
# Transport Refrigeration Unit Emissions Inventory and Preliminary Health Analyses Workshop

October 31, 2019:  Sacramento


# Introduction

# Agenda

- Introduction
- Statewide Emissions Inventory
- Preliminary Health Analyses
  - Health Risk
    - Methodology
    - Potential Cancer Risk
    - Potential Noncancer Chronic Risk
  - Regional Analysis
    - Methodology
    - Results


# Statewide Emissions Inventory

# 2019 Draft Transport Refrigeration Units (TRU) Emissions Inventory

CALIFORNIA
AIR RESOURCES BOARD

Air Quality Planning and Science Division
Mobile Source Analysis Branch
Off-Road Diesel Analysis Section

October 31, 2019

# TRU Types

Truck TRU

Trailer TRU


Domestic Shipping Container TRU


Railcar TRU

# TRU Generator Sets

# Significance of TRUs

- Significant source of diesel particulate matter (DPM) even compared to major freight sources such as locomotive
- TRUs can operate close together for extended periods of time, near communities

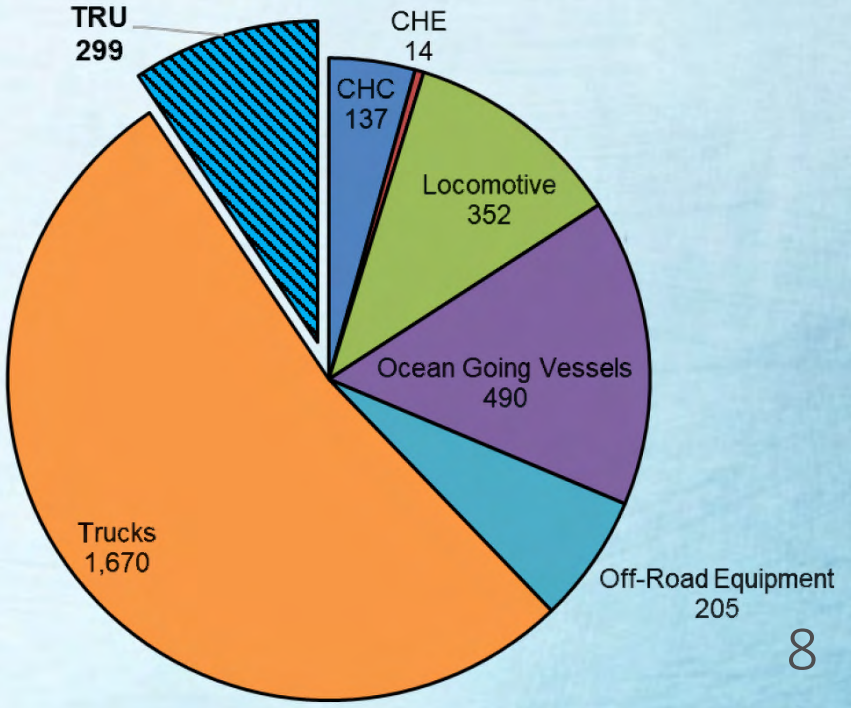
Transport Refrigeration Unit

vs.

Heavy Duty Diesel Trucks

1 hour of TRU Operation in 2030 is equivalent to emissions from a truck driving at 60 mph

*2019 Diesel PM for Freight Sources (tons per year)*

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# How are TRUs Currently Regulated?

- Adopted in 2004 (amended in 2010 and 2011)
- Requires TRU and TRU generator sets to meet in-use performance standards
- Requires California based units to register with CARB at ARBER Database

| TRU and TRU Generator Set Compliance Schedule | | |
|---|---|---|
| **Engine Model Year** | **Low-Emission TRU (50% PM Reduction)** | **Ultra-Low-Emission TRU (85% PM Reduction)** |
| 2001 or older | December 31, 2009 | December 31, 2015 |
| 2002 | December 31, 2009 | December 31, 2016 |
| 2003 | December 31, 2010 | December 31, 2017 |
| 2004 (<25 hp) | December 31, 2011 | December 31, 2018 |
| 2004 (>25 hp) | Not Applicable | December 31, 2011 |
| 2005 and newer | Not Applicable | December 31st of the model year plus 7 years |

# What is an Emissions Inventory?

- An emissions inventory models the emissions of pollutants from a certain sector, such as construction equipment, or TRUs

Emissions (tons/day) = Population x Activity x Horsepower x Load Factor x Emissions Factor

- **Elements of TRU Inventory:**

| | |
|---|---|
| Base Year Population | Number of TRUs currently operating inside California |
| Horsepower | Maximum brake horsepower |
| Activity | Hours of use per year |
| Load Factor | Percent of maximum horsepower |
| Emission Factor | How much pollutant per horsepower-hour |
| Growth Forecast | How much the activity and population will grow in future years |
| Controls (Regulations/ATCM) | How will ATCMs and regulation impact emissions |

# Overview of Inventory Updates

| Inventory Elements | 2011 Inventory | 2019 Inventory (Updated Inventory) |
|---|---|---|
| **Population and Horsepower** | 2010 ARBER* Data | 2018 ARBER* Data |
| **Activity** | 2008 Survey of Facilities | 2018 Telematics Data & 2008 Survey of Facilities |
| **Load Factor** | 2011 Engine Certification Data | 2011 Method, 2018 Telematics, and Efficiency Improvements Data from Manufacturers |
| **Emission Factor** | MSC1999 | 2018 TRU Specific Certification Data |
| **Compliance** | Assumed Full Compliance | 2018 Compliance Trends from Reporting Data and Enforcement |

*ARB Equipment Registration

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# Base Year Population

- ARB Equipment Registration (ARBER) database provides information on:
  - TRU Model, model year, rebuild / retrofit / electric standby status, state of registration
  - Out of State (OOS) TRUs are reporting on a voluntary basis – Reporting data is a subset of population

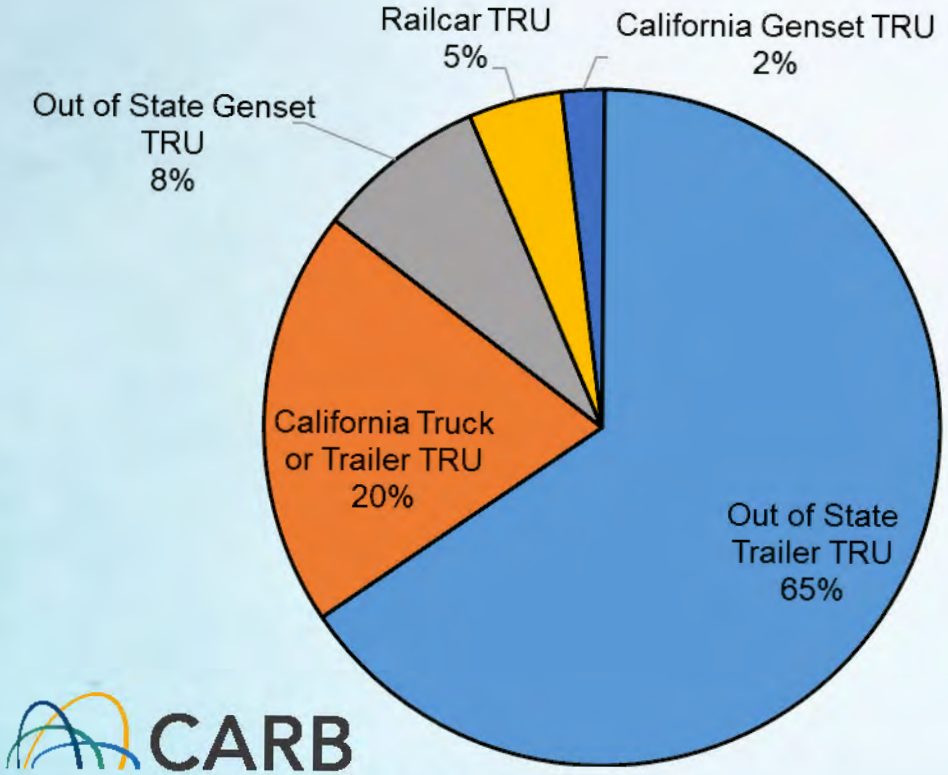
- Population Groups Pulled from ARBER
  - Trailers – 23 to 35 horsepower (interstate and instate)
  - Trucks – 7 to 23 horsepower (instate)
  - TRU Genset – 23 to 35 horsepower
  - Rail and Domestic Shipping Container (DSC) – 23 to 35 horsepower

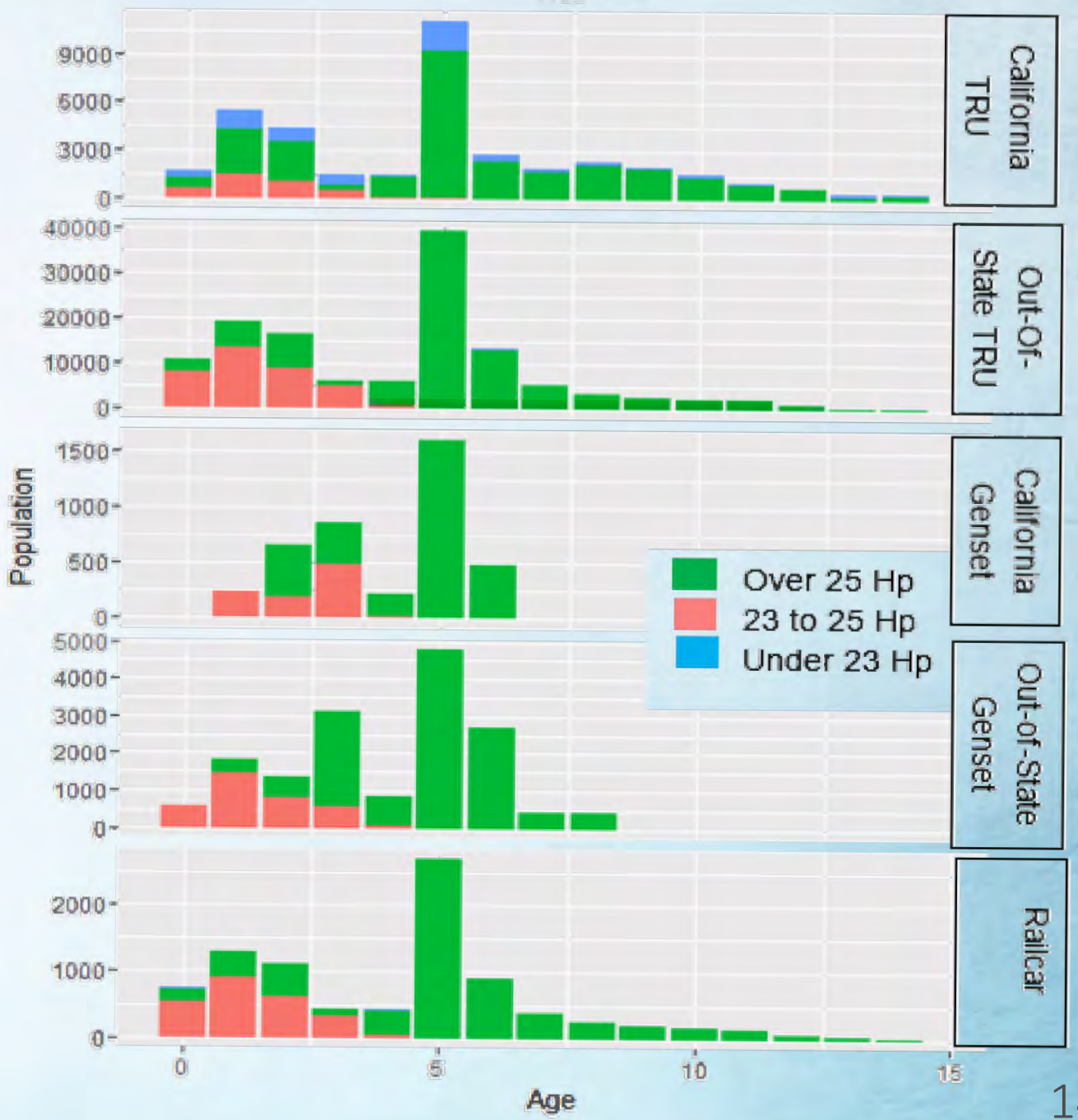
# Base year Population: Out of State TRUs

- To estimate total population visiting California, CARB uses trucking patterns for instate vs. out-of-state trucks using EMFAC2017
- According to EMFAC2017 model, for every instate truck, there are about 3.6 out of state trucks that visit California each year
- Instate TRU population multiplied by 3.6 to estimate out of state TRU visits (results in 134,950 out-of-state TRUs in 2019)
- Age distribution and horsepower based on the approximately 61,000 non-California TRUs that are voluntarily reported in ARBER

# 2018 Population

- Significant share of California trailer TRUs are now between 23 to 25 horsepower
- Majority of OOS TRU, railcar TRUs, and recent genset TRU sales are 23 to 25 horsepower

