Appendix I

Health Analyses: Transport Refrigeration Units

Proposed Amendments to the Airborne Toxic Control Measure for In-Use Diesel-Fueled Transport Refrigeration Units (TRU) and TRU Generator Sets, and Facilities Where TRUs Operate

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I. Overview

California Air Resources Board (CARB) staff are proposing amendments to the Airborne Toxic Control Measure for In-Use Diesel-Fueled Transport Refrigeration Units (TRU) and TRU Generator Sets, and Facilities Where TRUs Operate (TRU ATCM; title 13, California Code of Regulations, section 2477), hereafter referred to as the "Proposed Amendments." In support of this effort, staff conducted health analyses to evaluate the health impacts of emissions from the diesel engines that power TRUs when operating at a cold storage warehouse (CSW) and a grocery store. These health analyses compare the current and future impacts of the TRU ATCM (Baseline) to the current and future impacts of the Proposed Amendments.

Exposure to diesel particulate matter (PM) has both potential cancer and noncancer chronic health impacts. This document presents two separate analyses, a health risk assessment (HRA) and a PM mortality and illness analysis. Each quantifies different health effects and each is equally important.

The HRA focuses on diesel PM emitted from diesel engines that power TRUs. The mortality and illness analysis focuses on "primary" (directly emitted) fine particulate matter (PM2.5) emissions and "secondary" PM2.5 formed in the atmosphere from oxides of nitrogen (NOx) from these same engines. Exposure to these pollutants can result in health outcomes that include premature death from cardiopulmonary disease, hospitalizations for cardiovascular and respiratory illnesses, and emergency room visits for asthma. The approaches used in each of these health analyses are outlined below:

<u>Health Risk Assessment</u>

- Develop a diesel PM emissions inventory that estimates the amount of diesel PM released annually from TRUs.
- Conduct air dispersion modeling to estimate the ground-level concentrations of diesel PM that result from these emissions.
- Estimate the potential health impacts from the modeled exposures.

<u>Mortality and Illness Analysis</u>

- Develop a PM2.5 and NOx emissions inventory that reflects the anticipated amount of each pollutant released annually from TRUs under the Baseline and the Proposed Amendments.
- Estimate statewide PM2.5 noncancer mortality and illness impacts associated with exposure to primary PM2.5 emitted from the diesel engines that power TRUs and secondary PM2.5 from NOx emissions.

To evaluate the effectiveness of the Proposed Amendments in reducing health impacts in communities that have facilities where TRUs typically operate, staff evaluated two facility types, a CSW and a grocery store.

Cold Storage Warehouse

- CARB staff evaluated two types of vehicles that are equipped with TRUs, trucks and semi-trailers. The CSW analysis evaluated the impacts of diesel PM emissions from the diesel engines that power TRUs when the truck or trailer, on which the TRU is mounted, is parked either at a loading dock or in a staging area, traveling to or from the facility, and moving around within the facility boundaries.

Grocery Store

- CARB staff evaluated two types of vehicles that are equipped with TRUs, trucks and semi-trailers. Throughout the year, grocery stores receive daily deliveries from both trucks and trailers; however, during the holiday seasons, some grocery stores have one or more semi-trailers parked for an extended period behind the store to provide additional storage for refrigerated or frozen products. For the purposes of this analysis, these are referred to as seasonal trailers. The grocery store analysis evaluated the impacts of diesel PM emissions from the diesel engines that power TRUs when the truck or trailer, on which the TRU is mounted, is parked and unloading, traveling to or from the grocery store, and moving within the grocery store parking lot, as well as seasonal trailers.

The assumptions used to determine potential cancer risk are not based on a specific facility. Instead, a representative generic facility was developed based on industry practice and operations. Actual potential risk estimates will vary for any one facility due to site-specific parameters, including the number of TRUs operating, hours of TRU activity, operating schedules, site configuration, site meteorology, distance to receptors, duration of exposure, and inhalation rate.

II. Health Risk Assessment for Facilities with Transport Refrigeration Unit Operations

A. Health Risk Assessment Overview

Risk assessment is a complex process that requires the analysis of many variables to model real-world situations. The standard approach used for this HRA involves four steps: 1) hazard identification, 2) exposure assessment, 3) dose-response assessment, and 4) risk characterization.

1. Hazard Identification

Hazard Identification is the process of determining the substances, or causing agents, that can cause an increase in adverse health effects (i.e., cancer, reproductive, developmental) and their likely impacts to humans. For this assessment, the pollutant of concern is diesel PM from the diesel engines that power TRUs. In 1998, CARB identified diesel PM as a toxic air contaminant based on its potential to cause cancer and other health impacts under the AB 1807 Toxic Air Contaminant Identification and Control Program (CARB, 1998).

2. Exposure Assessment

Exposure assessment is an estimate of the level, duration, and frequency of exposures of an individual or population to a substance. This involves emissions quantification, modeling of environmental transport, evaluation of environmental fate, identification of exposure routes and exposed populations, and estimation of exposure levels. At facilities where TRUs operate, the receptors that are most likely to be exposed include residents and off-site workers. On-site workers could also be impacted by the emissions; however, they are not included in this HRA because the California Department of Industrial Relations, Division of Occupational Safety and Health (Cal/OSHA) has jurisdiction over on-site exposure to workers who are employed at the facility. Diesel PM only has health values for the inhalation pathway. As a result, inhalation is the only pathway evaluated. The magnitude of exposure is assessed through diesel PM emission estimates and computer air dispersion modeling, resulting in downwind ground-level concentrations of diesel PM at near-source locations.

3. Dose-Response Assessment

Dose-response describes the amount of exposure (the dose) and its relation to the likelihood and severity of adverse health effects (the response). The assessment characterizes the relationship between exposure to a pollutant and the incidence or occurrence of an adverse health effect. This step of the HRA uses the health values developed by the Office of Environmental Health Hazard Assessment (OEHHA). OEHHA supplies these dose-response relationships in the form of cancer potency factors (CPF) for carcinogenic effects and reference exposure levels (REL) for non-carcinogenic effects. See the OEHHA guidelines (OEHHA, 2015), for a list of health factors.

Staff used an inhalation CPF of 1.1 milligrams per kilogram body weight day $(mg/kg\text{-}day)^{-1}$ and a chronic REL of 5.0 micrograms per cubic meter (µg/m3) for diesel PM emitted by the diesel engines that power TRUs. Diesel PM does not have an associated acute REL.

4. Risk Characterization

Finally, risk characterization communicates the results of the evaluation of the risks as well as the assumptions and uncertainties inherent in the assessment. Modeled concentrations, which are determined through exposure assessment, are combined with CPF and REL values determined under the dose-response assessment. This step integrates the information used to quantify the potential cancer and noncancer risks.

B. Selection of Facilities with TRU Operations

TRUs typically operate at refrigerated warehouses or distribution centers (WHDC), grocery stores, port facilities, intermodal railyards, and other locations that are often near sensitive receptors, such as schools, hospitals, elder care facilities, and residential neighborhoods. CARB staff conducted an analysis to estimate the number and types of facilities where TRUs operate as well as their contribution to statewide diesel PM emissions with the purpose of determining the applicability of the Proposed Amendments at these facilities. More information on these facility types and their TRU operations can be found in Appendix F to the Staff Report.

Based on this analysis, the facility types with the highest estimated contribution of statewide diesel PM emissions from diesel-powered TRUs are refrigerated WHDCs (which includes CSWs) and grocery stores. Therefore, CARB staff modeled a generic CSW and a generic grocery store to characterize existing health risk and the effectiveness of the Proposed Amendments.

C. Emission Inventory Summary

HRAs rely on information about the type of operation and the amount of pollutants emitted by the sources of study. Although TRUs operate across the State, their impact is often concentrated in communities near facilities where a large number of TRUs may be operating simultaneously and continously. In addition, the diesel engines that power TRUs emit a significant amount of PM2.5, due in part to a less stringent PM emission standard for smaller diesel engines (i.e., less than 25 horsepower).

TRUs operating in California are subject to the TRU ATCM, which requires all in-use TRUs and TRU generator sets that operate in California to reduce their PM emissions in accordance with a compliance schedule based on a seven-year operational life for the equipment. This can be achieved by using a TRU equipped with an engine certified to the United States Environmental Protection Agency (U.S. EPA) Tier 4 final off-road engine standards for 25-50 horsepower engines, installing a Level 3 filter (with at least 85 percent PM control) on the TRU engine, replacing the TRU, or using a qualifying alternative technology.

The 2021 update to the statewide emission inventory for TRUs, which was previously released in 2011, reflects improvements to a number of parameters, including, but not limited to:

- Population and age distribution of in-use TRUs.
- Annual TRU engine activity and the portion of activity that occurs within the State.
- Turnover (replacement of old units) and purchasing trends (addition of new units).

The emission inventory reflects a substantial increase in the number of trailer TRUs equipped with engines between 23 and 25 horsepower. This increase began with 2013 model year units. The emergence of trailer TRUs with engines between 23 and 25 horsepower is notable because the U.S. EPA Tier 4 final PM emission standard for these smaller horsepower engines is 15 times higher than the Tier 4 final PM standard for engines above 25 horsepower. Emissions from these smaller and dirtier engines will become responsible for the majority PM emissions from TRUs in the near future, if current trends continue.

The emissions inventory for any given year is calculated by combining the population of TRUs, the hours of activity of TRUs, the horsepower of the TRU engine, load factors, emission factors, and fuel correction factors, in the following equation:

Emissions = Population x Activity x HP x LF x EF x FCF

Where:

Population =	Count of equipment population
Activity =	Time the engine is running (hours)
HP =	Horsepower of the engine (max brake horsepower)
LF =	Load factor (unit-less)
EF =	Emission factor specific to horsepower and model year and pollutant (grams/kW-hr)
FCF =	Fuel correction factor based on calendar year (unit-less)

Detailed information on the data sources and methodology used in the statewide TRU emission inventory can be found in Appendix H to the Staff Report.

Table II.C.1 shows the diesel PM emission factors for truck and trailer TRUs used in each health analysis presented in this document. Staff analyzed health impacts in the following years:

- 2019: Serves as a baseline year, in which the Proposed Amendments are not yet implemented
- 2024: First year of implementation of the zero-emission truck TRU requirement beginning December 31, 2023 and second year of implementation of the more stringent PM emission standard requirement beginning December 31, 2022.
- 2030: Proposed Amendments fully implemented December 31, 2029

Table II.C.1. Health Risk Assessment TRU Emission Factors for Diesel PM

Year	Baseline Truck TRU Emission Factor	Proposed Truck TRU Emission Factor	Baseline Trailer TRU Emission Factor	Proposed Trailer TRU Emission Factor
2019	1.74	1.74	2.08	2.08
2024	1.68	1.42	1.26	1.12
2030	1.67	0.00	0.99	0.49

Note: Emission factors listed in grams per hour.

The values in the “Baseline Emission Factor” columns represent the rate at which diesel PM would be emitted from a diesel engine that powers a TRU if the Proposed Amendments were not implemented. The values in the “Proposed Emission Factor” columns represent the rate at which diesel PM would be emitted from a diesel engine that powers a TRU if the Proposed Amendments were to be implemented.

D. Air Dispersion Model

The selection of an air dispersion model depends on many factors, such as characteristics of emission sources (e.g., point, area, volume, or line), the type of terrain (e.g., flat or complex) at the emission source locations, and the relationship between sources and receptors. For this HRA, CARB staff selected U.S. EPA’s AERMOD, Version 18081 (U.S. EPA, 2018b) to simulate the impacts of TRU diesel PM emissions on nearby receptors. AERMOD is a steady-state plume model that incorporates air dispersion based on a planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources and distances up to 50 kilometers (km) in both flat and complex terrain.

1. Meteorological Data

AERMOD requires hourly meteorological data as inputs to the model. Meteorological parameters include wind speed, wind direction, atmospheric stability, and ambient temperature. These parameters are recorded by meteorological stations. To aid in the selection of representative data, CARB staff evaluated ten meteorological stations.

Each station's average wind speed, wind direction, surface characteristics, and proximity to refrigerated WHDC hubs were compared. Additionally, a sensitivity study was conducted using each meteorological dataset to provide a relative comparison of ground-level concentrations.[1] Of the ten meteorological stations, three were chosen for their collective range of meteorological conditions and land cover type, community interest and concern over the prevalence of nearby refrigerated WHDCs, and proximity of the meteorological station to refrigerated WHDC hubs and grocery stores. The three stations chosen were Watsonville Municipal Airport (Watsonville), Fresno Yosemite International Airport (Fresno), and Banning Station (Banning). The modeled concentrations that resulted from using each of these meteorological datasets were averaged to produce the potential statewide averaged cancer risk from TRUs.

The Watsonville, Fresno, and Banning AERMOD-ready meteorological data files were processed using U.S. EPA's AERMET processor and the AERMINUTE and AERSURFACE pre-processors. More detail on each station's meteorological data processing is described below.

Watsonville Municipal Airport Meteorological Data

Watsonville's AERMOD-ready meteorological data files were processed by CARB staff for years 2013-2017. The following options were used in AERMET to aid in the development of those files:

- One-Minute ASOS Wind Data File.
- 1-Minute ASOS wind speed threshold of 0.5 m/s.
- Adjust Surface Friction Velocity (ADJ_U*).
- AERSURFACE options:
  - Airport site.
  - Site surface moisture: Dry, Wet, Average, Wet, and Wet for years 2013-2017, respectively.
  - Assign Month/Season: default values (U.S. EPA, 2013).

In AERMOD, the wind direction rotation adjustment option was selected for Watsonville with an input of 45 degrees. This option aligned Watsonville's prevailing winds with the area sources in each model to provide health-protective downwind cancer risk estimates.

Watsonville's wind rose is shown in Figure II.D.1. The wind rose presents the frequency of winds at the specified wind direction sector and wind speed class during the years 2013-2017.

[1] See Section II.H for a detailed description of the meteorological station sensitivity study.

Fresno Yosemite International Airport Meteorological Data

Fresno Yosemite International Airport's AERMOD-ready meteorological data files were processed by the San Joaquin Valley Air Pollution Control District for years 2013-2017.[2]

In AERMOD, the wind direction rotation adjustment option was selected for Fresno with an input of 38 degrees. This option aligned Fresno's prevailing winds with the area sources in each model to provide health-protective downwind cancer risk estimates. Figure II.D.2 shows the wind rose for the Fresno Yosemite International Airport station. The wind rose presents the frequency of winds at the specified wind direction sector and wind speed class during the years 2013-2017.

Banning Station Meteorological Data

Banning Station's AERMOD-ready meteorological data files were processed by the South Coast Air Quality Management District for years 2011-2015.[3]

For the Banning Station data, the wind direction rotation adjustment was not selected because the prevailing winds were already aligned with each model's area sources to provide health-protective downwind cancer risk estimates. Figure II.D.3 shows the wind rose for the Banning Municipal Airport stations. The wind rose presents the frequency of winds at the specified wind direction sector and wind speed class during the years 2011-2015.

[2] Additional detail on how the San Joaquin Valley Air Pollution Control District processed Fresno's meteorological data.is available on their website at: https://www.valleyair.org/busind/pto/Tox_Resources/AirQualityMonitoring.htm#met_data.

[3] Additional detail on how the South Coast Air Quality Management District processed Banning's meteorological data is available on their website at: http://www.aqmd.gov/home/air-quality/meteorological-data/data-for-aermod.

