California Air Resources Board Staff

PRELIMINARY HEALTH ANALYSES: TRANSPORT REFRIGERATION UNIT REGULATION

Public Review Draft

Release Date: October 18, 2019
Comments Due: November 21, 2019

CALIFORNIA AIR RESOURCES BOARD

FORWARD

Staff is releasing these preliminary health analyses for public review in advance of the Initial Statement of Reasons (ISOR) for the Transport Refrigeration Unit Regulation to support early public review and comment.

Please submit any comments on this draft by Thursday, November 21, 2019 to the electronic comment log at:

https://www.arb.ca.gov/lispub/comm2/bcsubform.php?listname=truhealthanalyses-ws&comm_period=1.

Questions may be addressed to:

Greg Harris, Manager
Risk Analysis Section
Transportation and Toxics Division
California Air Resources Board

Greg may be reached by email at greg.harris@arb.ca.gov or by phone at (916) 327-5980.

PRELIMINARY HEALTH ANALYSES: CONTROL MEASURE FOR TRANSPORT REFRIGERATION UNITS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

California Air Resources Board (CARB) staff is developing a new regulation to further reduce emissions from transport refrigeration units (TRU) and TRU generator sets. In support of this effort, CARB staff conducted health analyses to evaluate the health impacts of emissions from TRUs operating at cold storage warehouses (CSW) and grocery stores. These health analyses examine the current and future impacts of the existing TRU Airborne Toxic Control Measure (TRU ATCM) and compare them to the health benefits from implementing the draft concept for the new TRU Regulation (Concept). Additionally, they are designed to be health protective while accounting for the variances in activity at CSWs and grocery stores.[1]

CARB staff presented the Concept for comment and discussion at public workshops in August and September 2019. These preliminary draft health analyses evaluate the version of the Concept presented at the workshops. The Initial Statement of Reasons (ISOR) will contain the official staff proposal for consideration by the Board. The ISOR will be released 45 days prior to the Board hearing and will include updated analyses of health benefits, emissions, and environmental and economic impacts based on the formal regulatory proposal.

This section of the document provides an overview and summary of the results in a question and answer format. A more technical discussion on the health analyses follows in the body of this document.

1. What are transport refrigeration units (TRU) and TRU generator sets?

Under the existing TRU ATCM, TRUs are refrigeration systems powered by integral internal combustion engines designed to control the environment of temperature-sensitive products transported in insulated trucks, trailers, shipping containers, and railcars. In general, TRUs may be capable of both cooling and heating.

TRU generator sets, which typically operate at ports and intermodal rail yards, are systems designed and used to provide electricity to electrically-driven refrigeration units of any kind. These include, but are not limited to, generator sets that provide electricity to power refrigeration systems for semi-trailers, vans,

[1] The California Air Resources Board (CARB) adopted the TRU Airborne Toxic Control Measure (ATCM) on February 26, 2004, with amendments in 2010 and 2011, to reduce diesel PM emissions. For more information see: https://www.arb.ca.gov/our-work/programs/transport-refrigeration-unit/about.

and shipping containers, when not plugged into ocean-going ship electric power or dock shore power.

2. Why is CARB concerned about air pollution from the engines that power TRUs and TRU generator sets?

The diesel engines that power TRUs and TRU generator sets emit multiple air pollutants, including diesel particulate matter (diesel PM) which encompasses fine particulate matter ($PM_{2.5}$) and black carbon, nitrogen oxides (NO_x), carbon monoxide (CO), hydrocarbons, and greenhouse gases (GHG). Additionally, in California, TRUs typically operate at refrigerated warehouses and distribution centers (WHDC), CSWs, grocery stores, and other locations that are often near sensitive receptors, such as schools, hospitals, senior care facilities, and residential neighborhoods. Despite the progress made under current control programs, emissions from the engines that power TRUs and TRU generator sets are still a significant contributor to community air pollution and the associated health impacts.

Diesel PM: In 1998, CARB identified diesel PM as a toxic air contaminant based on its potential to cause lung cancer and other health problems. These health issues include premature death, increased hospital admissions for heart and lung disease, and increased emergency room (ER) visits for asthma. This is especially true for children, the elderly, outdoor workers, and other sensitive populations.

$PM_{2.5}$ and NO_x: These pollutants are directly emitted from the diesel engines that power TRUs and TRU generator sets and can react in the atmosphere with other chemicals to create regional air pollutants over a larger geographic area. For example, NO_x emissions contribute to both regional ozone and regional $PM_{2.5}$ levels. The noncancer health impacts from exposure to $PM_{2.5}$ are consistent with those described above for diesel PM, with the primary concern being adverse cardiac and respiratory effects.

Carbon Monoxide: CO is a byproduct of incomplete combustion and is directly emitted from the diesel engines that power TRUs and TRU generator sets. Carbon monoxide is readily absorbed into the body from the lungs. It decreases the capacity of the blood to transport oxygen, which leads to health risks for unborn children and people suffering from heart and lung disease.

Hydrocarbons: Hydrocarbons are directly emitted from the diesel engines that power TRUs and TRU generator sets and can react in the atmosphere with other chemicals to create ozone.

GHG and Black Carbon: GHGs and the short-lived climate pollutant black carbon (a subset of $PM_{2.5}$) from the diesel engines that power TRUs and TRU generator sets contribute to climate change. Climate scientists agree that human activities over the past century are the cause of global warming and other shifts in the climate system.

These recorded changes are occurring at an unprecedented rate.[2] According to new research, unabated GHG emissions could cause sea levels to rise 10 feet by the end of this century, which is an outcome that could devastate coastal communities in California and around the world.[3]

California is already feeling the effects of climate change, and projections show that these effects will continue and worsen over the coming centuries. The impacts of climate change on California have been documented by the Office of Environmental Health Hazard Assessment (OEHHA) in the Indicators of Climate Change Report.[4]

Impacts on Communities: Communities near facilities where TRUs are operated bear a disproportionate health burden due to their close proximity to emissions from diesel engines that power TRUs and TRU generator sets. There are several occurrences across the state where communities contain “groups” or “clusters” of refrigerated warehouses. In many cases, these warehouses are in disadvantaged communities. The California Environmental Protection Agency (CalEPA) uses the California Communities Environmental Health Screening Tool (CalEnviroScreen) as a tool to identify disadvantaged communities within California. CalEPA bases its identification of the disadvantaged communities on the CalEnviroScreen tool. This tool considers geographic, socioeconomic, public health, and environmental hazard criteria. In this capacity, CalEPA currently designates a disadvantaged community, from an environmental hazard and socioeconomic standpoint, as the top 25 percent highest scoring census tracts, using results provided by the CalEnviroScreen. Exposure to diesel pollution is a main contributor to many communities scoring in the top 10th percentile statewide. CARB has also identified several neighborhoods as selected communities within the first year of implementation of the Community Air Protection Program, developed in response to Assembly Bill (AB) 617, which highlights the need for further emission reductions in communities with high exposure burdens.

3. In California, what regulations are already in place to reduce emissions and community exposure to air pollution from the diesel engines that power TRUs and TRU generator sets?

In addition to national standards for off-road diesel engines and diesel fuel, in 2004, CARB adopted the existing TRU ATCM to reduce diesel PM emissions from the engines that power TRUs and TRU generator sets. The ATCM 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

[2] Cook et. al., 2016. Consensus On Consensus: A Synthesis of Consensus Estimates On Human-caused Global Warming. Environ. Res. Lett. 11 (2016) 048002, doi:10.1088/1748-9326/11/4/048002. Available at http://iopscience.iop.org/article/10.1088/1748-9326/11/4/048002/pdf.

[3] OPC, 2017. California Ocean Protection Council, Rising Seas in California: An Update On Sea-Level Rise Science. Available at www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sealevel-rise-science.pdf.

[4] Office of Environmental Health Hazard Assessment (OEHHA)*, Indicators of Climate Change in California* (May 2018), available at https://oehha.ca.gov/media/downloads/climatechange/report/2018caindicatorsreportmay2018.pdf.

the equipment. This can be achieved by meeting the U.S. EPA Tier 4 final emission standard for 25-50 horsepower (hp) 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.

4. What is CARB staff's new Concept to further reduce emissions from the diesel engines that power TRUs and TRU generator set?

CARB staff is developing a new regulation to further reduce emissions from TRUs and TRU generator sets. The Concept includes the following requirements:

Starting in 2022:

- All TRUs and TRU generator sets that operate in California, regardless of the home state of the unit/company must register with CARB.
- All new truck TRUs, trailer TRUs, domestic shipping container TRUs, and railcar TRUs that operate in California must use refrigerant with a global warming potential (GWP) $\leq$2,200.

Starting in 2023:

- All applicable facilities (e.g., refrigerated warehouses and distribution centers, CSWs, grocery stores, truck stops, ports, and intermodal rail yards) in California must register with CARB and provide geofence information.

Starting in 2024:

- All applicable facilities must complete installation of electrical charging/fueling infrastructure to support zero-emission operation of TRUs.

Starting in 2025:

- All truck TRU fleets must turnover at least 15 percent each year (for 7 years) to full zero-emission technology. All truck TRUs must be fully zero-emission by 2031.
- All trailer TRUs, domestic shipping container TRUs, and TRU generator sets must use zero-emission operation if parked or stationary for more than 15 minutes at an applicable facility and be equipped with an electronic telematics system.
- All diesel engines in trailer TRUs, domestic shipping container TRUs, railcar TRUs, and TRU generator sets that operate in California, regardless of horsepower, must meet the more stringent U.S. EPA Tier 4 final emission standard for 25-50 hp engines.

5. What types of health analyses did CARB staff perform to assess the impacts of emissions from TRUs?

CARB staff evaluated the health impacts attributable to emissions from the diesel engines that power TRUs using two different methods: 1) a health risk assessment (HRA) that considers the near source impacts around a CSW and a grocery store, and 2) a mortality and illness analysis that estimates statewide potential health outcomes.

Risk assessment is a tool useful in evaluating the potential for a pollutant to cause cancer or other noncancer illnesses. Health risk assessments evaluate the potential health impacts of various sources of air pollution and can project how those impacts would change with the reduction in emissions from future reduction control measures, such as those identified in the Concept.

A mortality and illness analysis uses air quality monitoring, emissions inventory data, and county-specific statistics on health outcomes (e.g., premature death due to cardiac or respiratory effects, plus hospitalizations and emergency room visits attributed to those causes) attributable to emissions from TRU operations. This analysis focuses on the impacts of regional $PM_{2.5}$ pollution, either directly emitted from TRU engines, or formed in the atmosphere from NO_x emissions from the same sources.

6. What are the key inputs and outputs for the health analyses in this preliminary draft report?

The major elements of the health analyses include emissions data, air dispersion modeling, and the assessment of cancer and noncancer health impacts. These analyses rely on the following key input and outputs:

- Development of a diesel PM emissions inventory from TRU engines at refrigerated warehouses and grocery stores.
- Calculation of the statewide $PM_{2.5}$ and NO_x emission reduction benefits for the Concept, beyond the benefits of the existing TRU ATCM.
- Estimation of the diesel PM concentrations around a refrigerated warehouse and grocery store using a U.S. Environmental Protection Agency (U.S. EPA) approved air dispersion model (AERMOD).[5]
- Population data at the census tract level for five-year age brackets, mortality incidence data at the county level, and hospital admissions and emergency room visits at the state level.

[5] The American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) is a steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.

- Concentration-response function relating changes in $PM_{2.5}$ concentrations to changes in the number of health outcomes.
- Quantification of the potential near source cancer and noncancer health impacts associated with diesel PM concentrations using the State's methodology for HRAs established by OEHHA in the Air Toxics Hot Spots Program Risk Assessment Guidelines: The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments (OEHHA, 2015) (OEHHA Guidance Manual).
- Quantification of the potential statewide $PM_{2.5}$ mortality and illness impacts.

7. What facilities did CARB staff select to evaluate the localized benefits of the Concept in reducing the impacts from TRUs?

To evaluate the effectiveness of the Concept in reducing health impacts in communities that have facilities where TRUs typically operate, staff evaluated three facility types:

- Cold Storage Warehouse: Staff's analysis included the impacts of diesel PM emissions from the engines that power TRUs when they are parked either at a loading dock or in a staging area. The analysis also evaluated the impacts when the truck or trailer, on which the TRU is mounted, is traveling to, or from the facility and moving around within the facility boundaries.
- Grocery Store: Staff's analysis included the impacts of diesel PM emissions from daily trailer TRUs, daily truck TRUs, and seasonal trailer TRUs that are parked at the store. The analysis also evaluated the impacts when the truck TRU or trailer TRU is traveling to, or from the grocery store, and moving within the grocery store parking lot.
- Multi-Facility: Staff's analysis included the impacts of diesel PM emissions from a cluster of four refrigerated warehouses. This scenario illustrates the cumulative health effects on communities near multiple facilities within a short distance of one another. However, the Concept, does not place specific requirements on these type of multi-facility configurations. Please see the CSW analysis for the TRU activities considered for the clusters.

The assumptions used to determine potential cancer risks are not based on TRUs at a specific facility, but rather a generic (i.e., example) facility was developed for each type of facility, 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.

8. What is the process CARB staff used to assess the localized health risk for the facilities evaluated?

CARB staff estimated the amount of diesel PM emitted from engines that power TRUs operating at a generic CSW and a generic grocery store. CARB staff generated the exposure estimates with U.S. EPA's preferred air dispersion model, AERMOD, to estimate the annual average off-site concentration of diesel PM resulting from the activity at these two types of facilities. The key inputs to AERMOD were the diesel PM emissions information (e.g., how much, when, and where), the meteorological data (e.g., temperature, wind speed, wind direction, etc.), and the dispersion coefficients (e.g., consideration of land cover, such as concrete surfaces versus open fields and trees).

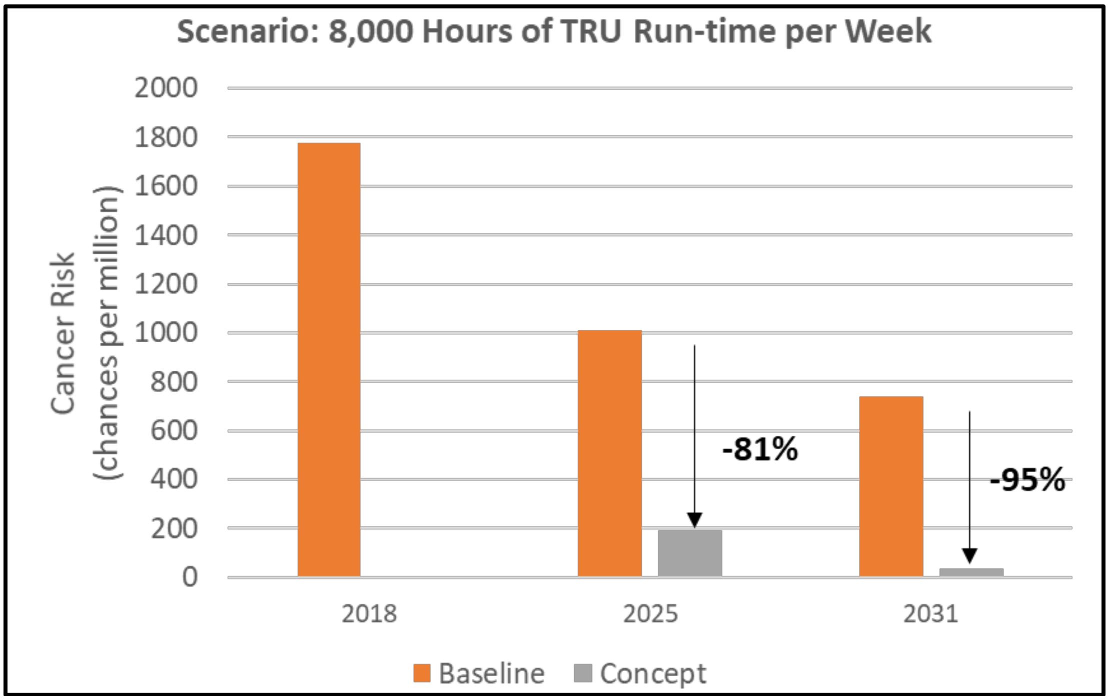
CARB staff then calculated the potential cancer risks using the annual average concentration of diesel PM predicted by the AERMOD model and a health risk factor (referred to as a cancer potency factor) that correlates cancer risk to the amount of diesel PM inhaled. This HRA is consistent with the methodology presented in the OEHHA Guidance Manual. The cancer potency factor was developed by OEHHA and approved by the Scientific Review Panel on Toxic Air Contaminants as part of the public process to identify diesel PM as a toxic air contaminant.

In a risk assessment, cancer risk is typically expressed as the chance an individual has of developing cancer if a million people were exposed to a toxic air contaminant continuously for a specified duration of exposure (e.g., 30 or 70 years).

9. How much would the implementation of the Concept reduce residential cancer risk?

The preliminary health analyses estimate that the implementation of the Concept may reduce residential cancer risk from diesel fueled engines that power TRUs by 95 percent in the CSW scenario shown in Figure ES-1 below.

