Board-Adopted Methodology (Technical Appendix) for the Mobile Sources Air Toxics Protocol

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Sacramento Metropolitan Air Quality Management District

Table of Contents

1. Introduction

Ramboll US Corporation (“Ramboll”) prepared this technical appendix document in support of the Sacramento Metropolitan Air Quality Management District (Sac Metro Air District) Mobile Sources Air Toxics Protocol (MSAT Protocol) document and its Mapping Tool. This technical appendix outlines the methodology used by Ramboll to estimate the cancer risk and $PM_{2.5}$ concentrations displayed in Sac Metro Air District’s Mapping Tool. Specifically, this appendix describes the methodologies used for roadway and railway emissions estimates, the air dispersion modeling of those emissions, and the cancer risk calculations performed.

1.1 Scope

High volume roadways, freeways, and railways within Sacramento County are sources of toxic air contaminant (TAC) emissions. The TACs of concern from railway and roadway sources are diesel particulate matter (DPM), particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) and total organic gases (TOG). DPM and TOG are considered carcinogenic, and $PM_{2.5}$ is known to be harmful to public health and the environment.

Cancer risk (from TOG and DPM exposure) and $PM_{2.5}$ concentrations resulting from the modeled roadway and railway emissions were estimated at equally spaced gridded intervals out to 2 km away from any modeled railway or roadway sources. The Mapping Tool includes all railways within the County, and Interstate 5; Interstate 80; Interstate 80 Business; US Highway 50; State Route 99; and segments of State Route 160, Sunrise Boulevard, Watt Avenue and Hazel Avenue; and all commercial tracks within and immediately adjacent to the county except SSRR and SVRR. The Mapping tool does not include stationary sources, all other roads, or existing background risk.

2. Emissions Methodology

Emissions estimation methodologies for roadway and railway sources are discussed in detail in this section.

2.1 Railway Emissions

Rail activities are typically described in terms of two different types of locomotives, line-haul and switching. Line-haul refers to locomotives that move cargo over long distances. Switching refers to locomotives that conduct short movements of rail cars, primarily in rail yards for activities such as assembling and disassembling trains and moving railroad cars over short distances. Rail emissions for the Mapping Tool were only estimated for line-haul activities, as that is the representative activity occurring on the modeled railway sections. Switching activity generally occurs only inside rail yards, or for very minimal usage along major railway sections.

The TACs of concern from railway sources are DPM and $PM_{2.5}$ from locomotive exhaust. PM_{10} (which is assumed to be all DPM) and $PM_{2.5}$ emission factors for years 2016 to 2050, in units of grams per mile, were calculated following methodology consistent with the California Air Resources Board (ARB) Vision 2.0 locomotive inventory[1] (Vision inventory).

[1] The Vision 2.0 model is available to download at http://www.arb.ca.gov/planning/vision/downloads.htm#vision2.

The Vision inventory contains emission factors specific to California's line-haul locomotive fleet which Ramboll adjusted with fuel correction factors and combined with gross-ton-mile per gallon factors to estimate PM_{10} and $PM_{2.5}$ emission rates per train-mile as described below.

The Vision inventory is a California-specific locomotive emission inventory. Ramboll extracted Sacramento-specific fleet average PM_{10} and $PM_{2.5}$ emission factors (in units of grams per gallon) from the Vision inventory. These emission factors are based on 2009 US/EPA emission factors[2], which assumes a fuel sulfur level of 3000 parts per million (ppm) for uncontrolled/Tier 0/Tier 1/Tier 2 locomotives and 500 ppm for Tier 0/1r/2r locomotives. However, a 2015 US/EPA regulation[3] requires that after 2014, all locomotive diesel fuel must be ultra-low sulfur diesel (ULSD), which has a sulfur level of 15 ppm. Consistent with the Vision inventory methodology, Ramboll applied fuel correction factors to account for ULSD effects on PM_{10} and $PM_{2.5}$ emission rates as follows:

$$FCF_{PM} = \rho_{Fuel} \times CF \times C_{SO_3} \times \left(\frac{MW_{H_2SO_4 \cdot 7H_2O}}{MW_S}\right) \times (SC_{current} - SC_{base})$$