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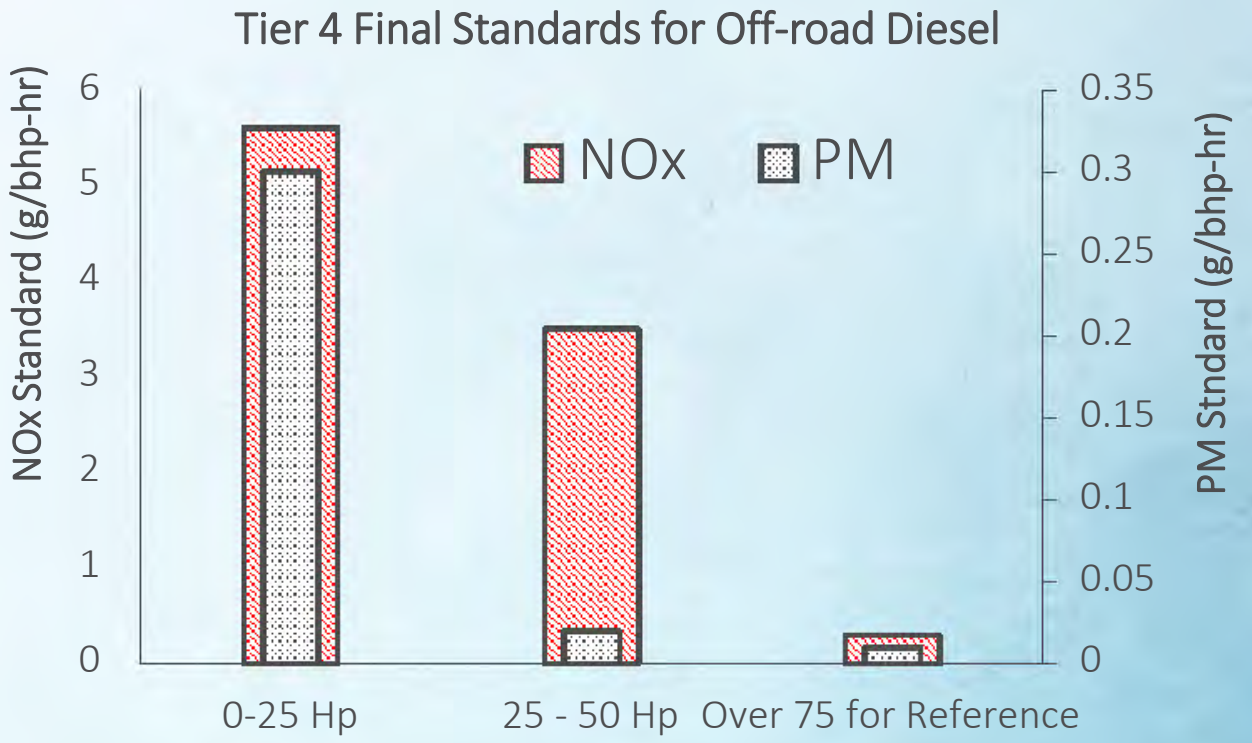
# Important Trend From 2011

- Emergence of 23 to 25 horsepower trailer TRUs
- Compared to 25 – 50 hp engines, 23 – 25 hp engines have
  - **15x** higher **PM** emissions
  - **1.5x** higher **NOx** emissions
- With higher sales of 23 – 25 hp in recent years, diesel PM emissions are not reduced as expected

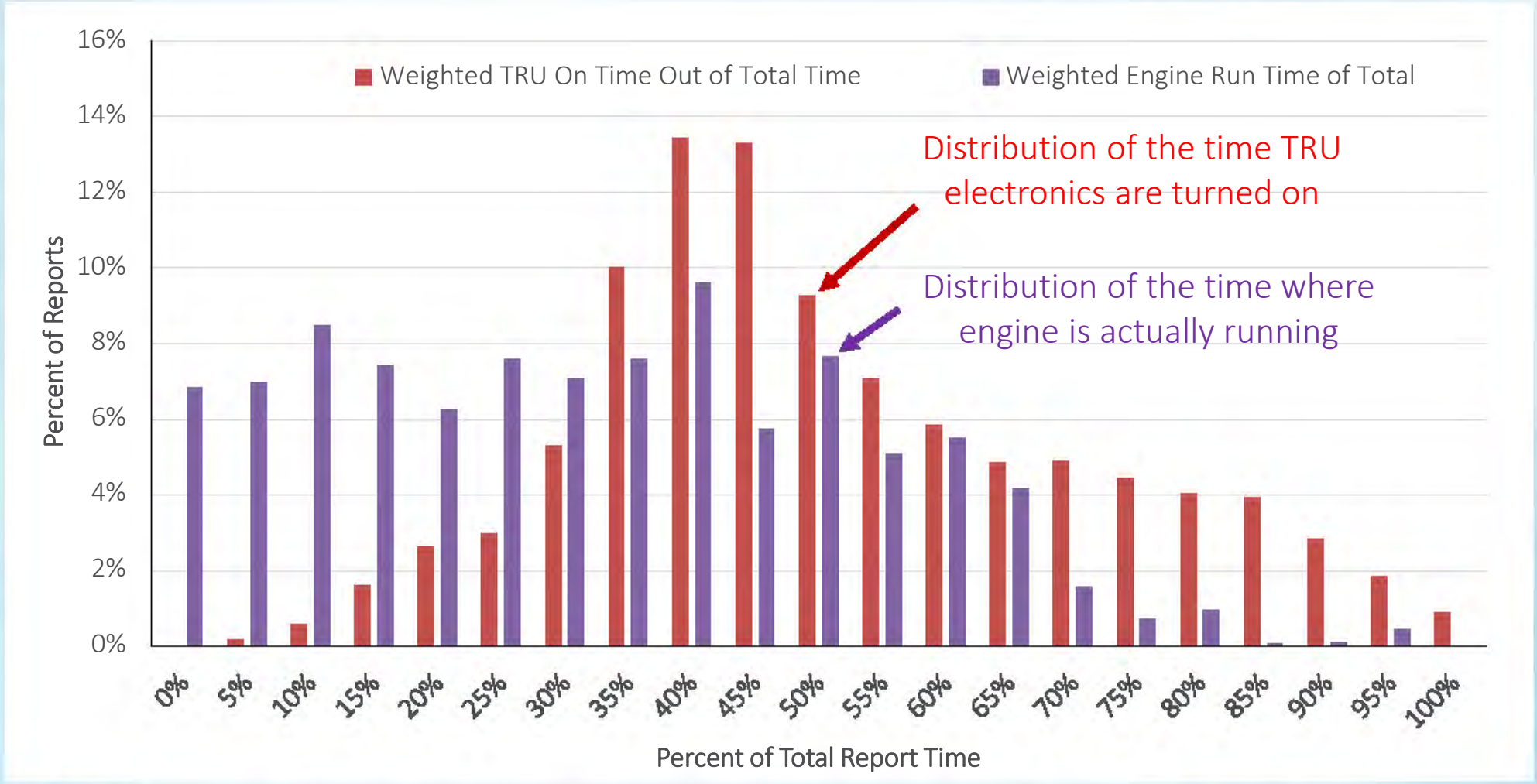


# Activity

- Activity from 2006 survey of facilities, including over 6,000 TRUs, 1.1 million TRU hours:
  - 1697 hrs per year / trailer
  - 1360 hrs per year / truck

- Telematics Data
  - 879,000 hours of telematics data  from trailers only
  - Average of 2,702 hours per year / TRU
  - 33 to 65% of engine run time while stationary

# Activity: Telematics Results

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# Activity: Combined Results

- Activity from telematics combined with survey results
- Each data source weighted relative to overall TRU time represented
  - Result was about 58 percent weight to survey, 42 percent to new telematics data

| Data source | Percent of Engine Time | Average Annual Hours |
|---|---|---|
| Facility Survey | 19.5% | 1,712 |
| Telematics Data | 32.8% | 2,876 |
| Overall Average (Time Weighted) | **25.1%** | **2,201** |

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# Activity: All TRU Groups

- Updated data used for trailers, other categories maintained data source from previous inventory (facility survey for truck TRUs, information from railcar and Genset owners)

| Category | 2019 Model Annual Hours | 2019 Model Annual Hours *Within California* | 2011 Model Annual Hours *Within California* |
|---|---|---|---|
| California Trailer TRU | 2,201 | 1,719 | 1,325 |
| Out-of-state Trailer TRU | 2,201 | 272 | 210 |
| Truck TRU | 1,360 | 1,360 | 1,360 |
| California Genset | 1,000 | 781 | 781 |
| Out-of-state Genset | 1,000 | 124 | 124 |
| Railcar | 1,697 | 322 | 322 |

# Load Factors

- **Load Factor:** *Percent of maximum horsepower*
- **Previous model:** Load factors in the 2011 emissions inventory were based on manufacturer responses for engine certification, and engine lug curves
- **Telematics** data on fuel is limited (4% of reports), but load factor only 0.7% off of this estimate
  - A load factor of 0.467 derived from telematics vs 0.460 that was used in the previous inventory
- Currently plan to maintain load factors used in the 2011 emissions inventory

| Model | Horsepower Bin | Load Factor |
|---|---|---|
| TRU (California-based and Out-of-State) | 25-50 | 0.46 |
| TRU | 11-25 | 0.56 |
| TRU | > 11 | 0.56 |
| Generator set | All | 0.33 |
| Railcar | All | 0.46 |

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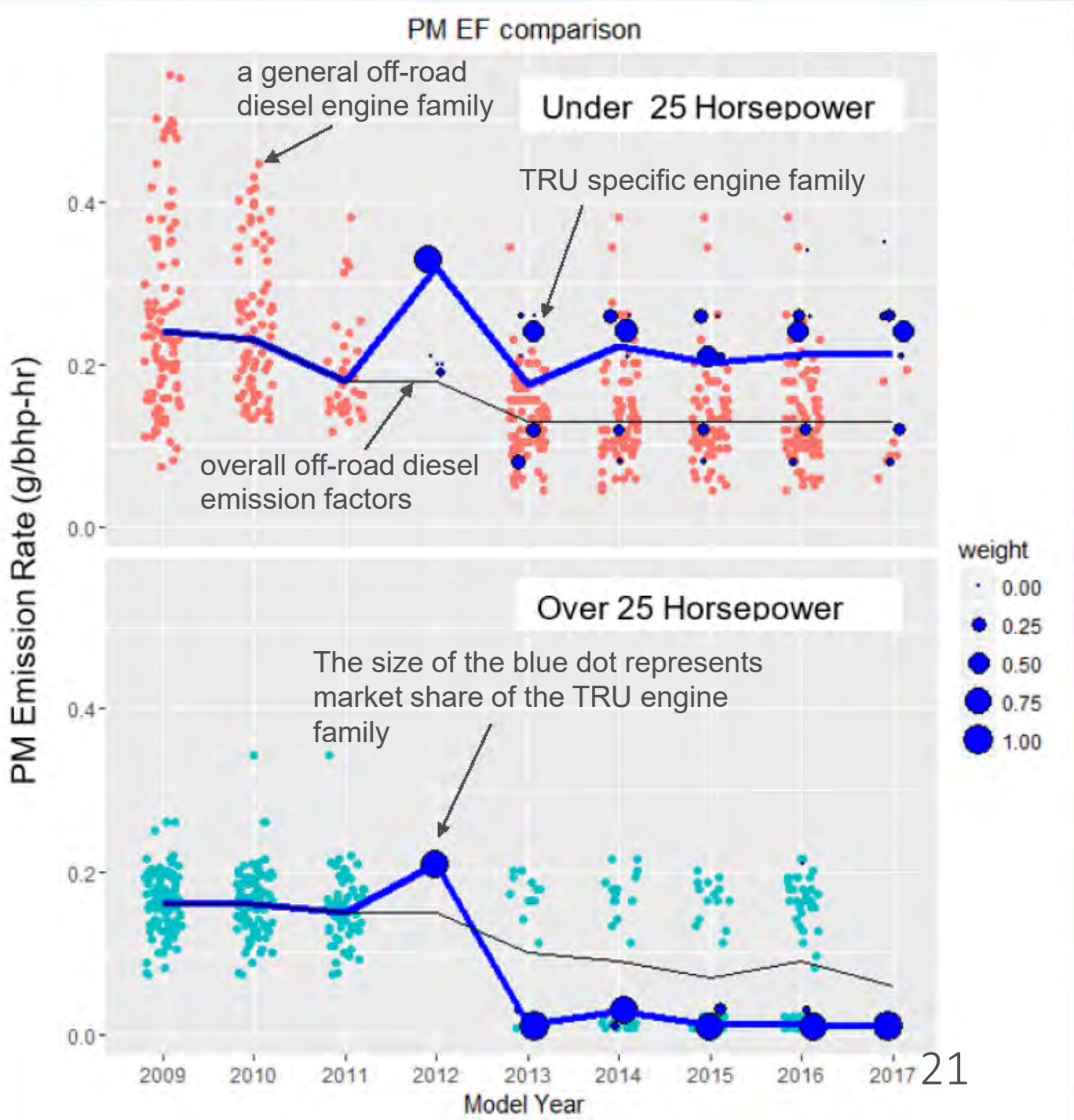
# TRU Specific PM Emission Factor