Figure II.D.1. Wind Rose for Watsonville Municipal Airport

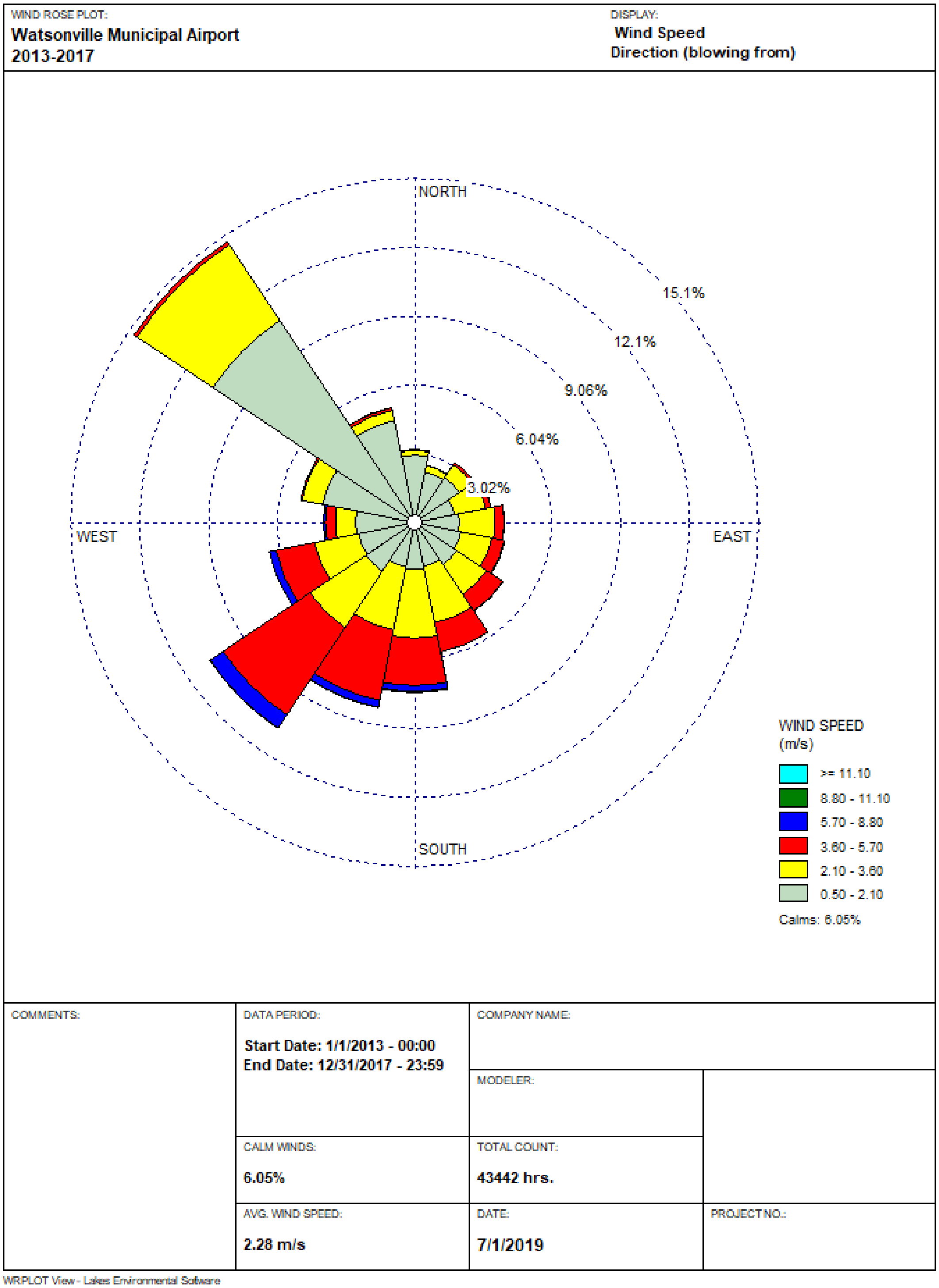


Figure II.D.2. Wind Rose for Fresno International Airport

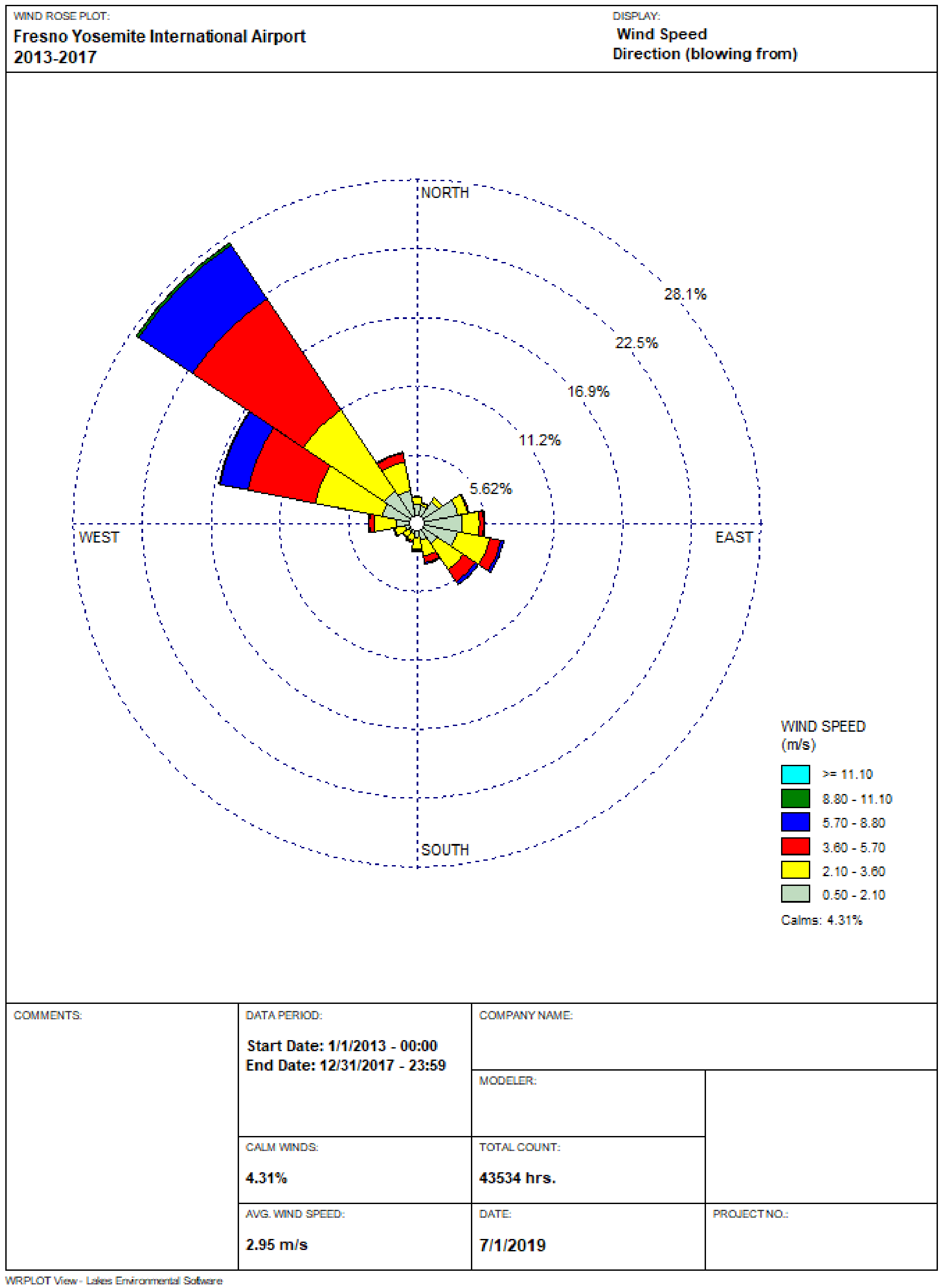
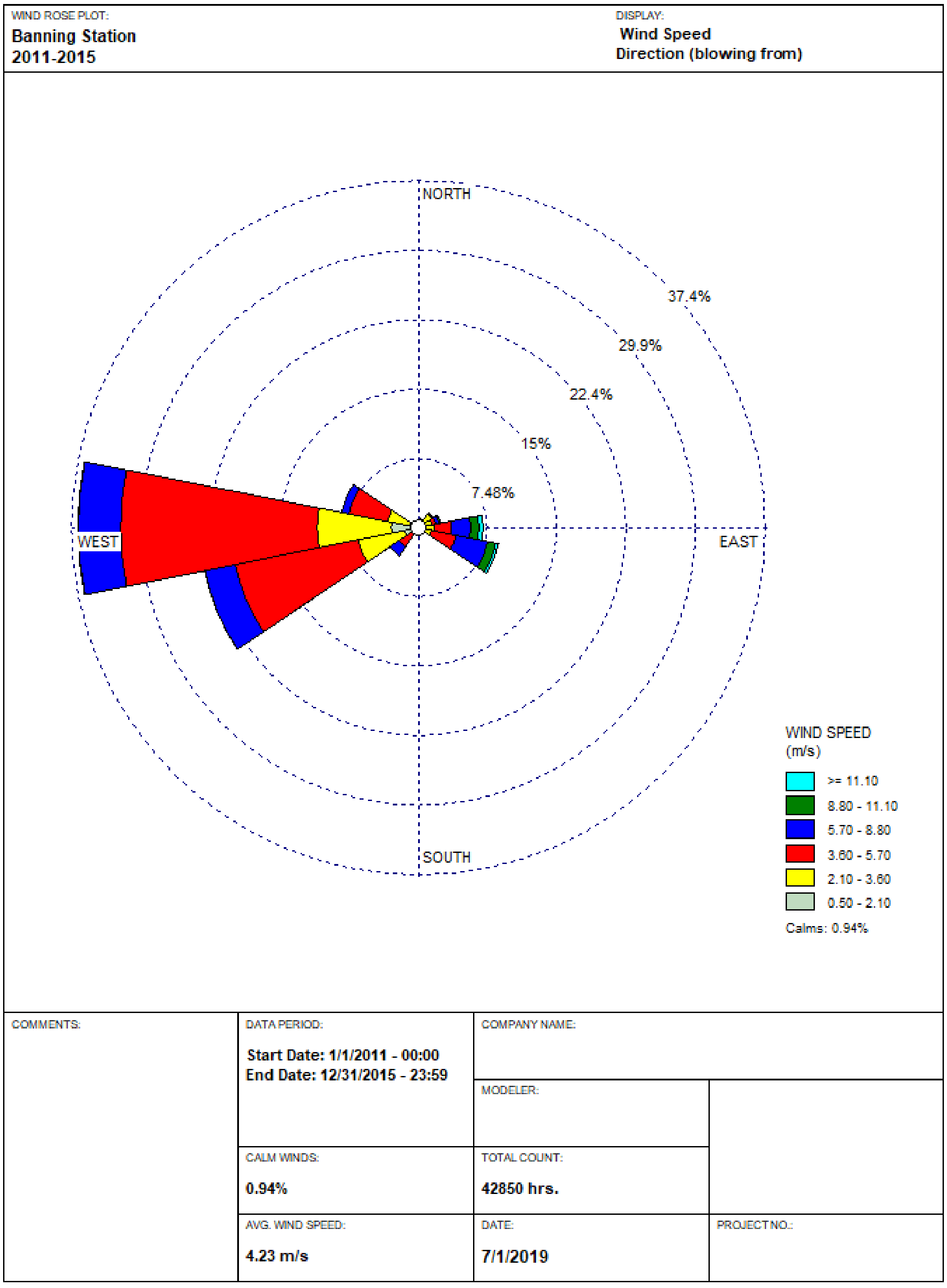


Figure II.D.3. Wind Rose for Banning Station



E. Risk Exposure Scenarios

To analyze the health impacts from TRUs at a CSW and grocery store, staff evaluated exposure scenarios for inhalation cancer risk and noncancer chronic risk. Staff calculated the health impacts using the methodology consistent with the OEHHA Guidance Manual. For the Proposed Amendments, health impacts were evaluated for years 2019, 2024, and 2030. The description of the exposure scenarios and assumptions are presented below.

1. Exposure Scenarios for Inhalation Cancer Risk

The OEHHA Guidance Manual provides a description of the risk algorithms, recommended exposure variates, and health values for calculating potential cancer risk. Potential cancer risk is calculated by converting an annual average concentration to a dose and then comparing it to a pollutant-specific health value.

Staff calculated potential cancer risk values for two exposure scenarios, residential exposure and off-site worker exposure.

- 30-Year Individual Residential Cancer Risk: An individual residential cancer risk evaluation assumes that a resident is exposed to the emission source for 30 years. This assumes an individual will live at a single location for that timeframe.
- Off-Site Worker Cancer Risk: An off-site worker cancer risk evaluation assumes that an individual who works at a facility near a grocery store or refrigerated warehouse and distribution center is exposed to the emission sources for 25 years, 8 hours per day, and 250 days per year. For this HRA, the sources are assumed to emit continuously. Therefore, no adjustment factor was applied to the annual concentration.

For residential exposure, staff applied the CARB and the California Air Pollution Control Officers Association (CAPCOA) risk management policy (RMP) for inhalation-based cancer risk (CARB & CAPCOA, 2015). The policy recommends using the 95th percentile breathing rates for age bins less than 2 years old and the 80th percentile breathing rates for age bins greater than or equal to 2 years old. Staff also used the recommended Fraction of Time at Home (FAH) value of 0.73 for age bins greater than 16 years of age. For off-site worker exposure, staff used the OEHHA Guidance Manual recommended eight hour breathing rate for moderate intensity activities.

Table II.E.1 summarizes the exposure assumption for each scenario.

Table II.E.1. Summary of Exposure Parameters

Risk Scenario	Consideration			Breathing Rate (BR)	FAH	Pathway Evaluated
	Hours per Day	Days per Year	Years			
Individual Resident (30-year Residential Cancer Risk)	24	350	30	RMP (95th percentile DBRs for age bins less than 2 years and 80th percentile DBRs for age bins greater than 2 years)	1 for age bins less than 16 years[4] 0.73 for age bins greater than 16 years	Inhalation only
Off-site Worker	8	250	25	8-hour moderate intensity BRs	Not applied (all age bins use 1)	

Because people have different breathing rates and different levels of sensitivity to carcinogens at different ages, cancer risk is calculated by age ranges or bins (i.e., third trimester, 0<2, 2<9, 2<16, 16<30, and 16-70). After the risk is calculated for each applicable age bin, the results are summed for the exposure duration of interest (e.g., 30 years) to yield a total cancer risk. Table II.E.2 summarizes the age bin exposure durations for each scenario.

[4] Assumes schools are in the 1/million isopleth.

Table II.E.2. Age Bin Exposure Duration Distribution

Risk Scenario	Exposure Duration Applied for Each Age Bins					Total
	3rd Trimester	0<2	2<16	16<30	16-70	
Individual Resident (30-year Residential Cancer Risk)	0.25	2 years	14 years	14 Years	-	30 years
Off-site Worker	-	-	-	-	25 years	25 years

The bins allow for the use of age-specific exposure variates. Exposure variates include breathing rates, age sensitive factors, fraction of time at home, and exposure duration. For example, age sensitivity factors will multiply the risk by a factor of 10 for age bins less than 2 years of age and use a factor of 3 for age bins between 2 and 16.

2. Exposure Scenarios for Noncancer Chronic Risk

The exposure scenario is identical for residents and off-site workers. The chronic health hazard index (HI) is calculated by dividing the annual average diesel PM concentration by the diesel PM inhalation chronic REL. A health hazard index value above one may indicate potential health impacts and may require further evaluation. To determine potential noncancer chronic risk, staff used the recommended diesel PM reference exposure level of 5 $\mu g/m^3$.

F. Grocery Store Methodology and HRA Results

1. Source Description

Grocery stores range in size from small local markets to supercenter grocery stores. The primary emission sources of diesel PM at these facilities are TRUs mounted on box trucks or semi-trailers. Because of the variability of size and operation, CARB staff elected to model a generic grocery store using three operational scenarios, which are described in the Emission Inventory section.

a) Facility Layout

To develop a generic grocery store layout, CARB staff evaluated various grocery stores throughout California, including stand-alone and those located within a strip mall. Due to the ubiquitous nature of grocery stores and their prevalence throughout the State, 60 grocery stores were randomly selected from a population of over 3,000 California stores from the Refrigerant Management Program database. CARB staff used aerial photos of each grocery store (an example of which is shown in Figure II.F.1) to develop a generic facility plot and to determine the approximate dimensions and locations of all stationary and mobile sources of emissions from diesel engines that power TRUs at a grocery store.

Figure II.F.1. Aerial Image and Spatial Analysis of a California Grocery Store

Map data: Google, DigitalGlobe

In addition to evaluating the on-site locations of where TRU activity occurs at a grocery store, the aerial photos were used to determine the following parameters:

- Property Boundary: The red outline denotes the total property area associated with the facility within the property boundary.
- Grocery Store Location: The blue outline denotes the area occupied by the grocery store.

- Loading Dock Location: The yellow outline denotes the loading docks and the size of stationary TRU activity area, which includes loading docks and truck/trailer parking. Loading docks are typically found behind a grocery store. If a loading dock could not be found, it was assumed that deliveries would be unloaded somewhere near the facility. Therefore, a minimum of one loading dock would be assumed for each facility.
- Width of the Road: The width of the road entering the facility property and the corresponding speed limit were determined.
- Total on-site TRU Transiting Path Length: This was determined to be any path a TRU may travel on the facility property, which includes entering the property, traveling to any dock doors or parking areas, and exiting the property.
- Distance to Nearest Off-Site Receptors: The white lines indicate the distances from the stationary TRU activity area to the nearest resident, worker, and sensitive receptor (i.e., school, nursing home, residential care facility, daycare center, or hospital). Of the 60 grocery stores analyzed, the nearest resident was found at 3 meters, the nearest worker was found at 6 meters, and the nearest sensitive receptor at 28 meters.

2. Emission Inventory

For this HRA, CARB staff evaluated two types of vehicles that are equipped with TRUs, smaller delivery trucks and semi-trailers. Throughout the year, grocery stores receive deliveries daily from both trucks and trailers. However, during the holiday seasons, some grocery stores have a semi-trailer parked for an extended period behind the store to provide additional storage for refrigerated or frozen products. For the purposes of this analysis, these are referred to as seasonal trailers. The diesel engines that power TRUs on trucks and trailers generate emissions during three different modes of operation: 1) off-site transiting, when the truck or trailer is traveling to the store, 2) on-site transiting, when the truck or trailer is traveling from the street to the point where it unloads, and 3) stationary, when the truck or trailer is parked and unloading. To quantify emissions from each equipment type and for each mode of operation, the following equation was used:

$$Emissions = \ Emission\ Factor\ \left(\frac{grams}{hour}\right) x\ Activity\ \left(\frac{hours}{week}\ of\ TRU\ engine\ operation\right)$$

Emission factors for truck and trailer TRUs can be found in Table II.F.2.