Where:

FCF_{PM} = PM Fuel Correction Factor (g/gal)

ρ_{Fuel} = Density of diesel fuel (7.1 lbs/gal)

CF = Conversion factor to convert pounds to grams (453.6 g/lb)

C_{SO_3} = Percent of fuel sulfur to SO_3, 0.02247

MW_S = Molecular weight of sulfur (32 g/mole)

$MW_{H_2SO_4 \cdot 7H_2O}$ = Molecular weight of H_2SO_4 hydrate, 224 (g/mole)

$SC_{current}$ = Diesel sulfur content after year 2014, 15 (ppm)

SC_{base} = Base diesel sulfur content (ppm), varied by engine tier

Based on the methodology provided in the Vision Inventory, Ramboll also applied the California Diesel (CD) Adjustment Factor, which is 0.93 or a 7% reduction, to the PM_{10} and $PM_{2.5}$ emissions rates. It was assumed that 50% of the line-haul locomotives would use California diesel and 50% of locomotives would use standard US diesel; thus, a factor of 0.965 was applied to estimate CD adjusted emission rates. The fleet average emission factor is estimated as follows:

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[2] United States Environmental Protection Agency (US/EPA). 2009. Emission Factors for Locomotives. Office of Transportation and Air Quality. USEPA-420-F-09-025. Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100500B.pdf

[3] United States Environmental Protection Agency (US/EPA). 2015. Diesel Fuel Standards & Rulemakings. Last updated on September 28, 2015. Available at: https://www.epa.gov/diesel-fuel-standards/diesel-fuel-standards-rulemakings#locomotive-and-marine-diesel-fuel-standards

$$Fleet\ Average\ EF\ = (EF_{base} - FCF_{PM}) \times CD_{adj}$$

Where:

$Fleet\ Average\ EF$ = Fleet average PM_{10} or $PM_{2.5}$ emission factor (g/gal), adjusted for ULSD and CD usage.

EF_{base} = US/EPA (2009) base emission factor (g/gal)

FCF_{PM} = PM Fuel Correction Factor (g/gal)

CD_{adj} = California diesel adjustment (unitless)

Finally, the adjusted PM_{10} and $PM_{2.5}$ emission rates were converted to grams per train per distance travelled based on the total train gross-ton weight and fuel productivity factor as follows:

$$Final\ EF = \sum (Fleet\ Average\ EF) \times \frac{GTW}{FP}$$

Where:

$Final\ EF$ = PM_{10} or $PM_{2.5}$ emission factor (g/mile)

$Fleet\ Average\ EF$ = Fleet average PM_{10} or $PM_{2.5}$ emission factor (g/gal), adjusted for ULSD and CD usage.

GTW = Gross ton weight (10,000 tons[4]).

FP = Fuel Productivity Factor[5] (gross-ton miles/gal)

The modeled emission rates for each of the railway segments were calculated using the above described emission factor in grams per train per distance travelled, multiplied by the estimated number of trains traveling that railway segment. The number of trains on each railway segment was calculated based on Sacramento County line haul gross weight tonnage data provided by an industrial partner. The gross weight tonnage data for each railway segment was divided by an average train weight of 10,000 tons to estimate the total number of trains traveling that segment.

2.2 Roadway Emissions

The TACs of concern from on-road mobile sources are DPM, TOG and $PM_{2.5}$. Heavy duty truck or light duty diesel exhaust contains DPM. TOG emissions result from gasoline vehicle exhaust and fuel evaporation. $PM_{2.5}$ emissions result from roadway dust, brake wear, tire wear, and engine exhaust.

[4] Train weight was assumed to be 10,000 tons per engineering judgment.

[5] Sacramento Valley estimates, which increase by 1% per year, were taken from California Air Resources Board (ARB) Locomotive Inventory Update: Line Haul Activity. Air Quality Planning and Science. Available at: http://www.arb.ca.gov/msei/goods_movement_emission_inventory_line_haul_octworkshop_v3.pdf

Emission factors for each of the TACs of concern were calculated for years 2016 to 2050, in units of grams per mile, using emission factors from ARB's California EMission FACtor (EMFAC) 2014 database[6], along with traffic counts and traffic speeds on each section of modeled roadway.