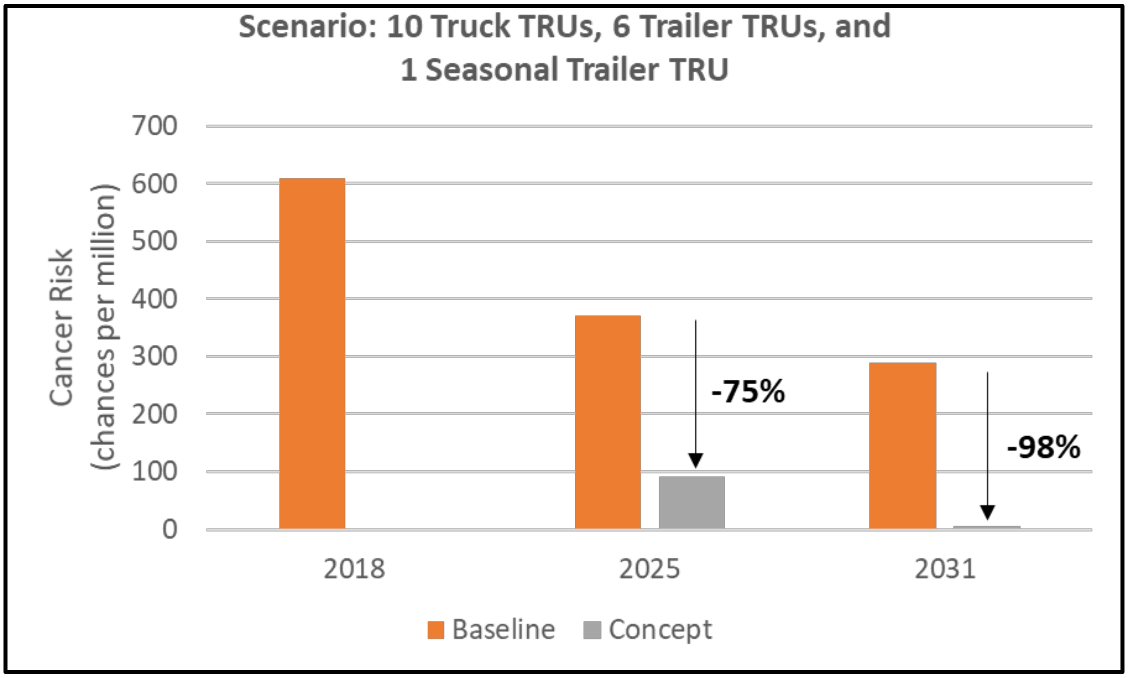
Figure ES-1. Cancer Risk Reduction from Implementation of the Concept – Cold Storage Warehouse Scenario[1]



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

Additionally, the preliminary health analyses estimate that the implementation of the Concept may reduce residential cancer risk from diesel fueled engines that power TRUs by 98 percent in the grocery store scenario shown in Figure ES-2 below.

Figure ES-2 Cancer Risk Reduction from Implementation of the Concept - Grocery Store Scenario[1]



10. What is the process CARB staff used to assess the premature death and illness impacts from regional $PM_{2.5}$ pollution from TRUs?

CARB staff estimated the health benefits of the Concept using the incidents-per-ton (IPT) methodology. The IPT methodology uses relationships between emissions, air quality, and health outcomes. The basis of the IPT methodology is that changes in emissions are approximately proportional to changes in health outcomes. The methodology captures this relation through “IPT factors”. IPT factors are derived by estimating the number of health outcomes associated with exposure to measured $PM_{2.5}$ concentrations for a 2014-2016 baseline period, which represents the most recent data available at the time the current IPT factors were computed. Health outcomes, by air basin, are estimated by multiplying the emission reduction from the regulation by the IPT factor. More information on the IPT methodology can be found on CARB’s website (https://www.arb.ca.gov/resources/documents/carbs-methodology-estimating-health-effects-air-pollution).

11. How much would the Concept reduce the premature death and illness impacts from regional $PM_{2.5}$ pollution from TRUs?

CARB staff estimated the potential statewide PM mortality and illness impacts associated with exposure to $PM_{2.5}$ from the Concept. These health outcomes include cardiopulmonary mortality, hospital admissions, and emergency room visits.

Based on the analysis, staff estimates that the total number of cases that may be reduced from implementation of the Concept are as follows:

- 409 premature deaths.[6]
- 128 hospital admissions.[7]
- 200 emergency room visits.[8]

Monetization of Health Outcomes

In accordance with U.S. EPA practice, CARB staff monetized the health outcomes above by multiplying incidence by a standard value derived from economic studies resulting in a valuation per incident (NCEE, 2010). This results in valuations for avoided premature mortality, avoided hospitalizations, and emergency room visits. The valuation for avoided premature mortality is based on willingness to pay (U.S. EPA, 2000). The valuation for avoided hospitalizations and emergency room visits is based on a combination of typical costs associated with hospitalization 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, lost recreation value, and lost household protection (e.g., valuation of time-losses from inability to maintain the household or provide childcare)(Chestnut et. al., 2006).

Statewide valuations of health benefits were calculated by multiplying the avoided health outcomes by the valuation per incident. Staff quantified the total statewide valuation due to avoided health outcomes between 2022 and 2032. These values are summarized in Table ES-1. 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 lesser benefits in the Sacramento Valley and San Diego County air basins.

[6] Range: 320 to 500, 95 percent confidence interval.
[7] Range: 16 to 237, 95 percent confidence interval.
[8] Range: 127 to 274, 95 percent confidence interval.

Table ES-1 Statewide Values from Avoided Adverse Health Outcomes Between 2022 and 2032 as a Result of the Concept[1]

Outcome	Valuation
Avoided Premature Deaths	$3,986,282,600
Avoided Hospitalizations	$6,955,700
Avoided Emergency Room Visits	$167,700
Total Valuation	$3,993,406,000

1. Values have been rounded and are based on the 2019 dollar year.

I. OVERVIEW

California Air Resources Board (CARB) staff is developing the draft concept for the new Transport Refrigeration Unit (TRU) Regulation (Concept) that will replace the existing TRU Airborne Toxic Control Measure (ATCM) when adopted. In support of this effort, staff has conducted health analyses to evaluate the health impacts of emissions from the diesel engines that power TRUs operating at cold storage warehouses (CSW) and grocery stores. These health analyses examine the current and future impacts of the existing TRU ATCM and compare them to the health benefits from implementing the Concept. These preliminary draft health analyses evaluate the version of the Concept presented at public workshops in August and September 2019. The Initial Statement of Reasons (ISOR) will contain the official staff proposal for consideration by the Board. The ISOR will be released 45 days prior to the Board hearing and will include updated analyses of health benefits, emissions, and environmental and economic impacts based on the formal regulatory proposal.

Exposure to diesel particulate matter (diesel PM) has both potential cancer and noncancer chronic health impacts. This document describes two separate and important analyses, a health risk assessment (HRA) and a mortality and illness analysis. 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 ($PM_{2.5}$) emissions and “secondary” $PM_{2.5}$ formed in the atmosphere from nitrogen oxides (NO_x) from these same engines. Exposure to these pollutants can result in health outcomes that include premature death from cardiopulmonary disease, hospital admissions, and emergency room visits. 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 diesel PM released annually from TRUs for the implementation dates outlined in the regulatory Concept.
- 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 $PM_{2.5}$ and NO_x emissions inventory based on implementation dates that reflect the anticipated amount of each pollutant released annually from TRUs.
- Estimate statewide $PM_{2.5}$ noncancer mortality and illness impacts associated with exposure to primary $PM_{2.5}$ emitted from the diesel engines that power TRUs and secondary $PM_{2.5}$ from NO_x emissions.

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. These four steps are briefly discussed below.

1. Hazard Identification

Hazard Identification is the process of determining the substance, or causing agent, that can cause an increase in the 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 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, 1998a).

2. Exposure Assessment

The 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

Dose-response describes the amount of exposure (the dose) and its relation to the likelihood and severity of adverse health effects (the response). The assessor 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 OEHHA. The 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 risk assessor's 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 and TRU generator sets typically operate at refrigerated warehouses and distribution centers (WHDC), CSWs, grocery stores, truck stops, ports, 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 population of facilities where TRUs operate as well as their contribution to statewide diesel PM emissions with the purpose of determining the applicability of the Concept at these facilities. A more detailed discussion of this analysis will be available in the ISOR, which will be released 45 days prior to the Board hearing.

Based on this analysis, the facility types with the highest estimated contribution of statewide diesel PM emissions from the engines that power 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 Concept. Additionally, a cluster of four CSWs was modeled to illustrate the cumulative health effects when multiple facilities are within a short distance of one another.

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 $PM_{2.5}$ due in part to less stringent particulate matter emissions standards for smaller diesel engines (i.e., less than 25 hp).

TRUs operating in California are subject to the existing 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 meeting the United States Environmental Protection Agency (U.S. EPA) Tier 4 final emission standard for 25-50 horsepower (hp) 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. CARB has recently updated the statewide emission inventory for TRUs which was previously released in 2011. The 2019 Update to the Statewide Emissions Inventory for TRUs (Update) reflects improvements to a number of parameters from the 2011 inventory, including, but not limited to:

- Population and age distribution.
- 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 2019 Update reflects a substantial increase in the number of trailer TRUs equipped with engines between 23 and 25 hp. This increase began with 2013 model year units. The emergence of trailer TRUs with engines between 23 and 25 hp is notable because the U.S. EPA Tier 4 final PM emission standard for these smaller hp engines is 15 times higher than the Tier 4 final PM standard for engines above 25 hp. The 2019 Update also estimates that, under current conditions, emissions from these smaller and dirtier engines will become the majority of emissions in the near future.

The emissions inventory for any given year is calculated by combining the population of TRUs, the hours of activity of TRUs, the hp of the engines powering TRUs, 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 (max brake horsepower) of the engine
LF = Load factor (unit-less)
EF = Emission factor (grams/kW-hr) specific to horsepower and model year and pollutant
FCF = Fuel correction factor (unit-less) based on calendar year

The updates and methodology are discussed in detail in the 2019 Update to the Statewide Emission Inventory for TRUs (which is available as a separate stand-alone document on CARB's website).[9]

[9] https://www.arb.ca.gov/newTRU.

Table III.C.1, below, shows the diesel PM emission factors, for truck and trailer TRUs that are used in each health analysis presented in this document. TRU generator sets also have requirements under the Concept. However, they are primarily used at ports and intermodal railyards and are not included in this analysis.

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

Year	Truck TRU		Trailer TRU	
	Baseline Emission Factor	Concept Emission Factor	Baseline Emission Factor	Concept Emission Factor
2018	1.86	1.86	2.57	2.57
2025	1.59	1.35	1.41	0.79
2031	1.57	0.00	0.98	0.30

Note: Emission factors listed in grams per hour.

A “Baseline Emission Factor” represents the rate at which diesel PM would be emitted from a diesel engine powering a TRU if the Concept were not implemented. A “Concept Emission Factor” represents the rate at which diesel PM would be emitted from a diesel engine powering a TRU if the Concept were to be implemented.

D. Air Dispersion Model

Air dispersion models can simulate physical and chemical processes that affect air toxics as they disperse and react in the atmosphere. 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, 2018) 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. For this HRA, three meteorological stations where chosen to represent a range of meteorological and geographical conditions across the State. The modeled concentrations that resulted from using each of these meteorological datasets were averaged to produce the potential Statewide averaged cancer risk from TRUs. To aid in this selection, CARB staff evaluated ten meteorological stations. Each station’s average wind speed, wind direction, surface characteristics, 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.[10] Of those 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 warehouses and distribution centers, and proximity of the meteorological station to WHDC hubs and grocery stores. The three stations chosen are Watsonville Municipal Airport (Watsonville), Fresno Yosemite International Airport (Fresno), and Banning Station (Banning).

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 of 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:

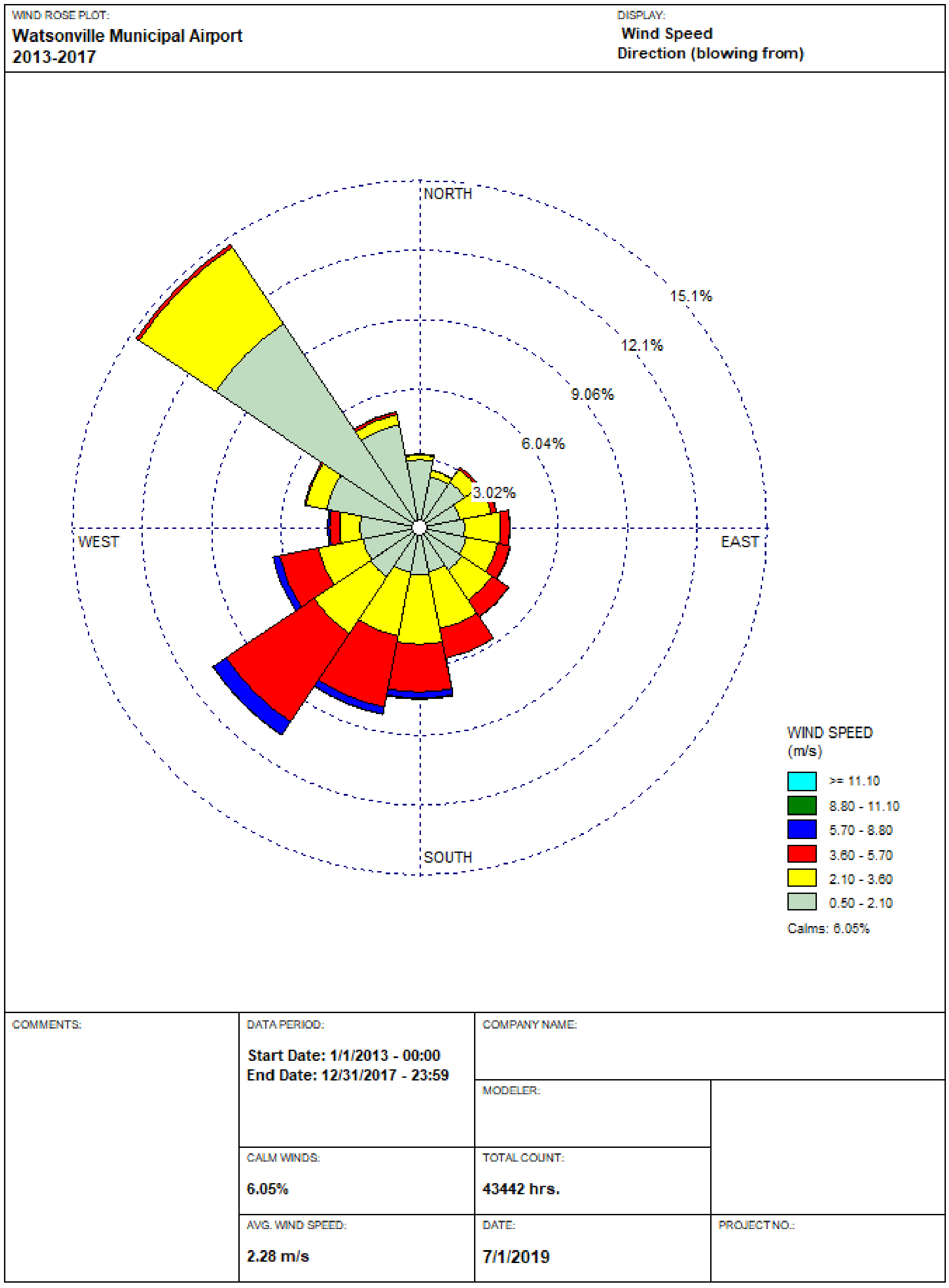
- One-Minute ASOS Wind Data File.
- 1-Minute ASOS wind speed threshold of 0.5 m/s.
- Adjust Surface Friction Velocity (ADJ_U*).
- AERSURFACE options:
  - Airport site.
  - Site surface moisture: Dry, Wet, Average, Wet, and Wet for years 2013-2017, respectively.
  - Assign Month/Season: default values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

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

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



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. Please visit the San Joaquin Valley Air Pollution Control District website for more detail on how they processed Fresno's meteorological data.[11]

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. The wind rose for the Fresno Yosemite International Airport station is shown in Figure II.D.2. 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. Please visit the South Coast Air Quality Management District website for more detail on how they processed Banning's meteorological data.[12]

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. The wind rose for the Banning Municipal Airport stations is shown in Figure II.D.3. The wind rose presents the frequency of winds at the specified wind direction sector and wind speed class during the years 2011-2015.

[11] San Joaquin Valley Air Pollution Control District. *Air Quality Modeling: Permitting and CEQA, Meteorological Data.* Available at https://www.valleyair.org/busind/pto/Tox_Resources/AirQualityMonitoring.htm#met_data.

[12] South Coast Air Quality Management District. *Data for AERMOD.* Available at http://www.aqmd.gov/home/air-quality/meteorological-data/data-for-aermod.

