Appendix 3.3-2

Photochemical Modeling Data

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ANALYSIS OF POTENTIAL HEALTH EFFECTS OF CRITERIA AIR POLLUTANT EMISSION IMPACTS

MISSION POINT PROJECT
SANTA CLARA, CALIFORNIA

CONTENTS

ATTACHMENTS

1. INTRODUCTION

This report presents an estimate of the potential health effects of the emissions of criteria pollutants that may result from the construction and operation of the Mission Point Project, a mixed-use development in Santa Clara, California (referred to hereafter as "the Proposed Project" or "Project"). As discussed in more detail below, the Project's maximum contribution to adverse health incidences from the emission of criteria air pollutants is de minimis.

1.1 Friant Ranch Decision

As background for this evaluation, Environmental Impact Reports (EIRs) prepared pursuant to the California Environmental Quality Act (CEQA) have long evaluated project-related health effects of toxic air contaminants, such as diesel particulate matter (PM), through quantitative and/or qualitative means relative to air district-issued thresholds of significance. However, EIRs historically have not evaluated the specific health effects of project-related increases in criteria pollutants,[1] other than to note and summarize scientific literature regarding the general effect of those pollutants on health. Instead, in accordance with air district-issued thresholds of significance and industry standard practice, CEQA analysis historically focused on estimating project-related mass emissions totals for criteria pollutants and, in certain cases, conducting dispersion modeling to assess impacts on local ambient air quality concentrations.

The California Supreme Court, on December 24, 2018, issued its ruling in *Sierra Club v. County of Fresno* ([2018] 6 Cal.5th 502), referred to as the Friant Ranch Decision. The EIR at issue in that case concluded that criteria air pollutants would exceed the district-issued thresholds of significance and impacts would be significant and unavoidable. The Court found the EIR's conclusion to be insufficient because the air quality analysis did not adequately explain the nature and magnitude of the health effects from long-term emissions of criteria air pollutants and ozone precursors that exceeded district thresholds.

Significance thresholds for health risks from human exposure to criteria air pollutants have not been published by the Bay Area Air Quality Management District (BAAQMD), the California Air Resources Board (CARB), or other local agencies. In Chapter 5 of the recently updated BAAQMD CEQA Guidelines,[2] a general framing is offered for analyses to demonstrate compliance with the Friant Ranch Decision. The guidelines recommend a project introduce health impacts from criteria air pollutants, describe the mass emissions thresholds used to determine significance, describe ozone and secondary PM formation, and if scientifically feasible, recommends estimating potential negative health impacts from criteria air pollutant thresholds. The guidelines do not define significance thresholds or a means of making a significance determination for health effects related to criteria air pollutants and precursors.

This report presents an analysis that correlates project-related mass emissions totals for criteria pollutants to estimated health-based consequences. More specifically, to estimate the health effects of the increases of criteria pollutants for the proposed Project the

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[1] Criteria pollutants are those pollutants with an air pollution standard or pollutants which are precursors to those with a standard. Pollutants with an air pollution standard include nitrogen dioxide, sulfur dioxide, ozone, carbon monoxide, particulate matter smaller than 2.5 microns in diameter and 10 microns in diameter ($PM_{2.5}$ and PM_{10}), and ozone. Precursor pollutants to criteria pollutants include oxides of nitrogen (NOx), oxides of sulfur (SOx), carbon monoxide (CO), and volatile organic compounds (VOCs).

[2] https://www.baaqmd.gov/plans-and-climate/california-environmental-quality-act-ceqa/updated-ceqa-guidelines

Comprehensive Air Quality Model with extensions (CAMx)—a photochemical grid model (PGM)— was used to estimate the increases in concentrations of ozone and $PM_{2.5}$ in the region as a result of the emissions of criteria and precursor pollutants from the Project. A U.S. Environmental Protection Agency (USEPA)-authored program, the Benefits Mapping and Analysis Program Community Edition (BenMAP-CE, herein referred to as "BenMAP"),[3] was then applied to estimate the resulting health effects from the small increases in concentration. Only the health effects of ozone and $PM_{2.5}$ are estimated, as those are the pollutants that USEPA uses in BenMAP to estimate the health effects of emissions of nitrogen oxides (NOx), volatile organic compounds (VOCs), carbon monoxide (CO), sulfur dioxide (SO_2), and particulate matter smaller than 2.5 microns in diameter ($PM_{2.5}$). Ozone and $PM_{2.5}$ have the most critical health effects and thus are the emissions evaluated to determine the Project's health effects.

1.2 Additional Evaluation

This analysis estimates the health effects of criteria pollutants and their precursors, specifically those that are evaluated by the USEPA in rulemaking setting the national ambient air quality standards: NOx, VOC,[4] CO, ozone, SO_2, and $PM_{2.5}$. Consistent with USEPA's assessment of health effects of PM, the health effects evaluation focuses on $PM_{2.5}$ and not PM_{10} because $PM_{2.5}$ has a much larger body of evidence that this size fraction is associated with health effects due to the sources, composition, chemical properties and lifetime in the atmosphere (USEPA, 2009). $PM_{2.5}$ is capable of penetrating deeper into the lungs because of its size compared to larger particles and this is believed to contribute to greater health effects. Consistent with USEPA health effects evaluations, the health effect functions in BenMAP for PM use fine particulate ($PM_{2.5}$) as the causal PM agent. VOCs are not a criteria air pollutant but, together with NOx and in the presence of sunlight, they form ozone and contribute to the formation of secondary $PM_{2.5}$ and thus are analyzed here. As a conservative measure, SO_2 and CO are evaluated due to their small contribution to the formation of secondary $PM_{2.5}$ and ozone. The health effects from ozone and $PM_{2.5}$ are examined for this Project because the USEPA has determined that these criteria pollutants would have the greatest effect on human health. The emissions of other criteria pollutants and precursors, VOC, NOx, CO and SO_2, are analyzed in their contribution in the formation of ozone and secondary $PM_{2.5}$.

The evaluation presented herein serves to describe the potential health effects of the criteria pollutant emissions associated with the Project.

[3] https://www.epa.gov/benmap/benmap-ce-manual-and-appendices.

[4] VOCs, as defined by EPA, are a subset of "total organic gases." Total organic gases are a class of gases containing carbon with varied degrees of volatility. EPA excludes certain organic gases with negligible photochemical reactivity from the regulatory definition of volatile organic compounds (VOC). The California Air Resources Board ("CARB") uses a similar term, reactive organic gases (ROG). ROG means total organic gases minus ARB's "exempt" compounds (e.g., methane, ethane, CFCs, etc.). ROG is similar, but not identical, to USEPA's term "VOC" because different gases are excluded. However, the terms are substantially similar. For the purposes of this analysis, ROG emissions are quantified consistent with BAAQMD thresholds and statewide emission tools (e.g. EMFAC), and modeled as VOCs.

2. TECHNICAL APPROACH

The USEPA's air quality modeling guidelines (Appendix W[5]) and ozone and $PM_{2.5}$ modeling guidance[6] recommend using a PGM to estimate ozone and secondary $PM_{2.5}$ concentrations. The USEPA's modeling guidance does not recommend specific PGMs but provides procedures for determining an appropriate PGM on a case-by-case basis. Both the modeling guidelines and guidance note that the CAMx[7] and the Community Multiscale Air Quality (CMAQ[8]) PGMs have been used extensively in the past and would be acceptable PGMs. As such, the USEPA has prepared a memorandum[9] documenting the suitability for using CAMx and CMAQ for ozone and secondary $PM_{2.5}$ modeling of single-sources or group of sources.

The first step in the process is to run the PGM with appropriate information to assess the increases in ambient air concentrations that the Project emissions may cause. PGMs require a database of information, including the spatial allocation of emissions, in the area to be modeled. This includes both base (background/existing) emissions and Project emissions. The latest publicly available PGM for Northern California was originally developed by BAAQMD in support of the 2000 Central California Ozone Study (CCOS),[10] and was adapted for this analysis.[11,12] This modeling dataset represents the most recent data available for this type of modeling in California. The modeling dataset used for this study has a base emissions and meteorological year representative of 2012 and a corresponding future year emissions projection for 2035. This PGM database was tailored for the region using California-specific input tools (e.g., the Emission FACtors (EMFAC)[13] mobile source emissions model) and uses a high-resolution 4- kilometer (km) horizontal grid to better simulate meteorology and air quality in the complex terrain and coastal environment of California.

Modeled Project emissions include NO_X, SO_2, CO, respirable (PM_{10}) and fine ($PM_{2.5}$) primary particulate matter (collectively PM), and VOCs. As discussed above, NO_X and VOC are precursors to ozone and, along with SO_2, are also precursors to secondarily formed $PM_{2.5}$. CO also plays a smaller role in the formation of ozone and is thus conservatively evaluated here.

To estimate the potential outcome of the proposed Project's emissions on ambient air concentrations, the Project's maximum daily emissions processed over an annual timescale were added to the CAMx 4-km annual PGM modeling database.[14] Operational emissions from

5 https://www3.epa.gov/ttn/scram/appendix_w/2016/AppendixW_2017.pdf.

6 https://www3.epa.gov/ttn/scram/guidance/guide/O3-PM-RH-Modeling_Guidance-2018.pdf.

7 http://www.camx.com/.

8 https://www.epa.gov/cmaq.

9 https://www3.epa.gov/ttn/scram/guidance/clarification/20170804-Photochemical_Grid_Model_Clarification_Memo.pdf.

10 http://www.baaqmd.gov/about-air-quality/research-and-data/research-and-modeling.

11 The modeling platform developed by BAAQMD in support of AB617 was not used because it lacks future year emissions. In particular, it does not provide emissions for 2035 which is the focus of this study. The AB617 modeling platform only has emissions for the year 2016.

12 The USEPA has a 2016 modeling platform, but it has a much coarser horizontal resolution (12 km), which is not as ideal for the modeling of single source projects, and thus was not utilized here.

13 https://www.arb.ca.gov/emfac/.

14 Consistent with the modeling platform developed by BAAQMD and adapted for use in this analysis, BAAQMD performed WRF meteorological modeling for the CCOS 4-km domain and 2012 calendar year that has been processed by WRFCAMx to generate CAMx 2012 4-km meteorological inputs for the CCOS domain. The CMAQ 2012 emissions have been converted to the format used by CAMx using the CMAQ2CAMx processor. Future year emissions projections for 2035 are utilized for more representative conditions at the Project build-out year.

the Project are consistent with the analysis prepared for the Project's Draft Environmental Impact Report (DEIR) in Section 3.3, Air Quality.[15] Operational emissions for the first year of full buildout (2034) were modeled.

For use in PGMs, each Project emissions source must be spatially distributed across the modeling grid cells so that they can be incorporated into the gridded emission inventory. The incremental emission inventory for the Project at full buildout was used in the analysis. On a maximum daily basis, the operational emissions utilized in this analysis are higher than the maximum mitigated construction emissions and thus represent conservative impacts that would exceed potential impacts during any construction year. Emissions evaluated include architectural coatings, VOCs in consumer products, natural gas combustion, emergency generators, and emissions associated with motor vehicle use. The emissions from architectural coatings, consumer products, natural gas combustion and emergency generators are located onsite, and were therefore allocated to the grid cell representing the Project site. The mobile source category was spatially distributed in both the Project site's grid cells, as well as offsite grid cells along nearby travel routes. Annual emission estimates from the Project were spatially gridded, temporally allocated, and chemically speciated to be used for photochemical grid modelling using the Sparse Matrix Operator Kerner Emissions (SMOKE) modelling system supported by the USEPA. The emissions inventory, spatial allocation, and SMOKE inputs and outputs are shown in **Attachment A.**

As discussed above, the Northern California 2000 CCOS modeling database was used for this Project. The Northern California 4-km PGM modeling database is based on a 2012 base meteorological year. The 2035 future year projection was used for this analysis, as that is the nearest future year to the Project build out year (2034) with base emissions available as of the date of this report. The Project's emissions were isolated by the source apportionment tools in CAMx to obtain the incremental ozone and $PM_{2.5}$ concentration changes due to the Project's emissions. More details and inputs for the PGM modeling are included in **Attachment B.**

Following completion of the CAMx source apportionment modeling, The USEPA's BenMAP program (USEPA 2022a, USEPA 2022b) was used to estimate the potential health effects of the Project's contribution to ozone and $PM_{2.5}$ concentrations. BenMAP uses the concentration estimates produced by CAMx, along with population and health effect concentration-response (C-R) functions, to estimate various health effects of the concentration increases. BenMAP has a wide history of applications by the USEPA and others, including for local-scale analysis[16] as needed for assessing the health effects of a project's emissions. The analysis used the BenMAP health effects C-R functions that have been used in national rulemaking, such as the health effects assessments for $PM_{2.5}$ National Ambient Air Quality Standard (NAAQS) (USEPA 2010, USEPA 2022b). The health endpoints used for $PM_{2.5}$ include mortality (all causes), hospital admissions (respiratory, asthma, cardiovascular), emergency room visits (asthma, cardiovascular), and acute myocardial infarction (non-fatal). For ozone, the endpoints are mortality (respiratory), emergency room visits (respiratory), and hospital admissions (respiratory). Details on the BenMAP inputs and outputs and definitions for the health effects are shown in **Attachment C.**

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[15] To the extent that the Air Quality analysis used conservative inputs to estimate Project-related criteria pollutants and precursors, the analysis provided herein also is conservatively influenced by those inputs.

[16] https://www.epa.gov/benmap/benmap-ce-applications-articles-and-presentations#local.

3. RESULTS

This section presents the results of the health effects analysis for the increases in $PM_{2.5}$ and ozone resulting from primary and precursor emissions for these constituents. As previously discussed, BAAQMD and other agencies do not have published significance thresholds to evaluate health risks from human exposure to criteria air pollutants. The results presented here describe the potential health effects of the criteria pollutant emissions associated with the Project, and the results themselves do not constitute a new significance determination.