2.2.1 Traffic Counts

Emission factors for each of the emissions pathways of concern are provided by EMFAC in units of tons per mile per car. In order to calculate the necessary emission factor of grams per mile, traffic counts on modeled roadways had to be estimated. For details on the emission factor calculations, see Section 2.2.3 of this technical appendix.

Annual average daily traffic (AADT) counts from each of the modeled roadways were gathered from the following data sources. For all modeled highways (Interstates 5 and 80, Interstate 80 Business, State Routes 50 and 99, Caltrans 2014 AADT traffic volumes were used[7]. The Caltrans dataset includes "ahead" and "back" AADT traffic count estimates for highway segments at specific mileposts or cross streets. "Ahead" AADT represents counts to the north or east of the nearest milepost location, and "back" AADT represents counts to the south or west. Ramboll allocated Caltrans AADT estimates to the modeled roadways by projecting milepost or cross street counts onto the modeled segment. If there was a discrepancy between the "ahead" and "back" AADT counts for a segment, the average between the two values was used.

Surface streets are not included in the Caltrans dataset. Traffic counts for the modeled surface streets (Hazel Ave., Watt Ave. and Sunrise Blvd.) were taken from the Sacramento Department of Transportation (Sacramento DOT) Traffic Count Program[8]. The Sacramento DOT traffic counts represent AADT counts for each direction of travel split up into segments based on major cross streets. Total AADT for each modeled roadway was allocated by projecting the total Sacramento AADT counts (both directions of travel summed together) at each cross street to the modeled segments.

2.2.2 Traffic Speeds

In order to accurately estimate emissions from major roadways, traffic speeds must also be estimated due to the variability of vehicle emission factors with speed. In general, as the speed of a vehicle increases, emission factors decrease.

To estimate the speeds at which vehicles are traveling on each of the modeled roadway segments, Ramboll relied on an hourly travel speed dataset provided by Sac Metro Air District. This dataset was compiled from the National Performance Monitoring Research Dataset (NPMRDS) by HERE inc. under contract to the Federal Highway Administration, and contains annual average 7-day directional hourly speeds from calendar year 2015 for all roadways in the modeling domain[9]. The hourly speeds

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[6] Available online at: https://www.arb.ca.gov/emfac/2014/

[7] California Department of Transportation. Traffic Volumes (AADT). Available online at: http://www.dot.ca.gov/hq/tsip/gis/datalibrary/Metadata/AADT.html

[8] Sacramento County. Traffic Count Program. Available online at: http://www.sacdot.com/Pages/TrafficCountProgram.aspx. Accessed July 15th, 2016.

[9] SACOG 2017, based on the National Performance Monitoring Research Dataset (NPMRDS), provided by HERE, Inc. under contract to the Federal Highway Administration. More details on the NPMRDS can be found online here: https://ops.fhwa.dot.gov/freight/freight_analysis/perform_meas/vpds/npmrdsfaqs.htm

in this dataset were estimated based on 5-minute GPS speed data. The hourly speed profile on each modeled roadway was assumed be constant for each year from 2016-2050.

Due to the hourly scope of the HERE speed data, hourly traffic counts also had to be estimated to accurately utilize EMFAC's speed-based emission factors. To estimate hourly traffic counts, Ramboll relied on Caltran's 7-day average PEMS hourly traffic counts for all of the modeled highways[10]. PEMS data can only be gathered in three-month increments. Thus, Ramboll gathered PEMS traffic counts from March 2015 through May 2015 for all modeled highways. Any surface streets in the modeling domain (Watt Avenue, Hazel Avenue and Sunrise Boulevard) are not included as part of the PEMS dataset. For these roadways, Sac Metro Air District provided Ramboll a 2012 hourly traffic count dataset from the Sacramento Area Council of Governments (SACOG)[11]. Ramboll used the hourly traffic counts from these two data sources to scale the Caltrans AADT values on each modeled roadway down to hourly traffic counts for use in emission factor calculations.