TRU activity at a grocery store is dependent on the number of truck and trailer trips generated by the facility. CARB staff developed equipment and activity profiles for three grocery store scenarios based on a literature review and survey results:

- One daily truck TRU, one daily trailer TRU, one seasonal trailer TRU.
- Seven daily truck TRUs, two daily trailer TRUs, one seasonal trailer TRU.
- Ten daily truck TRUs, six daily trailer TRUs, one seasonal trailer TRU.

These numbers were determined by evaluating data on the total number of deliveries grocery stores receive each day. For all three scenarios, staff assumed that 50 percent of the total number of smaller delivery trucks and trailers are equipped with TRUs. The emission inventory for grocery stores assumes that delivery trucks equipped with TRUs stay on-site for 0.9 hours and semi-trailers equipped with TRUs stay on-site for 3.5 hours (CARB, 2016 and Trans Now, 2010).

The first activity scenario serves as a baseline scenario for each equipment type. The second scenario, consisting of seven daily truck TRUs and two daily trailer TRUs, is based on a study prepared for Washington State's Department of Transportation (Trans Now, 2010). This activity profile represents potential TRU activity at grocery stores ranging in size from 23,000-53,000 square feet and assumes 50 percent of the total daily truck and trailer traffic is equipped with TRUs. The third scenario, consisting of ten daily truck TRUs and six daily trailer TRUs, is based on a Draft Environmental Impact Report (First Carbon Solutions, 2016). This activity profile represents potential TRU activity at a 192,000 square-foot grocery store.

All three grocery store scenarios include trailer TRUs that stay on-site seasonally. Seasonal trailer TRU operations are based on data from CARB's 2016 Grocery Store Survey. For this HRA, there are a total of three seasonal trailer TRUs which each visit for one month out of the year: one in October, one in November, and one in December. They are assumed to operate 24 hours per day, 7 days per week while at the facility.

For this evaluation, the definition of a truck trip is a truck entering or exiting the facility. This means that when one TRU-equipped truck or trailer enters and exits the facility, it counts as two trips. For on-site and off-site transiting, activity is determined by multiplying the number of trips for each equipment type by its assumed traveling speed and traveled distance. However, for stationary operations, activity is determined by multiplying the number of each equipment type by the residency time of the equipment at the facility (i.e., unloading or storage time). Table II.F.1 summarizes the emission estimate inputs for grocery stores developed for this analysis.

Table II.F.1. Emission Estimate Inputs for a Grocery Store

Facility Characteristics	Assumptions/References	Value
Facility Location	Site reflects a generic grocery store in California.	None
Grocery Store Footprint	Footprint reflects a generic grocery store in California.	None
Facility Height	Height of modeled facility.	30 feet high
Facility Operation (days/week)	24 hours per day, 7 days a week.	8,760 hours per year
TRU Trip Rate	Scenario:	trips/week
	1 Daily Truck TRU 1 Daily Trailer TRU 1 Seasonal Trailer TRU (Oct., Nov., Dec.)	14 14 0.5
	7 Daily Truck TRUs 2 Daily Trailer TRUs 1 Seasonal Trailer TRU (Oct., Nov., Dec.)	98 28 0.5
	10 Daily Truck TRUs 6 Daily Trailer TRUs 1 Seasonal Trailer TRU (Oct., Nov., Dec.)	140 84 0.5
Stationary TRU Engine Runtime Hours	The amount of time a TRU spends stationary and idling at a grocery store (CARB, 2016 and Trans Now, 2010).	Trailer: 3.5 Truck: 0.9
Docking, Parking, and Transiting TRU Emission Factors	CARB Statewide Emission Inventory Model for TRUs (2020 Update) 341 meter on-site transit route at a speed of 5 miles/hour speed 3,048 meter off-site transit route at a speed of 30 miles/hour	Trailer TRU: 2.08 g/hour Truck TRU: 1.74 g/hour

Table II.F.2 summarizes the TRU diesel PM emission results for a generic grocery store. The baseline year for all emission estimates is 2019.

Table II.F.2. Baseline Grocery Store TRU Emissions in 2019

Grocery Store Scenario	Diesel PM Emissions (tons per year)
1 Daily Truck 1 Daily Trailer 1 Seasonal Trailer	0.009
7 Daily Trucks 2 Daily Trailers 1 Seasonal Trailer	0.017
10 Daily Trucks 6 Daily Trailers 1 Seasonal Trailer	0.31

Note: Values are rounded.

3. Air Dispersion Modeling

To run AERMOD, modelers are required to define and setup the project and emissions sources, provide the meteorological data files, and specify the receptor locations. This can be done through four model pathways: control, source, meteorology, and receptor. These pathways are described below.

a) Control Pathway

Control inputs are required to specify the global model options for the model run. For all inputs, staff used the regulatory defaults with exception of those listed in Table.II.F.3.

Table II.F.3. AERMOD Control Inputs – Grocery Store

Control Parameter	Consideration	Model Input
Dispersion Coefficient	The urban dispersion option addresses potential issues associated with the transition from the nighttime urban boundary layer to the daytime convective boundary layer. Selecting the urban dispersion option allows AERMOD to model enhanced dispersion during nighttime stable conditions due to the urban heat island effect. The height of the urban boundary layer is dependent on population (U.S. EPA, 2018b). An area may be considered urban if the land use type(s) within a 3 km radius of the source accounts for 50 percent or more of the following categories: industrial, commercial, and/or residential. The majority of California grocery stores are located in an urban environment. A population of 500,000 was selected based on research and a sensitivity study performed by CARB staff. More details of that research and sensitivity study are provided in Section II.H.2.	Urban Population: 500,000
Terrain Option	Modeling a generic facility does not require terrain data. The terrain was considered flat for this HRA.	Flat

b) Source Pathway

Source inputs require source identification and a defined source type (e.g., point, area, volume, or open pit). Each source type requires specific parameters to define the source. For example, the required inputs for an area source are emission rate, release height, and dimensions. Table II.F.4 describes six source inputs that were used for this HRA.

Table II.F.4. AERMOD Source Inputs – Grocery Store

Source Parameter	Consideration	Model Input
Source Type	Area sources were used to model both stationary and mobile source releases for the following reasons: • Enough data was available to model with an area source. The lack of current engine data prevented the use of point sources. • Area sources do not have exclusion zones. Exclusion zones prevented the use of volume sources.	Area Source
Stationary Area Source Dimension	The stationary area source dimensions for both the daily unloading area source and the seasonal parking area source are set to 7.4 meters (i.e., the width of two trailers) by 21.34 meters (i.e., the length of a tractor trailer) (Nova Technology, 2013).	Daily: 21.34 x 7.4 meters Seasonal: 21.34 x 7.4 meters
On-site Roadway Area Source Dimensions	The median on-site transiting path length of 341 meters was determined using data from CARB staff's grocery store spatial analysis. The on-site transiting path width of 3.3 meters represents a one-lane arterial/collector roadway (U.S. EPA, 2015).	341 x 3.3 meters
Off-site Roadway Dimensions	Following guidance from CAPCOA's Health Risk Assessments for Proposed Land Use Projects, an off-site roadway length of 3,048 meters was used in the model (CAPCOA, 2009). The off-site transiting width was set to 12.6 meters. This includes a two-lane roadway width of 6.6 meters and an additional 6 meters of width to account for wake effects.	3,048 x 12.6 meters

Table II.F.4. AERMOD Source Inputs – Grocery Store (Cont.)

Source Parameter	Consideration
Release Height	<u>Stationary and On-site Transiting:</u> Release heights were determined for each meteorological station location and is the sum of the average heavy-duty vehicle height of 4 meters (U.S. EPA, 2015) and the plume rise/effective stack height. The plume rise/effective stack height was determined for each meteorological station using U.S. EPA's *Effective Stack Height/Plume Rise* instructional document (U.S. EPA, 1974). Release heights for each meteorological station are listed below. Watsonville: 4.0 meters + 2.4 meters = **6.4 meters** Banning: 4.0 meters + 1.6 meters = **5.6 meters** Fresno: 4.0 meters + 2.0 meters = **6.0 meters** <u>Off-site Transiting:</u> Release Height: 0.5 X Top of Plume Height = 0.5 X 6.8 meters = **3.4 meters** Where: • Vehicle Height: **4.0 meters** (U.S. EPA, 2015) • Top of Plume Height: 1.7 X Vehicle Height = 1.7 X 4.0 meters = **6.8 meters**

Table II.F.4. AERMOD Source Inputs – Grocery Store (Cont.)

Source Parameter	Consideration
Initial Vertical Dimension (σ_z)	<u>Stationary Sources and On-site Transiting:</u> Initial Vertical Dimension on or adjacent to a building (i.e., Sigma Z, SZINIT): Building Height / 2.15 = 9.14 meters (30 feet) / 2.15 = 4.25 Initial Vertical Dimension NOT on or adjacent to a building: • Watsonville: Vertical Dimension of the Source / 4.3 = 6.4 meters / 4.3 = **1.49 meters** • Banning: Vertical Dimension of the Source / 4.3 = 5.6 meters / 4.3 = **1.30 meters** • Fresno: Vertical Dimension of the Source / 4.3 = 6.0 meters / 4.3 = **1.40 meters** Where: • Vertical Dimension of the Source = Release Height <u>Off-site Transiting (U.S. EPA, 2012):</u> Sigma Z (i.e., SZINIT, Initial Vertical Dimension): Top of Plume Height / 2.15 = 6.8 meters / 2.15 = **3.16 meters** Where: • Vehicle Height: **4 meters** (U.S. EPA, 2015) • Top of Plume Height: 1.7 X Vehicle Height = 1.7 X 4 meters = **6.8 meters**

c) Receptor Inputs

A uniform polar receptor grid was chosen for the grocery store HRA. Additionally, discrete receptors were placed ten meters away from the stationary area sources to capture fence line concentrations. Table II.F.5 describes the receptor inputs that were used.

Table II.F.5. Receptor Grid Inputs

Receptor Parameter	Consideration	Model Input
Receptor Grid Type	A uniform polar grid sets a ring of receptors at specific distances from the origin. The polar grid contained 36 radials set 10 degrees apart. Eighty-six rings were placed at various distances from the center of the polar grid, extending out to 7,000 meters away. A discrete receptor was placed at the origin of the uniform polar grid to capture downwind fence line ground-level concentrations.	Uniform Polar and Discrete Receptors
Receptor Height	The receptor height was set to an average breathing height of 1.2 meters.	1.2 meters

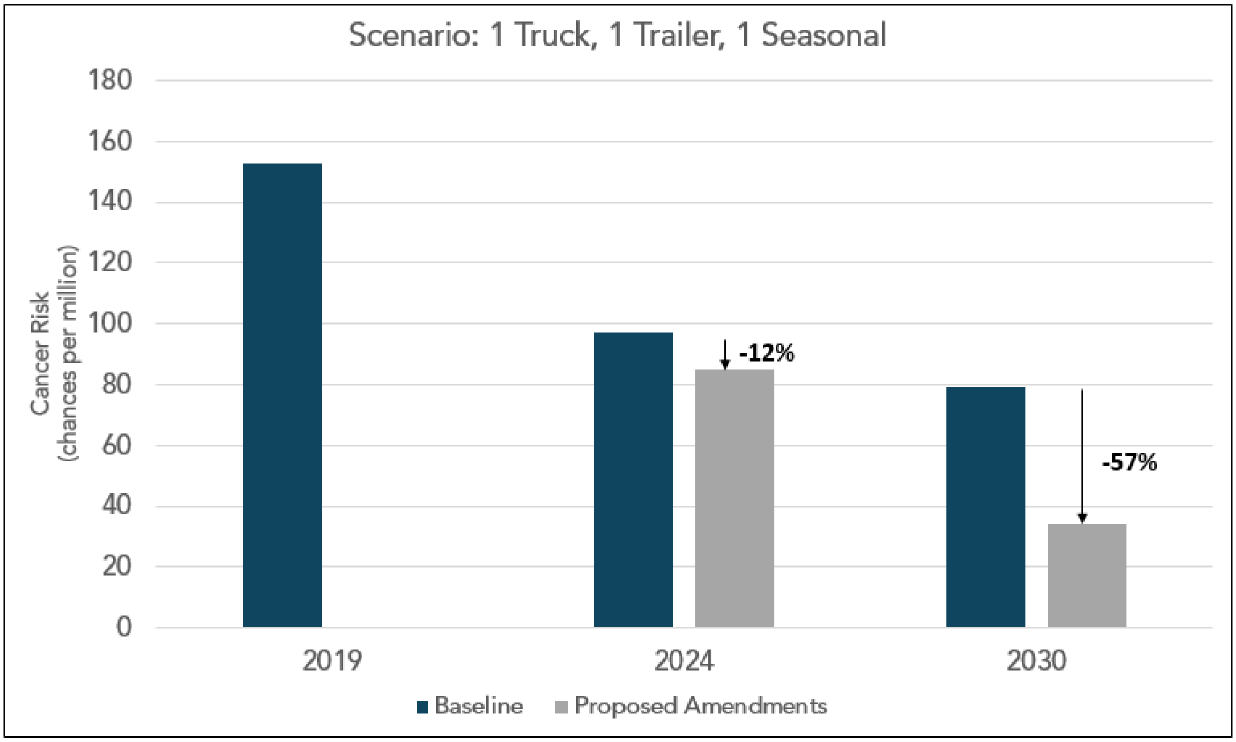
4. Health Risk Assessment – Summary of Cancer Risk

For the generic grocery store model, CARB staff evaluated the potential downwind cancer risk at nearby receptors under the Proposed Amendments and the Baseline. The Proposed Amendments would provide reductions in potential cancer risk to individual residents and off-site workers when compared to the Baseline.

a) Individual Residential Cancer Risk

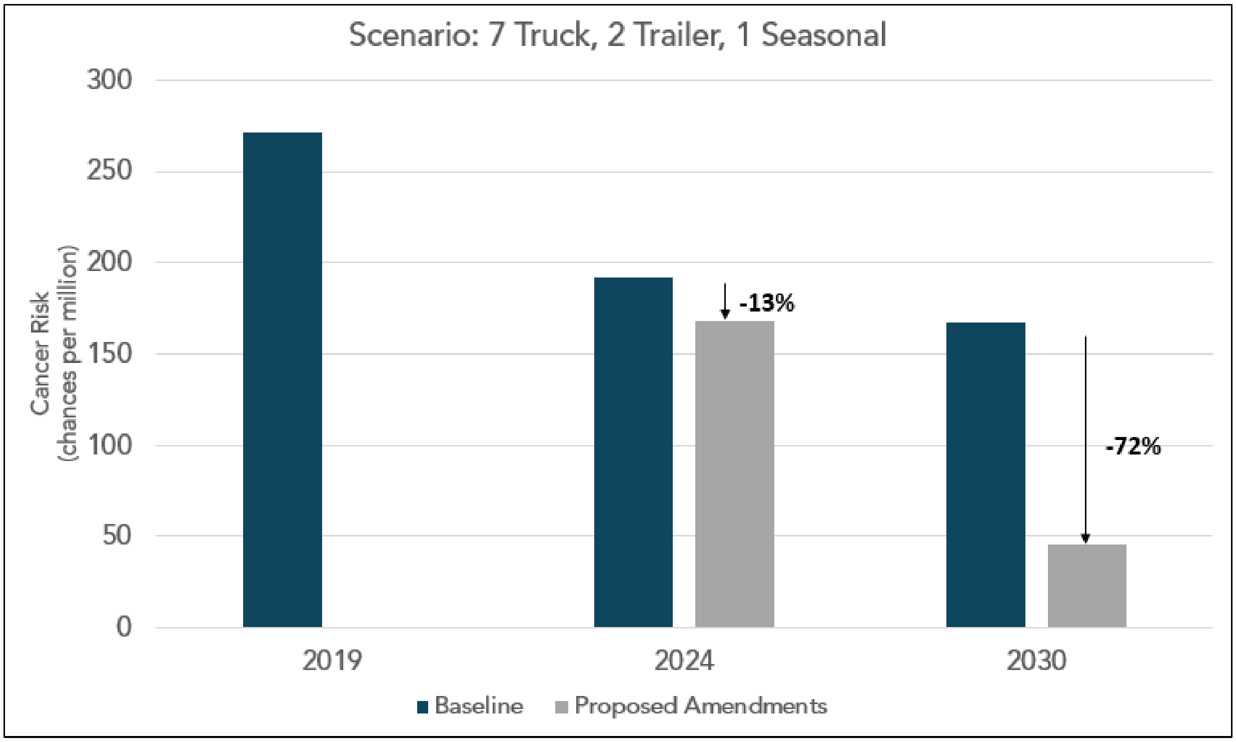
As shown in Figure II.F.2., the potential residential cancer risk for the one daily truck, one daily trailer, and one seasonal trailer scenario is reduced by approximately 12 percent in 2024, and 57 percent in 2030 when compared to the Baseline.

