Appendix C

IDLING DIESEL SCHOOL BUS HEALTH RISK ASSESSMENT METHODOLOGY

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Introduction

This appendix presents the methodology used to estimate the potential cancer risk from exposure to particulate matter (PM) from idling diesel school buses. This methodology was developed to assist in the development of the Airborne Toxic Control Measure to Limit School Bus Idling and Idling at Schools (Idling School Bus ATCM). The assumptions used to determine these risks are not based on a specific school bus unloading/loading site. Instead, source parameters that bracket a broad range of possible operating scenarios were used. These estimated risks are used to provide an approximate range of potential risk levels near school bus loading/unloading areas. Actual risk levels will vary due to site specific parameters, including the number of buses, emission rates, operating schedules, site configuration, site meteorology, and distance to receptors.

Source Description

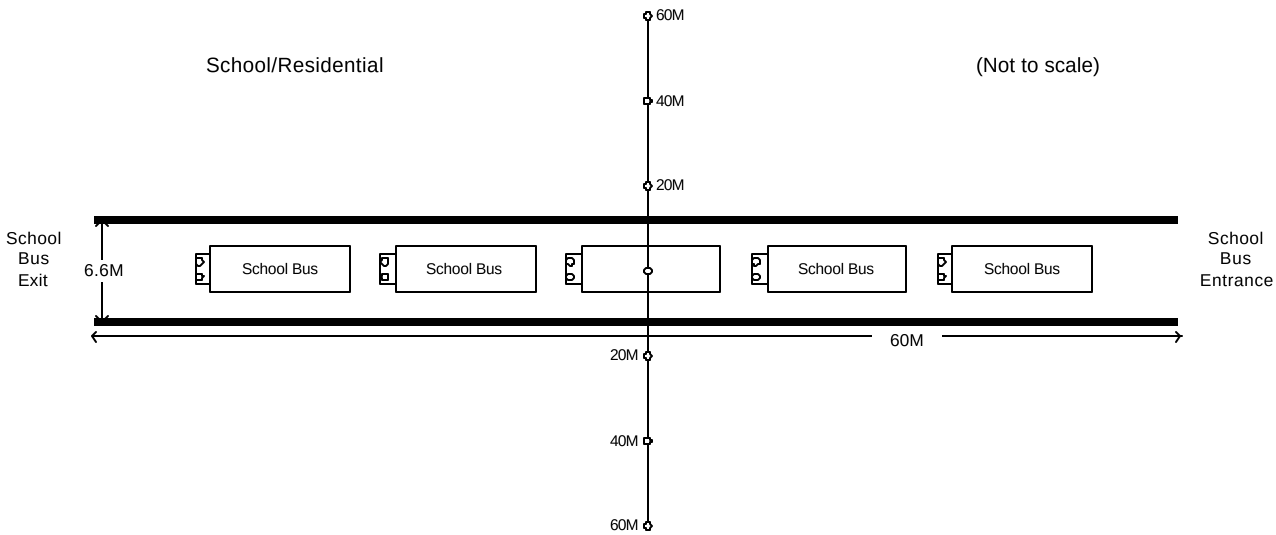
Staff developed a generic scenario to represent idling diesel-fueled school buses during student pick-up and drop-off at the school. Exposures were estimated for children who use a bus for transportation to and from the school, for teachers working at the school, and for residents who live nearby the school. The methodology used in this risk assessment is consistent with the Tier-1 analysis presented in the draft Office of Environmental Health Hazard Assessment (OEHHA), Air Toxics Hot Spots Program Risk Assessment Guidelines: The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments (OEHHA, 2002).

The OEHHA draft guidelines and this assessment use health and exposure assessment information that is contained in the Air Toxics Hot Spot Program Risk Assessment Guidelines, Part II, Technical Support Document for Describing Available Cancer Potency Factors (OEHHA 1999); and the Air Toxics Hot Spot Program Risk Assessment Guidelines, Part IV, Technical Support Document for Exposure Analysis and Stochastic Analysis (OEHHA 2000).