2.2.3 Emission Factors

Using all of the above data and ARB's EMFAC 2014 database, emission factors for each of the TACs of concern were calculated for years 2016 to 2050, in units of grams per mile according to the following methodology.

All of the modeled roadways were assumed to contain vehicles traveling at speed from point A to point B. Thus, only applicable types of on-road vehicle emitting activities were considered (i.e. some EMFAC emission types do not occur on the modeled roadways, or are assumed to be negligible, such as starting emissions or diurnal hot soak evaporative emissions). These activities include exhaust emissions (DPM, TOG and $PM_{2.5}$), running loss evaporative emissions (TOG), brake wear and tire wear emissions ($PM_{2.5}$), and fugitive dust emissions ($PM_{2.5}$).

Exhaust Emission Factors

The exhaust emissions are the dominant activity occurring on modeled roadways, and is the only emission type where the speed of travel affects the emission factor magnitude. The online EMFAC 2014 database was run for the Sacramento Metropolitan Air District region for years 2016-2050 using EMFAC2011 categories, aggregated model years, all fuels and all speeds.

Exhaust emission factors were obtained from EMFAC for each pollutant of concern (DPM, TOG and $PM_{2.5}$) in tons per mile per car for all speeds and all years. Emission factors for each modeled roadway were then calculated in grams per mile by selecting the applicable exhaust emission factor for each hour's directional speed, then multiplying that emission factor by the direction hourly traffic count.

[10] California Department of Transportation. PeMS. Available online at: http://pems.dot.ca.gov/. Data was gathered for each freeway by navigating to the Sacramento County page, selecting the freeway of interest, then navigating to the following pathway: Performance > Spatial Analysis > Hourly Summary Flow.

[11] SACOG Staff. 2012 highway network used in SACOG traffic demand model. Published in 2016. Data available by request.

All Other Emission Factors

The running loss evaporative, brake wear and tire wear, and fugitive dust emissions pathways do not depend on the speed that a vehicle is traveling. Thus, a separate EMFAC 2014 dataset was used. The EMFAC 2014 database was run using the same parameters as above, but with aggregated speeds.

For all emission pathways except fugitive dust, emission factors for modeled roadways were calculated by using the EMFAC emission factors in tons per mile per car for each year, then multiplying by the AADT on each modeled roadway link.

EMFAC includes emission factors for all pathways except fugitive dust. To estimate fugitive dust emissions from the modeled roadways, calculations were conducted outside of EMFAC using AP-42's paved roads fugitive dust equation according to the following methodology:

A county-wide $PM_{2.5}$ emission factor in lb/mile was calculated using equation 2 from AP-42 section 13.2.1[12]:

$$E = k*(sL)^{0.91} * (W)^{1.02} * (1-P/4N)$$

Where E is the particulate emission factor in lb/mile, k is the particle size multiplier (from AP-42 Table 13.2.1-1: 0.00054 lb/mile), sL is the road surface silt loading in g/m2 (from AP-42 Table 13.2.1-2: 0.03 g/m2), W is the average weight in tons of all vehicles on the road (from CalEEMod Appendix D[13], table 4.1: 2.4 tons), P is the number of wet days with at least 0.01 inches of precipitation (from CalEEMod Appendix D, table 1.1: 58 days) during the averaging period (N=365) in Sacramento County.

This fugitive $PM_{2.5}$ emission factor is assumed to be constant over all years of the analysis (2016-2050). To calculate the final fugitive emission factor in the appropriate units of grams per mile, the AP-42 emission factor was multiplied by the AADT on each modeled roadway.

3. Estimated Air Concentrations Methodology

As mentioned in Section 2, above, the chemicals emitted from roadway and railways within Sacramento County include DPM, TOG and $PM_{2.5}$. These TAC emissions will be transported (dispersed) away from the railways and roadways, potentially impacting nearby receptors. In order to estimate health impacts from exposure to these chemicals, chemical concentrations must be estimated at potential nearby receptor locations. To do so, air dispersion of TAC emissions was estimated.