Figure II.F.2. Potential Individual Resident Cancer Risk and Risk Reduction for the Grocery Store 1 Truck, 1 Trailer, 1 Seasonal Scenario



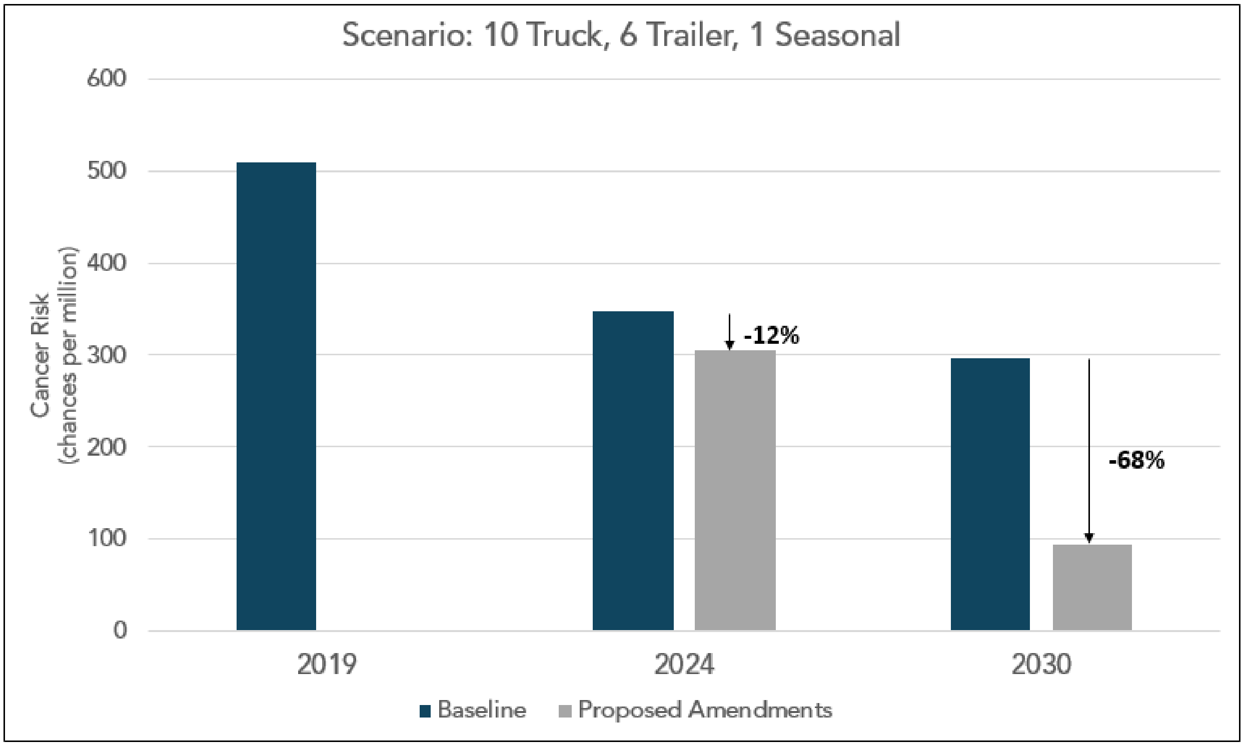
As shown in Figure II.F.3., the 7 daily truck, 2 daily trailer, and 1 seasonal trailer scenario achieves an estimated reduction in residential cancer risk of approximately 13 percent in 2024, and 72 percent in 2030 when compared to the Baseline.

Figure II.F.3. Potential Individual Resident Cancer Risk and Risk Reduction for the Grocery Store 7 Trucks, 2 Trailers, 1 Seasonal Scenario



As shown in Figure II.F.4., the 10 daily truck, 6 daily trailer, and 1 seasonal trailer scenario achieves an estimated reduction in residential cancer risk of approximately 12 percent in 2024, and 68 percent in 2030 when compared to the Baseline.

Figure II.F.4. Potential Individual Resident Cancer Risk and Risk Reduction for the Grocery Store 10 Trucks, 6 Trailers, 1 Seasonal Scenario



These figures highlight the reduction in cancer risk by the year 2030 after implementation of the Proposed Amendments. They also show that the amount of risk reduction achieved in the years leading up to 2030 is dependent on equipment type. This is due to the different requirements and implementation schedules for truck and trailer TRUs under the Proposed Amendments.

Table II.F.6 shows the potential cancer risk for individual residents under the Baseline for the year 2019. The three grocery store scenarios show potential cancer risk ranging from approximately 150 to 510 chances per million at the facility fence line.

Table II.F.6. Grocery Store Individual Resident Cancer Risk – Year 2019 (chances per million)

Scenario	Total Hours of TRU Engine Operation		Downwind Distance (m) from Grocery Store Fence Line															
	Per Week	Per Year	0	10	25	50	75	10 0	15 0	20 0	25 0	30 0	35 0	40 0	50 0	60 0	70 0	80 0
1 Daily Truck 1 Daily Trailer 1 Seasonal Trailer	202	3,940	150	110	74	45	31	23	14	10	7	6	5	4	3	2	2	2
7 Daily Trucks 2 Daily Trailers 1 Seasonal Trailer	274	7,717	270	200	130	81	56	41	26	18	14	11	9	7	6	5	4	3
10 Daily Trucks 6 Daily Trailers 1 Seasonal Trailer	402	14,334	510	370	250	150	100	77	48	33	25	20	16	14	10	8	7	6

Note: Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins <16 years and 0.73 for age bin 16-70 years. All numbers are rounded.

For the years 2024 and 2030, Table II.F.7 and Table II.F.8 show the potential cancer risk for the three grocery store scenarios under the Baseline. The risk ranges from approximately 97 to 350 chances per million in 2024 and approximately 79 to 300 chances per million in 2030. After implementation of the Proposed Amendments, the potential cancer risk is reduced to a range of approximately 85 to 310 chances per million in 2024 and a range of approximately 34 to 94 chances per million for the year 2030.

Table II.F.7. Grocery Store Individual Resident Cancer Risk – Year 2024 (chances per million)

Control Measure	Downwind Distance (m) from Grocery Store Fence Line															
	0	10	25	50	75	100	150	200	250	300	350	400	500	600	700	800
1 Daily Truck, 1 Daily Trailer, 1 Seasonal Trailer (Baseline TRU Engine Hours: 202 per week; 3,940 per year)																
Baseline	97	69	47	29	20	14	9	6	5	4	3	2	2	1	1	<1
Prop. Am.	85	61	41	25	17	13	8	6	4	3	3	2	2	1	1	<1
7 Daily Trucks, 2 Daily Trailers, 1 Seasonal Trailer (Baseline TRU Engine Hours: 274 per week; 7,717 per year)																
Baseline	190	140	94	58	40	29	18	13	10	8	6	5	4	3	3	3
Prop. Am.	170	120	82	51	35	26	16	11	8	7	6	5	4	3	3	2
10 Daily Trucks, 6 Daily Trailers, 1 Seasonal Trailer (Baseline TRU Engine Hours: 402 per week; 14,334 per year)																
Baseline	350	250	170	110	72	53	33	23	17	14	11	10	7	6	5	4
Prop. Am.	310	220	150	92	63	46	29	20	15	12	10	8	6	5	4	4

Table II.F.8. Grocery Store Individual Resident Cancer Risk – Year 2030 (chances per million)[1]

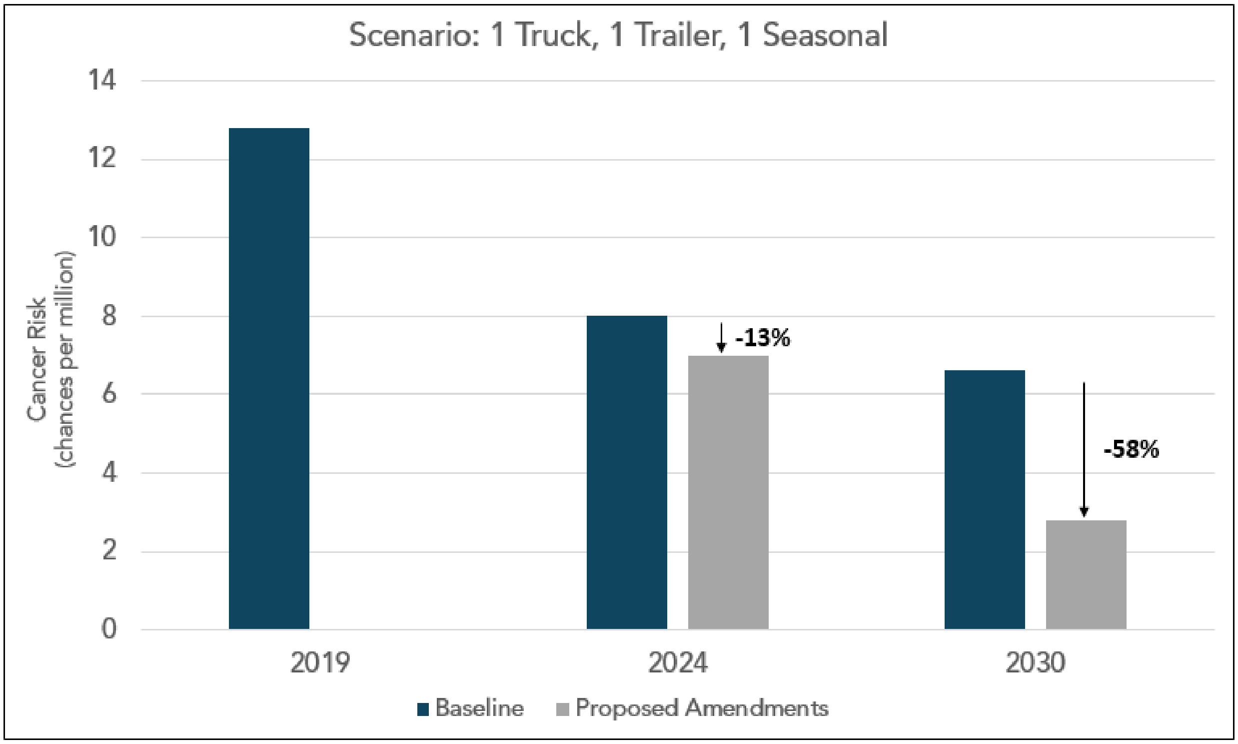
Control Measure	Downwind Distance (m) from Grocery Store Fence Line															
	0	10	25	50	75	100	150	200	250	300	350	400	500	600	700	800
1 Daily Truck, 1 Daily Trailer, 1 Seasonal Trailer (Baseline TRU Engine Hours: 202 per week; 3,940 per year)																
Baseline	79	56	38	23	16	12	7	5	4	3	2	2	2	1	<1	<1
Prop. Am.	34	24	16	10	7	5	3	2	2	1	<1	<1	<1	<1	<1	<1
7 Daily Trucks, 2 Daily Trailers, 1 Seasonal Trailer (Baseline TRU Engine Hours: 274 per week; 7,717 per year)																
Baseline	170	120	82	51	35	26	16	11	9	7	6	5	4	3	3	2
Prop. Am.	46	33	22	14	9	7	4	3	2	2	1	1	<1	<1	<1	<1
10 Daily Trucks, 6 Daily Trailers, 1 Seasonal Trailer (Baseline TRU Engine Hours: 402 per week; 14,334 per year)																
Baseline	300	210	150	90	61	45	28	20	15	12	10	8	6	5	4	4
Prop. Am.	94	68	46	28	19	14	9	6	4	3	3	2	2	1	1	<1

Note: Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins <16 years and 0.73 for age bin 16-70 years. All numbers are rounded.

b) Off-site Worker Cancer Risk

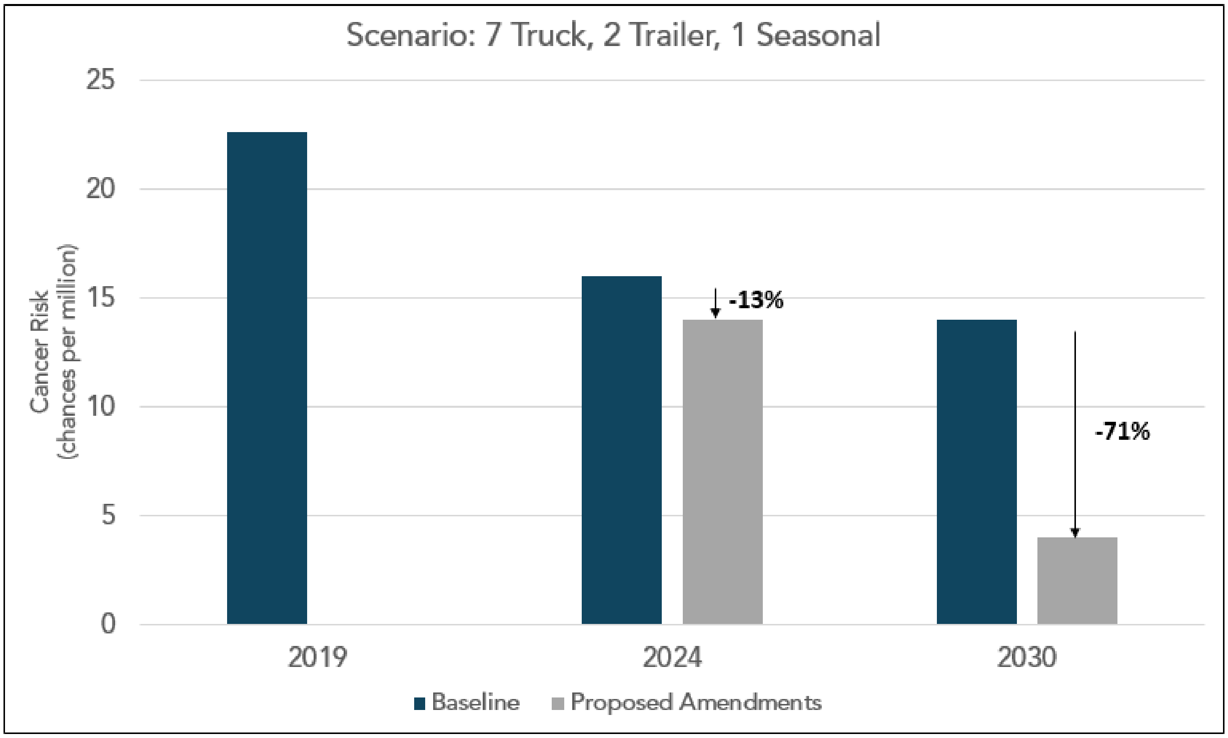
As shown in Figure II.F.5., off-site worker cancer risk for the one daily truck, one daily trailer, and one seasonal trailer scenario is reduced by approximately 13 percent in 2024, and 58 percent in 2030 when compared to the Baseline.

Figure II.F.5. Potential Off-site Worker Cancer Risk and Risk Reduction for the Grocery Store 1 Truck, 1 Trailer, 1 Seasonal Scenario



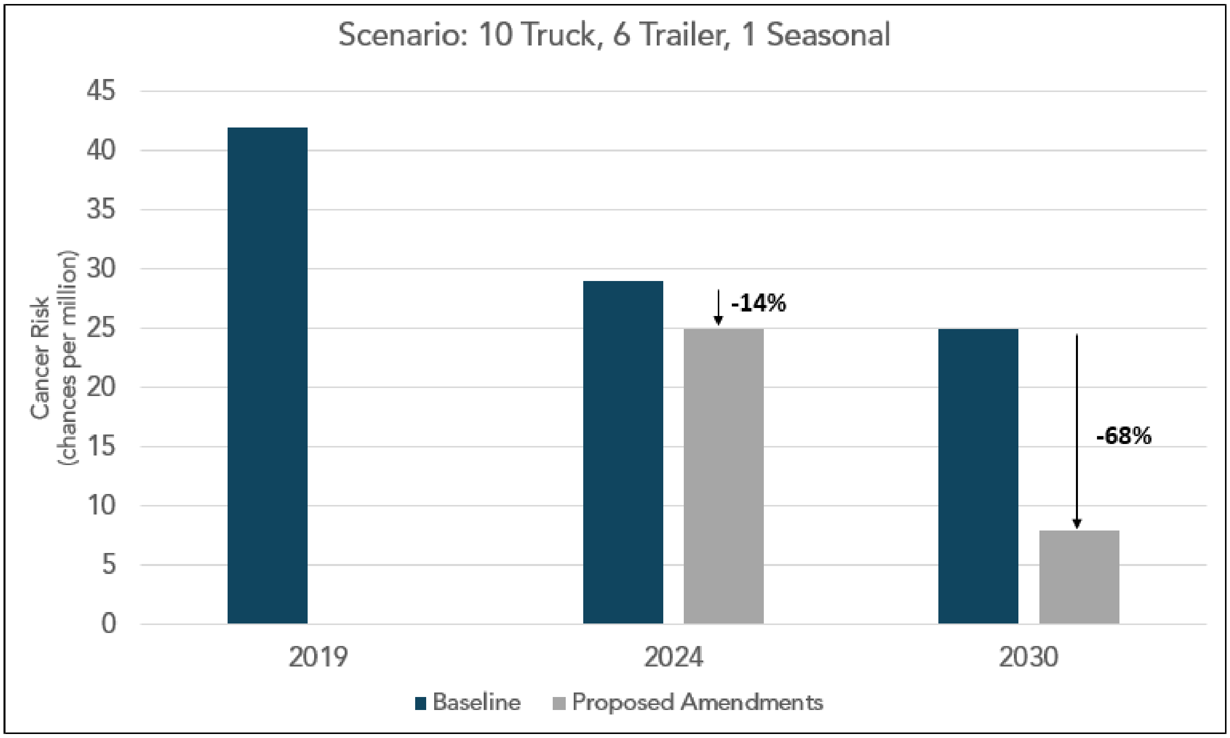
As shown in Figure II.F.6., the 7 daily truck, 2 daily trailer, and 1 seasonal trailer scenario achieves an estimated reduction in off-site worker cancer risk of 13 percent in 2024, and 71 percent in 2030 when compared to the Baseline.