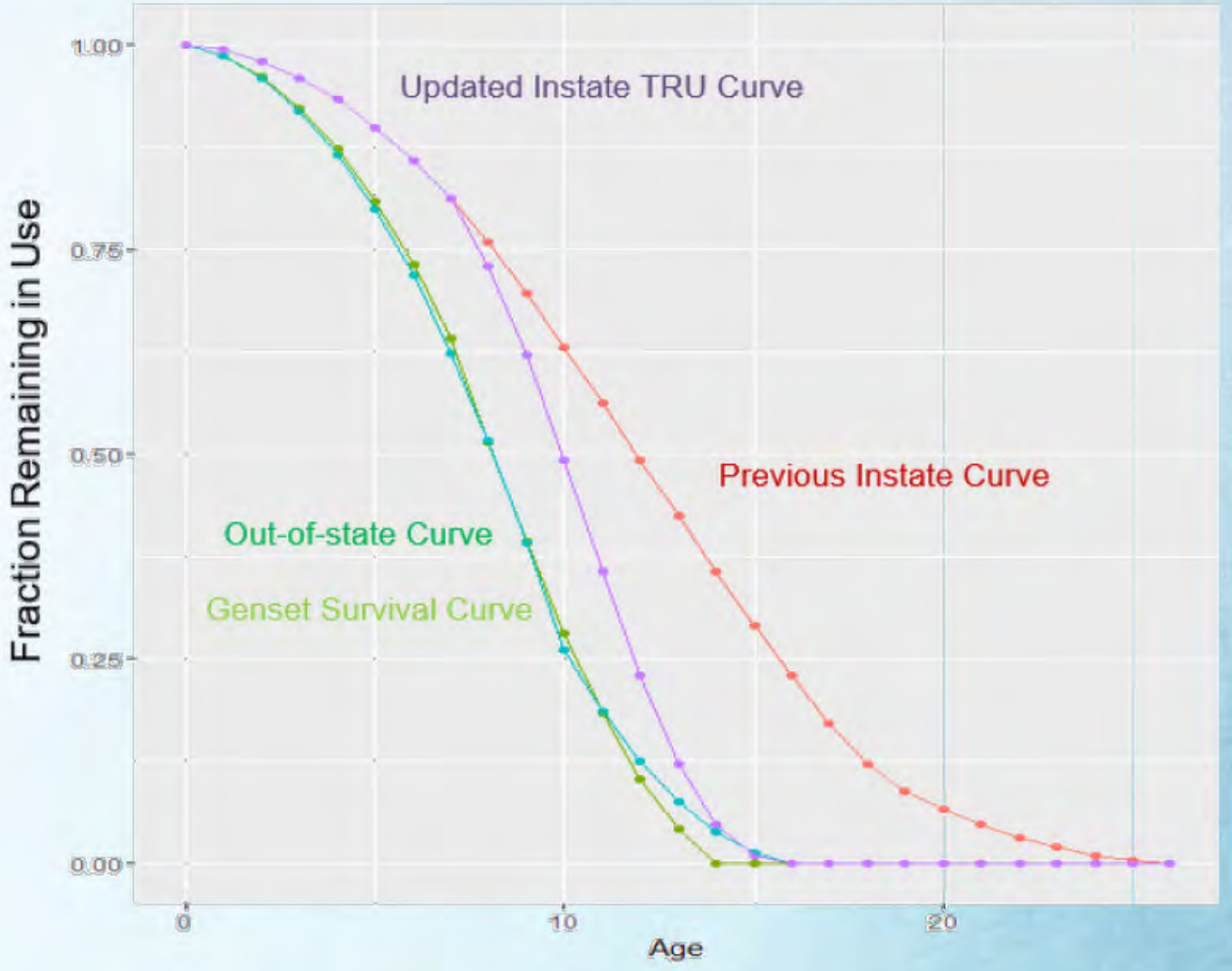
- Starting in 2012, TRUs are one of the only categories to have a unique testing cycle specific to end use

- Emissions factors based on certification results, weighted against ARBER reporting data (more engine models results in higher weight for emissions results)



# Natural Turnover

- Survival curves are based the 2011 inventory model, with one significant adjustment
- While the survival curve extended to 25 years, the existing age distribution shows no units older than 15 years
- The new survival curve reaches zero at approximately 16 years, instead of the previous 25 years



# Growth Forecast

- Updated growth based on
  - IBIS world reports for frozen goods sector and supermarket sector
  - May 2017 ACT Research on reefer sale forecasts
- Both show ~1.6% annual growth in sector
- Growth modeled after natural turnover, additional purchases modeled to achieve 1.6% overall growth in total activity

| IBIS World Report – NAICS Code | | Annual growth 2011 – 2016 |
|---|---|---|
| Manufacturing | Frozen food production in the US (NAICS 31141) | 1.6% |
| Retail | Supermarkets & Grocery Stores in the US(44511) | 1.6% |

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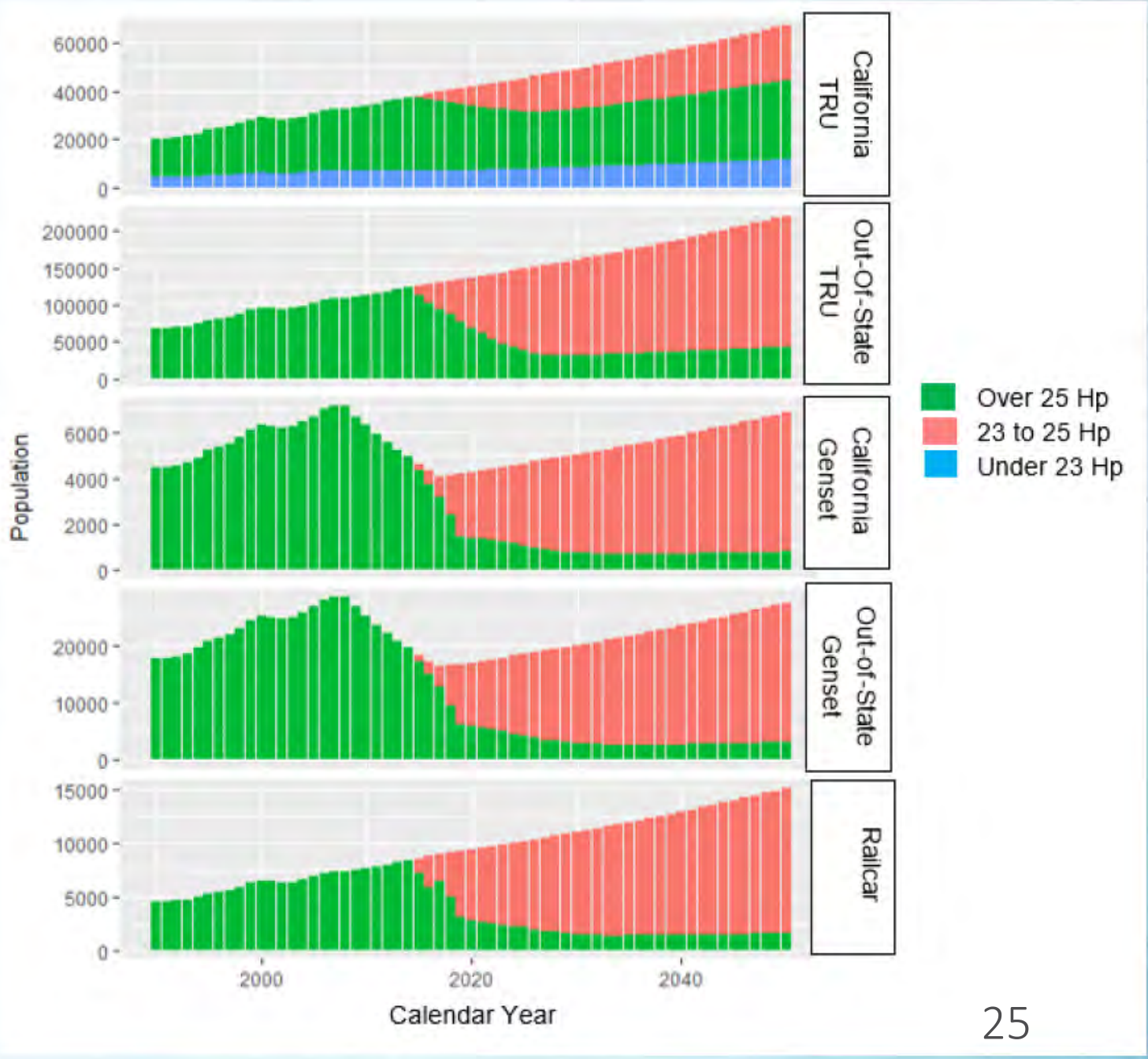
# Purchasing Trends

- Purchasing based on trends derived from ARBER database
- Instate TRUs purchase majority over 25 horsepower trailers
- Out-of-state vast majority are 23-25 horsepower
- Monitoring new sales, dealers are aware of regulatory concept and may be shifting purchasing habits

| Category | 2016 and after<br>25+ HP / 23-25 Hp |
|---|---|
| California Based TRU | 60 / 40 |
| Out-of-State TRU | 20 / 80 |
| California Based Genset | 20 / 80 |
| Out-of-state Genset | 20 / 80 |
| Rail | 20 / 80 |

# Population Results

- Populations reach equilibrium between 23 to 25 horsepower units and 25+ horsepower units in late 2020s
- Genset populations likely dropping due to change in registration strategies with owner companies
  - Additional research ongoing

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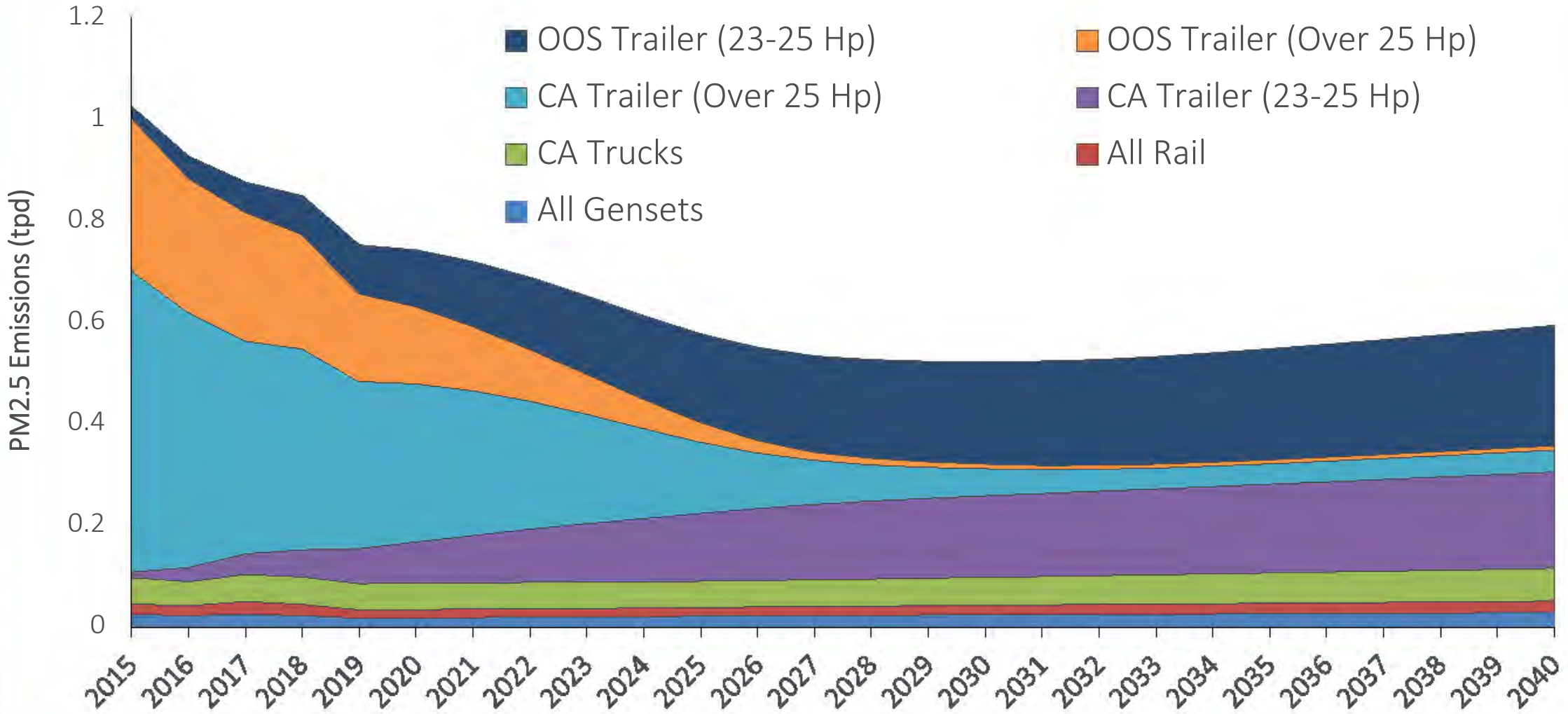
# PM Emissions Under Existing ATCM