The most recent version of AERMOD (Version 15181) was used to evaluate air concentrations of DPM, TOG and $PM_{2.5}$ at receptors potentially impacted by roadway and railway emissions. For each receptor location, the model generates air concentrations that result from emissions from multiple sources. Air dispersion models such as AERMOD require a variety of inputs such as meteorological

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[12] United States Environmental Protection Agency. AP-42 Section 13.2.1 Paved Roads. Available online at: https://www3.epa.gov/ttnchie1/ap42/ch13/final/c13s0201.pdf

[13] California Air Pollution Control Officers Association (CAPCOA). 2016. California Emissions Estimator Model Appendix D Default Data Tables. Available online at: http://www.aqmd.gov/docs/default-source/caleemod/upgrades/2016.3/05_appendix-d2016-3-1.pdf?sfvrsn=2

conditions, topographical information, emission rates, source parameters, and receptor parameters. Each of these required inputs are discussed in more detail below.

3.1 Meteorological Data

Air dispersion modeling requires the use of meteorological data that ideally are spatially and temporally representative of conditions in the immediate vicinity of the site under consideration. Ramboll used surface and upper air meteorological data from the Sacramento Executive Airport for years 2011 through 2015.

3.2 Terrain Considerations

Elevation and land use data were imported from the National Elevation Dataset (NED) maintained by the United States Geological Survey[14]. An important consideration in an air dispersion modeling analysis is the selection of whether or not to model an urban area. Here, the model assumes rural land use for all modeled roadways. This is an accurate assumption for much of the county. For the more urban areas in Sacramento, it is a conservative assumption since the rural option does not include the enhanced buoyancy associated with the urban heat island.

3.3 Source Parameters

Source locations and release parameters are necessary to model the dispersion of air emissions from roadway and railway sources. Ramboll modeled all roadways and railways in the modeling domain using the AERMOD "LINE" source type. The LINE source type allows the modeling of line-type sources using a start-point and end-point of the line, the elevation of the source above sea level, the emission rate in g/(s-m^2), the release height of the emissions, the width of the line and the initial vertical dimension. This source type is similar to the AERMOD "AREA" source type, and will give identical results with equivalent inputs[15]. Additionally, to take into account the diurnal pattern of traffic volumes (high volumes during rush hour and during the day, with low volumes overnight), Ramboll utilized the AERMOD EMISFACT option which allows for modeling of variable emission rates.

3.3.1 Roadway Source Parameters

All roadway segments in the modeling domain were modeled as LINE sources. The modeled roadway locations were determined using GIS mapping software. In order to utilize the LINE source type, the modeled source must be represented as a rectangle (i.e. the source must be a straight line). Thus, the modeled roadways were segmented into 893 straight line segments for modeling purposes.

Source Location, Elevation and Width

The start-point and end-points of the LINE sources were determined using GIS, and the elevation of each source was determined using elevation data from the National Elevation Dataset[16]. Due to the large volume of modeled roadway segments, Ramboll assumed a constant roadway width of 24

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[14] United States Geological Survey (USGS). 2013. National Elevation Dataset. Available at: https://viewer.nationalmap.gov/advanced-viewer/.

[15] United States Environmental Protection Agency. 2015. USER'S GUIDE FOR THE AMS/EPA REGULATORY MODEL - AERMOD. Available for download at: https://www3.epa.gov/ttn/scram/models/aermod/aermod_userguide.zip

[16] United States Geological Survey (USGS). 2013. National Elevation Dataset. Available at: https://viewer.nationalmap.gov/advanced-viewer/.

meters for modeling purposes. This modeling width is based on the assumption that all roadways are modeled as three lane highways with 3 meter lanes (18 meters total). To account for vehicle turbulence, 3 meters were added to either side of the roadway (24 meters total), consistent with the US/EPA's Haul Road Workgroup Report[17].

Release Heights and Initial Vertical Dimension

As has been mentioned previously, the three TACs of concern from roadways are DPM, TOG and $PM_{2.5}$. In general, DPM emissions are driven by heavy duty truck emissions, and TOG and $PM_{2.5}$ emissions are driven by passenger vehicles. In order to reflect this in the dispersion model, a heavy duty truck exhaust release height of 4.57 meters was used for modeling of DPM emissions and a passenger vehicle exhaust release height of 0.6 meters was used for TOG and $PM_{2.5}$ emissions. The heavy duty truck exhaust release height is based on the Oakland Army Base Redevelopment Plan EIR Appendix A: Air Quality and Greenhouse Gas Emissions Model Outputs[18]. The passenger vehicle exhaust release height is based on a year 2000 ARB study "Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles", where ARB modeled an idling school bus with an exhaust release height of 0.6m[19].