There are a number of conservative assumptions built into this evaluation, beginning with the quantification of emissions themselves. These conservative assumptions include, but are not limited to, the following:

- Mobile emissions were estimated using EMFAC2021 emission factors, which do not forecast fleet electrification mandated by Advanced Clean Cars II Regulations or EO N-79-20.[17,18] Therefore, the mobile emissions estimated in this analysis do not include emission reductions associated with increased electric vehicle adoption.
- The Project analysis of mass emissions conservatively used maximum daily emissions in comparison to the significance thresholds, because BAAQMD is supportive of lead agencies using conservative and health-protective methodologies. However, BAAQMD thresholds of significance as presented in their CEQA guidelines are based on average daily emissions.
- Operational emissions were calculated assuming buildout completed by 2034. Should the Project buildout be completed after 2034, this would be a conservative estimate due to state and federal mandates that are expected to reduce criteria air pollutant emissions rates over time.
- It was assumed that health effects occur at any concentration, including at small incremental concentrations (discussed further in **Attachment C**); and
- It was also assumed that all $PM_{2.5}$ is of equal toxicity (discussed further in **Attachment C**).

As such, results presented below are meant to represent an upper bound of potential health effects, and actual effects may be zero. For example, should health effects in fact only occur above a certain threshold, and the increment from the Project when added to existing conditions would not cause an exceedance of that threshold, actual health effects could be zero.

3.1 Potential Health Effects Associated with the Project

Overall, the estimated change in health effects from ozone and $PM_{2.5}$ associated with the Project's additional emissions are minimal relative to background incidences. **Tables 3-1 and 3-2** below show the annual percent of background health incidence for $PM_{2.5}$ and ozone health effects associated with the Project. The "background health incidence" is an estimate of the average number of people that suffer from some adverse health effect in a given population over a given period of time, in the absence of additional emissions from the Project. Health incidence rates and other health data are typically collected by the government as well as the World Health Organization. Background health incident rates presented in this report are over the full model domain, as defined in **Attachment B**, which

[17] https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/advanced-clean-cars-ii

[18] https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf

has a projected population of 22,502,033 in 2035. Project-related health incidences occur both in closer proximity to Project emissions, particularly for $PM_{2.5}$ health effects (see **Attachment B** for maps of modeled concentration changes), or over a large area due to the regional nature of emission dispersion and photochemical reactions that occur, particularly for ozone health effects (concentration changes also shown in **Attachment B**). When taken into context, the small increase in incidences and the small percent of the number of background incidences indicate that these health effects are minimal in a developed environment.

Table 3-1. BenMAP-Estimated Annual Mean $PM_{2.5}$ Health Effects of the Project Emissions Across the Northern California Model Domain [1]

Health Endpoint[2]	Project Mean as Percent of Background Health Incidence (%) (Annual)	Background Health Incidence (Mean, Annual)
Emergency Room Visits, Asthma [0-99]	0.00084%	115,302
Emergency Room Visits, Cardiovascular [0-99]	0.00011%	441,046
Mortality, All Cause [30-99]	0.00091%	176,797
Hospital Admissions, Asthma [0-64]	0.00063%	13,394
Hospital Admissions, All Cardiovascular [65-99] (Bell et al., 2015)	0.00013%	220,836
Hospital Admissions, Respiratory [65-99] (Bell et al., 2015)	0.00004%	82,964
Acute Myocardial Infarction, Nonfatal [18-24]	0.00043%	27
Acute Myocardial Infarction, Nonfatal [25-44]	0.00052%	1,583
Acute Myocardial Infarction, Nonfatal [45-54]	0.00042%	4,025
Acute Myocardial Infarction, Nonfatal [55-64]	0.00054%	6,762
Acute Myocardial Infarction, Nonfatal [65-99]	0.00044%	28,174

[1] Health effects are shown terms of incidences of each health endpoint and how it compares to the base values (2035 base year health effect incidences or "background health incidence"). Health effects and background health incidences are across the Northern California model domain.
[2] Affected age ranges are shown in square brackets.

Annual mean $PM_{2.5}$-related health effects attributed to Project-related increases in ambient air concentrations include asthma-related emergency room visits (0.97 incidences per year), cardiovascular-related emergency room visits (0.49 incidences per year), all-cause mortality (1.62 incidences per year), asthma-related hospital admissions (0.084 incidences per year), all cardiovascular-related hospital admissions (0.28 incidences per year), all respiratory-related hospital admissions (0.0317 incidences per year), and nonfatal acute myocardial infarction (Up to 0.124 incidences per year for people aged 65 to 99).

Table 3-2. BenMAP-Estimated Annual Mean Ozone Health Effects of the Project Emissions Across the Northern California Model Domain[1]

Health Endpoint[2]	Project Mean as Percent of Background Health Incidence (%) (Annual)	Background Health Incidence (Mean, Annual)
Hospital Admissions, All Respiratory [65-99]	0.000043%	63,783
Mortality, Respiratory [30-99]	0.00093%	19,099
Emergency Room Visits, Asthma [0-17]	0.0014%	19,786
Emergency Room Visits, Asthma [18-99]	0.00050%	38,023

1 Health effects are shown terms of incidences of each health endpoint and how it compares to the base values (2035 base year health effect incidences, or "background health incidence"). Health effects and background health incidences are across the Northern California model domain.
2 Affected age ranges are shown in square brackets.

Annual mean ozone-related health effects attributed to Project-related increases in ambient air concentrations include respiratory-related hospital admissions (0.027 incidences per year), respiratory mortality (0.18 incidences per year), and asthma-related emergency room visits (0.27 incidences for ages 0-17 and 0.19 incidences for ages 18-99).

The health effects from ozone and $PM_{2.5}$ are minimal in light of background incidences. The analysis did not quantify the potential health effects from other criteria air pollutants, consistent with how USEPA quantifies the health impacts and economic costs for criteria air pollutants (other than ozone and $PM_{2.5}$). Specifically, USEPA relies on studies that evaluate the health effects of $PM_{2.5}$ as a surrogate for general PM effects (including PM_{10}) in health effect assessments (e.g., USEPA 2022c). In addition, for NO_2, USEPA has noted that uncertainty remains regarding the independent effects of NO_2 from other air pollutants, including ozone and $PM_{2.5}$ (USEPA, 2016). Additionally, in 2017, USEPA concluded that a quantitative risk assessment was not supported for NO_2, stating that there were significant limitations in the available epidemiological studies including "the potential for co-pollutant confounding of the NO_2 association, potential bias due to exposure measurement error, and the shape of the concentration-response function" (USEPA, 2017).

3.2 Uncertainty

Analyses that evaluate the changes in concentrations resulting from individual sources and the health impacts of increases or decreases in pollutants as a result of regulation on a localized basis are routinely done. This analysis does not tie the changes in concentration to a specific health effect in an individual; however, it does use scientific correlations of certain types of health effects from pollution to estimate effects on the population at large.

There is a degree of uncertainty in these results from a combination of the uncertainty in the emissions themselves, the change in concentration resulting from the PGM, and the uncertainty of the application of the C-R functions. All simulations of physical processes, whether ambient air concentrations or health effects from air pollution, have a level of uncertainty associated with them due to simplifying assumptions. The overall uncertainty is a combination of the uncertainty associated with each piece of the modeling study, in this case, the emissions quantification, the emissions model, the PGM, and BenMAP. While these results reflect a level of uncertainty, regulatory agencies, including the USEPA have judged that, even with the uncertainty, they provide sufficient information to the public to allow them to understand the potential health effects of increases or decreases in air pollution.

3.2.1 PGM Uncertainty

PGMs generally represent the state-of-the-science when the treatment of photochemically formed air pollution is required over multiple spatial scales (e.g., from single-source to continental). PGMs are part of a modeling system in which there are several other major components that determine model performance, including meteorology, emissions inventories (including background), and chemical mechanisms, all of which have associated uncertainties, as discussed further in **Attachment B**.

Despite these complexities and associated uncertainties, the USEPA recommends using PGMs for a variety of applications including State Implementation Plans and Regional Haze Planning, and CAMx or CMAQ specifically for single-source modeling of ozone and secondary $PM_{2.5}$. The USEPA believes that the relative change in the PGM-predicted concentrations (e.g., the incremental changes due to the emissions from a single-source) is more accurate and reliable than the total predicted concentrations (USEPA, 2020a).

3.2.2 C-R Function Uncertainty

The approach and methodology of this analysis ensures that despite the uncertainty the reported health risks are conservative in nature (i.e., overstated rather than understated). In addition to the conservative assumptions built into the emissions noted above, there are a number of assumptions built into the application of C-R functions in BenMAP that may lead to an overestimation of health effects. In the Policy Assessment for the Reconsideration of the National Ambient Air Quality Standards (NAAQS) for Particulate Matter prepared by the EPA (USEPA, 2022c), the EPA acknowledges the many factors of uncertainty in selected C-R functions and resulting risk estimates, including the shape of the exposure-response function and statistical uncertainty (especially at low concentrations), temporal mismatch between ambient air data and the health effect, exposure measurement error in the epidemiological studies that produced the C-R function, potential confounding of the effect of $PM_{2.5}$ or ozone on mortality, and compositional and source differences of PM, all of which similarly apply to the results presented above.

Another uncertainty highlighted by the USEPA (2012, 2022c) which applies to potential health effects from both $PM_{2.5}$ and ozone, is the assumption of a log-linear response between exposure and health effects, without consideration for a threshold concentration below which effects may not be measurable. In the latest USEPA Policy Assessment for PM (USEPA, 2022c), while it is noted that some studies show evidence supporting a linear, no-threshold relationship, the USEPA continues to acknowledge that interpreting the shapes of concentration-response relationships is a recognized uncertainty, particularly at lower $PM_{2.5}$ concentrations, where lower data density, possible influence of measurement error, and variability among individuals with response to air pollution health effects can obscure the existence of a threshold or nonlinear relationship. Without consideration of a threshold concentration, any changes in air pollution are assumed to adversely affect health, which is a conservative assumption.

For $PM_{2.5}$ health effects, the USEPA has also stated that results from various studies have shown the importance of considering particle size, composition, and particle source in determining the health effects of PM (USEPA, 2009). Park et al. (2018) found that toxicity levels varied among different particle sources with a higher toxicity being associated with combustion aerosols rather than non-combustion aerosols. Diesel engine exhaust particles demonstrated the highest toxicity score, followed by gasoline engine exhaust particles, biomass burning particles, coal combustion particles, and road dust. This aligns with previous research by Rohr and Wyzga (2012) and others, as well as the USEPA (2009) which found that particles from industrial sources and from coal combustion appear to be the most significant contributors to PM-related mortality. This is particularly important to note here, as the majority of PM emissions generated from the Project are from brakewear, tirewear, and entrained roadway dust (see **Attachment A**), and not from combustion. Therefore, by not considering the relative toxicity of PM components, the results presented here are conservative.

For both the $PM_{2.5}$ and ozone health effects calculated, each of the pollutants may be a confounder of the other. That is, in studies that only evaluate health effects from $PM_{2.5}$ exposures, the observed health effects could actually be partly due to ozone, but are attributed fully to $PM_{2.5}$, yielding a higher effect estimate for $PM_{2.5}$. Thus, while C-R functions are from studies that evaluated the effects for each pollutant individually, while sometimes adjusting for the other as a co-pollutant, both air pollutants could contribute to the health effect outcomes evaluated, and thus the overall health effects from a single pollutant may be overstated.

In summary, and with consideration of the uncertainty discussed above, health effects presented in this report are conservatively estimated, and the actual effects may be zero.

Additional discussion of the uncertainty associated with C-R functions and health effect estimates is included in **Attachment C**.

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ATTACHMENT A
EMISSIONS INVENTORY, SPATIAL ALLOCATION, AND SMOKE SETUP

1. INTRODUCTION

Operational emissions from the Project were estimated using methodologies consistent with the California Emissions Estimator Model (CalEEMod®). The model employs widely accepted calculation methodologies for emission estimates combined with appropriate default data if site-specific information is not available.

Annual emission estimates from the Project need to be spatially gridded, temporally allocated, and chemically speciated to be used for photochemical grid modeling. The Sparse Matrix Operator Kerner Emissions (SMOKE) emissions modeling system (Coats, 1996; Coats and Houyoux, 1996)[19] is used for this process.

2. PROJECT EMISSIONS AND SPATIAL ALLOCATION

Emissions were estimated for the Project to support the photochemical grid model (PGM) and were allocated into 4 km x 4 km grid cells. This section describes those emissions and how they were spatially allocated.

2.1 Project Emissions and Spatial Allocation

For use in PGMs, emissions must be spatially allocated over the area so that they can be incorporated into the baseline gridded emission inventory, as developed by the Bay Area Air Quality Management District (BAAQMD), and adapted for this analysis as discussed in **Attachment B**. The maximum daily incremental emission inventory modeled for the Project is shown below in **Table 2-1**.[20] Project emissions modeled in the PGM include oxides of nitrogen (NOx), reactive organic gases (ROG), carbon monoxide (CO), sulfur dioxide (SO_2), and fine primary particulate matter ($PM_{2.5}$). Since some of these pollutants incorporate a wide range of chemical species (e.g., ROG and PM), the Project emissions were further speciated into detailed chemical species or groups of species to be used as inputs for the PGM's robust chemistry solver. Mobile source emissions were split into emissions categories based on the EMFAC2021 emission rates. Fleets at full buildout conservatively use 2034 emission factors. For PM, less than 2.5 microns in diameter ($PM_{2.5}$) emissions are used in the modeling; less than 10 microns in diameter (PM_{10}) emissions are presented for information below.

[19] https://www.cmascenter.org/smoke/

[20] Maximum daily emissions, which were used to evaluate Project significance, are modeled for consistency with the Project's air quality analysis.

Table 2-1. Maximum Daily Incremental Operational Emissions

Emission Category	ROG/ VOC	NOx	CO	SO_2	PM_{10}	$PM_{2.5}$
	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Mobile	90	72	825	2.3	247	63
Diurnal	34	--	--	--	--	--
Hotsoak	7.5	--	--	--	--	--
Idling Exhaust	0.88	0.36	11	0.0026	0.0014	0.0013
Brakewear	--	--	--	--	8.0	2.8
Tirewear	--	--	--	--	7.0	1.8
Road Dust	--	--	--	--	231	58
Running Exhaust	6.1	38	610	2.2	0.87	0.81
Running Loss	23	--	--	--	--	--
Starting Exhaust	19	33	203	0.066	0.19	0.18
Architectural Coatings	7.7	--	--	--	--	--
Natural Gas	0.005	0.005	0.005	0.005	0.005	0.005
Consumer Products	101	--	--	--	--	--
Emergency Generators	1.4	35	39	0.070	1.4	1.2
Total:	**200**	**107**	**864**	**2.4**	**248**	**64**

Table 2-2 provides a summary of the spatial distribution of mobile emissions due to the Project. The mobile spatial distribution was estimated based on roadway segments and Project generated average daily trip rates in 2034 provided by the Project's transportation consultant. The roadway segments were mapped according to the provided segment limits and were used to allocate the emissions based on each segment's relative trip rate. In cases where a roadway segment fell between two provided segment volumes, an estimated traffic volume was calculated and assumed to travel between the two segments with trip rates provided. To account for such gap segments, the average trip count of all bordering segments was assumed to be equal to the trip count for the gap segments. Project trip rates utilized to spatially allocate mobile emissions are shown in **Table 2-2**.