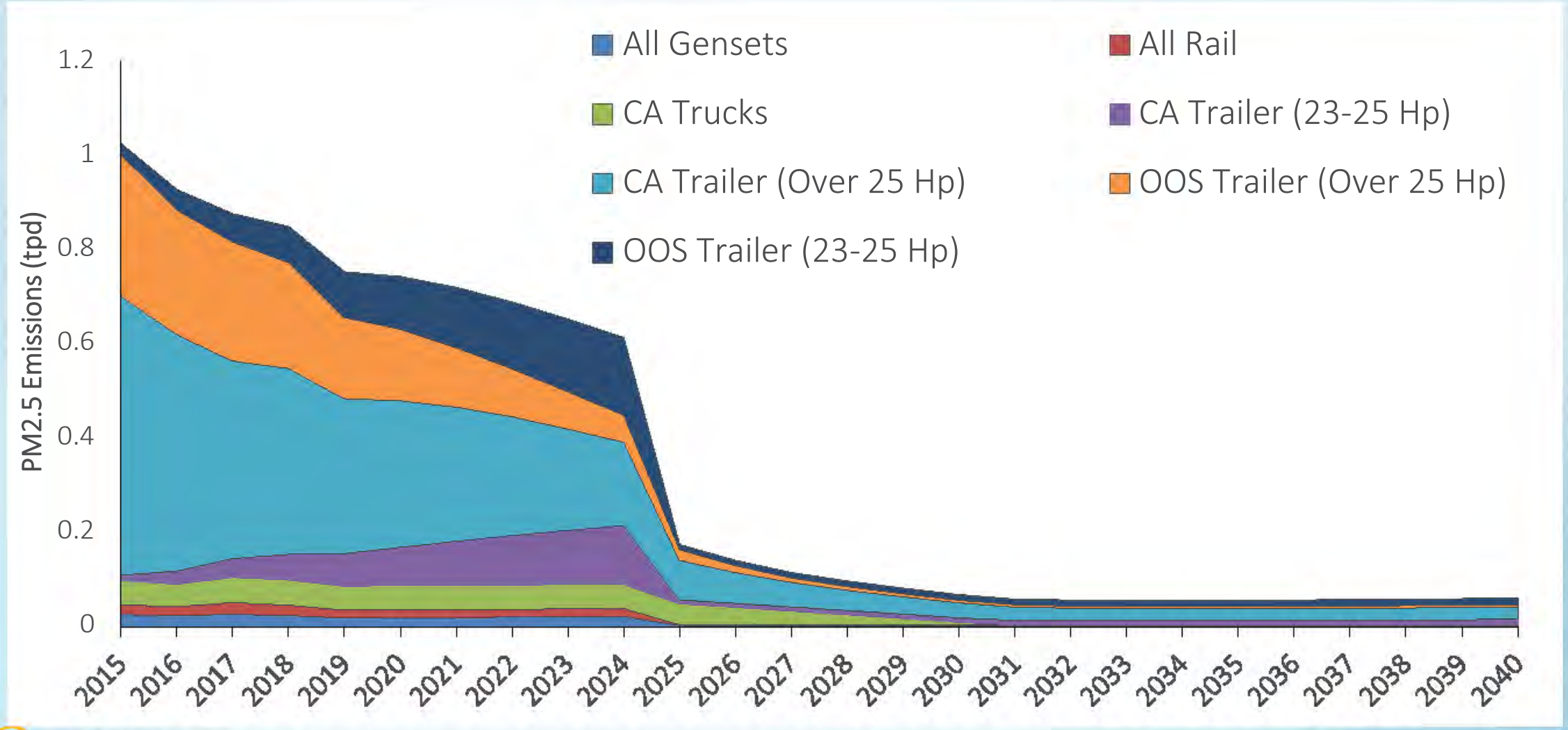


# Draft Regulatory Concept

- Starting in 2025, all truck TRU fleets phase in full zero-emission at 15 percent each year (over 7 years).
- Starting in 2025, all trailer TRUs, domestic shipping container TRUs, and TRU gensets use zero-emission operation when parked or stationary for more than 15 minutes at an applicable facility
- Starting in 2025, all diesel engines in trailer TRUs, domestic shipping container TRUs, railcar TRUs, and TRU gensets meet the U.S. EPA Tier 4 final emission standards for 25-50 hp engines

Note: There are additional reporting, infrastructure and other concepts not mentioned here. See presentation linked below for more details. https://ww3.arb.ca.gov/cc/cold-storage/documents/slidesworkshop82019.pdf

# PM Emissions Under Draft Concept



# Next Steps and Items in Progress

- Refine compliance rate data and assumptions
- Genset and railcar populations and visits
- Load factors comparison vs. TRU engine testing data

# Contact

- Questions, comments, and feedback are encouraged and welcome
- To address comments and reflect any changes, please submit comments and any supporting data by

**Thursday, November 21, 2019**

- Off-Road Emissions Inventory Team is available at:

offroadinventory@arb.ca.gov


# Discussion


# Health Analyses

# Health Impacts

## Health Risk Assessment

Near-source impacts for individual residents and off-site workers around cold storage warehouses and grocery stores.

- *Potential cancer risk*
- *Potential noncancer chronic health impacts*

## Regional Analysis

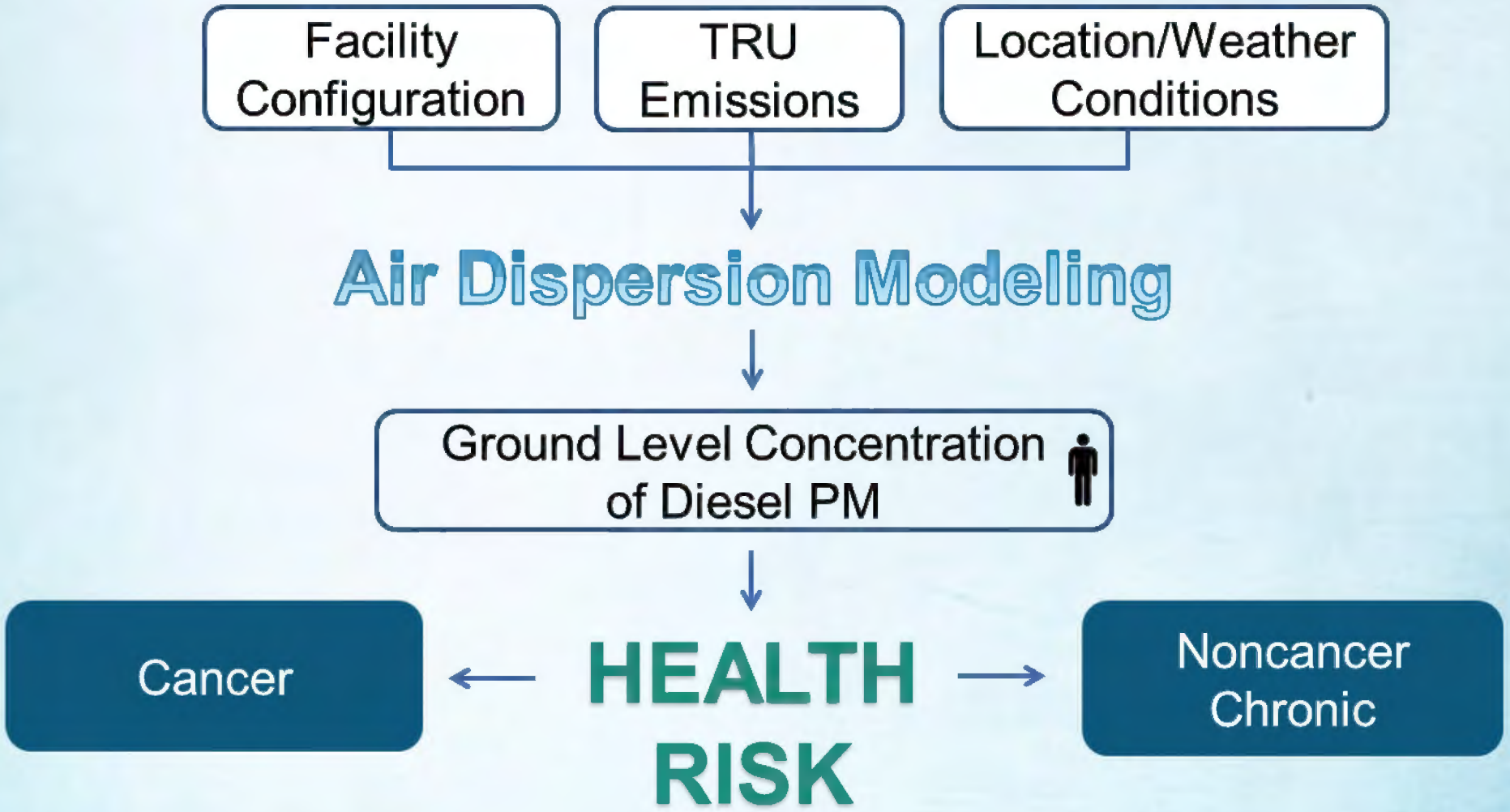
Estimate and valuate regional impacts due to emissions from TRU operations.

# Facility Types

- Grocery Stores
- Cold Storage Warehouses


# Health Risk

# Health Risk Assessment - Overview



# Methodology

Meteorological Stations:

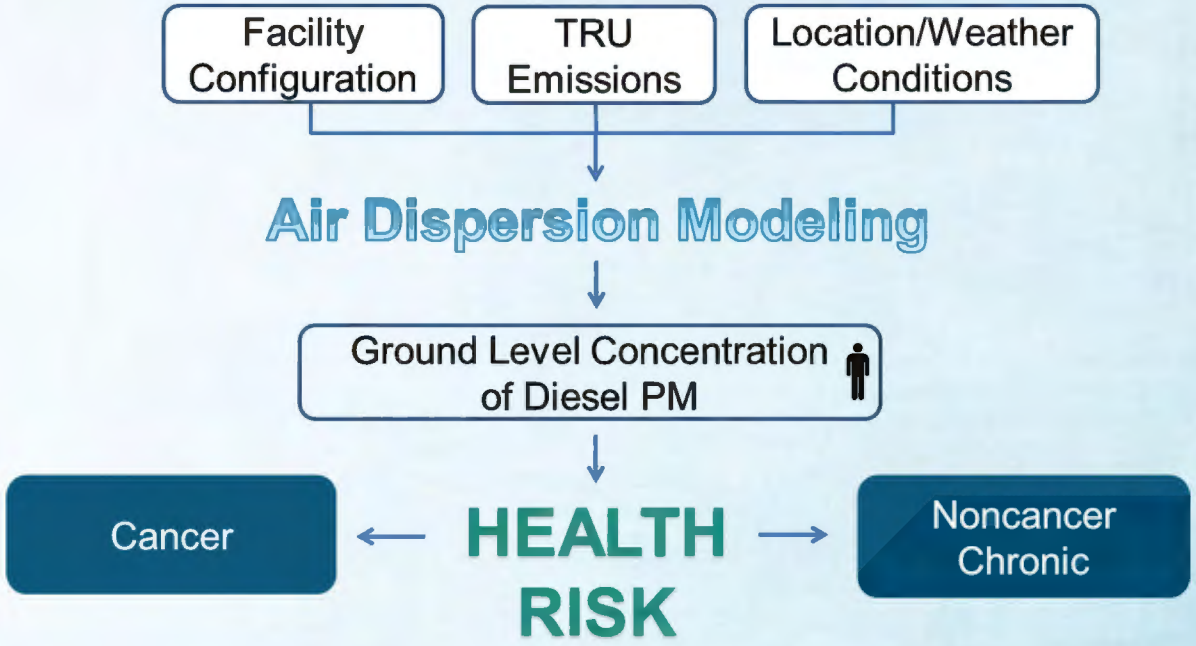
- Banning
- Fresno
- Watsonville

Air Dispersion Model:

- U.S. EPA's AERMOD

Health Risk:

- Office of Environmental Health Hazard Assessment (OEHHA) Guidance Manual
- California Air Resources Board and California Air Pollution Control Officers Association (CAPCOA) Risk Management Policy




# Grocery Store Results

# Aerial Image – Grocery Store

# Aerial Image – Grocery Store

# Model Configuration – Grocery Store

Grocery Store Concept

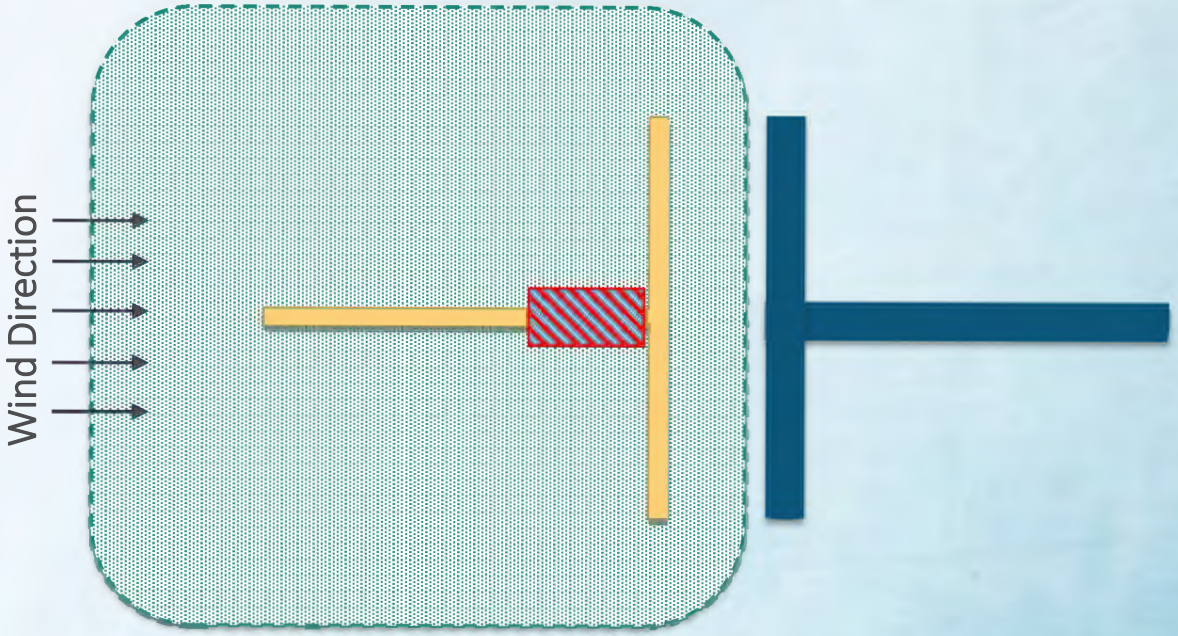
Roadway (Off-site Transiting)

Stationary TRU Operations
- Daily Unloading
- Seasonal Parking

Transiting TRU Operations

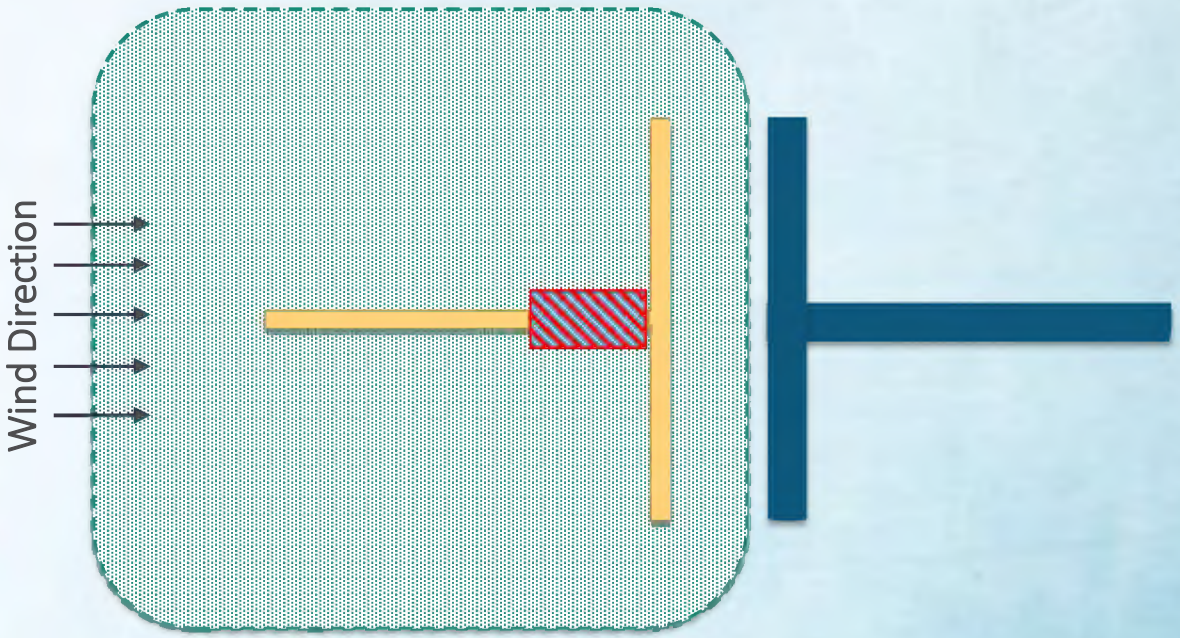
Property

Note: Not to scale.