Figure II.F.6. Potential Off-site Worker Cancer Risk and Risk Reduction for the Grocery Store 7 Trucks, 2 Trailers, 1 Seasonal Scenario



As shown in Figure II.F.7., the 10 daily truck, 6 daily trailer, and 1 seasonal trailer scenario achieves an estimated reduction in off-site worker cancer risk of approximately 14 percent in 2024, and 68 percent in 2030 when compared to the Baseline.

Figure II.F.7. Potential Off-site Worker Cancer Risk and Risk Reduction for the Grocery Store 10 Trucks, 6 Trailers, 1 Seasonal Scenario



These figures highlight the reduction in off-site worker cancer risk in 2030 with implementation of the Proposed Amendments. These figures also show that the amount of cancer risk reduction achieved in the years leading up to 2030 is dependent on equipment type. This is due to the different requirements and implementation schedules for truck and trailer TRUs under the Proposed Amendments.

Table II.F.9 shows the potential cancer risk for off-site workers under the Baseline for the year 2019. The three grocery store scenarios show cancer risk ranging from approximately 13 to 42 chances per million at the facility fence line.

Table II.F.9. Grocery Store Off-site Worker Cancer Risk – Year 2019 (chances per million)[5]

Scenario	Total Hours of TRU Engine Operation		Downwind Distance (m) from Grocery Store Fence Line															
	Per Week	Per Year	0	10	25	50	75	100	150	200	250	300	350	400	500	600	700	800
1 Daily Truck 1 Daily Trailer 1 Seasonal Trailer	**202**	**3,940**	13	9	6	4	3	2	1	1	1	<1	<1	<1	<1	<1	<1	<1
7 Daily Trucks 2 Daily Trailers 1 Seasonal Trailer	**274**	**7,717**	23	16	11	7	5	3	2	1	1	1	1	1	<1	<1	<1	<1
10 Daily Trucks 6 Daily Trailers 1 Seasonal Trailer	**402**	**14,334**	42	31	21	13	9	6	4	3	2	2	1	1	1	1	1	1

[5] Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

For 2024, Table II.F.10 shows the potential cancer risk for the three grocery store scenarios ranging from approximately 8 to 29 chances per million at the facility fence line under the Baseline. After implementation of the Proposed Amendments, the range reduces to approximately 7 to 25 chances per million at the facility fence line.

Table II.F.10. Grocery Store Off-site Worker Cancer Risk – Year 2024 (chances per million)[6]

Control Measure	Downwind Distance (m) from Facility															
	0	10	25	50	75	100	150	200	250	300	350	400	500	600	700	800
1 Daily Truck, 1 Daily Trailer, 1 Seasonal Trailer (Baseline TRU Engine Hours: 202 per week; 3,940 per year)																
Baseline	8	6	4	2	2	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Proposed Am.	7	5	3	2	1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
7 Daily Trucks, 2 Daily Trailers, 1 Seasonal Trailer (Baseline TRU Engine Hours: 274 per week; 7,717 per year)																
Baseline	16	12	8	5	3	2	2	1	<1	<1	<1	<1	<1	<1	<1	<1
Proposed Am.	14	10	7	4	3	2	1	<1	<1	<1	<1	<1	<1	<1	<1	<1
10 Daily Trucks, 6 Daily Trailers, 1 Seasonal Trailer (Baseline TRU Engine Hours: 402 per week; 14,334 per year)																
Baseline	29	21	14	9	6	4	3	2	1	1	<1	<1	<1	<1	<1	<1
Proposed Am.	25	18	12	8	5	4	2	2	1	1	<1	<1	<1	<1	<1	<1

[6] Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

For 2030, Table II.F.11 shows the potential cancer risk for the three grocery store scenarios ranging from approximately 7 to 26 chances per million at the facility fence line under the Baseline. After implementation of the Proposed Amendments, the range reduces to approximately 3 to 8 chances per million at the facility fence line.

Table II.F.11. Grocery Store Off-site Worker Cancer Risk – Year 2030 (chances per million)[7]

Control Measure	Downwind Distance (m) from Facility															
	0	10	25	50	75	100	150	200	250	300	350	400	500	600	700	800
1 Daily Truck, 1 Daily Trailer, 1 Seasonal Trailer (Baseline TRU Engine Hours: 202 per week; 3,940 per year)																
Baseline	7	5	3	2	1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Proposed Am.	3	2	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
7 Daily Trucks, 2 Daily Trailers, 1 Seasonal Trailer (Baseline TRU Engine Hours: 274 per week; 7,717 per year)																
Baseline	14	10	7	4	3	2	1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Proposed Am.	4	3	2	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
10 Daily Trucks, 6 Daily Trailers, 1 Seasonal Trailer (Baseline TRU Engine Hours: 402 per week; 14,334 per year)																
Baseline	26	18	13	8	5	4	2	2	1	1	<1	<1	<1	<1	<1	<1
Proposed Am.	8	6	4	2	2	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

[7] Off-site worker cancer risk estimates are based on a 25-year exposure duration with 95th percentile 8-hour DBR for moderate activity levels. All numbers are rounded.

5. Health Risk Assessment – Summary of Noncancer Chronic Results

For the generic grocery store, CARB staff evaluated the noncancer chronic HI using the modeled diesel PM concentrations. For this assessment, the HI is a ratio of the modeled annual average concentrations of diesel PM at each receptor point divided by the chronic inhalation REL. OEHHA has adopted a chronic REL of 5 µg/m^3. An HI value above one may indicate potential health impacts and may require further evaluation. CARB staff used the highest modeled annual average concentration in the downwind direction and determined the HI for each grocery store scenario. These results are summarized in Table II.F.12. For each scenario the HI value is below one.

Table II.F.12. Summary of the Grocery Store Noncancer Chronic Hazard Indices

Control Measure	Downwind Distance (m) from Facility		
	2019	2024	2030
1 Daily Truck, 1 Daily Trailer, 1 Seasonal Trailer			
Baseline	0.04	0.03	0.02
Proposed Am.	-	0.01	0.01
7 Daily Trucks, 2 Daily Trailers, 1 Seasonal Trailer			
Baseline	0.07	0.05	0.04
Proposed Am.	-	0.05	0.01
10 Daily Trucks, 6 Daily Trailers, 1 Seasonal Trailer			
Baseline	0.14	0.09	0.08
Proposed Am.	-	0.08	0.02

Note: Dashes are used for the Proposed Amendments in 2019 because the Proposed Amendments are not yet implemented.

G. Cold Storage Warehouse Methodology and HRA Results

1. Source Description

CSWs range in size depending on the location, and type of operation. The primary emission sources of diesel PM at these facilities are the diesel engines that power TRUs mounted either on box trucks or on semi-trailers. Because of the variability in size and operation, CARB staff elected to model a generic CSW that could accommodate a range of TRU engine activity, ranging from 500 hours per week, representing a small warehouse, to 8,000 hours per week, representing a large warehouse.

a) Facility Layout

To develop a generic CSW, CARB staff evaluated 50 CSWs located throughout California. The CSWs were randomly selected from a population of California facilities from various sources, including databases (i.e., ParcelQuest and Manta), surveys, facility reports, online searches, and facility tours. CARB staff used aerial photos of each CSW (an example of which is shown in Figure II.G.1) to develop a generic facility plot, and to determine the approximate dimensions and locations of all stationary and mobile sources of emissions from the diesel engines that power TRUs at a CSW.

Figure II.G.1. Aerial Image and Spatial Analysis of a California Cold Storage Warehouse

Map data: Google, DigitalGlobe

In addition to evaluating the on-site locations of where TRU activity occurs at a CSW, the aerial photos were used to determine the following parameters:

- Property Boundary: The red outline denotes the total property area associated with the facility within the property boundary.
- Warehouse Location: The blue outline denotes the area occupied by the cold storage warehouse.

- Loading Dock and Parking Location: The yellow outline denotes the loading docks and the size of stationary TRU activity area, which includes both the loading docks and areas where trailers would stage or park.
- Width of the Road: The width of the road entering the facility property and the corresponding speed limit were determined.
- Total on-site TRU Transiting Path Length: This was determined to be any path a TRU may travel on the facility property, which includes entering the property, traveling to any dock doors or parking/staging areas, and exiting the property.
- Distance to Nearest Off-Site Receptors: The white lines indicate the distances from the stationary TRU activity area to the nearest resident, worker, and sensitive receptor (i.e., school, nursing home, residential care facility, daycare center, or hospital).

2. Emission Inventory

CARB staff developed an equipment and activity profile to represent TRU-engine runtime, ranging from 500 to 8,000 hours per week. Staff assumed that the facility operates 24 hours per day, 7 days per week. The model accounts for both on-site and off-site transiting as well as stationary TRU engine operations.

The emission inventory for a CSW assumes that every truck or trailer equipped with a TRU enters a facility fully loaded and leaves fully loaded. Each model also assumes that the TRU stays on-site for approximately four hours (i.e., unloading for two hours and loading for another two hours – for a total of four hours). The number of inbound and outbound loads at the facility was determined by dividing the total amount of TRU activity by the assumed amount of residency time for each TRU (CARB, 2011).

Emissions that occur while the TRU is in transit on-site are based on the number of truck trips staff estimated for TRU-engine runtime, ranging from 500 to 8,000 hours per week. For this evaluation, the definition of a truck trip is a truck entering or exiting the facility. One TRU-equipped truck, which enters and then leaves, creates two truck trips. Table II.G.1 summarizes the emission estimate inputs for a CSW developed for this analysis.

Table II.G.1. Emission Estimate Inputs for a Cold Storage Warehouse

Facility Characteristics	Assumptions/References	Value
Facility Location	Site reflects a generic CSW facility in California	None
CSW Footprint	Footprint reflects generic CSW facility in California	None
Facility Height	Height of modeled facility.	29.4 feet high
Facility Operation (days/week)	24 hours per day, 7 days a week.	8,760 hours per year
TRU Trip Rate[8]	A TRU-equipped vehicle enters the facility fully loaded (inbound) and exits the facility fully loaded (outbound) Each TRU entering the facility takes 2 hours to unload and 2 hours to load – 4 hours total. [TRU engine runtime hours/week] ÷ [4 hours/TRU trip] = TRU trips/week	trips/week
	8,000 hours per week	2,000
	5,000 hours per week	1,250
	3,000 hours per week	750
	2,000 hours per week	500
	1,000 hours per week	250
	500 hours per week	125
Docking, Parking, and Transiting TRU Emission Factors	CARB Statewide Emission Inventory Model for TRUs (2020 Update) 775-meter on-site transit route at a speed of 5 miles/hour speed 3,050-meter off-site transit route at a speed of 30 miles/hour	Trailer TRU: 2.08 g/hour Truck TRU: 1.74 g/hour

[8] It is assumed that trailer TRUs account for 90 percent of the trips at a CSW, with the remaining 10 percent of trips coming from truck TRUs

Table II.G.2 summarizes the TRU diesel PM emission results for a CSW. The baseline year for all emission estimates is 2019.

Table II.G.2. Baseline Cold Storage Warehouse TRU Emissions in 2019

	Weekly Hours of Operation					
	500	**1,000**	**2,000**	**3,000**	**5,000**	**8,000**
Diesel PM Emissions (tons per year)	0.064	0.127	0.25	0.38	0.64	1.02

Note: Values are rounded.

3. Air Dispersion Modeling

To run AERMOD, modelers are required to define and setup the project and emissions sources, select the meteorological data files, and specify the receptor locations. This is done through four model pathways: control, source, meteorology, and receptor. These pathways are described below.

a) Control Pathway

Control inputs are required to specify the global model options for the model run. Table II.G.3 describes the non-regulatory control inputs that were used for this HRA.

Table II.G.3. AERMOD Control Inputs – Cold Storage Warehouse

Control Parameter	Consideration	Model Input
Dispersion Coefficient	The urban dispersion option addresses potential issues associated with the transition from the nighttime urban boundary layer to the daytime convective boundary layer. Selecting the urban dispersion option allows AERMOD to model enhanced dispersion during nighttime stable conditions due to the urban heat island effect. The height of the urban boundary layer is dependent on population (U.S. EPA, 2018b). An area may be considered urban if the land use type(s) within a 3 km radius of the source accounts for 50 percent or more of the following categories: industrial, commercial, and/or residential. The majority of California cold storage warehouses are typically located in an urban environment. A population of 500,000 was selected based on research, and a sensitivity study performed by CARB staff. More details about the research and sensitivity study are provided in Section II.H.	Urban Population: 500,000
Terrain Option	Modeling a generic facility does not require terrain data. The terrain was considered flat for this HRA.	Flat

b) Source Pathway

Source inputs require source identification and a defined source type (e.g., point, area, volume, or open pit). Each source type requires specific parameters to define the source. For example, the required inputs for an area source are emission rate, release height, and dimensions. Table II.G.4 describes six source inputs that were used for this HRA.

Table II.G.4. AERMOD Source Inputs – Cold Storage Warehouse

Source Parameter	Consideration	Model Input
Source Type	Area sources were used to model both stationary and mobile source releases for the following reasons: • Enough data was available to model with an area source; the lack of current engine data prevented the use of point sources. • Area sources do not have exclusion zones; exclusion zones prevented the use of volume sources.	Area Source
Stationary Area Source Dimension	The stationary area source dimension for docking was set to 350 meters (i.e., the width of about 85 docking spaces) by 21.34 meters (i.e., the length of a tractor trailer) (Nova Technology, 2013). The stationary area source dimension for parking was set to 440 meters (i.e., the width of about 110 parking spaces) by 21.34 meters (i.e., the length of a tractor trailer) (Nova Technology, 2013).	Docking: 21.34 x 350 meters Parking: 21.34 x 440 meters
On-site Roadway Area Source Dimensions	The median on-site transiting path length of 775 meters was determined using data from CARB staff's CSW spatial analysis. The on-site transiting path width of 6.6 meters represents two one-lane arterial/collector roadways (U.S. EPA, 2015).	775 x 6.6 meters
Off-site Roadway Dimensions	Following guidance from CAPCOA's Health Risk Assessments for Proposed Land Use Projects, the off-site roadway length of 3,048 meters was used in the model (CAPCOA 2009). The off-site transiting width was set to 12.6 meters. This includes a two-lane roadway width of 6.6 meters and an additional 6 meters of width to account for wake effects.	3,048 x 12.6 meters

Table II.G.4. AERMOD Source Inputs – Cold Storage Warehouse (Cont.)

<table>
<tr><th>Source Parameter</th><th>Consideration</th></tr>
<tr><td>Release Height</td><td><u>Stationary and On-site Transiting:</u>

Release heights were determined for each meteorological station location and is the sum of the average heavy-duty vehicle height of four meters (U.S. EPA, 2015) and the plume rise/effective stack height. The plume rise/effective stack height was determined for each meteorological station using U.S. EPA's Effective Stack Height/Plume Rise instructional document (U.S. EPA, 1974). Release heights for each meteorological station are listed below.

Watsonville: 4.0 meters + 2.4 meters = 6.4 meters
Banning: 4.0 meters + 1.6 meters = 5.6 meters
Fresno: 4.0 meters + 2.0 meters = 6.0 meters

<u>Off-site Transiting:</u>

Release Height: 0.5 X Top of Plume Height = 0.5 X 6.8 meters = 3.4 meters

Where:
• Vehicle Height: 4.0 meters (U.S. EPA, 2015)
• Top of Plume Height: 1.7 X Vehicle Height = 1.7 X 4.0 meters = 6.8 meters</td></tr>
</table>

Table II.G.4. AERMOD Source Inputs – Cold Storage Warehouse (Cont.)

<table>
<tr><th>Source Parameter</th><th>Consideration</th></tr>
<tr><td>Initial Vertical Dimension (σ_z)</td><td>
<u>Stationary Sources and On-site Transiting:</u>

Initial Vertical Dimension on or adjacent to a building
(i.e., Sigma Z, SZINIT):
• Building Height / 2.15 = 9.14 meters (30 feet) / 2.15 = 4.25 meters

Initial Vertical Dimension NOT on or adjacent to a building:
• Watsonville: Vertical Dimension of the Source / 4.3 = 6.4 meters / 4.3 = 1.49 meters
• Banning: Vertical Dimension of the Source / 4.3 = 5.6 meters / 4.3 = 1.30 meters
• Fresno: Vertical Dimension of the Source / 4.3 = 6.0 meters / 4.3 = 1.40 meters

Where:
• Vertical Dimension of the Source = Release Height

<u>Off-site Transiting (U.S. EPA, 2012):</u>

Sigma Z (i.e., SZINIT, Initial Vertical Dimension):
Top of Plume Height / 2.15 = 6.8 meters / 2.15 = 3.16 meters

Where:
• Vehicle Height: 4 meters (U.S. EPA, 2015)
• Top of Plume Height: 1.7 X Vehicle Height = 1.7 X 4.0 meters = 6.8 meters
</td></tr>
</table>

c) Receptor Inputs

A uniform polar receptor grid was chosen for the cold storage warehouse HRA. Additionally, discrete receptors were placed at the fence line and ten meters downwind from the fence line. Table II.G.5 describes the receptor inputs that were used.