Table 2-2. Spatial Allocation of Mobile Emissions

Roadway Segment Limits	2034 Average Daily Trips	Percent of Mobile Emissions
Tasman between Reamwood and Patrick Henry	23,700	1.8%
Tasman between Birchwood and Lawrence Expressway	25,700	2.0%
Lawrence Expressway between US-101 and Tasman	34,100	2.6%
Lawrence Expressway between Tasman and Elko	36,800	2.8%

Table 2-2. Spatial Allocation of Mobile Emissions

Roadway Segment Limits	2034 Average Daily Trips	Percent of Mobile Emissions
Tasman between Lawrence Expressway and Fair Oaks	10,600	0.8%
Tasman between Great America and Old Ironside	18,100	1.4%
Great America Parkway between Tasman and Bunker Hill	42,000	3.2%
Tasman between Great America and Lafayette	25,700	2.0%
Lafayette between Tasman and Agnew	21,400	1.7%
Lafayette between Tasman and SR-237	30,100	2.3%
Great America Parkway between US-101 and Mission College	76,500	5.9%
Lawrence Expressway between Oakmead and Arques	59,200	4.6%
Bowers between Scott and Central Expressway	33,900	2.6%
Tasman between Lickmill and Renaissance Drive	32,600	2.5%
Great America Parkway between Old Mountain View Alviso Road and SR-237	38,200	3.0%
Mission College between Freedom (West) and Freedom (East)	13,600	1.1%
Bowers between US-101 and Scott	55,400	4.3%
Agnew between Lafayette and Mission College	8,600	0.7%
Lawrence Expressway between Central Expressway and Arques	48,600	3.8%
Mission College between Burton and Wyatt	17,000	1.3%
Montague Expressway between Lafayette and Thomas	61,400	4.8%
Montague Expressway between US-101 and Thomas	74,400	5.8%
Montague Expressway between De La Cruz and Lafayette	62,800	4.9%
Great America Parkway between Old Glory and Patrick Henry	56,000	4.3%
Great America Parkway between Old Glory and Mission College	67,600	5.2%
Lawrence Expressway between US-101 and Oakmead[1]	46,700	3.6%
Tasman between Lick Mill and Lafayette[1]	27,500	2.1%

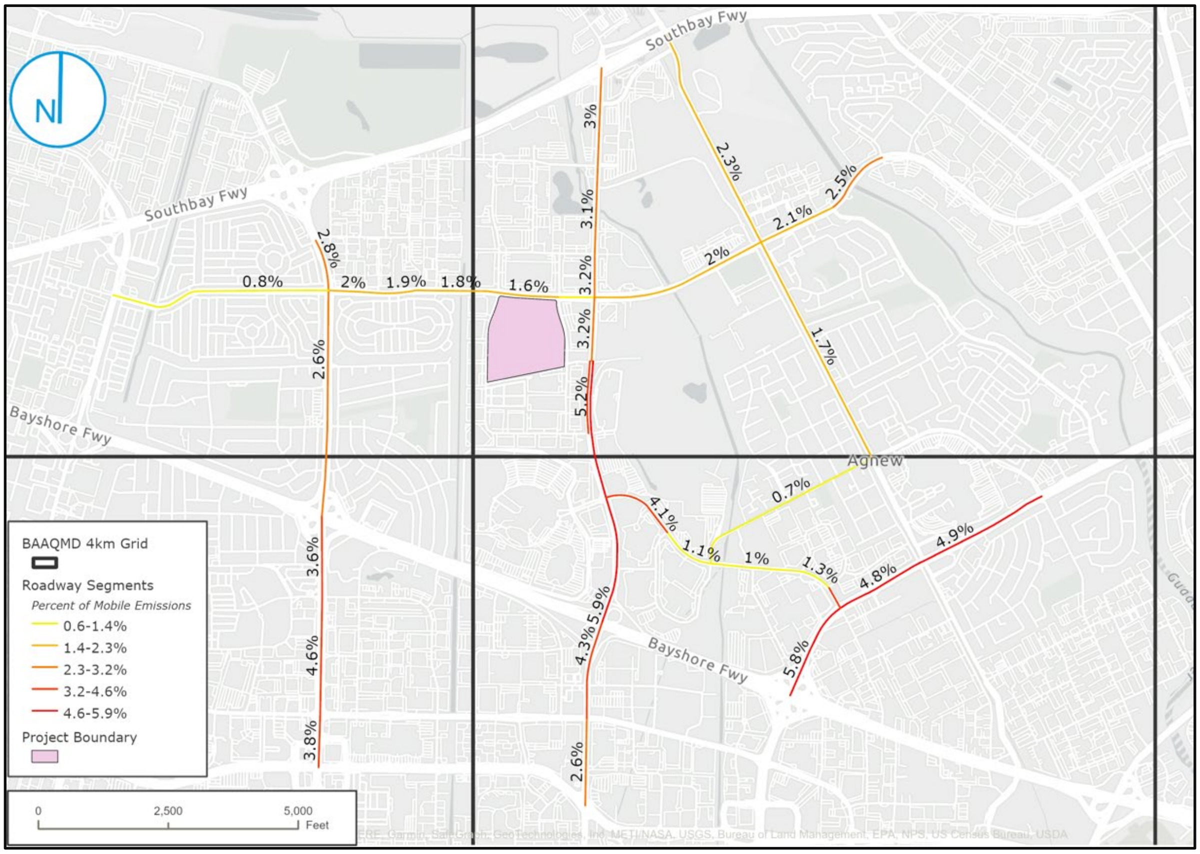
Table 2-2. Spatial Allocation of Mobile Emissions

Roadway Segment Limits	2034 Average Daily Trips	Percent of Mobile Emissions
Great America Parkway between Old Mountain View Alviso Road and Bunker Hill[1]	40,100	3.1%
Tasman between Lawrence Expressway and Reamwood[1]	24,700	1.9%
Mission College between Great America Parkway and Freedom (West) [1]	52,600	4.1%
Mission College between Freedom (East) and Burton[1]	13,100	1.0%
Tasman between Patrick Henry and Old Ironside[1]	20,900	1.6%
Mission College between Wyatt and Montague Expressway[1]	50,900	3.9%
Great America Parkway between Tasman and Old Glory[1]	41,900	3.2%
Total:	1,292,400	100%

[1] The daily trip rate of this segment was estimated by taking the average trip rate of adjacent segments with known trip rates.

Figure 2-1 below shows a close-up of the Project boundary overlay with the 4-km grid and the nearby grid cells where mobile emissions were allocated as summarized in **Table 2-2**. All on-site emissions (architectural coatings, consumer products, natural gas, emergency generators) were assumed to be emitted in the grid cell where the project is located.

Figure 2-1. Project Mobile Emissions Allocation by Roadway Segment



2.2 Converting Project Inventories to SMOKE Input Format

The first step in the emissions processing was to convert the Project emission inventory into the Flat File 2010 (FF10) format for input to SMOKE. We assigned appropriate Source Classification Codes (SCCs) to the Project emissions sources. **Table 2-3** provides SCC assigned to each project source.

Table 2-3. Assigned SCC to Project Emission Sources

Emission Source	SCC	SCC Description
Mobile -HHDT	2230072110	Mobile Sources; Highway Vehicles – Diesel; Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, & 5; Rural Interstate: Total
Mobile -HHDT	2294000000	Mobile Sources; Paved Roads; All Paved Roads; Total: Fugitives
Mobile -HHDT	220107011B	Mobile Sources; Highway Vehicles – Gasoline; Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV); Rural Interstate: Brake Wear
Mobile -HHDT	220107011S	Mobile Sources; Highway Vehicles – Gasoline; Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV); Rural Interstate: Start
Mobile -HHDT	220107011T	Mobile Sources; Highway Vehicles – Gasoline; Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV); Rural Interstate: Tire Wear

Table 2-3. Assigned SCC to Project Emission Sources		
Emission Source	**SCC**	**SCC Description**
Mobile -HHDT	220107011V	Mobile Sources; Highway Vehicles – Gasoline; Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV); Rural Interstate: Evap (except Refueling)
Mobile -HHDT	220107011X	Mobile Sources; Highway Vehicles – Gasoline; Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV); Rural Interstate: Exhaust
Mobile -HHDT	223007311B	Mobile Sources; Highway Vehicles – Diesel; Heavy Duty Diesel Vehicles (HDDV) Class 6 & 7; Rural Interstate: Brake Wear
Mobile -HHDT	223007311I	Mobile Sources; Highway Vehicles – Diesel; Heavy Duty Diesel Vehicles (HDDV) Class 6 & 7; Rural Interstate: Idling
Mobile -HHDT	223007311S	Mobile Sources; Highway Vehicles – Diesel; Heavy Duty Diesel Vehicles (HDDV) Class 6 & 7; Rural Interstate: Start
Mobile -HHDT	223007311T	Mobile Sources; Highway Vehicles – Diesel; Heavy Duty Diesel Vehicles (HDDV) Class 6 & 7; Rural Interstate: Tire Wear
Mobile -HHDT	223007311X	Mobile Sources; Highway Vehicles – Diesel; Heavy Duty Diesel Vehicles (HDDV) Class 6 & 7; Rural Interstate: Exhaust
Mobile -LDA	220100111B	Mobile Sources; Highway Vehicles – Gasoline; Light Duty Gasoline Vehicles (LDGV); Rural Interstate: Brake Wear
Mobile -LDA	220100111S	Mobile Sources; Highway Vehicles – Gasoline; Light Duty Gasoline Vehicles (LDGV); Rural Interstate: Start
Mobile -LDA	220100111T	Mobile Sources; Highway Vehicles – Gasoline; Light Duty Gasoline Vehicles (LDGV); Rural Interstate: Tire Wear
Mobile -LDA	220100111V	Mobile Sources; Highway Vehicles – Gasoline; Light Duty Gasoline Vehicles (LDGV); Rural Interstate: Evap (except Refueling)
Mobile -LDA	220100111X	Mobile Sources; Highway Vehicles – Gasoline; Light Duty Gasoline Vehicles (LDGV); Rural Interstate: Exhaust
Mobile -LDA	223000111B	Mobile Sources; Highway Vehicles – Diesel; Light Duty Diesel Vehicles (LDDV); Rural Interstate: Brake Wear
Mobile -LDA	223000111T	Mobile Sources; Highway Vehicles – Diesel; Light Duty Diesel Vehicles (LDDV); Rural Interstate: Tire Wear
Mobile -LDA	223000111X	Mobile Sources; Highway Vehicles – Diesel; Light Duty Diesel Vehicles (LDDV); Rural Interstate: Exhaust
Mobile -LDT1	220102011B	Mobile Sources; Highway Vehicles – Gasoline; Light Duty Gasoline Trucks 1 & 2 (M6) = LDGT1 (M5); Rural Interstate: Brake Wear
Mobile -LDT1	220102011S	Mobile Sources; Highway Vehicles – Gasoline; Light Duty Gasoline Trucks 1 & 2 (M6) = LDGT1 (M5); Rural Interstate: Start
Mobile -LDT1	220102011T	Mobile Sources; Highway Vehicles – Gasoline; Light Duty Gasoline Trucks 1 & 2 (M6) = LDGT1 (M5); Rural Interstate: Tire Wear
Mobile -LDT1	220102011V	Mobile Sources; Highway Vehicles – Gasoline; Light Duty Gasoline Trucks 1 & 2 (M6) = LDGT1 (M5); Rural Interstate: Evap (except Refueling)
Mobile -LDT1	220102011X	Mobile Sources; Highway Vehicles – Gasoline; Light Duty Gasoline Trucks 1 & 2 (M6) = LDGT1 (M5); Rural Interstate: Exhaust

Table 2-3. Assigned SCC to Project Emission Sources

Emission Source	SCC	SCC Description
Mobile -LDT1	223006011B	Mobile Sources; Highway Vehicles – Diesel; Light Duty Diesel Trucks 1 thru 4 (M6) (LDDT); Rural Interstate: Brake Wear
Mobile -LDT1	223006011T	Mobile Sources; Highway Vehicles – Diesel; Light Duty Diesel Trucks 1 thru 4 (M6) (LDDT); Rural Interstate: Tire Wear
Mobile -LDT1	223006011X	Mobile Sources; Highway Vehicles – Diesel; Light Duty Diesel Trucks 1 thru 4 (M6) (LDDT); Rural Interstate: Exhaust
Mobile -LHDT1	220107011I	Mobile Sources; Highway Vehicles – Gasoline; Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV); Rural Interstate: Idling
Mobile -LHDT1	223007111B	Mobile Sources; Highway Vehicles – Diesel; Heavy Duty Diesel Vehicles (HDDV) Class 2B; Rural Interstate: Brake Wear
Mobile -LHDT1	223007111I	Mobile Sources; Highway Vehicles – Diesel; Heavy Duty Diesel Vehicles (HDDV) Class 2B; Rural Interstate: Idling
Mobile -LHDT1	223007111T	Mobile Sources; Highway Vehicles – Diesel; Heavy Duty Diesel Vehicles (HDDV) Class 2B; Rural Interstate: Tire Wear
Mobile -LHDT1	223007111X	Mobile Sources; Highway Vehicles – Diesel; Heavy Duty Diesel Vehicles (HDDV) Class 2B; Rural Interstate: Exhaust
Mobile -LHDT2	223007211B	Mobile Sources; Highway Vehicles – Diesel; Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, & 5; Rural Interstate: Brake Wear
Mobile -LHDT2	223007211I	Mobile Sources; Highway Vehicles – Diesel; Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, & 5; Rural Interstate: Idling
Mobile -LHDT2	223007211T	Mobile Sources; Highway Vehicles – Diesel; Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, & 5; Rural Interstate: Tire Wear
Mobile -LHDT2	223007211X	Mobile Sources; Highway Vehicles – Diesel; Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, & 5; Rural Interstate: Exhaust
Mobile -MCY	220108011B	Mobile Sources; Highway Vehicles – Gasoline; Motorcycles (MC); Rural Interstate: Brake Wear
Mobile -MCY	220108011S	Mobile Sources; Highway Vehicles – Gasoline; Motorcycles (MC); Rural Interstate: Start
Mobile -MCY	220108011T	Mobile Sources; Highway Vehicles – Gasoline; Motorcycles (MC); Rural Interstate: Tire Wear
Mobile -MCY	220108011V	Mobile Sources; Highway Vehicles – Gasoline; Motorcycles (MC); Rural Interstate: Evap (except Refueling)
Mobile -MCY	220108011X	Mobile Sources; Highway Vehicles – Gasoline; Motorcycles (MC); Rural Interstate: Exhaust
Mobile -OBUS	220107013B	Mobile Sources; Highway Vehicles – Gasoline; Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV); Rural Other Principal Arterial: Brake Wear
Mobile -OBUS	220107013I	Mobile Sources; Highway Vehicles – Gasoline; Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV); Rural Other Principal Arterial: Idling
Mobile -OBUS	220107013S	Mobile Sources; Highway Vehicles – Gasoline; Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV); Rural Other Principal Arterial: Start