# Model Configuration – Grocery Store

| Activity Area | Length (meters) | Width (meters) | Speed (mph) |
|---|---|---|---|
| Stationary TRU Operation | | | |
| Daily Unloading | 7.4 | 21.3 | NA |
| Seasonal Parking | 7.4 | 21.3 | NA |
| Transiting TRU Operation | | | |
| On-site Transiting | 341 | 3.3 | 5 |
| Off-site Transiting | 3,048 | 12.6 | 30 |



# Grocery Store TRU Activity

Three scenarios:

- Scenario A: 1 daily truck, 1 daily trailer, and 1 seasonal trailer
- Scenario B: 7 daily trucks, 2 daily trailers, and 1 seasonal trailer
- Scenario C: 10 daily trucks, 6 daily trailers, and 1 seasonal trailer

# Grocery Store TRU Activity

| TRU Equipment | Daily TRU Operational Hours |
|---|---|
| Daily Truck | 0.9 |
| Daily Trailer | 3.5 |
| Seasonal Trailer | 24 hours per day, 7 days per week<br>(Months of October, November, and December) |

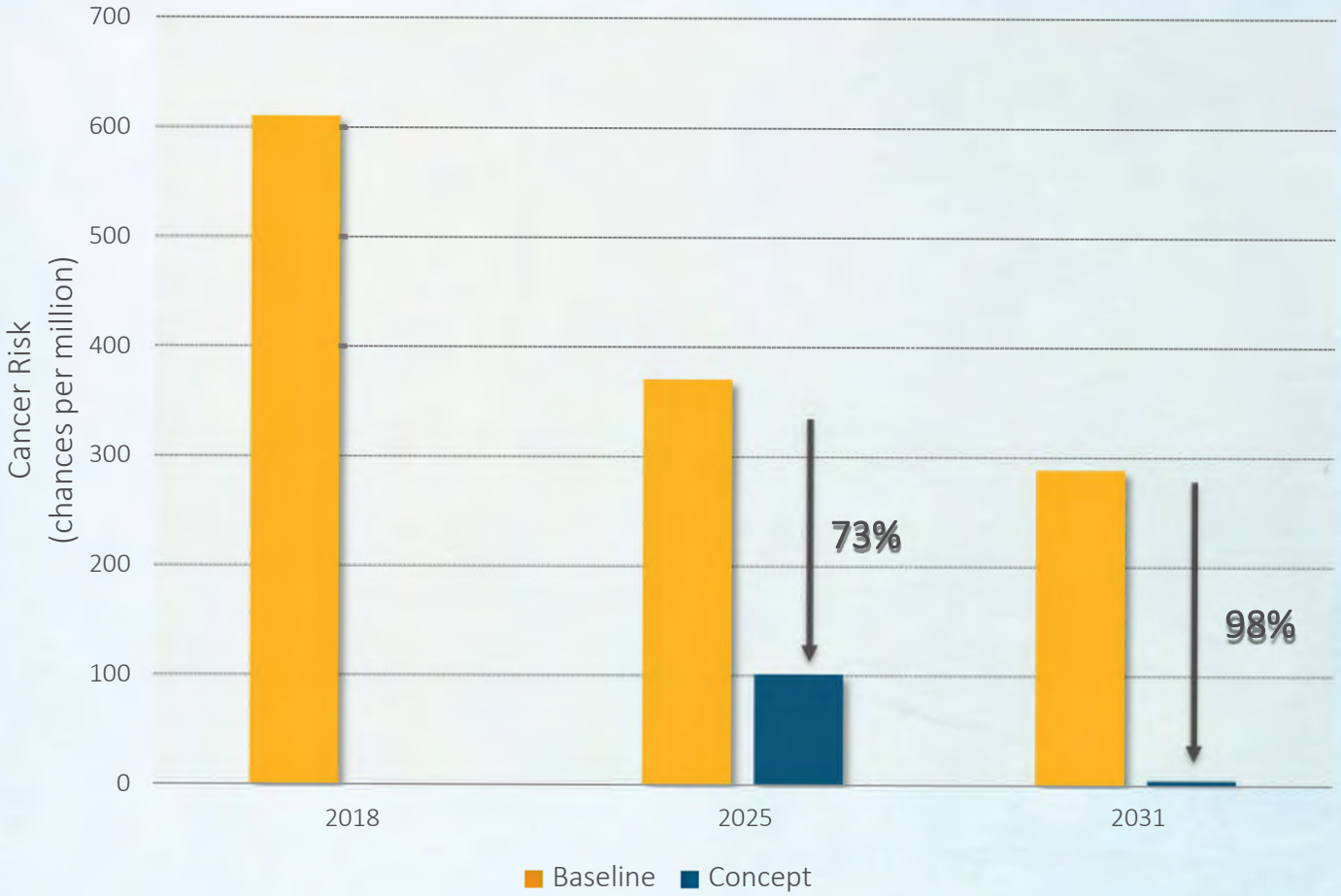
# Potential Cancer Risk – Baseline Grocery Store

| Scenario | Total Hours of TRU Engine Operation Per Week | Downwind Distance (m) from Facility | | | |
|---|---|---|---|---|---|
| | | 0 | 50 | 100 | 400 |
| 1 Daily Truck<br>1 Daily Trailer<br>1 Seasonal Trailer | 202 | 190 | 56 | 28 | 5 |
| 7 Daily Trucks<br>2 Daily Trailers<br>1 Seasonal Trailer | 274 | 320 | 97 | 49 | 9 |
| 10 Daily Trucks<br>6 Daily Trailers<br>1 Seasonal Trailer | 402 | 610 | 180 | 92 | 16 |

Notes:

1. Residential Receptor. 30-year exposure duration. FAH: = 1 for ages less than 16.
2. Represents the average risk from three meteorological data sets: Banning, Fresno, Watsonville.

# Concept Trends and Effectiveness – Grocery Store (Scenario C)

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3. Results represent maximum values at the property boundary.

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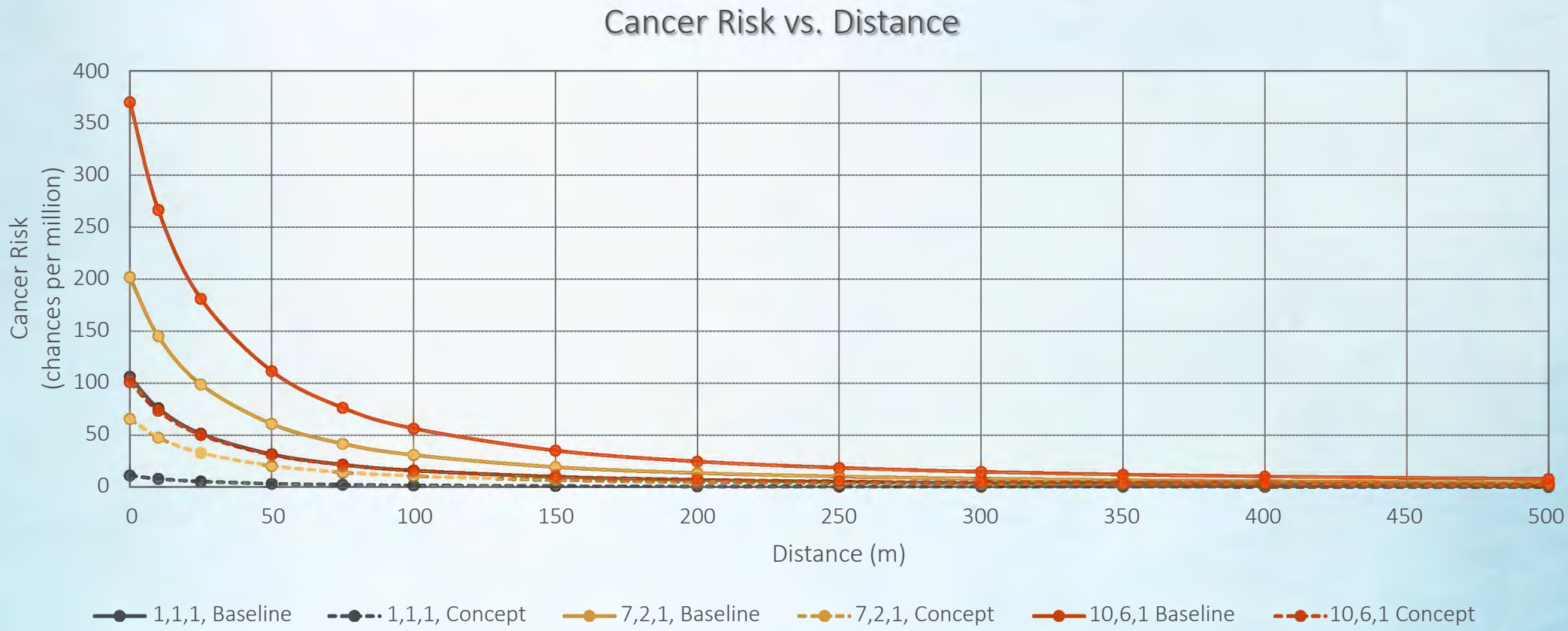
# TRU Concept: Grocery Store Comparison of Scenarios in 2025

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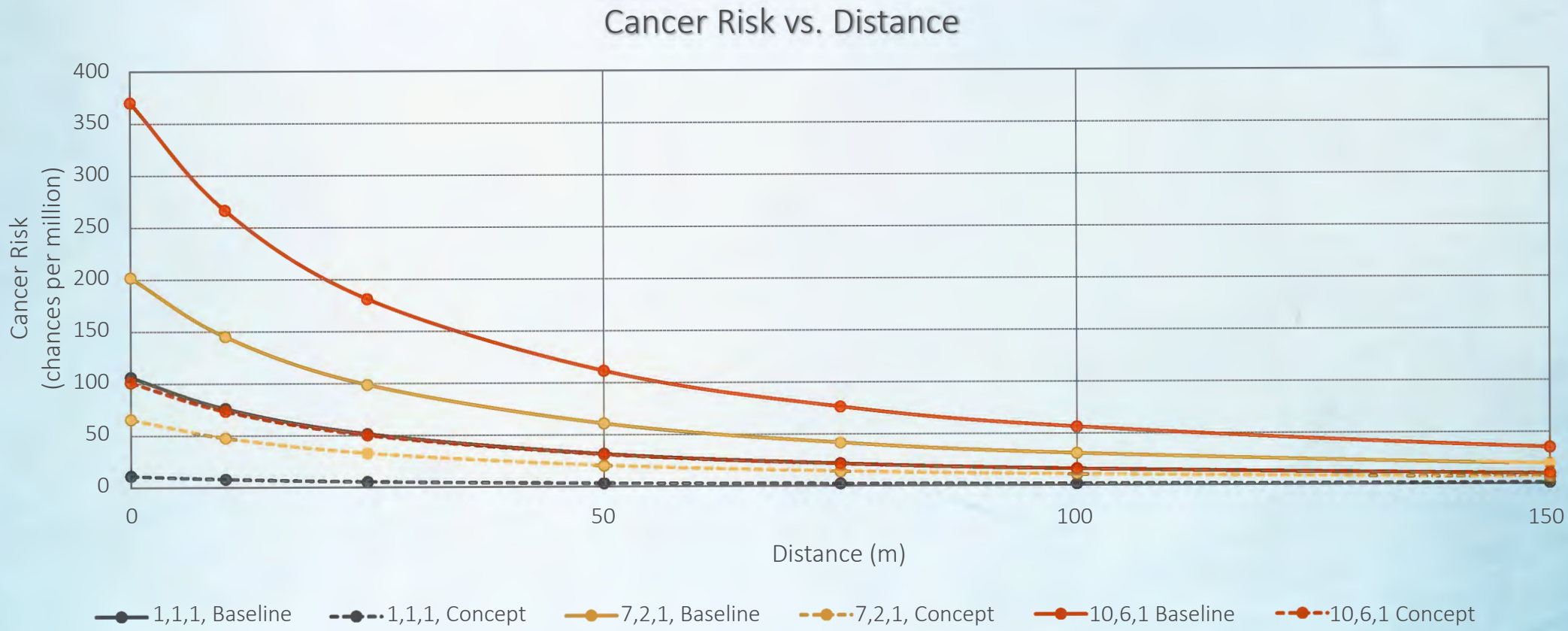