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

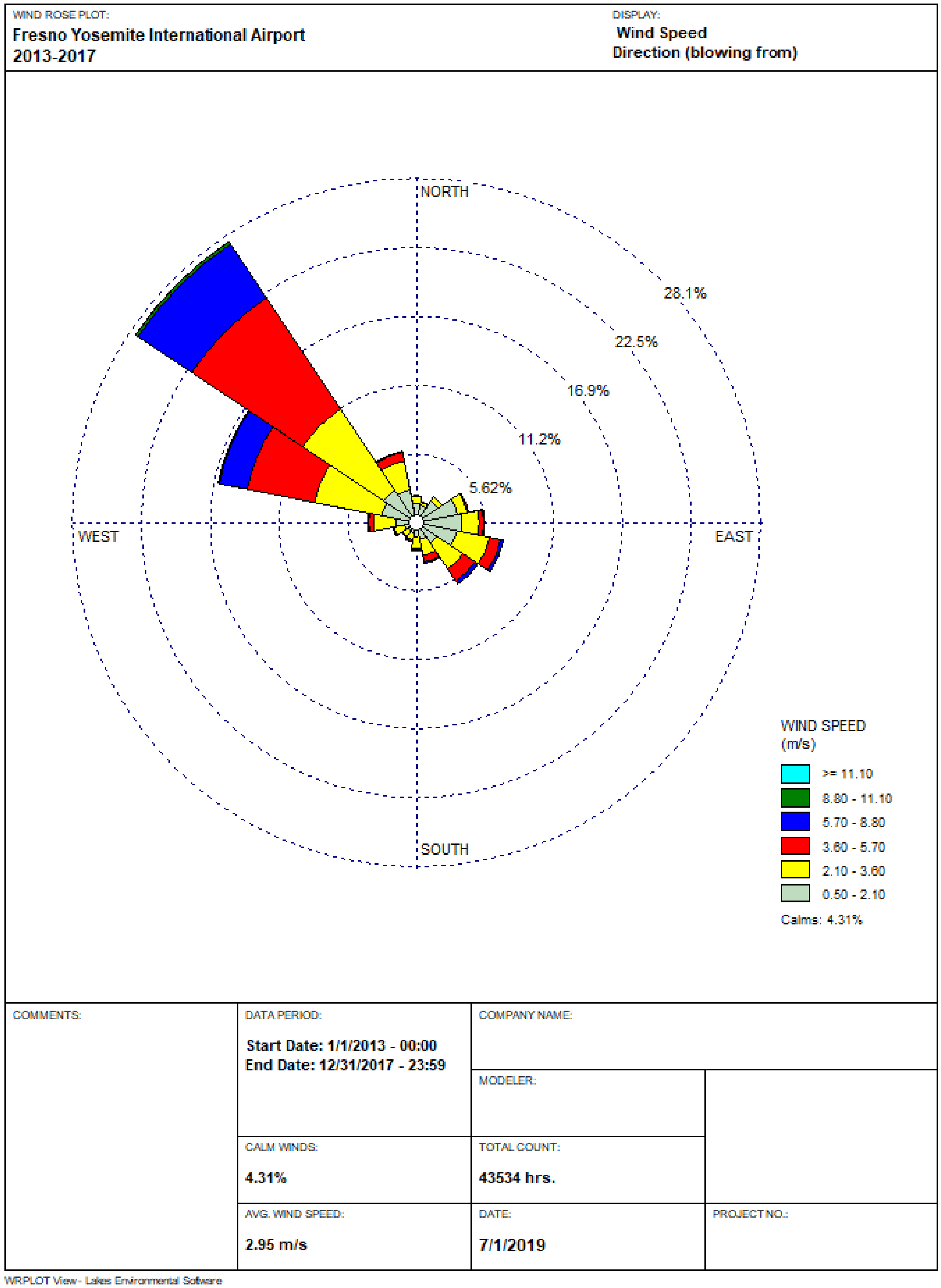
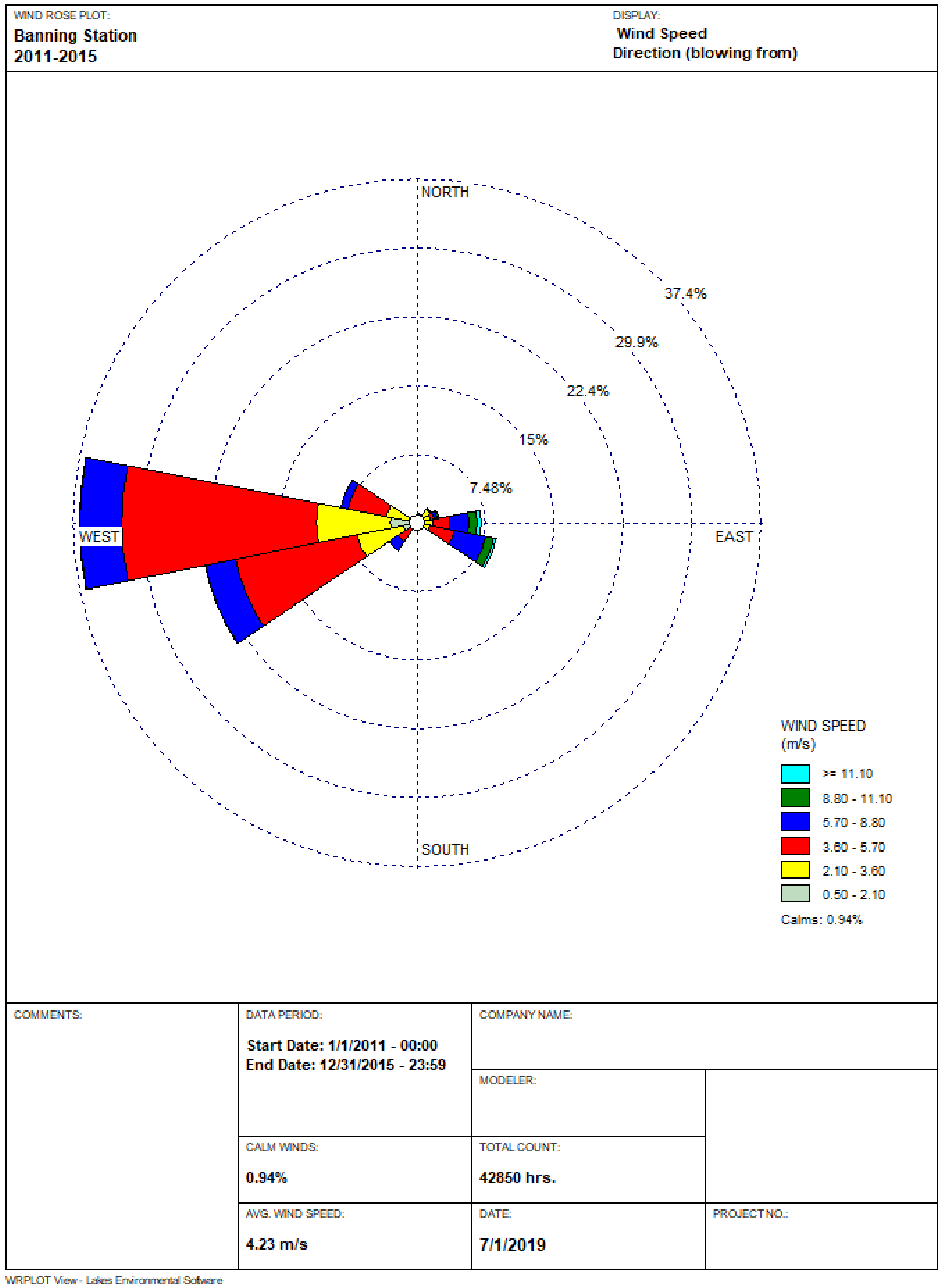


Figure II.D.3. Wind Rose for Banning Station



E. Risk Exposure Scenarios

To analyze the health impacts from TRUs at CSWs, grocery stores, and multi-facility configurations, 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 Concept, health impacts were evaluated for years 2018 (baseline year), 2025, and 2031. 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 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 assumes that a worker who operates outside a grocery store or CSW 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. Staff used the Guidance Manual recommendation of an eight-hour breathing rate for moderate intensity activities.

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 (RMP, 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 work exposure, which assumes a 25-year exposure period, staff applied the recommended 8-hour breathing rates for moderate activity level and used the recommended exposure frequency of 250 days per year. Since the emission sources are assumed to be continuously emitting, no worker adjustment factor was applied to the annual concentration. 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 (95^{th} percentile DBRs for age bins less than 2 years and 80^{th} percentile DBRs for age bins greater than 2 years)	1 for age bins less than 16 years[1] 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)	

1. Assumes school is in the 1/million isopleth.

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.

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 below in the Emission Inventory section.

a) Facility Layout

To develop a generic grocery store layout, CARB staff evaluated grocery stores, either stand-alone or located within a strip mall, throughout California. 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 facilities 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 below, 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 stores 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, 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 will have a semi-trailer parked for an extended period behind the store to provide additional storage of refrigerated or frozen foods. For the purposes of this analysis, these are referred to as seasonal trailers. The engines powering TRUs on both trucks and trailers generate emissions during three different modes of operations, 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 regarding the total number of deliveries grocery stores receive each day. For all 3 scenarios, staff assumed that 50 percent of the total number of 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.

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 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.

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 (2019Update) 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: 2.58 g/hour Truck TRU: 1.86 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 2018.

Table II.F.2. Baseline Grocery Store TRU Emissions in 2018

Grocery Store Scenario	Diesel PM Emissions (tons per year)
1 Daily Truck 1 Daily Trailer 1 Seasonal Trailer	0.011
7 Daily Trucks 2 Daily Trailers 1 Seasonal Trailer	0.020
10 Daily Trucks 6 Daily Trailers 1 Seasonal Trailer	0.038

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 the Table.II.F.3 below.

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, 2018). 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 is provided in Section II.I.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 is 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)	Stationary Sources and On-site Transiting: 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 Off-site Transiting (U.S. EPA, 2012): 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

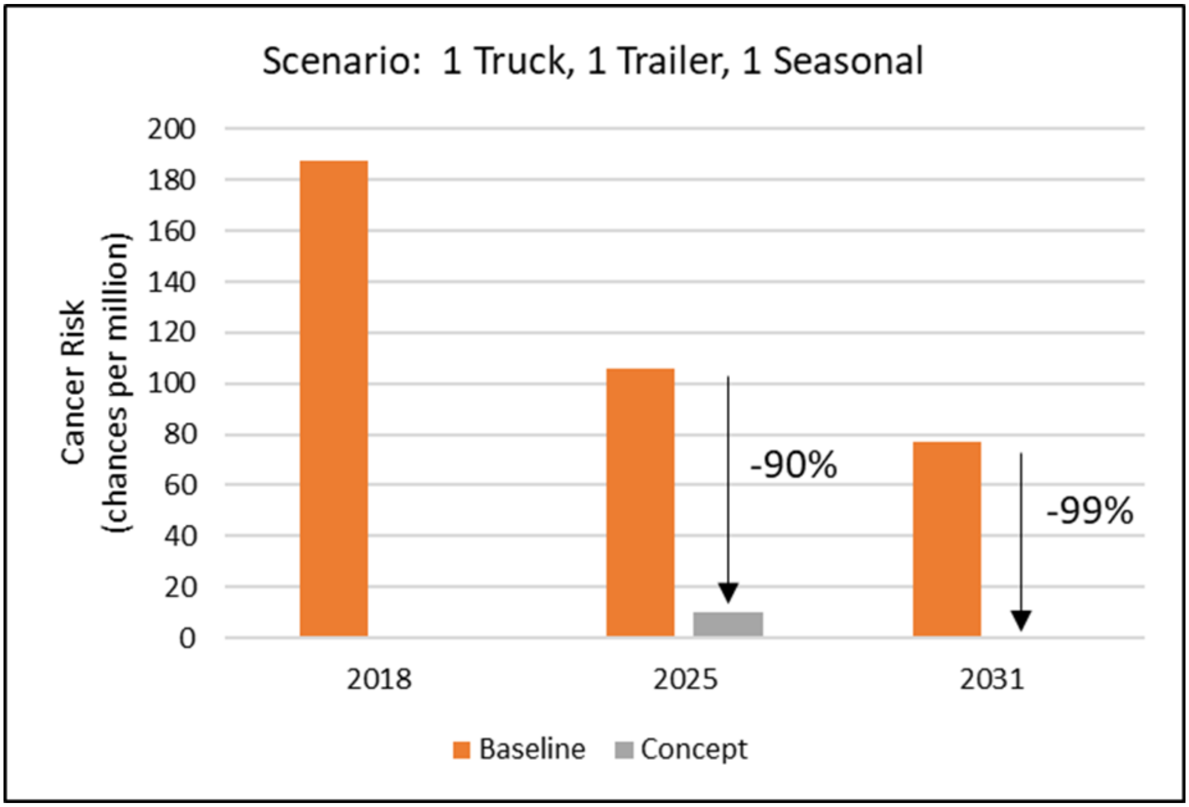
4. Health Risk Assessment – Summary of Cancer Risk

For this generic grocery store model, CARB staff evaluated the potential downwind cancer risk at nearby receptors based on the requirements of the existing TRU ATCM and the Concept. The Concept would provide significant risk reductions in potential cancer risk to individual residents and off-site workers when compared to the existing ATCM.

a) Individual Residential Cancer Risk

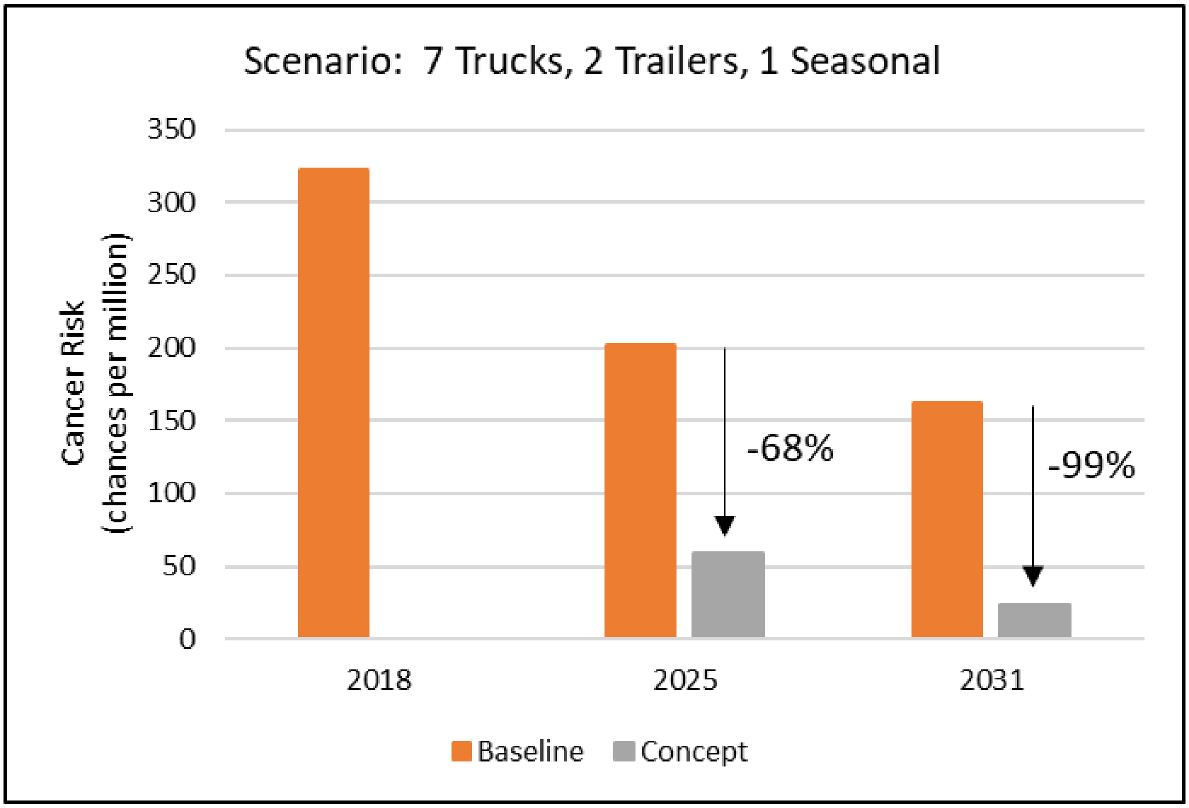
As shown in Figure II.F.2., the potential residential cancer risk for the one daily truck, one daily trailer, and one seasonal trailer scenario is reduced by approximately 90 percent in 2025 and 99 percent in 2031 when compared to the baseline.

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



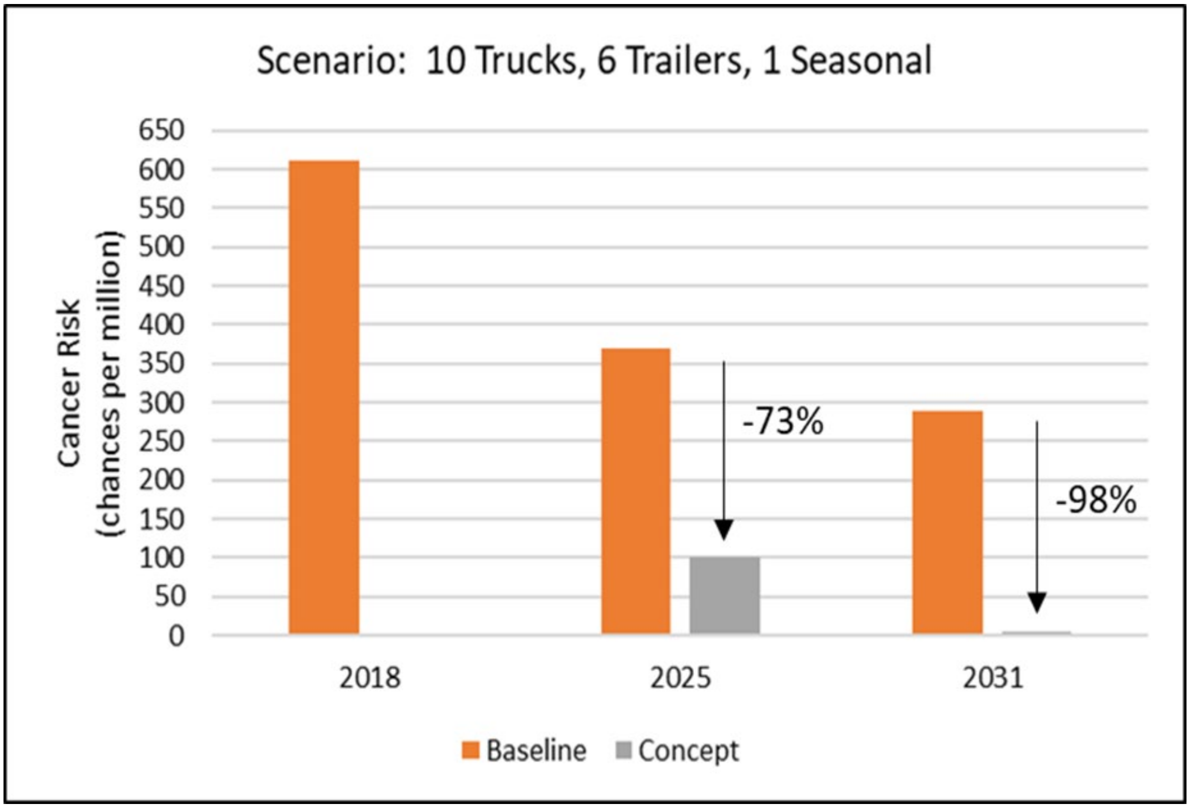
As shown in Figure II.F.3., the 7 daily truck, 2 daily trailer, and 1 seasonal trailer scenario achieves an estimated reduction in residential cancer risk of approximately 68 percent in 2025 and 99 percent in 2031 when compared to the baseline.