Table II.G.5. Receptor Grid Inputs

Receptor Parameter	Consideration	Model Input
Receptor Grid Type	A uniform polar grid sets a ring of receptors at specific distances from the origin. The polar grid contained 36 radials set 10 degrees apart. One-hundred-ten rings were placed at various distances from the center of the polar grid, extending out to 12,000 meters away. A discrete receptor was placed at the origin of the uniform polar grid to capture downwind fence-line ground-level concentrations. An additional discrete receptor was placed ten meters downwind from the origin of the uniform polar grid.	Uniform Polar and Discrete Receptors
Receptor Height	The receptor height was set to an average breathing height of 1.2 meters.	1.2 meters

4. Health Risk Assessment – Summary of Cancer Risk

For a generic CSW, CARB staff evaluated the potential downwind cancer risk at nearby receptors under the Baseline and the Proposed Amendments. As discussed earlier in Section II.E, potential cancer risk was estimated under two exposure scenarios, individual resident and off-site worker.

a) Individual Residential Cancer Risk

The Proposed Amendments would reduce potential cancer risk to individual residents and off-site workers. After implementation of the Proposed Amendments, Figure II.G.2. shows that residential cancer risk is anticipated to be reduced by approximately 12 percent in 2024, and 58 percent in 2030 compared to the Baseline.

Figure II.G.2. Potential Individual Resident Cancer Risk and Risk Reduction for Cold Storage Warehouses[1]

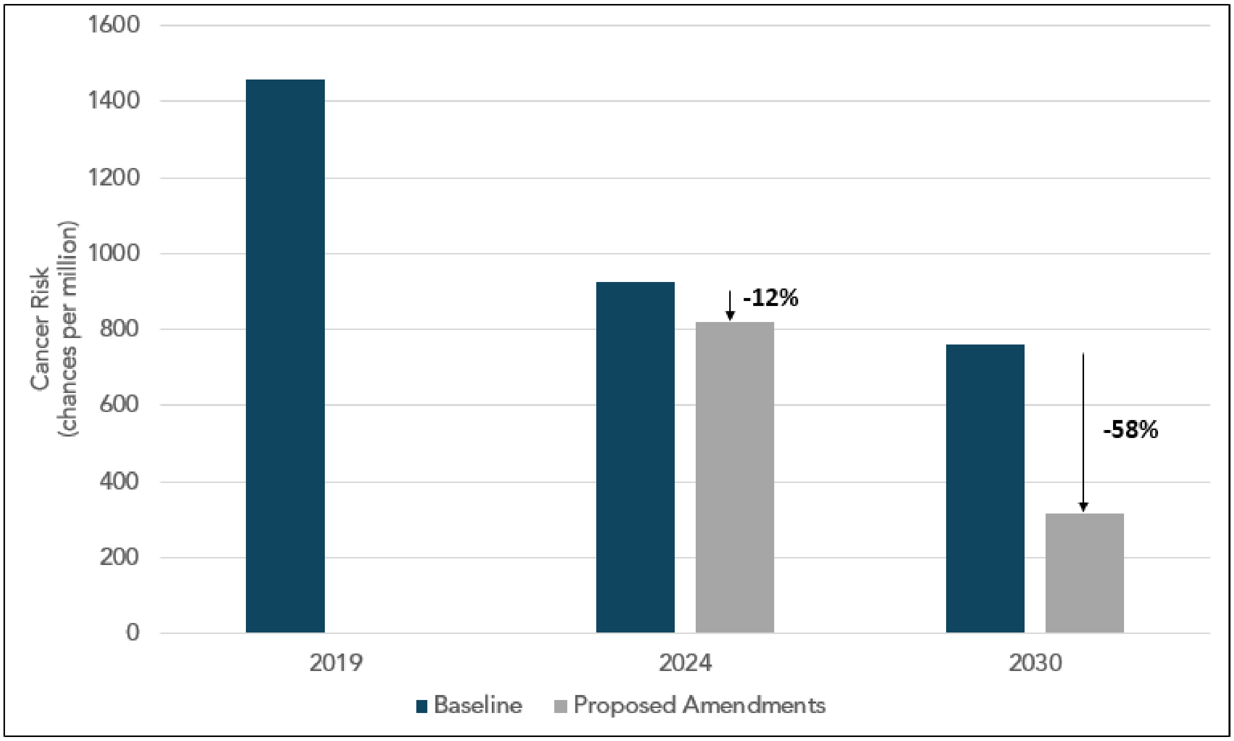


Table II.G.6 shows the potential cancer risk for individual residents under the Baseline for TRU engine hours, ranging from 500 to 8,000 hours per week, for the year 2019. The scenarios show residential cancer risk ranging from approximately 91 to 1,460 chances per million at 25 meters from the facility fence line.

Table II.G.6. Cold Storage Warehouse Individual Resident Cancer Risk – Year 2019 (chances per million)

Total Hours of TRU Engine Operation		Downwind Distance (m) from Facility																	
Per Week	Per year	25	50	75	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
8,000	416,000	1460	1260	1080	930	600	430	320	260	210	180	160	140	120	110	100	96	90	82
5,000	260,000	910	790	670	580	370	270	200	160	130	110	98	87	78	71	65	60	56	51
3,000	156,000	550	470	400	350	220	160	120	96	80	68	59	52	47	42	39	36	34	31
2,000	104,000	370	310	270	230	150	110	81	64	53	45	39	35	31	28	26	24	22	20
1,000	52,000	180	160	140	120	74	53	40	32	27	23	20	17	16	14	13	12	11	10
500	26,000	91	79	67	58	37	27	20	16	13	11	10	9	8	7	6	6	6	5

Note: Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins <16 years and 0.73 for age bin 16-70 years. All numbers are rounded.

Table II.G.7 compares the potential cancer risk for individual residents under Baseline and the Proposed Amendments in 2024. The scenarios show reductions in risk across all activity levels. For example, at 25 meters from the facility, for 8,000 TRU engine hours per week, the Proposed Amendments could reduce residual cancer risk to approximately 820 chances per million compared to the Baseline at around 930 chances per million.

Table II.G.7. Cold Storage Warehouse Individual Resident Cancer Risk – Year 2024 (chances per million)

Baseline

Total Hours of TRU Engine Operation		Downwind Distance (m) from Facility																	
Per Week	Per year	25	50	75	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
8,000	416,000	930	800	680	590	380	270	210	160	140	110	99	88	79	72	66	61	57	52
5,000	260,000	580	500	430	370	240	170	130	100	84	71	62	55	49	45	41	38	36	33
3,000	156,000	350	300	260	220	140	100	77	61	51	43	37	33	30	27	25	23	21	20
2,000	104,000	230	200	170	150	94	67	51	41	34	29	25	22	20	18	16	15	14	13
1,000	52,000	120	100	85	74	47	34	26	20	17	14	12	11	10	9	8	8	7	7
500	26,000	58	50	43	37	24	17	13	10	8	7	6	5	5	4	4	4	4	3

Proposed Am.

Total Hours of TRU Engine Operation		Downwind Distance (m) from Facility																	
Per Week	Per year	25	50	75	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
8,000	416,000	820	710	610	520	330	240	180	140	120	100	88	78	70	64	58	54	50	46
5,000	260,000	510	440	380	330	210	150	110	90	75	63	55	49	44	40	36	34	31	29
3,000	156,000	310	270	230	200	130	89	68	54	45	38	33	29	26	24	22	20	19	17
2,000	104,000	210	180	150	130	84	60	45	36	30	25	22	19	17	16	15	14	13	11
1,000	52,000	100	88	76	66	42	30	23	18	15	13	11	10	9	8	7	7	6	6
500	26,000	51	44	38	33	21	15	11	9	7	6	5	5	4	4	4	3	3	3

Note: Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) method (95^{th} percentile/80^{th} percentile daily breathing rates (DBR)). FAH equals 1 for age bins <16 years and 0.73 for age bin 16-70 years. All numbers are rounded.

Table II.G.8 compares the potential cancer risk for individual residents under the Baseline and the Proposed Amendments in 2030. The scenarios show reductions in risk across all activity levels. For example, at 25 meters from the facility, for 8,000 TRU engine hours per week, the Proposed Amendments would reduce residual cancer risk to approximately 320 chances per million compared to the Baseline at about 760 chances per million.

Table II.G.8. Cold Storage Warehouse Individual Resident Cancer Risk – Year 2030 (chances per million)

Baseline

Total Hours of TRU Engine Operation		Downwind Distance (m) from Facility																	
Per Week	Per year	25	50	75	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
8,000	416,000	760	650	560	490	310	220	168	130	110	94	81	72	65	59	54	50	47	43
5,000	260,000	470	410	350	300	190	140	105	84	69	58	51	45	40	37	34	31	29	27
3,000	156,000	280	250	210	180	120	83	63	50	41	35	30	27	24	22	20	19	17	16
2,000	104,000	190	160	140	120	77	55	42	33	28	23	20	18	16	15	13	13	12	11
1,000	52,000	95	82	70	61	39	28	21	17	14	12	10	9	8	7	7	6	6	5
500	26,000	47	41	35	30	19	14	10	8	7	6	5	4	4	4	3	3	3	3

Proposed Am.

Total Hours of TRU Engine Operation		Downwind Distance (m) from Facility																	
Per Week	Per year	25	50	75	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
8,000	416,000	320	270	230	200	130	92	70	56	46	39	34	30	27	25	22	21	19	18
5,000	260,000	200	170	150	130	81	58	44	35	29	24	21	19	17	15	14	13	12	11
3,000	156,000	120	100	87	76	48	35	26	21	17	15	13	11	10	9	8	8	7	7
2,000	104,000	79	68	58	51	32	23	18	14	12	10	8	8	7	6	6	5	5	4
1,000	52,000	40	34	29	25	16	12	9	7	6	5	4	4	3	3	3	3	2	2
500	26,000	20	17	15	13	8	6	4	3	3	2	2	2	2	2	1	1	1	1

Note: Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) method (95th percentile/80th percentile daily breathing rates (DBR)). FAH equals 1 for age bins <16 years and 0.73 for age bin 16-70 years. All numbers are rounded.

b) Off-site Worker Cancer Risk

Under this exposure scenario, the Proposed Amendments would reduce potential cancer risk to off-site workers working in close vicinity to a CSW. After implementation of the Proposed Amendments, Figure II.G.3. shows that risk is anticipated to be reduced by approximately 12 percent in 2024, and 58 percent in 2030 when compared to the Baseline.

Figure II.G.3. Potential Off-Site Worker Cancer Risk and Risk Reduction for Cold Storage Warehouses

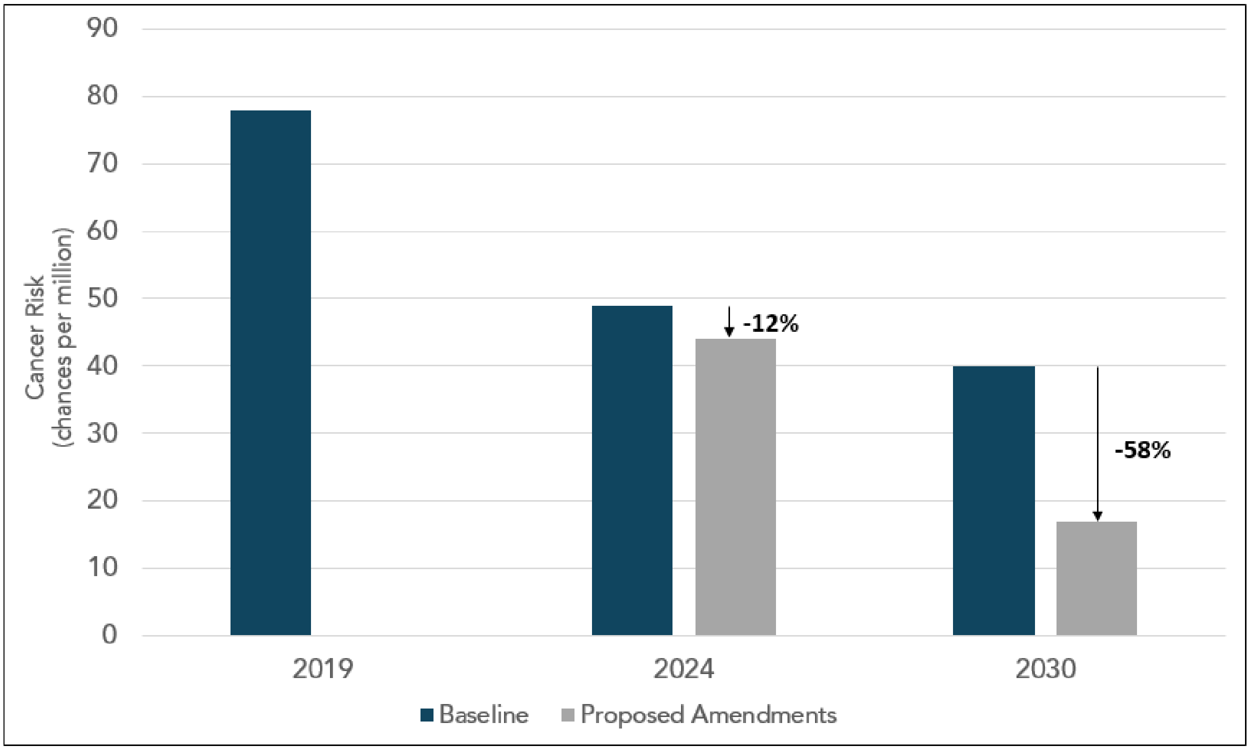


Table II.G.9 shows the potential cancer risk for off-site workers under the Baseline for TRU engine hours, ranging from 500 to 8,000 hours per week, for the year 2019. The scenarios show risk ranging from approximately 5 to 78 chances per million at 100 meters from the facility fence line.

Table II.G. 9. Cold Storage Warehouse Off-Site Worker Cancer Risk – Year 2019 (chances per million)

Total Hours of TRU Engine Operation		Downwind Distance (m) from Facility														
Per Week	Per year	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
8,000	416,000	78	50	35	27	21	18	15	13	12	10	9	9	8	7	7
5,000	260,000	49	31	22	17	13	11	9	8	7	6	6	5	5	5	4
3,000	156,000	29	19	13	10	8	7	6	5	4	4	4	3	3	3	3
2,000	104,000	19	12	9	7	5	4	4	3	3	3	2	2	2	2	2
1,000	52,000	10	6	4	3	3	2	2	2	1	1	1	1	1	1	1
500	26,000	5	3	2	2	1	1	1	1	1	1	1	1	1	< 1	< 1

Table II.G.10 compares the potential cancer risk for off-site workers under the Baseline and the Proposed Amendments in 2024. The scenarios show reductions in cancer risk across all activity levels. For example, at 100 meters from the facility, for 8,000 TRU engine hours per week, the Proposed Amendments could reduce residual cancer risk to approximately 44 chances per million compared to the Baseline at around 49 chances per million.

Table II.G. 10. Cold Storage Warehouse Off-Site Cancer Risk – Year 2024 (chances per million)

	Total Hours of TRU Engine Operation		Downwind Distance (m) from Facility														
	Per Week	Per year	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
Baseline	8,000	416,000	49	31	22	17	14	11	10	8	7	7	6	5	5	5	4
	5,000	260,000	31	20	14	11	9	7	6	5	5	4	4	3	3	3	3
	3,000	156,000	19	12	8	6	5	4	4	3	3	2	2	2	2	2	2
	2,000	104,000	12	8	6	4	3	3	2	2	2	2	1	1	1	1	1
	1,000	52,000	6	4	3	2	2	1	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	500	26,000	3	2	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

	Total Hours of TRU Engine Operation		Downwind Distance (m) from Facility														
	Per Week	Per year	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
Proposed Am.	8,000	416,000	44	28	20	15	12	10	8	7	6	6	5	5	5	4	4
	5,000	260,000	27	17	12	9	8	6	5	5	4	4	3	3	3	3	2
	3,000	156,000	16	10	7	6	5	4	3	3	2	2	2	2	2	2	1
	2,000	104,000	11	7	5	4	3	2	2	2	2	1	1	1	1	1	< 1
	1,000	52,000	5	3	2	2	2	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	500	26,000	3	2	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Table II.G.11 shows the potential cancer risk for off-site workers under the Proposed Amendments for the implementation year 2030. The scenarios show reductions in cancer risk across all activity levels. For example, at 100 meters from the facility, for 8,000 TRU engine hours per week, the Proposed Amendments could reduce residual cancer risk to approximately 17 chances per million compared to the Baseline at around 40 chances per million.