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# TRU Concept: Grocery Store Comparison of Scenarios in 2025

| Control Measure | Downwind Distance from Facility (meters) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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 | 106 | 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 Truck, 2 Daily Trailer, 1 Seasonal Trailer | | | | | | | | | | | | | | | |
| Baseline | 202 | 145 | 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 Truck, 6 Daily Trailer, 1 Seasonal Trailer | | | | | | | | | | | | | | | |
| Baseline | 370 | 267 | 181 | 111 | 76 | 56 | 35 | 25 | 18 | 15 | 12 | 10 | 8 | 6 | 5 | 5 |
| Concept | 101 | 73 | 50 | 31 | 22 | 16 | 10 | 7 | 6 | 5 | 4 | 3 | 3 | 2 | 2 | 2 |

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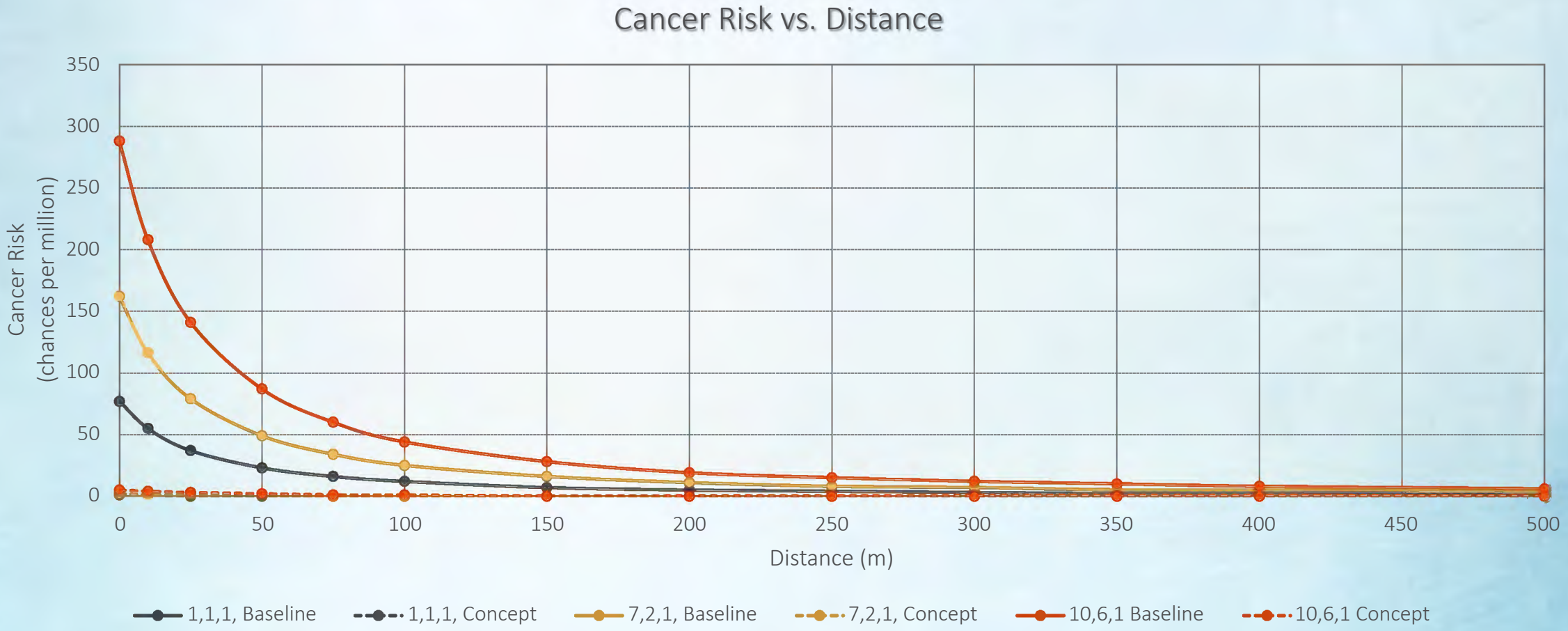
# TRU Concept: Grocery Store Comparison of Scenarios in 2031

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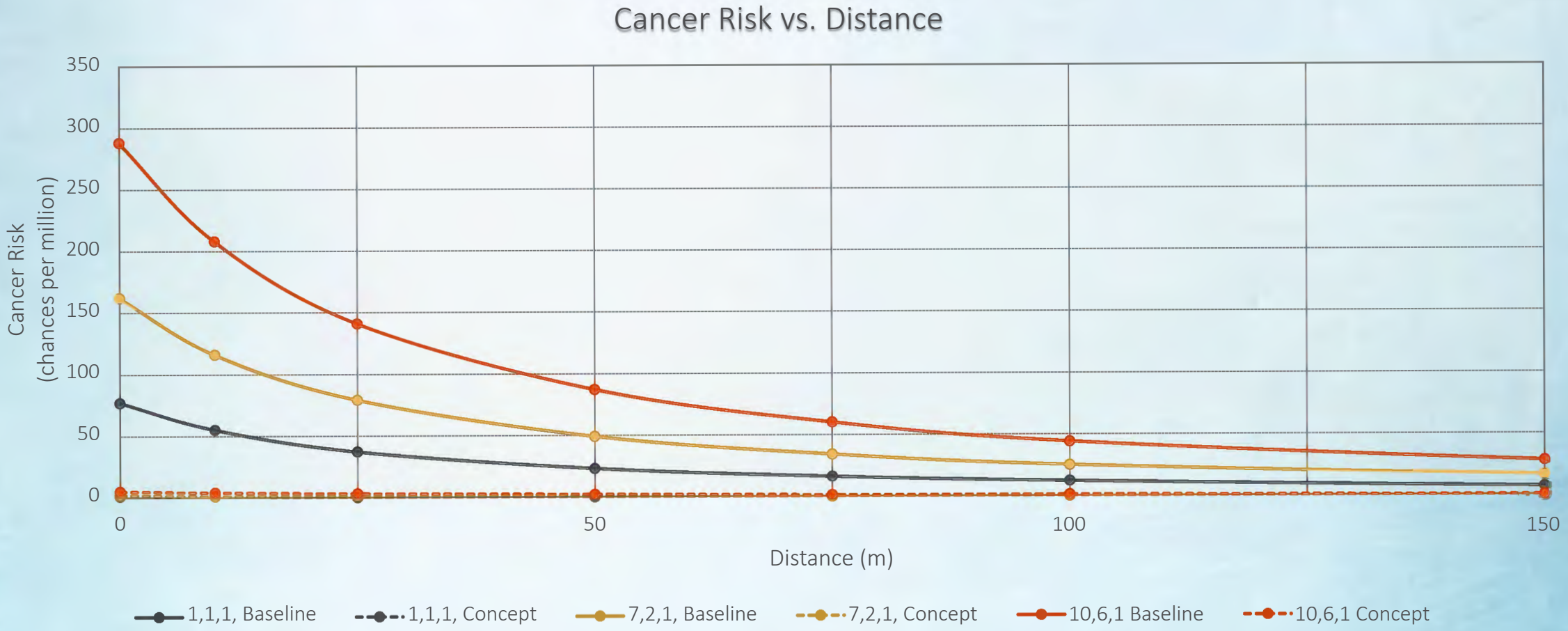


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# TRU Concept: Grocery Store Comparison of Scenarios in 2031

| Control Measure | Downwind Distance from Facility (meters) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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 | 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 Truck, 2 Daily Trailer, 1 Seasonal Trailer | | | | | | | | | | | | | | | |
| Baseline | 162 | 116 | 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 Truck, 6 Daily Trailer, 1 Seasonal Trailer | | | | | | | | | | | | | | | |
| Baseline | 288 | 208 | 141 | 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 |

Notes:

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# Cold Storage Warehouse Results

# Aerial Image – Cold Storage Warehouse

# Model Configuration – Cold Storage Warehouse

Cold Storage Warehouse Concept

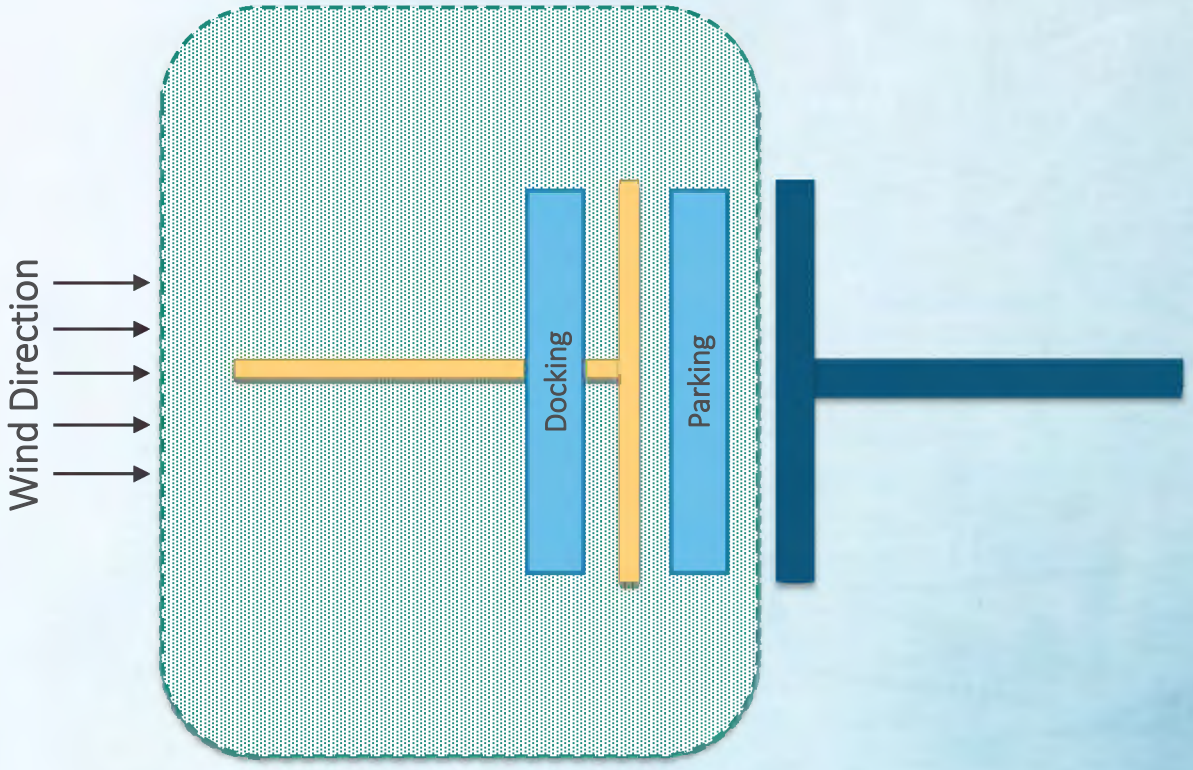
Roadway (Off-site Transiting)

Stationary TRU Operations

Transiting TRU Operations

Property

Note: Not to scale.

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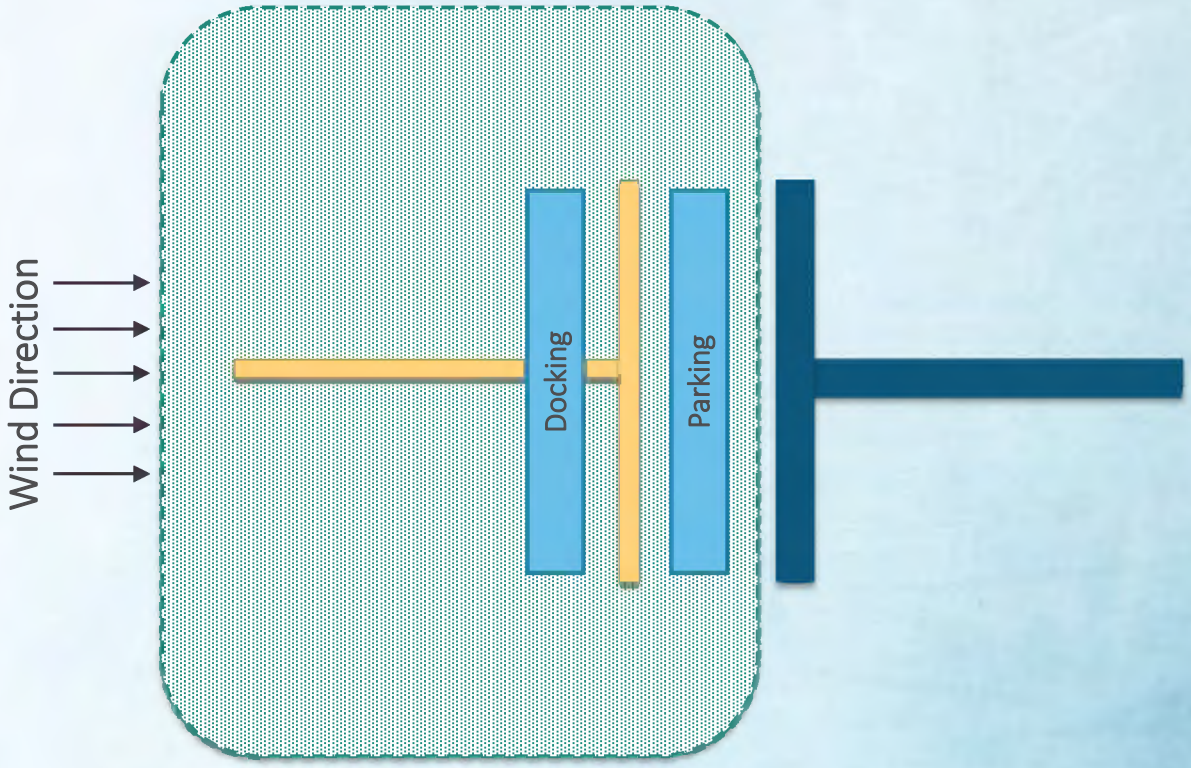
# Model Configuration – Cold Storage Warehouse

| Activity Area | Length (meters) | Width (meters) | Speed (mph) |
|---|---|---|---|
| Stationary TRU Operation | | | |
| Docking | 350 | 21.3 | NA |
| Parking | 440 | 21.3 | NA |
| Transiting Operation | | | |
| On-site Transiting | 775 | 6.6 | 5 |
| Off-site Transiting | 3,048 | 12.6 | 30 |