Modeling Assumptions

Staff modeled three school bus student pick-up zone configurations, with each configuration accommodating a different number of 78-passenger buses – 1, 5, or 10. All three zones are 6.6 meters wide. The zone for the one-school-bus model is 12 meters in length, for the five-school-bus model the zone is 60 meters in length, and for the ten-school-bus model the zone is 120 meters in length. The school buses are evenly spaced and placed end-to-end, as depicted in Figure 1 for the five-bus case. Staff considered only the emissions due to idling in the pick-up zone and assumed the buses would reside in their zone twice a day (once for drop-off between 8 to 9 a.m. and once for pick-up at 2 to 3 p.m.). Staff also incorporated the school schedule of 180 days per year. The buses in each configuration (one, five, or ten buses) were modeled to idle for both two and twenty minutes total per day (1 or 10 minutes each during the morning and afternoon). Two sets of meteorological data were used – West Los Angeles and Sacramento – to encompass the range of meteorological conditions in the State. In each case, two orientations were also considered in the modeling, buses pointing north-south and east-west, to reflect potential differences due to meteorology such as wind direction. Receptors were placed along parallel lines on each side of the buses located 20, 40 and 60 meters from an imaginary line bisecting lengthwise the designated loading and unloading area. These different distances were chosen to reflect potential locations for children either waiting for the bus, playing in the school yard or in the classroom, teachers at the school and residents in homes located near the bus loading and unloading zone. The estimated risks are based on the orientation producing the highest diesel PM concentration identified by air dispersion modeling along these lines.

Figure 1: Loading and Unloading of Students from School Buses – Five-Bus Case



Model Used

The PM emissions are modeled in this scenario using the United States Environmental Protection Agency's Industrial Source Complex Short Term Model – Version 3 (ISCST3 Version 00101). ISCST3 is an air dispersion model that allows an estimation of the annual average above-ambient diesel PM concentrations.[1] The potential cancer risk to receptors is obtained by multiplying annual average above-ambient concentration of diesel PM by the unit risk factor (URF) for diesel PM (300 excess cancers/ug/m^3 over a 70-year exposure period). The results are expressed as an estimate of potential cancer risk in chances per million.

[1]The pollutant concentrations obtained from this modeling exercise that are used to estimate cancer risk do not include the background (or ambient) levels of the modeled pollutant. The final risk value is determined by multiplying the modeled pollutant concentration by the Unit Risk Factor (URF), as determined by ARB and the Office of Environmental Health Hazard Assessment (OEHHA).

Residents were assumed to have a 70-year exposure period. For school children and teachers staff assumed 9-year and 40-year exposures, respectively. To estimate the potential cancer risk, staff adjusted the expected risk based on a 70-year exposure to reflect these differences. In addition, staff adjusted the potential risk for children to reflect their increased daily breathing rate (581 liters per kilogram (body weight) in a day (l/kg-day) vs. 393 l/kg-day for adults).

Meteorological Data

Meteorological data are site-specific parameters that are input to the air dispersion model to calculate pollutant concentrations and, subsequently, risk. For this scenario, West Los Angeles (1981) meteorological data were selected as the input to the ISCST3 model to represent "conservative" atmospheric conditions – with the term "conservative" used to indicate conditions that will result in higher risk estimates. Staff chose the West Los Angeles meteorology because this location tends to have the lowest average wind speed and more persistent wind directions, which result in less pollutant dispersion and higher estimated risks. Staff also ran the model using the Sacramento Executive Airport meteorological data (1989) to represent less conservative atmospheric conditions. Sacramento tends to have a higher average wind speed and more varied wind directions, resulting in greater pollutant dispersion and, consequently, lower risk values.

Model Parameters and Emission Factors

The key modeling parameters and the school bus idling emission factor are presented in Table 1. The analyses were performed using emission rates from EMFAC2000 Version 2.02 (ARB, May 2000). For this scenario the emission factor used represents the statewide school bus fleet weighted average emission factor for the 1965 through 2002 model years. For this scenario staff chose the urban dispersion option because a large proportion of schools are located in urban environments. Staff also chose to model the emission plumes as point sources, rather than volume sources, since the point source option takes into account the plume rise that results from the bus exhaust temperature being higher than the ambient temperature.[2]

[2] Using the rural dispersion option results in estimated potential cancer risk about two times higher than that estimated with the urban dispersion option. Using the volume source option would result in estimated potential cancer risks about 25 percent lower than those determined by using the point source model option.