Table II.G. 11. Cold Storage Warehouse Off-Site Cancer Risk – Year 2030 (chances per million)

Baseline

Total Hours of TRU Engine Operation		Downwind Distance (m) from Facility														
Per Week	Per year	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
8,000	416,000	40	26	18	14	11	9	8	7	6	5	5	4	4	4	4
5,000	260,000	25	16	11	9	7	6	5	4	4	3	3	3	3	2	2
3,000	156,000	15	10	7	5	4	3	3	3	2	2	2	2	2	1	1
2,000	104,000	10	6	5	3	3	2	2	2	1	1	1	1	1	< 1	< 1
1,000	52,000	5	3	2	2	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
500	26,000	3	2	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Proposed Am.

Total Hours of TRU Engine Operation		Downwind Distance (m) from Facility														
Per Week	Per year	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
8,000	416,000	17	11	8	6	5	4	3	3	3	2	2	2	2	2	1
5,000	260,000	11	7	5	4	3	2	2	2	2	1	1	1	1	1	< 1
3,000	156,000	6	4	3	2	2	1	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
2,000	104,000	4	3	2	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1,000	52,000	2	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
500	26,000	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

5. Health Risk Assessment – Summary of Noncancer Chronic Results

For the generic CSW, CARB staff evaluated the noncancer chronic HI using the modeled diesel PM concentrations. For this assessment, the HI is a ratio of annual average concentrations of diesel PM to the chronic inhalation REL. OEHHA has adopted a chronic REL of 5 µg/m^3. This means that diesel PM concentrations with an HI above one may indicate potential health impacts and may require further evaluation. CARB staff used the highest modeled annual average downwind concentration and determined the HI to be less than one for all activity profiles modeled, these are summarized in Table II.G.12.

Table II.G.12. Summary of the Cold Storage Warehouse Noncancer

Control Measure	Downwind Distance (m) from Facility		
	2019	2024	2030
8,000 Hours of TRU Engine Run-Time per Week			
Baseline	0.39	0.25	0.20
Proposed Am.	-	0.22	0.09
5,000 Hours of TRU Engine Run-Time per Week			
Baseline	0.25	0.16	0.13
Proposed Am.	-	0.14	0.05
3,000 Hours of TRU Engine Run-Time per Week			
Baseline	0.15	0.09	0.08
Proposed Am.	-	0.08	0.03
2,000 Hours of TRU Engine Run-Time per Week			
Baseline	0.10	0.06	0.05
Proposed Am.	-	0.055	0.02
1,000 Hours of TRU Engine Run-Time per Week			
Baseline	0.05	0.031	0.025
Proposed Am.	-	0.028	0.01
500 Hours of TRU Engine Run-Time per Week			
Baseline	0.024	0.016	0.013
Proposed Am.	-	0.014	0.005

Note: Dashes are used for the Proposed Amendments in 2019 because the Proposed Amendments are not yet implemented.

H. Sensitivity Studies

CARB staff performed sensitivity studies to aid in the selection of model inputs. The topics for these sensitivity studies include meteorological station selection and urban population. A detailed discussion of these sensitivity studies is below.

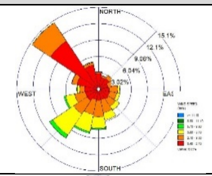
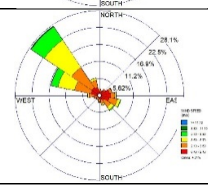
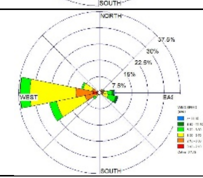
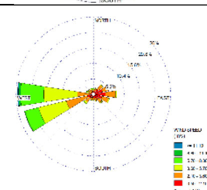
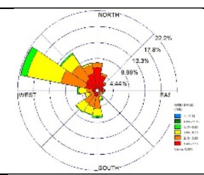
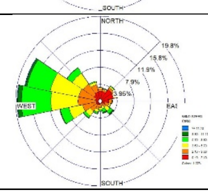
1. Meteorological Station Selection

AERMOD requires hourly surface and upper air meteorological data as inputs to the model, including wind speed, wind direction, cloud cover, ambient temperature, and dew point. Surface stations and radiosondes (i.e., weather balloons) record these meteorological parameters.

To prepare the meteorological data files for input into AERMOD, CARB staff used AERMOD's meteorological preprocessor, AERMET. AERMET extracts surface and upper air information from each station's meteorological dataset, merges the data together, and estimates boundary layer parameters. In addition to meteorological data, boundary layer parameter estimates require surface characteristic values (i.e., albedo, Bowen ratio, and surface roughness) for its calculations. Surface characteristic values are based on the type of land coverage surrounding the surface station.
For this HRA, CARB staff evaluated ten meteorological stations across the State with varying meteorological conditions and land coverage types. Each station's average wind speed, wind direction, land cover, and proximity to refrigerated warehouse and distribution center hubs were compared. Additionally, a sensitivity study was conducted using each meteorological dataset to provide a relative comparison of ground level concentrations.

Table II.H.1 shows the results of the sensitivity study and compares each of the ten meteorological station's meteorological conditions and land cover type.

Table II.H.1. Meteorological Station Comparison

Meteorological Station Location	Average Wind Speed (m/s)	% Calms	Urban	Wind Rose	Maximum Concentration (µg/m³)[9]
Watsonville	2.28	6.05	No		11.09
Fresno	2.95	4.31	Yes		8.61
Banning	4.23	0.15	No		7.39
Los Angeles	3.47	1.04	Yes		6.09
San Diego	2.81	0.99	Yes		12.23
Oakland	3.88	1.22	No		4.59

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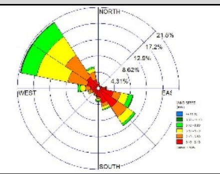
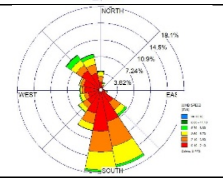
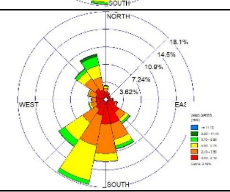
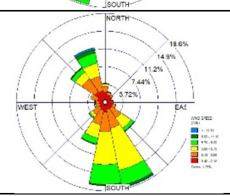
[9] One area source (32.2 x 181.4 meters) was modeled using each station's meteorological dataset. The following inputs were used: an emission rate of 8.012E-06 g/(s-m2), a release height of 5.5 meters, and an initial vertical dimension of 1.28 meters.

Table II.H.1. Meteorological Station Comparison (Cont.)

Meteorological Station Location	Average Wind Speed (m/s)	% Calms	Urban	Wind Rose	Maximum Concentration (µg/m^3)[10]
San Jose	3.14	1.58	No		4.39
Sonoma	2.42	2.44	No		9.93
Sacramento - Executive Airport	2.82	2.42	Yes		9.39
Sacramento - International Airport	3.59	1.27	No		6.18

[10] One area source (32.2 x 181.4 meters) was modeled using each station's meteorological dataset. The following inputs were used: an emission rate of 8.012E-06 g/(s-m^2), a release height of 5.5 meters, and an initial vertical dimension of 1.28 meters.

Of the ten meteorological stations, three were chosen for their collective range of meteorological conditions and land cover type, community interest and concern over the prevalence of refrigerated WHDCs within its city limits, and proximity of the meteorological station to CSW hubs. The three meteorological stations are Watsonville Municipal Airport (Watsonville), Fresno Yosemite International Airport (Fresno), and Banning station (Banning).

2. Urban Population

The urban heat island effect is the phenomena where urban areas are warmer than surrounding rural areas due to human activities and manmade structures. This temperature difference is most apparent during nighttime stable conditions and can cause the formation of a "convective-like" boundary layer. More convection or mixing of air due to an urban-rural temperature difference increases the dispersion of pollutants.

The urban option allows AERMOD to account for the urban heat island effect and the population input serves as a surrogate to define its magnitude (U.S. EPA, 2018a). Without the urban option, urban areas may see higher ground-level concentrations.

CARB staff compared different population results for each meteorological station. Table II.H.2 summarizes these results.

Table II.H.2. Meteorological Station Population Results

Meteorological Station	Metropolitan Statistical Area or MSA (City Population, 2021) (USCB, 2021)	Population (UCSB, 2021)	3 km radius census block (HARP)[11]
Banning	4,224,851 (Riverside-San Bernardino-Ontario Metro Area)	29,603	13,030
Fresno	930,450 (Fresno Metro Area)	494,665	36,059
Watsonville	262,366 (Santa Cruz – Watsonville Metro Area)	51,199	28,311

Additionally, CARB staff conducted a sensitivity study on the effects of differing population inputs. The focus of this sensitivity study was not the ground-level concentration results themselves, but the relative difference of results due to changes

[11] This refers to the census block population within a 3 km radius of the meteorological station.

in population inputs. The results of this sensitivity study are shown in Figure II.H.1 and Table II.H.4.

Figure II.H.1. Sensitivity Study Results – Population vs. Concentration

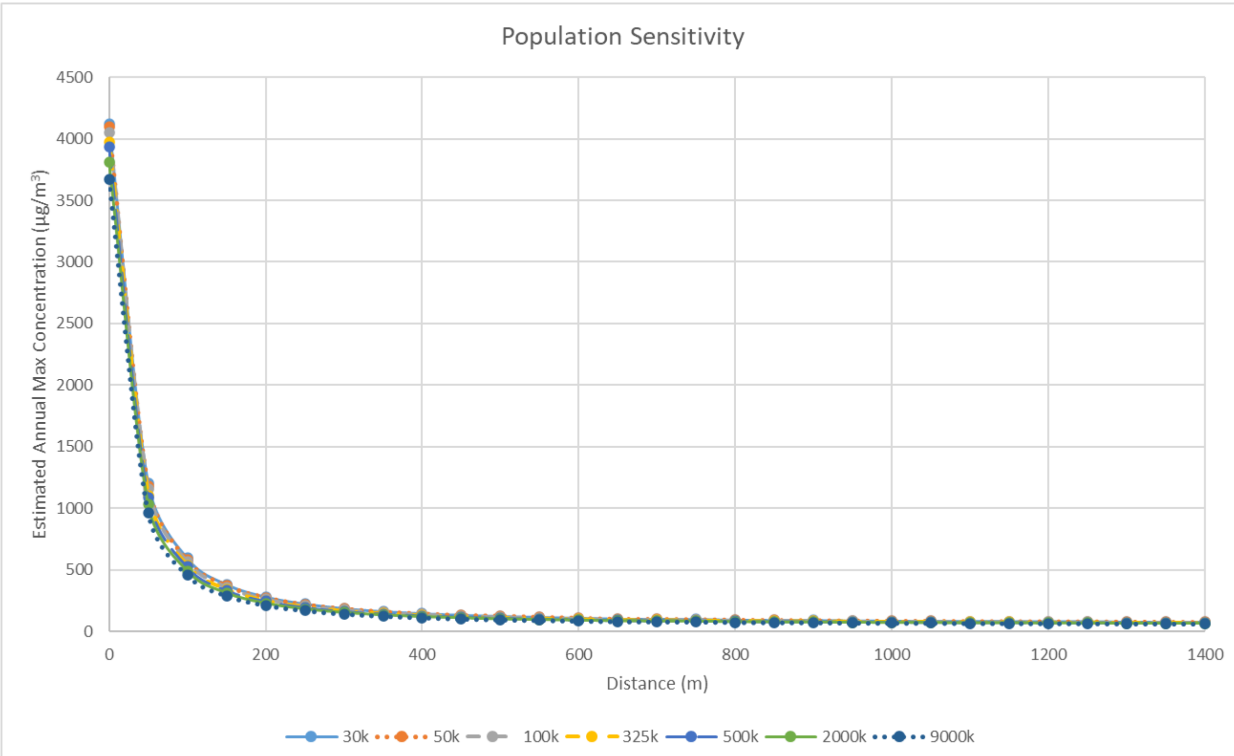


Table II.H.3. Sensitivity Study Results – Population vs. Concentration

Population	30k	50k	100k	325k	500k	2,000k	9,000k
Max Concentration ($\mu g/m^3$)	4,124	4,094	4,051	3,967	3,934	3,813	3,665

Note: The model was set up similar to the grocery store model with stationary, on-site, and off-site area sources. The Watsonville meteorological dataset was used for each model run.

A population of 500,000 was selected for use in the grocery store and CSW for the following reasons:

- A population of 500,000 is representative of a larger city or smaller county or Metropolitan Statistical Area.
- A population of 500,000 resulted in a ground-level concentration 3,934 $\mu g/m^3$. This value is similar to the averaged ground-level concentrations that resulted from the use of the low and high-end populations (i.e., 30,000 and 9,000,000 people).

I. Uncertainty Associated with the HRA Analysis

Health risk assessment is a complex process, which requires the integration of many variables and assumptions. The estimated diesel PM concentrations and potential health risks produced by a risk assessment are based on several assumptions, many of which are designed to be health protective so that potential risks to individuals are not underestimated.

1. Health Values

The toxicity of toxic air contaminants is often established by available epidemiological studies, or use of data from animal studies where data from humans are not available. The diesel PM CPF is based on long-term studies of railyard workers exposed to diesel exhaust in concentrations approximately ten times greater than typical ambient exposures. The differences within human populations usually cannot be easily quantified and incorporated into risk assessments. Factors including metabolism, target site sensitivity, diet, immunological responses, and genetics may influence the response to toxicants.

Human exposures to diesel PM are often based on limited availability of data and are mostly derived based on estimates of emissions and duration of exposure. Different epidemiological studies also suggest somewhat different levels of risk. When the Scientific Review Panel (SRP) identified diesel PM as a toxic air contaminant (CARB, 1998), the panel members endorsed a range of inhalation CPF (1.3 x 10^{-4} to 2.4 x 10^{3} ($\mu g/m^3)^{-1}$) and a risk factor of 3 x 10^{-4} ($\mu g/m^3)^{-1}$, as a reasonable estimate of the unit risk. From the unit risk factor an inhalation CPF of 1.1 $(mg/kg\text{-}day)^{-1}$ was calculated by OEHHA, which is used in this HRA. Many epidemiological studies support the finding that diesel exhaust exposure elevates relative risk for lung cancer. However, the quantification of each uncertainty applied in the estimate of cancer potency is very difficult and can be itself uncertain.

2. Air Dispersion Models

As mentioned previously, there is no direct measurement technique to measure diesel PM in ambient air (e.g., ambient air monitoring). This analysis used air dispersion modeling to estimate the concentrations to which the public is exposed. While air dispersion models are based on state-of-the-art formulations using the best science, uncertainties are associated with the models.

The air dispersion model predictions have been improved over the years because of better representations in the model structure. In 2006, the U.S. EPA modeling guidance adopted AERMOD as the preferred model for near-field dispersion of emissions for distances up to 50 km. Many updated formulations have been incorporated into the model structure for better predictions from the air dispersion process. The primary purpose of this HRA analysis is to quantify the improvement in health impacts that would result from the regulatory proposal. The U.S. EPA preferred air dispersion model, AERMOD, was selected for use in this HRA.

3. Model Inputs

The model inputs include emission rates, modeling source parameters, meteorological conditions, and dispersion coefficients. Each of the model inputs has uncertainty associated with it. Among these inputs, emission rates and meteorological conditions have the greatest effect on modeling results.

This emission rate for each source was estimated from the emission inventory. The emission inventory has several sources of uncertainty, including emission factors, equipment population and age, equipment activity, and load factors. The uncertainties in the emission inventory can lead to over predictions or under predictions in the modeling results. CARB staff estimated TRU emissions based on the best available information regarding past, current, and projected TRU activities.

The modeling parameters also have several sources of uncertainty, including dispersion coefficients, release height, and initial vertical dimension. The inputs for these modeling parameters are based on sensitivity studies conducted by CARB staff.

III. REGIONAL PM2.5 MORTALITY AND ILLNESS ANALYSIS FOR CALIFORNIA AIR BASINS

CARB staff conducted a mortality and illness analysis based on the statewide emission reductions of PM2.5 and NOx that would be achieved by the Proposed Amendments. This section provides a summary of the mortality and illness impacts, which include premature death from cardiopulmonary disease, hospital admissions, and emergency room visits.

A. PM2.5 Mortality and Illness Overview

The Proposed Amendments would reduce NOx, and PM2.5 emissions, resulting in health benefits for individuals in California. CARB analyzed four health outcomes: cardiopulmonary mortality, hospitalizations for cardiovascular illness, hospitalizations for respiratory illness, and emergency room visits for asthma. These health outcomes and others have been identified by U.S. EPA as having a causal or likely causal relationship with exposure to PM2.5 based on a substantial body of evidence (U.S. EPA, 2019).

U.S. EPA has determined that both long-term and short-term exposure to PM2.5 play a causal role in premature mortality, meaning that a substantial body of scientific evidence shows a relationship between PM2.5 exposure and increased risk of mortality. This relationship persists when other risk factors such as smoking, poverty and other factors are taken into account (U.S. EPA, 2019).