Table 2-3. Assigned SCC to Project Emission Sources		
Emission Source	**SCC**	**SCC Description**
Mobile -OBUS	220107013T	Mobile Sources; Highway Vehicles – Gasoline; Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV); Rural Other Principal Arterial: Tire Wear
Mobile -OBUS	220107013V	Mobile Sources; Highway Vehicles – Gasoline; Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV); Rural Other Principal Arterial: Evap (except Refueling)
Mobile -OBUS	220107013X	Mobile Sources; Highway Vehicles – Gasoline; Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV); Rural Other Principal Arterial: Exhaust
Mobile -OBUS	223007513B	Mobile Sources; Highway Vehicles – Diesel; Heavy Duty Diesel Buses (School & Transit); Rural Other Principal Arterial: Brake Wear
Mobile -OBUS	223007513I	Mobile Sources; Highway Vehicles – Diesel; Heavy Duty Diesel Buses (School & Transit); Rural Other Principal Arterial: Idling
Mobile -OBUS	223007513S	Mobile Sources; Highway Vehicles – Diesel; Heavy Duty Diesel Buses (School & Transit); Rural Other Principal Arterial: Start
Mobile -OBUS	223007513T	Mobile Sources; Highway Vehicles – Diesel ; Heavy Duty Diesel Buses (School & Transit);Rural Other Principal Arterial: Tire Wear
Mobile -OBUS	223007513X	Mobile Sources; Highway Vehicles – Diesel; Heavy Duty Diesel Buses (School & Transit); Rural Other Principal Arterial: Exhaust
Emergency Generator	2270006005	Mobile Sources; Off-highway Vehicle Diesel; Commercial Equipment; Generator Sets
Architectural Coating	2401001000	Solvent Utilization; Surface Coating; Architectural Coatings; Total: All Solvent Types
Natural Gas	2102006000	Stationary Source Fuel Combustion; Industrial; Natural Gas; Total: Boilers and IC Engines
Consumer Products	40100499	Chemical Evaporation; Organic Solvent Evaporation; Knit Fabric Scouring with Chlorinated Solvent; Other Not Classified
Consumer Products	2460000000	Solvent Utilization; Miscellaneous Non-industrial: Consumer and Commercial; All Processes; Total: All Solvent Types
Consumer Products	2460100000	Solvent Utilization; Miscellaneous Non-industrial: Consumer and Commercial; All Personal Care Products; Total: All Solvent Types
Consumer Products	2460110000	Solvent Utilization; Miscellaneous Non-industrial: Consumer and Commercial; Personal Care Products: Hair Care Products; Total: All Solvent Types
Consumer Products	2460140000	Solvent Utilization; Miscellaneous Non-industrial: Consumer and Commercial; Personal Care Products: Powders; Total: All Solvent Types
Consumer Products	2460150000	Solvent Utilization; Miscellaneous Non-industrial: Consumer and Commercial; Personal Care Products: Nail Care Products; Total: All Solvent Types
Consumer Products	2460160000	Solvent Utilization; Miscellaneous Non-industrial: Consumer and Commercial; Personal Care Products: Facial and Body Treatments; Total: All Solvent Types
Consumer Products	2460170000	Solvent Utilization; Miscellaneous Non-industrial: Consumer and Commercial; Personal Care Products: Oral Care Products; Total: All Solvent Types

Table 2-3. Assigned SCC to Project Emission Sources

Emission Source	SCC	SCC Description
Consumer Products	2460200000	Solvent Utilization; Miscellaneous Non-industrial: Consumer and Commercial; All Household Products; Total: All Solvent Types
Consumer Products	2460240000	Solvent Utilization; Miscellaneous Non-industrial: Consumer and Commercial; Household Products: Dishwashing Products; Total: All Solvent Types
Consumer Products	2460400000	Solvent Utilization; Miscellaneous Non-industrial: Consumer and Commercial; All Automotive Aftermarket Products; Total: All Solvent Types
Consumer Products	2460500000	Solvent Utilization; Miscellaneous Non-industrial: Consumer and Commercial; All Coatings and Related Products; Total: All Solvent Types
Consumer Products	2460600000	Solvent Utilization; Miscellaneous Non-industrial: Consumer and Commercial; All Adhesives and Sealants; Total: All Solvent Types
Consumer Products	2460800000	Solvent Utilization; Miscellaneous Non-industrial: Consumer and Commercial; All FIFRA Related Products; Total: All Solvent Types
Consumer Products	2460900000	Solvent Utilization; Miscellaneous Non-industrial: Consumer and Commercial; Miscellaneous Products (Not Otherwise Covered); Total: All Solvent Types

2.2.1 Generate Spatial Surrogates for 4-km Domains

As part of the analysis, the Project source emissions need to be spatially allocated to appropriate geographic locations. The emissions can be allocated to modeling grid cells using gridding surrogates. To process the Project emissions, a Project area-based spatial surrogate was developed. The surrogate was developed using the US Environmental Protection Agency (USEPA's) Spatial Allocation Tool,[21] which combines geographical information system (GIS)-based data (shapefiles) and modeling domain definitions to generate the appropriate gridded surrogate data set. The Project sources were then assigned specific surrogates for gridding by cross-referencing the SCCs. As mentioned above, all Project emissions were distributed in the modeling grid where the Project is located as shown in **Figure 2-1**. The mobile sources were spatially distributed in the site's grid cells and surrounding grid cells, as outlined in **Table 2-2**.

2.2.2 SMOKE 4 km Processing of Project Emissions

SMOKE system was used to process emissions for the Northern California 4-km modeling grid shown in **Figure 2-1**. Although CAMx is run for each day of the year using each day's meteorological data, emissions are processed using a representative week from each month (seven days a month) to represent the entire month's emissions. This method is used for emissions to avoid redundancy in data and save disk space and computational time since emissions, temporally, during one week of a given month are likely very similar to emissions from a different week of the same month. The representative week is then mapped to each day of a given month, with holidays mapped to Sundays. SMOKE was applied to perform the following tasks:

1. Chemical Speciation: Emission estimates of criteria air pollutants were speciated for the SAPRC07 AERO6 chemical mechanism employed in CMAQ in SMOKE processing.

[21] https://www.cmascenter.org/sa-tools/documentation/4.2/html/srgtool/SurrogateToolUserGuide_4_2.pdf

Speciation profiles compatible with the SAPRC07 AERO6 mechanism for $PM_{2.5}$ were used from the Bay Area Air Quality Management District (BAAQMD)'s modeling system to be consistent with the regional modeling emissions. Those emissions were then converted into CAMx-ready formats using CMAQ2CAMx conversion program and species mapping.

2. Temporal Allocation: Annual emission estimates were resolved on an hourly timescale for CAMx modeling. These allocations were determined from the particular source category, specified by the SCC. Monthly, weekly, and diurnal profiles were cross-referenced to SCC to provide the appropriate temporal resolution. The temporal profiles were also obtained from the BAAQMD's emissions modeling system.
3. Spatial Allocation: The Project emission estimates were spatially resolved to the grid cells for modeling using spatial surrogates as described above.

2.2.3 QA/QC of Emissions Modeling

Standard quality assurance/quality control (QA/QC) was conducted during all aspects of the SMOKE emissions processing. These steps followed the approach recommended in USEPA modeling guidance (USEPA, 2007). SMOKE includes quality assurance (QA) and reporting features to keep track of the adjustments at each processing stage and ensure that data integrity is not compromised. The SMOKE log files were reviewed for error messages and ensured that appropriate source profiles were used. All error records reported during processing were reviewed and resolved. This is important to ensure that source categories are correctly characterized. SMOKE input and output emissions were also compared, and summary tables were generated to compare input inventory totals against model-ready output totals to confirm consistency. Spatial plots were generated to visually verify correct spatial allocation of the emissions.

2.2.4 Merge SMOKE Pre-merged Emissions to Generate CAMx-ready Emission Inputs

The final step in the emissions processing is to merge the Project gridded emissions with other regional components through the gridded merge program (MRGUAM) for CAMx. The daily emissions were merged in the time format required by CAMx.

2.2.5 Emissions Summary

Summaries of the Project gridded CAMx model-ready emissions data are provided in this section. **Table 2-1** summarizes the annual emission inventory data input to SMOKE from the FF10 data files in pounds per day by project source types and by pollutants. The consistency in data in **Table 2-4** and **Table 2-5** as well as **Table 2-1** offer confidence in the correct operation of the SMOKE emissions processing for CAMx.

Table 2-4. Operational Project Emissions Inventory Data Input for SMOKE by Source Types (Maximum lbs/day)

Type	ROG/ VOC	NO_X	CO	SO2	PM_{10}	$PM_{2.5}$
Mobile (Total)	90.2	71.5	825.0	2.3	247.1	63.2
Onsite Area (Total)	110.06	35.1	39.4	0.1	1.4	1.2
Architectural Coatings	7.7	--	--	--	--	--
Consumer Products	101.0	--	--	--	--	--
Natural Gas	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Emergency Generator	1.36	35.10	39.40	0.07	1.36	1.21
Total	**200.2**	**106.6**	**864.4**	**2.4**	**248.4**	**64.4**

Table 2-5. Project Emission Inventory Data Total Output from SMOKE (Maximum lbs/day)

Type	ROG/ VOC	NO_X	CO	SO_2	PM_{10}	$PM_{2.5}$
Total	200.2	106.6	864.4	2.4	248.4	64.4

Spatial displays of the gridded emissions data are presented below. The gridded emissions in 4-km grid were examined to verify accurate spatial allocation by SMOKE. **Figures 2-2** through **2-7** displays gridded emissions for the Project inventory in the 4-km modeling grid.

Figure 2-2. Spatial Distribution of VOC Emissions (in lbs/day) for the Project in the Northern California 4-km Domain

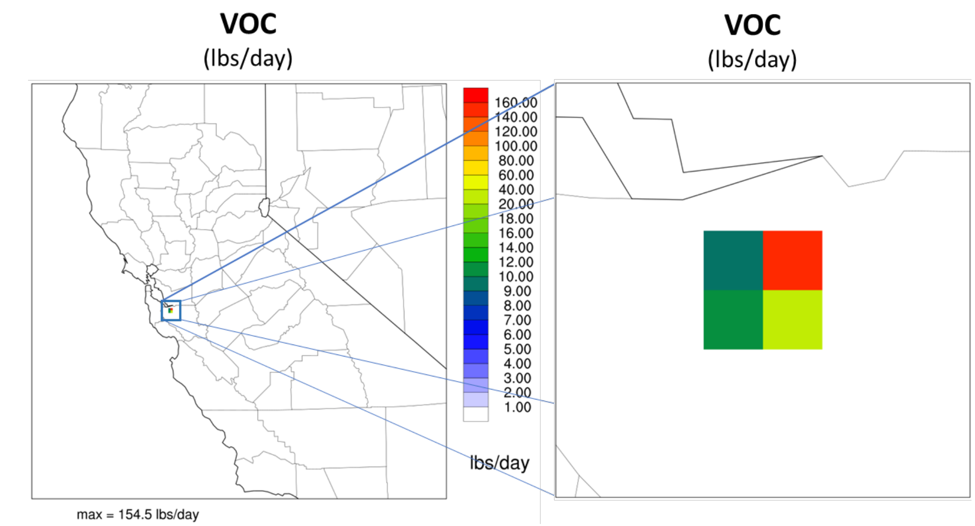


Figure 2-3. Spatial Distribution of NOx Emissions (in lbs/day) for the Project in the Northern California 4-km Domain

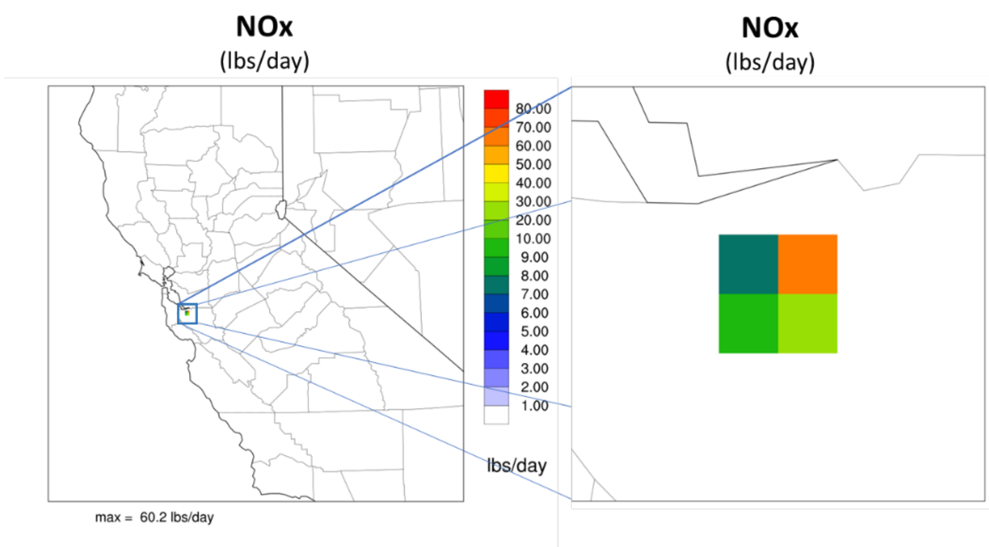


Figure 2-4. Spatial Distribution of CO Emissions (in lbs/day) for the Project in the Northern California 4-km Domain