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 73 percent in 2025 and 98 percent in 2031 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 significant reduction in cancer risk by the year 2031 after implementation of the Concept. They also show that the amount of risk reduction achieved in the years leading up to 2031 is dependent on equipment type. This is due to the different requirements and implementation schedules for truck and trailer TRUs under the Concept.

Table II.F.6 shows the potential cancer risk for individual residents under the existing TRU ATCM for the year 2018. The three grocery store scenarios show potential cancer risk ranging from approximately 190 to 610 chances per million at the facility fence line.

Table II.F.6. Grocery Store Individual Resident Cancer Risk – Year 2018 (chances per million)[1]

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	190	130	91	56	38	28	17	12	9	7	6	5	3	3	2	2
7 Daily Trucks 2 Daily Trailers 1 Seasonal Trailer	274	7,717	320	230	160	97	66	49	30	21	16	13	10	9	7	5	4	4
10 Daily Trucks 6 Daily Trailers 1 Seasonal Trailer	402	14,334	610	440	300	180	130	92	57	40	30	24	19	16	12	10	8	7

1. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) method ($95^{th}/80^{th}$ 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.

For the years 2025 and 2031, Table II.F.7 and Table II.F.8, on the following page, show the potential baseline cancer risk for the three grocery store scenarios. The risk ranges from approximately 110 to 370 chances per million in 2025 and approximately 77 to 290 chances per million in 2031. After implementation of the Concept, the potential cancer risk is reduced to a range of approximately 11 to 100 chances per million in 2025 and a range of less than one to approximately five chances per million for the year 2031.

Table II.F.7. Grocery Store Individual Resident Cancer Risk – Year 2025 (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	110	76	51	32	22	16	10	7	5	4	3	3	2	2	1	1
Concept	11	8	6	3	2	2	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	200	150	99	61	42	31	19	13	10	8	7	6	4	3	3	3
Concept	65	48	33	20	14	10	7	5	4	3	2	2	2	1	1	1
10 Daily Trucks, 6 Daily Trailers, 1 Seasonal Trailer (Baseline TRU Engine Hours: 402 per week; 14,334 per year)																
Baseline	370	270	180	110	76	56	35	25	18	15	12	10	8	6	5	5
Concept	100	73	50	31	22	16	10	7	6	5	4	3	3	2	2	2

Table II.F.8. Grocery Store Individual Resident Cancer Risk – Year 2031 (chances per million)[1]

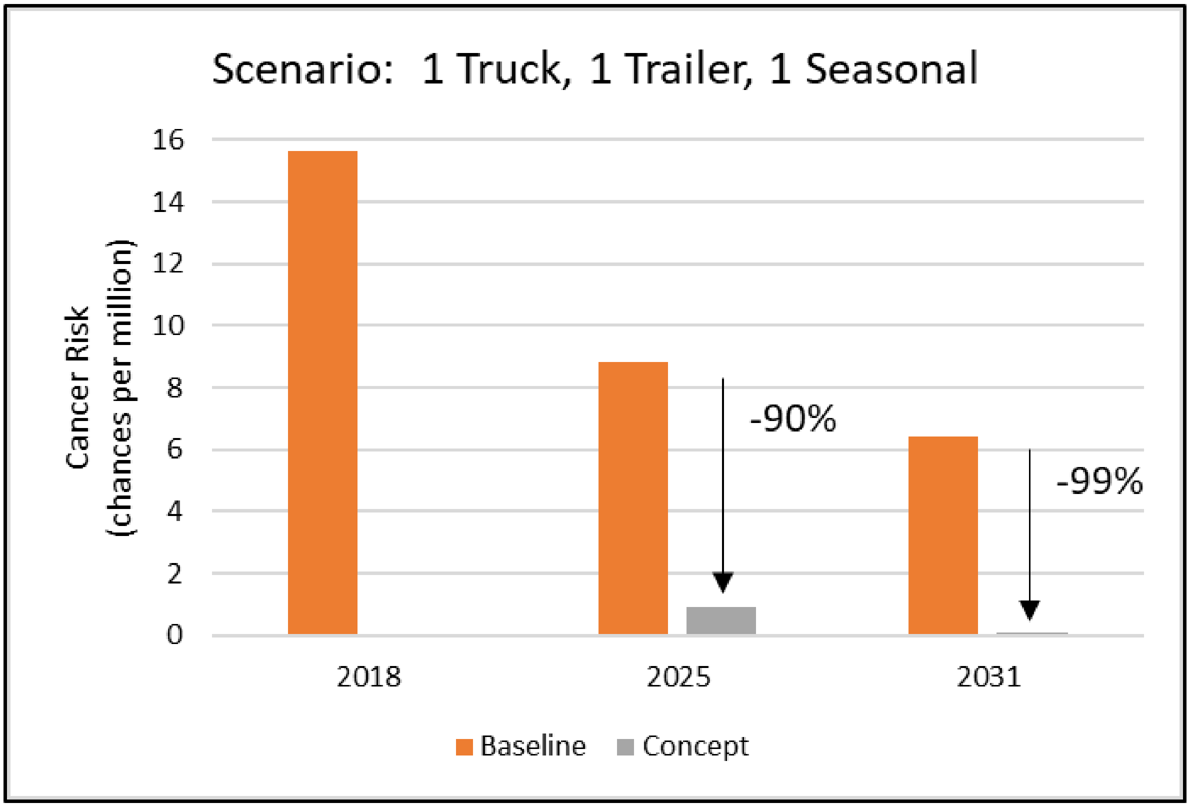
Control Measure	Downwind Distance (m) from Grocery Store Fence Line															
	0	10	25	50	75	100	150	200	250	300	350	400	500	600	700	800
1 Daily Truck, 1 Daily Trailer, 1 Seasonal Trailer (Baseline TRU Engine Hours: 202 per week; 3,940 per year)																
Baseline	77	55	37	23	16	12	7	5	4	3	2	2	1	1	<1	<1
Concept	<1	<1	<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	160	120	79	49	34	25	16	11	8	7	5	5	4	3	3	2
Concept	2	1	<1	<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	290	210	140	87	60	44	28	19	15	12	10	8	6	5	4	4
Concept	5	4	3	2	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

1. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) method ($95^{th}/80^{th}$ 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.

b) Off-site Worker Cancer Risk

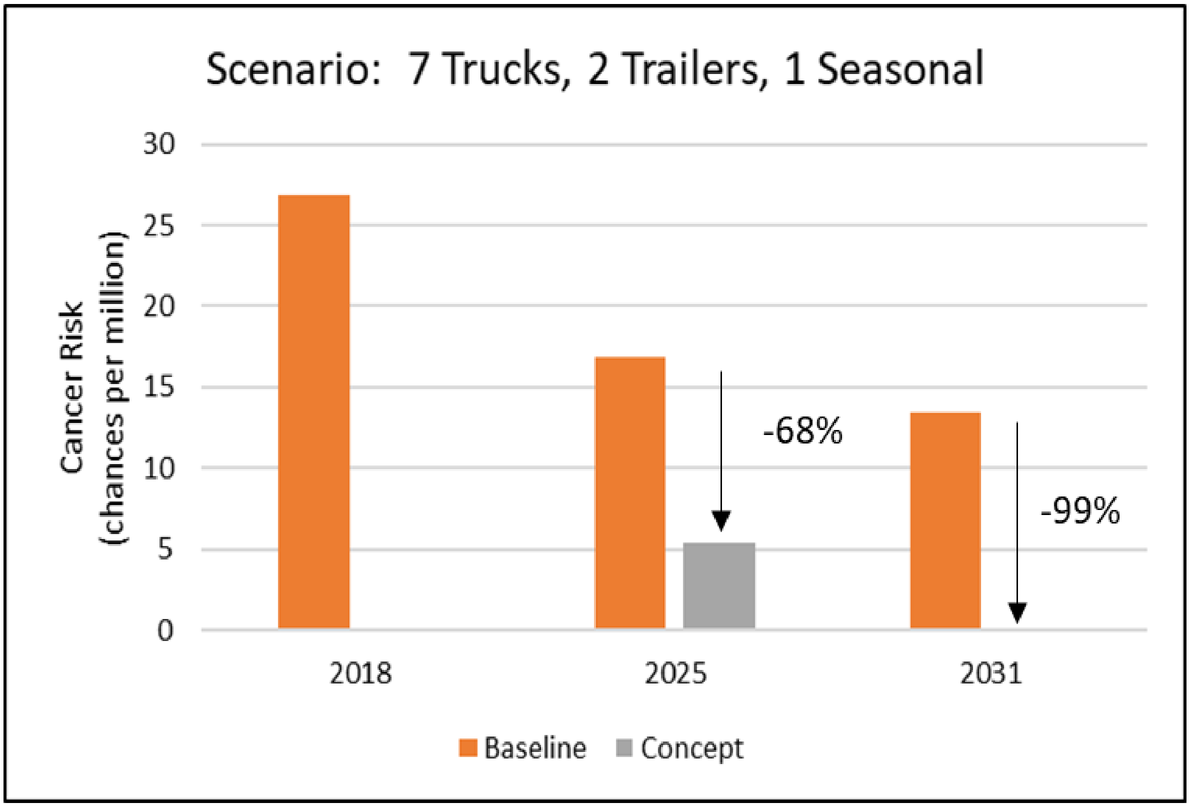
As shown in Figure II.F.5., the baseline off-site worker cancer risk for the one daily truck, one daily trailer, and one seasonal trailer scenario is reduced by approximately 90 percent in 2025 and 99 percent in 2031.

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



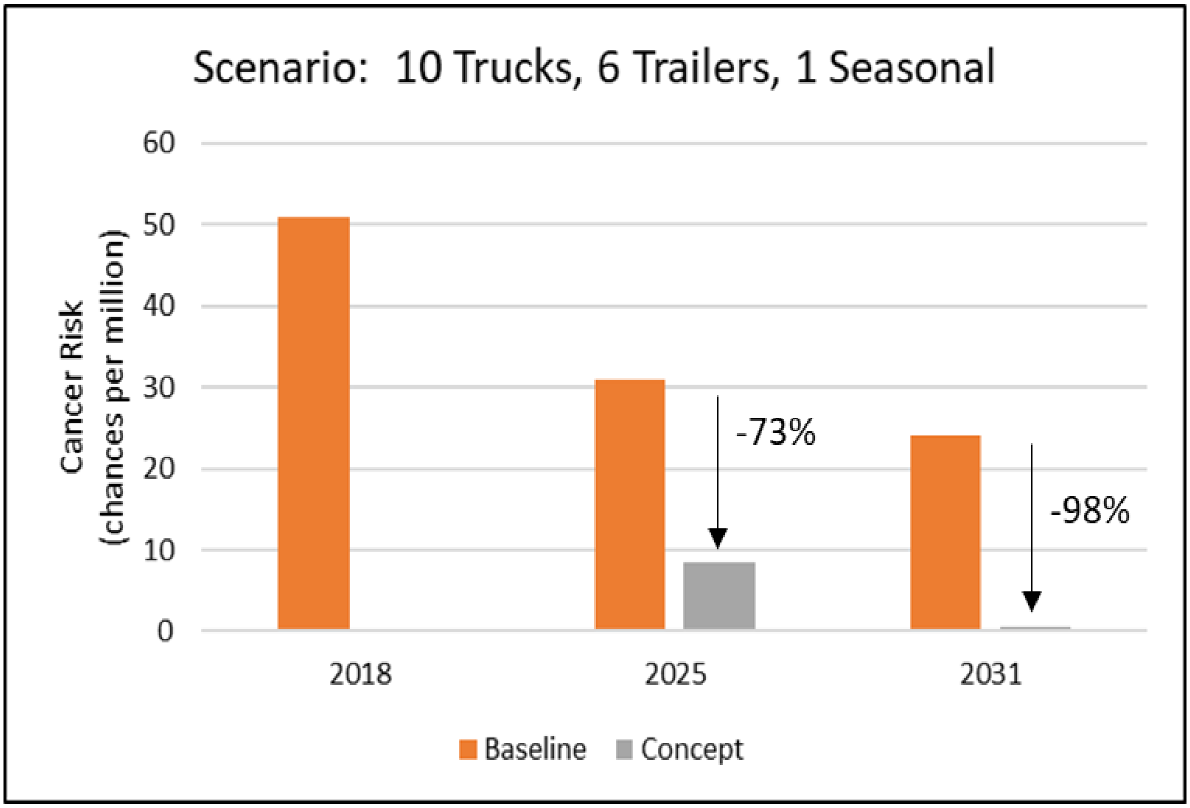
As shown in Figure II.F.6., the 7 daily truck, 2 daily trailer, and 1 seasonal trailer scenario achieves an estimated reduction in off-site worker cancer risk of 68 percent in 2025 and 99 percent in 2031 when compared to the baseline.

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 73 percent in 2025 and 98 percent in 2031 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 significant reduction in off-site worker cancer risk in 2031 with implementation of the Concept. These figures also show that the amount of cancer risk reduction achieved, in the years leading up to 2031 is dependent on equipment type. This is due to the different requirements and implementation schedules for truck and trailer TRUs under the Concept.

Table II.F.9 shows the potential cancer risk for off-site workers under the existing regulation for the year 2018. The three grocery store scenarios show cancer risk ranging from approximately 16 to 51 chances per million at the facility fence line.

Table II.F.9. Grocery Store Off-site Worker Cancer Risk – Year 2018 (chances per million)[1]

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**	16	11	8	5	3	2	1	1	1	1	<1	<1	<1	<1	<1	<1
7 Daily Trucks 2 Daily Trailers 1 Seasonal Trailer	**274**	**7,717**	27	19	13	8	6	4	3	2	1	1	1	1	1	<1	<1	<1
10 Daily Trucks 6 Daily Trailers 1 Seasonal Trailer	**402**	**14,334**	51	37	25	15	10	8	5	3	3	2	2	1	1	1	1	1

1. 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 2025, Table II.F.10 shows the potential baseline cancer risk for the three grocery store scenarios ranging from approximately 9 to 31 chances per million. After implementation of the Concept, the range reduces to a range of less than one to approximately eight chances per million.

Table II.F.10. Grocery Store Off-site Worker Cancer Risk – Year 2025 (chances per million)[1]

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	9	6	4	3	2	1	1	1	0	0	0	0	0	0	0	0
Concept	<1	<1	<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	17	12	8	5	3	3	2	1	1	1	1	0	0	0	0	0
Concept	5	4	3	2	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	31	22	15	9	6	5	3	2	2	1	1	1	1	1	0	0
Concept	8	6	4	3	2	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

1. 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 2031, Table II.F.11 shows the potential baseline cancer risk for the three grocery store scenarios ranging from approximately 6 to 24 chances per million. After implementation of the Concept, the cancer risk reduces to less than one chance per million at all distances.

Table II.F.11. Grocery Store Off-site Worker Cancer Risk – Year 2031 (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	6	5	3	2	1	1	1	0	0	0	0	0	0	0	0	0
Concept	<1	<1	<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	13	10	7	4	3	2	1	1	1	1	0	0	0	0	0	0
Concept	<1	<1	<1	<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	24	17	12	7	5	4	2	2	1	1	1	1	1	0	0	0
Concept	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

1. 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 hazard index (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	Applicable Year		
	2018	2025	2031
1 Daily Truck, 1 Daily Trailer, 1 Seasonal Trailer			
Baseline	0.05	0.03	0.02
Concept	-	0.00	0.00
7 Daily Trucks, 2 Daily Trailers, 1 Seasonal Trailer			
Baseline	0.09	0.05	0.04
Concept	-	0.02	0.00
10 Daily Trucks, 6 Daily Trailers, 1 Seasonal Trailer			
Baseline	0.16	0.10	0.08
Concept	-	0.03	0.00

Note: Dashes are used for the Concept in 2018 because the Concept is not 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 engines powering the 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 such as 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 a range of TRU-engine runtime, ranging from 500 hours a week to 8,000 hours a week. Staff assumed that the facility operates 24 hours per day, 7 days per week. The model accounts for both on and off-site transiting as well as stationary TRU engine operations.

The emission inventory for CSWs 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 8,000 hours of TRU engine runtime 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 CSWs.

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.	8760 hours per year
TRU Trip Rate[1]	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 (2019 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: 2.58 g/hour Truck TRU: 1.86 g/hour

1. 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 CSWs. The baseline year for all emission estimates is 2018.

Table II.G.2. Baseline Cold Storage Warehouse TRU Emissions in 2018

	Weekly Hours of Operation					
	500	**1,000**	**2,000**	**3,000**	**5,000**	**8,000**
Diesel PM Emissions (tons per year)	0.078	0.155	0.31	0.47	0.78	1.24

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, 2018). 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 is provided in Section II.I.	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.)