Table 1: Modeling and Health Risk Assessment Parameters

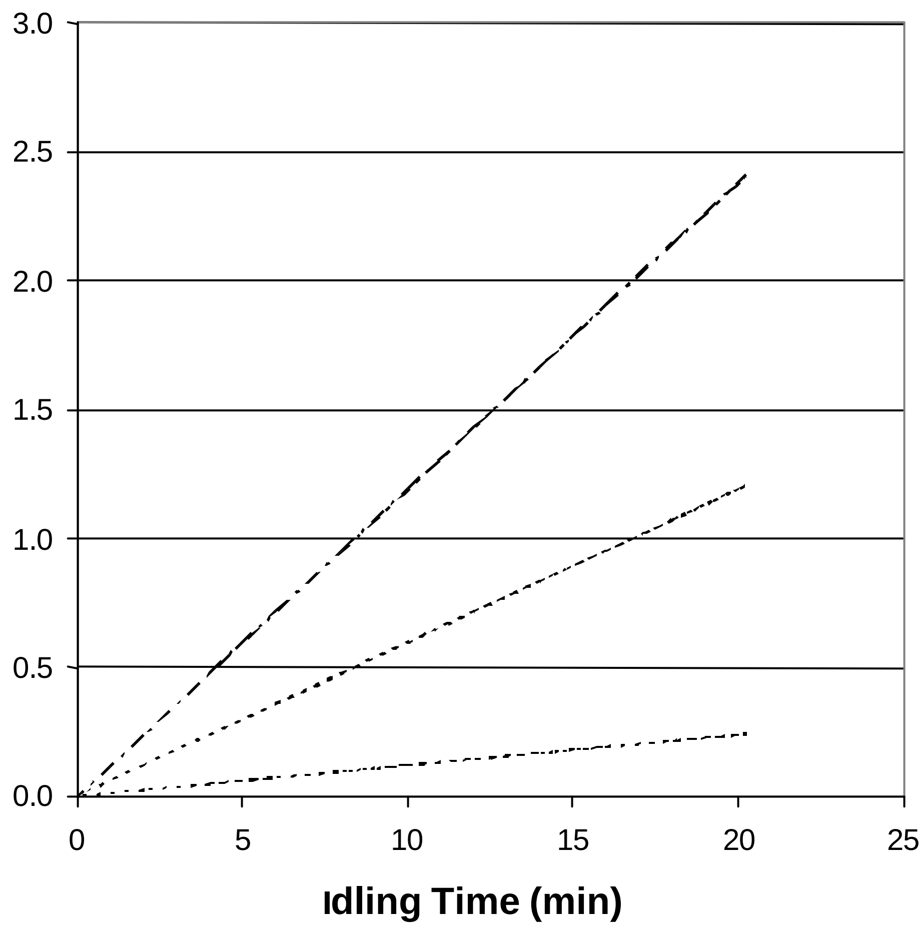
Modeling Parameters	
Source Type:	Point
Dispersion Setting	Urban
Receptor Height	1.2 meters
Point Source Modeling:	
Stack Temperature	366K
Stack Height	0.6 meters
Stack Diameter	0.1 meters
Stack Exit Velocity	0.001 meters/second
Source Width	6.6 meters
Source Length	12 meters/bus
PM Emission Factor	1.8 grams/hour/bus
Times Emissions Released	8AM and 2PM
Bus Operation Schedule	180 days per year
Health Risk Assessment Parameters	
Residents' Hypothetical Exposure Time	70 years @ 180 days/yr
Teachers' Hypothetical Exposure Time	40 years @ 180 days/yr
Childrens' Hypothetical Time in School	9 years @ 180 days/yr
Adult Daily Breathing Rate Range	271 - 393 l/kg body weight -day [3]
Adult Body Weight	70 kg
Child Daily Breathing Rate Range	452 - 581 l/kg body weight -day
Child Body Weight (0-9years)	18 kg

[3] The low end of the breathing rate range is the mean of the OEHHA breathing rate distribution and the high end is the 95th percentile of the distribution

Results

Figure 2 presents the estimated yearly diesel PM emissions from school buses idling between 2 and 20 minutes per day. As shown, the total diesel PM emissions ranged from less than 0.2 pounds per year for one bus idling 20 minutes a day to about 2.5 pounds per year for 10 buses idling 20 minutes a day.