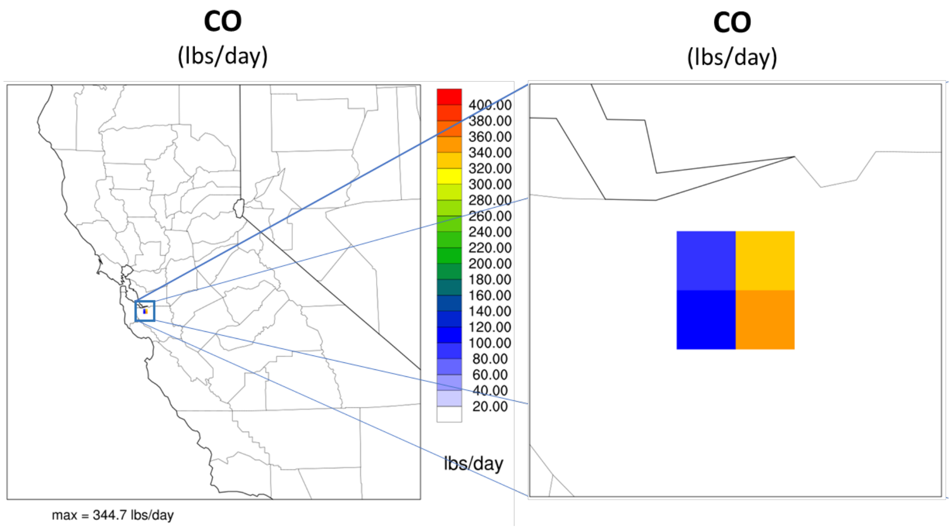


Figure 2-5. Spatial Distribution of SO_2 Emissions (in lbs/day) for the Project in the Northern California 4-km Domain

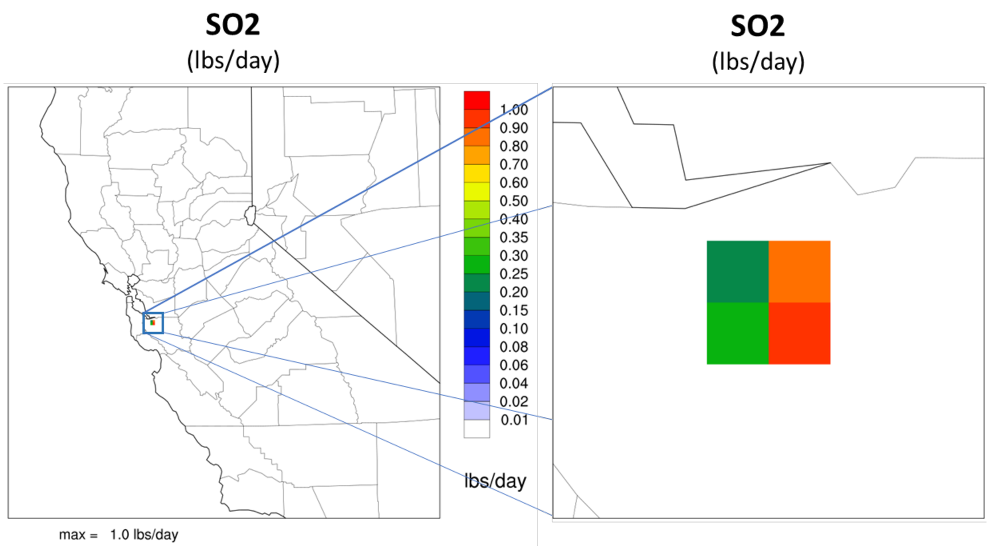


Figure 2-6. Spatial Distribution of PM_{10} Emissions (in lbs/day) for the Project in the Northern California 4-km Domain

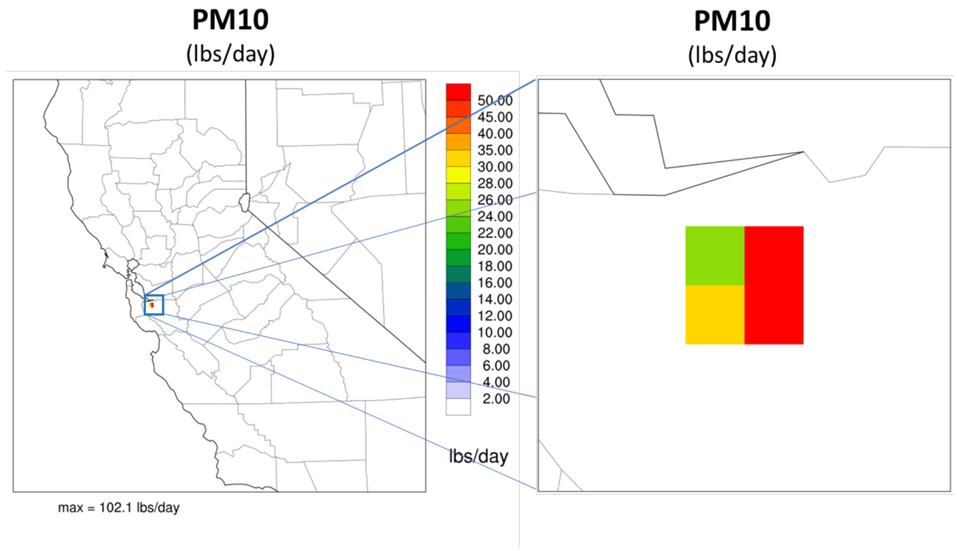
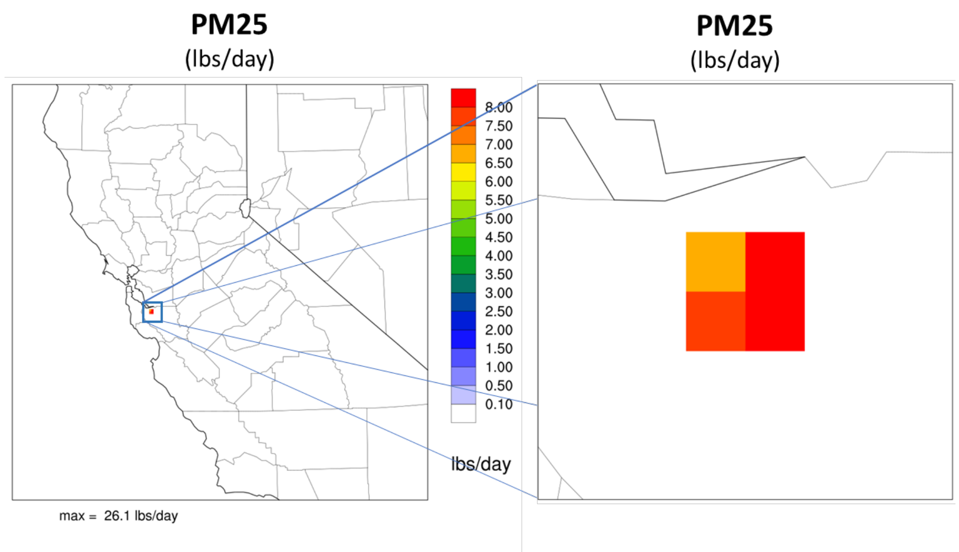


Figure 2-7. Spatial Distribution of $PM_{2.5}$ Emissions (in lbs/day) for the Project in the Northern California 4-km Domain



3. REFERENCES

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ATTACHMENT B
PGM INPUTS, OUTPUTS, AND ASSUMPTIONS

1. REGIONAL AIR QUALITY MODELING PLATFORM

The latest publicly available Photochemical Grid Model (PGM) database for Northern California was developed by the Bay Area Air Quality Management District (BAAQMD) in support of the 2000 Central California Ozone Study (CCOS), and was adapted for this analysis.[22] The Northern California 2012 4-km CAMx modeling database and a projected 2035 emissions database was used in this assessment.[23] The 2012 base case is based on a PGM modeling database developed by the BAAQMD. The BAAQMD PGM database is tailored for California using California-specific input tools (e.g., the EMFAC[24] mobile source emissions model) and uses a high-resolution 4-km horizontal grid to better simulate meteorology and air quality in the complex terrain and coastal environment of California. This contrasts with the United States Environmental Protection Agency's (USEPA) national modeling platforms[25] used for national rulemakings (e.g., transport rules such as CSAPR[26] or defining new NAAQS) that use a coarser 12-km horizontal grid resolution.

The BAAQMD selected the computational domain shown in **Figure 1-1** below to keep consistency with the 2000 CCOS (BAAQMD, 2009). The CCOS was established to understand and investigate the ozone formation in Central California, therefore the computational domain included all Central and portions of Northern California.

Details of the model inputs, configuration, and results are presented in Section 2 of this Attachment.

[22] http://www.baaqmd.gov/about-air-quality/research-and-data/research-and-modeling.

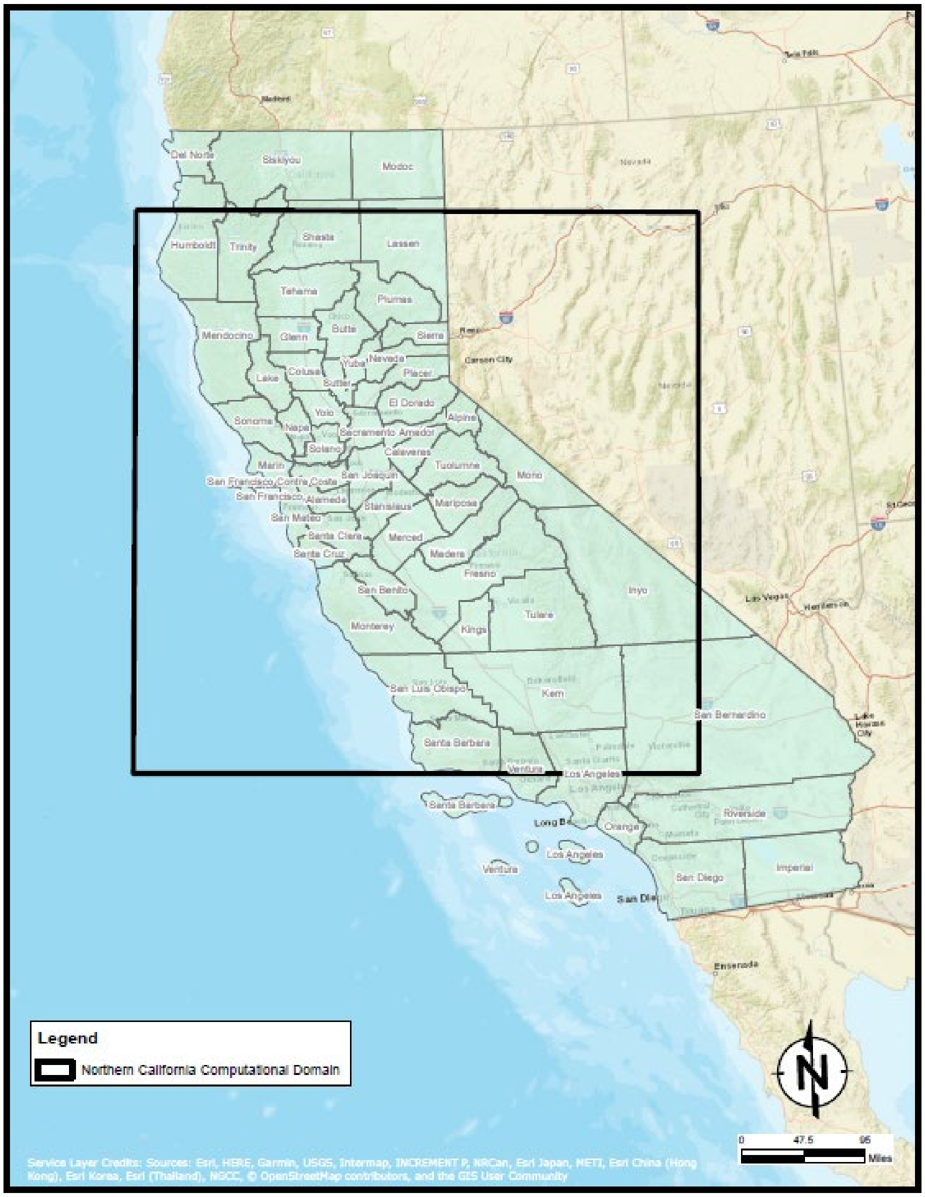
[23] Full project buildout is expected to occur as early as year 2034 and emissions were conservatively quantified assuming year 2034 emission factors. Year 2035 was selected for the PGM based on availability of modeling and emission databases for the Northern California domain at the time of the analysis. For consistency, Year 2035 populations are conservatively used in BenMAP, as discussed in Attachment C.

[24] https://www.arb.ca.gov/emfac/

[25] https://www.epa.gov/air-emissions-modeling/2014-2016-version-7-air-emissions-modeling-platforms

[26] https://www.epa.gov/csapr

Figure 1-1. Air quality modeling domain for Northern California



2. REGIONAL GRID MODELING

This section describes the regional PGM modeling setup to assess the outcome of the Project emissions on the ambient $PM_{2.5}$ levels in the region. The 2012 base case modeling databases were developed by the BAAQMD for the Community Multiscale Air Quality (CMAQ) PGM. The CMAQ annual 2012 4-km modeling database and annual 2012 4-km Weather Research and Forecasting (WRF) meteorological model output files were obtained from the BAAQMD. The BAAQMD CMAQ and WRF 2012 4-km data were then processed to obtain 2012 4-km annual PGM modeling database for the Comprehensive Air Quality Model with extensions (CAMx). The following sections described how Ramboll developed the CAMx 2012 4-km annual database used in this study, starting with the BAAQMD CMAQ and WRF 2012 4-km data. Preparation of the Project emissions inputs for CAMx is discussed in **Attachment A**.

2.1 Model Inputs and Configuration

Ramboll converted the 2012 CMAQ area and in-line point emissions files from BAAQMD to CAMx area and point-source emissions files using the CMAQ2CAMx interface program.[27] Seasalt emissions were developed using an emissions processor that integrates published sea spray flux algorithms to estimate sea salt particulate matter (PM) emissions for input to CAMx. The CAMx sea salt emissions were then merged with area emissions files. On-road mobile sources in the BAAQMD database were based on EMFAC2014. Thus, on-road mobile sources were first updated to EMFAC2021 using county and pollutant specific scaling factors. We then projected on-road emissions to 2035 using projection factors derived from EMFAC2021. All other anthropogenic sources were also projected to 2035 using county, pollutant and source category-specific growth factors derived from ARB's California Emissions Projection Analysis Model (CEPAM) 2016 state implementation plan (SIP) inventory. The farthest future year available in the CEPAM is 2035. CEPAM estimates emissions for a specific year based on growth and control factors. The growth factors account for county-specific economic activity profiles, population forecasts, and other socio/demographic activity. The control factors reflect the effects of adopted emission control rules.