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 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

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

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 existing TRU ATCM and the Concept. 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 Concept would provide significant risk reductions in potential cancer risk to individual residents and off-site workers. After implementation of the Concept, Figure II.G.2. shows baseline residential cancer risk is anticipated to be reduced by approximately 81 percent in 2025 and 95 percent in 2031.

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

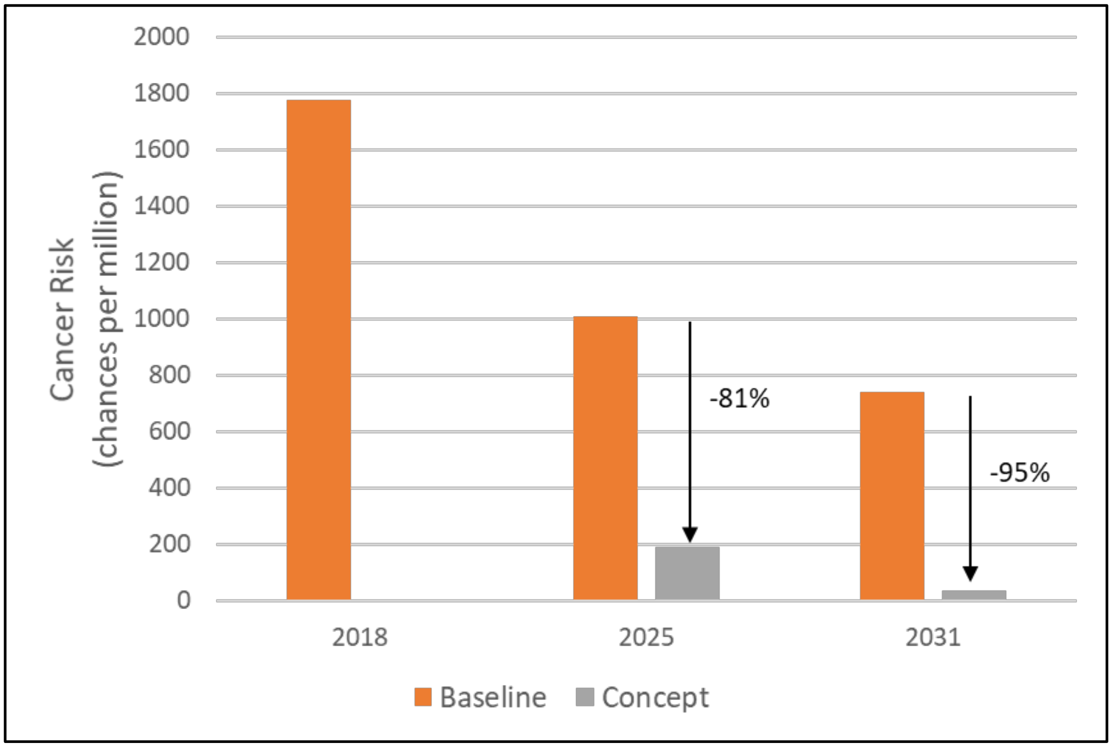


Table II.G.6, below, shows the potential cancer risk for individual residents under the existing TRU ATCM for a range of TRU engine hours, ranging from 500 hours per week to 8,000 hours per week, for the year 2018. The scenarios show residential cancer risk ranging from approximately 110 to 1,780 chances per million at 25 meters from the facility fence line.

Table II.G.6. Cold Storage Warehouse Individual Resident Cancer Risk – Year 2018 (chances per million)[1]

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	1780	1540	1310	1140	730	520	400	320	260	220	190	170	150	140	130	120	110	100
5,000	260,000	1110	960	820	710	460	330	250	200	160	140	120	110	95	87	79	74	68	63
3,000	156,000	670	580	490	430	270	200	150	120	98	83	72	64	57	52	48	44	41	38
2,000	104,000	440	380	330	290	180	130	99	79	65	55	48	42	38	35	32	30	27	25
1,000	52,000	220	190	160	140	91	65	49	39	33	28	24	21	19	17	16	15	14	13
500	26,000	110	96	82	71	45	32	25	20	16	14	12	11	10	9	8	7	7	6

1. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) method ($95^{th}/80^{th}$ 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.7 compares the potential cancer risk for individual residents under the existing TRU ATCM and the Concept in 2025, the first year of implementation. The scenarios show significant reductions in risk across all activity levels. For example, at 25 meters from the facility, for 8,000 TRU engine hours per week, the Concept could reduce residual cancer risk to under 200 chances per million compared to the baseline at over 1,000 chances per million.

Table II.G.7. Cold Storage Warehouse Individual Resident Cancer Risk – Year 2025 (chances per million)[1]

	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
Baseline	8,000	416,000	1020	880	750	650	410	300	230	180	150	130	110	96	87	79	72	67	62	57
	5,000	260,000	640	550	470	410	260	190	140	110	92	78	68	60	54	49	45	42	39	36
	3,000	156,000	380	330	280	240	160	110	84	67	55	47	41	36	32	30	27	25	23	21
	2,000	104,000	250	220	190	160	100	74	56	45	37	31	27	24	22	20	18	17	16	14
	1,000	52,000	130	110	94	81	52	37	28	22	18	16	14	12	11	10	9	8	8	7
	500	26,000	63	55	47	41	26	18	14	11	9	8	7	6	5	5	5	4	4	4

	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
Concept	8,000	416,000	190	170	140	130	83	62	50	42	37	32	30	27	26	24	23	22	21	20
	5,000	260,000	120	100	89	78	52	39	31	26	23	20	19	17	16	15	14	14	13	12
	3,000	156,000	72	62	53	47	31	23	19	16	14	12	11	10	10	9	9	8	8	7
	2,000	104,000	48	41	36	31	21	16	12	10	9	8	7	7	6	6	6	6	5	5
	1,000	52,000	24	21	18	16	10	8	6	5	5	4	4	3	3	3	3	3	3	2
	500	26,000	12	10	9	8	5	4	3	3	2	2	2	2	2	2	1	1	1	1

1. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) method ($95^{th}/80^{th}$ 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 existing TRU ATCM and concept for the implementation year 2031. Again, the scenarios show significant reductions in risk across all activity levels. For example, at 25 meters from the facility, for 8,000 TRU engine hours per week, the Concept could reduce residual risk to under 40 chances per million compared to the baseline at about 740 chances per million.

Table II.G.8. Cold Storage Warehouse Individual Resident Cancer Risk – Year 2031 (chances per million)[1]

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	740	640	550	480	300	220	160	130	110	92	80	70	63	58	53	49	46	42
5,000	260,000	460	400	340	300	190	140	100	82	68	57	50	44	40	36	33	31	28	26
3,000	156,000	280	240	200	180	110	81	62	49	41	34	30	26	24	22	20	18	17	16
2,000	104,000	190	160	140	120	76	54	41	33	27	23	20	18	16	14	13	12	11	10
1,000	52,000	92	80	68	59	38	27	21	16	14	11	10	9	8	7	7	6	6	5
500	26,000	46	40	34	30	19	13	10	8	7	6	5	4	4	4	3	3	3	3

Concept

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	36	31	27	24	16	13	11	9	8	8	7	7	7	6	6	6	6	5
5,000	260,000	22	19	17	15	10	8	7	6	5	5	5	4	4	4	4	4	4	3
3,000	156,000	13	12	10	9	6	5	4	4	3	3	3	3	2	2	2	2	2	2
2,000	104,000	9	8	7	6	4	3	3	2	2	2	2	2	2	2	2	1	1	1
1,000	52,000	4	4	3	3	2	2	1	1	1	1	1	1	1	1	1	1	1	1
500	26,000	2	2	2	1	1	1	1	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) method ($95^{th}/80^{th}$ 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.

b) Off-site Worker Cancer Risk

Under this exposure scenario, the Concept would provide significant risk reductions in potential cancer risk to off-site workers working in close vicinity to a refrigerated warehouse. After implementation of the Concept, Figure II.G.3. shows that baseline risk is anticipated to be reduced by approximately 81 percent in 2025 and 95 percent in 2031.

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

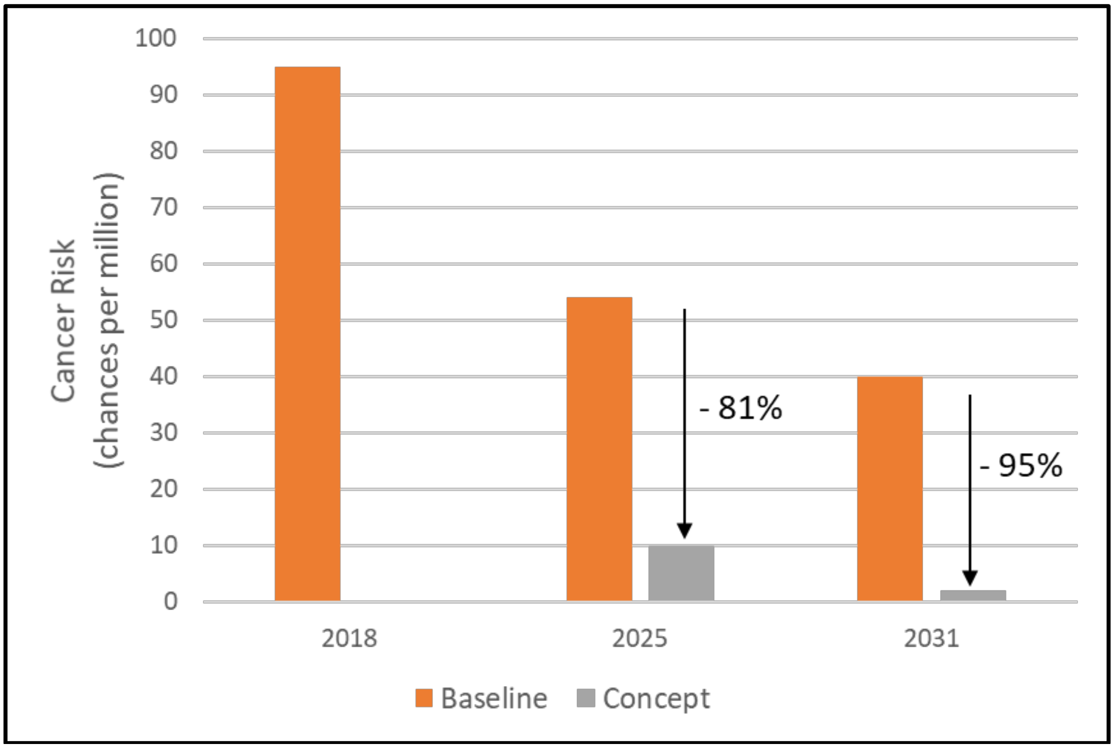


Table II.G.9 below, shows the potential cancer risk for off-site workers under the existing TRU ATCM for a range of TRU engine hours, ranging from 500 hours per week to 8,000 hours per week, for the year 2018. The scenarios show risk ranging from approximately 6 to 95 chances per million at 100 meters from the facility fence line.

Table II.G.9. Cold Storage Warehouse Off-Site Worker Cancer Risk – Year 2018 (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	95	61	43	33	26	22	18	16	14	13	12	11	10	9	8
5,000	260,000	59	38	27	21	16	14	11	10	9	8	7	7	6	6	5
3,000	156,000	36	23	16	12	10	8	7	6	5	5	4	4	4	3	3
2,000	104,000	24	15	11	8	7	5	5	4	4	3	3	3	2	2	2
1,000	52,000	12	8	5	4	3	3	2	2	2	2	1	1	1	1	1
500	26,000	6	4	3	2	2	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 existing TRU ATCM and the Concept in 2025, the first year of implementation. The scenarios show significant reductions in cancer risk across all activity levels. The scenarios show risk ranging from approximately one to 10 chances per million at 100 meters from the facility fence line.

Table II.G.10. Cold Storage Warehouse Off-Site Cancer Risk – Year 2025 (chances per million)

Total Hours of TRU Engine		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	10	7	5	4	3	3	3	2	2	2	2	2	2	2	2
5,000	260,000	6	4	3	3	2	2	2	2	1	1	1	1	1	1	1
3,000	156,000	4	3	2	2	1	1	1	1	1	1	1	1	1	1	1
2,000	104,000	3	2	1	1	1	1	1	1	1	1	1	< 1	< 1	< 1	< 1
1,000	52,000	1	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

Table II.G.11 shows the potential cancer risk for off-site workers under the concept for the implementation year 2031. The scenarios show significant reductions in cancer risk across all activity levels. The scenarios show risk ranging from less than 1 chance per million to approximately two chances per million at 100 meters from the facility fence line.

Table II.G.11. Cold Storage Warehouse Off-Site Cancer Risk – Year 2031 (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	2	1	1	1	1	1	1	1	1	1	1	1	< 1	< 1	< 1
5,000	260,000	1	1	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
3,000	156,000	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
2,000	104,000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1,000	52,000	< 1	< 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 hazard index (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 a 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, below.

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

Control Measure	Downwind Distance (m) from Facility		
	2018	2025	2031
8,000 Hours of TRU Engine Run-Time per Week			
Baseline	0.48	0.27	0.20
Concept	-	0.05	0.01
5,000 Hours of TRU Engine Run-Time per Week			
Baseline	0.30	0.17	0.12
Concept	-	0.03	0.006
3,000 Hours of TRU Engine Run-Time per Week			
Baseline	0.18	0.10	0.07
Concept	-	0.02	0.004
2,000 Hours of TRU Engine Run-Time per Week			
Baseline	0.12	0.07	0.05
Concept	-	0.01	0.002
1,000 Hours of TRU Engine Run-Time per Week			
Baseline	0.06	0.03	0.02
Concept	-	0.006	0.001
500 Hours of TRU Engine Run-Time per Week			
Baseline	0.03	0.02	0.01
Concept	-	0.003	0.0006

Note: Dashes are used for the Concept in 2018 because the Concept is not implemented.

H. Multi-facility Model Set Up and HRA Results

1. Source Description

Multi-facility CSWs are a cluster of individual CSW facilities operating near each other. In California, it is not uncommon for clusters of CSWs to be located close to residential neighborhoods, schools, and health-care facilities. However, there is no unique layout or specific activity profile for clusters due to the complexity of operations. They can have various physical configurations in terms of distance between individual facilities and cluster footprint geometry.

a) Facility Layout

To develop a model for a generic cold storage warehouse cluster, CARB staff performed a spatial analysis on CSW facilities throughout the state, focusing on those areas where CSWs are prevalent. Through the spatial analysis, CARB staff observed that CSWs tend to be situated within a couple of miles of each other. However, for the purposes of this spatial analysis, CARB staff focused on situations where three or more CSWs were located within one mile of each other. CARB staff used aerial photos to identify these clusters and to obtain data, including, but not limited to, the distance between facilities and the presence of nearby residential and sensitive receptors (e.g. schools, hospitals, etc.).

After establishing a list of these types of clusters, CARB staff further refined the list by focusing on those groupings having at least one warehouse that was 350,000 square feet or larger. The reason being, that larger warehouses of this size are more likely to have higher levels of TRU activity. Although smaller warehouses can have high levels of activity, staff determined that a 350,000 square-foot warehouse is a reasonably-sized facility to have higher TRU activity levels.

Based on this spatial analysis, the range of average distances between facilities within clusters was found to be approximately 350 to 1,000 meters. CARB staff chose to model a CSW cluster with a 750-meter distance between facilities to represent a medium-spaced cluster based on the following findings.

- The spatial analysis showed that residences and other sensitive receptors tend to be found within, or nearby, clusters with distances of approximately 750 meters or greater between facilities. The spatial analysis also showed that clusters with distances under 750 meters between facilities tend to be located in industrial areas, or, have residential receptors located outside the cluster.
- CARB staff observed that clusters with spacing of 350 meters or less between facilities were usually comprised of smaller facilities (approximately 20,000 to 150,000 square feet).

- An air dispersion modeling analysis was conducted to analyze the effects of four facilities spaced at distances of 400, 750, and 1,000 meters apart assuming equal TRU activity levels. This analysis indicated that any cluster of facilities spaced less than 1,000 meters apart had elevated potential health impacts downwind from the cluster that were greater than the sum for four facilities alone. The model showed that a spacing of 750 meters resulted in marginally higher cancer risks as compared to 1,000-meter spacing.