U.S. EPA has also determined a causal relationship between nonfatal cardiovascular effects and short and long-term exposure to PM2.5 and a likely causal relationship between non-mortality respiratory effects and short and long-term PM2.5 exposures (U.S. EPA, 2019). These outcomes lead to hospitalizations and emergency room visits and are included in this analysis.

CARB staff evaluated a limited number of statewide non-cancer health benefits associated with reductions in exposure to PM2.5 and NOx emissions resulting from the Proposed Amendments. NOx includes nitrogen dioxide, a potent lung irritant, which can aggravate lung diseases such as asthma when inhaled (U.S. EPA, 2016). However, the most serious quantifiable impacts of NOx emissions occur through the conversion of NOx to fine particles of ammonium nitrate aerosol through chemical processes in the atmosphere. PM2.5 formed in this manner is termed secondary PM2.5. Both directly emitted (primary) PM2.5 and secondary PM2.5 is associated with adverse health outcomes, such as cardiopulmonary mortality, hospitalizations for cardiovascular and respiratory illnesses, and emergency room visits for asthma. As a result, reductions in PM2.5 and NOx emissions are associated with reductions in these adverse health outcomes.

1. Incidence-Per-Ton Methodology

CARB uses the incidence-per-ton (IPT) methodology to quantify the health benefits of emission reductions in cases where air quality modeling results are not available. A description of this method is included on CARB's Methodology for Estimating the Health Effects of Air Pollution webpage (CARB, 2021a). CARB's IPT methodology is based on a methodology developed by U.S. EPA (Fann et al., 2009; Fann et al., 2012; Fann et al., 2018).

The IPT methodology assumes that changes in emissions are approximately proportional to changes in health outcomes. IPT factors are derived by calculating the number of health outcomes associated with exposure to PM2.5 concentrations for a baseline scenario and dividing by the emissions of PM2.5 or a precursor. The calculation is performed separately for each air basin using the following equation:

IPT = (number of health outcomes in air basin)/(annual emissions in air basin)

Multiplying the emission reductions from the Proposed Amendments in an air basin by the IPT factor then yields an estimate of the reduction in health outcomes achieved by the Proposed Amendments. For future years, the number of outcomes is adjusted to account for population growth. CARB's current IPT factors are based on a 2014-2016 baseline scenario, which represents the most recent data available at the time the current IPT factors were computed. IPT factors are computed for the two types of PM2.5: primary PM2.5 and secondary PM2.5 of ammonium nitrate aerosol formed from precursors.

2. Reduction in Health Outcomes

CARB staff estimated the reduction in adverse health outcomes associated with reduced emissions of PM2.5 and NOx due to the Proposed Amendments. These health outcomes include cardiopulmonary mortality, hospital admissions for cardiovascular and respiratory illnesses, and emergency room visits for asthma. Based on the analysis, staff estimates that the total reduction in the number of cases statewide due to the implementation of the Proposed Amendments from 2022 to 2034 would be as follows:

- 177 fewer premature deaths (138 to 217, 95 percent confidence interval (CI))
- 57 fewer hospital admissions for cardiovascular and respiratory illnesses (7 to 106, 95 percent CI)
- 87 fewer emergency room visits for asthma (55 to 119, 95 percent CI)

Tables III.A.1 through III.A.3 show the estimated reductions in adverse health outcomes resulting from the Proposed Amendments by air basin from 2022 to 2034.

The biggest health benefits are expected to occur in the South Coast, San Joaquin Valley, and San Francisco Bay Area air basins.

Table III.A.1. Reductions in Health Outcomes from PM2.5 Emissions as a Result of the Proposed Amendments (2022 to 2034)

Air Basin	Cardiopulmonary Mortality	Cardiovascular and Respiratory Hospital Admissions	Asthma Emergency Room Visits
Great Basin Valleys	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Lake County	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Lake Tahoe	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Mojave Desert	2 (2 - 3)	1 (0 - 1)	1 (1 - 1)
Mountain Counties	1 (1 - 1)	0 (0 - 0)	0 (0 - 0)
North Central Coast	1 (1 - 1)	0 (0 - 1)	1 (0 - 1)
North Coast	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Northeast Plateau	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Sacramento Valley	5 (4 - 7)	1 (0 - 2)	2 (1 - 3)
Salton Sea	1 (1 - 2)	0 (0 - 1)	1 (0 - 1)
San Diego County	5 (4 - 6)	1 (0 - 3)	2 (1 - 3)
San Francisco Bay Area	17 (14 - 21)	6 (1 - 11)	10 (6 - 13)
San Joaquin Valley	15 (12 - 19)	4 (0 - 7)	6 (4 - 8)
South Central Coast	1 (1 - 1)	0 (0 - 1)	0 (0 - 1)
South Coast	95 (74 - 117)	33 (4 - 61)	49 (31 - 67)
Total	146 (114 - 179)	47 (6 - 87)	72 (46 - 99)

Note: The values in parentheses represent the 95 percent confidence intervals of the central estimate. Totals may not add due to rounding.

Table III.A.2. Reductions in Health Outcomes from NOx Emissions as a Result of the Proposed Amendments (2022 to 2034)

Air Basin	Cardiopulmonary Mortality	Cardiovascular and Respiratory Hospital Admissions	Asthma Emergency Room Visits
Great Basin Valleys	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Lake County	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Lake Tahoe	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Mojave Desert	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Mountain Counties	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
North Central Coast	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
North Coast	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Northeast Plateau	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)

Air Basin	Cardiopulmonary Mortality	Cardiovascular and Respiratory Hospital Admissions	Asthma Emergency Room Visits
Sacramento Valley	1 (1 - 1)	0 (0 - 1)	0 (0 - 1)
Salton Sea	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
San Diego County	1 (1 - 1)	0 (0 - 1)	0 (0 - 1)
San Francisco Bay Area	3 (2 - 3)	1 (0 - 2)	1 (1 - 2)
San Joaquin Valley	6 (5 - 8)	2 (0 - 3)	2 (2 - 3)
South Central Coast	0 (0 - 1)	0 (0 - 0)	0 (0 - 0)
South Coast	19 (15 - 23)	7 (1 - 12)	10 (6 - 14)
Total	31 (25 - 38)	10 (1 - 19)	15 (10 - 21)

Note: The values in parentheses represent the 95 percent confidence intervals of the central estimate. Totals may not add due to rounding.

Table III.A.3. Total Reductions in Health Outcomes as a Result of the Proposed Amendments (2022 to 2034)

Air Basin	Cardiopulmonary Mortality	Cardiovascular and Respiratory Hospital Admissions	Asthma Emergency Room Visits
Great Basin Valleys	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Lake County	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Lake Tahoe	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Mojave Desert	2 (2 -3)	1 (0 - 1)	1 (1 - 1)
Mountain Counties	1 (1 - 1)	0 (0 - 0)	0 (0 - 0)
North Central Coast	1 (1 - 2)	0 (0 - 1)	1 (0 - 1)
North Coast	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Northeast Plateau	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Sacramento Valley	7 (5 - 8)	2 (0 - 3)	2 (2 - 3)
Salton Sea	1 (1 - 2)	0 (0 - 1)	1 (0 - 1)
San Diego County	6 (5 - 7)	2 (0 - 3)	2 (2 - 3)
San Francisco Bay Area	20 (16 - 25)	7 (1 - 12)	11 (7 - 15)
San Joaquin Valley	22 (17 - 27)	5 (1 - 9)	8 (5 - 11)
South Central Coast	2 (1 - 2)	0 (0 - 1)	1 (0 - 1)
South Coast	115 (89 - 140)	40 (5 - 74)	59 (37 - 81)
Total	177 (138 - 217)	57 (7 -106)	87 (55 - 119)

Note: The values in parentheses represent the 95 percent confidence intervals of the central estimate. Totals may not add due to rounding.

3. Uncertainties Associated with the Mortality and Illness Analysis

Although the estimated health outcomes presented in this report are based on a well-established methodology, they are subject to uncertainty. Uncertainty is reflected in the 95 percent confidence intervals included with the central estimates in Tables III.A.1 through III.A.3. These confidence intervals take into account uncertainties in translating air quality changes into health outcomes.

Other sources of uncertainty include the following:

- The relationship between changes in pollutant concentrations and changes in pollutant or precursor emissions is assumed to be proportional, although this is an approximation.
- Emissions are reported at an air basin resolution, and do not capture local variations.
- Future population estimates are subject to increasing uncertainty as they are projected further into the future.
- Baseline incidence rates can experience year-to-year variation.

4. Monetization of Health Impacts

In accordance with U.S. EPA practice, staff monetized health outcomes by multiplying the projected number of cases by a standard value derived from economic studies (NCEE, 2010).[12] The valuations assigned to different health outcomes is provided in Table III.A.4.

Table III.A.4. Valuation per Incident Avoided Health Outcomes (2019$)

Outcome	Valuation per Incident[1]
Avoided Premature Deaths	$9,864,695
Avoided Acute Respiratory Hospitalizations	$58,288
Avoided Cardiovascular Hospitalizations	$50,842
Avoided Emergency Room Visits	$834

The valuation for avoided premature mortality is based on willingness to pay (U.S. EPA, 2000). This value is a statistical construct based on the aggregated dollar amount that a large group of people would be willing to pay to avoid a single annual death in the population. This value is not an estimate of how much someone would be

[12] Aside from its role in the formation of secondary PM2.5, NOx is also a precursor to ozone. However, the health impacts associated with NOx-derived PM2.5 generally outweigh the impacts for NOx-derived ozone. As a result, this analysis only monetizes the value of reductions in PM2.5.

willing to pay to prevent the death of any person (U.S. EPA, 2021a), nor does it consider specific mortality-related costs such as hospital expenses.

Unlike premature mortality valuation, the valuation for avoided hospitalizations and emergency room visits is based on a combination of typical costs and the willingness of surveyed individuals to pay to avoid adverse outcomes that occur when hospitalized. These include hospital charges, post-hospitalization medical care, out-of-pocket expenses, and lost earnings for both individuals and family members. It also includes lost recreation value and lost household protection (e.g., valuation of time-losses from inability to maintain a household or provide childcare). These costs are most closely associated with specific cost savings to individuals and costs to the health care system.

CARB staff quantified the total statewide valuation due to avoided adverse health outcomes from 2022 to 2034. These values are summarized in Table III.A.5. The spatial distribution of these benefits follows the distribution of emission reductions and avoided adverse health outcomes. Therefore, most benefits to individuals would occur in the South Coast, San Joaquin Valley, and San Francisco air basins, with fewer benefits in the Sacramento Valley and San Diego County air basins.

Table III.A.5. Statewide Valuation from Avoided Adverse Health Outcomes as a Result of the Proposed Amendments from 2022 to 2034 (2019$)

Outcome	Valuation
Avoided Premature Deaths	$1,749,747,000
Avoided Hospitalizations	$3,092,000
Avoided Emergency Room Visits	$73,000
Total	$1,752,912,000

Note: Values have been rounded to the nearest thousand.

In addition to the health impacts for which valuations were provided, the Proposed Amendments would provide other health benefits that are not currently quantified. These include decreases in vulnerability and impacts in disadvantaged communities, work loss days, school loss days, nervous system and lung impacts, and cancer risk.

B. Potential Future Evaluation of Additional Health Benefits

While CARB’s PM2.5 mortality and illness analysis has been, and continues to be, a useful method for valuing the health benefits of regulations, it only represents a portion of those benefits. The full health benefits of the Proposed Amendments are underestimated because not all the adverse health outcomes associated with PM2.5 and additional pollutants such as air toxics are evaluated and monetized. Also, CARB’s current evaluation methodology does not take into account all PM2.5 precursor emissions. Expansion of the emissions inputs and health outcomes, including, but not limited to, additional cardiovascular and respiratory illnesses, nonfatal/fatal cancers, nervous system diseases, and work loss days would provide a more comprehensive picture of the benefits from reduced exposure to air pollution. In addition, in 2021, U.S. EPA issued a Technical Support Document (TSD) for their Cross-State Air Pollution Rule that provided both health functions and health valuation for lung cancer incidence, Alzheimer's disease, and Parkinson's disease, among other health endpoints related to PM2.5 exposures (U.S. EPA, 2021b).

In addition, regulatory sources such as TRUs generate additional pollutants beyond PM 2.5 that contribute to serious health outcomes. For instance, NOx reacts with other compounds to form ozone, which can then cause respiratory problems. Updated health impact functions and valuations for ozone are also provided in the aforementioned Cross-State Air Pollution Rule TSD provided by the U.S. EPA (U.S. EPA, 2021b). Additionally, exposure to TACs emitted from TRUs can lead to cancers.

Expanding CARB's health evaluation and economic valuation methodology to include any of the above additional inputs and health outcomes would allow the public to reach a better understanding of the benefits from reducing air pollution by moving toward zero-emission technologies. As indicated, the scientific literature has demonstrated an array of air pollutant-related health impacts, well beyond what CARB staff have quantified in Tables III.A.1 through III.A.3. Some of these impacts are summarized in the next section.

C. Adverse Impacts to Human Health from Diesel Emissions

Diesel-powered mobile sources emit a complex mixture of air pollutants, including diesel PM and gases. The gaseous pollutants include volatile organic compounds (VOC) and NOx, which can lead to the formation of ozone (O_3) and the secondary formation of PM (CARB, 2021b).

1. Air Toxic Impacts

Diesel PM is a toxic air contaminant (TAC) composed of PM and over 40 known cancer-causing substances, including polycyclic aromatic hydrocarbons, benzene, formaldehyde, acetaldehyde, acrolein, and 1,3-butadiene (CARB, 2021b). CARB listed diesel PM as a TAC in 1998, due largely to its association with lung cancer (CARB, 2021b). In 2012, additional studies on the cancer-causing potential of diesel exhaust published since CARB's listing led the International Agency for Research on Cancer (IARC, a division of the World Health Organization) to classify diesel engine exhaust as "carcinogenic to humans" (CARB, 2021b; IARC, 2012). In California, about 70 percent of known cancer risks from TACs are from diesel engine emissions (CARB, 2021b; Propper et al., 2015).

2. Particle Pollution Impacts

Diesel PM is composed primarily of PM2.5 (CARB, 2021c). Due to its small size, inhaled PM2.5 can reach the lower respiratory tract and potentially pass into the bloodstream to affect other organs (U.S. EPA, 2021c). In this way, PM2.5 contributes not only to increased cancer risk, but also respiratory and cardiovascular diseases and even premature death (U.S. EPA, 2019). Other adverse health outcomes from PM2.5 include asthma, chronic heart disease, and heart attack (CARB, 2021c U.S. EPA, 2019; WHO Europe, 2013). Moreover, PM2.5 can result in respiratory, cardiac, and mortality effects over short exposure times such as days or weeks (U.S. EPA, 2019). PM2.5 is well known to exacerbate asthma, bronchitis, and heart disease symptoms (U.S. EPA, 2019). Exposures to PM2.5 may also lead to myriad other health outcomes, including metabolic, nervous system, reproductive, and developmental effects (U.S. EPA, 2019). For example, adverse health conditions with possible links to airborne PM2.5 include high blood pressure, insulin resistance, and other risk factors for Type II Diabetes, as well as psychological/cognitive problems (U.S. EPA, 2019). PM2.5 may especially impact women and children via health effects such as pre-term birth, reduced birth weight, and abnormal lung and cardiovascular development (U.S. EPA, 2019).

3. Ozone Pollution Impacts

As a gaseous pollutant from diesel sources, NOx can react with other compounds to form ozone, which is the main component of smog. Based on extensive evidence from scientific studies, the US EPA has determined that short-term exposure from ozone is causally linked to adverse respiratory effects (U.S. EPA, 2020). Ozone can cause irritation and damage to lung tissue and worsen asthma and chronic illnesses including chronic obstructive pulmonary disease and reduced lung function. For instance, a study conducted in the San Joaquin Valley showed that increased ozone pollution led to increased risk for asthma emergency room visits, especially for children and Black residents (Gharibi et al., 2019). Metabolic functions are also likely to be affected by short-term ozone exposure, such as those leading to increased risk for complications and hospitalizations in diabetic individuals (U.S. EPA, 2020). And, similar to PM2.5, other potential health effects from ozone exposure may include impacts on the cardiovascular, nervous, and reproductive systems, and possibly increased risk of mortality (U.S. EPA, 2020).

D. Conclusion

TRUs generate criteria pollutants and TACs that are known to cause a range of serious health impacts including premature deaths. As shown in Tables III.A.1 through III.A.3, CARB estimates that implementation of the Proposed Amendments would result in substantial health and economic benefits, due to reduced cardiovascular/respiratory hospitalizations, asthma emergency room visits, and cardiopulmonary deaths. Despite these substantive benefits, CARB’s assessment is limited and thus likely an underestimation, because it does not consider the various other health outcomes that could be avoided with cleaner TRUs. Furthermore, those who live and work around areas with high TRU activity, especially those living in disadvantaged communities, are more heavily impacted by these pollutant exposures. For these individuals, actions like the Proposed Amendments to move to cleaner TRUs are critically important. Sections

V.A.1 and VI.D.1 provide an analysis of the potential cancer risk reductions with the Proposed Amendments, while Sections V.C and VIII provide a discussion of the potential benefits to nearby disadvantaged communities.

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