Figure 2. Yearly Diesel PM Emissions



Tables 2 and 3 present the estimated range of potential cancer risk to residents, teachers and children from exposure to diesel PM emissions for the one-bus, 5-bus, and 10-bus cases. The results based on the West Los Angeles meteorological data inputs are presented in Table 2 and those based on the Sacramento meteorological data inputs are presented in Table 3. Each table provides a range of potential cancer risks at 20, 40 and 60 meters and present risk as a function of receptor distance and bus idling time. The low end of the estimated risks is the potential cancer risk calculated using the mean of the OEHHA breathing rate distribution for adults and children while the high end is based on the 95th percentile of the breathing rate distribution. In cases where only < 1 is shown, both estimates resulted in a potential cancer risk of less than one in a million.

Overall, we estimate that the potential cancer risk for students exposed to emissions from idling diesel-fueled school buses will generally be less than 1 potential cancer case per million. The estimated potential cancer risk for teachers will generally be less than 5 potential cancer cases per million and, for nearby residents, the estimated potential cancer risk will be less than 10 potential cancer cases per million. These risk values assume exposure durations of 9 years for children (student), 40 years for teachers, and 70 years for nearby residents. These risk values also assume that an individual would remain within 20 to 40 meters of the idling school bus zone for up to 20 minutes per day for 180 days per year. The estimated risk level would be reduced proportionately if the actual exposure duration decreased from the assumed exposure duration of 9, 40, and 70 years or it the student, teacher or resident were further away from the loading zone.

The estimated risk levels presented here are based on a number of assumptions. The potential cancer risk for actual situations may be less than or greater than those presented here. For example, an increase in the number of buses or the duration of idling would increase the potential risk levels. A decrease in the exposure duration or an increase in the distance from the loading/unloading location would decrease potential risk levels. The risk levels would also decrease over time as newer, lower-emitting diesel-fueled school buses replace older buses. Therefore, the results presented are not directly applicable to any particular school. Rather, this information is intended to provide an indication as to the potential relative levels of risk that may be observed from idling school buses and to act as an example when performing a site-specific risk assessment for idling diesel school buses.

Table 2: Potential Cancer Risks (Per Million) from Idling Diesel School Buses for Residents, Teachers, and Children (West Los Angeles Meteorological Data)

Receptor Distance (m)	**2 min Idling (min/bus/day)**									**20 min Idling (min/bus/day)**								
	Bus Number									Bus Number								
	1			5			10			1			5			10		
	RE	TR	CH	RE	TR	CH	RE	TR	CH	RE	TR	CH	RE	TR	CH	RE	TR	CH
20	< 1	< 1	< 1	1 - 1	< 1 - 1	< 1	1 - 1	1 - 1	< 1	2 - 3	1 - 2	< 1 - 1	7 - 10	4 - 6	2 - 2	9 - 13	5 - 8	2 - 3
40	< 1	< 1	< 1	< 1	< 1	< 1	<1 - 1	< 1	< 1	1 - 1	< 1	< 1	2 - 3	1 - 2	1 - 1	4 - 5	2 - 3	1 - 1
60	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1 - 2	1 - 1	< 1	2 - 3	1 - 2	< 1 - 1

Note: RE = Residents; TE = Teachers; CE= Children. The low end risk is based on the mean breathing rate and high end risk is based on the 95th percentile breathing rate. These risk values assume that an individual would remain at the specified distance from the bus for up to 20 minutes per day for 180 days per year. These risk values also assume an exposure duration of 9 years for children (students), 40 years for teachers, and 70 years for nearby residents.

Table 3: Potential Cancer Risks (Per Million) from Idling Diesel School Buses for Residents, Teachers, and Children (Sacramento Meteorological Data)

Receptor Distance (m)	2 min Idling (min/bus/day)									20 min Idling (min/bus/day)								
	Bus Number									Bus Number								
	1			5			10			1			5			10		
	RE	TR	CH	RE	TR	CH	RE	TR	CH	RE	TR	CH	RE	TR	CH	RE	TR	CH
20	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1 - 1	1 - 1	< 1	3 - 4	2 - 2	1 - 1	3 - 4	2 - 3	1 - 1
40	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1 - 2	1 - 1	< 1	1 - 2	1 - 1	< 1
60	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1 - 1	< 1	< 1	1 - 1	< 1 - 1	< 1

Note: RE = Residents; TE = Teachers; CE= Children. The low end risk is based on the mean breathing rate and high end risk is based on the 95th percentile breathing rate. These risk values assume that an individual would remain at the specified distance from the bus for up to 20 minutes per day for 180 days per year. These risk values also assume an exposure duration of 9 years for children (students), 40 years for teachers, and 70 years for nearby residents.