The initial vertical dimensions for all pollutants is calculated consistent with AERMOD guidance for an elevated source not on or adjacent to a building, i.e. release height/4.3.

AERMOD EMISFACT Option

To take into account the diurnal profile of on-road traffic emissions, Ramboll modeled the roadways using a pollutant specific EMISFACT profile. To do so, Ramboll calculated hourly emissions on each modeled roadway link consistent with the methodology outlined above in Section 2.2. The average hourly emission rate was then calculated for each pollutant. An hourly diurnal profile was calculated for each pollutant and roadway link by scaling each hour's emissions relative to the average hourly emission rate.

3.3.2 Railway Source Parameters

Similar to the roadway modeling, all railway segments in the modeling domain were modeled as LINE sources, and the modeled railway locations were determined using GIS mapping software. Like the roadway modeling, in order to utilize the LINE source type, the modeled source must be represented

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[17] United States Environmental Protection Agency. 2012. Haul Road Workgroup Final Report Submission to EPA-OAQPS. Available online at: https://www3.epa.gov/scram001/reports/Haul_Road_Workgroup-Final_Report_Package-20120302.pdf

[18] City of Oakland. Oakland Army Base Redevelopment Plan EIR Appendix A: Air Quality and Greenhouse Gas Emissions Model Outputs. Available online at: http://www2.oaklandnet.com/Government/o/PBN/OurServices/Application/DOWD009157

[19] Air Resources Board (ARB). 2000. Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles. Available online at: https://www.arb.ca.gov/diesel/documents/rrpapp.htm. This release height was also recommended by ARB for a previous Ramboll project. See page 4-12 in Section 4.3.4 of a report found online at: https://www.arb.ca.gov/railyard/hra/env_sb_admrpt.pdf.

as a rectangle (i.e. the source must be a straight line). Thus, the modeled railways were segmented into 1355 straight line segments for modeling purposes.

Source Location, Elevation and Width

The start-point and end-points of the LINE sources were determined using GIS, and the elevation of each source was determined using elevation data from the National Elevation Dataset[20]. Due to the large volume of modeled railway segments, Ramboll assumed a constant railway width of 8 meters based on the assumption of one 3-meter-wide track in each direction, with a 2-meter gap between the tracks. These width assumptions are based on aerial imagery of railway segments within Sacramento County.

Release Heights and Initial Vertical Dimension

Ramboll used a release height of 5 meters for the railway sources, consistent with the South Coast Air Quality Management District Localized Significance Thresholds Methodology[21]. Similar to the roadway portion of the Mapping Tool model, the initial vertical dimensions for railway sources is calculated consistent with AERMOD guidance for an elevated source not on or adjacent to a building, i.e. release height/4.3.

3.3.3 Emission Rates

The AERMOD LINE source object used to represent both roadway and railway sources requires an input of an emission rate in the units of g/(s-m^2). Typically, for area and line sources, Ramboll uses area normalized unit emission rates when conducting air dispersion modeling (i.e. 1/area g/s). When unit emissions are modeled, the resultant AERMOD concentration at each receptor location is called the air dispersion factor, and is expressed in units of (µg/m^3)/(g/s). The resultant dispersion factor can then be simply multiplied by the annual average pollutant emission rate (in g/s) from the modeled area or line source to calculate the actual estimated air concentration in µg/m^3.

However, due to the large number of modeled sources in this modeling domain, each with a different line length, modeling an area normalized unit emission rate is no longer computationally simple; there would be thousands of unique unit emission rates to model which is cumbersome to add to a text based AERMOD input file.