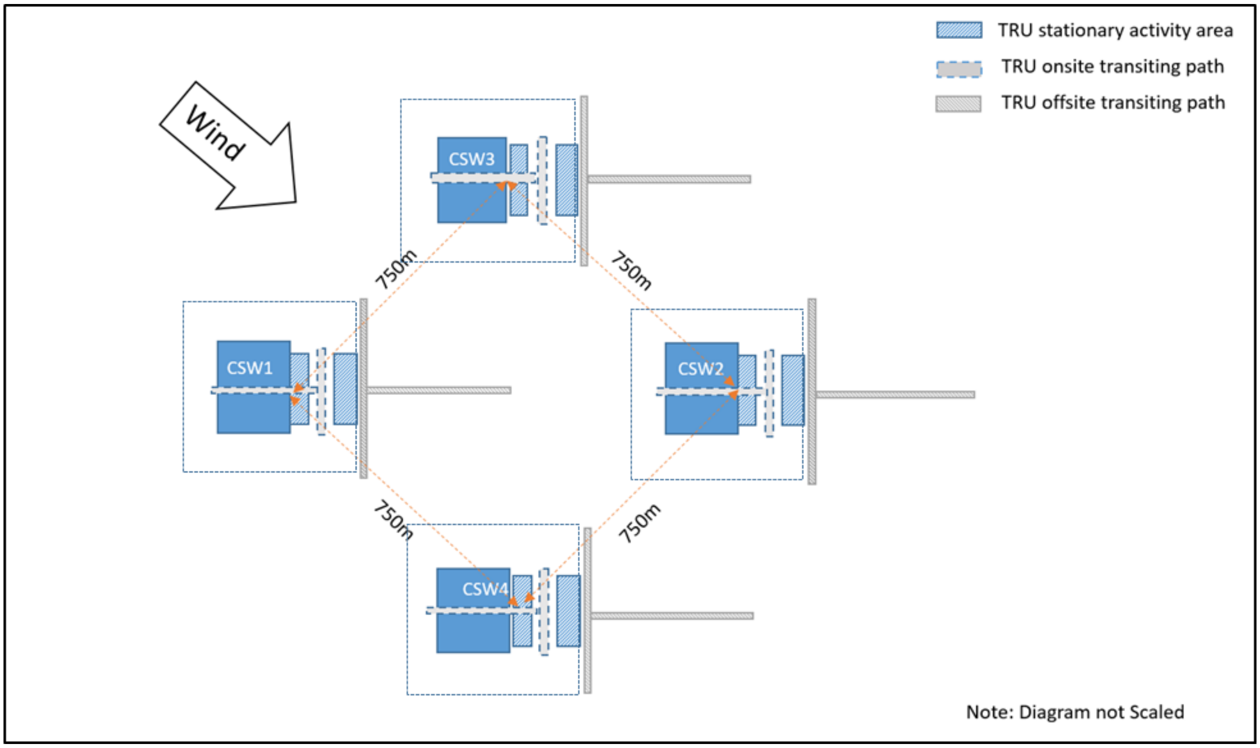
Figure II.H.1 shows an example of a cluster footprint and neighboring residential communities or schools identified from the spatial analysis. This example shows the spacing distances between individual facilities ranging from about 500 to 1,000 meters.

Figure II.H.1. Aerial Image and Spatial Analysis of a Cold Storage Warehouse Cluster

(Map data: Google, Digital Globe; circles indicate the facility footprint sizes)

For the modeling analysis, CARB staff chose four individual CSW facilities with equal TRU activity levels to represent a generic cluster layout. Figure II.H.2 illustrates the layout of a cluster with facilities spaced 750 meters apart. For this generic cluster layout, CARB staff also conducted a sensitivity analysis using the three meteorological stations (Watsonville, Fresno, and Banning). Among the three, the Watsonville Airport station dataset presented slightly higher diesel PM air concentrations downwind from emission sources; therefore, the Watsonville meteorological data was used for the cluster modeling and health risk analysis. The prevailing wind direction from the Watsonville meteorological station (see wind rose on page 7) is shown in Figure II.H.2.

Figure II.H.2. Schematic of a Cold Storage Warehouse Cluster



Note: Figure shows the prevailing wind direction from the Watsonville Airport meteorological station and a 750-meter spaced boundary for modeling work.

2. Emission Inventory

For a cluster, CARB staff assumed that each CSW facility operates independently, and the activity of each facility ranges from 500 hours up to 8,000 hours of TRU engine runtime per week, which is similar to a single CSW facility configured in Section II.A. As a result, cluster activity is assumed to range from 2,000 to 32,000 hours of TRU engine runtime per week for a generic cluster. CARB staff further assumed the average cluster activity would be about half of 32,000 hours, specifically 16,000 hours of TRU engine runtime (i.e., 4,000 hours x 4 facilities). Table II.H.1 outlines the emission estimate inputs for stationary and transit activities associated with a four-CSW cluster.

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

Facility Characteristics	Assumptions/References	Value
Facility Location	Site reflects generic multi-facility CSW clusters in California based on spatial analysis	N/A
Cluster Footprint	4 CSWs spaced 750 meters apart, from a medium-spaced footprint.	0.22 sq. miles
Facility Height	Height of modeled facility	29.4 feet high
Facility Operation (days/week)	24 hours per day, 7 days a week Total 16,000 TRU hours per week for a representative medium-spaced activity CSW cluster	365 days/year
TRU Trip Rate	A TRU 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. [TRU hours/week] ÷ [4 hours/TRU trip] = TRU trips/week	TRU trips/week
	32,000 hours per week	8,000
	16,000 hours per week	4,000
	8,000 hours per week	2,000
	4,000 hours per week	1,000
	2,000 hours per week	500
Docking, Parking, and Transiting TRU Emission Factors	CARB Off-Road Diesel PM Emission Inventory (2019 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: 2.58 g/hour Truck TRU: 1.86 g/hour

Table II.H.2 summarizes the TRU diesel PM emissions (tons per year) by emission source for a CSW cluster with different activity levels. The baseline year for all emission estimates is 2018.

Table II.H.2. Baseline Cold Storage Warehouse Cluster TRU Emissions in 2018

Emission Sources	Diesel PM Emissions (tons per year)				
	2,000 Hrs/wk	4,000 Hrs/wk	8,000 Hrs/wk	16,000 Hrs/wk	32,000 Hrs/wk
Docking and Parking TRU	0.29	0.58	1.15	2.30	4.60
On-site Transiting TRU	0.014	0.03	0.06	0.11	0.22
Off-site Transiting TRU	0.009	0.02	0.04	0.07	0.15
Total	0.31	0.63	1.25	2.48	4.97

Note: Numbers are rounded.

3. Air Dispersion Modeling

The air dispersion modeling configuration for the cluster is similar to the single facility setups in Section II.G.3 with the following exceptions:

1) A polar grid modeling domain is extended to 16 x16 km.

2) Only the Watsonville airport meteorological dataset was used because it has slightly higher downwind diesel PM concentrations as compared to the other two meteorological datasets (Banning and Fresno).

4. Health Risk Assessment – Summary of Cancer Risk

If a line is drawn connecting the facilities in a cluster, as shown in Figure II.H.2, the area inside the boundary behaves differently than the area outside the boundary. As a result, the potential cancer risk to a receptor that is located inside the boundary will be different when compared to a receptor outside that boundary. In addition, the size of the exposure area, or zone of impact, for multiple facilities is greater than the sum of the effects of the individual facilities. To illustrate these differences, CARB staff presents information about potential cancer risk from a cluster in three different ways.

- Cancer risk to receptors outside the boundary.
- Cancer risks to receptors inside the boundary.
- Zone of impact for combined facilities.

a) Cancer Risk Outside the Cluster Boundary

To analyze cancer risk from clusters, staff used the same assumptions regarding the number of TRU operating hours as those used for an individual facility (i.e., 500 to 8,000 hours/week per facility). Since this analysis assumes four equal-sized facilities, the cumulative hours for the four facilities are four times those values, or 2,000 to 32,000 hours/week. Table II.H.3, on the next page, shows the 2018 baseline potential cancer risk for an individual resident exposed to a CSW cluster with a range of TRU engine hours from 2,000 to 32,000 hours per week. The scenarios show residential cancer risk ranging from approximately 175 to 2,880 chances per million at 25 meters downwind from the cluster boundary.

Table II.H.4, on the next page, compares the potential cancer risk for individual residents for the baseline and the Concept in 2025, the first year of implementation. The scenarios show significant reductions in cancer risks across all activity levels. For example, at a distance of 25 meters from the cluster boundary, for 32,000 hours of TRU engine operation per week, the Concept would reduce potential cancer risks to under 300 chances per million as compared to the 2025 baseline, at about 1,560 chances per million.

Table II.H.3. Cluster Individual Resident Cancer Risks – Year 2018 (chances per million)

	Distance (m)	25	50	100	200	300	400	500	750	1,000	1,500	2,000	4,000	8,000	10,000	14,000
2018 Baseline	32,000 hrs/wk	2,800	2,430	1,820	1,110	780	600	490	350	240	150	110	50	20	10	9
	16,000 hrs/wk	1,400	1,220	910	560	390	300	250	180	120	75	55	25	10	5	5
	8,000 hrs/wk	700	610	460	280	200	150	120	90	60	40	30	13	5	3	2
	4,000 hrs/wk	350	300	230	140	100	75	60	45	30	20	15	6	3	1	1
	2,000 hrs/wk	175	150	115	70	50	40	30	23	15	10	8	3	1	< 1	< 1

Note: Cancer risk values are rounded.

Table II.H.4. Cluster Individual Resident Cancer Risks – Year 2025 (chances per million)

	Distance (m)	25	50	100	200	300	400	500	750	1,000	1,500	2,000	4,000	8,000	10,000	14,000
2025 Baseline	32,000 hrs/wk	1,560	1,370	1,030	630	450	340	280	200	130	90	60	30	10	6	5
	16,000 hrs/wk	780	690	520	320	230	170	140	100	65	45	30	15	5	3	3
	8,000 hrs/wk	390	340	260	160	110	85	70	50	33	23	15	8	3	2	1
	4,000 hrs/wk	200	170	130	80	55	43	35	25	16	11	8	4	1	1	< 1
	2,000 hrs/wk	100	85	65	40	28	20	20	13	8	6	4	2	< 1	< 1	< 1
	Distance (m)	25	50	100	200	300	400	500	750	1,000	1,500	2,000	4,000	8,000	10,000	14,000
2025 Concept	32,000 hrs/wk	290	250	190	120	80	60	50	45	25	16	12	5	2	1	1
	16,000 hrs/wk	150	130	100	60	40	30	25	23	13	8	6	3	1	< 1	< 1
	8,000 hrs/wk	70	60	50	30	20	15	13	11	6	4	3	1	< 1	< 1	< 1
	4,000 hrs/wk	35	30	25	15	10	8	6	6	3	2	2	< 1	< 1	< 1	< 1
	2,000 hrs/wk	18	15	13	8	5	4	3	3	2	1	< 1	< 1	< 1	< 1	< 1

Note: Cancer risk values are rounded.

Table II.H.5 compares the potential cancer risks for individual residents for the baseline and the Concept in 2031. Again, the scenarios show significant reductions in risks across all activity levels. For example, at 25 meters from the cluster boundary, for 32,000 TRU engine hours per week, the Concept could reduce residual risks to approximately 50 chances per million compared to the baseline at approximately 1,140 chances per million.

Table II.H.5. Cluster Individual Resident Cancer Risks – Year 2031 (chances per million)

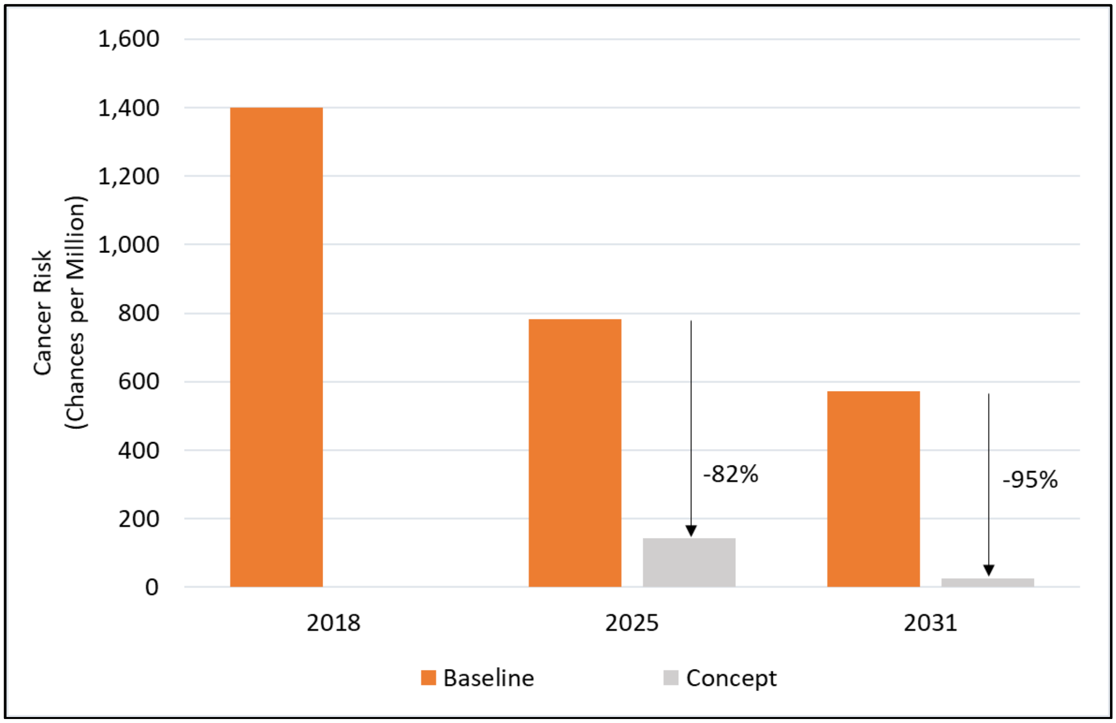
	Distance (m)	25	50	100	200	300	400	500	750	1,000	1,500	2,000	4,000	8,000	10,000	14,000
2031 Baseline	32,000 hrs/wk	1,140	1,000	750	460	330	250	200	150	100	60	45	20	8	6	4
	16,000 hrs/wk	570	500	380	230	160	130	100	75	50	30	23	10	4	3	2
	8,000 hrs/wk	290	250	190	120	80	65	50	38	25	15	11	5	2	2	1
	4,000 hrs/wk	140	130	95	60	40	30	25	19	13	8	6	3	1	< 1	< 1
	2,000 hrs/wk	70	60	50	30	20	15	13	9	6	4	3	1	< 1	< 1	< 1

	Distance (m)	25	50	100	200	300	400	500	750	1,000	1,500	2,000	4,000	8,000	10,000	14,000
2031 Concept	32,000 hrs/wk	50	45	30	20	15	12	10	10	5	3	2	1	< 1	< 1	< 1
	16,000 hrs/wk	25	23	15	10	8	6	5	5	3	2	1	< 1	< 1	< 1	< 1
	8,000 hrs/wk	13	11	8	5	4	3	3	3	1	< 1	< 1	< 1	< 1	< 1	< 1
	4,000 hrs/wk	6	6	4	3	2	2	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2,000 hrs/wk	3	3	2	1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Note: Cancer risk values are rounded.

For the potential downwind cancer risks, the Concept would provide significant risk reductions. After implementation of the Concept, Figure II.H.3 shows that baseline residential cancer risks are anticipated to be reduced by about approximately 82 percent in 2025 and 95 percent in 2031.

Figure II.H.3. Potential Individual Resident Cancer Risk and Risk Reduction for Cold Storage Warehouse Clusters



b) Cancer Risk Inside the Cluster Boundary

CARB staff also evaluated the potential cancer risks for individual residents within the area encompassed by the boundary connecting the facilities (shown in Figure II.H.2). Table II.H.6 shows the range of potential cancer risks for the existing TRU ATCM and the Concept with an activity of 16,000 hours of TRU engine operation per week (4,000 hours/week x 4 facilities). The table presents the highest and lowest cancer risk values for receptors within the cluster boundary. The scenarios show significant cancer risk reductions, estimated at about 81 to 83 percent in 2025 and about 95 to 96 percent in 2031.

Table II.H.6. The High and Low Bound of Potential Cancer Risks Estimated Inside the Cluster Boundary

Year	2018		2025		2031	
	High	Low	High	Low	High	Low
Baseline (16,000 hrs/wk)	1,670	200	930	110	680	83
Concept (16,000 hrs/wk)	-	-	160	23	28	4

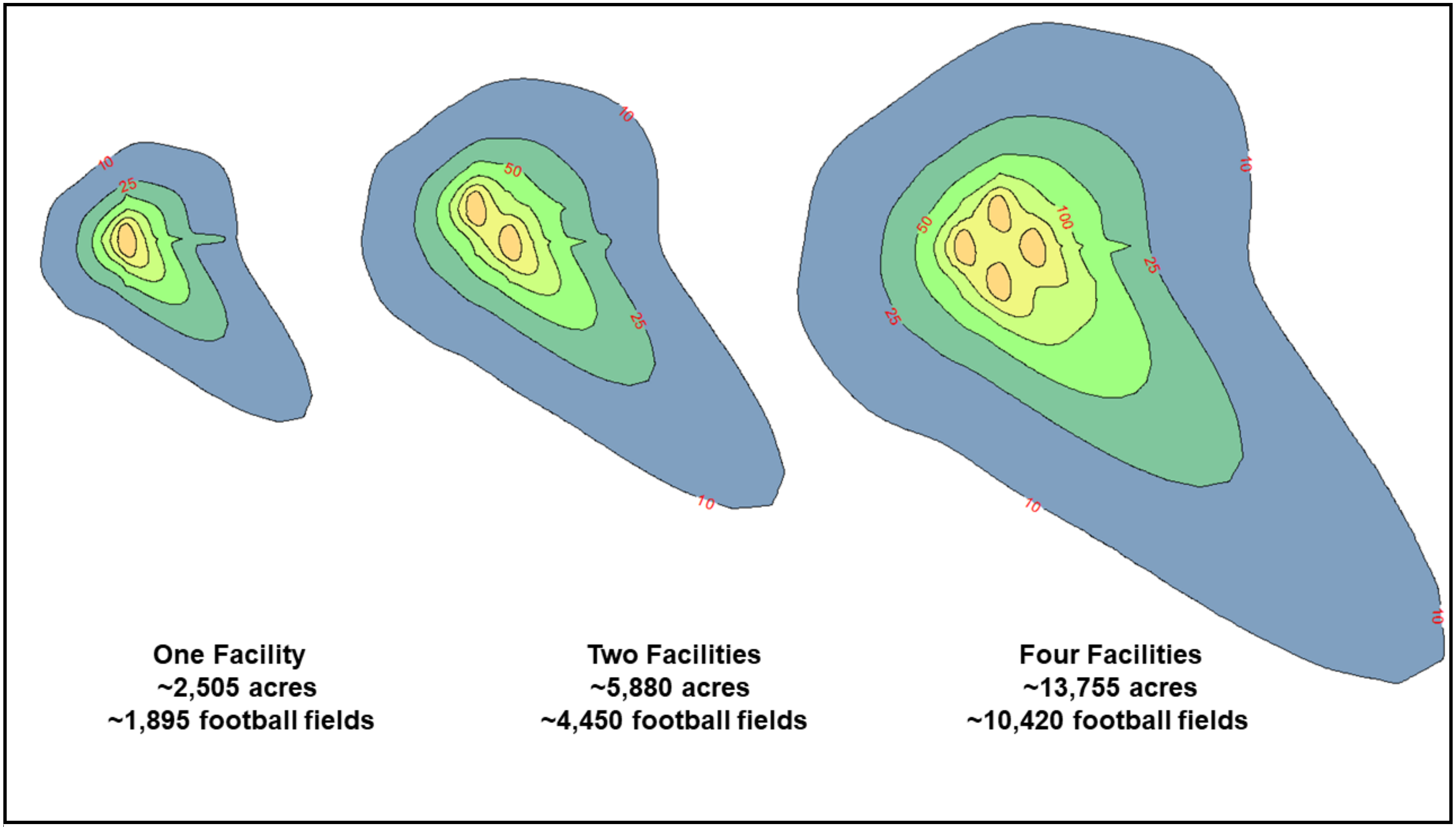
Note: Cancer risk values are rounded. Individual resident cancer risk estimates are based on a 30-year exposure duration using the Risk Management Policy (RMP) method ($95^{th}/80^{th}$ percentile daily breathing rates (DBR)). Dashes are used for the Concept in 2018 because the Concept is not implemented.

c) Zone of Impact

The zones of impact are different for the multi-facility and single facility assessments. The key difference is the cumulative impacts that are caused by the multi-facility scenario. For the cluster evaluation, staff used the concept of a “zone of impact” (ZOI) (OEHHA, 2015) to present the cumulative spatial impacts. ZOI is defined as the geographic area encompassed by the isopleth where the total excess lifetime (i.e., a 70-year exposure) cancer risk from inhalation exposure is greater than 10 chances per million.

