollutant exposure for all projects contemplated within 500 feet of a freeway or major roadway.

Distance

Exposure to diesel PM and all roadway-generated pollutants is best reduced by increasing project distance from the freeway or major roadway.

Site Redesign

SMAQMD may recommend site redesign and is available to work closely with the local jurisdiction and project consultant in this effort.

For mixed use projects, the sensitive uses should be located as far from the freeway or major roadway as possible. For example, commercial uses and parking lots could be placed closest to the freeway or major roadway, and residential uses could be located furthest away. [Land uses not considered sensitive in nature include retail, services (banks, fast food, etc.) and offices.] Simple changes, such as changing the location of air intakes and ensuring that windows nearest to the freeway or major roadway do not open can help to reduce PM exposure.

Tiered Vegetative Plantings

A laboratory study measured the removal rates of particulate matter passing through leaves and needles of vegetation. Particles were generated in a wind tunnel and a static chamber and passed through vegetative layers at low wind velocities. Redwood, deodar cedar, live oak, and oleander were tested. The results indicate that all forms of vegetation *were* able to remove 65-85 percent of very fine particles at wind velocities below 1.5 meters per second (roughly 3 miles per hour) with redwood and deodar cedar being the most effective. Even greater removal rates were predicted for ultra-fine particle $< 0.1\ \mu m$ in diameter.[9]

Please note that, while this study clearly supports the effectiveness of finely needled trees along sources of toxic particulate matter as an air toxics exposure reduction practice, studies are currently underway confirm these benefits for actual roadway conditions.

> SMAQMD continues to actively support and encourage research to identify effective and quantifiable exposure reduction measures.
>
> Please contact Rachel DuBose at 916.874.4876 if you have information you'd like to share on this subject.

Other Filtering Systems and Design Considerations

Passive (drop-in) electrostatic filtering systems, especially those with low air velocities (i.e., 1mph) have been shown to help reduce PM exposure.

[9] **Removal Rates of Particulate Matter onto Vegetation as a Function of Particle Size,** Final Report to Breathe California of Sacramento-Emigrant Trails Health Effects Task Force (HETF) and Sacramento Metropolitan AQMD, Erin Fujii, Jonathan Lawton, Thomas A. Cahill, David E. Barnes, Chui Hayes (IASTE intern), Nick Spada, the DELTA Group, http://delta.ucdavis.edu, Univ. of California, Davis 95616 and Greg McPherson, the Pacific Southwest USFS Urban Forest Program, February 24, 2008

Resources and References

- The Caltrans website reports peak traffic volumes at various intersection or milepost locations for all numbered roadways in the state: http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/

- The most recent version of EMFAC is EMFAC2007, released November 2006, http://www.arb.ca.gov/msei/onroad/latest_version.htm.

- The line source dispersion model CAL3QHCR can be obtained from the EPA website: http://www.epa.gov/scram001/dispersion_prefrec.htm. User guides for employing the model can be found on the same website.

- Cancer potency factors are provided by ARB on the following website: www.arb.ca.gov/toxics/healthval/healthval.htm.

- A FAQ for the Recommended Interim Risk Management Policy for Inhalation Based Residential Cancer Risk can be found at http://www.arb.ca.gov/toxics/harp/rmpolicyfaq.htm.

- *Removal Rates of Particulate Matter onto Vegetation as a Function of Particle Size , Final Report to Breathe California of Sacramento-Emigrant Trails Health Effects Task Force (HETF) and Sacramento Metropolitan AQMD*, Erin Fujii, Jonathan Lawton, Thomas A. Cahill, David E. Barnes, Chui Hayes (IASTE intern), Nick Spada, the DELTA Group, http://delta.ucdavis.edu, Univ. of California, Davis 95616 and Greg McPherson, the Pacific Southwest USFS Urban Forest Program, February 24, 2008.

- The Appendix to this document provides more discussion of the Protocol development, including site specific roadway modeling and health risk assessment guidance. The Appendix can be found at www.AirQuality.org. You may also request a copy by contacting Rachel DuBose at 916.874.4876 or rdubose@airquality.org.