To overcome this challenge, Ramboll modeled all line sources using a width normalized unit emission rate (i.e. 1/width g/s-m). This results in AERMOD dispersion factors with the units of (µg/m^3)/(g/s-m). The emissions that were calculated for railway and roadway sources (see Section 2 of this Technical Appendix) are in the units of g/mile based on annual average daily traffic counts, which can be converted to g/s-m. This allows Ramboll to calculate actual pollutant concentrations in µg/m^3 from the AERMOD dispersion factors, by multiplying by each pollutant's actual emission rate in g/s-m. Thus,

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[20] United States Geological Survey (USGS). 2013. National Elevation Dataset. Available at: https://viewer.nationalmap.gov/advanced-viewer/.

[21] South Coast Air Quality Management District. Localized Significance Thresholds. Available online at: http://www.aqmd.gov/home/regulations/ceqa/air-quality-analysis-handbook/localized-significance-thresholds

Ramboll modeled all railway sources with a width normalized unit emission rate of 1/8, and all roadway sources with a width normalized unit emission rate of 1/24.

3.4 Receptor Parameters

AERMOD calculates dispersion of air pollutants at discrete points known as “receptors” specified during model set-up. Ramboll created a uniform grid of receptors extending 2 km away from any modeled roadway or railway source. The receptors are spaced at intervals of 20m by 20m, and are modeled at a height of 1.8 meters above terrain height, as recommended in BAAQMD guidance[22]. Average annual chemical concentrations are estimated for each receptor location.

4. Risk Characterization Methods

Potential health impacts from roadway and railway DPM, TOG and $PM_{2.5}$ emissions are evaluated at all modeled receptors. $PM_{2.5}$ is considered harmful to public health, but due to the complexity of $PM_{2.5}$ as a pollutant, no toxicity values are currently approved for health calculation purposes by OEHHA. Thus, $PM_{2.5}$ health impacts are reported in the Mapping Tool simply as a concentration in ug/m^3. DPM and TOG are carcinogenic substances, and have known toxicities. Thus, an estimate of potential cancer risk impacts can be calculated for exposure to these chemicals. All cancer risk calculations are conducted consistent with the 2015 California Environmental Protection Agency Office of Environmental Health Risk Assessment (OEHHA) guidance, and are discussed in detail below[23].

4.1 Exposure Assumptions

All receptors in the modeling domain were conservatively assumed to be residents as defined by the OEHHA guidance. The resident exposure parameters used in the cancer risk calculations are presented in Table 1 and were obtained using risk assessment guidelines from OEHHA (2015) and draft guidelines from the BAAQMD that indicate how the BAAQMD would integrate the 2015 OEHHA Guidelines[24]. Residents were assumed to be present at one location for a 30-year period. Ramboll selected conservative exposure parameters assuming that exposure would begin during the third trimester of a residential child’s life, and used OEHHA’s 95^{th} percentile breathing rates up to age 2, and 80^{th} percentile breathing rates above age 2. Based on the TACs considered, the only relevant exposure pathway is inhalation, so the Mapping Tool considers inhalation exposure only.

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[22] BAAQMD. 2012. Recommended Methods for Screening and Modeling Local Risks and Hazards. May. Available at: http://www.baaqmd.gov/~/media/Files/Planning%20and%20Research/CEQA/Risk%20Modeling%20Approach%20May%202012.ashx?la=en

[23] Cal/EPA. 2015. Air Toxics Hot Spots Program. Risk Assessment Guidelines. Guidance Manual for Preparation of Health Risk Assessments. Office of Environmental Health Hazard Assessment (OEHHA). February. Available online at: http://oehha.ca.gov/air/hot_spots/hotspots2015.html.

[24] BAAQMD. 2016. Proposed Health Risk Assessment Guidelines. Air Toxics NSR program. January. Available at: http://www.baaqmd.gov/~/media/files/planning-and-research/rules-and-regs/workshops/2016/reg-2-5/hra-guidelines_clean_jan_2016-pdf.pdf?la=en

4.2 Calculation of Intake

The dose estimated for each exposure pathway is a function of the concentration of a chemical and the intake of that chemical. The intake factor for inhalation, IF_{inh}, can be calculated as follows:

$$IF_{inh} = \frac{DBR * FAH * EF * ED * CF}{AT}$$

Where:

IF_{inh}	= Intake Factor for Inhalation (m^3/kg-day)
DBR	= Daily Breathing Rate (L/kg-day)
FAH	= Fraction of Time at Home (unitless)
EF	= Exposure Frequency (days/year)
ED	= Exposure Duration (years)
AT	= Averaging Time (days)
CF	= Conversion Factor, 0.001 (m^3/L)

The chemical intake or dose is estimated by multiplying the inhalation intake factor, IF_{inh}, by the chemical concentration in air, C_i.