# Potential Cancer Risk – Baseline Cold Storage Warehouse

| Total Hours of TRU Engine Operation | Downwind Distance (m) from Facility | | | | |
|---|---|---|---|---|---|
| Per Week | 25 | 100 | 500 | 1,000 | 1,500 |
| 8,000 | 1,780 | 1,140 | 320 | 150 | 100 |
| 5,000 | 1,110 | 710 | 200 | 95 | 63 |
| 3,000 | 670 | 430 | 120 | 57 | 38 |
| 2,000 | 446 | 286 | 79 | 38 | 25 |
| 1,000 | 220 | 140 | 39 | 19 | 13 |

Notes:

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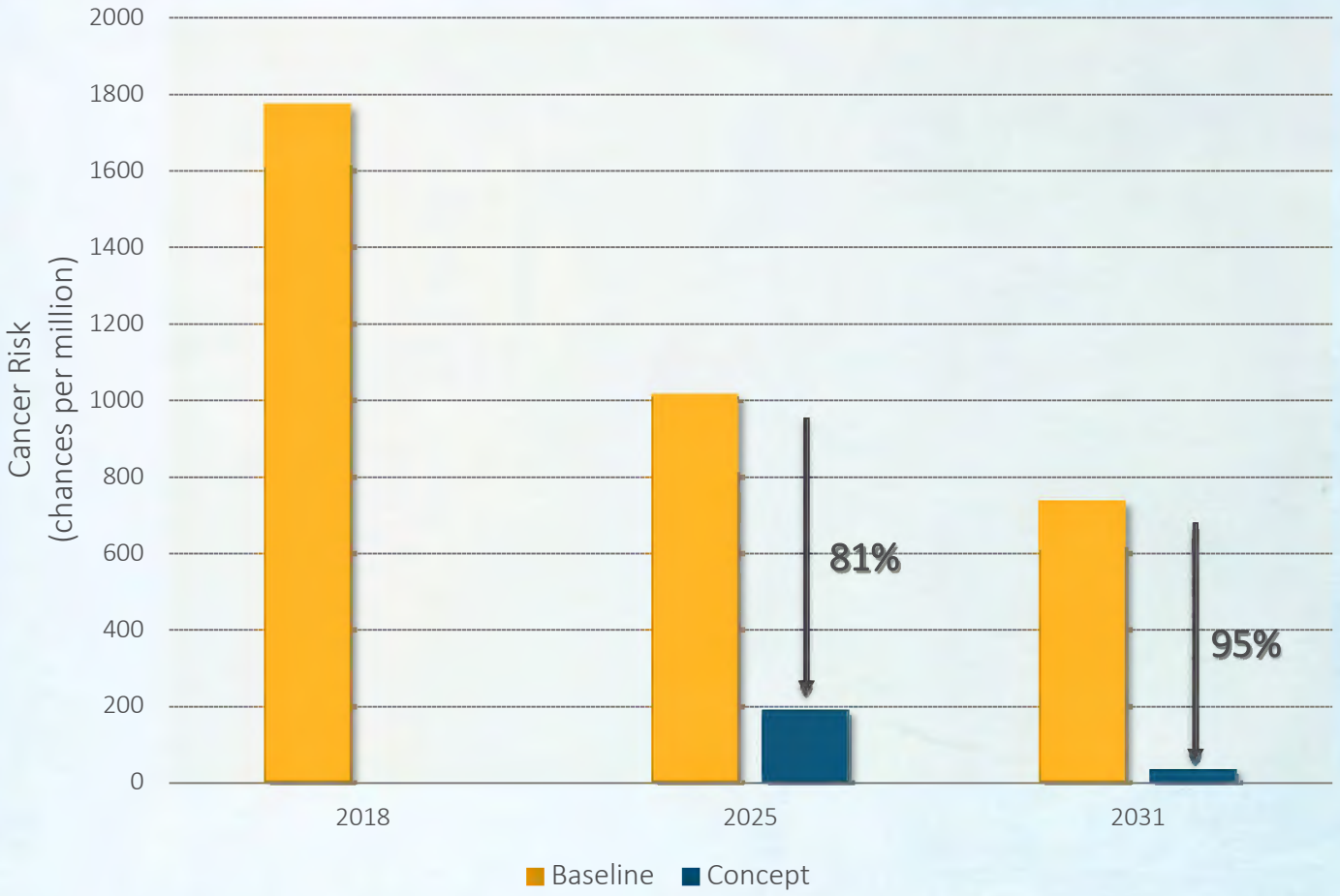
# Concept Trends and Effectiveness: Cold Storage Warehouse




Notes:

1. Residential Receptor. 30-year exposure duration. FAH: = 1 for ages less than 16.
2. Represents the average risk from three meteorological data sets: Banning, Fresno, Watsonville.
3. Results represent maximum values at 25 meters.

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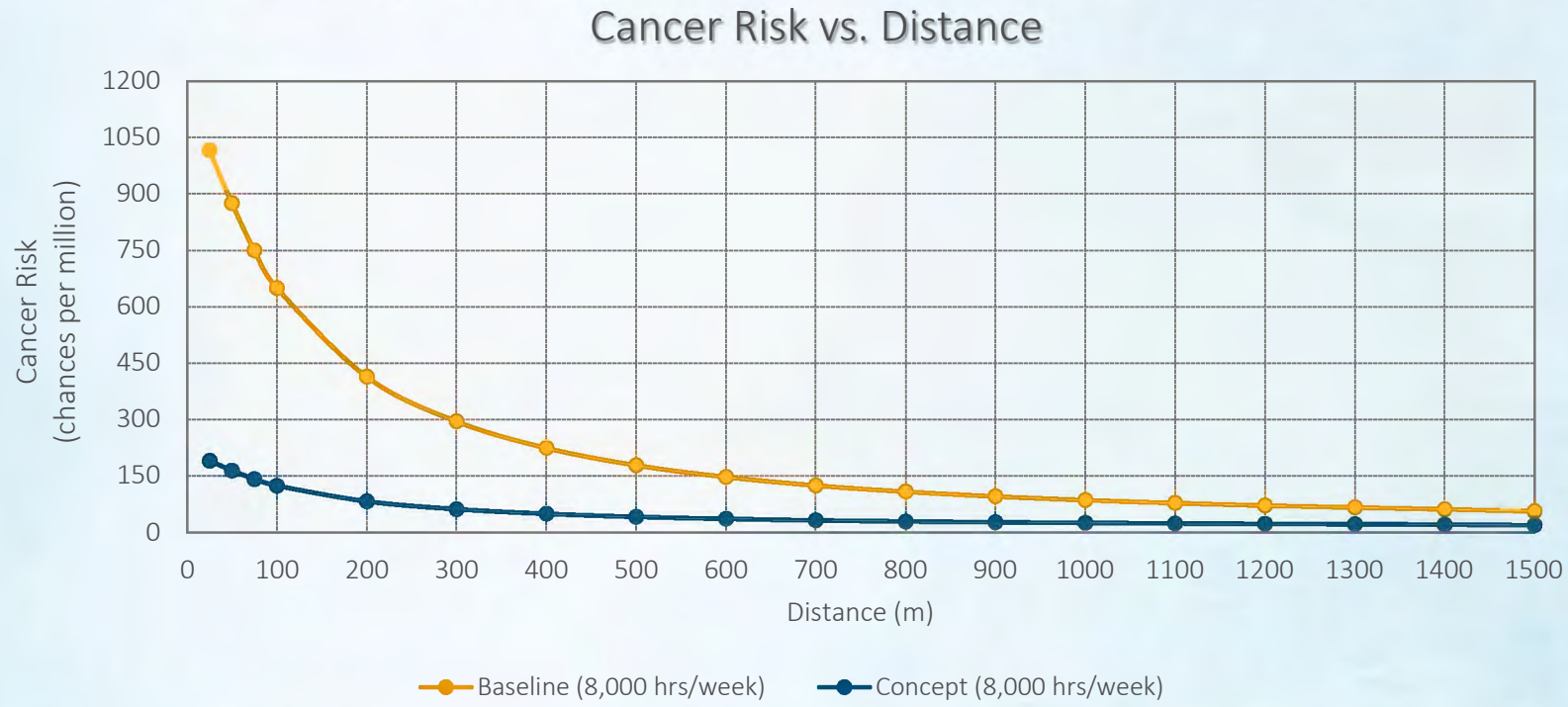
# TRU Concept: Cold Storage Warehouse Comparison of Scenarios in 2025




| Scenario (8,000 hrs/week) | Downwind Distance (m) from Facility | | | | |
|---|---|---|---|---|---|
| | 25 | 100 | 500 | 1,000 | 1,500 |
| Baseline | 1,016 | 650 | 179 | 87 | 57 |
| Concept | 191 | 125 | 42 | 26 | 20 |

Notes:

1. Residential Receptor. 30-year exposure duration. FAH: = 1 for ages less than 16.
2. Represents the average risk from three meteorological data sets: Banning, Fresno, Watsonville.

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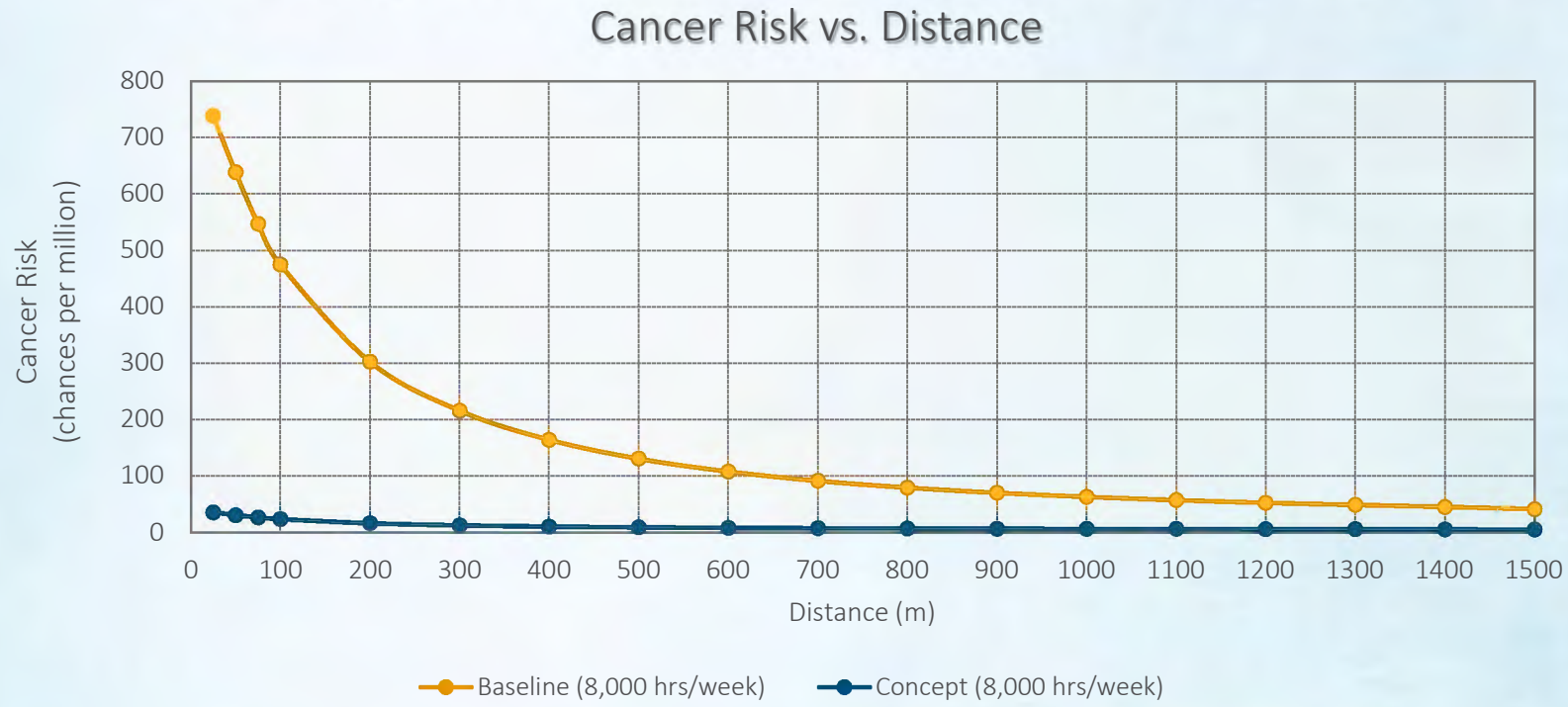
# TRU Concept: Cold Storage Warehouse Comparison of Scenarios in 2031




| Scenario (8,000 hrs/week) | Downwind Distance (m) from Facility | | | | |
|---|---|---|---|---|---|
| | 25 | 100 | 500 | 1,000 | 1,500 |
| Baseline | 742 | 475 | 131 | 63 | 42 |
| Concept | 36 | 24 | 9 | 7 | 5 |

Notes:

1. Residential Receptor. 30-year exposure duration. FAH: = 1 for ages less than 16.
2. Represents the average risk from three meteorological data sets: Banning, Fresno, Watsonville.