The WRF model (Skamarock et al., 2005) and the Fifth-Generation Mesoscale Model (MM5; Grell et al, 1994) are the most common prognostic meteorological models used to provide meteorological fields for air quality modeling. WRF was jointly developed by NCAR and the National Center for Environmental Prediction in late 1990s. It has been under continuous development, improvement, testing and open peer-review and is used world-wide by hundreds of researchers and practitioners. BAAQMD adopted WRF version 3.8 for the 2012 simulations. For the current application, the meteorology remains unchanged for the future year simulation and BAAQMD WRF 2012 4-km model outputs were processed using the WRFCAMx[28] processor to generate the meteorological fields ready for CAMx. The WRF model employs a terrain-following coordinate system defined by pressure, using multiple layers that extend from the surface to 50 millibars (approximately 19 kilometers above ground level [AGL]). A layer averaging scheme is adopted for CAMx simulations to reduce the computational burden. **Table 2-1** presents the mapping from the WRF vertical layer structure to the CAMx vertical layers.

[27] http://www.camx.com/download/support-software.aspx.

[28] WRFCAMx is available on the CAMx website (http://www.camx.com/download/support-software.aspx)

Table 2-1. Vertical layer structure for WRF and CAMx modeling.

WRF		CAMx			
Layer	Height (m)	Layer	Height (m)	Thickness (m)	Sigma[a]
50	19260	28	19260	2625	0.0000
49	16635				
48	14423				
47	12436	27	12436	1849	0.1339
46	10587				
45	9234				
44	8100	26	8100	960	0.3119
43	7140				
42	6324				
41	5629	25	5629	594	0.4630
40	5034				
39	4524				
38	4086	24	4086	376	0.5806
37	3710				
36	3387				
35	3097	23	3097	261	0.6668
34	2835				
33	2600				
32	2389	22	2389	191	0.7341
31	2198				
30	2028				
29	1873	21	1873	139	0.7863
28	1735				
27	1609				
26	1497	20	1497	102	0.8261
25	1396				
24	1304	19	1304	87	0.8471
23	1217				
22	1133	18	1133	81	0.8661
21	1052				
20	974	17	974	75	0.8840
19	899				
18	827				
17	758	16	758	66	0.9088
16	692	15	692	64	0.9165
15	628				
14	566	14	566	59	0.9312
13	507	13	507	57	0.9382
12	450	12	450	53	0.9450
11	398	11	398	50	0.9513
10	348	10	348	46	0.9573
9	302	9	302	44	0.9629
8	258	8	258	40	0.9682
7	218	7	218	38	0.9731
6	180	6	180	36	0.9777
5	144	5	144	32	0.9821
4	112	4	112	31	0.9861
3	81	3	81	29	0.9899
2	52	2	52	27	0.9935
1	25	1	25	25	0.9969
0	0	0	0	0	1.0000

The lateral boundary conditions (BCs) for the 4-km state-wide modeling grid were extracted from a global model simulation for the year 2012. The Model for Ozone and Related Chemical Tracers Version 4 (MOZART-4; Emmons et al., 2010) is a global chemical transport model developed jointly by NCAR, the Geophysical Fluid Dynamics Laboratory, and the Max Planck Institute for Meteorology. It simulates chemistry and transport of tropospheric gases and bulk aerosols. The MOZART-4 simulation with updated meteorological fields derived from the National Aeronautics and Space Administration's Goddard Earth Observing System Model Version 5 (GEOS-5)[29] were downloaded from the UCAR website[30] and the MOZART2CAMx processor was used to derive both the boundary and the initial conditions. The modeling results for the initial five days (spin-up period) were discarded from the analysis to minimize the influence of the initial concentrations.

Additional data used in the air quality modeling include ozone column data from the Ozone Monitoring Instrument (OMI) which continues the Total Ozone Mapping Spectrometer (TOMS) record for total ozone and other atmospheric parameters related to ozone chemistry (OMI officially replaced the TOMS ozone column satellite data on January 1, 2006). OMI data are available every 24-hours and are obtained from the TOMS ftp site.[31] The CAMx O3MAP program reads the OMI ozone column text file data and interpolates to fill gaps and generated gridded daily ozone column input data. The OMI data is used in the CAMx (TUV) radiation models which is a radiative transfer model that develops clear-sky photolysis rate inputs for CAMx. The landuse file was generated with the WRFCAMx processor and modified to remove lakes and set coastal waters with a surf zone width of 50 m, this file was used to update the emissions database and provide more realistic representation of sea salt emissions.

Table 2-2 presents the CAMx configuration used for the modeling in this Project analysis. Atmospheric pollutants in the gas-phase undergo several chemical reactions that are represented in the PGM using a chemical mechanism. Usually, there are multiple options to choose for these chemical mechanisms. The 2007 State-wide Air Pollution Research Center (SAPRC07) mechanism was used in this modeling. This is consistent with past guidance from the California Air Resources Board's (CARB's) Reactivity Scientific Advisory Committee, which recommended switching to the 1999 SAPRC chemical mechanism (Carter, 2000) based on a comprehensive review by Stockwell (1999). The SAPRC07 chemical mechanism has since been the mechanism of choice for the California SIPs. The version implemented in CAMx, SAPRC07TC, includes additional model species that represent selected toxics and reactive organic compounds. The partitioning of inorganic aerosol constituents (sulfate, nitrate ammonium and chloride) between gas and aerosol phases is performed using the ISORROPIA module. The SOAP semi-volatile equilibrium scheme performs the organic aerosol-gas partitioning. These processes are described in more detailed in the CAMx user guide.

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29 http://www.acd.ucar.edu/wrf-chem/mozart.shtml

30 https://www.acom.ucar.edu/wrf-chem/mozart.shtml

31 ftp://toms.gsfc.nasa.gov/pub/omi/data/

Table 2-2 CAMx modeling configuration.

Science Option	Configuration	Notes
Model Code	CAMx v6.5	Released April 2018. This version was used for consistency with BAAQMD modeling. Additionally, all the core science options in version 6.5 (e.g.. chemistry, transport, numerical algorithms) remain valid and almost identical to the most recent versions of CAMx (version 7.2)
Horizontal Grid	4-km 1-way nesting	
O3 and PM 4-km	185 x 185 grid cells	
Vertical Grid	28 vertical layers extending up to ~19 km AGL	Collapsed from 50 WRF/MM5 layers (see Table 3-1)
Initial Conditions	Extracted from the MOZART global model outputs	Modeling results for initial five days (spin-up period) discarded from analysis
Boundary Conditions	Extracted from the MOZART global model outputs	Boundary concentration set for 4-km domain extracted using MOZART2CAMx
Photolysis Rate	Photolysis rates lookup table	Derived from satellite measurements and TUV processor
Gas-phase Chemistry	SAPRC07TC	Solved by the Euler Backward Iterative (EBI) solver
Aerosol-phase Chemistry	ISORROPIA (inorganic aerosol) SOAP v2.1 (organic aerosol)	
Meteorological Input Preprocessor	WRFCAMx v4.7	
Advection	Piecewise Parabolic Method (PPM)	
Diffusion	Eddy diffusion algorithm	

2.2 Modeling Results

The future modeling scenario was simulated using the CAMx source apportionment technology. Both cumulative concentrations from all the sources and the concentrations from Project-specific emissions are derived from a single simulation following the previous section model configuration. The model results of hourly $PM_{2.5}$ concentrations were processed into aggregated metrics that are relevant to health effects.

The metrics relevant to the $PM_{2.5}$ health effects selected in this study are 24-hour annual average concentrations (see **Attachment C**). **Figure 2-1** shows spatial plots of annual average and a single day episode maximum 24-hour average $PM_{2.5}$ concentrations from the base case. In the base case, the central valley of California shows annual $PM_{2.5}$ concentrations that range between 8 and 15 μg/m³. A few areas in Glenn, Butte, and Colusa counties can reach up to 20 μg/m³. Isolated regions in San Bernardino and Los Angeles counties show maximum domain-wide concentrations of up to 36 μg/m³. Annual average concentrations near the Project range between 5 and 10 μg/m³. The largest increases in $PM_{2.5}$ concentrations from the Project occur over the grid cell where the Project is located, followed by the immediately adjacent grid cells. Contributions of the Project emissions to annual average $PM_{2.5}$ are 0.191 μg/m³ at the most affected areas and represent a 1.7 percent increase over the base case concentrations at that location. Contributions to the maximum 24-hour average are 0.742 μg/m³ at the most affected area and represent a 2.8 percent increase over the base case concentrations at that location. **Figure 2-2** presents increases in annual average and maximum 24-hour average $PM_{2.5}$ due to the Project by $PM_{2.5}$ chemical components at the grid cell of maximum impact. It confirms that the $PM_{2.5}$ increases due to the Project are mostly due to primary PM components (referred to in the chart as primary organic aerosol [POA], elemental carbon [EC] and other primary PM).

Figure 2-1 Results of the 4 km $PM_{2.5}$ Modeling Domain. $PM_{2.5}$ Concentrations from the Base Case Scenario (left panels); Increases in $PM_{2.5}$ due to the Project (center panels show most of the modeling domain and right panels show local project area); Annual Averages (top panels); Maximum 24-hour Averages (bottom panels)

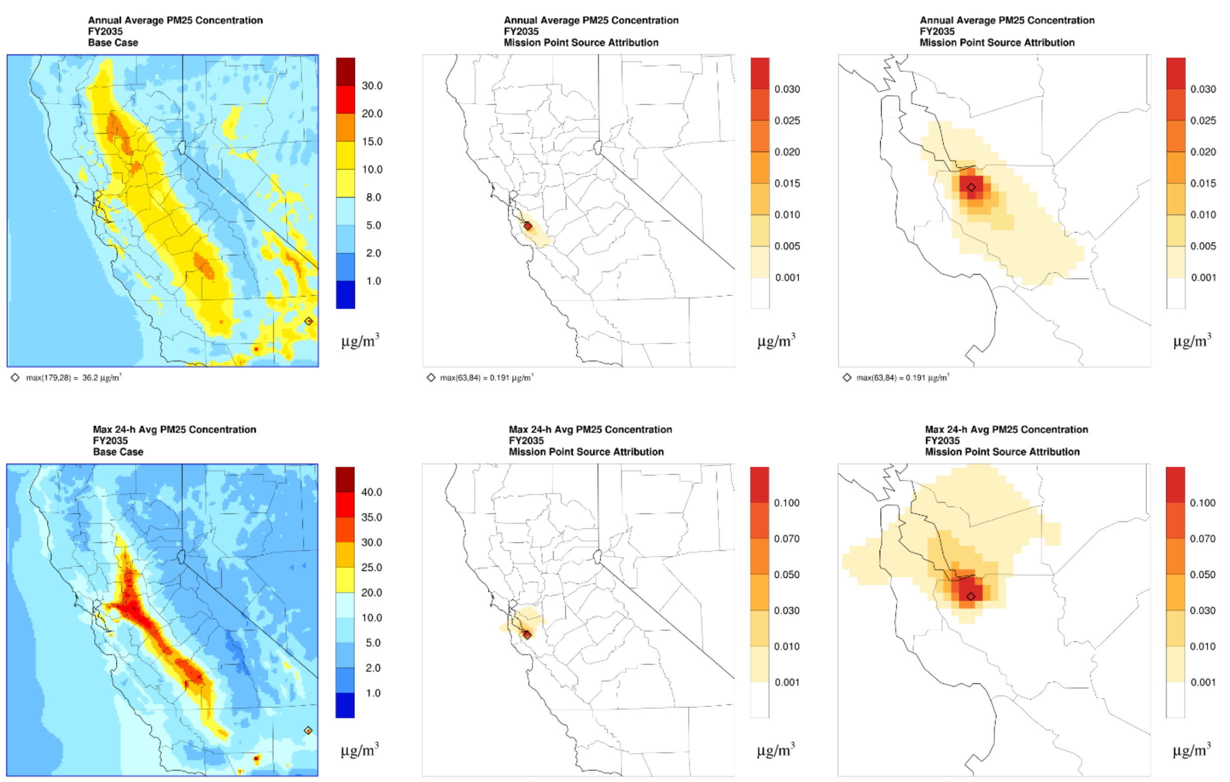
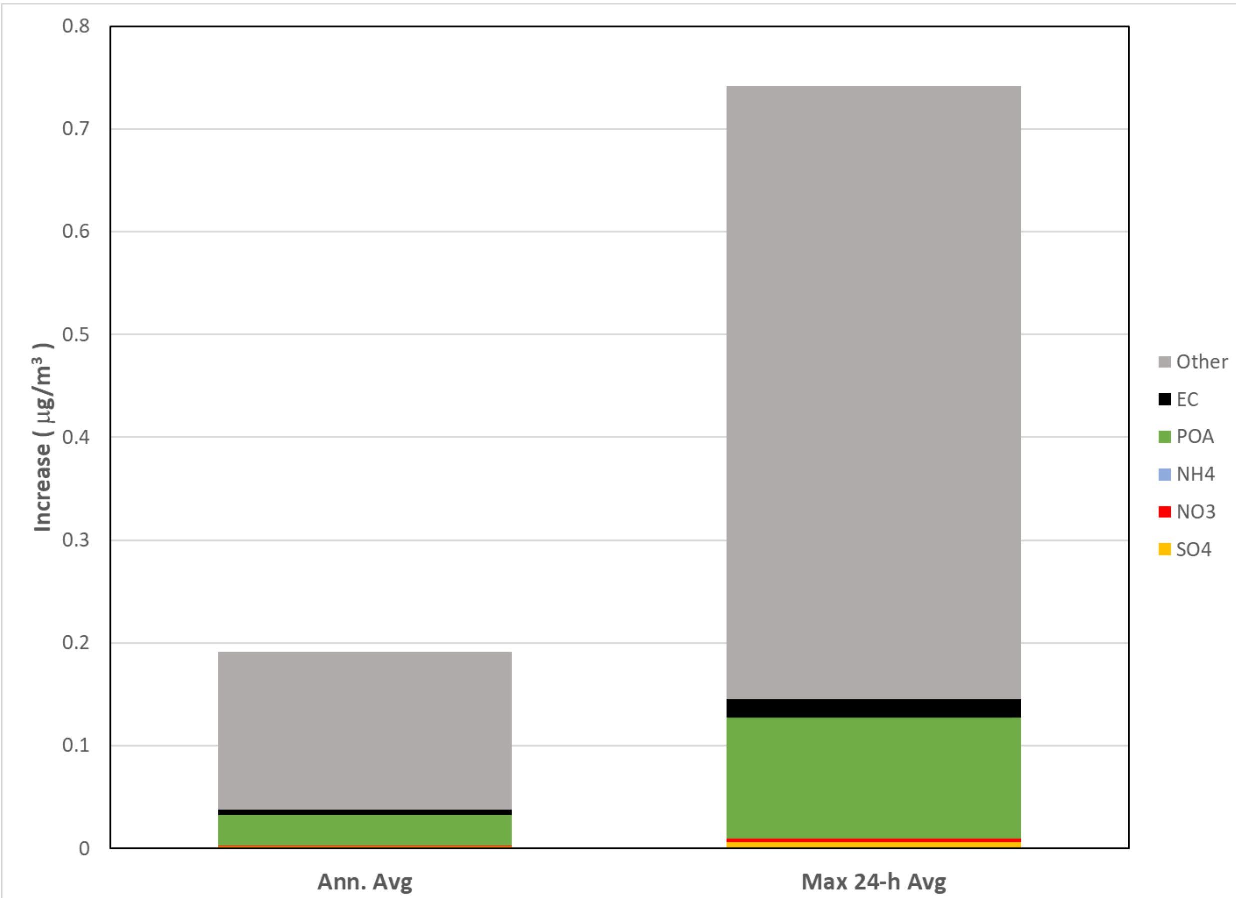


