Appendix F - Health Risk Assessment Method

Potential health risks were estimated in accordance with the guidance provided by the 2015 California Office of Environmental Health Hazard Assessment's (OEHHA) "Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments" (Guidance). As discussed in the Guidance, health risk assessment process generally consists of four parts: hazard identification, exposure assessment, dose response assessment, and risk characterization.

Hazard Identification. Hazard identification involves determining the existence of a hazard and, if present, whether the substance of concern is a potential human carcinogen or associated with other adverse health effects in humans. For this study, twelve air toxic substances have been identified as toxic air contaminants (TACs) by the OEHHA/CARB under the Assembly Bill (AB) 1807 Toxic Air Contaminant Identification and Control Program. These substances include diesel particulate matter (DPM), five heavy metals (cadmium, hexavalent chromium, lead, arsenic, and nickel), and six toxic reactive volatile organic compounds (VOCs) - benzene, 1,3-butadiene, formaldehyde, acetaldehyde, perchloroethylene, and p-dichlorobenzene.

Exposure Assessment. The purpose of exposure assessment is to estimate the extent of public exposure to a toxic substance. This involves quantifying emissions from a source, modeling environmental transport and fate, and estimating exposure levels over a specific period. In this study, annual averages of the air toxics of concern were estimated using air quality modeling techniques. CALPUFF was used to model inert DPM and the five toxic heavy metals, while CMAQ was utilized to simulate the six reactive toxic VOCs.

Dose-Response Assessment. Dose-response assessment involves characterizing the relationship between exposure to a toxic substance (such as DPM) and the incidence of adverse health effects in an exposed population (OEHHA, 2015). For assessing cancer risk, the dose-response is expressed in terms of a potency slope known as a cancer potency factor (CPF). CPFs are used to calculate the probability of cancer risk associated with exposure to a carcinogen. CPFs represent the 95th percentile upper confidence limit of the dose-response curve, assuming continuous lifetime exposure to a substance at a dose of one milligram per kilogram of body weight per day $[mg/kg/d]^{-1}$.

For this study, the dose-response estimates developed by OEHHA were used to estimate the potential for adverse health effects from chronic exposures. It's important to note that these estimates differ from those developed by the U.S. EPA. For example, OEHHA has developed a cancer potency factor for diesel exhaust, while the U.S. EPA has chosen not to do so. The risk associated with diesel exhaust, calculated using OEHHA's cancer potency factor, is the primary contributor to the overall air toxics cancer risk in this state.

The dose of a toxic substance through inhalation can be calculated as follows:

$$\textbf{Dose-air} = C_{AIR} \times \textbf{DBR} \times \textbf{A} \times \textbf{EF} \times \textbf{CF} \quad (1)$$

where:

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

Cair = Concentration in air (μg/m^3)

DBR = BR/BW = Daily breathing rate normalized to body weight (L/kg body weight-day)

A = inhalation absorption factor (1 for DPM, unitless)

EF = exposure frequency (unitless) (350 days/365 days)

CF = 10^{-6}, correction factor, micrograms to milligrams conversion, liters to cubic meters conversion

Note that for residential exposure, breathing rates are determined for specific age groups. Therefore, the inhalation dose (Dose-air) is calculated for each of these age groups: 3rd trimester, 0 to 2 years, 2 to 9 years, 2 to 16 years, 16 to 30 years, and 16 to 70 years. These age-specific groupings are necessary to accurately apply age sensitivity factors for cancer risk assessment.

Risk Characterization. In this step, information from the exposure assessment is combined with information from the dose-response assessment to characterize risks to the public from emissions. The potential cancer risk is calculated by multiplying the daily inhalation or oral dose by a cancer potency factor, an age sensitivity factor, the frequency of time spent at home (for residents only), and the exposure duration divided by the averaging time. This calculation yields the excess cancer risk.

For residential inhalation exposure, the excess cancer risk is calculated separately for each age group and then summed to determine the overall cancer risk at the receptor locations. The cancer risk due to all pollutants is the sum of the cancer risks for each individual pollutant.

It's important to note that a 30-year exposure duration with the Risk Management Policy (RMP) method is used for assessing potential cancer risk, specifically for inhalation exposure. The RMP method assumes a 95th percentile breathing rate for children from the last trimester through age 2, and an 80th percentile daily breathing rate for other age groups.

The potential cancer risk for a specific substance is expressed as the incremental number of potential cancer cases that could occur per million people, assuming that the population is exposed to the substance at a constant annual average concentration over a presumed 30-year period. These risks are typically presented as chances per million. For example, if the incremental air toxics cancer risks were estimated to be 100 per million, it means that the probability of an individual developing cancer due to lifetime exposure would be increased by 100 cases in a million people above the background levels of cancer risk (based on other factors such as age, diet, genetics, etc.). This estimation predicts an additional 100 cases of cancer in a population of one million people over a 70-year lifetime period.