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# Cold Storage Warehouse Cluster

# Aerial Image – CSW Cluster


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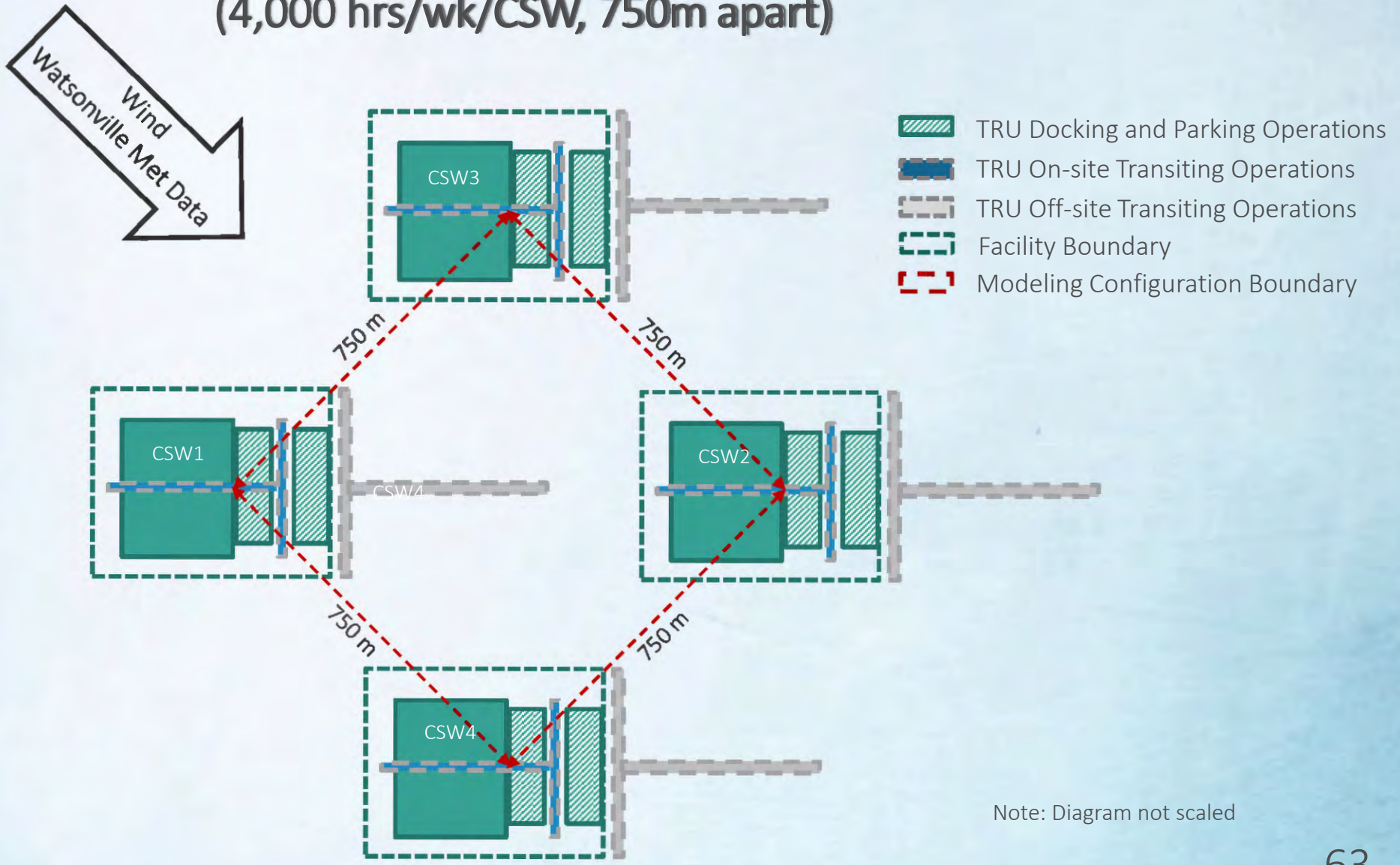
# Model Configuration - CSW Cluster

## (4,000 hrs/wk/CSW, 750m apart)




Note: Diagram not scaled

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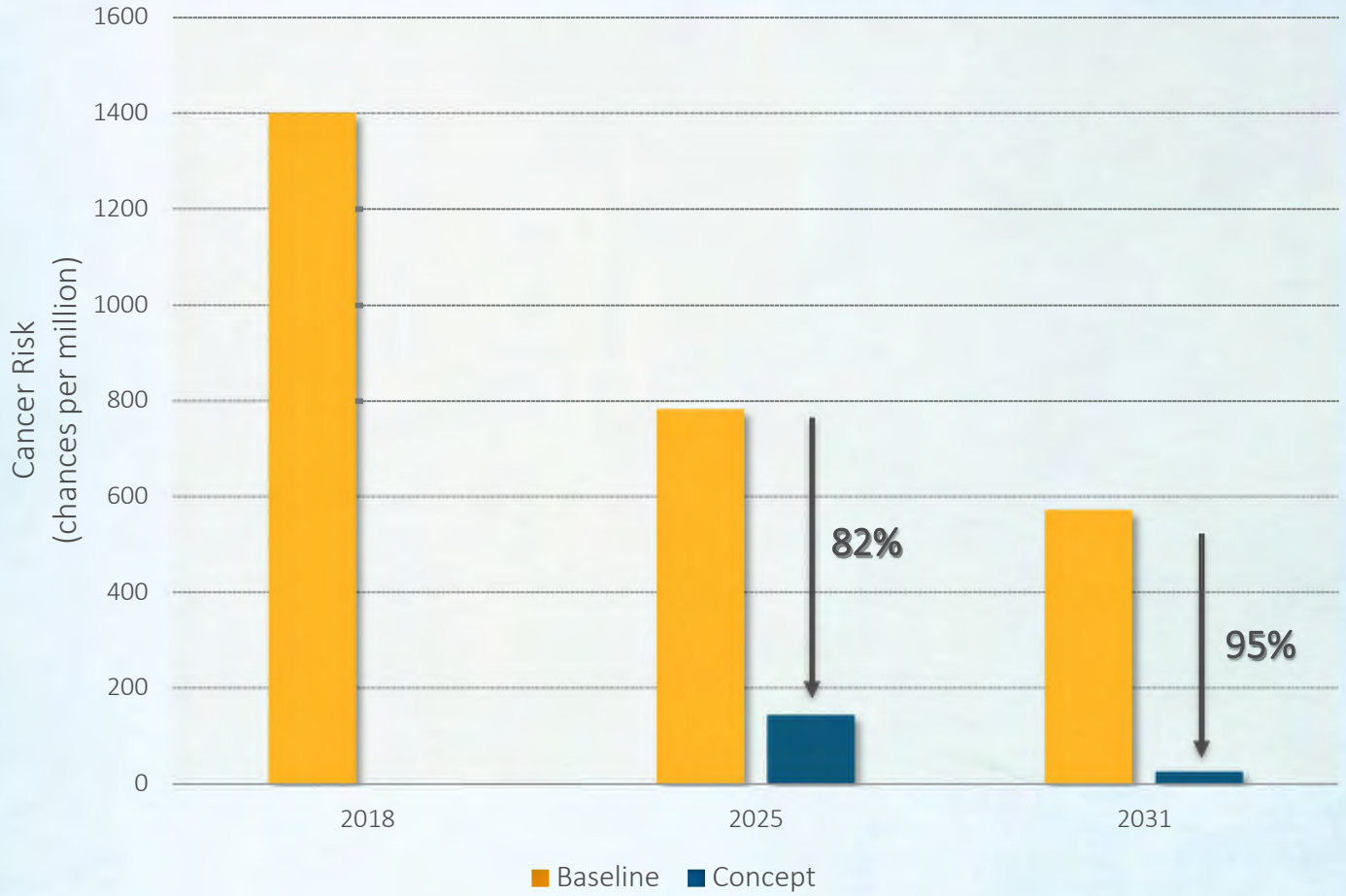
# Concept Trends and Effectiveness: CSW Cluster




Notes:

1. Residential Receptor. 30-year exposure duration. FAH: = 1 for ages less than 16.
2. Represents risk from the Watsonville meteorological data set.
3. Results represent 16,000 hours per week of TRU engine runtime.

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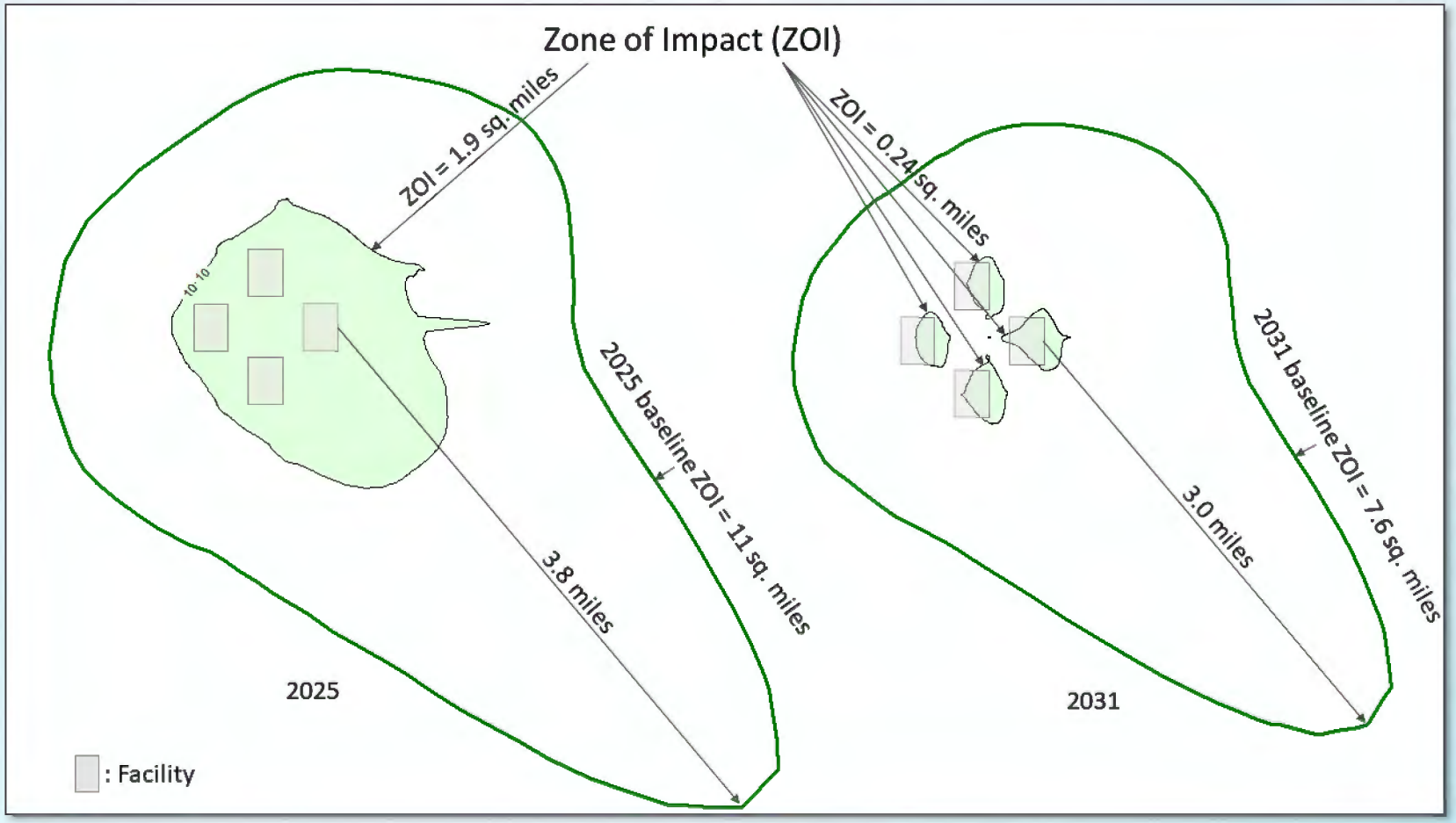
# TRU Concept - Comparison of Zone of Impact

## (Area of 10 chances per million)




Notes:

1. Residential Receptor. 70-year exposure duration. FAH: = 1 for ages less than 16.
2. Represents risk from the Watsonville meteorological data set.
3. Results represent 16,000 hours per week of TRU engine runtime.

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# Reduction of Zone of Impact
## (Area of 10 chances per million)

| Year / Scenario | 2018 | 2025 | 2031 |
|---|---|---|---|
| Baseline | 21.5 sq. miles | 11.0 sq. miles | 7.6 sq. miles |
| Concept | - | 1.9 sq. miles | 0.24 sq. miles |
| Reduction (%) from Baseline | - | 83% | 97% |


# Regional Analysis

# Regional Analysis Methodology

- Incidence-per-Ton (IPT)
  - Estimates benefits from reductions in primary and secondary $PM_{2.5}$
  - Changes in emissions are approximately proportional to changes in health outcomes
  - Estimate health impacts for baseline scenario, divide by emissions to get IPT factors
  - For more detail please visit: https://ww2.arb.ca.gov/resources/documents/carbs-methodology-estimating-health-effects-air-pollution

# Regional Analysis - Reduction in Health Outcomes

| Adverse Health Outcomes Avoided | |
|---|---|
| Premature Deaths | 409 (320 - 500) |
| Hospital Admissions | 128 (16 - 237) |
| Emergency Room Visits | 200 (127 - 274) |

- Statewide valuation from avoided adverse health outcomes: $3,993,405,956

# Public Comment Period

- Closes November 21, 2019
- Submit Health Analyses Comments at: https://www.arb.ca.gov/lispub/comm2/bcsubform.php?comm_period=1&listname=truhealthanalyses-ws&utm_medium=email&utm_source=govdelivery
- Submit Emissions Inventory Comments at: https://www.arb.ca.gov/lispub/comm2/bcsubform.php?comm_period=1&listname=2019truei-ws&utm_medium=email&utm_source=govdelivery

# Contact Information

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# Open Discussion