Figure 2-2 Increases in Annual Average and Episode Maximum 24-hour Average $PM_{2.5}$ Concentrations due to the Project by $PM_{2.5}$ Component: fine particulate sulfate (SO_4), nitrate (NO_3), ammonium (NH_4), primary organic aerosol (POA), elemental carbon (EC), and other primary PM (Other); Where the Maximum Change due to Project Emissions Occurred



The metrics relevant to the ozone health effects selected in this study are consistent with the ozone NAAQS (see **Attachment C**). The model provides hourly concentrations that are further post-processed to produce maximum daily average 8-hour (MDA8) ozone concentrations for each day.

Figure 2-3 displays spatial plots of the annual average MDA8 ozone for the 2035 emissions scenario and the corresponding annual average MDA8 increases to ozone concentrations due to the Project emissions. In the base case, counties located in the south-eastern portion of the domain (San Bernardino, Inyo, Tulare, Kern) show the highest MDA8 annual average ozone concentration between 45 and 50 ppb with isolated regions in Kern County with up to 53 ppb. Annual average ozone concentrations near the Project range between 40 and 48 ppb. The maximum increase in the annual average MDA8 ozone concentrations due to the

Project is 0.010 ppb and occurs in Santa Clara County where it represents a 0.23 percent increase over the base case concentrations.

Figure 2-4 displays MDA8 ozone for the base case and increases in MDA8 ozone due to the project on August 14 of the simulation year, the day that the Project has the highest ozone contribution. The highest MDA8 ozone contribution due to the Project is 0.067 ppb (

Figure 2-4, right) and occurs in Santa Clara County where it represents a 0.08 percent increase over the base case concentrations.

Figure 2-3 Annual Average MDA8 Ozone Concentrations from the Base Case Scenario (left) and Increases in Highest MDA8 Ozone Concentrations due to the Project (center for modeling domain and right for local project area) for the Annual Modeling of the 2035 Emissions Scenario

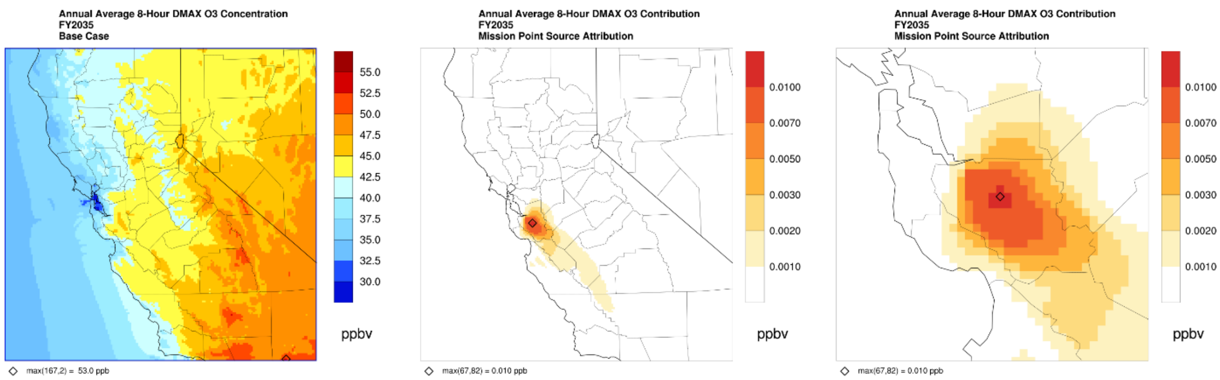
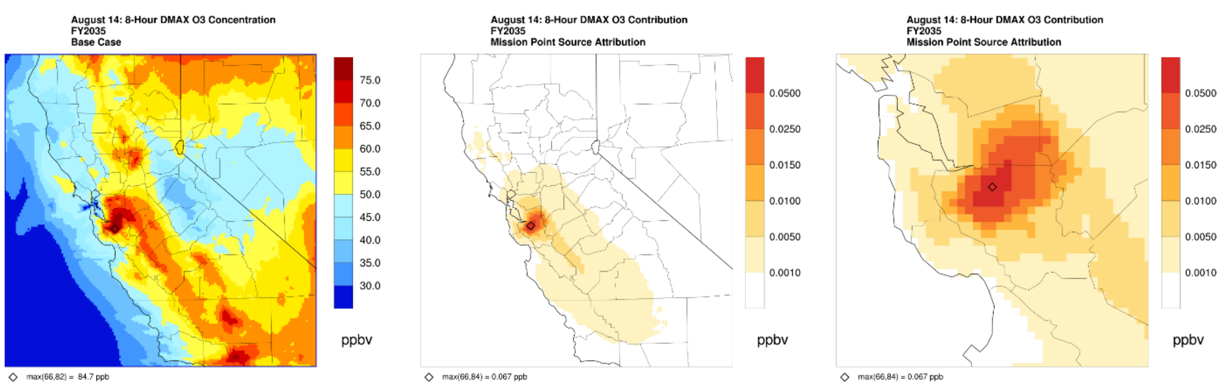


Figure 2-4 MDA8 Ozone Concentrations from the Base Case Scenario (left) and Increases in MDA8 Ozone Concentrations due to the Project (center for modeling domain and right for local project area) on August 14th, the Day with the Highest Project Ozone Contributions for the Annual Modeling of the 2035 Emissions Scenario



2.3 PGM Uncertainty

PGMs generally represent the state-of-the-science when the treatment of photochemically formed air pollution is required over multiple spatial scales (e.g., from single-source to continental). PGMs are part of a modeling system in which there are several other major components that determine model performance, including meteorology, emissions inventories (including background), and chemical mechanisms. It is important to note that both the meteorological models that inform the PGMs and PGM predictions, themselves, in accordance with EPA guidance, are compared with available observations through multiple statistical metrics to characterize any biases and errors.

One of the largest sources of uncertainty for PGM is the processing and accurate accounting of all emission sources into the model. PGMs are Eulerian models that require gridded data that vary in space and time. An accurate prediction of secondary formed pollutants, like ozone and secondary $PM_{2.5}$, requires a comprehensive accounting of all possible sources of pollution and not only those specific to a Project. This typically requires a significant level of effort to construct spatially and temporally varying emission inventories where there may be uncertainties in the characterization of emissions.

A second source of uncertainty is introduced by the meteorological inputs. PGMs require gridded meteorological inputs that are typically provided by mesoscale meteorological model (e.g., WRF) that provide three-dimensional characterization of winds, temperature, humidity and other meteorological variables.

An additional source of uncertainty pertains to the PGM formulations themselves. For example, the models' chemical mechanism represents a simplification of the thousands of chemical reactions involving hundreds of species that take place in the atmosphere in order to reduce the computational burden. PGM being state-of-the-science can only reflect what is understood or established on any given aspect: chemistry, transport, aerosol formation, etc. As the science advances and certain processes are better understood, the models' formulations are modified with the expectation to improve their predictions.

Despite these complexities and associated uncertainties, the USEPA recommends using PGM's for a variety of applications including State Implementation Plans and Regional Haze Planning, and CAMx/CMAQ specifically for single-source modeling of ozone and secondary $PM_{2.5}$. The USEPA believes that the relative change in the PGM-predicted concentrations (e.g., the incremental changes due to the emissions from a single-source) is more accurate and reliable than the total predicted concentrations (USEPA, 2020).

3. REFERENCES

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USEPA. 2020. DRAFT Guidance for ozone and Fine Particulate Matter Permit Modeling. Environmental Protection Agency, Office of Air Quality Planning and Standards, Air Assessment Division. Research Triangle Park, NC. Memorandum dated Feb 10 2020. Accessed on February, 2023. https://www.epa.gov/sites/default/files/2020-09/documents/draft_guidance_for_o3_pm25_permit_modeling.pdf

ATTACHMENT C
BENMAP AND HEALTH EFFECTS

1. HEALTH EFFECTS ANALYSIS

The potential health effects of ozone and particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) concentrations due to the Project's emissions were estimated using the Environmental Benefits Mapping and Analysis Program (BenMAP), Community Edition v1.5.8.23 (March 2023) (USEPA, 2022a).[32] BenMAP, developed by the United States Environmental Protection Agency (USEPA), is a powerful and flexible tool that helps users estimate human health effects and economic benefits resulting from changes in air quality. BenMAP outputs include PM- and ozone-related health endpoints such as premature mortality, hospital admissions, and emergency room visits. BenMAP uses the following simplified formula to relate changes in ambient air pollution to certain health endpoints (USEPA, 2022b)[33]:

$$\text{Health Effect} = \text{Air Quality Change} \times \text{Health Effect Estimate} \times \text{Exposed Population} \times \text{Background Health Incidence Rate}$$

- Air Quality Change – The difference between the starting air pollution level (the base) and the air pollution level after some change, such as a new source.
- Health Effect Estimate – An estimate of the percentage change in an adverse health effect due to a one unit change in ambient air pollution. Effect estimates, also referred to as concentration-response (C-R) functions, are obtained from epidemiological studies.
- Exposed Population – The number of people affected by the air quality change. The government census office is a good source for this information. This analysis uses data from PopGrid, which is an add-on program to BenMAP that allocates the block-level U.S. 2010 Census population to a user-defined grid.[34] The 2010 Census data is the most recent census data PopGrid (and similarly, BenMAP) contains. BenMAP projects the population into the future year to determine the exposed population in the year being analyzed (2035).
- Background Health Incidence Rate – An estimate of the average number of people over a given population that suffer from some adverse health effect over a given period of time. For example, the health incidence for asthma emergency room visits is the number of people over a given population who might visit the ER due to asthma in a given year. Health incidence rates and other health data are typically collected by the government as well as the World Health Organization. BenMAP calculates background health incidence rates based on the available health statistics and population data, with preference given to individual-level data counts (e.g., mortality counts or hospital and emergency department discharges) at the County-level. For California counties, data were available at the individual-level. The background health incidence data are also based on different years depending on data availability. For example, hospital admissions and emergency department visits for California are based on 2011 data. For mortality background incidence rates, USEPA obtained data for 2012-2014 from the Centers for Disease Control WONDER database (http://wonder.cdc.gov) and generated age-, cause-, and county-

[32] https://www.epa.gov/benmap

[33] The common function used for calculating health impacts is the following log-linear function: Health Effect = Background Health Incidence Rate x [1 – exponential (Health Effect Estimate * Air Quality Change)] x Exposed Population

[34] https://www.epa.gov/sites/production/files/2015-04/documents/benmap-ce_user_manual_march_2015.pdf

specific mortality rates as described in the BenMAP manual.[35] The projected mortality rates for the years 2015-2035 are then calculated using Census Bureau projected life tables.[36]

The health endpoints analyzed in this study and the BenMAP results are presented in Section 2 of this attachment.

2. HEALTH EFFECTS ANALYSIS RESULTS

This section presents the health effects of the Project emissions on the population in the Northern California domain, estimated by the BenMAP model. The Comprehensive Air Quality Model with extensions (CAMx) modeling results are processed to generate aggregated daily and annual average $PM_{2.5}$ and maximum daily 8-hour ozone concentrations appropriate for various health endpoints. The CAMx simulation results from the full year (January to December) are used to estimate the health effects of $PM_{2.5}$ and ozone. BenMAP translates increases in the pollutant concentration due to the Project emissions to changes in the incidence rate for each health effect using a C-R function derived from previously published epidemiological studies. BenMAP often provides multiple C-R functions based on different epidemiological studies for a given health endpoint. C-R functions selected here have been used in past USEPA regulatory assessments when evaluating health effects. This analysis uses population data from PopGrid, which allocates the census population to each modeled 4x4 kilometer (km) grid cell.

The population used for both the quantified health effects and the background health incidence presented here is future year 2035, for consistency with the CAMx model run year, and more conservative than the Project build out year of 2034. The PopGrid program was used to project 2010 block-level U.S. Census population to 2035. BenMAP reads this file to incorporate population changes into its health effect calculations. The population in the Northern California domain is projected to be 22,502,033 in 2035.

2.1 $PM_{2.5}$ Health Effects

Consistent with USEPA's assessment of health effects of particulate matter, the health effects evaluation focuses on $PM_{2.5}$ and not PM_{10}, as $PM_{2.5}$ has a much larger body of evidence that this size fraction is associated with health effects due to the sources, composition, chemical properties and lifetime in the atmosphere (USEPA 2009). $PM_{2.5}$ is capable of penetrating deeper into the lungs because of their size compared to larger particles and this is believed to contribute to greater health effects. Consistent with USEPA health effects evaluations, the health effect functions in BenMAP for PM use fine particulate ($PM_{2.5}$) as the causal PM agent.