4.3 Toxicity Assessment

The toxicity assessment characterizes the relationship between the magnitude of exposure and the nature and magnitude of adverse health effects that may result from such exposure. The health risk impact of concern for exposure to railway and roadway TACs is incremental increased cancer risk. Toxicity values used to estimate the likelihood of adverse effects occurring in humans at different exposure levels are identified as part of the toxicity assessment component of a risk assessment.

Potential excess lifetime cancer risk calculations for exposure to railway and roadway emissions utilized the toxicity values for DPM and for the carcinogenic TACs from speciated gasoline TOGs. TOG emissions from roadways are split into these individual toxic components using BAAQMD recommended gasoline speciations[25]. The recommended TOG speciation for gasoline engine exhaust is different from the TOG speciation for gasoline evaporative losses, so two gasoline TOG speciation profiles were used. The cancer risk attributed to a chemical is calculated by multiplying the chemical intake or dose at the human exchange boundaries (e.g., lungs) by the chemical-specific cancer potency factor (CPF).

Speciation profiles used in this analysis are provided in Table 2. Toxicity values are as presented in Table 3. The TACs of concern have inhalation health effects only.

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[25] BAAQMD. 2012a. Recommended Methods for Screening and Modeling Local Risks and Hazards. May. Available at: http://www.baaqmd.gov/~/media/Files/Planning%20and%20Research/CEQA/Risk%20Modeling%20Approach%20May%202012.ashx?la=en

4.4 Age Sensitivity Factors

The estimated excess lifetime cancer risks for residents was adjusted using the age sensitivity factors (ASFs) recommended in the Cal/EPA OEHHA Hot Spots Guidance[26]. This approach accounts for an "anticipated special sensitivity to carcinogens" of infants and children. Cancer risk estimates are weighted by a factor of 10 for exposures that occur from the third trimester of pregnancy to two years of age and by a factor of three for exposures that occur from two years through 15 years of age. No weighting factor (i.e., an ASF of one, which is equivalent to no adjustment) is applied to ages 16 and above. Table 4 shows the ASFs used for the residents.

4.5 Estimation of Cancer Risks

Excess lifetime cancer risks are estimated as the upper-bound incremental probability that an individual will develop cancer over a lifetime as a direct result of exposure to potential carcinogens. The estimated risk is expressed as a unitless probability. The cancer risk attributed to a chemical is calculated by multiplying the chemical intake or dose at the human exchange boundaries (e.g., lungs) by the chemical-specific CPF.

The equation used to calculate the potential excess lifetime cancer risk for the inhalation pathway is as follows:

$$Risk_{inh} = C_i \times CF \times IF_{inh} \times CPF \times ASF$$

Where:

$Risk_{inh}$	= Cancer Risk; the incremental probability of an individual developing cancer as a result of inhalation exposure to a particular potential carcinogen (unitless)
C_i	= Annual Average Air Concentration for chemical i (µg/m^3)
CF	= Conversion Factor (mg/µg)
IF_{inh}	= Intake Factor for Inhalation (m^3/kg-day)
CPF_i	= Cancer Potency Factor for chemical i (mg chemical/kg body weight-day)$^{-1}$
ASF	= Age Sensitivity Factor (unitless)

[26] Cal/EPA. 2015. Air Toxics Hot Spots Program. Risk Assessment Guidelines. Guidance Manual for Preparation of Health Risk Assessments. Office of Environmental Health Hazard Assessment (OEHHA). February. Available online at: https://oehha.ca.gov/air/crnr/notice-adoption-air-toxics-hot-spots-program-guidance-manual-preparation-health-risk-0