Figure II.H.4 presents the zone of impact from a single facility and compares it to the zones of impact for a two-facility cluster and a four-facility cluster. For comparison, each facility is assumed to have 4,000 hours of TRU engine operation per week. Figure II.H.4 also provides the approximate acreage or equivalent number football fields correspond to the area within the ZOI. The figure shows that a two-facility cluster has a ZOI that is approximately 2.4 times larger than a single facility and a four-facility cluster has a ZOI that is approximately 5.5 times larger than a single facility.

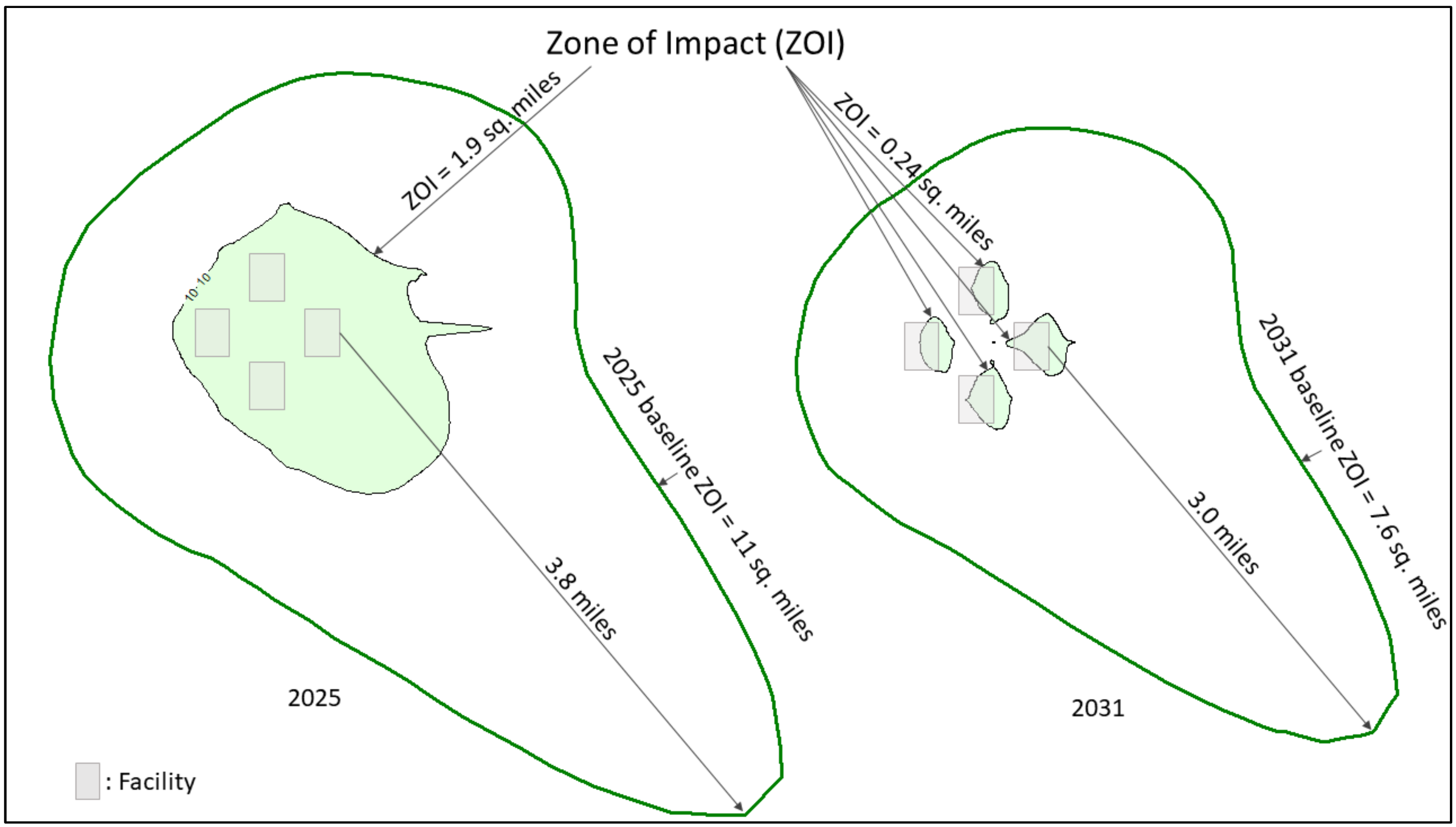
Figure II.H.4. Zone of Impacts for Single and Multiple Source CSW Facilities



Note: All isopleths are based on a 70-year exposure duration.
The numbers shown on the isopleths or contours indicate estimated potential cancer risk levels in chances per million.

Figure II.H.5 shows a spatial comparison of ZOIs under the existing TRU ATCM (shown as the areas bounded by green-colored lines or isopleths) and the Concept (shown as green-shaded areas bounded by black-colored isopleths) in 2025 and 2031. The Concept shows significant reductions on the size of ZOI compared to the existing TRU ATCM of approximately 83 and 97 percent in 2025 and 2031, respectively.

Figure II.H.5. Zone of Impact of Clusters for the Existing TRU ATCM and the Concept in 2025 and 2031



Note: All isopleths are based on a 70-year exposure duration.

5. Health Risk Assessment – Summary of Noncancer Chronic Results

Noncancer chronic health risk from diesel PM is estimated by calculating the chronic Hazard Index (HI) using diesel PM concentrations. Because diesel PM is the only pollutant of concern, and diesel PM has only one end point, the HI is the ratio of the annual average air concentrations of diesel PM to the chronic inhalation REL. OEHHA adopted a chronic REL of 5 µg/m^3 for the diesel PM. For the cluster analysis, the noncancer chronic risks are based on total 16,000 hours of TRU engine operation per week.

An HI value above one may indicate potential health impacts and may require further evaluation. Table II.H.7 below presents the highest modeled HI in each year based on the existing TRU ATCM and the Concept scenarios. All chronic HI values are less than one.

Table II.H.7. Summary of Chronic Hazard Indices for CSW Cluster

Year	2018	2025	2031
Baseline (16,000 hrs/wk)	≤ 0.45	≤ 0.25	≤ 0.18
Concept (16,000 hrs/wk)	-	≤ 0.04	≤ 0.01

Note: Dashes are used for the Concept in 2018 because the Concept is not implemented.

I. 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

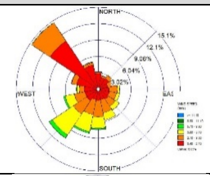
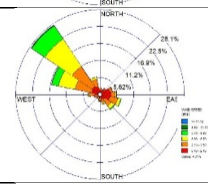
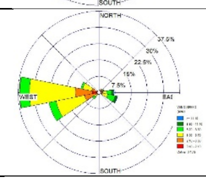
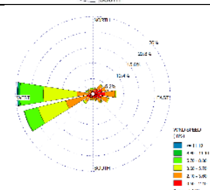
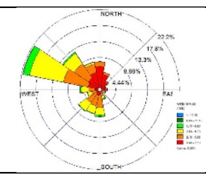
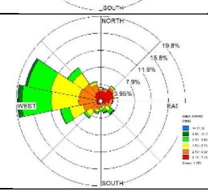
AERMOD requires hourly surface and upper air meteorological data as inputs to the model, including: wind speed, wind direction, cloud cover, ambient temperature, and dew point. Surface stations and radiosondes (i.e., weather balloons) record these meteorological parameters.

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.

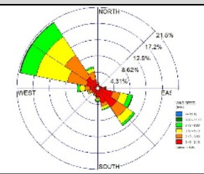
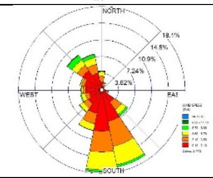
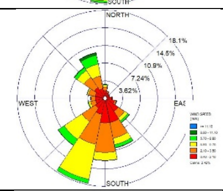
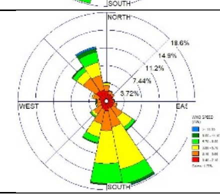
Table II.I.1, on the next page, shows the results of the sensitivity study and compares each of the ten meteorological station's meteorological conditions and land cover type.

Table II.I.1. Meteorological Station Comparison

Meteorological Station Location	Average Wind Speed (m/s)	% Calms	Urban	Wind Rose	Maximum Concentration (μg/m³)[1]
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

1. 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.I.1. Meteorological Station Comparison (Cont.)

Meteorological Station Location	Average Wind Speed (m/s)	% Calms	Urban	Wind Rose	Maximum Concentration (µg/m³)[1]
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

1. 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.

Table II.I.2. Top Ten Cities in California with the Most Refrigerated Warehouses and Distribution Centers[13]

City	Population of Refrigerated Warehouses and Distribution Centers[1]
Los Angeles	21
Vernon	15
Watsonville	13
Stockton	10
Bakersfield	8
Delano	8
San Diego	8
Fresno	7
Ontario	7
Reedley	6

1. These population values are based on data from Manta (an online directory for small businesses) and staff's spatial analysis of that data.

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 warehouses and distribution centers 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, 2007). Without the urban option, urban areas may see higher ground-level concentrations.

CARB staff compared different population results for each meteorological station. Table II.I.3 summarizes these results.

[13] Manta. *Refrigerated Warehousing and Storage Companies in California.* https://www.manta.com/mb_44_A90DE_05/refrigerated_warehousing_and_storage/california. Accessed July 16, 2019.

Table II.I.3. Meteorological Station Population Results

Meteorological Station	Metropolitan Statistical Area or MSA[14] (2010 Census)	Population[15] (2010 Census)	3 km radius census block (HARP)[16]
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 in population inputs. The results of this sensitivity study are shown in Figure II.I.1 and Table II.I.4.

[14] City Population. *Fresno Metropolitan Statistical Area in* USA. https://www.citypopulation.de/php/usa-metro.php?cityid=23420. Accessed January 2019.
[15] United States Census Bureau. *American Fact Finder.* https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml. Accessed January 2019.
[16] This refers to the census block population within a 3 km radius of the meteorological station.

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

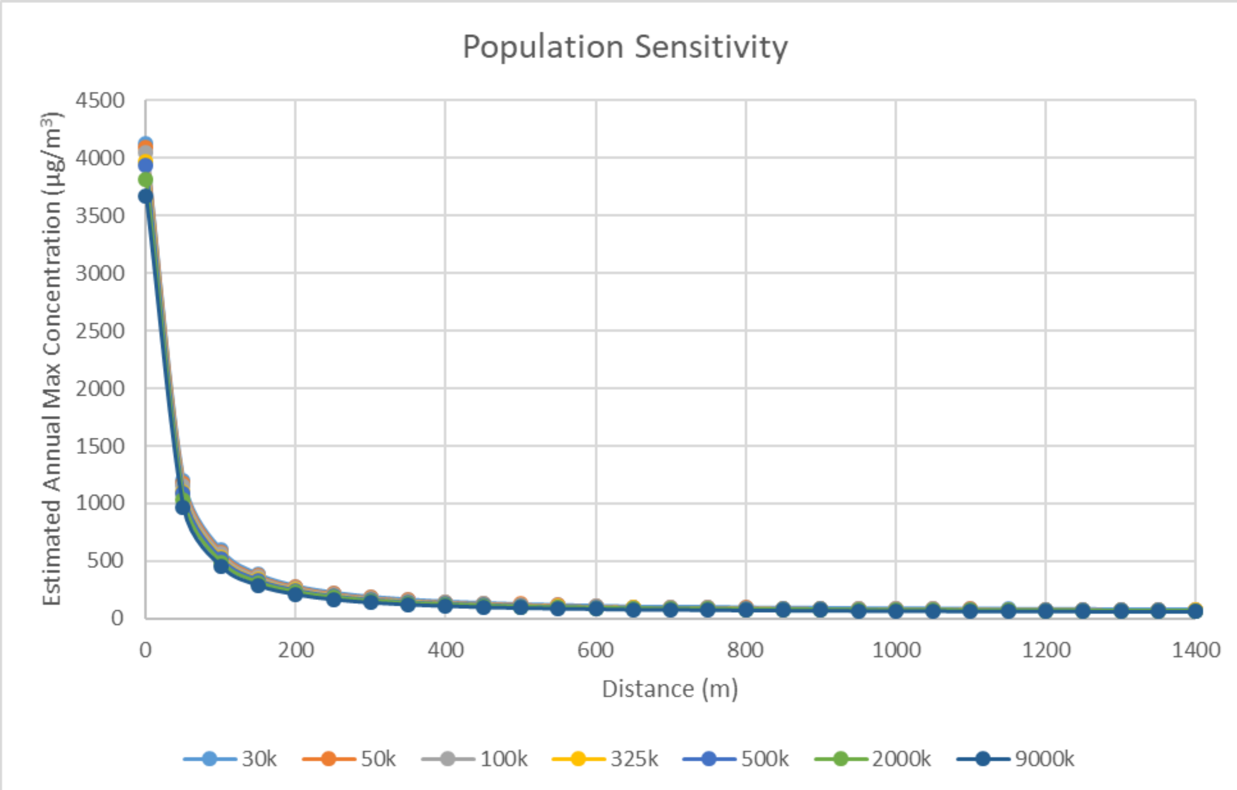


Table II.I.4. Sensitivity Study Results – Population vs. Concentration

Population	30k	50k	100k	325k	500k	2,000k	9,000k
Max Concentration (µg/m3)	4,124	4,094	4,051	3,967	3,934	3,813	3,665

1. 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, CSW, and multi-facility HRAs 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 µg/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).

J. 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, 1998a), the panel members endorsed a range of inhalation CPF (1.3×10^{-4} to 2.4×10^{3} $(\mu g/m^3)^{-1}$) and a risk factor of 3×10^{-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 Concept. 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 $PM_{2.5}$ MORTALITY AND ILLNESS ANALYSIS FOR CALIFORNIA AIR BASINS

This section describes the summary of findings regarding PM mortality and illness impacts that include premature death from cardiopulmonary disease, hospital admissions, and emergency room visits.

A. PM Mortality and Illness Overview

$PM_{2.5}$ is associated with adverse health outcomes such as the risk of premature deaths, hospitalizations and emergency room visits (U.S. EPA, 2010). As a result, reductions in $PM_{2.5}$ emissions are associated with reduction in these health outcomes. NO_x includes nitrogen dioxide (NO_2), a potent lung irritant, but its most serious impact on human health comes about when atmospheric processes convert NO_x into fine particles of ammonium nitrate. $PM_{2.5}$ formed in this manner is termed secondary $PM_{2.5}$ to distinguish it from primary $PM_{2.5}$, which is emitted directly from a source, such as soot from engine exhaust.

As part of the health analyses, CARB staff conducted a PM mortality and illness analysis based on the statewide emission reductions of $PM_{2.5}$ and NO_x that would be achieved by the implementation of the Concept. The methods used to estimate the premature deaths and other health outcomes related to $PM_{2.5}$ exposure are based on a peer-reviewed methodology developed by U.S. EPA (US EPA, 2010) and CARB's incidence-per-ton (IPT) methodology.[17] Unlike the HRA, the PM mortality and illness analysis presents the statewide health benefits in dollar amounts. For a detailed explanation of estimating health impacts, see the CARB document *Estimate of Premature Deaths Associated with Fine Particle Pollution* ($PM_{2.5}$*) in California Using a U.S. Environmental Protection Agency* Methodology (CARB, 2010a).