Although there are a large number of potential health endpoints that could be included in the analysis as described above, we selected health endpoints that have been the focus of United States Environmental Protection Agency (USEPA) risk assessments (e.g., USEPA, 2010; USEPA, 2014; USEPA, 2022c). For example, the USEPA notes that health endpoints were selected based on consideration of at-risk populations (e.g., asthmatics), endpoints that have public health significance, and endpoints for which information is sufficient to support a quantitative C-R relationship (USEPA, 2014).

[35] Ibid.

[36] https://www.census.gov/programs-surveys/popproj/data/tables.html

The health endpoints and associated C-R functions examined in this study are presented in **Table 2-1**. Each C-R function is based on a certain age range for the given health endpoint depending on the underlying epidemiological study on which it is based. Mean incidence rates, increases in the BenMAP-estimated health effect incidences and percent of background health incidence due to the Project emissions are presented in **Table 2-2**. These values reflect the total health effects across the Northern California model domain, though the regions of primary health effect results are shown **in Figures 1-2**, **1-4**, and **1-5** of **Attachment B**.

Table 2-1. Summary of $PM_{2.5}$ Health Endpoints Used in this Study

Health Endpoint	Age Range	Daily Metric	Seasonal Metric	Annual Metric	C-R Function Selected
Emergency Room Visits, Asthma	0-99	24-hr mean			Mar et al., 2010[1]
Emergency Room Visits, Cardiovascular	0-99	24-hr mean			Ostro et al., 2016
Mortality, All Cause	30-99	24-hr mean	Quarterly mean	Mean	Turner et al., 2016[1]
Hospital Admissions, Asthma	0-64	24-hr mean	-	-	Sheppard, 2003[1]
Hospital Admissions, Cardiovascular	65-99	24-hr mean	-	-	Bell et al., 2015
Hospital Admissions, Respiratory	65-99	24-hr mean	-	-	Bell et al., 2015
Acute Myocardial Infarction, Nonfatal	18-24	24-hr mean	-	-	Zanobetti et al., 2009[1]
Acute Myocardial Infarction, Nonfatal	25-44	24-hr mean	-	-	
Acute Myocardial Infarction, Nonfatal	45-54	24-hr mean	-	-	
Acute Myocardial Infarction, Nonfatal	55-64	24-hr mean	-	-	
Acute Myocardial Infarction, Nonfatal	65-99	24-hr mean	-	-	

[1] C-R functions available in BenMAP (USEPA, 2020a; USEPA, 2022a)

The results show that the highest health effect is for all-cause mortality, with an estimated mean increased incidence of 1.62 deaths per year due to the Project emissions. Smaller mean increased incidences per year were estimated for other relevant $PM_{2.5}$-related health effects: 0.97 increase in incidence of asthma related emergency room visits, 0.0317 increase in incidence of respiratory hospital admissions, and a 0.279 increase in incidence of cardiovascular hospital admissions.

It should be noted, however, that the estimated increased incidence in those health effects is minimal compared to the background health incidence values (shown in **Table 2-2** as percent of Background Health Incidence). For example, for asthma emergency room visits, the increase of 0.97 incidences per year due to Project emissions represents 0.00084% of the total emergency room visits due to asthma for people ages 0 to 99.

Table 2-2. BenMAP-Estimated $PM_{2.5}$ Annual Health Effects of the Project Emissions Across the Northern California Model Domain[1]

Health Endpoint[2]	Project Incidences (Annual)			Background Health Incidence (Annual)	Project Mean as Percent of Background Health Incidence (%)
	2.5 Percentile[3]	Mean Project Incidences	97.5 Percentile[3]		
Emergency Room Visits, Asthma [0-99]	0.239	0.97	1.68	115,302	0.00084%
Emergency Room Visits, Cardiovascular [0-99]	-0.188[4]	0.49	1.14	441,046	0.00011%
Mortality, All Cause [30-99]	1.08	1.62	2.14	176,797	0.00091%
Hospital Admissions, Asthma [0-64]	0.031	0.084	0.136	13,394	0.00063%
Hospital Admissions, All Cardiovascular [65-99]	0.203	0.279	0.35	220,836	0.00013%
Hospital Admissions, All Respiratory [65-99]	0.00121	0.0317	0.061	82,964	0.00004%
Acute Myocardial Infarction, Nonfatal [18-24]	0.000055	0.000117	0.000177	27	0.00043%
Acute Myocardial Infarction, Nonfatal [25-44]	0.0039	0.0082	0.0124	1,583	0.00052%
Acute Myocardial Infarction, Nonfatal [45-54]	0.0080	0.0169	0.0256	4,025	0.00042%
Acute Myocardial Infarction, Nonfatal [55-64]	0.0172	0.036	0.055	6,762	0.00054%

Acute Myocardial Infarction, Nonfatal [65-99]	0.059	0.124	0.188	28,174	0.00044%

[1] Health effects are shown terms of incidences of each health endpoint and how it compares to the base (2035 base year health effect incidences) values.

[2] Affected age ranges are shown in square brackets.

[3] The percentiles are generated in BenMAP using a Monte Carlo analysis and represent the statistical uncertainty in the incidence associated with the CRF, but do not include other potential sources of uncertainty (i.e., in the air modeling, in estimates of projected background incidence or populations). These confidence bounds are typically used by USEPA to represent the 95% confidence intervals around the mean estimate.

[4] The negative lower bound of the confidence interval represents the statistical uncertainty in the CRF, which in this case is inclusive of a zero increase in the incidence.

2.2 Ozone Health Effects

As noted above, although a larger number of health endpoints could be evaluated, the health endpoints evaluated here were selected based on USEPA risk assessments (USEPA, 2010; USEPA, 2014; USEPA, 2021; USEPA, 2022c). The health endpoints and associated C-R functions examined in this study are presented in **Table 2-3.** Each C-R function is associated with a certain age range for the given health endpoint depending on the epidemiological study on which it is based. Increases in the BenMAP-estimated health effect incidences and percent of background health incidence due to the Project emissions are presented in **Table 2-4.** These values reflect the total health effects across the Northern California model domain, though the regions of primary health effect results are shown in **Figures 2-3** and **2-4** of **Attachment B**.

Table 2-3. Summary of Ozone Health Endpoints Used in this Study.

Health Endpoint	Age Range	Daily Metric	Seasonal Metric	Annual Metric	C-R Function Selected
Hospital Admissions, All Respiratory	65-99	MDA8	-	-	Katsouyanni et al., 2009[1]
Mortality, Respiratory	30-99	MDA8			Turner et al., 2016
Emergency Room Visits, Asthma	0-17	MDA8	-	-	Mar and Koenig, 2009[1]
Emergency Room Visits, Asthma	18-99	MDA8	-	-	Mar and Koenig, 2009[1]

[1] C-R functions available in BenMAP (USEPA, 2020a; USEPA, 2022a)

For this Project, asthma-related emergency room visits are associated with the highest health effects due to the Project emissions in the Northern California domain (0.19 incidences per year for adults ages 18 to 99 and 0.27 incidences per year for children ages 0 to 17). Mortality due to respiratory issues and hospital admissions due to respiratory issues for adults aged 65-99 have lower incidence increases (0.18 and 0.027 incidences per year, respectively).

The estimated increases in those health effect incidences are minimal compared to the background health incidence (shown in **Table 2-4** as percent of Background Health Incidence). For example, the increase in asthma emergency room visits of 0.19 per year represents 0.00050% of the total asthma-related emergency room visits for adults.

Table 2-4. BenMAP-Estimated Mean Ozone Annual Health Effects of the Project Emissions Across the Northern California Model Domain[1]

Health Endpoint[2]	Project Incidences (Annual)			Background Health Incidence (Annual)	Project Mean as Percent of Background Health Incidence (%)
	2.5 Percentile[3]	Mean Project Incidences	97.5 Percentile[3]		
Hospital Admissions, All Respiratory [65-99]	-0.0073[4]	0.027	0.061	63,783	0.000043%
Mortality, Respiratory [30-99]	0.12	0.18	0.23	19,099	0.00093%
Emergency Room Visits, Asthma [0-17]	0.044	0.27	0.49	19,786	0.0014%
Emergency Room Visits, Asthma [18-99]	-0.075[4]	0.19	0.45	38,023	0.00050%

[1] Health effects are shown terms of incidences of each health endpoint and how it compares to the base (2035 base year health effect incidences) values.

[2] Affected age ranges are shown in square brackets.

[3] The percentiles are generated in BenMAP using a Monte Carlo analysis and represent the statistical uncertainty in the incidence associated with the CRF, but do not include other potential sources of uncertainty (i.e., in the air modeling, in estimates of projected background incidence or populations). These confidence bounds are typically used by USEPA to represent the 95% confidence intervals around the mean estimate.

[4] The negative lower bound of the confidence interval represents the statistical uncertainty in the CRF, which in this case is inclusive of a zero increase in the incidence.

2.3 Conclusion

The $PM_{2.5}$ and ozone concentration changes modeled by CAMx were converted to potential health effects on various health endpoints including premature mortality, hospitalizations, and emergency room visits, using the BenMAP health effects assessment model and health endpoints typically used in past USEPA regulatory assessments. Estimated changes in the annual health effect incidences are presented across the California grids in the Northern California domain. Across the board, the estimated increases in those health effect incidences are minimal compared to the background health incidence values with the largest $PM_{2.5}$ health effect (all-cause mortality) from the Project (2034 build out) representing 0.00091% of the total of all deaths, and the largest health effect for ozone (asthma related emergency room visits by children) representing 0.0014% of all emergency room visits.

Project-related health incidences occur both in closer proximity to Project emissions, particularly for $PM_{2.5}$ health effects (see **Attachment B** for maps of modeled concentration changes), or over a large area due to the regional nature of emission dispersion and photochemical reactions that occur, particularly for ozone health effects (concentration changes also shown in **Attachment B**). When taken into context, the small increase in incidences and the small percent of the number of background incidences indicate that these health effects are minimal in a developed environment.

2.3.1 Uncertainty

The approach and methodology of this analysis ensures that the uncertainty is of a conservative nature. In addition to the conservative assumptions built into the emissions noted above, there are a number of assumptions built into the application of C-R functions in BenMAP that may lead to an overestimation of health effects. In the Policy Assessment for the Reconsideration of the National Ambient Air Quality Standards (NAAQS) for Particulate Matter prepared by the EPA (USEPA, 2022c), the EPA acknowledges the many factors of uncertainty in selected C-R functions and resulting risk estimates, including the shape of the exposure-response function and statistical uncertainty (especially at low concentrations), temporal mismatch between ambient air data and the health effect, exposure measurement error in the epidemiological studies that produced the C-R function, potential confounding of the effect of $PM_{2.5}$ or ozone on mortality, and compositional and source differences of PM, all of which similarly apply to the results presented above.

Another uncertainty highlighted by the USEPA (2022c) which applies to potential health effects from both $PM_{2.5}$ and ozone, is the assumption of a log-linear response between exposure and health effects, without consideration for a threshold concentration below which effects may not be measurable. In the latest USEPA Policy Assessment for PM (USEPA, 2022c), while it is noted that some studies show evidence supporting a linear, no-threshold relationship, the USEPA continues to acknowledge that interpreting the shapes of concentration-response relationships is a recognized uncertainty, particularly at lower $PM_{2.5}$ concentrations, where lower data density, possible influence of measurement error, and variability among individuals with response to air pollution health effects can obscure the existence of a threshold or nonlinear relationship. The issue of a threshold for $PM_{2.5}$ and ozone is highly debated and can have significant implications for health effects analyses as it requires consideration of current air pollution levels and calculating effects only for areas that exceed threshold levels. Without consideration of a threshold concentration, any changes in air pollution are assumed to adversely affect health, which is a conservative assumption. Although the USEPA traditionally does not consider thresholds in its cost-benefit analyses, the NAAQS itself is a health-based threshold level that the USEPA has developed based on evaluating the most current evidence of health effects.

For all-cause mortality effects from $PM_{2.5}$, uncertainty stems from the limitations of epidemiological studies, such as mismeasured exposure estimates and the different statistical adjustments to minimize potential confounding from incompletely measured individual lifestyle factors (such as smoking, diet, and others) that may be related to $PM_{2.5}$ or ozone exposure and mortality. Even when studies adjusted for potential confounders, residual confounding may still occur and distort the C-R function.

Several reviews have evaluated the scientific evidence of health effects from specific particulate components (e.g., Rohr and Wyzga 2012; Lippmann and Chen, 2009; Kelly and Fussell, 2007). These reviews indicate that the evidence is strongest for combustion-derived components of PM including elemental carbon (EC), organic carbon (OC) and various metals (e.g., nickel and vanadium), however, there is still no definitive data that points to any particular component of PM as being more toxic than other components. The USEPA has also stated that results from various studies have shown the importance of considering particle size, composition, and particle source in determining the health effects of PM (USEPA, 2009). Further, USEPA (2009) found that studies have reported that particles from industrial sources and from coal combustion appear to be the most significant contributors to PM-related mortality, consistent with the findings by Rohr and Wyzga (2012), Park et al. (2018), and others. This is particularly important to note here, as the majority of PM emissions generated from the Project are from brakewear, tirewear, and entrained roadway dust (see **Attachment A**), and not from combustion. Therefore, by not considering the relative toxicity of PM components, the results presented here are conservative.

For both the $PM_{2.5}$ and ozone health effects calculated, each of the pollutants may be a confounder of the other. Thus, while the C-R functions are from studies that evaluated the effects for each pollutant individually, while sometimes adjusting for the other as a co-pollutant, both air pollutants could contribute to the health effect outcomes evaluated, and thus the overall health effects from a single pollutant may be overstated.

Specific to potential health effects from ozone, the Integrated Science Assessment for Ozone and Related Photochemical Oxidants (USEPA, 2020b) retained the conclusion that long-term exposure to ozone is likely to be a causal relationship with respiratory effects. Therefore, potential respiratory-related mortality is conservatively evaluated. However, as outlined in the Policy Assessment for the Review of the Ozone National Ambient Air Quality Standards (USEPA, 2020c), the USEPA concluded that currently available evidence for total mortality is suggestive of, but not sufficient to infer, a causal relationship with short-term (as well as long-term) ozone exposures.

As noted above, the health effects estimation using this method presumes that health effects may be seen at any concentration difference, with no consideration of potential thresholds below which health effects may not occur. This methodology of linearly scaling health effects is broadly accepted for use in regulatory evaluations and is considered as being health protective (USEPA, 2010).

In summary, and with consideration of the uncertainty discussed above, health effects presented in this report are conservatively estimated, and the actual effects may be zero.

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