The equation used to calculate inhalation cancer risk is as follows:

$$\textbf{Risk}_{\text{INH-Res}} \textbf{ (chances per million) = Dose-air × CPF × ASF × ED/AT × FAH × CCF} \quad (2)$$

where:

Dose-air = Daily inhalation dose (mg/kg/day, see equation (1))

CPF = Cancer potency factor $(\text{mg/kg-day})^{-1}$

ASF = Age sensitivity factor (unitless)

ED = Exposure duration (years)

AT = Averaging time for lifetime cancer risk (years)

FAH = Fraction of time spent at home (unitless)

CCF = 10^6, cancer conversion factor to represent risk in chances per million

Specifically, the following two equations are used to calculate the 30-year exposure risk and the 70-year exposure risk, respectively:

30-Year Exposure Risk Calculation:

RISK inh-res = (Dose-air third trimester × CPF × 10 × 0.25/70 years × FAH3rd tri <2) + (Dose-air age 0<2 × CPF × 10 × 2/70 × FAH3rd tri <2) + (Dose-air age 2<16 × CPF × 3 × 14/70 × FAH2<16) + (Dose-air age 16<30 × CPF × 1 × 14/70 years × FAH16-30) (3)

70-Year Exposure Risk Calculation:

RISK inh-res = (Dose-air third trimester × CPF × 10 ×0.25/70 years× FAH3rd tri <2) + (Dose-air age 0<2 × CPF × 10 × 2/70 × FAH3rd tri <2) + (Dose-air age 2<16 × CPF × 3 × 14/70 × FAH2<16) + (Dose-air age 16<70 × CPF × 1 × 54/70 years × FAH16-70) (**4**)

The Cancer Potency Factors (CPFs) for the toxic species included in this study are provided in Table F-1. The exposure parameters necessary for calculating cancer risk, as mentioned earlier, are provided in Table F-2.

Table F-1. OEHHA Cancer Potency Factors and Unit Risk Factors for TACs used in this study.

Substance	Chemical Abstract number	Inhalation Unit Risk $(\mu g/m^3)^{-1}$	Inhalation Cancer Potency Factor $(mg/kg\text{-}d)^{-1}$
ACETALDEHYDE	75-07-0	2.7E-06	1.0E-02
ARSENIC	7440-38-2	3.3E-03	1.2E+01
BENZENE	71-43-2	2.9E-05	1.0E-01
1,3-BUTADIENE	106-99-0	1.7E-04	6.0E-01
CADMIUM	7440-43-9	4.2E-03	1.5E+01
CHROMIUM 6+	18540-29-9	1.5E-01	5.1E+02
p-DICHLOROBENZENE	106-46-7	1.1E-05	4.0E-02
DIESEL EXHAUST	9901	3.0E-04	1.1E+00
FORMALDEHYDE	50-00-0	6.0E-06	2.1E-02
LEAD	7439-92-1	1.2E-05	4.2E-02
NICKEL	7440-02-0	2.6E-04	9.1E-01
PERCHLOROETHYLENET	127-18-4	6.1E-06	2.1E-02

Table F-2. Exposure parameters used in risk calculation.

		Age Group				
Parameter	**Abbr.**	**3rd Tri**	**0<2**	**2<16**	**16<30**	**16<70**
Daily Breathing Rate (mg/kg/day)	DBR	361	1,090	572	261	233
Inhalation Absorption Factor (unitless)	A	1.0	1.0	1.0	1.0	1.0
Exposure Frequency (unitless)	EF	0.96	0.96	0.96	0.96	0.96
Age Sensitivity Factor (unitless)	ASF	10	10	3	1	1
Exposure Duration (years)	ED	0.25	2	14	14	54
Averaging Time for Lifetime (years)	AT[1]	70	70	70	70	70
Fraction of Time at Home (unitless)	FAH	1	1	1	0.73	1

Source: Extracted from OEEHA 2015, only inhalation pathway is considered.

The cancer burden can be determined by multiplying the cancer risk at the centroid of a census block (tract) by the population residing in that census block (tract). In this study, a 70-year exposure period is utilized to estimate the potential cancer burden.

The outcome of this calculation is a single value that aims to estimate the number of potential cancer cases within the population that has been exposed to the emissions for a lifetime of 70 years. For instance, if 10,000 individuals are exposed to DPM at a concentration resulting in a cancer risk of 1×10-5 within a census tract for their entire lifetime, the cancer burden would be 0.1. Similarly, if 100,000 people are exposed to a 1×10-5 risk, the cancer burden would be 1.

[1] Although AT actually sums to 70.25 years when the 3rd trimester (0.25 years) is included, OEHHA recommends rounding AT = 70 years (and rounding residential exposure durations at 9-and 30-years rather than 9.25-and 30.25-years) to simplify the calculation without causing a significant adjustment. Note that the dose for the 3rd trimester is based on the breathing rate of pregnant women using the assumption that the dose to the fetus during the 3rd trimester is the same as that to the mother.