Glossary of Terms	
Ahead Peak Hour	Ahead peak hour usually represents traffic north or east of a traffic count location
Ambient Background Concentration	The annual average of PM10 already present in the air
Back Peak Hour	Back Peak Hour represents traffic south or west of a traffic count location
Calculation Averaging Time	Expressed in minutes; the most common value is 60 minutes which represents calculations of averages over one hour period
Calculational Domain	The geographical area over which a simulation (air dispersion model run) is performed
Cancer Risk Value	Potential cancer chances per million
Compass Orientation	The location of a project expressed as being located north, south, east or west of a freeway or major roadway
Concentration	The concentration of particulate matter per a measure of air, usually expressed as micrograms per cubic meter of air ($\mu g/m^3$)
Deposition Velocity	The rate at which material leaving the air is deposited on the ground (cm/s)
Dispersion	The process or result of the spreading of pollutants from one place to another
Downwind	The direction toward which the wind is blowing; in the path of pollutant dispersal
DPM	Diesel Particulate Matter
EMFAC (on-road)	ARB's on-road motor vehicle emissions model which estimates the amounts and types of pollutants emitted from on road vehicles in California
Evaluation Criterion	The point at which SMAQMD recommends performing a site specific health risk assessment
Freeway	A divided arterial highway designed for the unimpeded flow of large traffic volumes
Health Risk Assessment (HRA)	Scientific evaluation of the probability of harm resulting from exposure to toxic or hazardous materials
High Traffic/Volume Roadway	A freeway, urban road with 100,000 vehicles per day, or rural road with 50,000 vehicles per day
Incremental (cancer chances)	Cancer chances in addition to the ambient background
Inhalation Dose	The dose through inhalation (mg/kg/day)
Line Source	A source of air pollution that emanates from linear (one-dimensional) geometry, such as vehicle emissions from a roadway
Major Roadway	See "High Traffic/Volume Roadway"
Mass Emission Rate	The rate of pollutant output expressed in mass, as in grams per second (g/s)
Mixing Zone	The mixing zone is considered to be the area of uniform emissions and turbulence
MSAT	Mobile Source Air Toxic
Peak Hour Traffic	The measure of the peak traffic volume for the year
PM 10 (diesel)	An air pollutant consisting of small particles with an aerodynamic diameter less than or equal to a nominal 10 microns (about 1/7 the diameter of a single human hair). Their small size allows them to make their way to the air sacs

	deep within the lungs where they may be deposited and result in adverse health effects such as the aggravation of existing respiratory and cardiovascular disease, alterations in the body's defense systems against foreign materials, damage to lung tissue, carcinogenesis and premature death (see Toxic Air Contaminant)
Receptor	A hypothetical individual exposed to diesel particulate matter
Receptor Height	Breathing height (receptors should be placed at the standard breathing height of 6 feet)
Risk Value	The result of a health risk assessment that produces an estimate of cancer chances/million people due to exposure to diesel particulate matter
Rural Road	A roadway located in a rural area with 50,000 vehicles per day or greater
Rural Area	Per the Health and Safety Code, Section 50101: "'Rural area' means any open country or any place, town, village, or city which by itself and taken together with any other places, towns, villages, or cities that it is part of or associated with: (a) has a population not exceeding 10,000; or (b) has a population not exceeding 20,000 and is contained within a nonmetropolitan area. "Rural area" additionally includes any open country, place, town, village, or city located within a Standard Metropolitan Statistical Area if the population thereof does not exceed 20,000 and the area is not part of, or associated with, an urban area and is rural in character"
Sensitive Receptor/Land Use	Those segments of the population most susceptible to poor air quality such as children, elderly, and those with compromised immune systems. Land uses where sensitive receptors are most likely to spend time include residential communities, schools and school yards, day care centers, parks and playgrounds, hospitals and medical facilities.
Settling Velocity	The velocity of material falling towards the ground (cm/s)
Surface Roughness	A measure of the roughness of a surface and the amount of air mixing due to mechanical turbulence as air moves over surface features (cm)
Toxic Air Contaminant	As defined by California Health and Safety Code, Section 39655 (a): "an air pollutant which may cause or contribute to an increase in mortality or in serious illness, or which may pose a present or potential hazard to human health"
Upwind	In the direction from which the wind is blowing; in the path of pollutant dispersal
Unit Risk Factor	A toxicity factor that is used to estimate the increase risk of developing cancer associated exposure to a concentration of a chemical
$\mu g/m^3$	Micrograms per cubic meter of air. A measure of concentration of a pollutant
VMT	Vehicle miles traveled are total miles traveled by all vehicles in a particular geographic area, often measured over a 24-hr period