1. Incidents-Per-Ton Methodology

CARB uses the IPT methodology to quantify the health benefits of emission reductions in cases where dispersion modeling results are not available. CARB's IPT methodology is based on the methodology developed by U.S. EPA (Fann et. al., 2009, 2012, 2018). It is used to estimate the benefits of reductions in primary $PM_{2.5}$ emitted directly from sources and secondary $PM_{2.5}$ formed from precursors by chemical processes in the atmosphere. More information on the IPT methodology can be found on CARB's website.[17]

Under the IPT methodology, 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 $PM_{2.5}$ for a baseline scenario using

[17] CARB's Methodology for Estimating the Health Effects of Air Pollution, https://www.arb.ca.gov/resources/documents/carbs-methodology-estimating-health-effects-air-pollution. accessed September 3, 2019.

measured ambient concentrations and dividing by the emissions of $PM_{2.5}$ or a precursor. The calculation is performed separately for each air basin:

$$IPT = \frac{number\ of\ health\ outcomes\ in\ air\ basin}{annual\ emissions\ in\ air\ basin}$$

Multiplying the emission reductions from the Concept in an air basin by the IPT factor then yields an estimate of the reduction in health outcomes achieved by the Concept. 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 two types of $PM_{2.5}$: primary $PM_{2.5}$ and secondary $PM_{2.5}$ of ammonium nitrate aerosol formed from precursors.

2. Reduction in Health Outcomes

CARB staff estimated the reduction in health outcomes from reduced emissions of $PM_{2.5}$ from the Concept. These health outcomes include cardiopulmonary mortality, hospital admissions, and emergency room visits. Based on the analysis, staff estimates that the total number of cases statewide that would be reduced due to the implementation of the Concept are as follows:

- 409 premature deaths (320 to 500, 95 percent confidence interval (CI))
- 128 hospital admissions (16 to 237, 95 percent CI)
- 200 emergency room visits (127 to 274, 95 percent CI)

Tables III.C.1 through III.C.3 show the estimated reductions in health outcomes resulting from the Concept summed over a 11-year period from 2022 to 2032. The values in parenthesis represent the 95^{th} percentile CI for each health outcome. All values have been rounded to no more than two significant digits.

Table III.C.1. Concept: Reductions in Health Outcomes from $PM_{2.5}$

Air Basin	Cardiopulmonary mortality	Hospital admissions	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 - 2)	2 (1 - 3)
San Francisco Bay	17 (14 - 21)	6 (1 - 10)	10 (6 - 13)
San Joaquin Valley	15 (12 - 19)	3 (0 - 6)	6 (4 - 8)
South Central Coast	1 (1 - 1)	0 (0 - 1)	0 (0 - 1)
South Coast	95 (74 - 116)	32 (4 - 60)	49 (31 - 68)
Total	145 (113 - 178)	46 (6 - 85)	72 (46 - 99)

Note: All values are rounded.

Table III.C.2. Concept: Reductions in Health Outcomes from NO_x

Air Basin	Cardiopulmonary mortality	Hospital admissions	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 - 2)	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 (1 - 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	9 (7 - 11)	2 (0 - 4)	4 (2 - 5)
Salton Sea	1 (1 - 2)	0 (0 - 1)	1 (0 - 1)
San Diego County	8 (6 - 10)	2 (0 - 4)	3 (2 - 5)
San Francisco Bay	22 (17 - 26)	7 (1 - 13)	12 (8 - 17)
San Joaquin Valley	54 (42 - 65)	12 (2 - 23)	20 (13 - 28)
South Central Coast	4 (3 - 4)	1 (0 - 2)	2 (1 - 2)
South Coast	161 (126 - 197)	55 (7 - 102)	84 (53 - 115)
Total	264 (206 - 322)	82 (10 - 152)	128 (81 - 175)

Note: All values are rounded.

Table III.C.3. Concept: Total Reductions in Health Outcomes

Air Basin	Cardiopulmonary mortality	Hospital admissions	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	4 (3 - 5)	1 (0 - 2)	2 (1 - 2)
Mountain Counties	2 (1 - 2)	0 (0 - 1)	1 (0 - 1)
North Central Coast	3 (2 - 3)	1 (0 - 2)	2 (1 - 2)
North Coast	1 (0 - 1)	0 (0 - 0)	0 (0 - 0)
Northeast Plateau	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Sacramento Valley	15 (11 - 18)	3 (0 - 6)	6 (4 - 8)
Salton Sea	3 (2 - 3)	1 (0 - 1)	1 (1 - 2)
San Diego County	13 (10 - 16)	4 (0 - 7)	6 (3 - 8)
San Francisco Bay	39 (30 - 48)	12 (2 - 23)	22 (14 - 30)
San Joaquin Valley	69 (54 - 84)	16 (2 - 30)	26 (16 - 35)
South Central Coast	5 (4 - 6)	1 (0 - 3)	2 (1 - 3)
South Coast	256 (200 - 313)	87 (11 - 162)	133 (84 - 182)
Total	409 (320 - 500)	128 (16 - 237)	200 (127 - 274)

Note: All values are rounded.

Aside from its role in the formation of secondary $PM_{2.5}$, NO_x is also a precursor to the formation of ozone. However, when the valuations for NO_x and $PM_{2.5}$ are monetized, the monetary impacts of $PM_{2.5}$ tend to overwhelm the ozone valuations, relative to NO_x. As a result, this analysis only monetizes the value of reductions in $PM_{2.5}$. In accordance with U.S. EPA practice, health outcomes were monetized by multiplying incidence by a standard value derived from economic studies.[18] This valuation per incident is provided in Table III.C.4 on the next page. The valuation for avoided premature mortality is based on willingness to pay.[19] This value is a statistical construct based on the aggregated dollar amount that a large group of people would be willing to pay for a reduction in their individual risks of dying in a year, such that one death would be avoided in the year across the population. This is not an estimate of how much any single individual would be willing to pay to prevent a certain death of any particular

[18] National Center for Environmental Economics et al., *Appendix B: Mortality Risk Valuation Estimates, Guidelines for Preparing Economic Analyses* (EPA 240-R-10-001, Dec. 2010) available at https://www.epa.gov/sites/production/files/2017-09/documents/ee-0568-22.pdf.

[19] United States Environmental Protection Agency Science Advisory Board (U.S. EPA-SAB), *An SAB Report on EPA's White Paper Valuing the Benefits of Fatal Cancer Risk Reduction* (EPA-SAB-EEAC-00-013, July 2000), available at http://yosemite.epa.gov/sab%5CSABPRODUCT.NSF/41334524148BCCD6852571A700516498/$File/eeacf013.pdf.

person,[20] nor does it consider any specific costs associated with mortality such as hospital expenditures.

Unlike premature mortality valuation, the valuation for avoided hospitalizations and emergency room visits is based on a combination of typical costs associated with hospitalization 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, lost recreation value, and lost household protection (e.g., valuation of time-losses from inability to maintain the household or provide childcare). These costs are most closely associated with specific cost savings to individuals and costs to the health care system.

Table III.C.4. Valuation per Incident Avoided Health Outcomes[1]

Outcome	Valuation per Incident[1]
Avoided Premature Deaths	$9,744,432
Avoided Acute Respiratory Hospitalizations	$51,062
Avoided Cardiovascular Hospitalizations	$58,541
Avoided ER Department Visits	$838

1. Values are for the 2019 dollar year.

Statewide valuation of health benefits are calculated by multiplying the avoided health outcomes by valuation per incident. Staff quantified the total statewide valuation due to avoided health outcomes between 2021 and 2032. These values are summarized in Table III.C.5. The spatial distribution of these benefits follow 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 lesser benefits in the Sacramento Valley and San Diego County air basins.

Table III.C.5. Statewide Valuation from Avoided Adverse Health Outcomes between 2021 and 2032 as a Result of the Concept[1]

Outcome	Valuation
Avoided Premature Deaths	$3,986,282,547
Avoided Hospitalizations	$695,5741
Avoided Emergency Room Visits	$167,668
Total Valuation	$3,993,405,956

1. Values have been rounded and are based on the 2019 dollar year.

[20] United States Environmental Protection Agency, *Mortality Risk Valuation – What does it mean the place a value on a life?*, available at https://www.epa.gov/environmental-economics/mortality-risk-valuation#means. (last visited Aug. 14, 2018).

3. Uncertainties Associated with the Mortality and Illness Analysis

Although the health outcome estimates presented in this report are based on the best methodologies currently available, they are subject to uncertainty. The uncertainty ranges on health estimates in this analysis only take into account the uncertainty of the relative risk, which is a parameter in the concentration response factor (CRF) that determines how changes in air quality translate into changes in health outcomes. Other sources of uncertainty include:

- Air quality data is subject to natural variability from meteorological conditions, local activity, etc.
- The assumption that changes in concentrations of pollutants are proportional to changes in emissions of those pollutants or their precursors is an approximation. There may be cases where actual changes in concentrations are higher or lower than predicted.
- The estimation of $PM_{2.5}$ concentrations and $PM_{2.5}/NO_x$ emission ratios are subject to uncertainty. Emissions are reported at an air basin resolution, and do not capture local variations.
- Inverse distance-squared weighting, a spatial interpolation method, is used to estimate concentrations each census tract. Compared with other geospatial estimation methods (such as Kriging), inverse distance-squared interpolation has the virtue of simplicity, and does not require selection of parameters. When data are abundant, most simple interpolation techniques give similar results (Jarvis et al., 2001). All geospatial estimation techniques exhibit greater uncertainty when data points are sparser, and uncertainty increases with distance from the nearest data points.
- Future population estimates are subject to increasing uncertainty as they are projected further into the future. For reasons of computational efficiency, the spatial resolutions of population estimates are limited to census tract resolution.
- Observed baseline incidence rates change over time, and are subject to random year-to-year variation and systematic shifts as population characteristics and medical treatments evolve. Sample size requirements necessitate estimating baseline incidence rates at large geographic scales (such as state or county).
- Relative risks in the CRFs are estimated with uncertainty and reported as confidence ranges.

IPT factors were developed for on-road diesel sources and NO_x sources. Application to other sources is subject to availability of relative potency factors.

IV. REFERENCES

Bell et. al., 2008. Seasonal and Regional Short-term Effects of Fine Particles on Hospital Admissions in 202 US Counties, 1999–2005. Am J Epidemiol. 2008 Dec 1; 168(11): 1301–1310. Available at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2732959/.

CARB ADAM air quality database. Available at https://www.arb.ca.gov/adam.

CARB, 2010a. California Air Resources Board, Appendix J of Staff Report, Initial Statement of Reasons for Proposed Rulemaking, "Proposed Amendments to the Truck and Bus Regulation, the Drayage Truck Regulation and the Tractor-Trailer Greenhouse Gas Regulation" (2010).

CARB, 2010b. California Air Resources Board, Estimate of Premature Deaths Associated with Fine Particle Pollution (PM2.5) in California Using a U.S. Environmental Protection Agency Methodology. Available at https://www.arb.ca.gov/research/health/pm-mort/pm-report_2010.pdf.

CARB, 2011. California Air Resources Board, Staff Report 2011 Amendments For the Airborne Toxic Control Measure For In-use Diesel-fueled Transport Refrigeration Units, Appendix B-A1 and B-A2. Available at https://www.arb.ca.gov/regact/2011/tru2011/truisor.pdf.

CARB, 2016. California Air Resources Board, 2016 Grocery Store Survey.

CARB, 2019. California Air Resources Board's Methodology for Estimating the Health Effects of Air Pollution. Available at https://ww2.arb.ca.gov/resources/documents/carbs-methodology-estimating-health-effects-air-pollution.

CAPCOA, 2009. California Air Pollution Control Offices Association, Health Risk Assessments for Proposed Land Use Projects. Available at http://www.capcoa.org/wp-content/uploads/downloads/2010/05/CAPCOA_HRA_LU_Guidelines_8-6-09.pdf.

CDOF. California Department of Finance population projection web site. http://www.dof.ca.gov/research/demographic/reports/view.php.

Chestnut et. al., 2006. Chestnut L, Thayer M, Lazo J. Eeden, S.. The Economic Value Of Preventing Respiratory And Cardiovascular Hospitalizations. Contemporary Economic Policy, 24: 127–143. doi: 10.1093/CEP/BYJ007. Available at http://onlinelibrary.wiley.com/doi/10.1093/cep/byj007/full.

City Population. *Fresno Metropolitan Statistical Area in* USA. https://www.citypopulation.de/php/usa-metro.php?cityid=23420. Accessed January 2019.

Cook et. al., 2016. Consensus On Consensus: A Synthesis of Consensus Estimates On Human-caused Global Warming. Environ. Res. Lett. 11 (2016) 048002, doi:10.1088/1748-9326/11/4/048002. Available at http://iopscience.iop.org/article/10.1088/1748-9326/11/4/048002/pdf.

Fann et. al., 2009. Fann N, Fulcher CM, Hubbell BJ. The influence of location, source, and emission type in estimates of the human health benefits of reducing a ton of air pollution Air Quality. Atmosphere & Health. 2:169-176.

Fann et. al., 2012. Fann N, Baker KR, Fulcher CM. Characterizing the PM2.5-related health benefits of emission reductions for 17 industrial, area and mobile emission sectors across the U.S. Environ Int. 2012 Nov 15;49:141-51.

Fann et. al., 2018. Fann N, Baker K, Chan E, Eyth A, Macpherson A, Miller E, Snyder J. Assessing Human Health PM2.5 and Ozone Impacts from U.S. Oil and Natural Gas Sector Emissions in 2025. Environ. Sci. Technol. 52 (15), pp 8095–8103.

First Carbon Solutions, 2016. Draft Environmental Impact Report, Eastvale Crossings Project, City of Eastvale, Riverside County, California. Available at http://www.eastvaleca.gov/home/showdocument?id=5289.

IMPROVE Visibility Network web site. http://vista.cira.colostate.edu/improve/Overview/Overview.htm.

Ito et. al., 2007. Characterization of PM2.5, gaseous pollutants, and meteorological interactions in the context of time-series health effects models. J Expo Sci Environ Epidemiol. Vol. 17 Suppl 2: S45-60. Available at http://www.nature.com/jes/journal/v17/n2s/full/7500627a.html.

Krewski et. al., 2009. Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality. Health Effects Institute Research Report 140. Available at https://ephtracking.cdc.gov/docs/RR140-Krewski.pdf.

Manta. *Refrigerated Warehousing and Storage Companies in California.* https://www.manta.com/mb_44_A90DE_05/refrigerated_warehousing_and_storage/california. Accessed July 16, 2019.

NCEE et. al., 2010. National Center for Environmental Economics et al., Appendix B: Mortality Risk Valuation Estimates, Guidelines for Preparing Economic Analyses (EPA 240-R-10-001, Dec. 2010). Available at https://www.epa.gov/sites/production/files/2017-09/documents/ee-0568-22.pdf.

Nova Technology, 2013. Dock Planning Standards. Available at https://www.novalocks.com/wp-content/uploads/Dock-Planning-Standards-Guide.pdf.

OEHHA, 2015. Office of Environmental Health Hazard Assessment, The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments, 2015. Available at https://oehha.ca.gov/media/downloads/crnr/2015guidancemanual.pdf.

OPC, 2017. California Ocean Protection Council, Rising Seas in California: An Update On Sea-Level Rise Science. Available at www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sealevel-rise-science.pdf.

Trans Now, 2010. Transportation Northwest, Truck Trip Generation by Grocery Stores. Available at https://ntlrepository.blob.core.windows.net/lib/33000/33900/33993/TNW2010-04.pdf.

United States Census Bureau. *American Fact Finder.* https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml.

U.S. EPA BenMAP. United States Environmental Protection Agency Benefits Mapping and Analysis Software. https://www.epa.gov/benmap/benmap-downloads.

U.S. EPA, 1974. United States Environmental Protection Agency, Effective Stack Height/Plume Rise. Available at https://nepis.epa.gov/Exe/ZyPDF.cgi/9100OX85.PDF?Dockey=9100OX85.PDF

U.S. EPA, 2000. United States Environmental Protection Agency Science Advisory Board (U.S. EPA-SAB), An SAB Report on EPA's White Paper Valuing the Benefits of Fatal Cancer Risk Reduction (EPA-SAB-EEAC-00-013, July 2000), available at http://yosemite.epa.gov/sab%5CSABPRODUCT.NSF/41334524148BCCD6852571A700516498/$File/eeacf013.pdf.

U.S. EPA, 2007. United States Environmental Protection Agency, AERMOD Implementation Guide. Available at https://www3.epa.gov/ttn/scram/models/aermod/aermod_implementation_guide.pdf.

U.S. EPA, 2010. United States Environmental Protection Agency Quantitative Health Risk Assessment for Particulate Matter. Available at http://www.epa.gov/ttn/naaqs/standards/pm/data/PM_RA_FINAL_June_2010.pdf.

U.S. EPA, 2012. United States Environmental Protection Agency, Haul Road Workgroup Final Report. Available at https://www3.epa.gov/ttn/scram/reports/Haul_Road_Workgroup-Final_Report_Package-20120302.pdf.

U.S. EPA, 2013. United States Environmental Protection Agency, AERSURFACE User's Guide. Available at https://www3.epa.gov/scram001/7thconf/aermod/aersurface_userguide.pdf.

U.S. EPA, 2015. United States Environmental Protection Agency, Transportation Conformity Guidance for Quantitative Hot-spot Analysis in PM2.5 and PM10 Nonattainment and Maintenance Areas, J-4 and J-5. Available at https://nepis.epa.gov/Exe/ZyPdf.cgi?Dockey=P100NN22.pdf.

U.S. EPA, 2018. United States Environmental Protection Agency, User's Guide for the AMS/EPA Regulatory Model (AERMOD). Available at https://www3.epa.gov/ttn/scram/models/aermod/aermod_userguide.pdf.